

TAXONOMY AND PHYLOGENY OF FUNGI ASSOCIATED WITH BANANA (*MUSA* SPP.)

BINU CHAMINI SAMARAKOON MUDIYANSELAGE

DOCTER OF PHILOSOPHY

IN

BIOLOGICAL SCIENCE

SCHOOL OF SCIENCE

MAE FAH LUANG UNIVERSITY

2023

©COPYRIGHT BY MAE FAH LUANG UNIVERSITY

TAXONOMY AND PHYLOGENY OF FUNGI ASSOCIATED WITH BANANA (*MUSA* SPP.)

BINU CHAMINI SAMARAKOON MUDIYANSELAGE

THIS DISSERTATION IS A PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN
BIOLOGICAL SCIENCE

SCHOOL OF SCIENCE
MAE FAH LUANG UNIVERSITY
2023
©COPYRIGHT BY MAE FAH LUANG UNIVERSITY

TAXONOMY AND PHYLOGENY OF FUNGI ASSOCIATED WITH BANANA (*MUSA* SPP.)

BINU CHAMINI SAMARAKOON MUDIYANSELAGE

THIS DISSERTATION HAS BEEN APPROVED
TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
BIOLOGICAL SCIENCE
2023

EXAMINATION COMMITTEE

....CHAIRPERSON
(Asst. Prof. Eleni Gentekaki, Ph. D.)

....ADVISOR
(Asst. Prof. Putarak Chomnunti, Ph. D.)

....CO-ADVISOR
(Adjunct Prof. Kevin David Hyde, Ph. D.)

....CO-ADVISOR
(Samantha Chandranath Karunarathna, Ph. D.)

....EXAMINER
(Mahamarakkalage Mary Ruvishika Shehali Jayawardena, Ph. D.)

Wipornpan Nuangmek .....EXTERNAL EXAMINER
(Asst. Prof. Wipornpan Nuangmek, Ph. D.)

....EXTERNAL EXAMINER
(Prof. Darbhe Jayarama Bhat, Ph. D.)

©COPYRIGHT BY MAE FAH LUANG UNIVERSITY

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Professor Kevin Hyde for the opportunity to conduct my postgraduate studies at the center of excellence in fungal research at Mae Fah Luang University, Chiang Rai, Thailand. His continuous support, patience, motivation, and guidance have been invaluable. I am also grateful to my advisor, Assistant Professor Putarak Chomnunti, who has been an extraordinary supervisor, shaping me with love, courage, and hard work. Her unwavering support, financial assistance, and patience over the past six years have been instrumental in my academic and personal growth. Professor Chomnunti taught me essential lab skills, involved me in workshops and seminars, and provided numerous opportunities that enriched my research experience. Her guidance, both professional and personal, has left an indelible mark on my life, for which I am profoundly grateful. I would like to thank Professor Samantha Karunarathna for his financial support and encouragement. His guidance and understanding have been invaluable throughout my studies.

I extend my sincere thanks to Associate Professor Eleni Gentekaki for her positive support, reinforcement, and for serving as the chairperson of my examination committee. I would also like to express my gratitude to Professor Jayarama Bhat for his role as an examiner in evaluating my PhD thesis, as well as for his unwavering support and encouragement over the years, enriched by his extensive knowledge. Additionally, I am thankful to Assistant Professor Wipornpan Nuangmek for joining the committee as an examiner and providing valuable evaluation of my thesis. Special thanks to Dr. Ruvishika Shehali Jayawardena for her invaluable assistance and mentorship throughout this challenging journey, and for her role as an examiner in evaluating my thesis.

I am thankful to Mae Fah Luang University for providing the financial support from the Dissertation Support Grant (Grant Number 0176) and the Publication

Support Grant (Grant Number 0230). I extend my heartfelt gratefulness to Mae Fah Luang University for granting the tuition scholarship for my Ph.D. studies.

My heartfelt thanks go to Dr. Dhanushka Wanasinghe, who has been a brotherly figure, providing unwavering support and kindness since my arrival in Thailand. His encouragement has been a source of strength throughout my journey. I am also deeply grateful to Dr. Milan Samarakoon, whose guidance and trust have been crucial. His willingness to share his expertise and time has significantly contributed to my development. Additionally, I extend my gratitude to Dr. Asanka Bandara for his invaluable assistance throughout my journey. These three individuals have played pivotal roles in my academic and personal growth, for which I am profoundly thankful.

I extend my sincere gratitude to Dr. Rungtiwa Phookamsak, Dr. Quin Tian (Teena), Dr. Hansika Perera, Dr. Saranyaphat Boonmee, Dr. Thilini Chethana, Dr. Rajesh Jeewon, Prof. D. Jayarama Bhat, Dr. Sajeewa Maharachchikumbura, Dr. Kasun Thambugala, Dr. Eric H. McKenzie, Dr. Phongon, Dr. Peter E. Mortimer, and Prof. Abhaya Balasooriya for their guidance and support.

I am grateful to Dr. Jun Fu Li for his support in saprobic fungal studies, and to Dr. Danuska Thennakoon, Dr. Nimali Indeewari, and Dr. Anurudhdha Karunarathna for their warmth and affection. Thanks to Dr. Chathu, Mr. Dimuth, Dr. Nanthanit Jaruseranee, Dr. Khanobporn Tangtrakulwanich, Dr. Sirappapa Mahanill, the scientists at Scientific Laboratory 3 (S3), and the staff at Kunming Institute of Botany, especially Dr. Thatsanee Luangharn, Dr. Elina, Erfu, and Leo. Special thanks to Mr. Songran and the family at Rattana Dormitory, Thailand.

I express my deepest appreciation to Erandi, Digvi, Sajini, Janith, my fellow students, and seniors in Thailand and China, especially Dr. Vino, Dr. Adarsh, Chasika, Nimeshi, Nethmini, Vidya, Divya, Zha, Dr. Bao, Dr. Nuwanthika, Dr.

Achala, Ray, Ren, Yu Wei, Toney, Nat, Few, Pai, Namfon, and Sudradej. Special thanks to Sornram Sukpisit, Wilawan Punyaboon, and Kasiphat Limsakul for their invaluable assistance.

I thank BRIG Priyantha Navaratne, Prof. Malkanthi Dawundasekara, Prof. Deepthi Yakandawela, Prof. Gehan Jayasooriya, Prof. Sumedha Madawala, and the academic and non-academic staff of the University of Peradeniya, Sri Lanka. I also thank my childhood and university friends Dishani, Hasara, Pabasara, Jayamini, Madumali, Erandi, Theekshana, and Aruna.

My heartfelt gratitude goes to Mr. Nandun Arangala and Mr. Lasantha Bandara for their invaluable assistance and understanding throughout this journey. As great friends and brothers, their support has been a constant source of strength and encouragement. I am profoundly grateful for their unwavering presence and guidance.

Finally, I am forever indebted to my parents (Mr. Gamini Samarakoon and Mrs. Seetha Malini), my brother Thiue Samarakoon, Nimal bappa, Ananda bappa and Punchi for their unwavering support, love, and encouragement.

Binu Chamini Samarakoon

Dissertation Title	Taxonomy and Phylogeny of Fungi Associated with Banana (*Musa* spp.)
Author	Binu Chamini Samarakoon Mudiyanselage
Degree	Doctor of Philosophy (Biological Science)
Advisor	Asst. Prof. Putarak Chomnunti, Ph. D.
Co-Advisors	Adjunct Prof. Kevin David Hyde, Ph. D. Samantha Chandranath Karunarathna, Ph. D.

ABSTRACT

Bananas and plantains predominantly belong to *Musa* (*Musaceae, Zingiberales*). These fruit crops are cultivated and consumed in around 135 countries and are among the most traded fruits in the world. *Musa* harbors different lifestyles of fungi, including endophytes, pathogens, and saprobes. Due to the monetary value of the fruit, in-depth systematic studies have been conducted worldwide on fungal pathogens associated with *Musa*. However, only a few mycologists worldwide have studied *Musa's* saprobic and endophytic fungal niches. Several previously identified fungal taxa lack morphological illustrations, descriptions, and DNA sequence data in public databases. Hence, the taxonomy and phylogeny of these latter extant taxa are under-examined.

Wild and cultivated varieties of *Musa* plants, as well as commercial banana fruits available in local markets, were selected for the study. Samples were mainly collected throughout the year from Thailand and China. Fungi were primarily isolated from leaves, leaf sheaths, pseudo stems, and fruits. Endophytic fungi were recovered from fresh, asymptomatic leaf parts, while saprobic fungi were isolated from dead or decaying tissues. Symptomatic leaves were selected to isolate the fungal taxa

associated with necrotic spots. Post-harvest pathogens were isolated from banana fruits available at commercial stalls.

Species identification was mainly conducted based on morphology and multi-gene phylogeny. The pathogenicity test was performed for pathogenic fungi in addition to morphological and phylogenetic analysis. Healthy banana fruits were artificially inoculated to evaluate the pathogenicity of fungi isolated from post-harvest fruit rots. Herbarium specimens of the fungi described in the thesis were deposited in the Mae Fah Luang University (MFLU) Fungarium, Chiang Rai, Thailand. Living cultures were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC). The obtained DNA sequences were verified, submitted to GenBank, and made available for public reference.

A total of 368 fungal cultures representing endophytes, saprobes, pathogens, and fungi associated with leaf spots were isolated during the study, and 206 species were morphologically recorded. Among them, 150 fungal cultures were selected to generate molecular data and evaluate phylogenetic relationships. Based on morpho-molecular data, the present study identified 67 *ascomycetous* fungal species in 51 different genera, with a taxonomic hierarchy of 34 families and 13 orders in *Dothideomycetes*, *Eurotiomycetes*, and *Sordariomycetes*. Among these, 44 species were illustrated, taxonomic descriptions were provided, and their phylogenetic relationships were investigated. Additionally, 20 fungal taxa were identified to the generic level with the aid of DNA sequence data and morphology. Among the 44 species illustrated in the thesis, seven are new species, 26 are new hosts and geographical records, and six are new collections.

The newly described species are *Dematipyriforma teristiris* (*Pleurotheciaceae*), *Dictyoarthrinium musae* (*Didymosphaeriaceae*), *Neohelicosporium terrestris* (*Tubeufiaceae*), *Pyrenochaetopsis musae* (*Pyrenochaetopsidaceae*), *Smaragdiniseta musae* (*Stachybotryaceae*), *Spegazzinia musae* (*Didymosphaeriaceae*) and *Stachybotrys musae* (*Stachybotryaceae*).

In addition, 17 endophytic fungal genera, *viz*. *Albifimbria, Alternaria, Colletotrichum, Corynespora, Curvularia, Daldinia, Diaporthe, Epicoccum, Fusarium, Lasiodiplodia, Musicillium, Neopestalotiopsis, Pestalotiopsis, Phyllosticta, Pseudophaeocytostroma, Pseudopithomyces,* and *Spegazzinia,* were isolated from the fresh leaves of *Musa* and identified based on morphology and DNA. Among them, eight taxa, *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Corynespora torulosa* (*Corynesporascaceae*), *Daldinia eschscholtzii* (*Hypoxylaceae*), *Lasiodiplodia theobromae* (*Botryosphaeriaceae*), *Musicillium tropicale* (*Plectosphaerellaceae*), *Pseudophaeocytostroma sacchari* (*Diaporthaceae*), *Pseudopithomyces chartarum* (*Didymosphaeriaceae*), and *Setoarthopyrenia chromolaenae* (*Roussoellaceae*) are illustrated and described with confirmed morphology and molecular phylogeny.

The morpho-molecular data revealed the occurrence of 48 genera of saprobic fungi *viz*. *Acrostalagmus, Albifimbria, Alternaria, Apiospora, Bahusandhika, Cladosporium, Clonostachys, Colletotrichum, Corynespora, Curvularia, Dematipyriforma, Dendryphiella, Diaporthe, Dictyoarthrinium, Durispora, Epicoccum, Fusarium, Gibellulopsis, Gliomastix, Hermatomyces, Kalmusia, Koorchaloma, Lasiodiplodia, Lasionectria, Lophiotrema, Memnoniella, Musicillium, Nectria, Neocordana, Neohelicosporium, Neopestalotiopsis, Nigrospora, Ophioceras, Periconia, Pestalotiopsis, Phaeosphaeria, Phyllosticta, Plectosphaerella, Pseudocercospora, Pseudophaeocytostroma, Pseudopithomyces, Pyrenochaetopsis, Setophoma, Smaragdiniseta, Spegazzinia, Stachybotrys* and *Torula* on *Musa* substrates. Among them, 33 species *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Apiospora locuta-pollinis* (*Apiosporaceae*), *Bahusandhika indica* (*Lentimurisporaceae*), *Colletotrichum musae* (*Glomerellaceae*), *Corynespora torulosa* (*Corynesporascaceae*), *Dematipyriforma teristiris* (*Pleurotheciaceae*), *Dendryphiella vinosa* (*Dictyosporiaceae*), *Dictyoarthrinium musae, D. thailandica, D. sacchari* (*Didymosphaeriaceae*), *Gibellulopsis serrae* (*Plectosphaerellaceae*), *Lasiodiplodia theobromae* (*Botryosphaeriaceae*), *Lophiotrema hydei*

(*Lophiotremataceae*), *Memnoniella levispora* (*Stachybotryaceae*), *Musicillium elettariae* (*Plectosphaerellaceae*), *Neocordana musae* (*Pyriculariaceae*), *Neohelicosporium terrestris* (*Tubeufiaceae*), *Nigrospora sphaerica* (*Apiosporaceae*), *Periconia cortaderiae, P. delonicis, P. echinochloae* (*Periconiaceae*), *Pseudopithomyces chartarum* (*Didymosphaeriaceae*), *Smaragdiniseta musae* (*Stachybotryaceae*), *Spegazzinia deightonii, S. musae, S. radermacherae* (*Didymosphaeriaceae*), *Stachybotrys microsporus, S. musae, S. subcylindrosporus* (*Stachybotryaceae*), *Torula chromolaenae, T. fici, T. mackenziei,* and *T. masonii* (*Torulaceae*) are included with full descriptions, illustrations and molecular phylogeny.

Eight fungal taxa, *viz*. *Colletotrichum siamense* (*Glomerellaceae*), *Curvularia umbiliciformis* (*Pleosporaceae*), *Metulocladosporiella musae* (*Herpotrichiellaceae*), *Neocordana musae* (*Pyriculariaceae*), *Neopestalotiopsis clavispora*, *N. musae* (*Sporocadaceae*), *Phaeosphaeria oryzae* (*Phaeosphaeriaceae*) and *Pyrenochaetopsis musae* (*Pyrenochaetopsidaceae*), associated with *Musa* leaf spots, are reported. Three fungal taxa, *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Lasiodiplodia theobromae* (*Botryosphaeriaceae*) and *Pseudopithomyces chartarum* (*Didymosphaeriaceae*), are identified as having both endophytic and saprobic lifestyles on the leaves of Nam Wa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak). Interestingly, the endophytic, pathogenic, and saprobic lifestyles of *Colletotrichum musae* (*Glomerellaceae*) and *Corynespora torulosa* (*Corynesporascaceae*) were recorded in Nam Wa banana leaves and fruits. These results were confirmed with pathogenicity tests combined with morpho-molecular evidence. These findings further support the hypotheses of lifestyle transitions of fungi on the same host.

Two banana fruit diseases, anthracnose and speckle, were carefully investigated during the study. Both symptomatic banana fruits were collected from the local markets in Northern Thailand's Chiang Mai, Chiang Rai, and Nan Provinces. To

isolate fungi, surface-sterilized segments of infected banana peels were placed on potato dextrose agar (PDA). *Colletotrichum musae* and *C. siamense* were identified from the post-harvest anthracnose lesions in Namwa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) and Khai bananas (*M. acuminata*; AA genomic group; Sucrier). In addition, *Corynespora torulosa* was found in the speckles of Nam Wa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) fruits. To establish Koch's postulates, fresh and unripe banana fruits were artificially inoculated with the identified strains, which confirmed their pathogenicity. This is the first confirmed occurrence of *Cory. torulosa* causing banana fruit speckles in Thailand. In addition, the presence of *C. siamense* causing post-harvest anthracnose in Khai bananas (*M. acuminata*; AA genomic group; Sucrier) was reported. With the updated molecular phylogeny for the *Pyriculariaceae*, a thorough review of the plant pathogenic genus *Neocordana* that causes leaf spots on *Musa* was also conducted. The findings of this study contribute to a better understanding of post-harvest disease control in the commercial banana industry in Thailand.

Furthermore, this study documents the fungi associated with *Musa* hosts globally, and the findings are presented here as a checklist. Seven hundred sixty (760) fungal species associated with *Musa* are listed, along with their respective geographical localities, updated classifications, and literature. These taxa belong to four major phyla: *Ascomycota* is the most species-rich (93%), followed by *Basidiomycota* (6%) and *Mucoromycota* (1%). This compilation serves as a valuable resource for further research in fungi associated with *Musa*.

The overall study provides some insights into the systematics of microfungi associated with *Musa* in the tropics. Molecular data were generated for several extant species, and the taxonomic placements were resolved. Saprobic lifestyles of previously reported endophytes and pathogens were discovered, which further justified lifestyle changes in fungi. DNA sequence data were made available in public databases for correct identification and future studies. Some selected fungal strains

that are known to produce bioactive compounds were reported, and those strains were made available for chemical analysis and screening in future works. The documentation of novel taxa contributes to the correct estimation of fungal diversity and the number of fungi in Asia and the world. The results of this study will provide improved awareness of pre- and post-harvest fungal disease management in Thailand for commercial banana producers, traders, and stakeholders in the banana post-harvest handling chain.

Keywords: *Ascomycota*, Coelomycetes, *Dothideomycetes*, Endophytes, Hyphomycetes, Pathogens, Post-harvest diseases, Saprobes, *Sordariomycetes*.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	**(3)**
ABSTRACT	**(6)**
LIST OF TABLES	**(17)**
LIST OF FIGURES	**(19)**
ABBREVIATIONS AND SYMBOLS	**(26)**
CHAPTER	
1 INTRODUCTION	**1**
1.1 Microfungi Associated with Banana (*Musa* spp.)	1
1.2 Importance of Studying Taxonomy and Phylogeny of Microfungi Associated with *Musa*	2
1.3 Research Objectives	3
1.4 Research Contents	4
2 LITERATURE REVIEW ON THE MICROFUNGI ASSOCIATED WITH *Musa* SPP.	**7**
2.1 Introduction	7
2.2 Endophytic Microfungi Associated with *Musa*	9
2.3 Saprobic Microfungi Recorded on *Musa*	10
2.4 Pathogenic Microfungi on *Musa*	11
2.5 Recent Advances in Fungal Taxonomy	12
3 EXPLORING FUNGI: A TAXONOMIC AND PHYLOGENETIC STUDY OF LEAF-INHABITING *Ascomycota* IN *Musa* SPECIES FROM NORTHERN THAILAND, WITH A GLOBAL CHECKLIST	**15**

TABLE OF CONTENTS (continued)

	Page
CHAPTER	
3.1 Introduction	15
3.2 Materials and Methods	17
3.3 Results	23
3.4 Discussion	158
3.5 Conclusion	170
4 THE FIRST REPORT OF *Daldinia eschscholtzii* AS AN ENDOPHYTE FROM LEAVES OF *Musa* sp. (*Musaceae*) IN THAILAND	**172**
4.1 Introduction	172
4.2 Materials and Methods	174
4.3 Results	178
4.4 Discussion	180
5 TAXONOMY AND PHYLOGENETIC APPRAISAL OF *Spegazzinia musae* SP. NOV. AND *S. deightonii* (*Didymosphaeriaceae, Pleosporales*) ON *Musaceae* FROM THAILAND	**183**
5.1 Introduction	183
5.2 Materials and Methods	184
5.3 Results	188
5.4 Discussion	195
6 MULTI-GENE PHYLOGENETIC EVIDENCE SUGGESTS *Dictyoarthrinium* BELONGS IN *Didymosphaeriaceae* (*Pleosporales, Dothideomycetes*) AND *Dictyoarthrinium musae* SP. NOV. ON *Musa* FROM THAILAND	**197**

TABLE OF CONTENTS (continued)

	Page
CHAPTER	
6.1 Introduction	197
6.2 Materials and Methods	199
6.3 Results	204
6.4 Discussion	210
7 NEW HOST AND GEOGRAPHIC RECORDS OF FIVE PLEOSPORALEAN HYPHOMYCETES ASSOCIATED WITH *Musa* SPP. (BANANA)	**216**
7.1 Introduction	216
7.2 Materials and Methods	219
7.3 Results	224
7.4 Discussion	243
8 *Stachybotrys musae* SP. NOV., *S. microsporus*, AND *Memnoniella levispora* (*Stachybotryaceae, Hypocreales*) FOUND ON BANANAS IN CHINA AND THAILAND	**246**
8.1 Introduction	246
8.2 Materials and Methods	249
8.3 Results	251
8.4 Discussion	259
9 TAXONOMY AND PHYLOGENY OF *Smaragdiniseta musae* SP. NOV. AND *Albifimbria verrucaria* (*Hypocreales, Stachybotryaceae*) ON *Musa* FROM THAILAND	**262**
9.1 Introduction	262

TABLE OF CONTENTS (continued)

	Page
CHAPTER	
9.2 Materials and Methods	263
9.3 Results	267
9.4 Discussion	274
10 THE PLANT PATHOGENIC GENUS *Neocordana*	**276**
10.1 Introduction	276
10.2 Diversity, Distribution, and Morphology	277
10.3 History and Taxonomy of *Neocordana*	281
10.4 Taxonomic Placement of the Genus *Neocordana* in the Family *Pyriculariaceae*	282
10.5 Biology and Pathogenicity of the genus *Neocordana*	285
10.6 Disease Formation of *N. musae*	287
10.7 Isolation, Culturing, Identification and Biological Characteristics	288
10.8 Endophytic Nature of *Neocordana* Members and Association with *Mycosphaerella* sp.	289
10.9 Antagonistic Activity of *N. musae*	290
10.10 Possible Future Studies	290
11 TAXONOMIC AND PHYLOGENETIC ASSESSMENT OF SELECTED FUNGAL PATHOGENS ASSOCIATED WITH BANANA FRUITS IN THE LOCAL MARKETS OF NORTHERN THAILAND	**292**
11.1 Introduction	292
11.2 Materials and Methods	294
11.3 Results	299
11.4 Discussion	320

TABLE OF CONTENTS (continued)

	Page
CHAPTER	
11.5 Conclusion	322
12 OVERALL CONCLUSIONS	**323**
12.1 The Microfungal Groups Found in *Musa* and the Challenges	323
12.2 Endophytic Fungal Study	324
12.3 The Study of Saprobic Microfungi on *Musa*	330
12.4 The Study of Microfungi Associated with Leaf Spots	333
12.5 Pathogenic Fungi on *Musa* Fruits	334
12.6 Different Life Styles of the Same Fungi Found on *Musa* Leaves and Fruits	335
12.7 Comparison of Results	336
12.8 Global Checklist of Fungi Associated with *Musa*	339
12.9 Advantages and Outcomes of this Research	340
12.10 Future Directions	342
12.11 Publications Generated from the Thesis	343
REFERENCES	**347**
APPENDICES	**464**
APPENDIX A THE GLOBAL CHECKLIST OF FUNGI ASSOCIATED WITH *Musa*	465
APPENDIX B COLLECTION DETAILS OF CHAPTER 11	625
APPENDIX C CHEMICAL REAGENTS AND MEDIA	630
APPENDIX D PUBLICATIONS	632
CURRICULUM VITAE	**640**

LIST OF TABLES

Table	Page
2.1 Genera of saprobic fungi associated with *Musa*	11
2.2 Major fungal diseases associated with *Musa*	13
3.1 Partial gene regions, primers and PCR amplification conditions used in this study	22
4.1 Taxa that used in the phylogenetic analysis of *D. eschscholtzii* with the corresponding GenBank Accession numbers	176
5.1 Taxa used in the phylogenetic analysis of *Spegazzinia* with the corresponding GenBank accession numbers	187
6.1 Hosts, substrates and geographical distribution of *Dictyoarthrinium* species	200
6.2 Selected taxa with their corresponding GenBank accession numbers in the family *Didymosphaeriaceae* that are utilised in the phylogenetic analyses	202
7.1 Taxa used in the phylogenetic analyses of *Periconiaceae* with the corresponding GenBank accession numbers	221
7.2 Taxa used in the phylogenetic analyses of *Torulaceae* with the corresponding GenBank accession numbers	222
9.1 Names, culture collection numbers, and their respective GenBank accession numbers of the *Stachybotryaceae* that have been subjected to phylogenetic analyses	266
10.1 Recorded species of *Neocordana*, hosts and distribution	278
10.2 Comparison of the size and the shape of conidia in the genus *Neocordana*	278
10.3 Distinct morphological differences between *N. musae* and *N. versicolor*	280
10.4 Distinct features of the conidiophore between *N. johnstonii* and *N. versicolor*	280
10.5 Comparison of conidia and conidiophores of *N. musae* and *N. johnstonii*	280

LIST OF TABLES (continued)

Table	Page
10.6 Comparison of culture characteristics in the genus *Neocordana*	282
10.7 Taxa used in the phylogenetic analysis of *Pyriculariaceae* and their corresponding GenBank accession numbers	283
11.1 Characterization of anthracnose symptoms of collected samples based on disease severity (Disease severity index)	296
11.2 Characterization of speckle symptoms of collected samples based on disease severity (Disease severity index)	296
11.3 The taxa of the *Colletotrichum gloeosporioides* species complex that were used in the phylogenetic analyses, along with their names, culture collection numbers, and respective GenBank accession numbers	300
11.4 The taxa of *Corynesporascaceae* and associated species used in the phylogenetic analyses	302
12.1 Fungal taxa that identified during the study to the generic level based on morphology and molecular data of the ITS region	325
12.2 Fungal taxa that identified during the study to the species level based on morphology and phylogeny	326

LIST OF FIGURES

Figure	**Page**
3.1 *Lasiodiplodia theobromae* (MFLU 23-0285 and MFLU 23-0286)	27
3.2 Maximum likelihood tree revealed by RAxML analyses of ITS and *tef*1 sequence data of the taxa of *Lasiodiplodia*	28
3.3 *Corynespora torulosa* (MFLU 23-0287 and MFLU 23-0319)	32
3.4 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of selected genera of *Pleosporales*	35
3.5 *Dendryphiella vinosa* (MFLU 23-0288)	38
3.6 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of the selected genera of *Dictyosporiaceae* and *Pleosporaceae*	39
3.7 *Dictyoarthrinium musae* (MFLU 23-0289)	43
3.8 *Dictyoarthrinium thailandica* (MFLU 23-0290)	46
3.9 *Pseudopithomyces chartarum* (MFLU 23-0291 and MFLU 23-0320)	50
3.10 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS, and *tef*1 sequence data of the selected genera of *Didymosphaeriaceae*	51
3.11 *Spegazzinia musae* (MFLU 23-0292)	54
3.12 *Bahusandhika indica* (MFLU 23-0293)	57
3.13 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS and *tef*1 sequence data of selected genera of *Pleosporales*	58
3.14 *Lophiotrema hydei* (MFLU 23-0294)	63
3.15 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *rpb2* and *tef*1 sequence data of the taxa of *Pleosporales*	64

LIST OF FIGURES (continued)

Figure **Page**

3.16 Maximum likelihood tree revealed by RAxML analyses of combined SSU, LSU, ITS and *tef*1 sequence data of the selected taxa of *Massarinaceae* and *Periconiaceae* 67
3.17 *Periconia echinochloae* (MFLU 23-0295) 68
3.18 *Phaeosphaeria oryzae* (MFLU 23-0296) 72
3.19 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *rpb2* and *tef1* sequence matrix of some selected genera in *Phaeosphaeriaceae* showing the phylogenetic position of *Phaeosphaeria oryzae* 73
3.20 Maximum likelihood tree revealed by RAxML analyses of ITS, *gapdh* and *tef1* sequence data of the selected genera of *Pleosporaceae* 77
3.21 *Curvularia umbiliciformis* (MFLU 23-0298) 78
3.22 *Pyrenochaetopsis musae* (MFLU 23-0299, Holotype) 82
3.23 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tub2* and *rpb2* sequence data of the genera of *Pyrenochaetopsidaceae* illustrating the taxonomic position of *Pyrenochaetopsis musae* 83
3.24 *Setoarthopyrenia chromolaenae* (MFLU 23-0300) 86
3.25 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tef1* and *rpb2* sequences of some selected genera of *Roussoellaceae*, illustrating the phylogenetic position of *Setoarthopyrenia chromolaenae* 87
3.26 *Torula mackenziei* (MFLU 23-0301) 90
3.27 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS, *tef*1 and *rpb2* DNA sequences of some selected genera in *Torulaceae* 91

LIST OF FIGURES (continued)

Figure **Page**

3.28 *Neohelicosporium terrestris* (MFLU 23-0302, Holotype) 95

3.29 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tef*1 and *rpb*2 sequence data of some selected genera of *Tubeufiales* 96

3.30 *Metulocladosporiella musae* (MFLU 23-0303) 100

3.31 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of *Herpotrichiellaceae* 101

3.32 *Apiospora locuta-pollinis* (MFLU 23-0304) 105

3.33 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tub2* and *tef*1 sequence data of some selected genera of *Apiosporaceae* 106

3.34 *Nigrospora sphaerica* (MFLU 23-0305) 109

3.35 Maximum likelihood tree revealed by RAxML analyses of ITS, *tub2* and *tef*1 sequence data of the taxa of *Apiosporaceae* 110

3.36 *Neopestalotiopsis clavispora* (MFLU 23-0306) 113

3.37 *Neopestalotiopsis musae* (MFLU 23-0307) 116

3.38 Maximum likelihood tree revealed by RAxML analyses of ITS, *tub2, and tef1* sequence data of the taxa of *Sporocadaceae* 117

3.39 *Pseudophaeocytostroma sacchari* (MFLU 23-0308) 122

3.40 Maximum likelihood tree revealed by RAxML analyses of ITS, LSU, and *tef*1 sequence data for the taxa of *Diaporthaceae* 123

3.41 *Colletotrichum siamense* (MFLU 23-0309) 127

3.42 Maximum likelihood tree revealed by RAxML analyses of ITS, *gapdh*, *cmdA*, *act*, and *chs*-1 sequence data for selected taxa of the *Colletotrichum gloeosporioides* complex 128

3.43 *Gibellulopsis serrae* (MFLU 23-0310) 132

3.44 *Musicillium elettariae* (MFLU 23-0311) 135

LIST OF FIGURES (continued)

Figure	Page
3.45 *Musicillium tropicale* (MFLU 23-0312)	137
3.46 Maximum likelihood tree revealed by RAxML analyses of ITS, LSU, *rpb2* and *tef*1 sequence data of the taxa of *Plectosphaerellaceae*	138
3.47 *Albifimbria verrucaria* (MFLU 23-0313 and MFLU 23-0314)	142
3.48 Maximum likelihood tree revealed by RAxML analyses of ITS, *rpb2* and *tub2* sequence data of some selected taxa of *Stachybotryaceae*	143
3.49 *Stachybotrys subcylindrosporus* (MFLU 23-0315)	146
3.50 Maximum likelihood tree revealed by RAxML analyses of *cmdA*, ITS *rpb2* and *tub2* sequence data of the taxa of *Stachybotryaceae*, showing the phylogenetic position of *Stachybotrys subcylindrosporus*	147
3.51 *Neocordana musae* (MFLU 23-0316)	151
3.52 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of the taxa of *Pyriculariaceae*	152
3.53 *Dematipyriforma terrestris* (MFLU 23-0317, Holotype)	156
3.54 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS and *tef*1 sequence data of the taxa of *Pleurotheciaceae*	157
3.55 The familial distribution of selected genera of microfungi presented in this study, which inhabit the leaves of *Musa* in three sub-classes (*Dothideomycetes, Eurotiomycetes,* and *Sordariomycetes*)	160
3.56 The familial positions of micro-fungi exhibit different lifestyles associated with *Musa* leaves	161
3.57 The familial positions of micro-fungi inhabiting different tissue parts of *Musa* leaves	163
3.58 Percentage occurrence and the distribution of fungi associated with *Musa* hosts worldwide	165

LIST OF FIGURES (continued)

Figure **Page**

3.59 Distribution of fungi associated with *Musa*: Percentage of occurrences by country (including leading countries) 168

3.60 Percentage occurrences of the most common fungal families associated with *Musa* worldwide 169

3.61 Percentage occurrences of the most common fungal genera associated with *Musa* worldwide 169

4.1 Maximum likelihood tree revealed by RAxML from an analysis of combined LSU-ITS- *rpb2* and *btub* rDNA matrix of *Daldinia* 181

4.2 *Daldinia eschscholtzii* (MFLU 19–0409) 182

5.1 Maximum likelihood tree revealed by RAxML from an analysis of SSU, LSU and ITS and *tef1*-α sequence data of selected genera of *Didymosphaeriaceae* 192

5.2 *Spegazzinia deightonii* (MFLU 19-2908) 193

5.3 *Spegazzinia musae* (MFLU 19-2907, holotype) 194

6.1 Maximum Likelihood tree revealed by RAxML from an analysis of SSU, LSU and ITS and *tef*1-α sequence data of the genera of *Didymosphaeriaceae*, showing the phylogenetic position of *Dictyoarthrinium musae* and *D. sacchari* 206

6.2 *Dictyoarthrinium musae* (MFLU 20-0437, holotype) 211

6.3 *Dictyoarthrinium sacchari* (MFLU 20-0439) 212

6.4 Morphology of conidia and conidiophores of previously described *Dictyoarthrinium* species 215

7.1 Maximum likelihood tree revealed by RAxML from an analysis of a concatenated SSU, LSU, ITS and TEF sequence dataset of the species in *Periconiaceae* 227

LIST OF FIGURES (continued)

Figure	Page
7.2 Maximum likelihood tree (RAxML) revealed by an analysis of a concatenated SSU, LSU, ITS, *tef*-1 and *rpb2* sequence dataset of the species in *Torulaceae*	228
7.3 *Periconia delonicis* (MFLU 20−0696)	229
7.4 *Periconia cortaderiae* (MFLU 20−0697)	233
7.5 *Torula chromolaenae* (MFLU 20–0698)	236
7.6 *Torula fici* (MFLU 20−0699)	239
7.7 *Torula masonii* (MFLU 20–0700)	242
8.1 Maximum likelihood tree revealed by RAxML analyses of ITS, *cmdA*, *rpb*2, *tub*2, and *tef*1 sequence dataset of selected genera in *Stachybotryaceae* showing the phylogenetic position of *Stachybotrys musae*	254
8.2 *Stachybotrys musae* (MFLU 20–0626, holotype)	255
8.3 *Stachybotrys microspora* (MFLU 20–0628)	258
8.4 *Memnoniella levispora* (MFLU 20–0627)	261
9.1 Maximum likelihood tree revealed by RAxML analyses of ITS, *rpb*2 and *tub2* sequence data of selected genera of *Stachybotryaceae*	268
9.2 *Smaragdiniseta musae* (MFLU 22-0047, holotype)	273
9.3 *Albifimbria verrucaria* (MFLU 22-0048)	274
10.1 *Neocordana musae*	279
10.2 Maximum likelihood tree revealed by RAxML from an analysis of combined LSU and ITS partial sequence data of the genera of family *Pyriculariaceae*, showing the phylogenetic position of the genus *Neocordana*	284
11.1 Fungal colonies grow on the PDA after 7 days'	305

LIST OF FIGURES (continued)

Figure	Page
11.2 Anthracnose and speckle symptoms that have been reported in this study	309
11.3 *Colletotrichum musae* (MFLU 23-0279)	312
11.4 *Colletotrichum siamense* (MFLU 23-0282)	313
11.5 Maximum likelihood tree revealed by RAxML analyses of ITS, *gapdh*, *cmdA*, *act*, and *chs-1* sequence data for selected taxa of the *Colletotrichum gloeosporioides* complex	316
11.6 *Corynespora torulosa* (MFLU 23-0321)	317
11.7 Maximum likelihood tree constructed by RAxML analyses of LSU and ITS, sequence data for selected taxa of *Pleosporales* showing the phylogenetic placement of *Corynespora torulosa*	318
11.8 Results of the pathogenicity test	319

ABBREVIATIONS AND SYMBOLS

cm	centimeter
diam.	diameter
e.g.	for example
et al.	and others
gen.	genus (singular) and genera (plural)
ibid.	in the same place
hr.	hour
mm	millimeter
nov.	novum (Latin for new thing)
s	second
sp.	species
spp.	species (plural)
$\bar{x}$	average
°C	degree centigrade
=	equal (for measurement size)
=	heterotypic (taxonomic, facultative) a synonym
≡	homotypic (nomenclatural, obligate) a synonym
µm	micrometer
µl	microliter
%	percent
≥	greater than or equal to
v.	version
vs.	versus
viz.	namely

CHAPTER 1

INTRODUCTION

1.1 Microfungi Associated with Banana (*Musa* spp.)

Banana and plantain are predominately considered as monocotyledonous plants belong to *Musa* (*Musaceae*, *Zingiberales*) (Heslop-Harrison & Schwarzacher, 2007). As a commercial fruit crop, *Musa* are cultivated and consumed in 135 countries (Voora et al., 2020). Additionally, *Musa* is one of the most traded fruits in the world (Voora et al., 2020).

Musa are host to a wide range of diseases mainly caused by fungi. *Fusarium* wilt (Panama disease) is one of the most destructive pre-harvest diseases in *Musa* caused by the soil-borne fungus, *Fusarium oxysporum* f. sp. *cubense* (Dita et al., 2018). *Mycosphaerella* leaf spots (mainly caused by *Mycosphaerella eumusae*, *M. fijiensis* and *M. musicola*) are the most common foliar diseases of *Musa* (Carlier et al., 2002). Anthracnose caused by *Colletotrichum* spp. (i.e. *C. gloeosporioides* and *C. musae*) (Su et al., 2011; Zakaria et al., 2009) and crown rot caused by *Colletotrichum* spp., *Fusarium* spp. and *Lasiodiplodia theobromae* (Johanson & Blazquez, 1992; Lassois et al., 2008) are the major post-harvest fungal diseases of *Musa*.

In addition to pathogens, several genera of endophytic and saprobic fungi were also reported from *Musa* worldwide (Brown et al., 1998; Ellis, 1971, 1976; Matsushima, 1971; Pereira et al., 1999; Photita et al., 2001a, 2001b, 2001c, 2002, 2004; Somrithipol, 2007). Some endophytic fungi (i.e. *Colletotrichum musae*) are latent pathogens in the host (Photita et al., 2004) and display disease symptoms at a later stage of the life cycle. Endophytic or pathogenic fungi can shift to the saprobic nutritional mode and decompose dead plant materials (Promputtha et al., 2010). In *Musa* plantations, saprobes possess the ability to persist on dead tissues until the next

crop rotation. Furthermore, saprobes have the potential to shift the host and move to soil, complete their life cycle, and wait for the commencement of a new crop rotation Jones (2019). Therefore, the taxonomy, nomenclature, and identification of fungi associated with *Musa* are essential in disease identification, monitoring, and management.

1.2 Importance of Studying Taxonomy and Phylogeny of Microfungi Associated with *Musa*

Due to the further advancement of molecular methods, most mycologists implement DNA sequence data in fungal taxonomy. Even though taxonomists had explored the fungal niches associated with *Musa* (Brown et al., 1998; Ellis, 1971, 1976; Matsushima, 1971; Pereira et al., 1999; Photita et al., 2001a, 2001b, 2001c, 2002, 2004; Somrithipol, 2007), integration of molecular data in species identification was not widely used. The identified fungi associated with *Musa,* few DNA sequence data in GenBank. Hence the phylogenetic relationships of fungi associated with *Musa* were not well investigated.

In addition, due to the economic value of *Musa,* most of the studies are also oriented towards some specifically selected groups of fungi (*Colletotrichum, Fusarium, Mycosphaerella, Neocordana,* and *Phyllosticta*) (Churchill, 2011; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019; Wulandari et al., 2010). Therefore, the hidden fungal niches of *Musa* (mainly undiscovered saprobes and endophytes) must be investigated. Few scientific studies reported fungal diseases of *Musa* from Thailand and China based on disease symptoms. In-depth studies on taxonomy, phylogeny and pathogenicity tests of the causative fungal agents were not conducted in latter studies.

Fungi have the potential of shifting nutritional modes (from endophytes to pathogens or saprobes and pathogens to saprobes), host jumping ability, and host specificity (Promputtha et al., 2010). These intimate associations of fungi associated with *Musa* were not widely studied in previous research works.

To address these research gaps, this study has collected plant tissues of *Musa* from different geographical locations in China (Yunnan Province) and Thailand. The endophytic, pathogenic, and saprobic fungal niches were investigated and identified based on morpho-molecular evidences. To establish Koch's postulates, pathogenic fungal isolates were subjected to pathogenicity tests. The taxonomy of all known and new fungal taxa was illustrated and described along with phylogenetic relationships.

The living cultures were preserved in the culture collection of Mae Fah Luang University (MFLUCC) for future applications and studies. The herbarium materials of all the fungal collections were deposited in the Fungarium of Mae Fah Luang University (Herb. MFLU) for future reference.

The documentation could generate detailed, digitized descriptions and illustrations of fungi associated with *Musa* coupled with molecular phylogeny, which will further contribute to biodiversity and conservation. The correct nomenclature and documentation of fungi will provide strong platforms to the future research works of taxonomists, pathologists, and quarantine systems. The outcome of this research work will contribute to the advanced pre-harvest productivity and improved post-harvest quality of the commercial *Musa* industry. The information that generate from this study will be implemented in disease identification, management and control. In addition, the results will be further utilized in establishing quarantine regulations and prevent the international spread of fungal diseases associated with *Musa*.

1.3 Research Objectives

1.3.1 To study the systematics of fungi (endophytes, pathogens and saprobes) associated with *Musa* and evaluate species in terms of morphology and multi-gene phylogenies.

1.3.2 To provide a global checklist of microfungi associated with *Musa* with the respective host species and the distribution

1.4 Research Contents

This thesis is divided into twelve chapters.

Chapter 1 is the general introduction that explains the importance of studying the taxonomy and phylogeny of microfungi associated with bananas (*Musa* spp.). It also contains the research objectives and the outline of the thesis.

Chapter 2 provides a literature review of the microfungi associated with banana hosts. This provides general background on *Musa* hosts and the previous research works that investigated the endophytic, saprobic and pathogenic microfungi found on bananas.

Chapter 3 presents the taxonomy and phylogeny of leaf-inhabiting *Ascomycota* from *Musa* species in northern Thailand. Thirty ascomycetous taxa from *Dothideomycetes, Eurotiomycetes* and *Sordariomycetes*, comprising eight subclasses, ten orders, twenty-three families and twenty-seven genera, are illustrated and identified based on molecular data in this study. Four new species, thirteen new host records and nine new geographical reports of fungi are included in this chapter. Furthermore, this chapter documents the global fungi associated with *Musa* hosts, and the findings are presented here as a checklist. A total of 760 fungal species associated with *Musa* are listed, along with their respective geographical localities, updated classifications, and literature.

Chapter 4 reports the first occurrence of *Daldinia eschscholtzii* as an endophyte from the leaves of *Musa* sp. (*Musaceae*) in Thailand. Fungal isolates are illustrated, described and subjected to LSU-ITS-*rpb2-btub* concatenated phylogenies using maximum likelihood and Bayesian analysis with an updated tree of *Hypoxylaceae*.

Chapter 5 introduces *Spegazzinia musae* as a novel saprobe, isolated from the dead leaves of *Musa* sp. Contrasting morphological features, single and multi-gene analysis of combined SSU, LSU, ITS and *tef1-α* sequence data support the validity of *Spegazzinia musae* and its taxonomic placement in *Didymosphaeriaceae*. In addition, *S. deightonii* is present herein as a new host record from *Musaceae*.

Chapter 6 presents the establishment of the saprobic genus *Dictyoarthrinium* in *Didymosphaeriaceae* (*Massarineae, Pleosporales, Dothideomycetes*) sister to *Spegazzinia. Dictyoarthrinium musae* sp. nov. is introduced herein with the morphological support and the phylogenetic analyses of combined SSU, LSU, ITS and *tef1-α* sequence data. In addition, *D. sacchari* presents with morphology and an updated phylogeny.

Chapter 7 illustrates five brown pleosporalean hyphomycetous taxa in *Periconiaceae* and *Torulaceae viz. Periconia cortaderiae*, *P. delonicis*, *Torula chromolaenae*, *T. fici*, and *T. masonii*. The saprobic fungal taxa were identified for the first time from *Musa* spp. (*Musaceae*). Morphology and phylogenetic analyses of a combined SSU, LSU, ITS, *rpb2* and *tef1-α* DNA sequence dataset further justified the taxonomic placements of the latter taxa.

Chapter 8 investigates the saprobic fungal niches of *Stachybotryaceae* (*Hypocreales*) associated with the leaves of *Musa* in China and Thailand. Three hyphomycetous taxa are illustrated and a phylogenetic tree was constructed using a concatenated sequence dataset of ITS, *cmdA*, *rpb2*, *tub2*, and *tef1-α* gene regions. *Stachybotrys musae* is introduced as a novel taxon from Yunnan, China, while *S. microsporus* is reported from Chiang Rai Province in Thailand on Musa. In addition, *Memnoniella levispora* is also reported from China for the first time as associated with *Musa* leaves.

Chapter 9 introduces *Smaragdiniseta musae* as a leaf-based novel saprobic species from *Musa* based on morphology and phylogeny. This is the first report of *Smaragdiniseta* from Thailand and on *Musaceae*. In addition, this chapter reports *Albifimbria verrucaria* for the first time from Thailand, based on morpho-molecular evidence.

Chapter 10 comprehensively reviews *Neocordana* species that mainly cause leaf spots on *Musa* spp. The phylogenetic relationships of *Neocordana* with other genera in *Pyriculariaceae* based on LSU and ITS DNA sequence data are investigated.

Chapter 11 focuses on two banana fruit diseases, *viz*., anthracnose and speckle. Both symptomatic banana fruits were collected from the local markets in three different provinces of northern Thailand (Chiang Mai, Chiang Rai, and Nan).

Colletotrichum musae and *C. siamense* were identified from the post-harvest anthracnose lesions in Namwa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) and Khai fruits ((*M. acuminata*; AA genomic group; Sucrier). In addition, *Corynespora torulosa* was found in the speckles of Namwa bananas (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak). To establish Koch's postulates, fresh and unripe banana fruits were artificially inoculated with the identified strains, which confirmed their pathogenicity. This is the first confirmed occurrence of *C. torulosa* causing banana fruit speckles in Thailand. In addition, we document the presence of *C. siamense* causing post-harvest anthracnose in Khai bananas.

Chapter 12 provides the overall conclusion of the above studies and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW ON THE MICROFUNGI ASSOCIATED WITH *Musa* SPP.

2.1 Introduction

Banana and plantain are monocotyledonous plants that mainly belong to *Musa* (*Musaceae, Zingiberales*) (Heslop-Harrison & Schwarzacher, 2007). *Musa* is widely distributed across the tropics (175°E to 150°W longitude and from 30°N to 23°S latitude). Most *Musa* species are found across south and southeast Asia and the western tropical Pacific Ocean (i.e., Bangladesh, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, New Guinea, the Philippines, Thailand, Vietnam, and the south and southeast regions of China) as wild and cultivated varieties (Nayar, 2010). Wild bananas usually occur in warm-regions (Heslop-Harrison & Schwarzacher, 2007; Nayar, 2010) as do cultivated species, which cover the entire climatic region in the distributed areas. Limited species of *Musa* prefer cool climates, as the genus does not have any resistance to low temperatures and drought (Nayar, 2010; Simmonds, 1962).

Musa acuminata (genome A) was considered the origin of most cultivated banana varieties. *Musa balbisiana* (genome B) is simultaneously distributed with *M. acuminata* (genome A) among most of the banana cultivating areas, with a high degree of intraspecific variability (Nayar, 2010; Ude et al., 2002; Uma et al., 2005, 2006; Wu & Kress, 2000). Based on genomic constitution, several cultivars (variants) of *Musa* were originated and distributed among tropics and subtropics by having several vernacular names (i.e. AA, AAA, AAAA, BB, BBB, AB, AAB, ABB, AS, AT, AAT, ABBT) where A=*M. acuminata*, B=*M. balbisiana*, S=*M. schizocarpa*, T=*M. textiles* (Daniells et al., 2001; Jones, 2000; Pascua, 1989; Ramirez, 1989;

Shepherd & Ferreira, 1982; Silayoi, 1989; Stover & Simmonds, 1987; Uma & Sathiamoorthy, 2002).

Musa spp. provide potential habitat for micro fungi in different life styles (i.e. endophytes, pathogens and saprobes) (Brown et al., 1998; Crous et al., 2016; Ellis, 1971, 1976; Hernández-Restrepo et al., 2015; Hyde et al., 2017; Matsushima, 1971; Pereira et al., 1999; Photita et al., 2000, 2001, 2002, 2004; Samarakoon et al., 2019, 2020, 2021; Somrithipol, 2007). Endophytes inhabit living and healthy tissues of *Musa* spp. without causing apparent disease symptoms (Schulz & Boyle, 2006). Fungal pathogens cause pre-harvest and post-harvest diseases targeting all the tissue parts (i.e. root, pseudo stem, leaves, inflorescence and fruit) of the crop (Jones, 1999). Saprobes inhabit dead or decaying plant materials of the plant (fallen down leaf sheaths and leaves, dead pseudo-stems or decaying fruits) during senescence (Promputtha et al., 2010). Several fungal endophytes colonize living plant tissues and pass a dormant stage. During natural senescence and abscission, endophytes start sporulation, switch off their current nutritional mode and become saprobes by secreting extra cellular enzymes (Promputtha et al., 2007, 2010). Some endophytic assemblages in *Musa* spp. can be latent pathogens and onset disease symptoms during stresses conditions (Photita et al., 2004).

Since the nineteenth century, many taxonomists have explored fungal niches associated with *Musa*. Before the integration of molecular data in fungal taxonomy, many fungi were introduced and documented based only on detailed morphological illustrations and descriptions (Brown et al., 1998; Ellis, 1971, 1976; Matsushima, 1971; Pereira et al., 1999; Photita et al., 2001, 2002, 2004; Somrithipol, 2007). During the past two decades, DNA sequence data were implemented in fungal taxonomy on *Musa*, and more descriptive and comprehensive taxonomic works were conducted based on phylogenetic evidence (Crous et al., 2016, 2017, 2019, 2020; Hernández-Restrepo et al., 2015; Hyde et al., 2017; Samarakoon et al., 2019, 2020, 2022).

The first fungal taxon described from *Musa* was *Dothidea musae* (=*Phyllachora musae*) (Klotzsch, 1833) as a saprobic ascomycete on the leaves of a *Musa* sp. from India. The first coelomycetous fungus that was described from *Musa* was *Phoma musarum* (Cooke, 1883) from Georgia (United States). *Stachybotrys*

subsimplex (= *Brevistachys subsimplex*) was the first hypohomycetous taxon introduced on *Musa* sp. by Cooke (1883) from Georgia (United States).

2.2 Endophytic Microfungi Associated with *Musa*

Endophytes inhabit living, healthy tissues of *Musa* without causing any noticeable disease symptoms (Schulz & Boyle, 2006). Several endophytic fungi have been recorded from *Musa* in Australia (Brown et al., 1998), Brazil (Pereira et al., 1999), Central America (Pocasangre et al., 1999), China (Cao et al., 2002, 2003) and Hong Kong (Brown et al., 1998). *Acremonium*, *Colletotrichum* (Brown et al., 1998; Cao et al., 2003), *Fusarium*, *Nigrospora* (Brown et al., 1998), *Pestalotiopsis*, *Phoma*, *Trichoderma* and *Verticillium* (Cao et al., 2003; Pocasangre et al., 1999) were recorded as endophytic genera in *Musa*. In addition, numerous taxa from the *Xylariaceae* (Brown et al., 1998; Pereira et al., 1999) also identified as endophytes. Cao et al., (2002) have recorded *Alternaria, Aureobasidium*, *Aspergillus*, *Cephalosporium*, *Cladosporium*, *Deightoniella*, *Gloeosporium*, *Myxosporium*, *Penicillium*, *Sphaceloma*, *Sarcinella*, and *Uncinula* from *Musa*.

Photita et al. (2001) reported fungal endophytes of wild *M. acuminata* at Doi Suthep-Pui National Park in northern Thailand. *Colletotrichum musae*, *C. gloeosporioides*, *Guignardia cocoicola* and Xylariaceous species were the most abundant taxa that have been recorded. In addition, Photita et al. (2004) further reported *D. torulosa*, *G. cocoicola*, *Periconiella musae* and *Pestalotiopsis* spp. as endophytic fungi in *Musa*. Photita et al. (2004) investigated the pathogenicity of *Cladosporium musae*, *Colletotrichum gloeosporioides*, *D. torulosa*, *G. cocoicola*, *N. musae* and *Periconiella musae*. Among all the isolates, the *in vitro* application of *D. torulosa* was able to cause disease symptoms in *Musa* leaves. The rest of the isolates failed to cause leaf spots. Photita et al. (2004) indicated that fungal pathogens can live as endophytes and be latent in the host for a period of time in their life cycle before causing the disease.

In addition to previously reported taxa, recent studies have discovered *Bipolaris papendorfii*, *Colletotrichum siamense*, *Fusarium equiseti*, *F.*

chlamydosporum, *Nigrospora sphaerica*, *Phoma sorghina*, *Pestalotiopsis oxyanthi*, *P. theae*, *P. eugeniae*, *Penicillium steckii*, and *P. purpurogenum* as fungal endophytes in *Musa* (Zakaria & Aziz 2018; Zakaria et al., 2016). Souza-Junior et al. (2018) documented *Acrocalymma*, *Byssochlamys*, *Meyerozyma*, *Myrothecium Peniophora*, *Periconia*, *Peroneutypa*, and *Saccharicola* from *Musa* leaves as endophytes. In addition, Samarakoon et al. (2019) documented *Daldinia* from *Musaceae* for the first time as an endophyte from Thailand.

2.3 Saprobic Microfungi Recorded on *Musa*

Saprobes inhabit dead or decaying plant materials of the plant (fallen down leaf sheaths and leaves, dead pseudo-stems or decaying fruits) during senescence (Promputtha et al., 2010). Many taxa of saprobic fungi were reported from *Musa* spp. by Ahmad and Khalid (1997), Batista and Ciferri (1962), Benjamin (1969), Brayford (1987), Chen et al. (2020), Crous et al. (2016, 2017, 2019), Dennis (1970), Hernández-Restrepo et al. (2015), Hyde et al. (2017), Liu et al. (2015), Lombard et al. (2016), Lumyong et al. (2002), Mendes et al. (1998), Photita (2002), Samarakoon et al. (2022), Sawada (1959), Tai (1979), Van-Hove et al. (2011) and Zhang and Wu (2003).The saprobic genera introduced and reported from latter studies are listed in Table 2.1.

Ellis (1971, 1976) concluded 21 saprobic hyphomycetous genera on *Musa* with geographical records based on morphology. Photita et al. (2001) identified 46 saprobes on *Musa acuminata* in Hong Kong. In addition to major studies, Kirschner and Piepenbring (2014), Lumyong et al. (2002), Matsushima (1975), Photita et al. (2003), and Somrithipol (2007) also documented saprobes on *Musa* spp. Aptroot (1995), Arnold (1986), Gao et al. (2014), Hao et al. (2013), Heredia-Abarca et al. (1997), Quaedvlieg et al. (2014), Shaw (1984) and Videira et al. (2017) also further studied saprobic fungi on *Musa*. A concluded account on saprobic genera reported on *Musa* are listed in Table 2.1.

Table 2.1 Genera of saprobic fungi associated with *Musa*

Reported genera on *Musa* spp.	Main study
Arthrinium, Cladosporium, Cordana, Curvularia, Deightoniella, Gliomastix, Gyrothrix, Haplobasidion, Memnoniella, Periconia, Periconiella, Pithomyces, Pyriculariopsis, Spegazzinia, Stachylidium, Tetraploa, Zygosporium	Ellis (1971)
Bidenticula, Chlamydomyces, Parapyricularia, Veronaea	Ellis (1976)
Anthostomella, Bipolaris, Chloridium, Corynesporopsis, Curvularia, Dactylella, Deightoniella, Diaporthe, Didymosphaeria, Durispora, Glomerella, Hansfordia, Hyponectria, Massarina, Memnoniella, Mycosphaerella, Nigrospora, Ophioceras, Periconiella, Phomatospora, Phomopsis, Phialoeephala, Pyriculariopsis, Staehylidium, Stemphylium, Tetraploa, Torula, Verticillium	Photita et al. (2001)
Acremonium, Alternaria, Amerodothis, Arthrobotryum, Brevistachys, Byssosphaeria, Calyptella, Capnodium, Cellypha, Chalara, Citromyces, Cladocillium, Cladosporium, Coniothyrium, Corynespora, Cylindrocarpon, Dactylella, Diplodia, Dothiorella, Epicoccum, Helminthosporium, Lasiodiplodia, Leptosphaeria, Metasphaeria, Myrothecium, Myxospora, Nectria, Neocordana, Neopestalotiopsis, Parapallidocercospora, Phaeodothis, Phaeosphaeria, Pseudoramularia, Pyricularia, Pyriculariopsis, Radaisiella, Scolecobasidium, Stagonospora, Torulopsis, Trichoderma, Trichothecium, Uwebraunia, Virgariella, Volutella, Wojnowicia, Zasmidium, Zygophiala	Ahmad and Khalid (1997), Aptroot (1995), Arnold (1986), Batista and Ciferri (1962), Benjamin (1969), Brayford (1987), Crous et al. (2016, 2017, 2019), Dennis (1970), Gao et al. (2014), Hao et al. (2013), Heredia-Abarca et al. (1997), Hernández-Restrepo et al. (2015), Liu et al. (2015), Lumyong et al. (2002), Mendes et al. (1998), Photita (2002), Quaedvlieg et al. (2014), Sawada (1959), Shaw (1984), Tai (1979), Van Hove et al. (2011), Videira et al. (2017), and Zhang and Wu (2003)

2.4 Pathogenic Microfungi on *Musa*

Fungal pathogens cause pre-harvest and post-harvest diseases targeting all the tissue parts (root, pseudo stem, leaves, inflorescence and fruit) of the crop (Jones, 1999). *Musa* are susceptible for many fungal diseases such as Anthracnose

(*Colletotrichum musae*), Black cross (*Phyllachora musicola*), Black leaf streak or Black Sigatoka (*Mycosphaerella fijiensis*), Brown spot (*Cercospora hayi*), Cigar-end rot (*Trachysphaera fructigena, Verticillium theobromae*), Cladosporium speckle (*Cladosporium musae*), Cordana leaf spot (*Neocordana johnstonii, N. musae*), Crown rot (*C. musae, Fusarium pallidoroseum, Verticillium theobromae*), Panama disease (*Fusarium oxysporum* f. sp. *cubense*) (Jones, 1999, 2018; Kumar et al., 2015; Raut & Ranade, 2004; Tushemereirwe et al., 2004). A list of fungal diseases associated with *Musa* are concluded in Table 2.2.

Wardlaw (1972) and Jones (1999, 2018) provided an updated account on fungal diseases associated with *Musa* including morphology of causative agents, disease identification, disease cycle, epidemiology and the controlling measures. Abd-Elsalam et al. (2010), Alvindia and Natsuaki (2008), Anthony et al. (2004), Su et al. (2011) and Thangamani et al. (2011) studied on fungi which cause post-harvest diseases (Antharcnose and crown rot) of *Musa*. Arzanlou et al. (2008), Carlier et al. (2000), Crous and Mourichon (2002), Jacome (2003), Meredith and Lawrence (1969) conducted researches on *Mycosphaerella* pathogens that causes Black Sigatoka leaf spots on *Musa*. In addition, Abayasekara et al. (2013), McMaster et al. (2020), Wong et al. (2012) and Wu et al. (2014) conducted detailed research works on *Phyllosticta* species associated with *Musa*. Maryani et al. (2019) and Ploetz (2006, 2015), studied the taxonomy of *Fusarium* which cause Panama disease (*Fusarium* wilt) in *Musa*.

2.5 Recent Advances in Fungal Taxonomy

Many studies identified fungi associated with *Musa* by integrating molecular data in taxonomy. *Metulocladosporiella* was introduced by Crous et al. (2006) as a causative agent of Cladosporium speckle disease of a *Musa* sp. Arzanlou et al. (2007) investigated Sigatoka disease complex of *Musa* spp. and identified *Mycosphaerella fijiensis, M. musicola,* and *M. eumusae* using molecular data as causal agents. Further, Arzanlou et al. (2008) documented and identified more than 20 species of *Mycosphaerella* from *Musa* spp. In addition, 8 novel taxa were introduced from *Musa*

by Arzanlou et al. (2008) (i.e. *Dissoconium musae*, *Mycosphaerella mozambica*, *Pseudocercospora assamensis*, *P. indonesiana*, *P. longispora*, *Stenella musae*, *S. musicola*, and *S. queenslandica*). Wong et al. (2012) provided molecular evidences to identify *Phyllosticta* which associated with freckle disease of *Musa* spp. Zakaria and Aziz (2018) identified endophytic fungi in *Musa* leaves using ITS (Internal Transcribed Spacer region) sequence data and documented 10 endophytic genera with 17 species. Chen et al. (2020), Crous et al. (2016, 2017, 2019), Hernández-Restrepo et al. (2015), Hyde et al. (2017), Liu et al. (2015), Lombard et al. (2016), Samarakoon et al. (2020, 2021, 2022) and Van Hove et al. (2011) explored saprobic fungal niches of *Musa* spp. and introduced taxonomic novelties with the aid of molecular evidences (i.e. *Dictyoarthrinium musae*, *Spegazzinia musae* and *Stachybotrys musae*). Crous et al. (2020) documented *Pseudocercospora* and other allied genera that cause leaf spots of *Musa*.

Table 2.2 Major fungal diseases associated with *Musa*

Foliage (pre-harvest diseases)	**Pseudo stem (pre-harvest diseases)**	**Root and Corm (pre-harvest diseases)**	**Fruit (pre-harvest diseases)**	**Fruit (post-harvest diseases)**
Black cross, Black leaf streak, Cordana leafspot, Deightoniella leaf spot, Drechslera leaf spot, Freckle disease, Malayan leaf spot, Phaeoseptoria leaf spot, Pyricularia leafspot, Septoria leaf spot, Sigatoka disease	Deightoniella pseudo stem rot, Fusarium wilt, Marasmiellus pseudo-stem and root rot, Pseudo-stem heart rot	Armillaria corm rot, Cylindrocladium root rot, Marasmiellus pseudo-stem and root rot, Rosellinia corm and root rot, Sclerotium root and corm rot	Anthracnose fruit rot, Brown spot, Cigar end rot, Deightoniella speckle, Diamond spot, Fruit freckle, Peduncle rot, Pitting disease, Sooty mold and sooty blotch, Tip end rot	Anthracnose, Botrydiploidia finger rot, Crown rot, Fungal scald, Main stalk rot, Stem end rot

The impact of fungal diseases plays a significant role in commercial banana and plantain production. Foliar diseases and wilting cause the reduction of the yield or total crop damage. Anthracnose and other associated fungal diseases directly contribute to the post-harvest loss (quality and quantity) of the commodity as well as the reduction of local demand of the fruit. There for fungal pathogens contribute to a serious and notable economic loss in commercial banana industry. Some endophytic fungi (i.e. *Colletotrichum musae*) also can be latent pathogens (Photita et al., 2004) in the fruit and leaves and later cause post-harvest decay of the commodity. Endophytic or pathogenic fungi can shift to the saprobic nutritional mode and inhabit dead plant materials of the field and persist until the next crop rotation of the mono culture. In addition, these fungi may have a potential to shift the host and move to soil, complete their life cycle and wait for a new rotation. Therefore taxonomy, nomenclature and identification of fungi associated with *Musa* spp. is crucial in disease monitoring and controlling strategies.

Due to the renaissance of molecular methods, several mycologists implemented DNA sequence data in fungal nomenclature and taxonomy. According to Hyde et al. (2020) still the fungal diversity is hidden and 15% of the niches are only identified. Around 85% of diversity is yet to discover. Even though taxonomist explored the fungal niches associated with *Musa* spp. (Brown et al., 1998; Ellis, 1971, 1976; Matsushima, 1971; Pereira et al., 1999; Photita et al., 2000, 2001, 2002, 2003; Somrithipol, 2007), integrating molecular data in species identification was not widely used. Many identified fungi associated with *Musa* spp. are lack DNA sequence data in Gene Bank. Hence the phylogenetic relationships of fungi associated with *Musa* spp. are not well investigated. Due to the economic value of the fruit most of fungal studies are also oriented towards some selective groups of fungi (i.e. *Colletotrichum, Fusarium, Mycosphaerella, Neocordana* and *Phyllosticta*) (Churchill, 2011; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019; Wulandari et al., 2010). Therefore, the hidden fungal niches of *Musa* spp. (mainly undiscovered saprobes and endophytes) should be investigated.

CHAPTER 3

EXPLORING FUNGI: A TAXONOMIC AND PHYLOGENETIC STUDY OF LEAF-INHABITING *Ascomycota* IN *Musa* SPECIES FROM NORTHERN THAILAND, WITH A GLOBAL CHECKLIST

3.1 Introduction

Banana and plantain (*Musa* spp.) are monocotyledonous plants in the family *Musaceae* of *Zingiberales* (Heslop-Harrison & Schwarzacher, 2007). The fruit crop is cultivated and consumed globally, being present in 135 countries, and it ranks among the most traded fruits worldwide (Voora et al., 2020). *Musa* provides an excellent habitat for many fungi with different lifestyles, *i.e*., endophytes, pathogens and saprobes (Brown et al., 1998; Crous et al., 2016; Ellis, 1971, 1976; Hernández-Restrepo et al., 2015; Hyde et al., 2017; Matsushima, 1971; Photita et al., 2000, 2001, 2002, 2004; Samarakoon et al., 2019, 2020, 2021; Somrithipol, 2007). Prior research on fungi in *Musa* spp. across various ecological niches rarely employed polyphasic species identification methods. Many identified fungi lack DNA sequence data in GenBank. Hence, the phylogenetic relationships of fungi associated with *Musa* spp. are yet to be investigated.

The absence of recent comprehensive taxonomic investigations on micro-fungi associated with *Musa* in Thailand has left a notable gap since the detailed studies by Chen et al. (2017), Lumyong et al. (2003), Photita et al. (2000, 2001, 2002, 2003, 2004) and Somrithipol (2007). Most taxa of Photita et al. (2000, 2001, 2002, 2003, 2004) and Somrithipol (2007) were documented based only on morphological characters. Hence, the phylogenetic relationships of these taxa are not well-resolved.

Many prior studies lacked descriptive morphological illustrations and only explored fungal biodiversity in *Musa* from specific habitats in Thailand. Globally, few studies (Crous et al., 2006, 2016, 2021; Hernández-Restrepo et al., 2015; Zakaria & Aziz, 2018, 2021) investigated the morpho-molecular taxonomy of leaf-inhabiting fungi on *Musa*, with limited genera reported.

Due to the economic value of *Musa*, most studies were oriented towards specifically selected groups of pathogenic fungi (such as *Colletotrichum, Fusarium, Mycosphaerella, Neocordana,* and *Phyllosticta*) (Arzanlou et al., 2008; Crous et al., 2002a; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019). Therefore, it becomes imperative to investigate the hidden diversity of *Musa*-associated microfungi such as saprobic *Ascomycota*. Since Photita et al. (2002) there has been no updated index for fungi associated with *Musa*.

Dead and living leaves of *Musa* (banana) were collected from northern Thailand during the 2017–2021 investigation of microfungi. Thirty fresh collections of ascomycetous taxa from *Dothideomycetes, Eurotiomycetes* and *Sordariomycetes*, comprising eight subclasses, ten orders, 23 families and 28 genera, are illustrated in this study. Among them, three new species, 14 new host records and nine new geographical reports are included. The newly described species are *Dematipyriforma terrestris* (*Pleurotheciaceae*), *Neohelicosporium terrestris* (*Tubeufiaceae*) and *Pyrenochaetopsis musae* (*Pyrenochaetopsidaceae*). Eight fungal taxa, *viz. Colletotrichum siamense* (*Glomerellaceae*), *Curvularia umbiliciformis* (*Pleosporaceae*), *Metulocladosporiella musae* (*Herpotrichiellaceae*), *Neocordana musae* (*Pyriculariaceae*), *Neopestalotiopsis clavispora, N. musae* (*Sporocadaceae*), *Phaeosphaeria oryzae* (*Phaeosphaeriaceae*) and *Pyrenochaetopsis musae* (*Pyrenochaetopsidaceae*), associated with leaf spots are reported. Fifteen species, *viz. Apiospora locuta-pollinis* (*Apiosporaceae*), *Bahusandhika indica* (*Lentimurisporaceae*), *Dematipyriforma terrestris* (*Pleurotheciaceae*), *Dendryphiella vinosa* (*Dictyosporiaceae*), *Dictyoarthrinium musae, D. thailandica* (*Didymosphaeriaceae*), *Gibellulopsis serrae* (*Plectosphaerellaceae*), *Lophiotrema hydei* (*Lophiotremataceae*), *Musicillium elettariae* (*Plectosphaerellaceae*), *Neohelicosporium terrestris* (*Tubeufiaceae*), *Nigrospora sphaerica* (*Apiosporaceae*), *Periconia echinochloae* (*Periconiaceae*), *Spegazzinia musae* (*Didymosphaeriaceae*),

Stachybotrys subcylindrosporus (*Stachybotryaceae*), *Torula mackenziei* (*Torulaceae*) are reported as saprobes. In addition, four species, *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Musicillium tropicale* (*Plectosphaerellaceae*), *Pseudophaeocytostroma sacchari* (*Diaporthaceae*) and *Setoarthopyrenia chromolaenae* (*Roussoellaceae*) are documented as endophytes. Four fungal taxa, *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Corynespora torulosa* (*Corynesporascaceae*), *Lasiodiplodia theobromae* (*Botryosphaeriaceae*) and *Pseudopithomyces chartarum* (*Didymosphaeriaceae*), are identified as exhibiting both endophytic and saprobic lifestyles on the leaves of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak).

These findings further support the hypotheses of lifestyle transition in fungi on the same host. This is the first comprehensive study that combines the morphology and phylogeny of the systematics of leaf-occupying microfungi in *Musa* from northern Thailand. The current research particularly focuses on understanding the biodiversity and ecological dynamics of fungi in relation to *Musa* species. Furthermore, this study documents the global fungi associated with *Musa* hosts, and the findings are presented here as a checklist. A total of 760 fungal species associated with *Musa* are listed, along with their respective geographical localities, updated classifications, and literature. These taxa belong to four major phyla: *Ascomycota* is the most species-rich (93%), followed by *Basidiomycota* (6%), and *Mucoromycota* (1%). This compilation serves as a valuable resource for further research in the mycology and plant pathology of *Musa*.

3.2 Materials and Methods

3.2.1 Sample Collection, Morphological Studies and Isolation

3.2.1.1 Fungi associated with dead leaf materials (saprobes) and leaf spots

Dead and symptomatic leaves of *Musa* spp. were collected from three provinces (Chiang Mai, Chiang Rai and Tak) in northern Thailand during both dry and rainy seasons in 2017–2021. The collected specimens were transferred to the laboratory using zip-lock bags and cardboard boxes. Fungi on dead leaf materials and

leaf spots were examined with a Motic SMZ 168 Series microscope (Motic Asia, Kowloon, Hong Kong). Fungal fruiting structures were mounted in water for microscopic studies and photomicrography with a Nikon ECLIPSE 80i compound microscope (Nikon Instruments Inc., Melville, NY, USA) fitted with a Canon 750D digital camera (Canon Inc., Ota, Tokyo, Japan). Measurements were made with the Tarosoft (R) Image Frame Work program and images used for figures were processed with Adobe Photoshop CS3 Extended version 10.0 software (Adobe Systems, USA). In the taxonomic descriptions, the exceptional values of the dimensions are denoted with brackets.

Single spore isolation was carried out following the method described in Senanayake et al. (2020). Germinated spores were individually transferred to potato dextrose agar (PDA) plates and incubated at 25 °C in daylight. Colony characteristics were observed and measured after 3 weeks.

3.2.1.2 Fungi associated with fresh leaf materials and symptomatic leaves

Fresh *Musa* leaves were collected from Chiang Rai Province, Thailand, during the dry season from 2017–2021. Small pieces (<5 mm^2) from the leaf tissues were separated using a sterilized scalpel, disinfected in 75% ethanol for 1 min, rinsed three times in sterile distilled water, dried and plated on PDA or oat meal agar (OMA). The plates were incubated at 25 °C for at least 5 days until fungi developed from the healthy and symptomatic plant tissues. The hyphal tips of colonies were transferred to fresh PDA plates using a sterilized scalpel and incubated until they produced conidiomata and conidia. Fungi were initially identified based on their morphological characteristics.

The conidia of these isolates were observed with a Motic SMZ 168 stereo zoom microscope. The conidia suspension was spread over the surface of the PDA plates. After incubation at 25 °C overnight, single germinating conidia were transferred to PDA plates to obtain pure cultures, which were then used for determination of growth rate, observation of morphological characteristics, and DNA extraction. Pure cultures were incubated at 25 °C in daylight until the formation of fruiting structures, which were then photographed following the same procedure used for saprobic fungi.

Sporulated cultures were used to prepare dry culture herbarium material as follows: The glycerol agar medium was prepared by mixing 100 ml of a 15% glycerol solution, 7.1 g of agar, and 200 ml of distilled water. The final mixture was autoclaved at 121 °C for 20 minutes to ensure sterility. The autoclaved agar solution was cooled to 60–90 °C and poured onto a flat, sterilized plastic or glass petri dish lid. The culture was then cut with the growth medium and placed on the hot agar solution, allowing immersion. The agar plates were incubated in an open area at 25 °C–35 °C for drying. After one day, the agar blocks were removed from the plastic surface and transferred to sterilized parchment paper for additional drying. The drying period was continued for one week. The flexibility of the agar blocks was carefully observed after one week, ensuring the complete removal of water from the glycerol agar medium. Throughout the process, sterile conditions were maintained to prevent contamination.

Herbarium specimens of the fungi described in the manuscript were deposited in the Mae Fah Luang University (MFLU) Fungarium, Chiang Rai, Thailand. Permanent slides were also prepared following Senanayake et al. (2020) and deposited together with the dry specimens. Cultures were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC). The names of new fungal taxa were registered in Index Fungorum (http://www.indexfungorum.org/). Following Jayasiri et al. (2015), the Faces of Fungi numbers (FoF) were acquired for the isolates. Morphological illustrations and related information were submitted to GMS MICROFUNGI (https://gmsmicrofungi.org) website, followed by Chaiwan et al. (2021).

3.2.2 DNA Extraction, PCR Amplification and Sequencing

Mycelium was scraped from seven-day old cultures and crushed with metal beads by TissueLyser LT (QIAGEN: Sample and Assay Technologies; Miami, Florida, United States) to extract DNA. A column based PureDireX Genomic DNA Isolation Kit (Blood/Cultured Cell/Fungus; New Taipei City, Taiwan) was used for the extraction following the manufacturer’s guidelines. In addition, DNA was extracted directly from hyphomycete fruiting structures as follows: 15–20 fruiting structures (visible conidia and conidiophores) were removed from the substrate using a sterilized needle. In aseptic conditions, the latter were transferred to a drop of

distilled water in a sterile microcentrifuge tube (1.5 mL). E. Z. N. A. ® Tissue DNA KIT (Omega Bio-tek, Thermo Fisher Scientific, United States) was used to extract DNA following the instructions of the manufacturer.

Polymerase chain reaction (PCR) was conducted according to the following protocol: The total volume of the PCR reaction was 25 μL and consisted of 12.5 μL of DreamTaq Green PCR Master Mix (2X) (a ready-to-use solution containing DreamTaq DNA polymerase, optimized DreamTaq Green buffer, $MgCl_2$, and dNTPs) (Thermo Fisher Scientific Inc. USA), 1 μL of each primer (10 pM), 2 μL genomic DNA extract and 8.5 μL double distilled water (ddH_2O). The gene regions, primers and respective PCR cycles are mentioned in Table 3. 1. PCR amplification was confirmed on 1% agarose electrophoresis gels loaded using Invitrogen DNA gel loading dye (6X) (Thermo Fisher Scientific Inc., USA). The amplified PCR fragments were sent to a commercial sequencing provider. The amplified PCR fragments were sent to SolGent Co., Ltd., South Korea, for sequencing. Generated molecular data have been deposited in GenBank (https://www.ncbi.nlm.nih.gov/).

3.2.3 Sequence Alignment

Obtained sequences were subjected to a BLASTn search in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi) and verified. Sequences used in the phylogenetic analyses were acquired from GenBank based on previous literature published until October 2023. The single gene alignments were done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/large.html, Katoh et al., 2019) using the default settings. The latter alignments were visualized and combined with BioEdit v. 7.0.5.2 (Hall, 1999).

3.2.4 Phylogenetic Analyses

Maximum likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis, 2014; Stamatakis et al., 2008) on the CIPRES Science Gateway platform (Miller et al., 2010) using the GTR+I+G model of evolution. Bootstrap supports were obtained by running 1000 pseudo-replicates. Maximum likelihood bootstrap values equal to or greater than 60% are given near each node of the phylogenetic trees.

Bayesian analyses were conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov chain Monte Carlo sampling (BMCMC). Two parallel runs were conducted, using the default settings, but with the following adjustments: Four simultaneous Markov chains were run for 1,000,000 to 2,000,000 generations (depending on the data set) and trees were sampled every 100th generation. The first 25% of the trees, representing the burn-in phase of the analyses, were discarded. The remaining 75% of trees were used for calculating PP in the majority rule consensus tree. Branches with Bayesian posterior probabilities (PP) equal to or greater than 0.90 are indicated near each node of the phylogenetic trees. Phylograms were visualized with the FigTree v1.4.0 program (Rambaut, 2011) and reorganized in Microsoft Power Point. The statistical parameters of the ML trees of the respective species are displayed in the figure legends. Strains generated in this study are shown in blue, with ex-type strains in bold.

3.2.5 The Global Checklist of Fungi Associated with *Musa*

The global checklist of fungi associated with *Musa* (Appendix A) was prepared based on previous written and online literature. The historical fungal species were recorded using the following bibliographic information; Index of Fungi (from 1940 to the present), including Petrak's Lists (1920 – 1939), Sylloge Fungorum by Saccardo (1882 – 1920), Traverso (1878 – 1955), Trotter (1874 –1967). In addition, the available data resources at the Mycological Library of the Mushroom Research Foundation (Chiang Rai, Thailand), were primarily utilized to collect information. For the curation of hyphomycetous fungi, references from Ellis (1889, 1957a, 1957b, 1960, 1967, 1971a, 1971b, 1972, 1976) were used. Online bibliographic reports were mainly extracted from the US National Fungus Collections Fungal Databases search site (Farr & Rossman, 2021; dataset; https://doi.org/10.15482/USDA.ADC/1524414; accessed 2024-01-02). Additional online literature was downloaded from various research publications available in different search engines. Extra information was also derived from Photita et al. (2002) and the ongoing studies conducted by the authors from 2017 to 2024.

Table 3.1 Partial gene regions, primers and PCR amplification conditions used in this study

Gene/Locus	Primer		PCR protocol					Reference
	Forward	Reverse	Initial Denaturation	Denaturation	Annealing	Extension	Final extension	
Internal Transcribed Spacers (ITS)	ITS4	ITS5	94 °C, 4 min, 1 cycle	94 °C, 45 secs, 35 cycles	53 °C, 60 sec	72 °C, 1 min	72 °C, 10 min, 1 cycle	White et al. (1990)
28S ribosomal RNA (LSU)	LR0R	LR5						Vilgalys and Hester (1990)
18S ribosomal RNA (SSU)	NS1	NS4			53 °C, 45 sec			White et al. (1990)
Translation Elongation Factor 1–alpha (*tef*1)	728F	986R	94 °C, 3 min, 1 cycle	94°C, 30 secs, 35 cycles	58°C, 50 sec			Carbone and Kohn (1999)
	983F	2218R						Rehner (2001)
	526F	1567R						Rehner (2001)
RNA polymerase II second largest subunit (*rpb*2)	5F2	7cr	95 °C, 5 min, 1 cycle	95 °C, 45 secs, 40 cycles	57 °C, 2 min	72 °C, 1.5 min		Liu et al. (1999)
β-tubulin (*tub*2)	Bt2a	Bt2b	94 °C, 3 min, 1 cycle	94 °C, 30 sec 35 /40 cycles	58 °C, 50 sec	72 °C, 1 min		Glass and Donaldson (1995)
	T1	T2			58 °C, 55 sec			O'Donnell and Cigelnik (1997)
Glyceraldehyde-3-Phosphate Dehydrogenase (*gapdh*)	gpd1	gpd2	96 °C, 1 min, 1 cycle	96 °C, 1 min 35 / 40 cycles	58/59 °C, 1 min	72 °C, 45 sec		Myllys et al. (2002)
	gdf	gdr			58/59 °C, 1 min			Templeton et al. (1992)
Chitin synthase 1 (*chs*-1)	79F	354R	95 °C, 1 min, 1 cycle	96 °C, 1 min, 35 cycles	53 °C, 1 min			Carbone and Kohn (1999)
Actin (*act*)	512F	783R						

The documentation includes known hosts (solely the genus name or coupled with the species epithet) and the geographical locality of fungi recorded on *Musa*. The nomenclature of Index Fungorum (2024) was followed for all the records. Taxonomic classification updates (Phylum, Class, Order, and Family) were implemented according to Wijayawardene et al. (2022). Fungal names are arranged in descending order in the taxonomic hierarchy. The reachable bibliographic information is in-text cited in front of each record. Fungal species for which molecular data are available in GenBank are indicated with an asterisk (*) mark.

3.3 Results

Phylum *Ascomycota* Caval. Sm

Subphylum *Pezizomycotina* O. E. Erikss. & K. Winka

Class *Dothideomycetes* O. E. Erikss. & Winka

Botryosphaeriales C. L. Schoch, Crous & Shoemaker

Botryosphaeriales (*Dothideomycetes* order *incertae sedis*) represent a morphologically diverse group of fungi associated with different hosts and geographical localities (Slippers et al., 2017). Most of the fungi in the order are usually reported as saprobes, pathogens and are sometimes found as endophytes associated with the woody parts of angiosperms and gymnosperms (Phillips et al., 2019; Zhang et al., 2021). Some species were equally reported as opportunistic human pathogens; some were also documented in marine environments associated with sea grasses (Sakayaroj et al., 2010). Thirty-three genera have been identified in six families of *Botryosphaeriales* (*viz*., *Aplosporellaceae*, *Botryosphaeriaceae*, *Melanopsaceae*, *Phyllostictaceae*, *Planistromellaceae* and *Saccharataceae*) (Phillips et al., 2019; Wijayawardene et al., 2022; Wu et al., 2021).

Botryosphaeriaceae Theiss. & Syd.

The sexual morph of *Botryosphaeriaceae* taxa is characterized by uni- to multi-loculate ascostromata with 8-spored, bitunicate asci and hyaline to brown, aseptate, or septate ascospores (Batista et al., 2021; Phillips et al., 2013). The asexual morph comprises coelomycetes that produce uni- to multi-loculate pycnidia, hyaline,

phialidic conidiogenous cells, and large hyaline or dematiaceous conidia (Phillips et al., 2013). There are 24 genera hosting more than 200 species in the family (Burgess et al., 2019). *Botryosphaeriaceae* taxa can be cosmopolitan and are common endophytes, saprobes, or plant pathogens on various hosts in terrestrial and aquatic environments (Phillips et al., 2019). Controlling *Botryosphaeriaceae* pathogens becomes a great challenge in commercial agriculture as many taxa have the ability to be persistent as endophytes and shift to a pathogenic lifestyle when the host is under stress (Batista et al., 2020, 2021). The pathogens then cause diseases that eventually kill the host, emerge as saprobes on decaying tissue, and colonize new hosts (Batista et al., 2021). In this study, we found the endophytic and saprobic lifemodes of *Lasiodiplodia theobromae* on *Musa accuminata*, which further supports the hypothesis of lifestyle shifting of fungi in the same host to adapt to environmental pressures (Burgess et al., 2019; Hill et al., 2022; McDowell, 2013).

Lasiodiplodia Ellis & Everh., Clendenin, Bot. Gaz. 21: 92 (1896)

Lasiodiplodia is well distributed in tropical and subtropical regions and occurs on a wide range of plant hosts (Abeywickrama et al., 2023; Chethana et al., 2023; Hattori et al., 2023; Hyde et al., 2020; Jayasiri et al., 2019; Phillips et al., 2013; Rathnayaka et al., 2023; Senanayake et al., 2023; Senwanna et al., 2021; Silva et al., 2022, 2023; Tennakoon et al., 2021). Most *Lasiodiplidia* species are causal agents of cankers, dieback, rots, and branch blights on many agricultural crops (de Silva et al., 2019; Gómez et al., 2021; Santos et al., 2023; Wang et al., 2023). *Lasiodiplodia* can be distinguished from other genera in *Botryosphaeriaceae* by having longitudinal striations on the mature conidia (Phillips et al., 2013). At present, 64 *Lasiodiplodia* taxa are listed in the Index Fungorum (2024). Previous research has provided evidence for the occurrence of endophytic and saprobic lifestyles (Abeywickrama et al., 2023; de Silva et al., 2019; Huang et al., 2017; Mohali et al., 2005; Tennakoon et al., 2021) in many *Lasiodiplodia* species. *Lasiodiplodia theobromae* was reported as one of the causative organisms of the crown rot disease on *Musa* fruits worldwide (Sangeetha et al., 2012). In this study, we report the endophytic and saprobic life modes of *Lasiodiplodia theobromae* on Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) leaves in Thailand. We can further predict that the endophytic *L. theobromae* has the potential to function as a saprobe

during the senescence of Namwa banana leaves, which further validates the findings of Promputtha et al. (2007, 2010), Nelson et al. (2020) and Weatherhead et al. (2022).

Lasiodiplodia theobromae (Pat.) Griffon & Maubl., Bull. Soc. mycol. Fr. 25: 57 (1909)

Figure 3.1

Index Fungorum number: IF 188476; Facesofungi number: FoF 00167

Saprobic on dead leaves of *Musa*. Sexual morph: Not observed. Asexual morph: Coelomycetous. *Conidiomata* 180–190 × 165–175 µm ($\bar{x}$=185 × 171 µm, n=20), pycnidial, semi-immersed and erumpent at maturity, black, globose to sub globose, uniloculate. *Peridium* 3–4 layered, 20–30 µm, with pale brown or dark brown pseudoparenchymatous cells, *textura angularis*. *Conidiophores* 15–18 × 2–4 µm ($\bar{x}$=16 × 3.5 µm, n=20), reduced to conidiogenous cells, hyaline, simple, aseptate, unbranched, cylindrical, smooth, erect from the cells of the pycnidial cavity. *Conidia* (20–) 25–30 × 12–15 µm ($\bar{x}$=26.5 × 13 µm, n=40), immature condia, rough to smooth surfaces, simple, hyaline, aseptate; mature conidia 1-septate, dark brown, oblong or ovoid, straight, rounded at the apex and base, thick-walled, longitudinal striations are visible.

Cultural characteristics — Colonies on PDA, reaching 50 mm in diameter after 10 days at 25 °C, colonies initially dirty brownish white, later becoming brown and finally black at maturity, dusty, circular or irregular margined, entire edge, cottony or fluffy, reverse brown at the center, Sporulation was initiated after 14 days on PDA at 25 °C under light conditions.

Material examined — Thailand, Chiang Rai Province, Nang Lae, Rattana Dormitory area, on a dead leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 13 March 2019, B. C. Samarakoon, BNS60 (MFLU 23-0285), culture MFLUCC 23-0223.

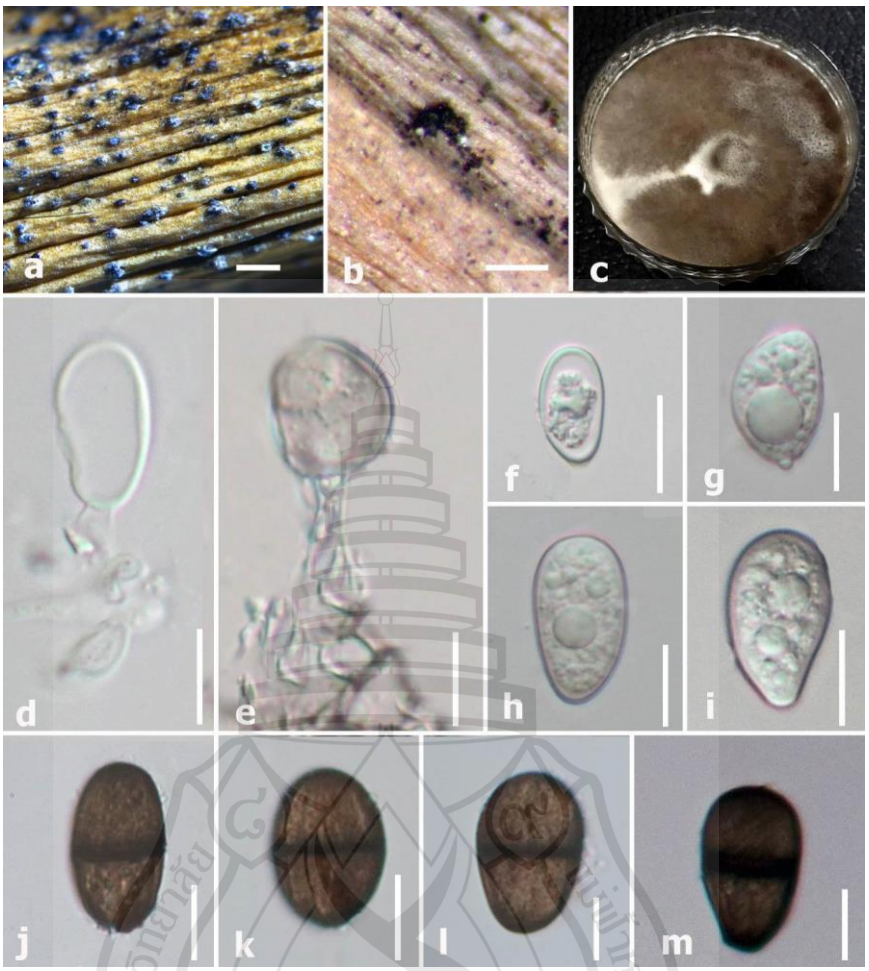
Other material — Thailand, Chiang Rai Province, Nang Lae, Rattana Dormitory area, fresh leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 12 October 2018, B. C. Samarakoon, EN15 (MFLU 23-0286), culture MFLUCC 23-0224.

GenBank numbers — MFLUCC 23-0224: ITS=PP809073 and MFLUCC 23-0223: ITS= PP809074, *tef*1= OR206053

Notes — In the multigene phylogeny of combined ITS and *tef*1 sequence data (Fig. 3.2), the endophytic isolate (MFLUCC 23-0224) and the saprobic strain (MFLUCC 23-0223) nested together with *Lasiodiplodia theobromae* (CBS 164.96, CBS 124.13, CBS 11530) with ML=71%, PP=0.94 statistical support. The BLAST search results for ITS and *tef*1 sequence data indicate that our endophytic isolate (MFLUCC 23-0224) exhibits the highest percentage similarity to *L. theobromae* (CBS 11530) (ITS=100%, *tef*1=100%) with a 100% query cover. The saprobic strain (MFLUCC 23-0223) shows 100% similarity in ITS to *L. theobromae* (CBS 164.96) and 100% similarity in *tef*1 to *L. theobromae* (CBS 11530), both with a 100% query cover. There are no noticeable morphological differences between the endophytic and saprobic strains. There is a possibility that the endophytic lifestyle of *L. theobromae* can shift to saprobic upon the decay of Namwa banana leaves. Salvatore et al. (2020) studied the lifestyle shift of *L. theobromae* from endophytic to pathogenic based on taxonomic and phylogenetic approaches. In this study, we report the endophytic and saprobic lifestyle occurrences of *L. theobromae* associated with *Musa acuminata* leaves from Thailand.

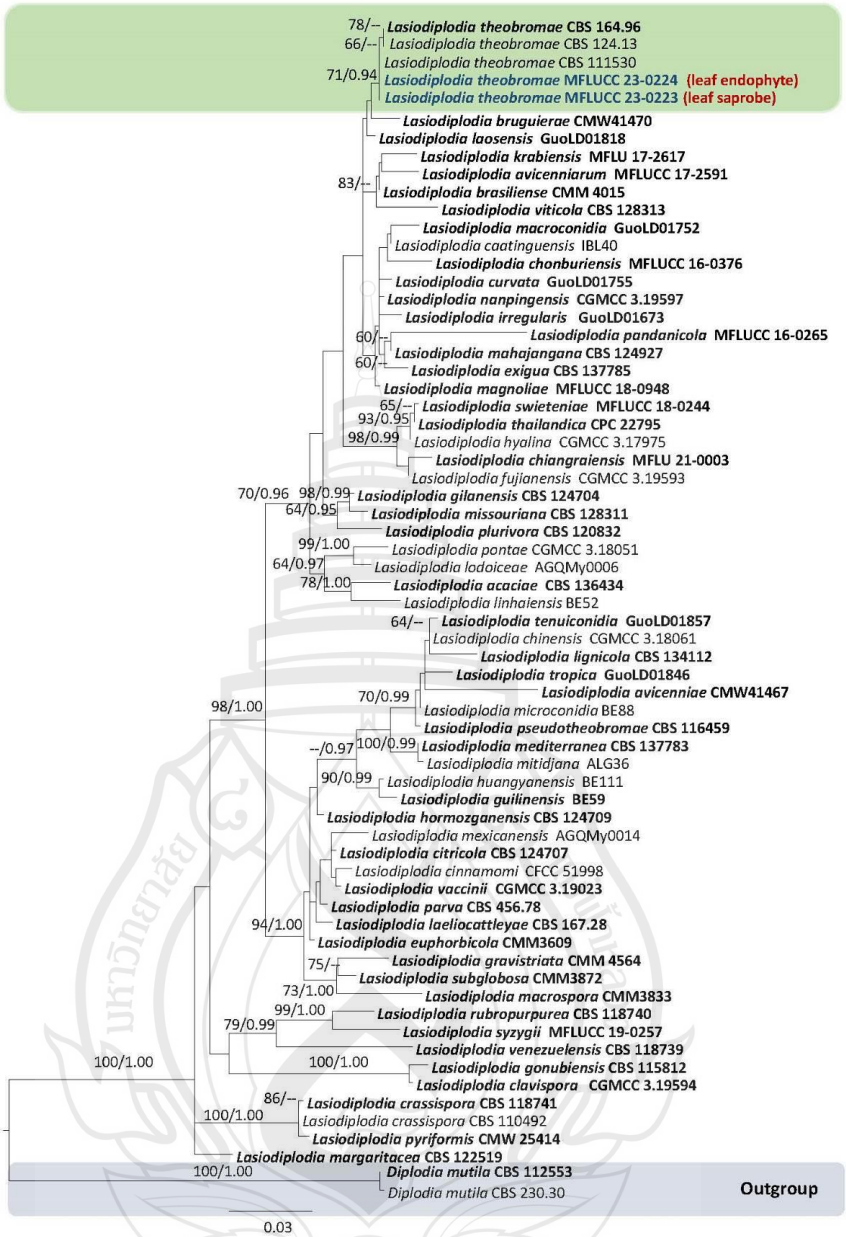
Pleosporales Luttr. ex M. E. Barr

Pleosporales account for a quarter of the dothideomycetous taxa (Hongsanan et al. 2020). The taxa have a wide global geographic distribution, representing several lifestyles (*i.e.*, epiphytic, endophytic, fungicolous, lichenicolous, plant and human pathogenic, and saprobic lifestyles) (He et al., 2024; Ren et al., 2022; Tennakoon et al., 2021). Hongsanan et al. (2020) accepted 91 families in *Pleosporales*. In this study, we present different sexual and asexual morphs of *Pleosporales* species in 11 families (*viz*., *Corynesporascaceae*, *Dictyosporiaceae*, *Didymosphaeriaceae*, *Lentimurisporaceae*, *Lophiotremataceae*, *Periconiaceae*, *Phaeosphaeriaceae*, *Pleosporaceae*, *Pyrenochaetopsidaceae*, *Roussoellaceae* and *Torulaceae*) associated with *Musa* leaves.



Note a, b Saprobic occurrence on and the conidiomata on host. c Colony on PDA after 14 days (endophytic isolate). d, e Conidiogenesis. f–i Immature conidia. j–m Mature conidia. Scale bars: a, b=500 µm, d–m=10 µm.

Figure 3.1 *Lasiodiplodia theobromae* (MFLU 23-0285 and MFLU 23-0286)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.90 PP) are shown. The tree is rooted in *Diplodia mutila* (CBS 112553 and CBS 230.30) in the *Botryosphaeriaceae*. Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Lasiodiplodia theobromae.*

Figure 3.2 Maximum likelihood tree revealed by RAxML analyses of ITS and *tef*1sequence data of the taxa of *Lasiodiplodia*

Corynesporascaceae Sivan.

The family was established by Sivanesan (1996), based on *Corynesporasca*. It was previously placed in *Melanommatales* and accepted in *Pleosporales* by Hyde et al. (2013). *Corynesporascaceae* comprises *Corynesporasca* and *Corynespora* (Voglmayr & Jaklitsch, 2017). *Corynesporascaceae* has saprobic, pathogenic and endophytic lifestyles, which have mainly been discovered in the tropics and subtropics (Kumar et al., 2012; Liu et al., 2023). In this study, we report the saprobic and endophytic lifestyle of *Corynespora torulosa* found on *Musa acuminata* in Thailand.

Corynespora Güssow, J. Royal Agric. Soc. England 65: 272 (1905)

Corynespora was established by Güssow (1906) to accommodate *Corynespora melonis* (= *Cercospora melonis*). The genus is pathogenic on several agricultural crops (*i.e.*, cotton, papaya, pepper, roselle, rubber and tomato) worldwide, causing leaf and fruit spots (Butler et al., 2016; Conner et al., 2013; Kumar & Singh, 2021; Kwon et al., 2001; Ortega-Acosta et al., 2015; Salunkhe et al., 2019; Tsai et al., 2015). In addition, *Corynespora* exhibits saprobic and endophytic lifestyles (Kumar & Singh, 2016; Scomparin et al., 2012; Xu et al., 2020). The genus has also been discovered in air, lower plants, lichens and soil in terrestrial environments and aquatic habitats (Hyde et al., 2020; Kumar & Singh, 2021).

Corynespora torulosa (Syd. & P. Syd.) Crous, Persoonia 31: 211 (2013)

Figure 3.3

Index Fungorum Number: IF 805829; Facesoffungi Number: FoF 14164

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* effuse, grey, brown or black, often hairy. *Mycelium* immersed, occasionally superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* erect from the mycelium, (29–) 55–63 (–70) × 4–6 µm ($\bar{x}$=57 × 5 µm, n=30), 9–12 µm wide at the base, 1–3 µm near the apex, arising singly, simple, torsive, straight or flexuous, unbranched, pale brown to dark brown, septate, 4–5 thin flange of tissue parts appearing as wings on the surface. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, doliiform, collarette, producing hyaline spherical immature conidia at terminal end. *Conidia* (20–) 24–28 (–32) × 7–9.5 µm ($\bar{x}$=24.5 × 7.9 µm, n=40) with blackish-brown scar at the base, formed singly,

cylindrical, straight or slightly curved, tapering towards the rounded apex, mid brown or golden brown, smooth or verruculose, with 0, 1, 2, 3 or more transverse pseudosepta.

Material examined — Thailand, Chiang Rai Province, Nang Lae, Rattana Dormitory area, on a dead leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 20 July 2019, Binu Samarakoon, BNS288 (MFLU 23-0287), culture MFLUCC 23-0241.

Other material examined — Thailand, Chiang Rai Province, Nang Lae, Rattana Dormitory area, on a fresh leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 16 May 2021, Binu Samarakoon, EN06 (MFLU 23-0319), culture MFLUCC 23-0031.

GenBank numbers — MFLUCC 23-0031: LSU=PP800315, ITS=PP809076 and MFLUCC 23-0241: LSU=PP800314, ITS=PP809075

Notes — *Corynespora torulosa* was previously known as *Deightoniella torulosa* (= *Brachysporium torulosum*) and was accommodated in the *Corynesporascaceae* by Crous et al. (2013c) based on molecular data. The taxon has been previously reported to cause black leaf spots on banana leaves in Georgia, India, Jamaica and Thailand (Jones, 2018; Koné et al., 2008; Meredith, 1961; Tongsri et al., 2017; Vardhana, 2017). In addition, *C. torulosa* was reported to cause fruit speckles on banana fruits at the pre-harvest stage in Jamaica and Cuba (Almenares & Pérez-Vicente, 2019; Meredith, 1961). The fungus also has saprobic and endophytic lifestyles, which have primarily been discovered in terrestrial habitats (Meredith, 1962; Photita et al., 2001; Photita et al., 2004). The morphology of our strains is similar to the illustration of *C. torulosa* in Elis (1971). In the phylogeny based on LSU and ITS (Fig. 3.4), the endophytic isolate (MFLUCC 23-0031) and the saprobic isolate (MFLUCC 23-0241) grouped with *C. torulosa* isolates with ML=100%, PP=1.00 statistical support. The BLAST search results for LSU and ITS sequence data indicate that MFLUCC 23-0031 exhibits the highest percentage similarity to *C. torulosa* (CBS 136419: LSU=100%, ITS=100%) with a 100% query cover. The saprobic strain shows 100% similarity in LSU to *C. torulosa* (CPC 15989) and 100% similarity in ITS to *C. torulosa* (CATAS-XJC796), both with a 100% query cover. The findings of our study further witness the lifestyle transition of endophytic fungi to

the saprobic mode upon host senescence (Promputtha et al. 2010). Future chemical evaluations, such as cellulase, β-mannanase, polygalacturonase and xylanase like enzymatic evaluations, are necessary to check this hypothesis (Promputtha et al. 2007, 2010). Based on morphological illustrations and strong molecular justification, we document the endophytic and saprobic occurrence of *C. torulosa* associated with Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) in Thailand.



Note Colony on oat meal agar after 3 weeks (endophytic isolate). b Sporulation on OMA. c–f, p–w Conidia. g, h, o Conidiogenesis. i, j Saprobic colony on *Musa* host. k–n Conidiophores. Scale bars: b=1000 µm, c–h=10 µm, i=500 µm, j=100 µm, k–w=5 µm.

Figure 3.3 *Corynespora torulosa* (MFLU 23-0287 and MFLU 23-0319)

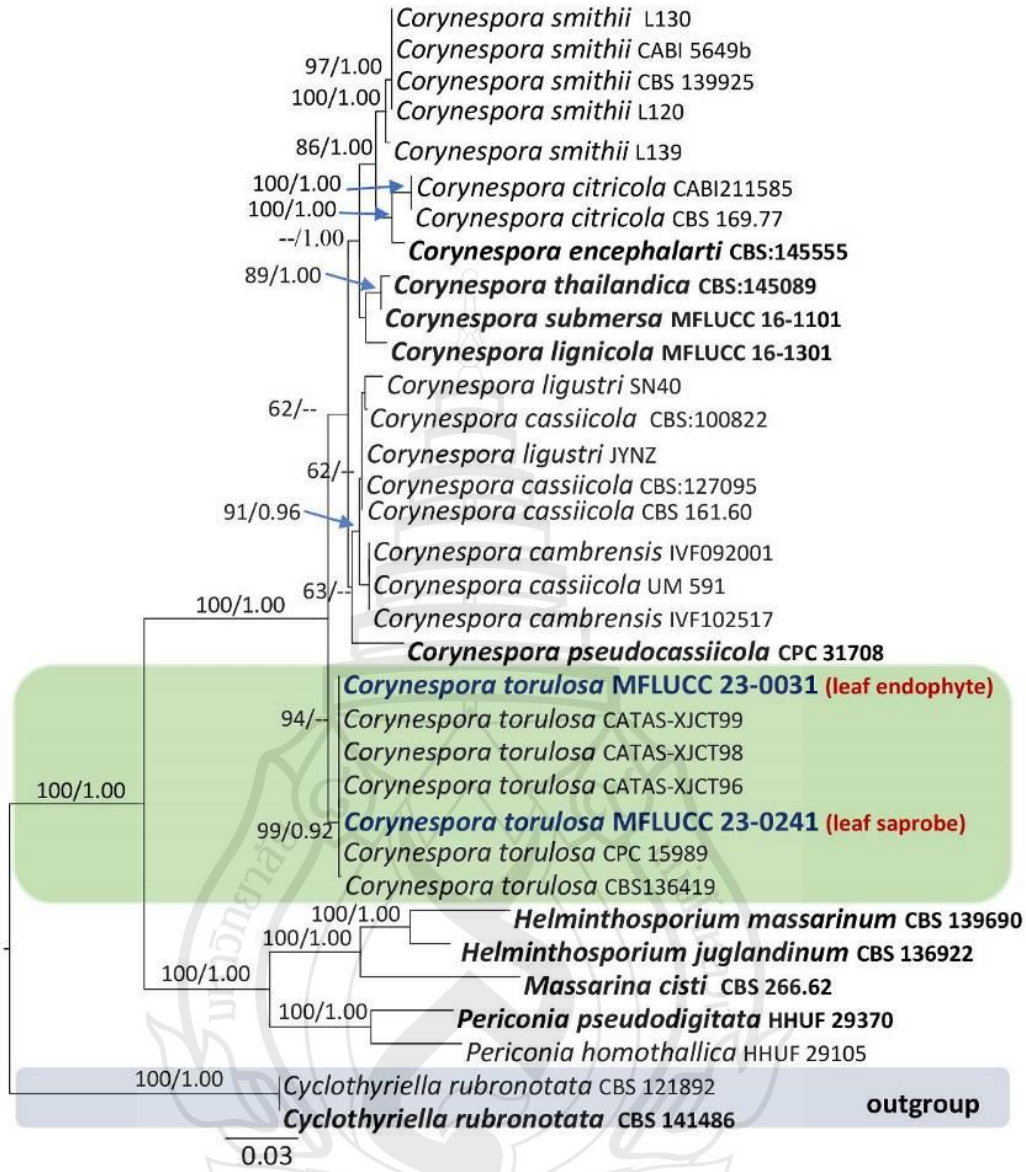
Dictyosporiaceae Boonmee & K.D. Hyde

Dictyosporiaceae was erected by Boonmee et al. (2016) and typified by *Dictyosporium*. Hongsanan et al. (2020) accepted 15 genera and Jiang et al. (2021) accommodated *Immotthia* in the *Dictyosporiaceae*. In addition, *Neodigitodesmium* (Tian et al., 2022), *Paradictyocheirospora* (Rajeshkumar et al., 2021) and *Verrucoccum* (Atienza et al., 2021) were recently added as new genera to the family. Taxa of *Dictyosporiaceae* are found on plant litter and wood in terrestrial and aquatic habitats. The sexual morph is characterized as perithecial, superficial and somewhat soft ascomata that collapse when dry. An apical ostiole is present in the ascomata with a wall of *textura epidermoidea*. Asci are bitunicate, cylindrical and pedicellate. Ascospores are bi seriate and fusiform and are often hyaline, 1-septate, with or without mucilaginous sheaths. The hyphomycetous asexual morphs are sporodochial, effuse and often dark brown (Boonmee et al., 2016). Conidiophores are sometimes reduced to conidiogenous cells and often unbranched or rarely branched. Conidiogenesis occurs in the terminal or intercalary parts of the conidiophore. Conidia can be acrogenous or pleurogenous, simple, dry, complanate or non-complanate, and brown. Some genera possess aseptate conidia, but most genera have multi-septate, euseptate or distoseptate conidia, with or without appendages (Hongsanan et al., 2020). *Dictyosporiaceae* taxa are saprobes, discovered on decaying wood and plant debris in terrestrial and freshwater habitats (Boonmee et al., 2016; Hyde et al., 2018; Liu et al., 2017a).

Dendryphiella Bubák & Ranoj., Ranojevic, Annls mycol. 12: 417 (1914)

The genus was established by Ranojevic (1914) and is typified by *Dendryphiella interseminata.* Sixteen species epithets are currently listed in Index Fungorum (2024). Seven *Dendryphiella* species have DNA sequence data in GenBank. The sexual morph of the genus has not been reported. The asexual morph is hyphomycetous and is characterized by macronematous conidiophores and polytretic, integrated conidiogenous cell apex and intercalary parts. The conidiogenous areas are often swollen and produce simple conidia or conidial chains (Chethana et al., 2021; Ellis, 1971; Hyde et al., 2018, 2020b). Liu et al. (2017a) updated the taxonomy of *Dendryphiella* with the addition of novel taxa. Dong et al. (2020) synonymized *D. phitsanulokensis* under *D. vinosa.* The genus has only been reported as saprobes. The

taxa were often found in aquatic and terrestrial environments and were also associated with woody debris (Liu et al., 2017a). We could not find any literature on the occurrence of this genus in the *Musaceae*. *Dendryphiella fasciculata* and *D. vinosa* were previously documented from Thailand by Liu et al. (2017a). This study presents the first occurrence of *Dendryphiella* on *Musaceae* as a saprobe from Thailand.



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.90 PP) are shown. The tree is rooted in *Cyclothyriella rubronotata* (CBS 141486 and CBS 121892) in the *Cyclothyriellaceae*. Strains generated in this study are shown in blue, with ex-type strains in bold. The tree is showing the phylogenetic position of *Corynespora torulosa.*

Figure 3.4 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of selected genera of *Pleosporales*

Dndryphiella vinosa (Berk. & M. A. Curtis) Reisinger, Bull. trimest. Soc. mycol. Fr. 84: 27 (1968)

Figure 3.5

Index Fungorum number: IF 329796; Facesoffungi number: FoF 08673

Saprobic on the mid rib of the leaf of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* on host superficial, effuse, brownish black. *Mycelium* immersed, septate, pale brown to brown, smooth, thick-walled hyphae. *Conidiophores* 70–130 (–250) × 3–5 μm ($\bar{x}$=90 × 4.3 μm, n=30), macronematous, mononematous, sometimes fasciculate, unbranched or branched, swollen from the middle and gives a gall or spherical shape 5–6 μm in width, un swollen parts are cylindrical, thick-walled, septate, slightly constricted at the septa, clavate or straight, unevenly thickened, smooth or slightly verruculose, base is globular to spherical, apex is flat or spherical or bulbous, brown to reddish brown, becoming paler and tapering towards the apex, slightly swollen at nodes where branching starts. *Conidiogenous cells* polytretic, terminal or intercalary, proliferating asymmetrically, smooth, subcylindrical, with 1–2 conidiogenous loci, brown to reddish brown, somewhat paler than the conidiophore. *Conidia* 18–25 × 4–5.5 μm ($\bar{x}$=22.5 × 4.5 μm, n=30), simple, dry, acrogenous or pleurogenous, oblong, obtuse ends, 2-septate or aseptate and verruculose at immature stage, 3-septate at maturity, thick-walled, brown to reddish brown, hilum is visible at immature stage, dry, smooth at maturity.

Cultural characteristics — On PDA, colony circular, reaching 40 mm in 15 days at 25 °C, pale yellow-brown to white from above, yellow-brown from below, surface rough, with dense mycelium in the middle, sparse mycelium in the outer layer, dry, raised, edge entire.

Material examined — Thailand, Tak Province, Pradang, on dead leaf petiole of *Musa* sp., 4 August 2019, Erandi Yasanthika, BNS293 (MFLU 23-0288), culture MFLUCC 23-0242.

GenBank numbers — LSU=PP800316, ITS=PP809077

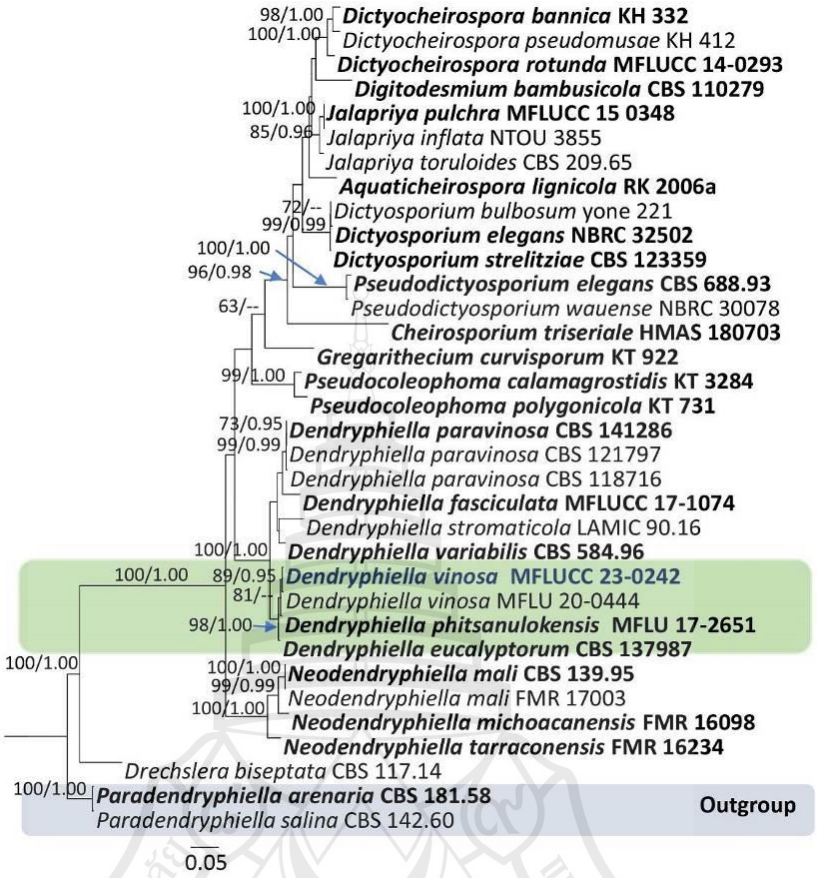
Notes — *Dendryphiella vinosa* was found in different geographical localities as a saprobe (*i.e.*, Belgium, Ghana, India, Kenya, Malaysia, Myanmar, New Caledonia, Taiwan, Zambia) on many plant hosts (*Allamanda, Abelmoschus, Bactris,*

Bauhinia, Carica, Cassia, Citrus, Collinsonia, Crotalaria, Hibiscus, Passiflora, Pisum, Sauropus, Sesbania, Vanilla) in terrestrial environments (Farr & Rossman, 2024). In addition, the species has been reported from marine and freshwater habitats (Dong et al., 2020; Jones et al., 2008). In the analyses using LSU and ITS sequence data, our strain (MFLUCC 23-0242) grouped with *D. vinosa* strains retrieved from GenBank with strong statistical support (Fig. 3 6). Based on the BLASTn search results of LSU and ITS sequences, our strain (MFLUCC 23-0242) demonstrated a high similarity to *D. vinosa* (MFLU 20-0444) as follows: LSU=100%, ITS=99.23%, with query covers of 100% and 96%, respectively. Notably, a 0.76% (4/521; without gaps) base pair difference in ITS sequences was observed between our isolate and *D. vinosa* (MFLU 20-0444). However, the morphological illustrations of *D. vinosa* by Jones et al. (2008) and Dong et al. (2020) are similar to our collection. Hence, we report *D. vinosa* on *Musa* spp. as a saprobe for the first time in Thailand.



Note a, b Conidiophores on the host. c, f, h Attachment of conidia and conidiophores. d, e Conidiophores. g Base of a conidiophore. i–m Conidia. Scale bars: a=500 μm, b=100 μm, c–h=20 μm, i–m=10 μm.

Figure 3.5 *Dendryphiella vinosa* (MFLU 23-0288)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Paradendryphiella arenaria* (CBS 181.58) and *P. salina* (CBS 142.60) (*Pleosporaceae*). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Dendryphiella vinosa*.

Figure 3.6 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of the selected genera of *Dictyosporiaceae* and *Pleosporaceae*

Didymosphaeriaceae Munk

The family was introduced by Munk (1953) and is typified by *Didymosphaeria epidermidis*. Ariyawansa et al. (2014) confirmed the taxonmic position of *Didymosphaeriaceae* in *Pleosporales* based on morpho-molecular data. The family comprises saprobes, endophytes and pathogens associated with plant hosts over a large geographical distribution (Hu et al., 2023; Mapook et al., 2020; Ren et al., 2022; Wanasinghe et al., 2024). The sexual morph is characterized by ostiolate ascomata, cellular or trabeculate pseudoparaphyses (Liew et al., 2000) and bitunicate, fissitunicate asci with pedicells. The ascospores are often septate or muriform, 2–4-spored or 8-spored, 1–2-seriate, and ellipsoid to oblong. The asexual morphs of *Didymosphaeriaceae* are diverse (*i.e.*, camarosporium-like, diplodia-, fusicladium-, pithomyces-, phoma-, and spegazzinia-like) (Wijayawardene et al., 2022). Currently, ten genera of *Didymosphaeriaceae* (*Alloconiothyrium, Cylindroaseptospora, Dictyoarthrinium, Neptunomyces, Paraconiothyrium, Paracamarosporium, Pseudocamarosporium, Pseudopithomyces, Spegazzinia,* and *Xenocamarosporium*) have been described based solely on asexual characteristics (Hongsanan et al., 2020).

Dictyoarthrinium Hughes, Mycol. Pap. 48: 29 (1952)

Dictyoarthrinium was introduced by Hughes (1952) using *D. quadratum* as the type species. Previously, the genus was placed in *Apiosporaceae* (*Sordariomycetes*) and Samarakoon et al. (2020b) accommodated the genus in *Didymosphaeriaceae* based on morphology and molecular data. Nine species epithets of *Dictyoarthrinium* are listed in Index Fungorum (2024). Five *Dictyoarthrinium* taxa (*D. africanum, D. microsporum, D. lilliputeum, D. synnematicum, D. rabaulense*) were established based only on morphology. *Dictyoarthrinium hydei, D. musae, D. sacchari* and *D. thailandicum* have been recently introduced based on morpho-molecular data (Maharachchikumbura et al., 2021; Ren et al., 2022; Samarakoon et al., 2020b). *Dictyoarthrinium* is characterized by having basauxic conidiophores (Damon, 1953; Hughes, 1952; Matsushima, 1971). Conidiophores of *Dictyoarthrinium* are minutely verruculose, sub-hyaline and transversely septate (Elis, 1971a). Usually, the septa are dark brown and appear as thick stripes on the conidiophores. The conidiophore mother cell is usually hyaline or pale brown and cup-shaped (Hughes, 1952) or subspherical (Elis, 1971a). The length of conidiophore

varies within the genus but in some species, the lengths are similar. The conidia of *Dictyoarthrinium* arise from the terminal or lateral parts of the conidiophore. Conidiogenesis is monoblastic or polyblastic and integrated (Elis, 1971a). Conidia are simple, solitary, pigmented, and often comprise 4 cells. Some taxa rarely produce 16-celled conidia (such as *D. africanum*). The surface of conidia is verruculose and most of the species have warts on the surface. The shape of conidia varies within the genus, such that they are either square, spherical, subspherical or oblong. The conidia usually appear to be flattened in one plane. The sexual morph of *Dictyoarthrinium* has yet to be determined. The majority of the taxa are saprobes that colonize dead plant materials, but *D. rabaulense* was recorded from soil (Kobayasi et al., 1971) and air (Elis, 1976). Endophytic or pathogenic lifestyles of *Dictyoarthrinium* have also not been recorded (Wijayawardene et al., 2022). Most of the species are recorded from monocot plants and the genus is widely distributed across the tropics and only in terrestrial environments (Samarakoon et al., 2020a). In this study, we report the occurrence of *Dictyoarthrinium musae* as a new collection from Thailand.

Dictyoarthrinium musae Samarakoon, Chomnunti & K. D. Hyde, MycoKeys 71: 109 (2020)

Figure 3.7

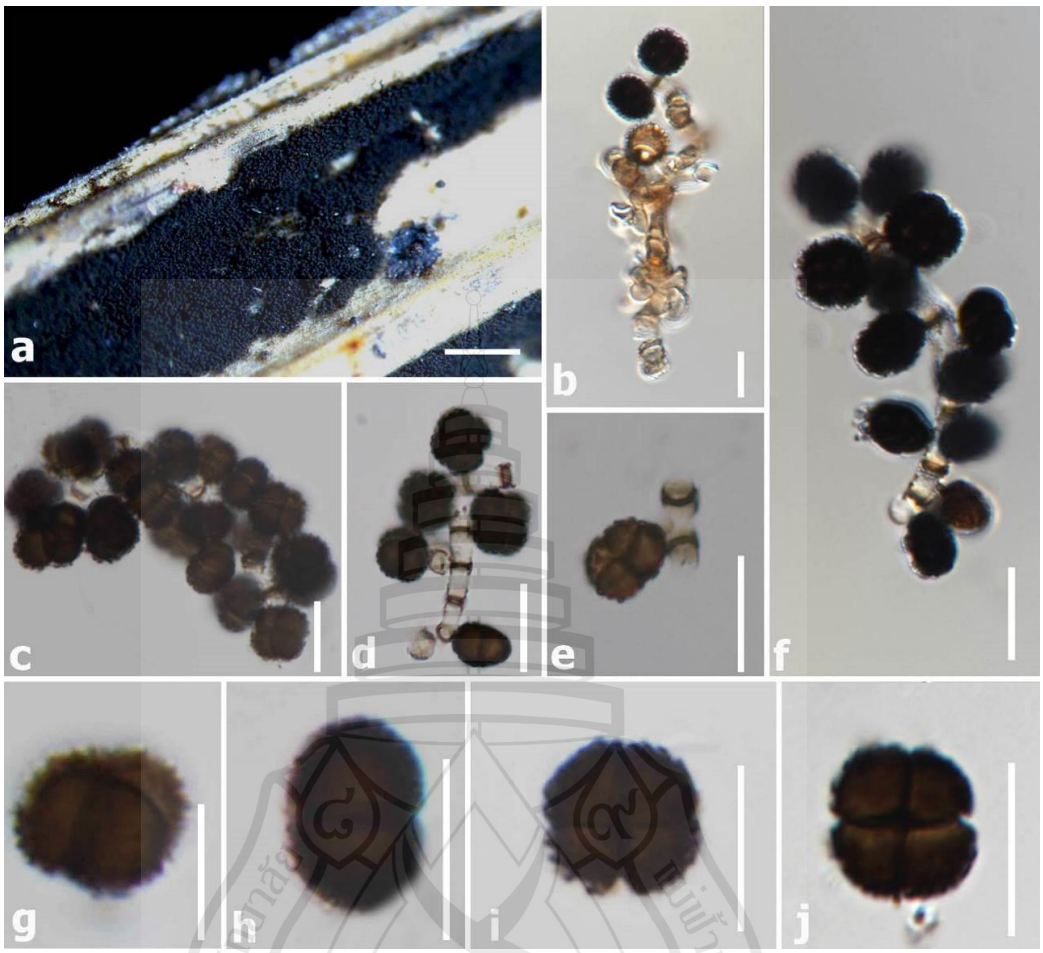
Index Fungorum Number: IF 835764; Facesoffungi Number: FoF 08467

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* powdery, black, shiny, superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* (40–) 72–80 × 3.8–4.5 µm ($\bar{x}$=75.6 × 4.3 µm, n=40), basauxic, simple, unbranched, erect from subspherical, pale brown conidiophore mother cells 4–5 × 3.5–4.5 µm ($\bar{x}$=4.5 × 3.9 µm, n = 10), macronematous, mononematous, often straight or sometimes flexuous, cylindrical, sub-hyaline, dark brown transverse septa appearing as stripes, surface rough. *Conidiogenous cells* 4–5 × 3.5–4 µm ($\bar{x}$=4.4 × 3.8 µm, n=10), terminal and intercalary, cylindrical, sub-hyaline to pale brown. *Conidia* 6–9.5 × 7–8.5 µm ($\bar{x}$ =8 × 7 µm, n = 40), simple**,** dark brown or blackish brown, dry, acropleurogenous, square rounded, often 4-celled, verrucose, with light brown to dark brown warts on the cellular surface. Immature conidia 1–2-celled and sub-hyaline or pale brown. The terminal conidium is 4-celled, falling down before lateral conidia.

Material examined — Thailand, Chang Rai, Mae Chan, on dead leaves of *Musa* sp. (*Musaceae*), 7 June 2019, B. C. Samarakoon, BNS333 (MFLU 23-0289).

GenBank numbers — SSU=PP811804, LSU=PP800319, ITS=PP809080

Notes — In the multi-gene phylogeny, our strain (MFLU 23-0289) was grouped with the ex-type strain of *Dictyoarthrinium musae* (MFLUCC 20-0105), sister to *D. thailandicum* with ML=99%, PP=0.95 statistical support (Fig. 3.10). Based on BLAST search results of SSU, LSU, ITS, and *tef*1 sequence data, MFLU 23-0289 exhibited high similarity to *D. musae* (MFLUCC 20-0105) as follows: SSU=99.8%, LSU=100%, ITS=100%, and *tef*1=99.8%, all with 100% query covers. *Dictyoarthrinium musae, D. sacchari* and *D. synnematicum* were previously found on *Musa* spp. in Thailand. Our collection has similar morphology to the holotype of *D. musae* except for the length of the conidiophore, which is a factor that is highly variable with environmental stresses and geographical localities (Treseder & Lennon, 2015). Based on the similar morphology and strong statistical support from our molecular phylogeny, we report *D. musae* as a saprobe on *Musa* sp. from Thailand. This is the second occurrence of *D. musae* on *Musa* sp. after the findings of Samrakoon et al. (2020a) in Thailand.



Note a. Colonies on the host. b, c–f Conidiophores and conidial attachments. g–j Mature conidia. Scale bars: a=500 μm, b–j=10 μm.

Figure 3.7 *Dictyoarthrinium musae* (MFLU 23-0289)

Dictyoarthrinium thailandicum G. C. Ren & K. D. Hyde, Biology 11: 15 (2022)

Figure 3.8

Index Fungorum number: IF 559807; FacesofFungi number: FoF 10705

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* sparse, powdery, black, flat, superficial, minute. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* 50–55 × 3.8–4.5 µm ($\bar{x}$=52 × 4.3 µm, n=40), basauxic, sometimes minute, simple, unbranched or branched, erect from spherical, brown conidiophore mother cells 4–5 × 3.5–4.5 µm ($\bar{x}$=4.5 × 3.9 µm, n=10), macronematous, mononematous, flexuous, cylindrical, sub-hyaline, transversely septate, notably rough, slightly constricted at septa. *Conidiogenous cells* 5–6 × 3–4 µm ($\bar{x}$=5.5 × 3.5 µm, n=10), terminal and intercalary, cylindrical, sub-hyaline to pale brown. *Conidia* 9–10.5 × 8.5–10 µm ($\bar{x}$=10 × 9.8 µm, n=40), conidial formation initiating from the conidiophore and budding occurs forming conidial chains, immature conidia pale brown and dark brown at maturity, simple, dry, acropleurogenous, square rounded, often 4-celled, deeply constricted at septa, verrucose, with light brown to dark brown warts on the cellular surface, 1−2-celled at immature stage. The terminal conidium is 4-celled and persists with lateral conidia, forming terminal conidial chains. Comparatively large when compared with lateral conidia and deeply constricted at septa. Conidial splitting was not observed.

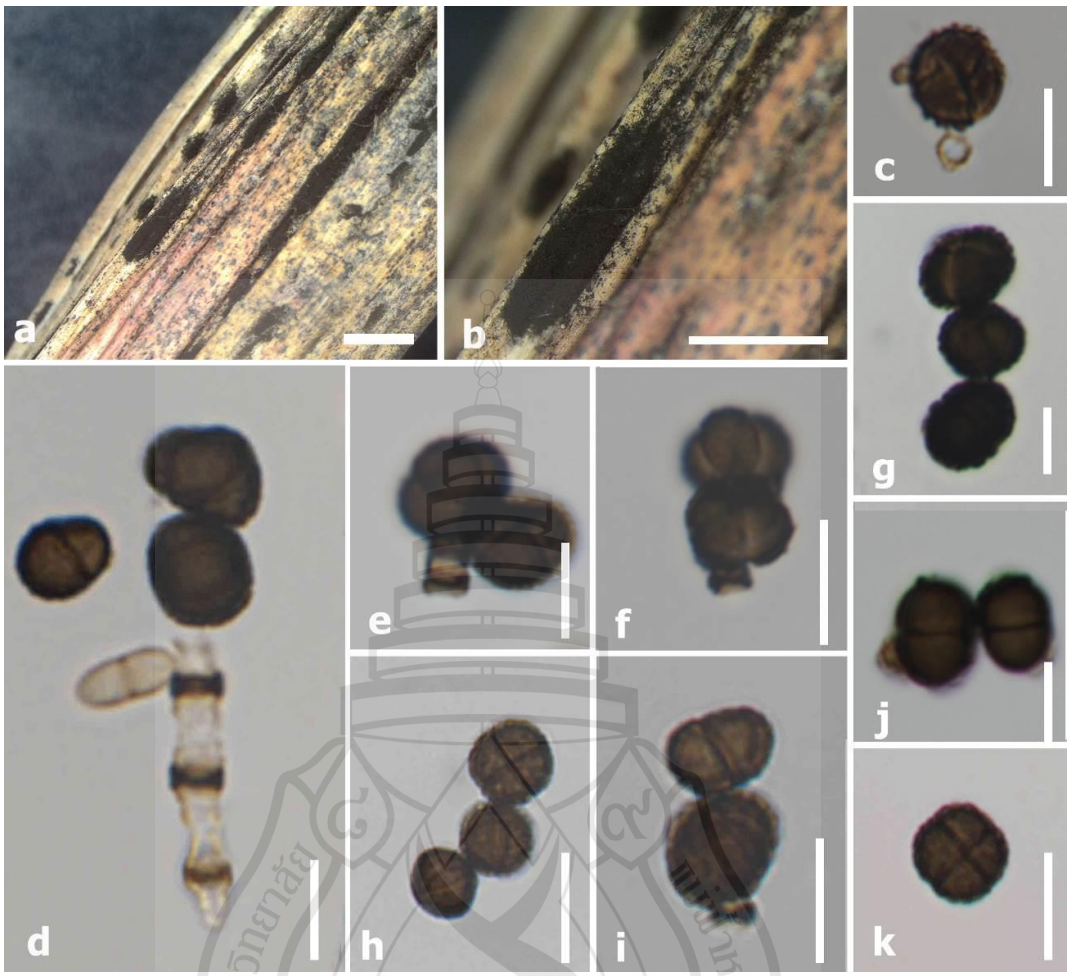
Cultural characteristics — Conidia germinating on PDA within 12 hrs. Colonies on PDA, reaching a diameter of 55 mm after 10 days at 25 °C, slightly raised, pinkish white, moderately dense, middle light gray, periphery white, reverse white to grayish white.

Material examined — Thailand, Chiang Rai, Doi Chang, on dead leaves of *Musa* sp. (*Musaceae*), 17 July 2022, B. C. Samarakoon, MN12 (MFLU 23-0290), culture (MFLUCC 23-0280).

GenBank numbers — LSU=PP800320, ITS=PP809081, *tef*1= PP817246

Notes — *Dictyoarthrinium thailandicum* was described by Ren et al. (2022) on a dead twig of *Castanopsis* sp. in Thailand. The colony was very young on the *Musa* host when we collected the sample. Hence, the basauxic conidiogenesis and formation of the first terminal conidium were clearly visible (Fig. 3.8 i) in our

collection. *Dictyoarthrinium thailandicum* differs from other taxa of the genus by forming conidial chains and budding in mature conidia. In the multi-gene phylogeny (Fig. 3.10), our strain (MFLUCC 23-0280) grouped with *D. thailandicum* (KUMCC 21-0664 and KUMCC 21-0665), sister to *D. musae* (MFLUCC 20-0105) with ML=97%, PP=0.95 statistical support. Based on BLAST search results of SSU, LSU, ITS, and *tef*1 sequence data, our strain shows high similarity to *D. thailandicum* (KUMCC 21-0664) with the following percentages: SSU=99.8%, LSU=99%, ITS=100%, and *tef*1=100%, all with 100%, 99.53%, 100%, and 99% query covers, respectively. The base pair differences between our strain and *D. thailandicum* (KUMCC 21-0664) are as follows: LSU=0.47% (4/848), ITS=0% (0/547), and *tef*1=0% (0/770) without gaps. Based on morphology and phylogeny, we report the saprobic occurrence of *D. thailandicum* on *Musa* as a new host record.



Note a. b Colony on the host. c Occurrence of the terminal conidium and the conidiophore mother cell. d–i Conidiophores and conidial chains. j–k Mature conidia. Scale bars: a, b=100 μm, c–k=10 μm.

Figure 3.8 *Dictyoarthrinium thailandicum* (MFLU 23-0290)

Pseudopithomyces Ariyawansa & K. D. Hyde, Fungal Diversity 75: 64 (2015)

Pseudopithomyces exhibits endophytic, saprobic, and pathogenic life modes on plants and also associates with humans. Additionally, pathogens in the genus are also the causative agents of facial eczema disease in animals (*i.e.*, sheep, cattle, and deer) (Abeywickrama et al., 2023; Chethana et al., 2023; Jayasiri et al., 2019; Senwanna et al., 2021; Silva et al., 2022; Tennakoon et al., 2021; Tian et al., 2024; Yuan et al., 2020). *Pseudopithomyces* was introduced by Ariyawansa et al. (2015) to accommodate *Pithomyces chartarum*, *P. maydicus*, *P. sacchari*, and some of the unidentified *Pithomyces* strains that clustered in *Didymosphaeriaceae*. Thirteen species epithets are listed in Index Fungorum (2024). *Pseudopithomyces chartarum* (Africa, Jamaica, Solomon Islands and Thailand), *P. sacchari* (Trinidad and Tobago) and *P. maydicus* (China, Taiwan) were previously reported on *Musa* spp. (Ellis, 1971; Lumyong et al., 2003; Matsushima, 1971; Matsushima, 1980). Da-Cunha (2014) identified *Leptosphaerulina chartarum* as the sexual morph of the genus. The asexual morph of *Pseudopithomyces* is hyphomycetous and appears as black or brownish colonies on the host. The septate or muriform multicellular conidia are notably verruculose and often have a spherical to fusiform shape (Ariyawansa et al., 2015). In this study, we report the endophytic and saprobic lifestyles of *P. chartarum* associated with living asymptomatic leaves and decaying leaves of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) plants in Thailand. Our phylogenetic evaluation gives some insights into the lifestyle change of fungi on the same host (Promputtha et al., 2007; Rai & Agarkar, 2016) and the transition of the endophytic lifestyle of *P. chartarum* to the saprobic mode during the senescence of the leaves.

Pseudopithomyces chartarum (Berk. & M. A. Curtis) J. F. Li, Ariyawansa & K. D. Hyde, Fungal Diversity 75: 64 (2015)

Figure 3.9

Index Fungorum number: IF 551393; Facesoffungi number: FOF 00938

Saprobic on the dead leaves of *Musa acuminata*. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* effuse, dark brown to black, powdery, scattered. *Vegetative hyphae* septate, branched, sub-hyaline to pale brown or hyaline, rough. *Conidiophores* 8–10 × 4–5µm ($\bar{x}$=9 × 4.5 µm, n=20) micronematous,

mononematous, unbranched, hyaline, thin-walled, septate or aseptate, smooth to rough, unbranched, with globular base and a truncate apex. *Conidiogenous cells* 5–8 × 3–5 µm ($\bar{x}$=7.8 × 4.6 µm, n=20), holoblastic, terminal, hyaline, globose or subglobose, phialide-like, integrated. *Conidia* (14–) 18–20 × (8–) 10–12 µm ($\bar{x}$=18.5 × 11 µm, n=40), brown and muriform at maturity, subglobose, 3–4-transversely septate, with 1-3 longitudinal septa, darken at the septa, verruculose, echinulate, amygdaliform or ovoid, thick-walled, sometimes slightly constricted at septa. Immature conidia are light brown, single celled, septation was visible at maturity.

Cultural characteristics — Conidia germinate on PDA within 14–15 hours. Colonies on PDA, cottony, pinkish white, light brown to brown, reaching 5 cm in 14 days at 25 °C. Mycelia are superficial, effuse and radially striate with a regular edge. Sporulation is usually observed after 30 days under 25 °C.

Material examined — Thailand, Chiang Rai Province, Nang Lae, on a dead leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 18 May 2019, B. C. Samarakoon, BNS249 (MFLU 23-0291), culture MFLUCC 23-0225.

Other materials examined — Thailand, Chiang Rai Province, Nang Lae, isolated from a fresh leaf of Namwa banana (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), 6 September 2018, B. C. Samarakoon, 24-6 (MFLU 23-0320), culture MFLUCC 23-0226.

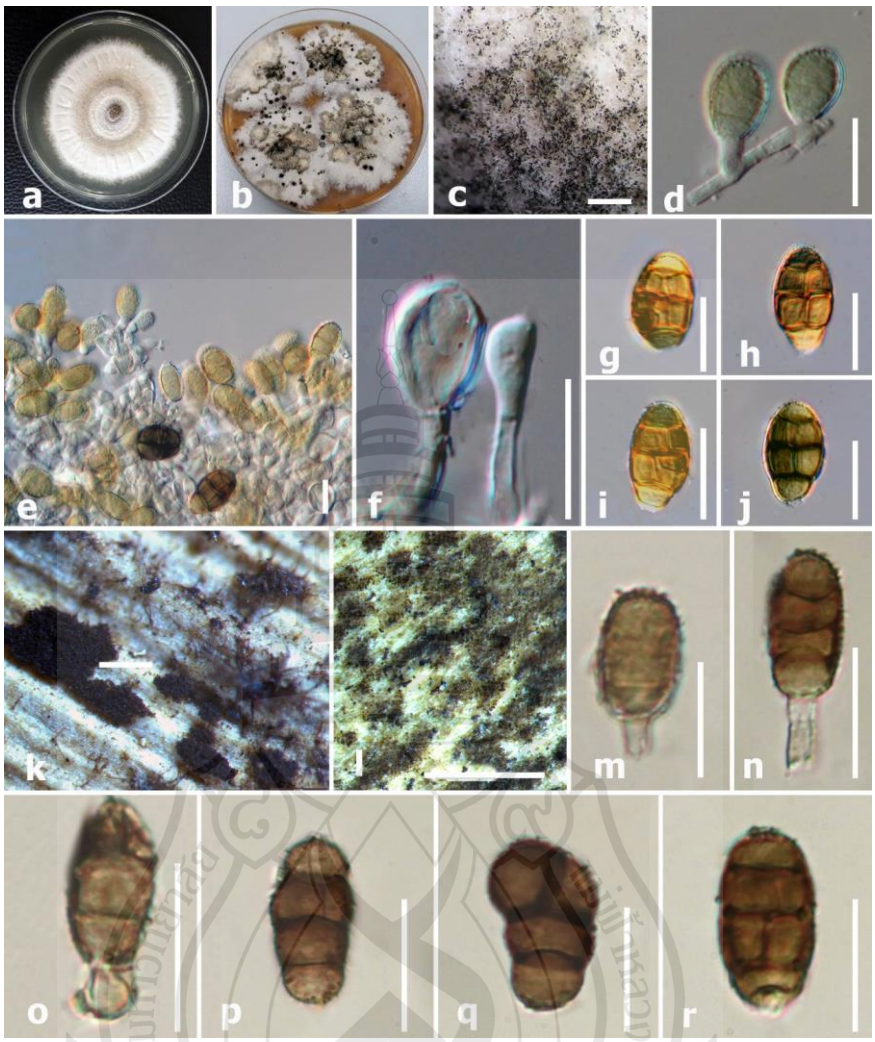
GenBank numbers — MFLUCC 23-0225: SSU=PP811802, LSU= PP800317, ITS= PP809078, *tef*1=PP817242, MFLUCC 23-0226: SSU= PP811803, LSU= PP800318, ITS= PP809079, *tef*1= PP817243

Notes — In the multi-gene phylogeny of combined SSU, LSU, ITS and *tef*1 sequence data, the endophytic isolate (MFLUCC 23-0226) and the saprobic isolate (MFLUCC 23-0225) grouped together with *Pseudopithomyces chartarum* with ML=100%, PP=0.98 statistical support (Fig. 3.10). There are some noticeable morphological differences between the endophytic and saprobic collections of *P. chartarum*. The shape and dimensions of the conidiophores and conidia are different in the endophytic collection as compared to the saprobic specimen. We noticed comparatively elongate conidiophores and enlarged conidia in the endophytic isolate, while the saprobic collection of *P. chartarum* has shortened conidiophores with

globular bases and rough surfaces as well as comparatively thick-walled and verruculose conidia. Such morphological differences may be accounted for by the fact that the endophytic collection has grown in an artificial medium while the saprobic strain has been more adapted to the natural environment and withstood environmental stresses (Powell & Koch, 1977). There is a possibility that the endophytic lifestyle of *P. chartarum* can manifest itself as a saprotroph upon host decay. Future scientific research such as enzymatic assays (cellulase, β-mannanase, polygalacturonase and xylanase activity) is necessary to evaluate our hypothesis (Promputtha et al., 2007, 2010). We report the endophytic and saprobic occurrence of *P. chartarum* associated with Namwa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) leaves from Thailand.

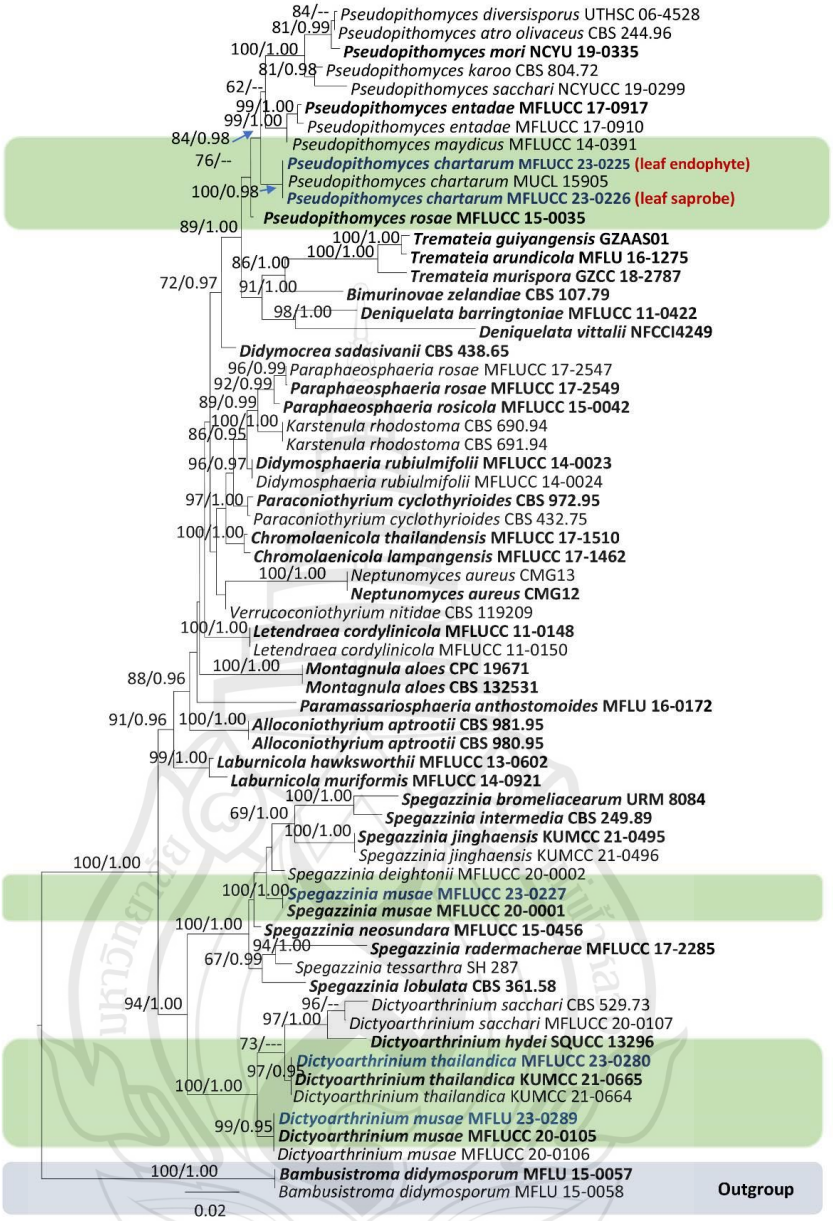
Spegazzinia Sacc. Michelia 2: 37 (1880)

Spegazzinia was established by Saccardo (1880) and is typified by *S. ornata*. At present, 18 taxa are listed in Species Fungorum (2024). Based on morphology, the genus was accommodated in *Apiosporaceae* (*Sordariomycetes*) by Hyde et al. (1998). Using the SSU, LSU, ITS and *tef*1 sequence data, Tanaka et al. (2015) established the genus in *Didymosphaeriaceae* (*Dothideomycetes*). This was supported by a phylogenetic analysis that placed *Spegazzinia* in a basal clade in *Didymosphaeriaceae* (Jayasiri et al., 2019; Ren et al., 2022; Samarakoon et al., 2020a; Thambugala et al., 2017). Hughes (1953) characterized *Spegazzinia* as a genus with a unique basauxic conidiophore ontogeny (conidiophores that erect and elongate from a basal conidiophore mother cell). The conidia of *Spegazzinia* are dematiaceous, and of two types in most species, with a disc-shaped form and a stellate form (Ellis, 1971b). *Spegazzinia* is widespread in various environments. The genus was discovered as saprobes associated with dead material of tropical, subtropical, and temperate vascular plant substrates (Boonmee et al., 2021; Chethana et al., 2021, 2023; Jayasiri et al., 2019; Jayawardena et al. 2022, Ren et al., 2022; Tennakoon et al., 2021).



Note a Colony on PDA after 3 weeks (endophytic isolate). b Colony on PDA after 8 weeks (endophytic isolate). c Conidiomata on PDA. d–f Conidial attachments and conidiogenous cells. g–j Conidia. k–l Colonies on a natural dead host as a saprobe. m–o Conidia and conidiophores. p–r Conidia. Scale bars: c, k, l=2 mm, d–j=15 μm.

Figure 3.9 *Pseudopithomyces chartarum*. (MFLU 23-0291 and MFLU 23-0320)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted to *Bambusistroma didymosporum* (MFLU 15-0057 and MFLU 15-0058). Strains generated in this study are shown in blue, with ex-type strains in bold.

Figure 3.10 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS, and *tef*1 sequence data of the selected genera of *Didymosphaeriaceae*

Spegazzinia musae Samarakoon, Phookamsak, Wanas., Chomnunti & K. D. Hyde, MycoKeys 70: 27 (2020)

Figure 3.11

Index Fungorum number: IF 835298; Facesoffungi number: FoF 07237

Saprobic on *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* on host, black, scattered powdery mass. *Conidiophore mother cells* 10–11 × 7–8.5 μm ($\bar{x}$=10.5 × 7.5 μm, n = 10), hyaline or pale brown, subspherical or sometimes lobate from the base. *Conidiophores* elongated type and shortened type, hold two types of conidia referred to herein as α and β. *Conidiophores of α conidia* (60–) 80–100 × 4–5 μm ($\bar{x}$=89 × 4.5 μm, n=40), sub- hyaline, pale brown to dark golden brown, verruculose, rough to smooth-walled, straight to slightly flexuous, narrow branched or often unbranched. *Conidiophores of β conidia* 12–15 × 11–12 μm ($\bar{x}$ =13.8 × 11.5 μm, n=10), erect, unbranched, hyaline. *Conidiogenous cell development* basauxic, occuring as single, terminal holoblastic conidium at the apex of conidiophore. *Conidial development* holoblastic. *Conidia* solitary, dry, powdery, dimorphic; *α conidia* (35–) 45–48 × (32–) 40–45 μm ($\bar{x}$=48 × 42.5 μm, n=40), stellate, 4–6-celled, globose to subglobose, deeply constricted at the septa, conspicuously spinulate, 4–6 spines in each cell, each 2–8 μm long, erect from the outer wall of each cell; *β conidia* 27–29 × 26–27 μm ($\bar{x}$=27.5 × 26.5 μm, n=10), disc-shaped, initially hyaline, dark brown to brown at maturity, 4-celled, crossed-septate, notably constricted at the septa, one side flattened.

Cultural characteristics — Colonies on PDA, reaching a diameter of 10 mm after 7 days at 25 °C, greyish white, evenly raised, smooth, moderately dense, margin entire to crenulate; reverse white to pinkish white. Sporulation was not observed.

Material examined — Thailand, Chiang Rai Province, Doi Thun, on a dead leaf on *Musa* sp. (*Musaceae*), 20 July 2021, B. C. Samarakoon, MN01 (MFLU 23-0292), culture MFLUCC 23-0227.

GenBank numbers — LSU=PP800321, ITS=PP809082, SSU= PP838745

Notes — *Spegazzinia musae* was introduced by Samarakoon et al. (2020b) as a saprobe on *Musa* sp. in Thailand. Morphologically, our new collection has short conidiophores in stellate conidia when compared with the type. Based on BLAST search results of SSU, LSU, ITS, and *tef*1 sequence data, our strain shows high

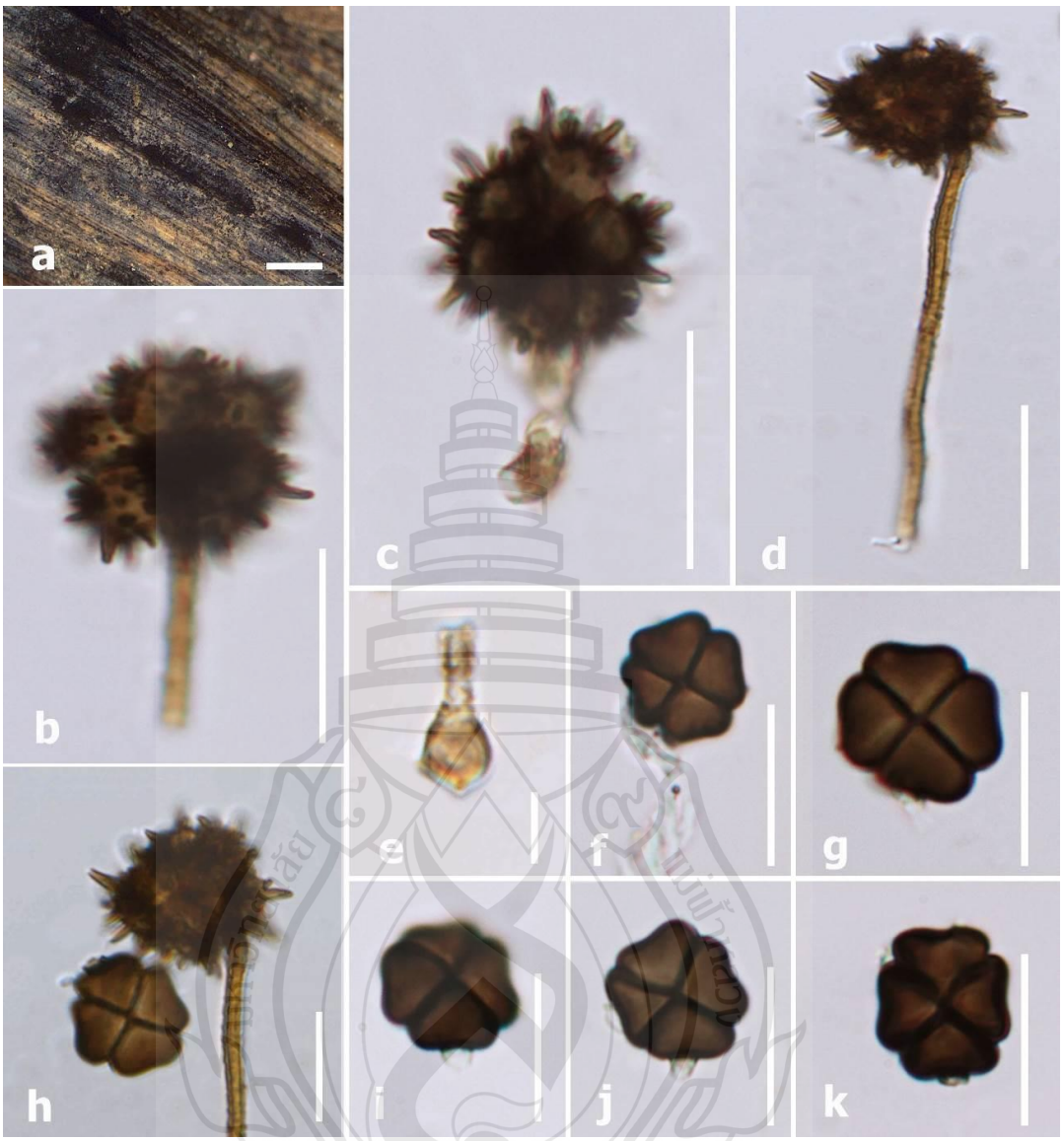
similarity to the ex-type of *Spegazzinia musae* (MFLUCC 20-0001) with the following percentages: SSU=99.73%, LSU=99.88%, ITS=100%, and *tef*1=100%, all with 100%, 99.53%, 100%, and 100% query covers, respectively. The base pair differences between our strain and *S. musae* (MFLUCC 20-0001) are as follows: SSU=0.27%, LSU=0.12% (2/848), ITS=0% (0/540), and *tef*1=0% (0/778) without gaps. The molecular phylogeny of LSU, SSU, ITS and *tef*1 has suggested that our new collection belongs to *Spegazzinia musae* with ML=100% and PP=1.00 statistical supports (Fig. 3.10). *Spegazzinia musae* was also reported from *Morus australis* (*Moraceae*) in Taiwan. This is the second report of *S. musae* in Thailand from *Musa*. Previously, *S. deightonii* and *S. radermacherae* were reported in Thailand on *Musa* sp. (Chethana et al., 2021; Samarakoon et al., 2020b).

Lentimurisporaceae N.G. Liu, J.K. Liu & K.D. Hyde

Lentimurisporaceae was introduced by Liu et al. (2018) and currently accommodates *Bahusandhika* and *Lentimurispora*. The taxa in the family are saprobes or soil-inhabiting fungi in terrestrial habitats. The hyphomycetous asexual morph has been reported from *Lentimurisporaceae* while the sexual morph remains unknown (Hongsanan et al., 2020). The asexual morph appears as powdery, scattered, brown or black colonies on the natural substratum with sporodochial conidiomata (Liu et al., 2018). The genera have brown or black, muriform to fusiform, cylindrical to rhomboidal, solitary or catenate conidia (Liu et al., 2018).

Bahusandhika Subram., J. Indian bot. Soc. 35: 469 (1956)

Bahusandhika was introduced by Subramanian (1956) to accommodate *Polydesmus indicus* and *Septonema intercalare*. Four species are now accepted in the genus (Index Fungorum, 2023). *Bahusandhika* is characterized by catenate, cylindrical or rhomboidal, phragmoseptate conidia. Pratibha et al. (2014) accommodated the genus in *Pleosporales* based on molecular data (ITS and LSU). *Latorua* was placed under *Bahusandhika* by Crane & Miller (2016) based on morphology. Liu et al. (2018) treated *Latorua* as a distinct genus in *Pleosporales* with molecular support.



Note a Colony on host. b–d, h Stellate conidia with the conidiophores. e Conidiophore mother cell. f–k Disk-shaped conidia. Scale bars: a=200 μm, b, c, d=20 μm, e=5 μm, f, g, i–k=15 μm, h=10 μm.

Figure 3.11 *Spegazzinia musae* (MFLU 23-0292)

Bahusandhika indica (Subram.) Subram., J. Indian bot. Soc. 35: 469 (1956)

Figure 3.12

Index Fungorum number: IF 293586; Facesoffungi number: FoF 09666

Saprobic on dead leaf sheath of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* on natural substrate dry, powder-like, effuse, black, glistening, conidia are liberated when disturbed. *Mycelium* partly superficial to immersed, brown, pale brown or sub-hyaline, septate, thick-walled, branched. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* 8–18 × 2–3 μm ($\bar{x}$=10.2 × 2.4 μm, n=20), micronematous, erect from the lateral hyphae, pale brown, often flexuous, or straight, septate, thick-walled, smooth, cylindrical or constricted at septa, each cell is spherical. *Conidiogenous cells* 2–4 × 2–3 μm ($\bar{x}$=3.4 × 2.5 μm, n=20), monotretic or bytretic, integrated or discrete, terminal, formed on conidiophores as well as on conidia, light to pale brown, subspherical, spherical or bulbous, smooth, thick- or thin-walled. *Conidia* 10–15 × 5–7 μm ($\bar{x}$=13.3 × 6 μm, n=40), catenate, long, branched chains, brownish black or dark brown, thin-walled or often thick-walled, ellipsoidal, with rounded ends, cylindrical or one side flattened, 1–3-septate, sometimes geniculate from the first septum, have 1–2 connecting cells on top; connecting cells 3–4 × 2–3 μm ($\bar{x}$=3.6 × 2.9 μm, n=40) spherical, paler than conidia, pale brown, smooth, thick walled, 3–4 μm.

Cultural characteristics — Colonies reaching 25 mm in 7 days at 25 °C, sparse and flat, greyish brown, irregular margined, wrinkled appearance, radially striated, mouse gray to black from the top view; reverse smoke grey. Sporulation was not observed. The culture medium notably turns pale red after one week.

Material examined — Thailand, Chiang Mai Province, Mushroom Research Centre, on a dead leaf of *Musa* sp., 11 November 2021, Milan C. Samarakoon, MN54 (MFLU 23-0293), culture MFLUCC 23-0304.

GenBank numbers — SSU=PP811805, LSU=PP800322, ITS=PP809083, *tef*1= PP817245

Notes — *Bahusandhika indica* (= *Polydesmus indicus*) was previously isolated from coconut litter in Himalaya region, India (Prasher & Verma, 2012; Subramanian, 1956). It has also been reported from Xishuangbanna, Yunnan Province, China on unidentified wood as a saprobe by Xia et al. (2014). BLAST search results of SSU,

LSU, and ITS sequence data indicate that our strain has a high percentage similarity to taxa in GenBank as follows: SSU=99.26% to *Lentimurispora urniformis* (MFLUCC 18-0497) with a 100% query cover, LSU=99.88%, and ITS=99.38% to *B. indica* (GUFCC 18001) with query covers of 96% and 92%, respectively. The base pair differences between our strain and the mentioned isolates are as follows: SSU=0.74% with *L. urniformis* (MFLUCC 18-0497) (6/810), LSU=0.12% (1/818), and ITS=0.62% (3/483) with *B. indica*, all without gaps. In the multi-gene phylogeny of SSU, LSU, ITS and *tef*1 sequence data of *Lentimurisporaceae* (Fig. 3. 13), our strain (MFLUCC 23-0304) was grouped with *B. indica* with ML=100%, PP=1.00 statistical support. There have been no endophytic or pathogenic occurrences of the species worldwide. This is the first report of the genus in Thailand and of *Musaceae*.

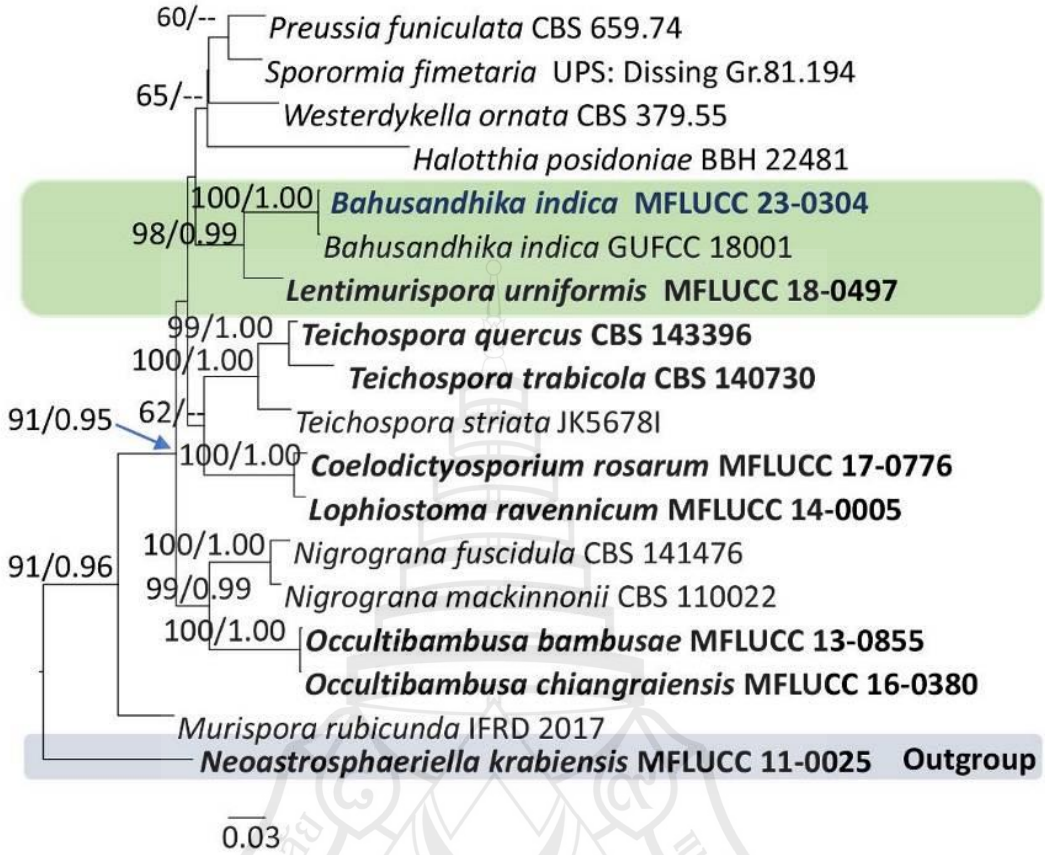
Lophiotremataceae K. Hiray. & Kaz. Tanaka

Lophiostoma and *Lophiotrema* were earlier accommodated in *Lophiostomataceae*. The phylogenetic analyses (LSU and SSU) of Hirayama and Tanaka (2011) however, separated the two genera into two distinct families. Hence, *Lophiotremataceae* was erected to accommodate *Lophiotrema* and is typified by *L. nucula* (Hirayama & Tanaka, 2011). Hashimoto et al. (2017) later introduced five genera (*viz*., *Atrocalyx, Crassimassarina, Cryptoclypeus, Galeaticarpa,* and *Pseudocryptoclypeus*) to *Lophiotremataceae* using morphology and molecular evidence. The sexual morph of *Lophiotremataceae* is characterized by beak-compressed ascomata with slit-like ostioles. The asci are cylindrical, short-pedicellate, bearing fusiform or cylindrical, 1-to multi-septate, hyaline to brown ascospores. In addition, some taxa of the family have a gelatinous sheath surrounding the ascospores (Hirayama & Tanaka, 2011). The family consists of saprobic taxa with a wide geographical distribution (Hongsanan et al., 2020).



Note a, b Colonies on dead *Musa* leaf sheath. c–m Conidiophores and conidial chains. n Conidia. Scale bars: a=100 µm, b=25 µm, c–n=10 µm.

Figure 3.12 *Bahusandhika indica* (MFLU 23-0293)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (0.95 PP) are shown. The tree is rooted with *Neoastrosphaeriella krabiensis* (MFLUCC 11-0025) in *Aigialaceae*. Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Bahusandhika indica*.

Figure 3.13 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS and *tef*1 sequence data of selected genera of *Pleosporales*

Lophiotrema Sacc., Sacc., Michelia 1: 338 (1878)

Lophiotrema comprises species with hyaline and multi-septate ascospores (Saccardo, 1883). In addition, the sexual morph also bears slit-like ostioles, cylindrical to cylindric-clavate asci, and a peridium of equal thickness (Hirayama & Tanaka, 2011). The pycnidial asexual morph is reported in the genus and the hypomycetous morph was not observed (Hirayama & Tanaka, 2011). The genus has a saprobic lifestyle and there are no reports on pathogenic or endophytic modes (Boonmee et al., 2021; Hongsanan et al., 2020; Hyde et al., 2020b; Li et al., 2023; Zhang et al., 2023). There were some taxonomic confusions regarding *Lophiostoma*, but with the integration of molecular data, *Lophiotrema sensu lato* was reclassified as new genera in *Lophiotremataceae* (Hashimoto et al., 2017).

Lophiotrema hydei J. F. Zhang, J. K. Liu & Z. Y. Liu, Phytotaxa 379: 172 (2018)

Figure 3.14

Index Fungorum number: IF 555509; Facesoffungi number: FoF 05216

Saprobic on dead petiole of *Musa* sp. Sexual morph: *Ascomata* 500–800 μm high, 200–300 μm diam. ($\bar{x}$=650 × 250 μm, n=10), dark brown to black, scattered, immersed, conical, notably elongated with flattened base, uni-loculate, ostiolate. *Ostioles* central or lateral, carbonaceous, with a pore-like opening, notably elongated until 500–550 μm and compressed laterally, periphyses observed, carbonaceous, masses of asci immersed as slimy heads from ostiolar canal. *Peridium* up to 25–30 μm thick, composed of several layers of pale brown, dark-brown to black, thick-walled pseudoparenchymatous cells, arranged in a *textura angularis* or *textura prismatica*, becoming pale towards the inner layer, outermost layer fused with host tissues. *Pseudoparaphyses* 1.5–2 μm ($\bar{x}$=1.8 μm, n=40), branched, cellular, numerous, anastomosing among and between the asci, embedded in a gelatinous matrix, hyaline, cylindrical, tubular, rough or smooth surfaced, notably curved, sometimes coiling, aseptate, fasciculate, with rounded apex. *Asci* 100–150 (–200) × 3–6 μm ($\bar{x}$=130 × 5.2 μm, n=40), 8-spored, bitunicate, fissitunicate, cylindrical, pedicellate, apically rounded, obtuse or acute, ocular chamber well developed. *Ascospores* 23–28 × 4.5–5.5 μm ($\bar{x}$=24.5 × 4.8 μm, n=40), often overlapping bi-seriate, hyaline, fusiform, straight or slightly curved, 4–5 distinctly guttulate at immature stage, narrower

towards both ends, smooth-walled, often 4–6-septate or multi-septate at maturity, with or without surrounded by a mucilaginous sheath. Asexual morph: Not observed.

Cultural characteristics — Colonies on PDA in circular, irregular margined, profuse growth at 25 °C, reaching 50 mm in diameter after 3 weeks, brownish-black from above, reverse grayish-brown, areal mycelium present, cottony and concentric ring patterns are visible. Sporulation was not observed.

Material examined — Thailand, Chiang Rai Province, Tap Tao, on a dead leaf of *Musa* sp., 18 October 2021, B. C. Samarakoon, MN48 (MFLU 23-0294), Cultures MFLUCC 23-0281 and MFLUCC 23-0303.

GenBank numbers — MFLUCC 23-0281: LSU=PP800328, ITS=OR206386, *rpb*2=OR206055, *tef*1= OR206051, MFLUCC 23-0303: LSU=PP800329, ITS= PP809655

Notes — The BLAST search results of LSU, ITS, and *tef*1 sequence data reveal that our strains have the highest percentage similarity to *L. mucilaginosum* (HMAS 255437) (LSU=100%, ITS=99.34%, *rpb*2=99%) with 100%, 95%, and 97% query coverage. In addition, our strains show 98.20% (*tef*1) similarity to *L. hydei* (MFLU 18-2075) with 100% query coverage. The base pair differences of the *tef*1 gene between our strains and *L. mucilaginosum* (HMAS 255437) are 2.1% (17/821) without gaps. Additionally, *L. hydei* (MFLU 18-2075) shows a 1.8% (15/834) base pair difference (without gaps) with our collection. The ITS region of our strain and the latter *Lophiotrema* species was noticed to be more or less similar, with slight base pair changes as follows: *L. hydei* 0.2% (1/477), and *L. mucilaginosum* 0.42% (2/467). In the phylogenetic analyses of combined LSU, ITS, *rpb*2 and *tef*1 sequence data, MFLU 23-0294 and MFLUCC 23-0303 were grouped with *L. hydei* (MFLU 18-2075) and *L. mucilaginosum* (HMAS 255437) with strong statistical support (ML=100%, BI=1.00) (Fig. 3.15). We could not find any notable morphological differences in our collection compared to *L. mucilaginosum* and *Lophiotrema hydei*. When we compare the ITS sequences of *L. mucilaginosum* (HMAS 255437) and *L. hydei* (MFLU 18-2075), only one base pair difference was noticed. The LSU base pair difference between these two species is 0.66% (6/903). In addition, the *tef1* base pair difference between the latter two species is only 1.3% (11/904). We have noticed that the *tef*1 sequences in *Lophiotremataceae* species have notable changes, even in the same

species as *L. vagabundum.* We were unable to find enough evidence to identify *L. mucilaginosum* (HMAS 255437) in Phookamsak et al. (2019) as an independent lineage based on morphology and molecular sequences. In addition, our new collection (MFLU 23-0294; Fig. 3.14) resembles the morphology of *L. mucilaginosum* and *L. hydei* when disregarding the length of the ostiolar canal, which is a factor that can be variable with environmental pressures. Hence, we identify our two strains as *L. hydei*. In addition, we synonymize *L. mucilaginosum* (Phookamsak et al., 2019) as *L. hydei* based on our morpho-molecular observations. This is the first geographical occurrence of *Lophiotrema* in Thailand and in *Musaceae*. *Lophiotrema hydei* was introduced by Zhang et al. (2018) on a dead branch found in karst landforms in southwest China. We report the first occurrence of *L. hydei* on *Musa* in Thailand.

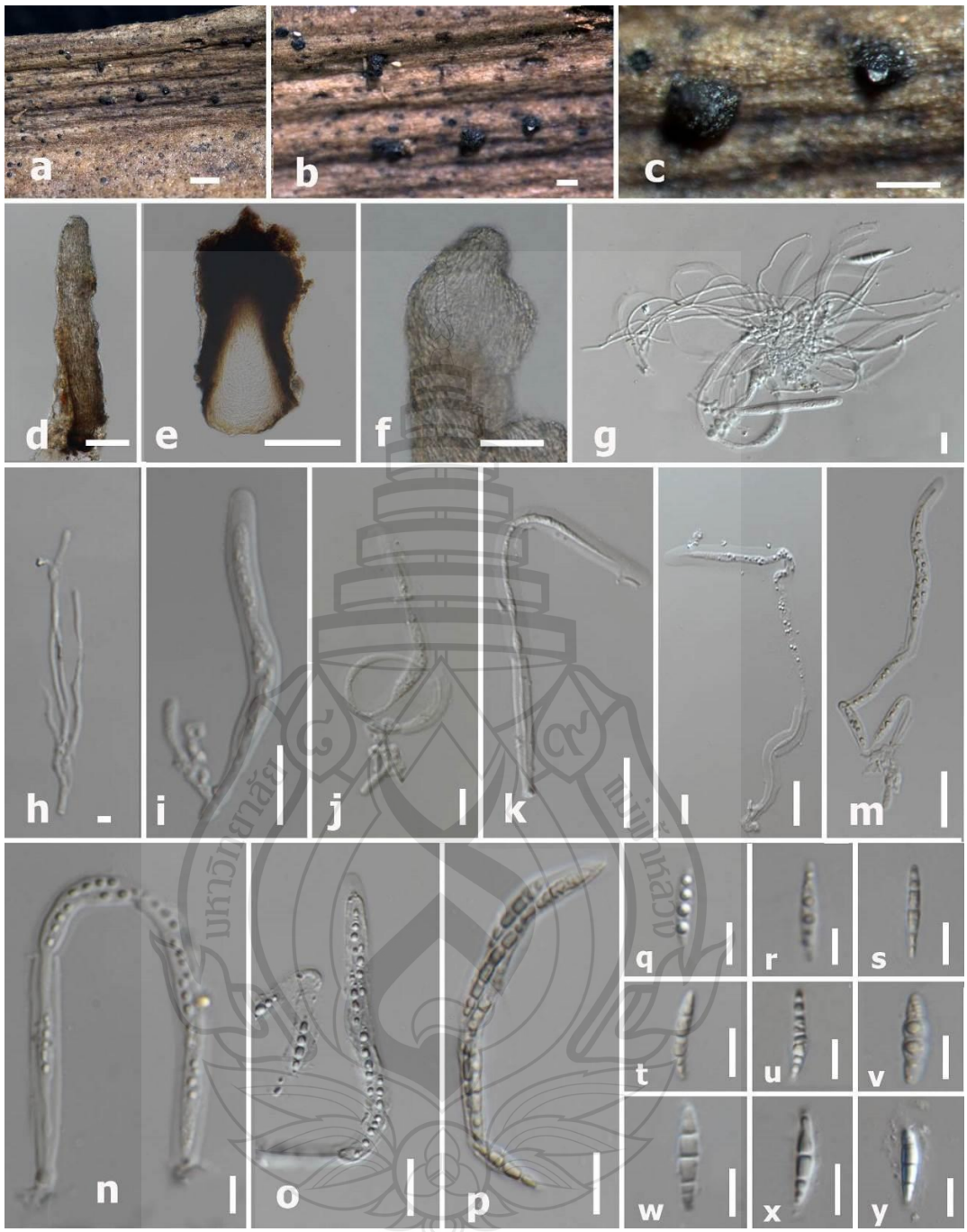
Periconiaceae (Sacc.) Nann.

Periconiaceae was accommodated as a distinct lineage in *Massarineae* by Tanaka et al. (2015) based on morpho-molecular data. Four genera (*viz*., *Bambusistroma*, *Flavomyces*, *Noosia* and *Periconia*) are accepted with endophytic, saprobic and pathogenic lifestyles (Hongsanan et al., 2020; Samarakoon et al., 2021b; Sarkar et al., 2019).

Periconia Tode, Fung. mecklenb. sel. (Lüneburg) 2: 2 (1791)

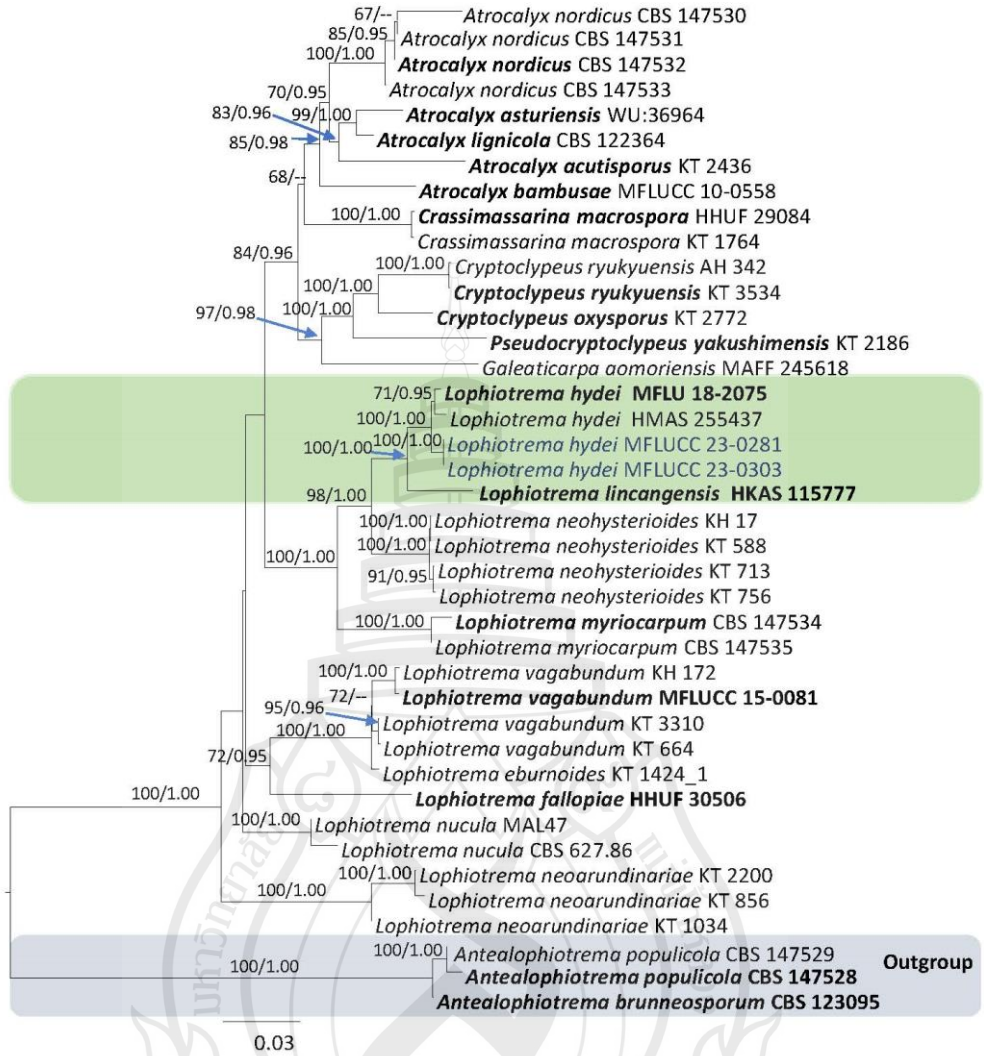
Periconia was introduced by Tode (1791) and is typified by *P. lichenoides*. Both the sexual and asexual (hypomycetous) morphs are recorded in *Periconia* (Jayawardena et al., 2022; Liu et al., 2017; Samarakoon et al., 2021a; Senwanna et al., 2021; Silva et al., 2022; Tanaka et al., 2015; Tennakoon et al., 2021; Tian et al., 2024). The sexual morph bears an immersed or erumpent ascomata with an ostiolar neck. The eight ascospores are biseriate, bear a gelatinous sheath and are broadly fusiform with a nearly median septum (Tanaka et al., 2015). The asexual morph of *Periconia* has pale to dark brown branched or unbranched conidiophores (referred to as stipes). Conidiogenous cells of *Periconia* can be monoblastic or polyblastic, and form at the terminal ends or intercalary parts of the conidiophore. *Periconia* usually produces spherical, aseptate, catenate or solitary, pale to dark brown conidia (Ellis, 1971, 1976; Seifert, 2011). Taxa of the genus have been reported as plant pathogens, endophytes and common saprobes in terrestrial and aquatic environments worldwide

(Ellis, 1971, 1976; Liu et al., 2017; Markovskaja & Kačergius, 2014). At present, 187 epithets are listed under *Periconia* (Index Fungorum 2023). *Periconia byssoides* (Venezuela, Cuba, and Somalia), *P. cortaderiae*, *P. digitata* (Thailand, Malaysia), *P. delonicis* (Thailand), *P. lateralis* (Thailand) and *P. minutissima* (Ghana) were previously reported on *Musa* spp. (Farr & Rossman, 2024; Samarakoon et al., 2021b). This study presents the occurrence of *P. echinochloae* as a saprobe on *Musa* leaves from Thailand for the first time.



Note a, b, c Ascomata on *Musa* sp. d–f Ostiolar canal. g Asci and pseudoparaphyses. h Pseudoparaphyses. i–o Immature asci. p Asci. q–y Ascospores. Scale bars: a=500 µm, b–e=100 µm, f=50 µm, g, q–y=10 µm, h=2 µm, i–p=20 µm.

Figure 3.14 *Lophiotrema hydei* (MFLU 23-0294)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Antealophiotrema brunneosporum* (CBS 123095) and *A. populicola* (CBS 147528, CBS 147529). Isolates from this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Lophiotrema hydei.*

Figure 3.15 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *rpb*2 and *tef*1 sequence data of the taxa of *Pleosporales*

Periconia echinochloae (Bat.) M. B. Ellis, Dematiaceous Hyphomycetes (Kew): 347 (197)

Figure 3.17

Index Fungorum number: IF 319348; Facesoffungi number: FoF 15200

Saprobic on a dead leaf of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* on host scattered, with a stipe and spherical to rod-shaped head. *Conidiophores* (650–) 800–850 × 15−18 μm ($\bar{x}$=823 × 16.5 μm, n=30), macronematous, mononematous, single or rarely 2–3 together, branched from the apex or unbranched, erect, thick-walled, dark brown to black, paler towards the apex, sub-hyaline at the apex where conidiogenesis occurs, septate, rough, base swollen and spherical, apex cylindrical, mature wall at the base masking the immature apical parts and resulting in an uneven width of the conidiophore, straight or flexuous. *Conidiogenous cells* 20–23.5 × 19.5–21 μm ($\bar{x}$=22 × 20 μm, n=10), discrete on stipe and branches, determinate, spherical. *Conidia* (15–) 18–20 × 13–18 μm ($\bar{x}$=18.5 × 17 μm, n=40), catenate, one-celled, spherical, hyaline to pale brown at immature stage, becoming brown to dark brown, smooth or minutely verruculose, rarely guttulate.

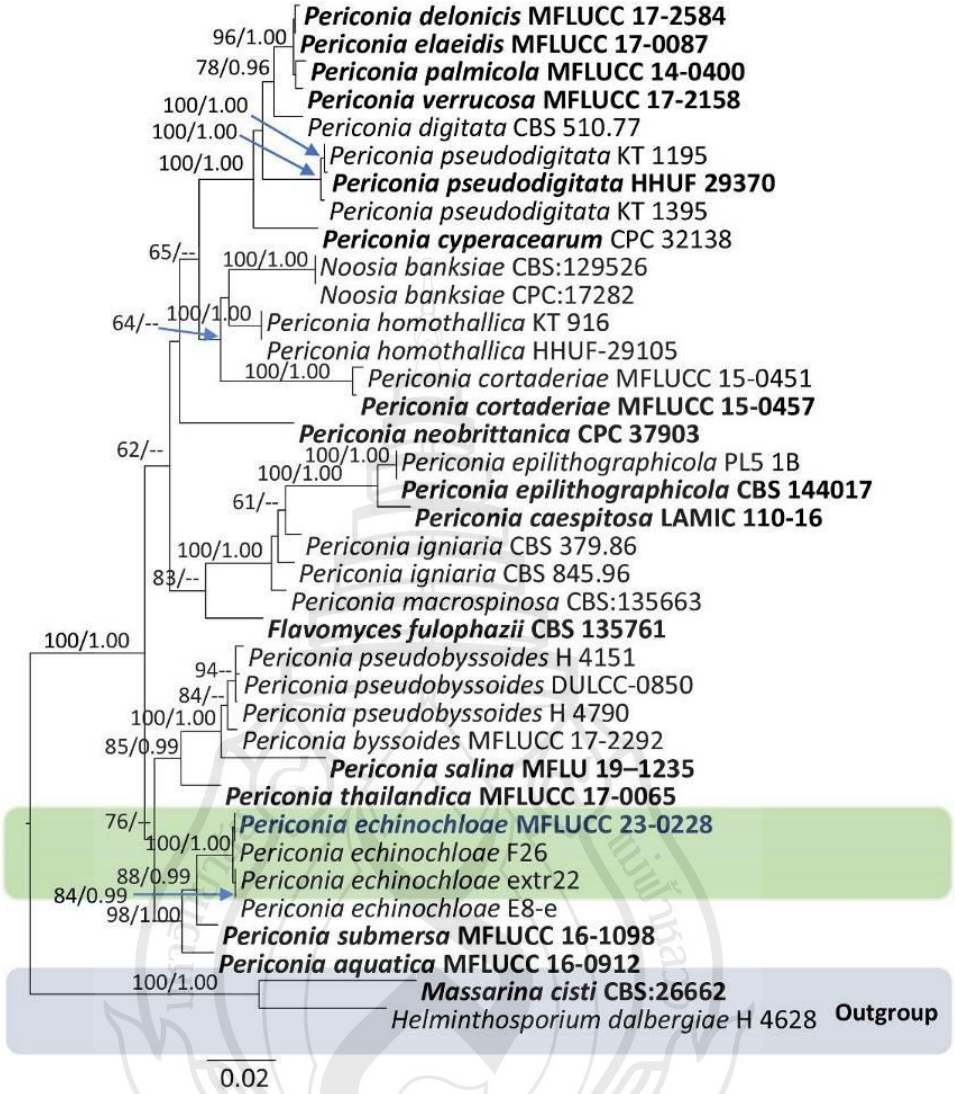
Cultural characteristics — Colonies on PDA, reaching a diameter of 30 mm after 14 days at 25 °C, flat at immature stage and raised at maturity, smooth to cottony or slightly hairy, with an entire edge, white to grey near the margin, moderately dense, circular; reverse white to greenish olivaceous.

Material examined — Thailand, Chiang Rai Province, Doi Mae Sa Long, on the mid-rib of a dead leaf of *Musa* sp., 9 September 2018, B.C. Samarakoon, BNS11 (MFLU 23-0295), culture MFLUCC 23-0228.

GenBank numbers — SSU= PP811806, LSU=PP800323, ITS=PP809084

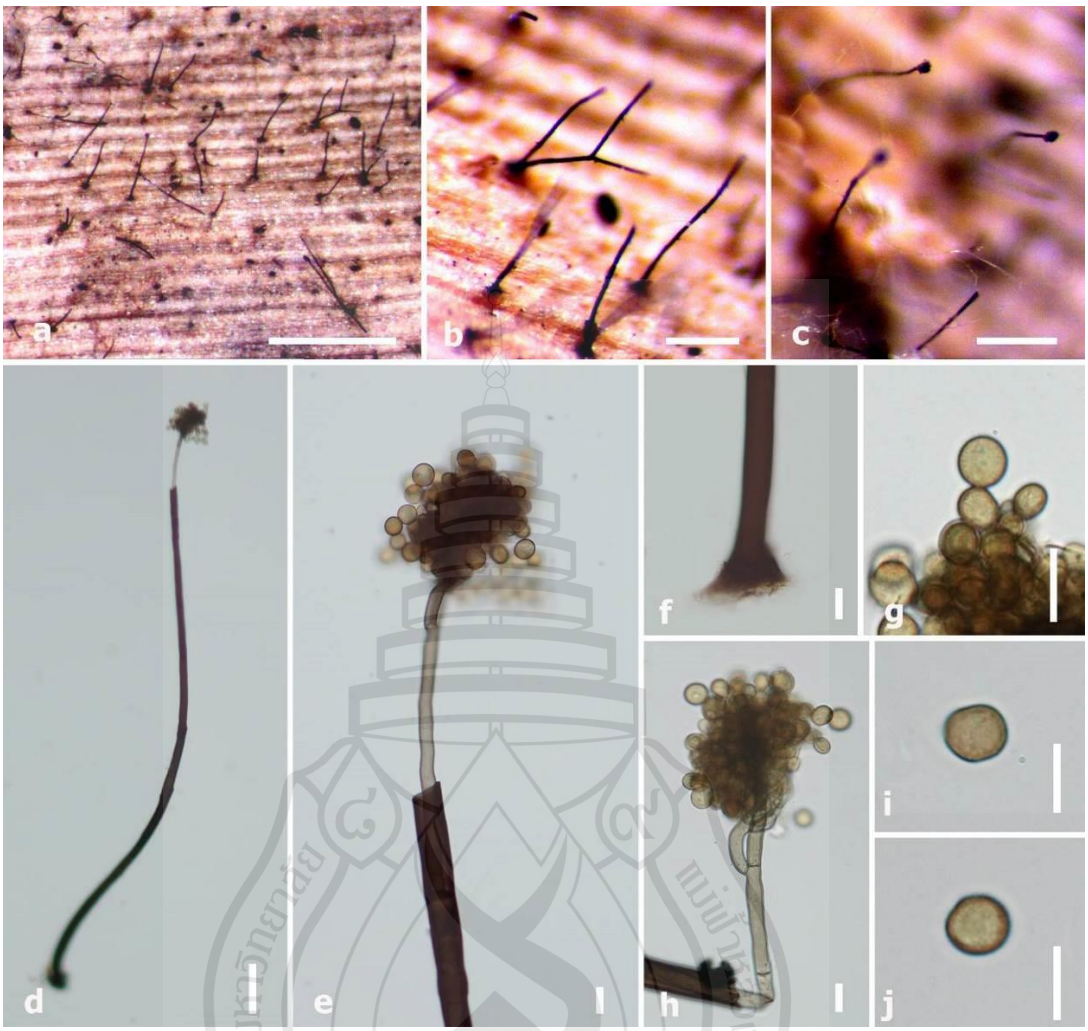
Notes — *Periconia echinochloae* has a cosmopolitan distribution and has been found on many plant hosts as a saprobe (i.e., *Andropogon, Brachiaria, Cenchrus, Cordia, Cynodon, Echinochloa, Heteropogon, Juncus, Monochoria, Pandanus, Panicum, Paspalum, Phragmites, Saccharum, Schoenoplectus, Sorghum, Zea mays*) (Ellis, 1971a; Ellis, 1976; Farr & Rossman, 2024). BLAST search results of SSU, LSU, and ITS sequence data indicate that our isolate has a high percentage similarity to taxa in GenBank as follows: ITS=100% to *P. echinochloae* (strain 3-F26), LSU=100% to *P. echinochloae* (isolate extr22) with a 100% query cover. The SSU

shows 98.57% similarity to *P. byssoides* (MFLUCC 17-0292) with 99% of total cover. The description of the holotype of *P. echinochloae* by Ellis (1971a) is similar to our new collection except for the verruculose conidia, whereas our collection has smooth conidia without warts. However, in the phylogenetic analyses (combined SSU, LSU, ITS and *tef*1), our strain (MFLUCC 23-0228) was grouped with the *P. echinochloae* strains, sister to *P. submersa* (MFLUCC 16−1098) with ML=100%, BI=1.00 statistical support (Fig. 3.16). This is the first report of *P. echinochloae* in Thailand and on *Musa*.



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Helminthosporium dalbergiae* (MAFF 243853) and *Massarina cisti* (CBS 266.62). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Periconia echinochloae.*

Figure 3.16 Maximum likelihood tree revealed by RAxML analyses of comnined SSU, LSU, ITS and *tef*1 sequence data of the selected taxa of *Massarinaceae* and *Periconiaceae*



Note a–c Conidiophores bearing conidia on host. d, e, h Conidia and conidiophores. f Base of the conidiophore. g Conidiogenesis from terminal mother cells. i, j Conidia. Scale bars: a=1 mm, b=100 μm, d=50 μm, f=25 μm. c, e, g–j=20 μm.

Figure 3.17 *Periconia echinochloae* (MFLU 23-0295)

Phaeosphaeriaceae M.E. Barr

Barr (1979) introduced the family and *Phaeosphaeria* was designated as the type genus. *Phaeosphaeriaceae* accommodates several groups of species exhibiting saprobic, endophytic and pathogenic lifestyles with a global ecological distribution (Hongsanan et al., 2020; Phookamsak et al., 2014). The family often has coelomycetous asexual fruiting structures and rarely comprises the hyphomycetous morph (Hongsanan et al., 2020; Phookamsak et al., 2014; Wanasinghe et al., 2018). More than 80 genera have been accepted in *Phaeosphaeriaceae* (Hongsanan et al., 2020; Jayawardena et al., 2023; Phookamsak et al., 2019).

Phaeosphaeria Miyake, Bot. Mag., Tokyo 23: 93 (1909)

Miyake (1909) introduced *Phaeosphaeria* with *P. oryzae* as the type species. *Phaeosphaeria* taxa are reported from temperate and tropical geographical localities (Farr & Rossman, 2024; Hyde et al., 2017; Phookamsak et al., 2014, 2019; Silva et al., 2022, Tian et al., 2024). The genus comprises saprobes, endophytes or pathogens and is notably associated with monocotyledon plants (Farr & Rossman, 2024; Hyde et al., 2017; Phookamsak et al., 2014, 2019). Some taxa (such as *P. nodorum*) cause serious foliar diseases in wheat and maize (Shoemaker et al., 1989). *Phaeosphaeria* is polyphyletic and several *sensu lato* taxa were grouped with various genera in *Phaeosphaeriaceae* (*i.e., Amarenomyces, Juncaceicola, Neosetophoma, Parastagonospora, Phaeopoacea, Pseudophaeosphaeria, Septoriella*) and also in other familial positions in *Pleosporales* (Phookamsak et al., 2014). *Phaeosphaeria musae* has been previously described on *Musa cavendishii* in Taiwan by Sawada (1959). This study reports the first occurrence of *P. oryzae* on *Musa* in Thailand.

Phaeosphaeria oryzae I. Miyake, Bot. Mag., Tokyo 23: 93 (1909)

Figure 3.18

Index Fungorum number: IF 142561; Faces of Fungi number: FoF 00234

Associated with the necrotic area of the leaf spots on *Musa* sp. Sexual morph: *Ascomata* 180–210 × 162–180 μm ($\bar{x}$=190 × 170 μm, n=20) scattered, rarely clustered, immersed, slightly raised from the host tissue, appearing as minute, black dots, uniloculate, often globose or subglobose, glabrous, golden brown to dark brown. *Ostioles* central, papillate. *Peridium* 20–30 μm wide, composed of 2–3 layers of thin-walled, brown to dark brown, flattened pseudoparenchymatous cells, arranged in

textura angularis. *Pseudoparaphyses* 2–3 μm wide, filiform, broad, septate, but septa are difficult to distinguish, hyaline, rough, cylindrical to clavate, constricted at the septa, sometimes connected from the apex. *Asci* (34–) 40–55 (−70) × 10–13 (−14) μm ($\bar{x}$=48.5 × 12.6 μm, n=40), fissitunicate, bitunicate, often 8-spored, broadly cylindrical, short-pedicellate or sometimes subsessile, apically rounded with distinct ocular chamber, sometimes ocular chamber indistinct. *Ascospores* (15–) 18–21 × 3–4 μm ($\bar{x}$=19 × 3.5 μm, n=30), phragmosporous, overlapping 2-seriate, narrowly fusiform, hyaline or often brown, 3-septate, rarely 2-septate, constricted at the septa in some spores, slightly curved, or sometimes straight, smooth to rough-walled. Asexual morph: not observed.

Cultural characteristics — Colonies on PDA brown from above, cottony, hairy, raised, concentric ring patterns are visible, irregular margin, profuse growth at 25 °C, reaching 30 mm in diameter after 3 weeks; reverse grayish-brown, areal mycelium is not visible. Sporulation was not observed.

Material examined — Thailand, Chiang Rai Province, Mae Fah Luang, on leaf spots on *Musa* sp., 20 June 2021, B.C. Samarakoon, 449 (MFLU 23-0296), MFLUCC 23-0244.

GenBank numbers — LSU=PP800324, ITS= PP809085, *tef*1= PP817244

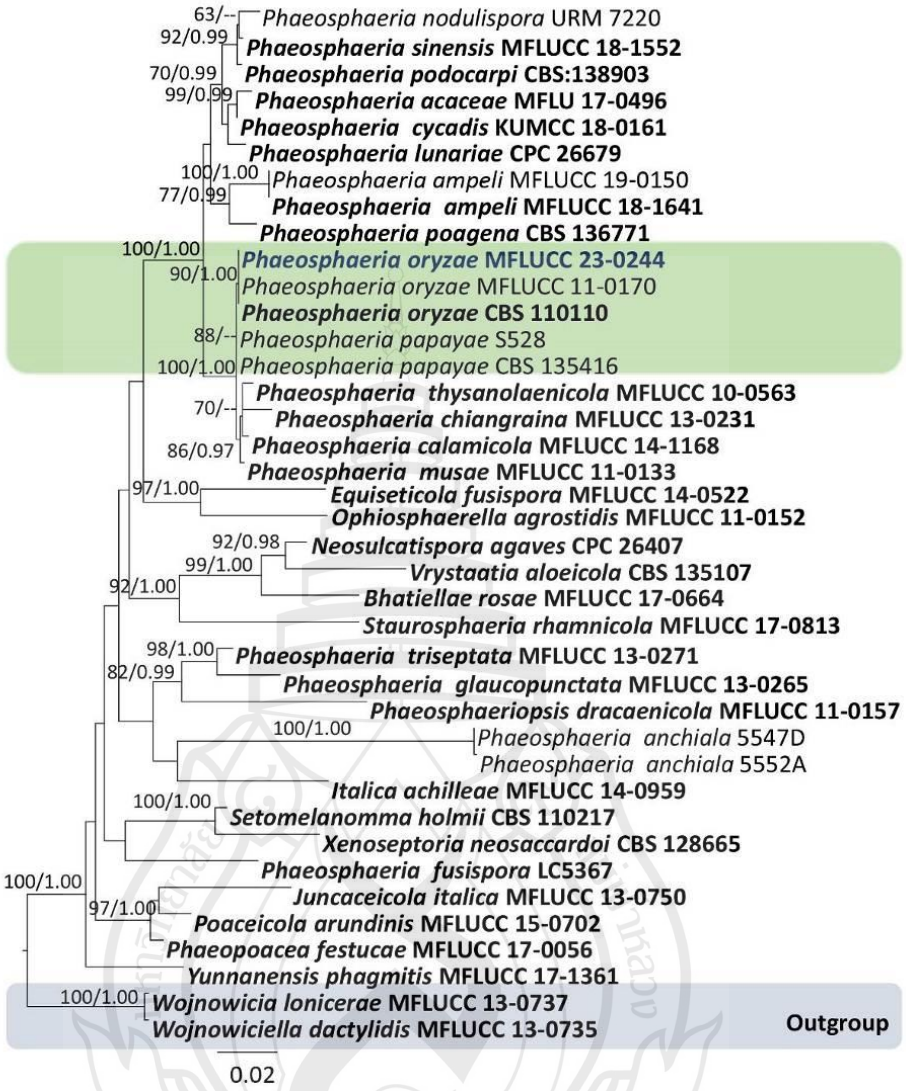
Notes — *Phaeosphaeria oryzae* was discovered in the Asian region, causing leaf spots on rice plants and also being found as a saprobe (Phookamsak et al., 2014). The species was later reported from a few plant hosts (*i.e.*, *Bambusa multiplex*, Japan; *Cyperus monti*, Italy; *Etlingera* sp., Thailand; and *Phragmites australis*, Japan) (Phookamsak et al., 2014; Shoemaker & Babcock, 1989; Tanaka & Harada, 2004). The fungus has not been reported on *Musa* sp. and this is its first occurrence. Interestingly, our strain was isolated from the leaf spots and may have pathogenicity for *Musa* sp. However, the artificial innoculation of the fungus should be conducted to prove the pathogenicity of *P. oryzae* in a natural setting. These variations can be regarded as environmental and host adaptations, and the molecular data of our strain are almost identical with the ex-type. In addition, the morphology of our collection is similar to the illustrations of Shoemaker and Babcock (1989). The BLAST search results of LSU, ITS, *rpb*2 and *tef*1 sequence data revealed that our new collection has the highest percentage similarity to *P. oryzae* (CBS 110110) (LSU=100% and

ITS=100%, *rpb*2=100% and *tef*1=100%) with 100% and 99% query cover. In the multi-gene analyses of combined LSU, ITS, *rpb*2 and *tef*1 sequence data, our strain (MFLUCC 23-0244) was grouped with *P. oryzae* (CBS 110110) with ML=90%, BI=1.00 statistical support (Fig. 3.19).



Note a, b, c Leaf spot symptoms on *Musa* sp. d, e Ascomata on the necrotic patch. f Transverse section of the ascomata. h Asci and pseudoparaphyses. i Pseudoparaphyses. g Deliquescing asci, j–m Immature asci. n–p Asci. r Immature spore. q, s–w Ascospores. Scale bars: d=1000 µm, e=100 µm, f, h, j–l=20 µm, g=30 µm, i=2 µm, m–w=15 µm.

Figure 3.18 *Phaeosphaeria oryzae* (MFLU 23-0296)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Wojnowicia lonicerae* (MFLUCC 13-0737) and *W. dactylidis* (MFLUCC 13-0735). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.19 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *rpb*2 and *tef*1 sequence matrix of some selected genera in *Pheosphariaceae,* showing the phylogenetic position of *Phaeosphaeria oryzae*

Pleosporaceae Nitschke

The taxa in this family represent various lifemodes, such as plant and human pathogens, woody and leaf saprobes, and endophytes (Woudenberg et al., 2013). The sexual morph is distinguished by perithecial, hairy or setose, ostiolate ascomata that range from erumpent to nearly superficial. The asci are 8-spored, bitunicate, and cylindric-clavate, with 1–2-seriate, partially overlapping, phragmosporous or muriform, brown or pale brown ascospores (Ariyawansa et al., 2015). The asexual morphs of the family are hyphomycetous and the conidiogenous cells are annellidic, sympodial blastic, and sometimes phialidic. The conidia are usually large, brown, septate, and have various shapes (Kodsueb et al., 2006). The most researched asexual morphs with a high propensity to become pathogens in terrestrial habitats are *Alternaria, Bipolaris, Curvularia*, and *Stemphylium* (Woudenberg et al., 2013). Hongsanan et al. (2020) accepted 23 genera in *Pleosporaceae*. Torres-Garcia et al. (2022) added two novel genera, *Neostemphylium* and *Scleromyces*, to the family.

Curvularia Boedijn, Bull. Jard. bot. Buitenz, 3 Sér. 13: 123 (1933)

Curvularia includes pathogens and saprobes on a wide range of plant hosts worldwide (Ferdinandez et al., 2021; Hyde et al., 2020b; Jayawardena et al., 2022; Marin-Felix et al., 2020; Olivas-Peraza et al., 2022; Tian et al., 2024). The pathogenic taxa of the genus target agricultural commercial crops of *Poaceae* such as maize, wheat, sorghum and rice (Tan et al., 2018). Recent studies report that *Curvularia* causes infections in immunocompromised patients (Carter & Boudreaux, 2004). The genus has also been discovered in air, aquatic environments and soil (Manamgoda et al., 2015). The asexual morph of *Curvularia* resembles brown distoseptate conidia with a characteristic curvature. This differentiates the genus morphologically from *Bipolaris* (Manamgoda et al., 2015). Molecular data is essential to distinguish *Curvularia* at the species level since several taxa have shared phenotypic characters with overlapping structural dimensions (Marin-Felix et al., 2020). Furthermore, Manamgoda et al. (2015) and Marin-Felix et al. (2020) revised the phylogeny of *Curvularia* and currently, there are around 114 confirmed taxa with molecular data. Previously, several taxa were reported on *Musa* spp. (*viz*., *C. clavata*, Bangladesh; *C. coatesiae*, Iran; *C. eragrostidis*, Brunei Darussalam; *C. fallax*, Solomon Islands and

Malaysia; *C. geniculata*, Cuba and Thailand; *C. lunata*, Ghana and Taiwan; *C. lunata*, *C. pallescens*, *C. senegalensis*, *C. verruculosa*, West Indies (Farr & Rossman, 2024).

Curvularia umbiliciformis M. Raza, K. D. Hyde & L. Cai, Fungal Diversity 99: 72 (2019)

Figure 3.21

Index Fungorum number: IF 556671; Facesoffungi number: FoF 06161

Associated with the necrotic area of the leaf spots on *Musa* sp. Sexual morph: Not observed. Asexual morph: Hypomycetous. *Colonies* eye-shaped, effuse, brown or black, hairy or cottony. *Mycelium* immersed in the substrate. *Stromata* not observed on the host. *Conidiophores* (30–) 40–50 (–65) × 5–7 μm ($\bar{x}$=44.5 × 6.4 μm, n=30) macronematous, mononematous, straight or flexuous, sub-hyaline or pale brown, verruculose, thick-walled, septate, globose or spherical apex, base wider or lobate. *Conidiogenous cells* 8–10 × 5–6 μm ($\bar{x}$=8.8 × 5.2 μm, n=30), polytretic, integrated, terminal, sympodial, cylindrical, cicatrized. *Conidia* (30–) 35–40 × 13–17 μm ($\bar{x}$=38 × 14.8 μm, n=40) solitary, acropleurogenous, simple, often curved, geniculate clavate, ellipsoidal, broadly fusiform, obovoid or pyriform with 3 or more transverse septa, pale or dark brown, immature conidia are hyaline, sometimes with dark bands at the septa, occasionally pseudo-septate, smooth or verrucose; hilum is present at the base.

Cultural characteristics — Colonies on PDA reaching 35 mm diameter after 2 weeks at 25 °C, sparse, embed, flat, radially striated, slightly wrinkled appearance, grayish black from the top view; reverse mouse gray, aerial mycelium absent, undulate to lobate margined. Sporulation was observed after 3 weeks.

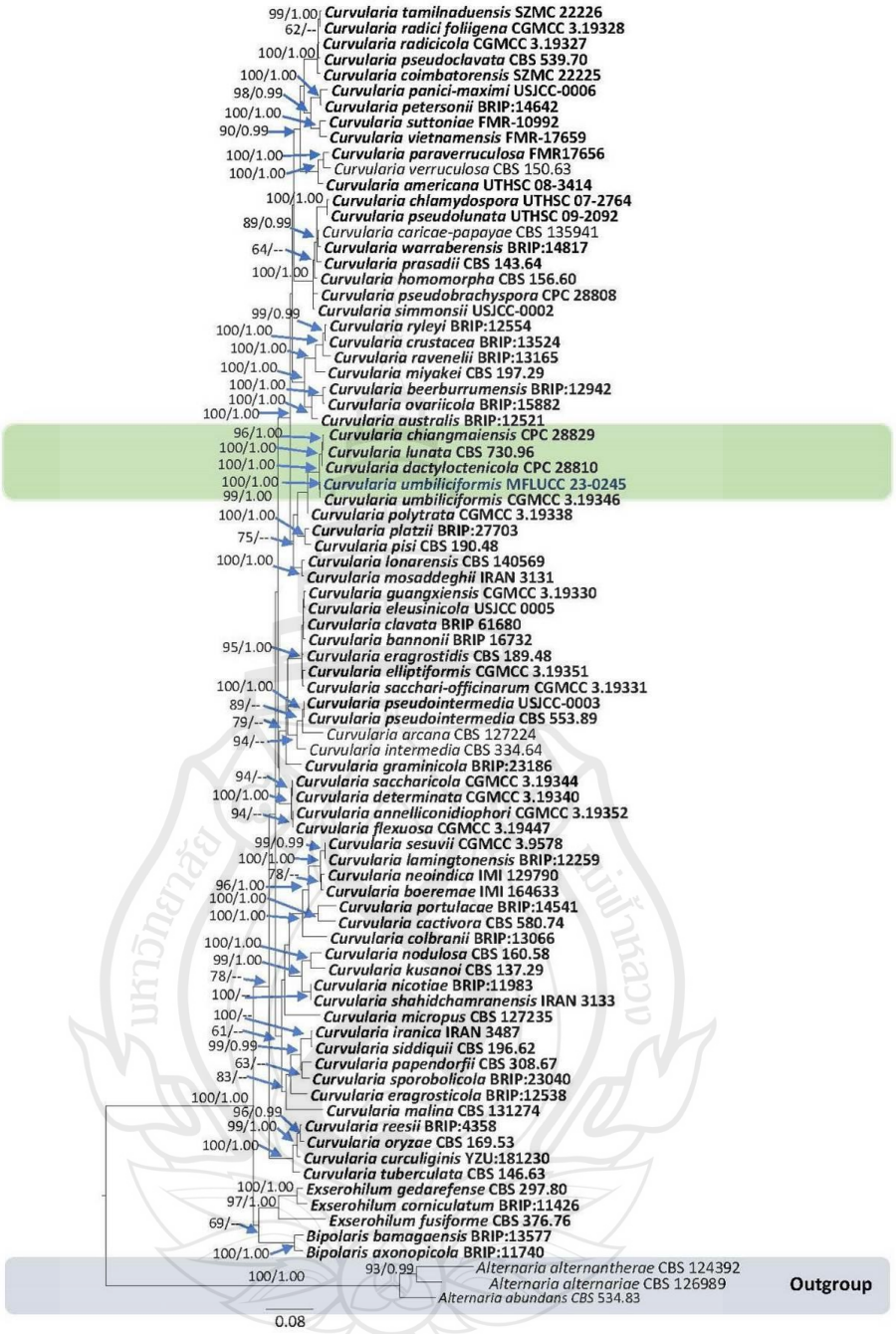
Material examined — Thailand, Chiang Rai Province, Mae Lao, on a fresh leaf spot on *Musa* sp. (*Musaceae*), 14 May 2021, B.C. Samarakoon, 433A (MFLU 23-0298), culture MFLUCC 23-0245.

Notes — *Curvularia umbiliciformis* was introduced by Raza et al. (2019) in Guangxi Province, China, and is associated with the leaf spots of *Saccharum officinarum*. Our new collection was discovered from the leaf spots on *Musa* sp., and there might be a potential pathogenicity. However, challenge inoculations should be conducted in the future to confirm this hypothesis. There has not been any occurrence of the species since the first discovery by Raza et al. (2019). The holotype has been described from the structures that have grown in an artificial medium, and there are

few morphological differences in spore dimensions and conidiophore morphology between the holotype and our collection. However, molecular evidence (Fig. 3.20) supports the conspecificity of our strain (MFLUCC 23-0245) with *C. umbiliciformis* in the multi-gene analysis of ITS, *gapdh* and *tef*1 sequence data (statistical support: ML = 100%, BI = 1.00) sister to *C. chiangmaiensis*, *C. dactylocteniicola* and *C. lunata*. BLAST search results of ITS, *gapdh*, and *tef*1 sequence data indicate that our isolate shows 100% similarity to *C. umbiliciformis* (CGMCC3.19346) in GenBank with a 100% query cover. This is the first report of *C. umbiliciformis* on *Musaceae* from Thailand.

Pyrenochaetopsidaceae Valenzuela-Lopez, Crous, Cano, Guarro & Stchige

The family was introduced by Valenzuela-Lopez et al. (2018) to accommodate *Pyrenochaetopsis* (type genus), *Neopyrenochaetopsis* and *Xenopyrenochaetopsis*. Previously, only the asexual morphic taxa were described, and recently, the sexual morph was described from *Pyrenochaetopsis chromolaenae* and *P. yunnanensis* (Mapook et al., 2020; Phookamsak et al., 2022). The asexual morph in *Pyrenochaetopsidaceae* comprises pycnidial, glabrous or setose, subglobose to ovoid conidiomata with papillate or apapillate ostioles. The conidiophores are hyaline, acropleurogenous and phialidic (Phookamsak et al., 2022). Most species produce numerous conidia, which are usually aseptate, hyaline, and ovoid, ranging from cylindrical to allantoid (Valenzuela-Lopez et al., 2018). The genera of the family can be saprobes, endophytes, or opportunistic pathogens for humans (Hongsanan et al., 2020).



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Alternaria abundans* (CBS 534.83), *A. alternantherae* (CBS 124392 and CBS 126989). The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.20 Maximum likelihood tree revealed by RAxML analyses of ITS, *gapdh* and *tef*1 sequence data of the selected genera of *Pleosporaceae*



Note a, b Leaf spots on bananas show a wide necrotic diseased area and the chlorotic region. c–e Conidiophores on the host resembling eye-shaped colonies. f Conidiogenesis. g–i Conidiophores. j Polytretic, integrated, terminal, cicatrized conidiogenous cells. k–v Conidia. Scale bars: c=1 cm, d=50 μm, e=100 μm, f–i, l–w=10 μm, j, k=1 μm.

Figure 3.21 *Curvularia umbiliciformis* (MFLU 23-0298)

Pyrenochaetopsis Gruyter, Aveskamp & Verkley, Mycologia 102: 1076 (2010)

The genus was introduced by de Gruyter et al. (2010) to include phoma-like taxa. Nineteen *Pyrenochaetopsis* species epithets can be found in the Index Fungorum (2024). The taxa have been found in different ecological niches as saprobes, endophytes, and pathogens associated with plants (de Gruyter et al., 2010). In addition, some *Pyrenochaetopsis* are facultative lichenicolous coelomycetes and have also been discovered on cysts of nematodes. Some species have been discovered in aquatic habitats, soil, dung, and air samples (Crous et al., 2014; de Gruyter et al., 2010, 2013), and recent scientific studies have recovered a variety of bioactive compounds from their members (Fan et al., 2020; Nogawa et al., 2018). *Pyrenochaetopsis chromolaenae* has been previously reported from Thailand by Mapook et al. (2020), but there is no report on the occurance of the genus on *Musa* spp. In this study, we introduce *Pyrenochaetopsis musae* as a novel taxon, which we report from the leaf spots on *Musa* sp. from Thailand. This is the first occurrence of *Pyrenochaetopsis* in *Musaceae* and the second report from Thailand.

Pyrenochaetopsis musae Samarakoon, K. D. Hyde & Chomnunti, sp. nov.

Figure 3.22

Index Fungorum number: IF901534; Facesoffungi number: FoF 15202

Holotype – MFLU 23-0299

Etymology – The species epithet represents the host genus *Musa* from which the novel taxon has been found.

Associated with the necrotic area of the leaf spots with a black leaf streak lesion on *Musa* sp. Sexual morph: Not observed. Asexual morph: Coelomycetous. *Conidiomata* 90–110 × 70–80 μm ($\bar{x}$=96 × 74 μm, n=20), pycnidial, pale brown to brown or black, solitary, scattered, often apapillate or sometimes papillate, immersed to superficial, globose to subglobose, uni-loculate. *Peridium* 10–12 μm wide from the side view, thin-walled in the middle and thick-walled at the periphery, 1–4 layers, hyaline, composed of sub-hyaline or pale to dark brown pseudoparenchymatous cells of *textura angularis* or sometimes *textura globulosa*. *Conidiophores* reduced to conidiogenous cells and produce simple conidia. *Conidiogenous* cells 4–6 × 1–2 μm ($\bar{x}$=5.2 × 1.5 μm, n=20), phialidic, elliptic, thick-walled, hyaline, discrete, aseptate,

erect from the inner cavity of the wall of pycnidia. *Conidia* 4–6 × 2–3 μm ($\bar{x}$=5 × 2.5 μm, n=40), numerous, hyaline, guttulate at immature stage, subglobose to oblong or spherical, sometimes kidney-shaped, aseptate, thick-walled at times.

Cultural characteristics — Conidia germinating on PDA within 18 hours. Colonies on PDA reach 25 mm diameter after one week at 25 °C. Colonies on PDA dense, irregular in shape, sometimes entire margined or lobate, mouse gray, black or brown, flat to slightly raised, surface smooth or rough, somewhat cottony; after one month, colony from above initially gray or golden brown or black; with time, cottony mycelium is reducing and becoming sparse, flat and immersed; after two months, the colony is radially striated, golden brown or black, leathery, shiny, pycnidial masses with numerous spores are visible, solitary or fused, uni-loculate or multi-loculate, conidial masses appear on the ostiole as slimy heads.

Material examined — Thailand, Chiang Rai Province, Doi Mae Sa Long, associated with the leaf spot on *Musa* sp., 24 June 2021, B.C. Samarakoon, 451 (MFLU23-0299, holotype), ex-type MFLUCC 23-0305.

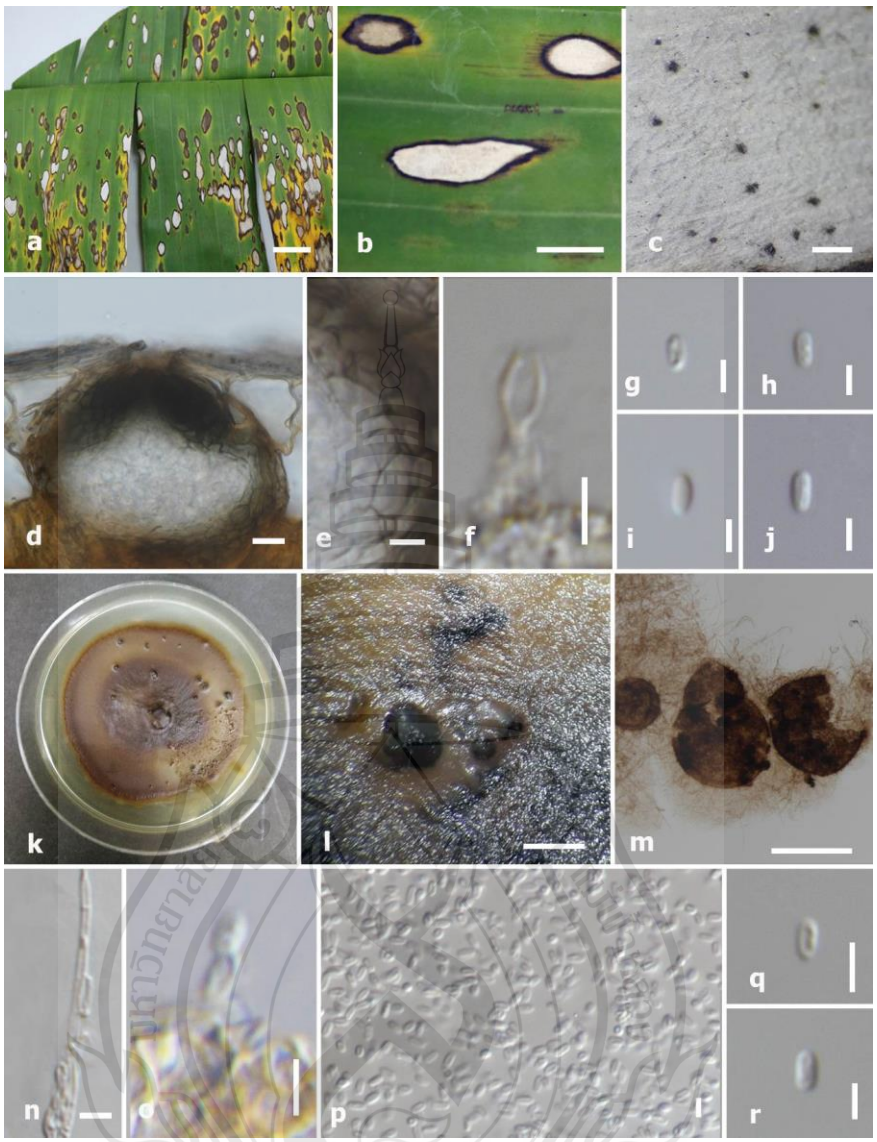
GenBank numbers — LSU=PP800332, ITS=OR206388, *tub*2= PP840935, *rpb*2= OR209486

Notes — The BLAST search results of LSU, ITS, *tub*2 and *rpb*2 sequence data revealed that *Pyrenochaetopsis musae* has the highest percentage similarity to *P. botulispora* (UTHSC: DI16-289) (LSU=99.88% and ITS=99.17%) with 100% and 97% query covers. The new taxon shows 94.65% (*tub*2) similarity to *P. kuksensis* (MEND-F-0058) and 96.15% (*rpb*2) match to *P. paucisetosa* (CBS 142460) with 97% and 96% query cover. In the multi-gene phylogeny of LSU, ITS, *tub*2 and *rpb*2 sequence data (Fig. 3.23), *P. musae* isolates (MFLUCC 23-0305 and MFLUCC 23-0306) formed an independent lineage, with closer phylogenetic affinity to *P. botulispora*, *P. Paucisetosa*, and *P. tabarestanensis* with ML=100%, BI=1.00 statistical support. Our new strains have 1.2% (LSU=11/859), 0.62% (ITS=3/478), 7.93% (*tub*2=35/441) and 3.85% (*rpb*2=31/805) base pair differences with *P. paucisetosa* (CBS 142460). Our new species morphologically differs from *P. paucisetosa* in lacking setae and having elliptic-shaped, thick-walled phialides. The phialides of *P. paucisetosa* are rather ampulliform and notably thin-walled (Valenzuela Lopez et al., 2018). Based on morpho-molecular evidence, *P. musae* is

introduced in this study as a new coelomycetous taxon associated with leaf spots on *Musa* sp. from Thailand.

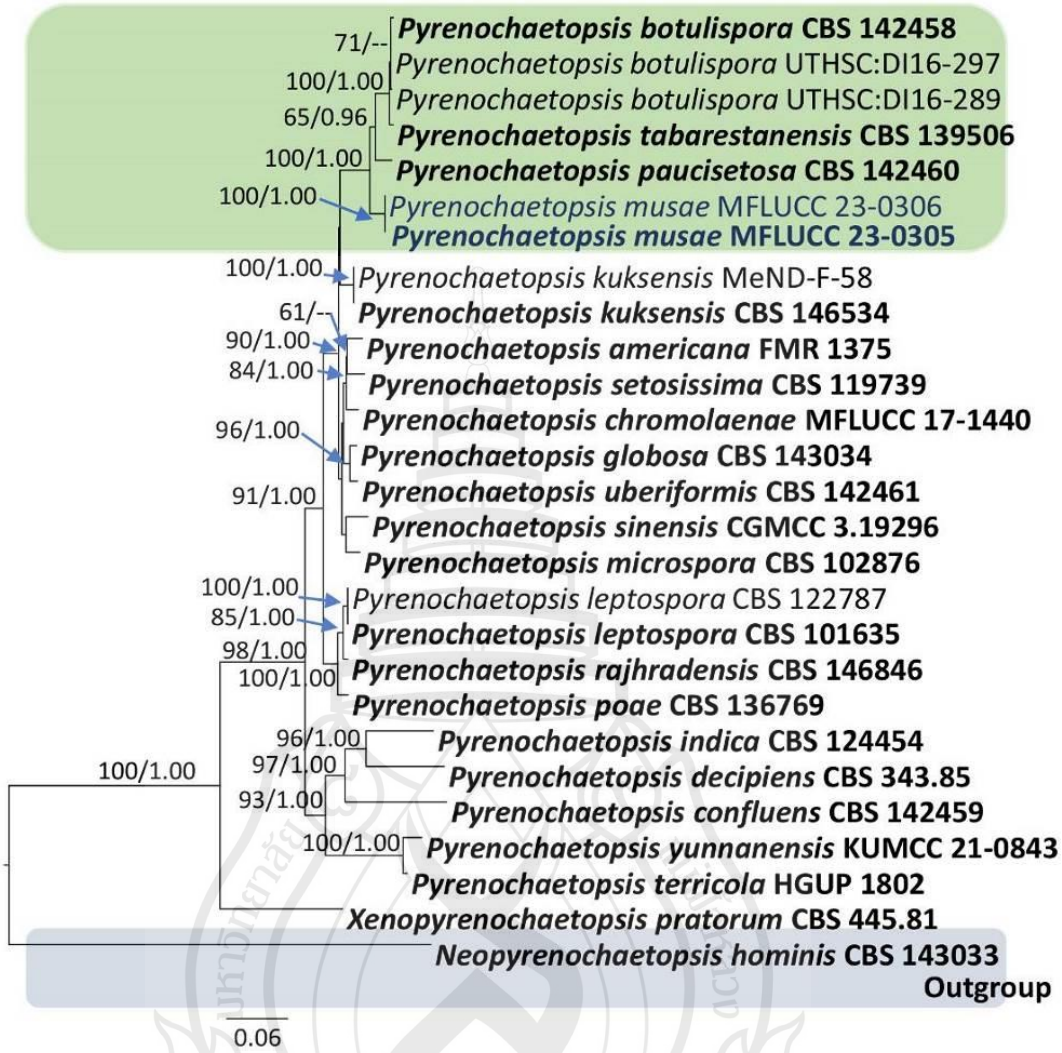
Roussoellaceae Jian K. Liu, Phook., D. Q. Dai & K. D. Hyde

Roussoellaceae was introduced by Liu et al. (2014a) to accommodate *Neoroussoella*, *Roussoella* and *Roussoellopsis*. Hongsanan et al. (2020) accepted 12 genera in the family. Most genera in *Roussoellaceae* exhibit a saprobic lifestyle on many plant hosts and are often discovered on bamboo and palms (Hongsanan et al., 2020). The sexual morph is represented by solitary or gregarious, loculate, ostiolate, or papillate ascostromata. The asci are 8-spored, bitunicate, and have a distinct ocular chamber. Ascospores are usually ellipsoidal to fusiform, septate and hyaline, and brown to dark brown. Sometimes the ascospores are constricted at the septum, have different ornamentations (*i.e.*, poroid, echinulate, striated, reticulate) and are surrounded by a wide mucilaginous sheath (Karunarathna et al., 2019; Liu et al., 2014a).



Note a, b Leaf spots with a black leaf streak lesion on *Musa* sp. c Appearance of conidiomata on the white necrotic center. d Transverse section of conidiomata. e Conidiomatal wall. f Conidiogenous cells. g–j, p–r Conidia. k Colonies on PDA after two months. l Conidiomata on PDA. m Squash mount of conidiomata. n Mycelium, o Conidiogenesis. Scale bars: a=15 cm, b=2 cm, l=1 mm, c=200 µm, m=100 µm, d=20 µm, e, f–j, o–r=5 µm, n=2 µm.

Figure 3. 22 *Pyrenochaetopsis musae* (MFLU 23-0299, Holotype)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are indicated. The tree is rooted with *Neopyrenochaetopsis hominis* (CBS143033). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.23 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tub*2 and *rpb2* sequence data of the genera of *Pyrenochaetopsidaceae,* illustrating the taxonomic position of *Pyrenochaetopsis musae*

Setoarthopyrenia Mapook & K. D. Hyde, Fungal Diversity 101: 92 (2020)

Setoarthopyrenia was established by Mapook et al. (2020) based on the multi-gene phylogeny of LSU, ITS, *tef*1, *rpb*2 and SSU sequence data, together with morphological evidence. *Setoarthopyrenia chromolaenae* was designated as the type and it was found on the dead stems of *Chromolaena odorata* (Siam Weed) as a saprobe in Thailand (Mapook et al. 2020). In this manuscript, we report the endophytic occurrence of *S. chromolaenae* associated with fresh leaves of *Musa* sp. from Thailand as a new host and lifestyle record.

Setoarthopyrenia chromolaenae Mapook & K. D. Hyde, Fungal Diversity 101: 92 (2020)

Figure 3.24

Index Fungorum number: IF 557362; Facesofungi number: FoF 07821

Endophytic on fresh leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Coelomycetous. *Colonies* on PDA reaching 45 mm diam. after 21 days at 25 °C in light conditions, circular, entire to irregular margined, sparse, flat or slightly raised, leathery, black or brownish black from top, shiny, olivaceous brown in reverse. *Mycelium* 2–4 µm ($\bar{x}$=3.4 µm) in width, thick-walled, hyaline, branched, septate, smooth. Sporulation was observed in mature cultures after 48 days. *Conidiomata* 500–550 × 480–500 µm ($\bar{x}$=560 × 485 µm, n=20), pycnidial, solitary or aggregated, uni or multi-loculate, scattered, black, shiny, globose. *Pycnidial wall* 10–15 µm wide, composed of 2–3 layers of light brown cells of *textura angularis* or *textura prismatica*. *Conidiophores* 1.5–2.8 × 1–2.5 µm ($\bar{x}$=1.7 × 2 µm, n=20) reduced to conidiogenous cells, ovate to obovate, hyaline, thick-walled unbranched. *Conidia* 2.5–3.8 × 1.5–1.8 µm ($\bar{x}$=3.4 × 1.7 µm, n=40), minute, often rod-shaped, oblong or spherical, hyaline, aseptate, thick-walled, none-guttulated.

Material examined — Thailand, Chiang Rai Province, Doi Chang, on a fresh leaf of *Musa* sp. (*Musaceae*), 18 July 2021, B. C. Samarakoon, MN27Cul (MFLU 23-0300), culture MFLUCC 23-0249.

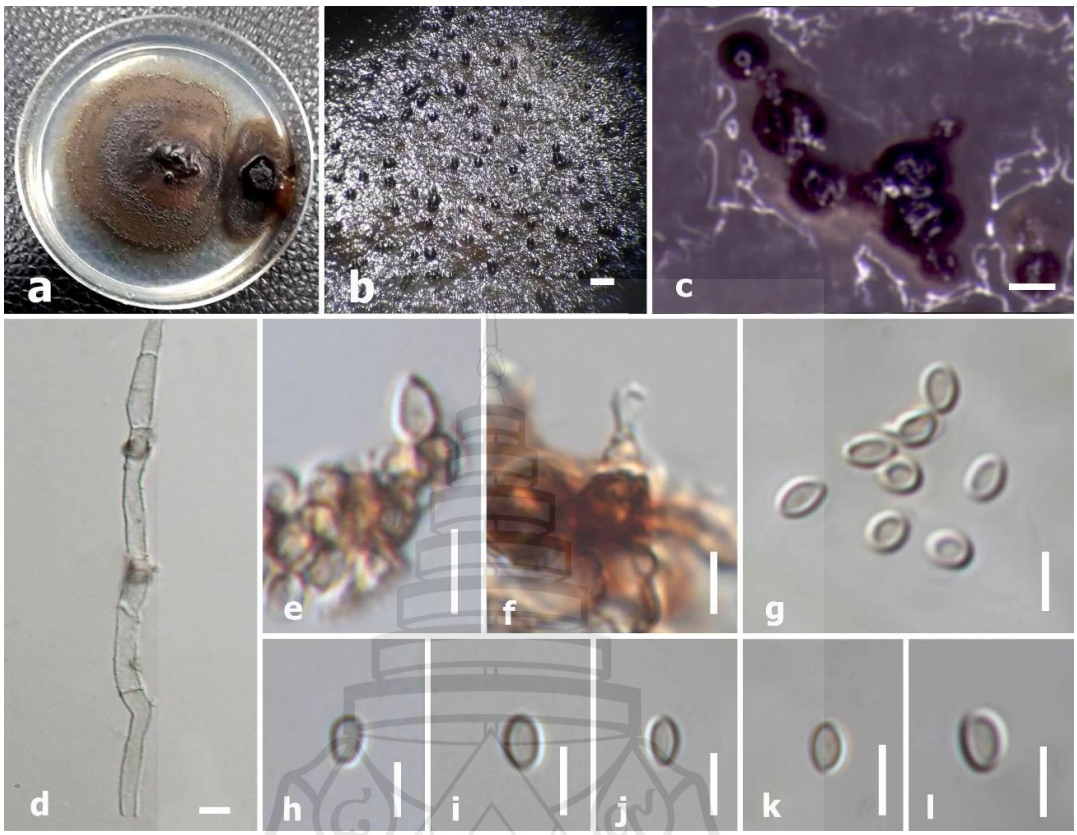
GenBank numbers — LSU= PP800439, *rpb*2= PP840924, *tef*1= PP840921

Notes — In the multi-gene phylogenetic analyses of LSU, ITS, *tef*1 and *rpb*2 sequence data, our strain (MFLUCC 23-0249) was grouped with the type strain of *Setoarthopyrenia chromolaenae* (MFLUCC 17-1444) and *Arthopyrenia* sp. (UTHSC:

DI16-362) with ML=100%, BI=1.00 statistical support (Fig. 3.25). The BLAST search results of LSU, ITS, *tef*1 and *rpb2* sequence data revealed that *S. chromolaenae* has the highest percentage similarity to *Arthopyrenia* sp. (UTHSC: DI16-362) (LSU=97%, *tef*1=100% and *rpb2*=100%) with 100%, 99.87%, 99.87% query covers. We could not locate any valid morpho-molecular reference literature for *Arthopyrenia* sp. (UTHSC: DI16-362) and further taxonomic investigation is recommended for the latter strain. The sexual morph of the taxon was described by Mapook et al. (2020). The sporulation of the asexual cultures was observed as tiny pin heads (pycnidia). We could not locate any similar reference asexual morph to compare the morphology of our collection as because *Setoarthopyrenia* is monotypic. We describe the occurrence of *S. chromolaenae* as an endophyte associated with *Musa* leaves from Thailand.

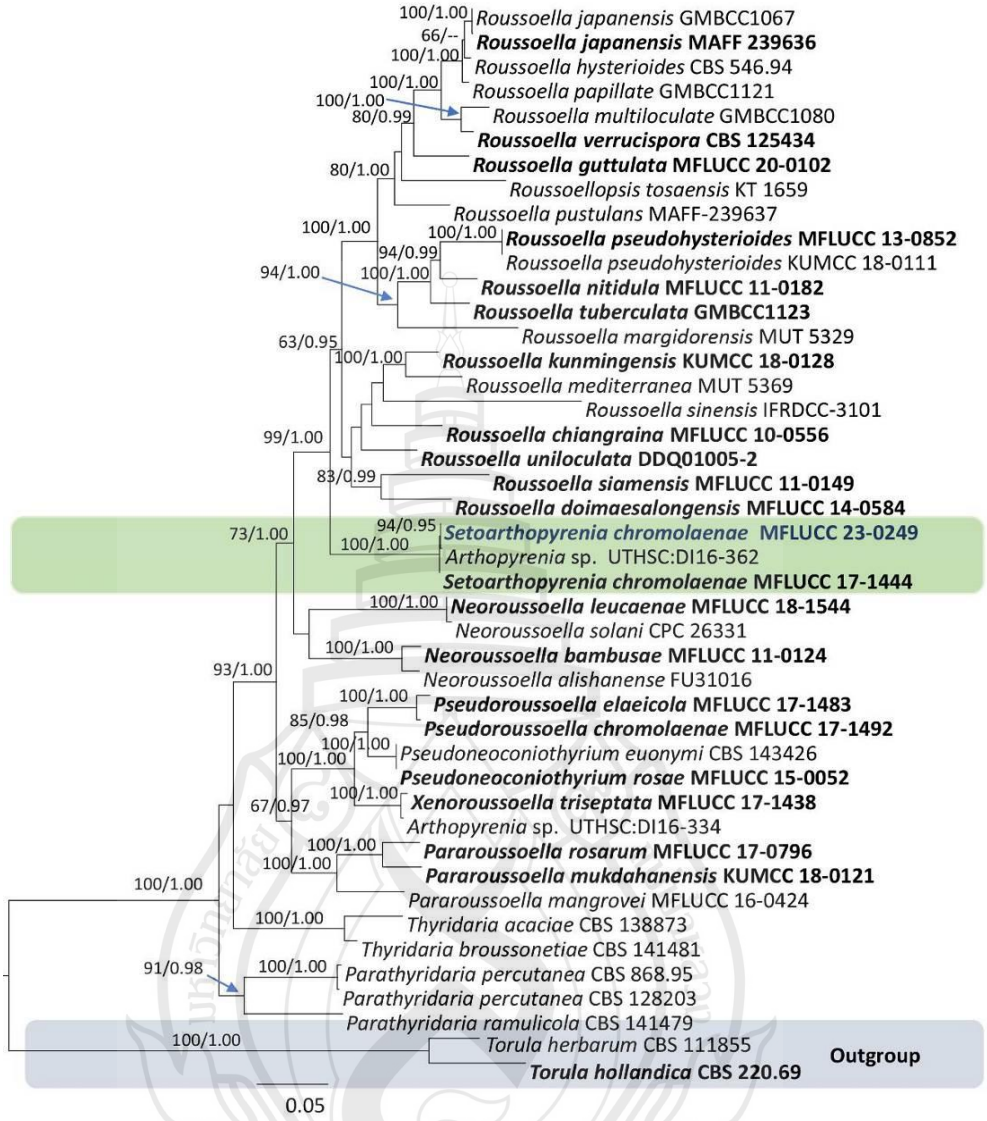
Torulaceae Corda

The family was introduced by Sturm (1829) and is typified by *Torula.* Hongsanan et al. (2020) accepted six genera in *Torulaceae* (*viz*. *Dendryphion*, *Neotorula*, *Rostriconidium*, *Rutola*, *Sporidesmioides* and *Torula*). However, Boonmee et al. (2021) included *Cylindrotorula* as a new genus and at present, *Torulaceae* accommodates seven genera. The taxa primarily exhibit hyphomycetous asexual morphs characterized by erect, subcylindrical to ellipsoid or clavate conidiophores that bear dematiaceous, smooth to verruculose conidiogenous cells. Conidia are subcylindrical, brown, septate, phragmosporous, acrogenous, sub-hyaline to brown and are produced as branched chains (Hyde et al., 2016; Li et al., 2017; Mapook et al., 2020). Most of the taxa in the family are saprobes, which are associated with ligneous hosts in terrestrial and aquatic habitats (Hongsanan et al., 2020).



Note a Colony on PDA after 48 days. b–c Pycnidia on PDA. d Mycelium, e, f Conidiogenesis and conidiophores. g–i Conidia. Scale bars: b, c=500 μm, d=3 μm, e–i=5 μm.

Figure 3.24 *Setoarthopyrenia chromolaenae* (MFLU 23-0300)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Torula herbarum* (CBS 111855) and *T. hollandica* (CBS 220.69) (*Torulaceae*). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.25 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tef*1 and *rpb*2 sequences of some selected genera of *Roussoellaceae* illustrating the phylogenetic position of *Setoarthopyrenia chromolaenae*

Torula Pers., Ann. Bot. (Usteri) 15: 25 (1795)

Torula was introduced by Persoon (1975) and is typified by *T. herbarum* (Pers.) Link. The neotype specimen of *T. herbarum* was designated by Crous et al. (2015). *Torula* is only known from its asexual morph, which is characterized by doliiform to ellipsoid or clavate, cupulate, conidiogenous cells (Crous et al., 2015; Li et al., 2017, 2020). The conidiogenous cells have thick and heavily melanized walls at the base and are thin-walled at the apex. In addition, the conidiogenous cells frequently collapse and are coronate (Li et al., 2017, 2020). The conidia appear as black, powdery masses on the host (Ellis, 1971a, 1976). They are subcylindrical, phragmosporous, brown, smooth to verrucose and are produced in branched or unbranched chains (Crous et al., 2015; Li et al., 2017, 2020). There are over 520 species epithets of *Torula* listed in the Index Fungorum (2024). *Torula* is common in terrestrial and aquatic habitats, mainly as a saprobe across tropical and temperate regions (Boonmee et al., 2021; Crous et al., 2015; Hyde et al., 2020b, 2023; Jayawardena et al., 2022; Li et al., 2020; Manawasinghe et al., 2022, 2024; Samarakoon et al., 2021a; Silva et al., 2022; Su et al., 2018; Tennakoon et al., 2021; Tian et al., 2024). *Torula herbarum* was reported from *Musa* in Papua New Guinea, Somalia, Taiwan, Thailand and Zambia (Photita et al., 2001a; Photita et al., 2003). In addition, *T. chromolaenae*, *T. fici* and *T. masonii* were recently reported on *Musa* spp. from Thailand and China by Samarakoon et al. (2021b). In this study, we report the occurrence of *T. mackenziei* for the first time on *Musa* sp. from Thailand.

Torula mackenziei Jun F. Li, Phook. & K. D. Hyde, Mycol. Progr. 16: 455 (2017)

Figure 3.26

Index Fungorum number: IF 819537; Facesoffungi number FoF 02714

Saprobic on the mid rib of a leaf of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* erect or flat, black, powdery, branched and thread-like. *Mycelium* slightly immersed or often superficial, septate, branched, smooth. *Conidiophores* 2–3.5 × 1–3 μm ($\bar{x}$=2.8 × 1.9 μm, n=20), macronematous, mononematous, unbranched, sub-hyaline, simple, erect, thick-walled, 2–3-celled, basal cell is corn-shaped or sub-cylindrical, globose to subglobose at apex, arising from prostrate hypha. *Conidiogenous cells* 11–13 μm × 9–10 μm ($\bar{x}$=12.5 × 9.5 μm,

n=10) polyblastic, terminal, pale or dark brown to black, thick-walled, ellipsoid, sub-hyaline at apex, dark at the base. *Conidia* (23–) 39–45 (–48) × (9–) 13–15 μm ($\bar{x}$=38 × 13.9 μm, n=40), solitary to catenate, often 4-celled, sometimes 1 to 6-celled, moniliform, acrogenous, simple, phragmosporous, dark brown, thin or thick-walled, constricted at septa, darker at each septum, slightly flexuous or straight, rounded at both ends, apical cell partially sub-hyaline, spherical.

Culture characteristics — Colonies on PDA, reaching 25 mm at 14 days at 25 °C, mycelium partly immersed to superficial, slightly raised, cottony and hairy, entire to irregular margined, whitish grey from the top view; reverse greenish white. Areal mycelium was not much visible, dense. Sporulation was not observed.

Material examined — Thailand, Chiang Mai Province, Chiang Dao, on the midrib of a dead leaf of *Musa* sp. (*Musaceae*), 20 July 2022, B.C. Samarakoon, MN40 (MFLU 23-0301), culture MFLUCC 23-0307.

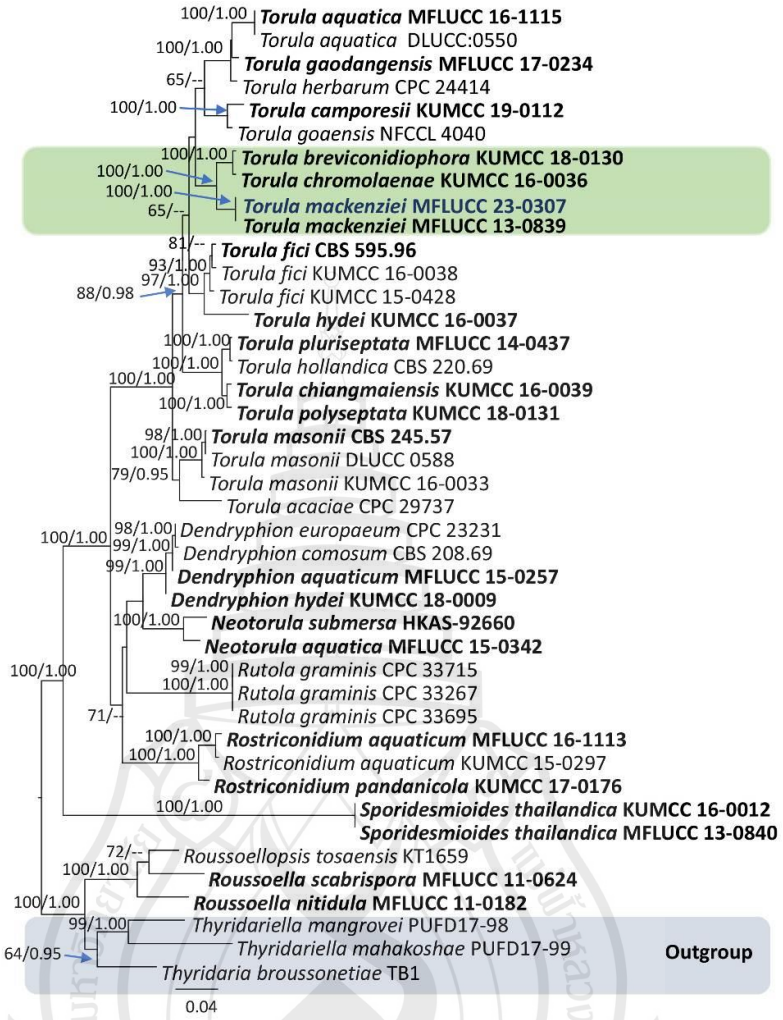
GenBank numbers — SSU= PP811807, LSU= PP800440, ITS= PP809107, *tef*1= PP840922, *rpb*2= PP840925

Notes — *Torula mackenziei* was described on a dead branch of *Bidens pilosa* (*Asteraceae*) in Doi Mae Salong, Thailand, by Li et al. (2017) based on morphology and phylogeny. There have been no other occurrences of the species, making this the first report of *T. mackenziei* on *Musa* in Thailand.When comparing the DNA sequences in BLAST search, our isolate showed a high percentage similarity to *T. mackenziei* (MFLUCC 13-0839) (SSU=100%, LSU=100%, ITS=99.81%, *tef*1=100% and *rpb*2=100%) with 99%, 100%, 100% and 100% query covers. In the multi-gene phylogeny (SSU, LSU, ITS, *tef*1 and *rpb*2 sequence data), our strain (MFLUCC 23-0307) grouped with *T. mackenziei* strains with ML=100%, BI=1.00 statistical support (Fig. 3.27). Our new collection shares similar morphology with the holotype in having moniliform conidia. In addition, we have noticed some distinct branching patterns of conidial chains and the dark coloration of the cells at each septum. This is the second occurrence of *T. mackenziei* from Thailand and the first report on monocot plants.



Note a Colony on host surface. b–p Budding, conidial formation and mature conidia. Scale bars: a=500 μm, b–p=20 μm.

Figure 3.26 *Torula mackenziei* (MFLU 23-0301)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Roussoella nitidula* (MFLUCC 11–0182), *R. scabrispora* (MFLUCC 11–0624) and *Roussoellopsis tosaensis* (KT 1659). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Torula mackenziei.*

Figure 3.27 Maximum likelihood tree revealed by RAxML analyses of SSU, LSU, ITS, *tef*1 and *rpb*2 DNA sequences of some seleted genera in *Torulaceae*

Tubeufiales Boonmee & K. D. Hyde

The order was introduced by Boonmee et al. (2014) to accommodate *Tubeufiaceae*, based on morpho-molecular evidence. *Tubeufiales* hosts helicosporous hyphomycetes, which produce bioactive secondary metabolites (Lu et al., 2018a). In addition, some taxa include dictyosporous, phragmosporous or globose to subglobose, chlamydospores forming asexual morphs (Tian et al., 2022; Wanasinghe et al., 2023). There are three families (*viz*., *Bezerromycetaceae*, *Tubeufiaceae* and *Wiesneriomycetaceae*) in this order (Tian et al., 2022; Wanasinghe et al., 2023). Two families (*Bezerromycetaceae* and *Wiesneriomycetaceae*) are currently only known in their sexual morphs. The taxa in the order are common saprobes on woody substrates or submerged decaying wood in terrestrial and aquatic environments (Boonmee et al., 2014; Lu et al., 2018b).

Tubeufiaceae M. E. Barr

The sexual morph of *Tubeufiaceae* is characterized by superficial, white to yellow, pale brown or black ascomata with or without setae, which are seated on a subiculum. The ascospores are fasciculate in bitunicate asci, and are filiform to fusiform (Boonmee et al., 2014). The asexual morph is hyphomycetous and can be dictyosporous, helicosporous or phragmosporous-like (Lu et al., 2018b). *Tubeufia* is the generic type of the family (Boonmee et al., 2014). At present, the family hosts 46 genera of fungi (Tian et al., 2022) with saprobic, hyperparasitic or hypersaprobic lifestyles in terrestrial and aquatic habitats (Boonmee et al., 2021; Jayasiri et al., 2017).

Neohelicosporium Y. Z. Lu, J. C. Kang & K. D. Hyde, Mycol. Progr. 17: 637 (2017)

Lu et al. (2018a) introduced the genus with new species and some extant taxa in *Helicosporium*, *Helicoma* and *Tubeufia* based on morphology and molecular data. Species of the genus are saprobic on decaying woody substrates in both aquatic and terrestrial habitats. The genus comprises helicosporous hyphomycetes as the asexual morph and Jayasiri et al. (2017) introduced the first sexual morph of the genus on a decaying fruit of *Malvaceae* sp. in Thailand. Most of the other species in the genus have been introduced from submerged decaying woody substrates in freshwater

streams in southern China and Thailand (Boonmee et al., 2021; Jayasiri et al., 2019; Lu et al., 2018a; Tian et al., 2020; Yang et al., 2023).

Neohelicosporium terrestris Samarakoon, K. D. Hyde & Chomnunti, sp. nov.

Figure 3.28

Index fungorum number: IF901535; Facesoffungi number: FoF 15203

Holotype – MFLU 23-0302

Etymology – “terrestris” is the Latin word for "terrestrial" and it refers to the new species discovered in terrestrial habitats.

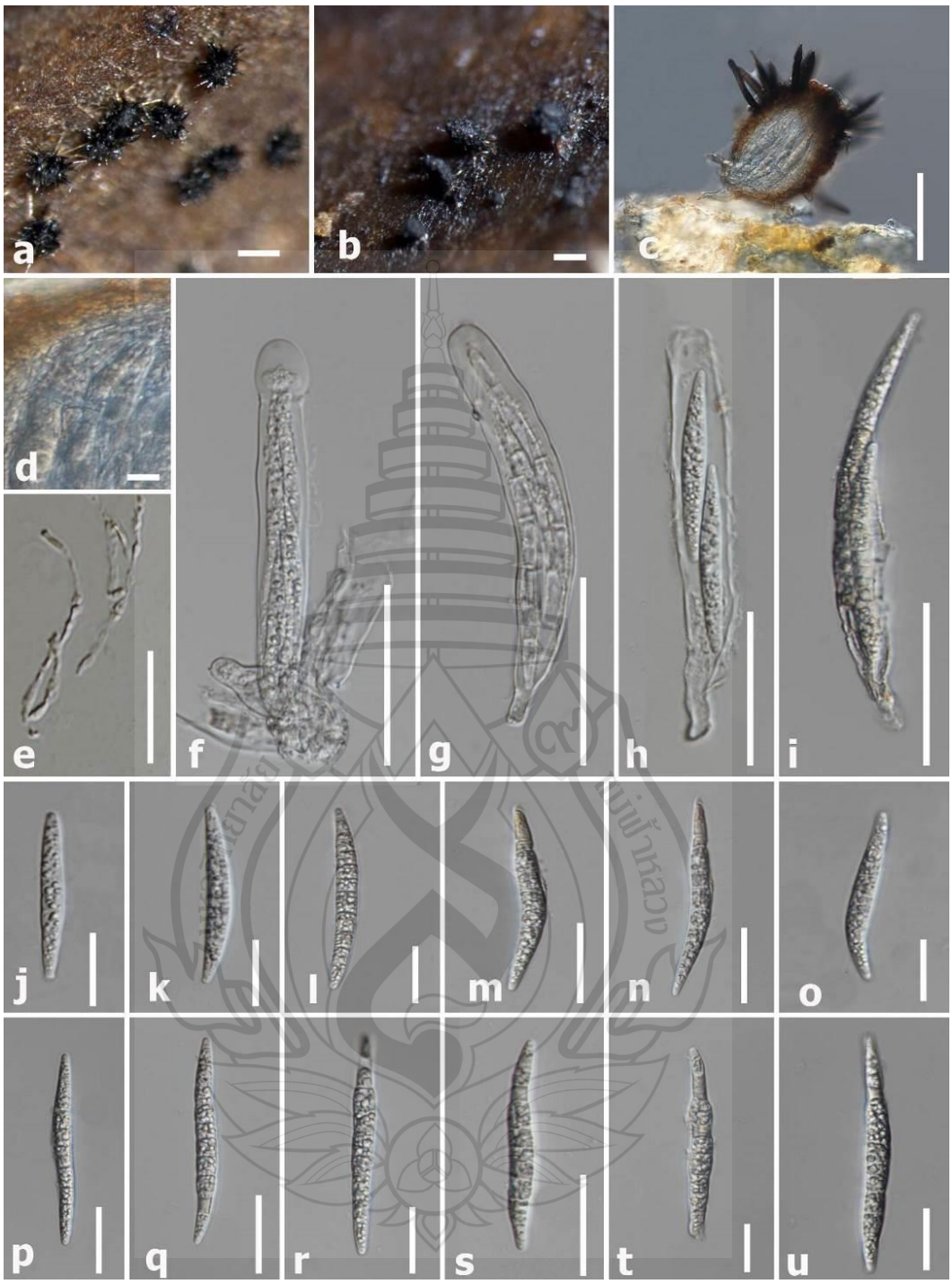
Saprobic on dead leaf petiole of *Musa* sp. Sexual morph: *Ascomata* 120–150 μm high, 90–110 μm diam. ($\bar{x}$=139.5 × 95 μm, n=20), superficial, seated on a subiculum, solitary, scattered or sometimes aggregated, in cross-section, globose to sub globose or spherical, dark brown to black, uni-loculate. *Setae* up to 70 μm long, 7–10 μm diam. ($\bar{x}$=56 × 8.5 μm, n=20), surrounding the ascomata, arising from the periphery, brown to black, aseptate, tapering towards the apex, straight or slightly clavate, with flat base and acute apex. *Peridium* 10–20 μm wide, composed of several layers of hyaline to brown cells of *textura angularis*, with outer layer comprising darkened cells and inner layer made up of pale brown to hyaline cells. *Pseudoparaphyses* 0.8–1.5 μm ($\bar{x}$=1.2 μm, n=40), numerous, clavate or coiled, thread-like, aseptate, unbranched, hyaline, smooth to rough-walled. *Asci* (80–) 120–160 × 9–14 μm ($\bar{x}$=140 × 12.5 μm, n=30), 2–4–6-spored, bitunicate, cylindrical, straight or mostly clavate, thin-walled, apex obtusely rounded or square, short-pedicellate or sessile. *Ascospores* (45–) 60–85 × (4–) 6–8.5 μm ($\bar{x}$=73 × 6.5 μm, n=40), overlapping, fusiform, with tapering or rounded ends, often straight or occasionally curved, septate, septa usually inconspicuous and difficult to distinguish, hyaline, rough surface, uni-seriate, bi-seriate or multi-seriate. Asexual morph: Not observed.

Culture characteristics — Conidia germinate on PDA after 36 to 48 hours. Colonies on PDA reaching 1–1.5 cm diam. after 4 weeks in the light condition at 25 °C, flat, sparse, mycelium is completely immersed, brownish black or black, radially striated or wrinkled. Sporulation was not observed.

Material examined — Thailand, Chiang Rai Province, Tap Tao, on dead leaf petiole of *Musa* sp., 18 October 2021, B. C. Samarakoon, MN50 (MFLU 23-0302, holotype), ex-type culture MFLUCC 23-0234.

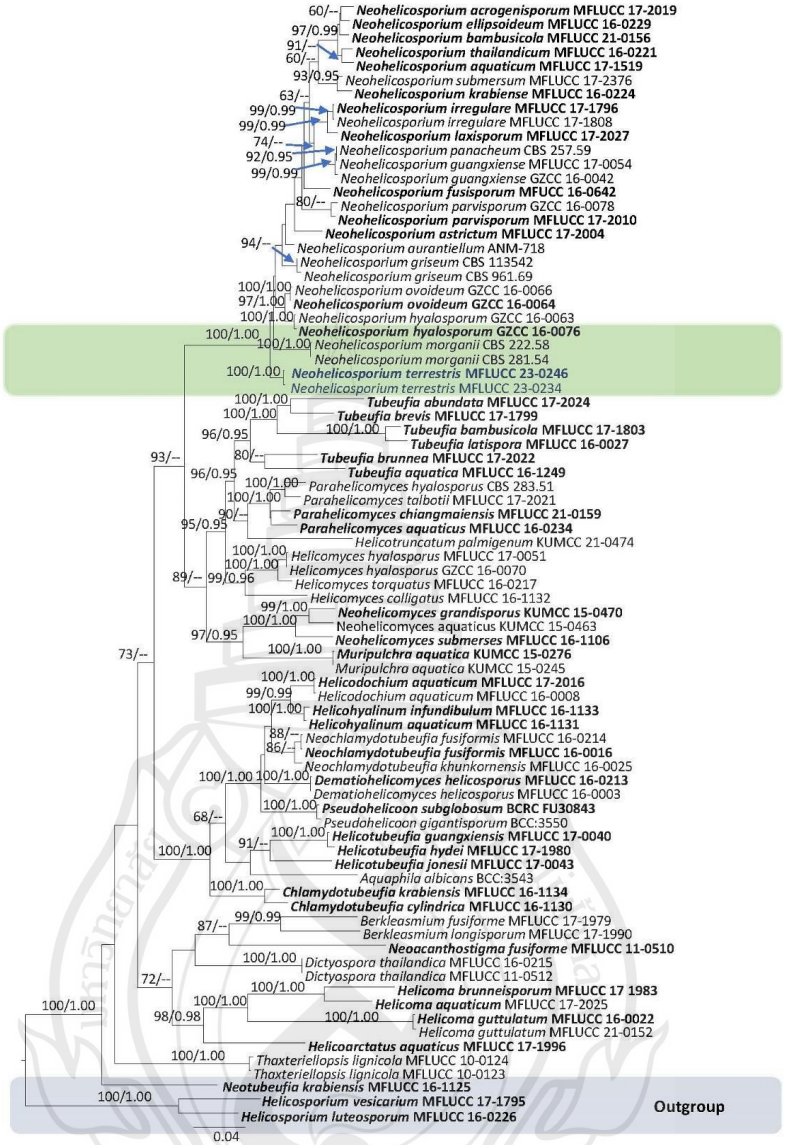
GenBank numbers — LSU= PP800330, ITS= OR206385, *tef*1= OR206052, *rpb*2= PP840926

Notes — When comparing the DNA sequences in BLAST search, *Neohelicosporium terrestris* showed a high percentage similarity to *N. hyalosporum* (GZCC 16-0063) (LSU=99.64% and ITS=92.72%) with 100% query cover. In addition, our new species shows 97.79% (*tef*1) and 98.03% (*rpb*2) similarities to *N. ovoideum* (GZCC 16-0064) with 99% and 96% query cover. In the multi-gene phylogeny of LSU, ITS, *tef*1 and *rpb*2 sequence data (Fig. 3.29), *N. terrestris* formed a well-supported basal clade with *N. hyalosporum*, *N. morganii*, and *N. ovoideum* with ML=100%, BI=1.00 statistical support. Our new strains have 1.38% (LSU=8/578) and 5.8% (ITS=24/412) base pair differences compared to *N. morganii* (CBS 281.54). *Neohelicosporium terrestris* differs from *N. hyalosporum* (GZCC 16-0063) by 0.49% (LSU=4/814), 7.69% (ITS=50/650), 3.5% (*rpb*2=26/742), and 2.5% (*tef*1=21/813) base pairs. In addition, MFLUCC 23-0234 differs from *N. ovoideum* (GZCC 16-0064) by 0.24% (LSU=2/814), 5.72% (ITS=22/384), 2.02% (*rpb*2=15/742), and 2.4% (*tef*1=20/813) base pairs. The sexual morphs of the sister clade have not been discovered and therefore we were unable to compare the morphology of our new taxon with the existing ones. However, the morphology of *N. terrestris* is similar to the other sexual genera in *Tubeufiaceae* (*i.e.*, *Berkleasmium, Dictyospora* and *Helicoma*) (Lu et al., 2018a). Moreover, Jayasiri et al. (2017) reported the first sexual morph of the genus for *N. fusisporum*, which has a similar morphology to our new species. Interestingly, our new collection has 2–4–8-spored asci, with square apices. Based on morphology and phylogeny, we introduce *N. terrestris* as a new saprobic taxon on *Musa* sp. from Thailand. Also, this is the first report of *Neohelicosporium* on *Musa*.



Note a, b Ascomata on the host. c Transverse section of an ascoma. d Peridium. e–i Asci. j–u Ascospores. Scale bars: a–c=100 µm, d=10 µm, e=20 µm, f–i=50 µm, j–u=25 µm.

Figure 3.28 *Neohelicosporium terrestris* (MFLU 23-0302, Holotype)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Botryosphaeria agaves* (MFLUCC 10–0051) and *B. dothidea* (CBS 115476) (*Botryosphaeriaceae*, *Botryosphaeriales*). The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Neohelicosporium terrestris.*

Figure 3.29 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tef*1 and *rpb*2 sequence data of some selected genera of *Tubeufiales*

Class: *Eurotiomycetes* O. E. Erikss. & Winka

Chaetothyriales M. E. Barr

Chaetothyriales was validated by Barr (1987) and is also known as ‘black yeasts fungi’ (Quan et al., 2020). The members of the order are opportunistic human and cold-blooded vertebrate pathogens, with melanized fungal structures (Quan et al., 2020). The order consists of 56 genera established in 11 families, representing diverse ecological niches (Wijayawardene et al., 2022). Some genera of *Chaetothyriales* are discovered in aquatic habitats, rocks, associated with ants, and as mycoparasites (Teixeira et al., 2017). Many taxa are also capable of tolerating extreme environmental conditions such as toxins, temperature, dryness, and nutrient limitations (Gostincar et al., 2019; Teixeira et al., 2017).

Herpotrichiellaceae Munk

The family consists of 19 recognized genera with a diverse ecological range and a high degree of extremotolerance (Teixeira et al., 2017; Wijayawardene et al., 2022). The sexual morph comprises ascomata with multi-locules, and the asexual morph is mostly black and yeast-like (Gostincar et al., 2019). *Herpotrichiellaceae* host**s** saprobes, endophytes and pathogens, that are often found in humans, plant hosts, soil and aquatic habitats (Chandrasiri et al., 2021; Crous et al., 2009; Narisawa et al., 2007; Tian et al., 2016; Wang et al., 2019).

Metulocladosporiella Crous, Schroers, Groenewald, U. Braun & K. Schubert

Crous et al. (2006) introduced *Metulocladosporiella* to accommodate (*M. Musae* = *Cladosporium musae*) that causes leaf spots on *Musa* spp. *Cladosporium musae* has a contrasting morphology to *Cladosporium sensu stricto* (the asexual morph of *Davidiella*) (Crous et al., 2006). In the phylogenetic analyses of ITS and LSU sequence data conducted by Crous et al. (2006), *C. musae* formed a distinct monophyletic clade in *Herpotrichiellaceae* (*Chaetothyriales*). The asexual morph of *Metulocladosporiella* produces pigmented blastoconidia in acropetal chains (Crous et al., 2006). Five species epithets of *Metulocladosporiella* are listed in Index Fungorum (2024) and all have been found on *Musa* spp., from Africa, America, Asia and Oceania (Marin-Felix et al., 2019). *Metulocladosporiella chiangmaiensis*, *M. musigena* and *M. samutensis* were described from Thailand on *Musa* associated with leaf spots (Marin-Felix et al., 2019).

Metulocladosporiella musae (E.W. Mason) Crous, Schroers, J. Z. Groenew., U. Braun & K. Schub., Mycol. Res. 110: 269 (2006)

Figure 3.30

Index Fungorum Number: IF 500185; Faces of Fungi Number: FoF 10438

Associated with the necrotic area of the leaf spot surrounded with the yellow halo on *Musa* sp., The spots elongate to streaks which increase in size. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Mycelium* 6–10 μm ($\bar{x}$=8.5 μm, n=20) in width, internal, external, superficial, hyphae pale olivaceous or sub-hyaline to hyaline, branched, septate, thin-walled, smooth. *Conidiophores* 200–800 × 3–5 μm ($\bar{x}$=550 × 3.8 μm, n=40), macronematous or micronematous, densely or loosely aggregated, stipe straight to slightly flexuous, unbranched at the base and persistently branched at the apex, septate, sub-cylindrical, lobed at the base, 10–13 μm ($\bar{x}$=11.5 μm, n=20), with short rhizoid hyphae, brown or sub-hyaline, paler towards the apex from the dark brown base, tips pale olivaceous or sub-hyaline, thick-walled at the base and thin-walled near the apex, smooth, subcylindrical. The primary and secondary branches are visible at the apex, producing terminal conidial chains, branchlets are compactly arranged, comparatively smooth, thin-walled, septate or aseptate. *Conidiogenous cells* 8–12 × 3–5 μm ($\bar{x}$=9.4 × 4.2 μm, n=40) visible at the terminal ends of the secondary branches, subcylindrical, sympodial, polyblastic, conidiogenous loci subconspicuous to conspicuous, subdenticulate, somewhat protuberant, truncate. *Conidia* 8–10 × 3–5 μm ($\bar{x}$=9.5 × 4.2 μm, n=40) in acropetal chains, smooth-walled, ellipsoid, obovoid, fusiform, hyaline, rough surfaced, pointed at the apex.

Cultural characteristics — Colonies on PDA 12 mm diameter after 14 days at 25 °C, irregular margin, sparse mycelium; olive gray, mouse-gray or blackish gray, sporulation occurs after 21 days at 25 °C from the submerged mycelium, areal mycelium is invisible; reverse greenish black.

Material examined — Thailand, Chiang Rai Province, Doi Thun, on a fresh leaf spot on *Musa* sp. (*Musaceae*), 20 June 2021, B.C. Samarakoon, 446 (MFLU 23-0303), culture MFLUCC 23-0235.

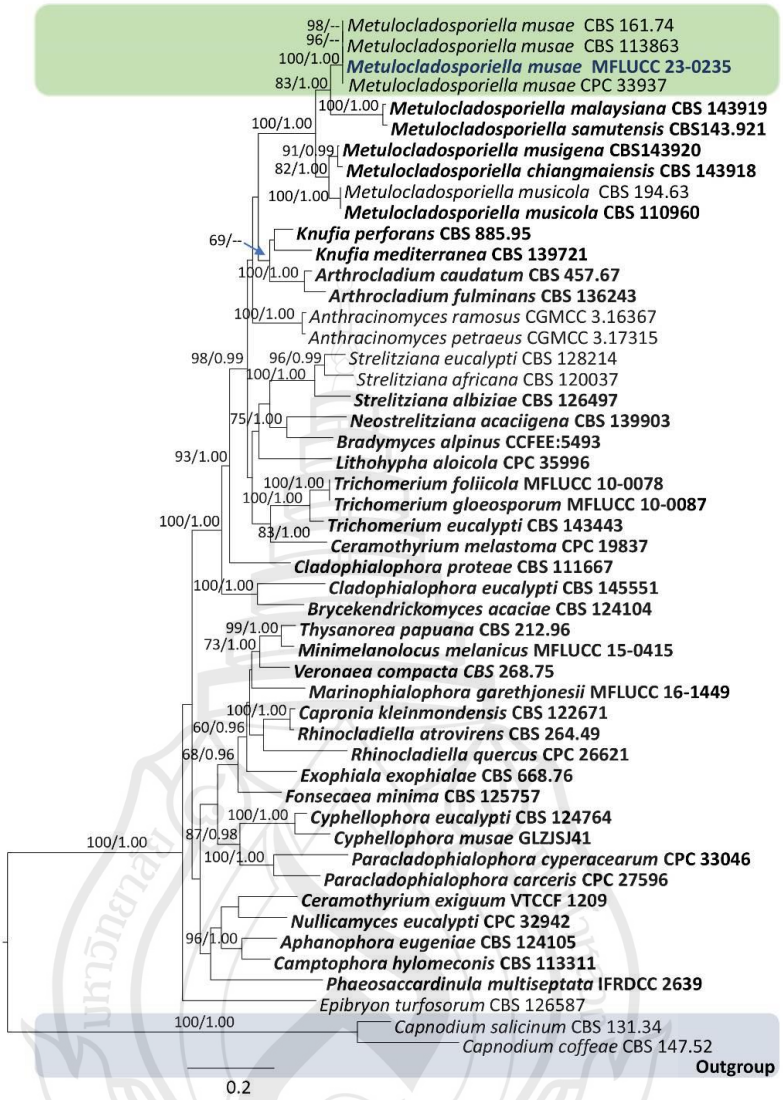
GenBank numbers — LSU= PP800441, ITS= PP809108

Notes — *Metulocladosporiella musae* was previously known as *Cladosporium musae* which causes speckle diseases in *Musa* spp. The fungus has been discovered in all the banana growing countries across the world, including Thailand (Jones, 2018). The species has been restricted to *Musa* spp. and its saprobic or endophytic lifestyles are still unknown. We found the species associated with the necrotic area of the leaf spots on *Musa* sp. However, the pathogenicity of our new collection is yet to be proven in future studies. When comparing the DNA sequences in BLAST search, our isolate showed a high percentage similarity to *M. musae* (CBS 161.74; LSU=100%) and (CPC 33937; ITS=100%) with the query covers of 100% and 92%, respectively. In the multi-gene analyses of combined LSU and ITS sequence data (Fig. 3.31), our isolate was grouped with the ex-type strain of *M. musae* with ML=100%, BI=1.00 bootstrap support. We report the occurrence of *M. musae* as a fungus that is associated with the leaf spots of *Musa* sp. from Thailand as a new collection.



Note a–b Leaf spots on *Musa* sp. c, d Conidiophores on the necrotic patch. e–g, j Conidiophores. h, i Base and the middle body of the conidiophore. k–q Conidiogenesis at the terminal branchlets of the conidiophore. r, s Conidia. Scale bars: a, b=30 cm, c=1 mm, d=200 μm, e, f, h–s=50 μm, g=100 μm, r, s=10 μm.

Figure 3.30 *Metulocladosporiella musae* (MFLU 23-0303)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Capnodium coffeae* (CBS 147.52) and *C. Salicinum* (CBS 131.34) (*Capnodiaceae*). The strain generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree shows the phylogenetic position of *Metulocladosporiella musae.*

Figure 3.31 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of *Herpotrichiellaceae*

Sordariomycetes O. E. Erikss. & Winka

Amphisphaeriales D. Hawksw. & O. E. Erikss.

Amphisphaeriales has been accepted in *Xylariomycetidae* (Senanayake et al., 2015; Samarakoon et al., 2022a). Hyde et al. (2020) and Wijayawardae et al. (2022) accepted 17 families and 88 genera in the order.

Apiosporaceae K. D. Hyde, J. Fröhl., Joanne E. Taylor & M. E. Barr

Apiosporaceae was established by Hyde et al. (1998) to accommodate *Appendicospora*, *Arthrinium* (= *Apiospora*), *Dictyoarthrinium*, *Endocalyx* and *Spegazzinia*. Tanaka et al. (2015) later included *Spegazzinia* in *Didymosphaeriaceae* (*Pleosporales*). Based on morpho-molecular data, Wang et al. (2017) included *Nigrospora* in *Apiosporaceae*. In addition, Samarakoon et al. (2020b) transferred *Dictyoarthrinium* to *Didymosphaeriaceae* (*Pleosporales*) sister to *Spegazzinia*. Konta et al. (2021) provided molecular data for *Endocalyx* and accommodated it in *Cainiaceae* (*Xylariales*) based on morphology and multi-gene phylogeny. Pintos and Alvarado (2021) suggested considering *Arthrinium sensu stricto* and *Apiospora* as two independent lineages in *Apiosporaceae*. Samarakoon et al. (2022a) established *Appendicosporaceae* as a new family and accommodated *Appendicospora*. At present, the family hosts three genera, *viz. Apiospora*, *Arthrinium* and *Nigrospora*. The species of the family can be saprobes, pathogens or endophytes associated with plant tissues, soil, lichens, and marine algae (Hyde et al., 2020a).

Apiospora Sacc., Atti Soc. Veneto-Trent. Sci. Nat., Padova, Sér. 4 4: 85 (1875)

The genus was introduced by Saccardo (1875), with *A. montagnei* as the type. The asexual morph of *Apiospora* has basauxic conidiogenesis, with globose to subglobose, pale brown to brown conidia (Crous & Groenewald, 2013; Hyde et al., 2020a). In addition, the conidia are generally lenticular from a side view (Tian et al., 2021). *Apiospora* considered the sexual morph of *Arthrinium* and was synonymized by Crous and Groenewald (2013). Pintos and Alvarado (2021) separated several taxa of *Arthrinium* and proved *Apiospora* to be a phylogenetically distinct lineage. *Apiospora* is cosmopolitan and can be found as endophytes, pathogens and saprobes (Tian et al., 2021). One hundred and thirty-seven *Apiospora* species epithets can be

found in Index Fungorum (2024). *Apiospora sacchari* has been reported on *Musa* sp. (Ellis, 1971a).

Apiospora locuta-pollinis (F. Liu & L. Cai) Pintos & P. Alvarado, Fungal Syst. Evol. 7: 206 (2021)

Figure 3.32

Index Fungorum number: IF 837763; Facesoffungi number: FoF 15204

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* on natural substrate dry, widely effused, dark brown to black, fructifications occasionally erumpent, glistening, conidia are liberated on the substrate when disturbed. *Mycelium* partly superficial, partly immersed, often with connecting hyphae which become very narrow where they pass through the host cuticle, hyaline, septate, smooth-walled. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* 5–6 × 0.8–1.2 μm ($\bar{x}$=5.8 × 0.9 μm, n=20), basauxic, macronematous, mononematous, arising singly from subspherical, ampulliform, conidiophore mother cells, simple, often narrow, more or less cylindrical, thread-like, hyaline. *Conidiogenous cells* terminal, cylindrical. *Conidia* 7.5–9 × 6–8.5 μm ($\bar{x}$=8.6 × 8 μm, n=40), solitary or catenate, terminal, brown, smooth, aseptate, in face view globose to subglobose, in side view lenticular with a longitudinal hyaline germ slit, germ tube visible. *Sterile cells* 7–8 × 3–4 μm ($\bar{x}$=7.5 × 3.5 μm, n=20), terminal or subterminal in place of conidia, smaller, paler and differ in shape to the conidia, one side flattened, polygonal, hat-shaped or irregularly-shaped, often with a highly refractive cubical body.

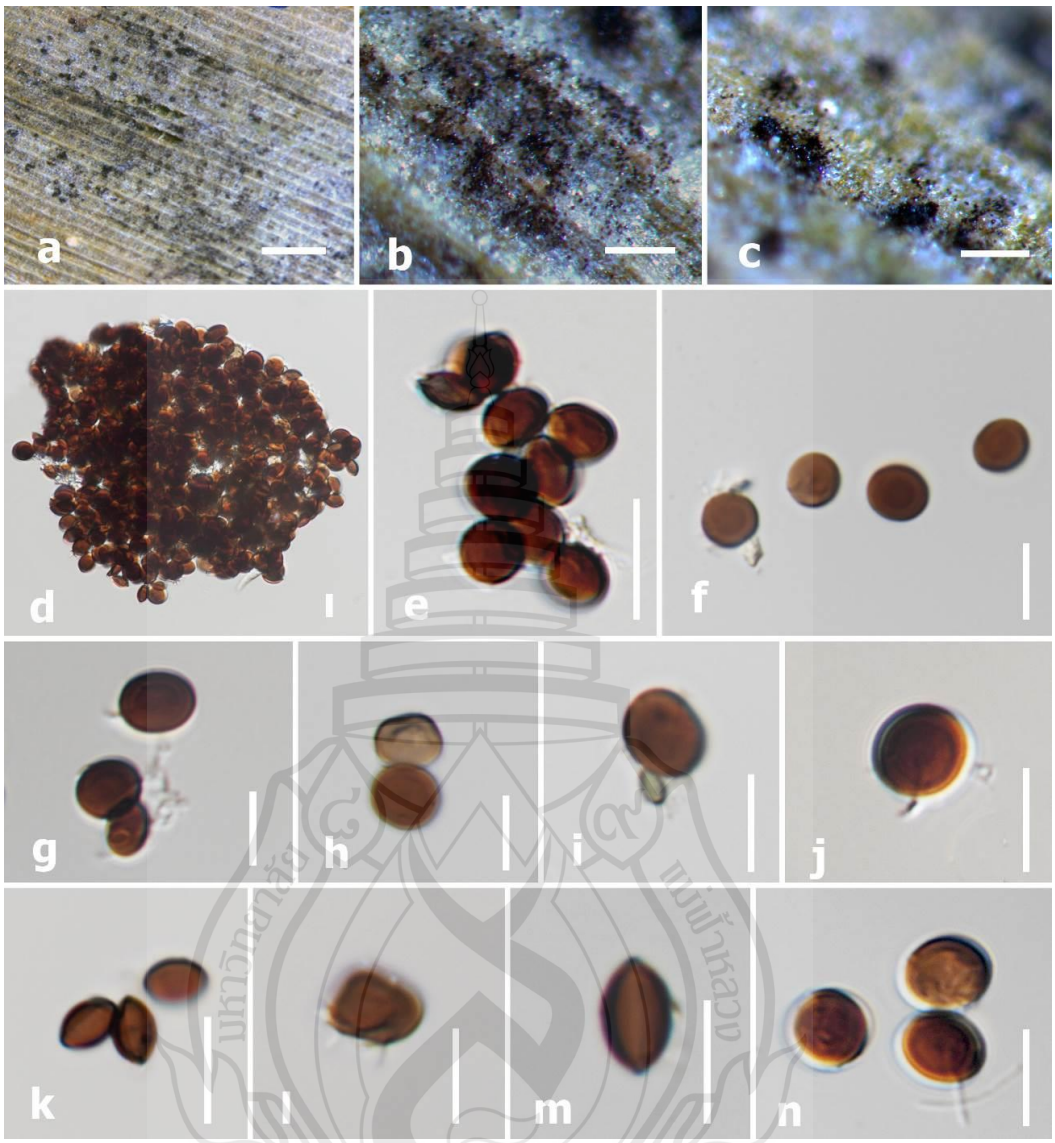
Cultural characteristics — Colonies on PDA, reaching 55 mm in 7 days at 25 °C, colonies white and fluffy, aerial mycelium is visible, reverse smoke grey. Sporulation was observed after 28 days at 25 °C.

Material examined — Thailand, Chiang Rai Province, Mae Sai, on a dead leaf of *Musa* sp., 19 April 2019, B.C. Samarakoon, BNS112 (MFLU 23-0304), culture MFLUCC 23-0229.

GenBank numbers — LSU= PP800442, ITS= PP809109, *tef*1= PP866296, *tub2*= PP840929

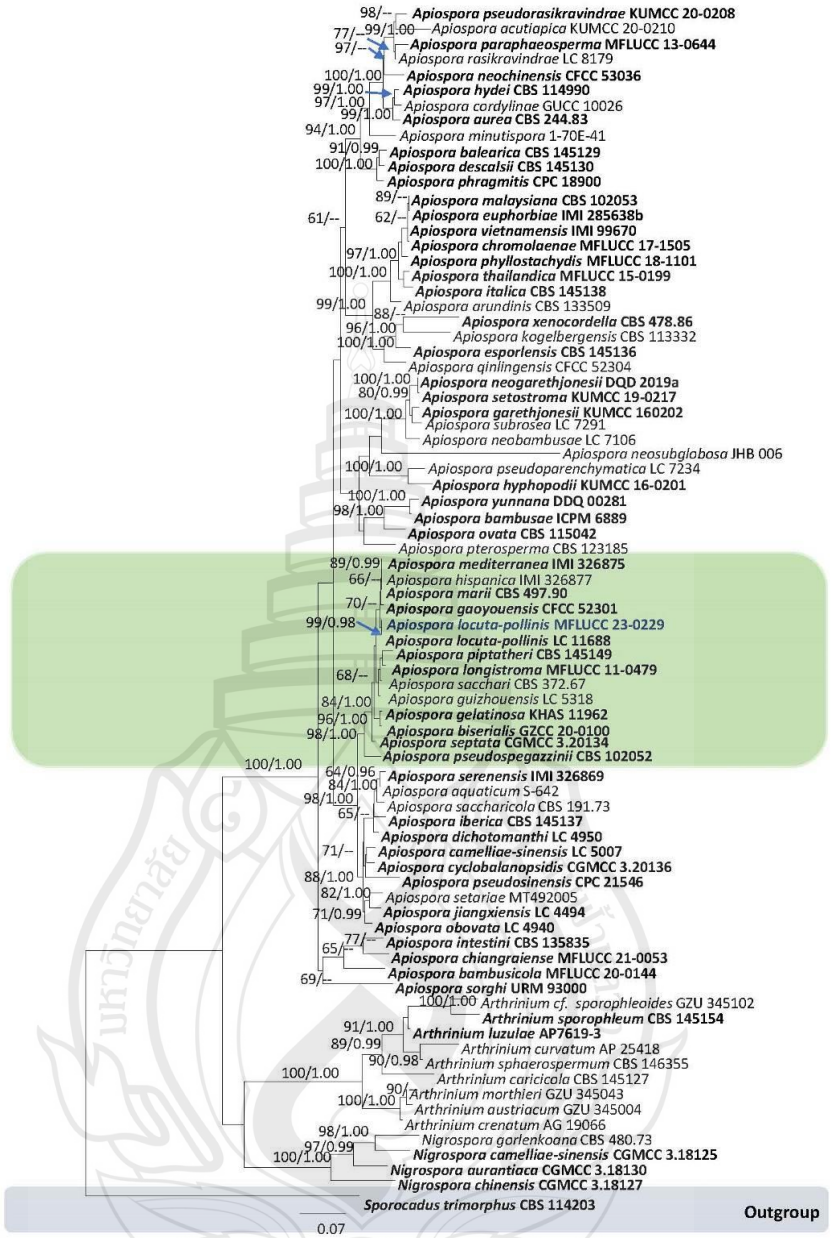
Notes — In the multi-gene phylogenetic analyses of LSU, ITS, *tub*2 and *tef*1 sequence data, MFLUCC 23-0229 grouped with *Apiospora locuta-pollinis* (LC11686)

(Zhao et al. 2018) with ML=99%, BI=0.98 statistical support (Fig. 3.33). Based on BLAST search results of LSU, ITS, *tub*2, and *tef1* sequence data, our strain exhibits high similarity to *A. locuta-pollinis* (LC11688) with the following percentages: LSU=99.76%, ITS=99.83%, *tub*2=99.32%, and *tef*1 =100%, all with 100%, 99.53%, 100%, and 100% query covers, respectively. We have noticed a slightly different morphology in the sterile cells of our collection when compared to that of the holotype. The sterile cells in our collection are hat-shaped to irregular in shape, while the holotype has elongated cells. However, MFLUCC 23-0229 is genetically identical to the ex-type. *Apiospora locuta-pollinis* (= *Arthrinium locuta-pollinis*) has been described from hive-stored pollen of Italian honey bee colonies from Hubei Province, China, by Zhao et al. (2018). This is the first saprobic report of the species in terrestrial habitats. In addition, this is the first occurrence of *Apiospora locuta-pollinis* in *Musaceae* and in Thailand.



Note a–c Colony on host. d Mass of conidia. e f g Conidiogenesis and conidiophores with conidia. h Conidia with the terminal sterile cell. i, j Conidia with conidiophores. k Lenticular conidia from the side view. l Hat-shaped sterile cell. m Hyaline germ slit of the conidium. n Solitary and catenate conidia. Scale bars: a, b, c=200 µm, d–j, l–n=10 µm, k=15 µm.

Figure 3.32 *Apiospora locuta-pollinis* (MFLU 23-0304)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are indicated. The tree is rooted with *Sporocadus trimorphus* (CBS 114203) (*Sporocadaceae*, *Amphisphaeriales*). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.33 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS, *tub*2 and *tef*1 sequence data of some selected genera of *Apiosporaceae*

Nigrospora Zimm., Centbl. Bakt. ParasitKde, Abt. II 8: 220 (1902)

Nigrospora exhibits endophytic, pathogenic and saprobic lifestyles on various plant hosts worldwide (Mason, 1925; Uzor et al., 2015; Wang et al., 2017). The genus principally causes leaf spots, leaf blight and squirter diseases in crops, fruits and ornamental plants (Wang et al., 2017). The asexual morph of the genus is characterized by branched conidiophores, monoblastic conidiogenous cells and black, shiny, aseptate conidia (Raza et al., 2019; Wang et al., 2017). There are 39 *Nigrospora* epithets reported in Index Fungorum (2024). Many taxa of the genus (*i.e.*, *N. aurantiaca, N. camelliae-sinensis, N. chinensis, N. hainanensis, N. lacticolonia, N. musae, N. oryzae, N. pyriformis, N. sphaerica* and *N. vesicularis*) were previously reported on *Musa* from Australia, Brunei Darussalam, China, Fiji, Japan and Venezuela (Farr & Rossman, 2024; Kobayashi, 2007; Photita et al., 2002; Wang et al., 2017).

Nigrospora sphaerica (Sacc.) E. W. Mason, Trans. Br. mycol. Soc. 12: 158 (1927)

Figure 3.34

Index Fungorum number: IF 254776; Facesoffungi number: FoF 06599

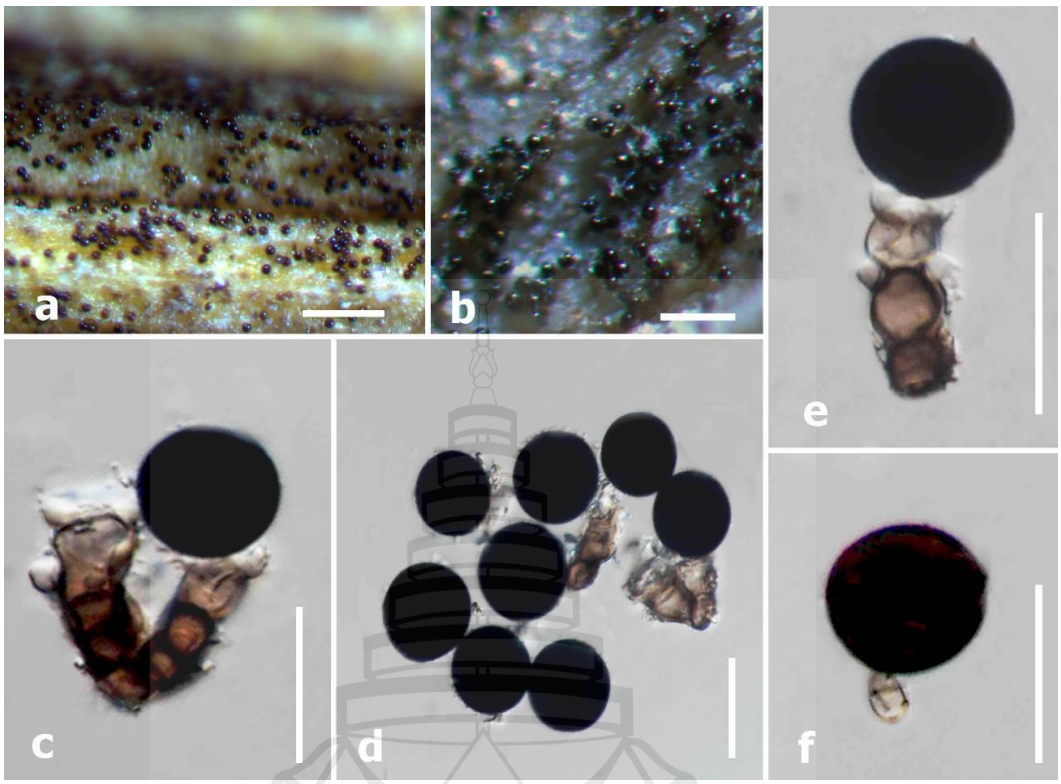
Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Colonies* at first white, with small, shining black conidia, later becoming brown or black when sporulated. *Mycelium* mostly immersed or partly superficial, hyaline or pale brown, septate. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* 25–30 × 8–14 μm ($\bar{x}$=27.5 × 12.5 μm, n=20) micronematous or semi-macronematous, branched, slightly flexuous and tapering towards the base, sub-hyaline to brown, septate, rough, thick-walled and constricted at septa, forming 3 or 4 flask-shaped cells. *Conidiogenus cells* 3–4.5 × 2.5–3.5 μm ($\bar{x}$=3.5 × 3.2 μm, n=10) monoblastic, discrete, solitary, terminal or intercalary, subspherical or flask-shaped, hyaline, with a flattened base and an acute apex, hyaline to sub-hyaline vesicles present at the apex of the conidiophore and surrounding the upper most septum to delimit the conidia and their conidiogenous cells. *Conidia* 19–24 × 18–21 μm ($\bar{x}$=21.5 × 20.2 μm, n=40) solitary, violently discharging, simple, spherical or broadly ellipsoidal, black, shining, smooth, aseptate, germ tube visible.

Cultural characteristics — Colonies on PDA reaching 55 mm diameter after 14 days at 25 °C, colonies, white, fluffy and woolly appearance, entire margin, at maturity light brown at the center, reverse: light brown and getting darker at maturity, sporulation was very rare and was observed after 8 weeks of incubation at 25 °C.

Material examined — Thailand, Chiang Rai Province, Ban Du, on a mid-rib of a dead leaf of *Musa* sp., 10 August 2019, B.C. Samarakoon, BNS228 (MFLU 23-0305), culture MFLUCC 23-0230.

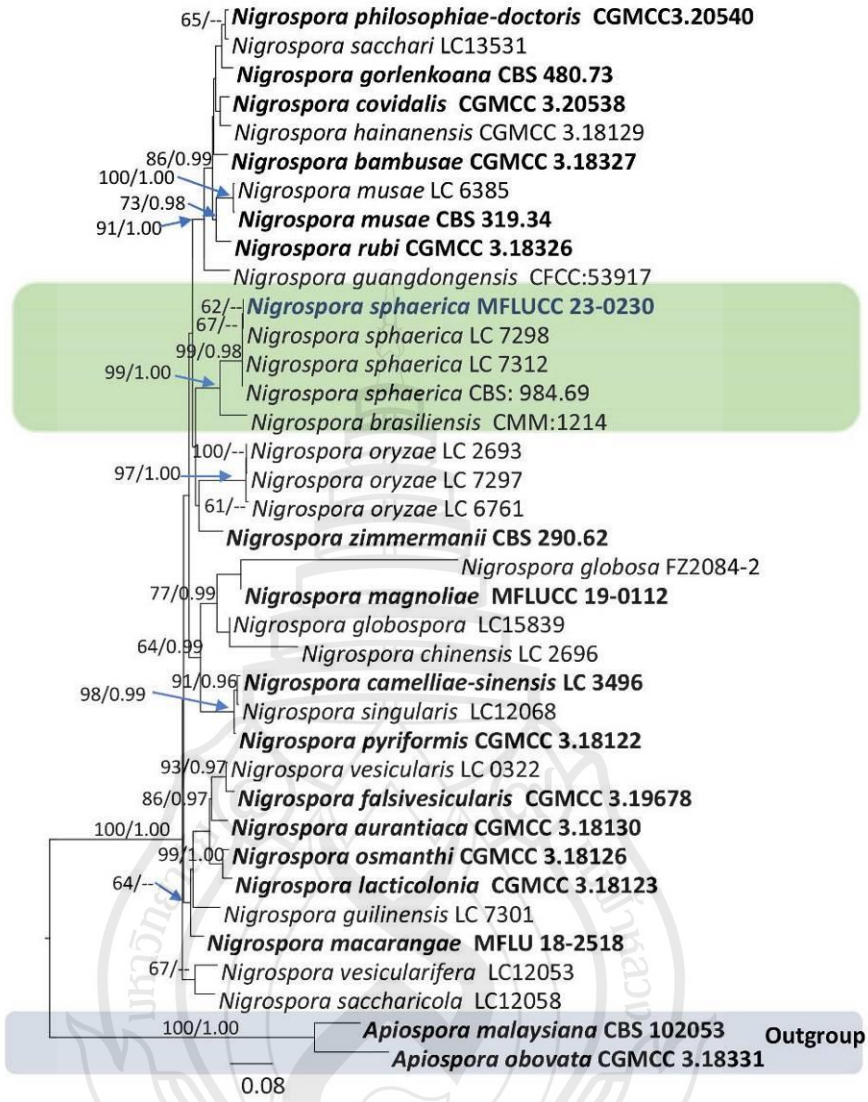
GenBank numbers — ITS= PP809110, *tef*1= PP866297

Notes — In the phylogenetic analyses of combined LSU, ITS, *tub*2 and *tef*1 sequence data, MFLUCC 23-0230 grouped with *Nigrospora sphaerica* (LC7298, LC7312 and CBS984.69) strains (ML=99%, BI=0.98) (Fig. 3.35). *Nigrospora sphaerica* was previously discovered in Thailand as a saprobe on decaying pine litter by Tokumasu et al. (1990). The species is a cosmopolitan plant pathogen causing leaf blights (Liu et al., 2015b), leaf spots, twigs and shoot blights in many commercial crops (Wright et al., 2008). *Nigrospora sphaerica* exhibits three lifestyles on *Musa* hosts. The fungus has been reported as an endophyte associated with *Musa* from Malaysia (Zakaria & Aziz, 2018). In addition, *N. sphaerica* has been documented as a pathogen causing crown rot and leaf spots on *Musa* from Australia, Brunei Darussalam, Fiji and Malaysia (Dingley et al., 1981; Firman, 1972; Peregrine & Ahmad 1982; Simmonds, 1966; Wallbridge & Pinegar, 1975). The fungus has also been found on dead plant materials of *Musa* from China, Guinea, Japan, Somalia, Taiwan, and the West Indies (Castellani & Ciferri, 1937; Kobayashi, 2007; Kranz, 1965; Matsushima, 1980) but has not verified by molecular data. We report the occurrence of the species as a saprobe on dead materials of *Musa* from Thailand for the first time with morphological support and molecular phylogeny.



Note a–b Colony on host. c–e Conidiogenesis and conidiophores with conidia. f Conidia with the germ tube. Scale bars: a, b =200 μm, c–f=30 μm.

Figure 3.34 *Nigrospora sphaerica* (MFLU 23-0305)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Apiospora malaysiana* (CBS 102053) and *A. obovata* (LC4940). The strain generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Nigrospora sphaerica.*

Figure 3.35 Maximum likelihood tree revealed by RAxML analyses of ITS, *tub*2 and *tef*1 sequence data of the taxa of *Apiosporaceae*

Sporocadaceae Corda

The family was introduced by Corda (1842) and is typified by *Sporocadus*. The taxa of *Sporocadaceae* are coelomycetes with appendages. The family includes endophytes, pathogens and saprobes associated with a broad spectrum of host plants (Liu et al., 2019). Most of the *Sporocadaceae* taxa are asexual morphs forming acervuli (Jaklitsch et al., 2016; Liu et al., 2019). Liu et al. (2019) revised the family with the support of morphology and concatenated phylogenetic analyses of LSU, ITS, *rpb*2, *tef*1 and *tub*2 sequence data. The latter study accepted 23 genera and Hyde et al. (2020) accepted 32 genera in the family.

Neopestalotiopsis Maharachch., K. D. Hyde & Crous, Stud. Mycol. 79: 135 (2014)

Neopestalotiopsis was described by Maharachchikumbura et al. (2014). The genus exhibits pathogenic, saprobic and endophytic lifestyles and has mostly been discoverd from tropics and subtropics (Jayawardena et al., 2019; Maharachchikumbura et al., 2014). The genus is a plant pathogen, causing leaf spots, post-harvest fruit rots and root rots (Jayawardena et al., 2016, 2019). Based on morphology, *Neopestalotiopsis* can be distinguished from *Pestalotiopsis* and *Pseudopestalotiopsis* by having versicolorous median cells (Maharachchikumbura et al., 2014). *Pestalotiopsis* and *Pseudopestalotiopsis* taxa have concolorous median cells (Maharachchikumbura et al., 2014).

Neopestalotiopsis clavispora (G.F. Atk.) Maharachch., K. D. Hyde & Crous, Stud. Mycol. 79: 138 (2014)

Figure 3.36

Index Fungorum number: IF 809764; Facesoffungi number: FoF 03819

Associated with the leaf blotch on *Musa* sp. Sexual morph: Not observed. Asexual morph: Hypomycetous. *Conidiomata* 200–250 μm diam. ($\bar{x}$=230.5 μm, n=40), acervulus, black, scattered, rupturing the epidermis and dehiscing irregularly, numerous. *Conidiophores* 9.5–12 × 4.5–6 μm ($\bar{x}$=11 × 5 μm, n=20) hyaline, simple, short to relatively long, wide from the center, acute from base and apex. *Conidia* 18–27 × 5–7 μm ($\bar{x}$=22.5 × 6 μm, n=40), fusiform, straight or clavate, 2-septate or aseptate at immature stage, 4-septate at maturity. *Basal cell* 4–5.5 × 2–2.8 μm ($\bar{x}$=5 × 2.5 μm, n=40), hyaline, elongated, cone-shaped, thin-walled and minutely

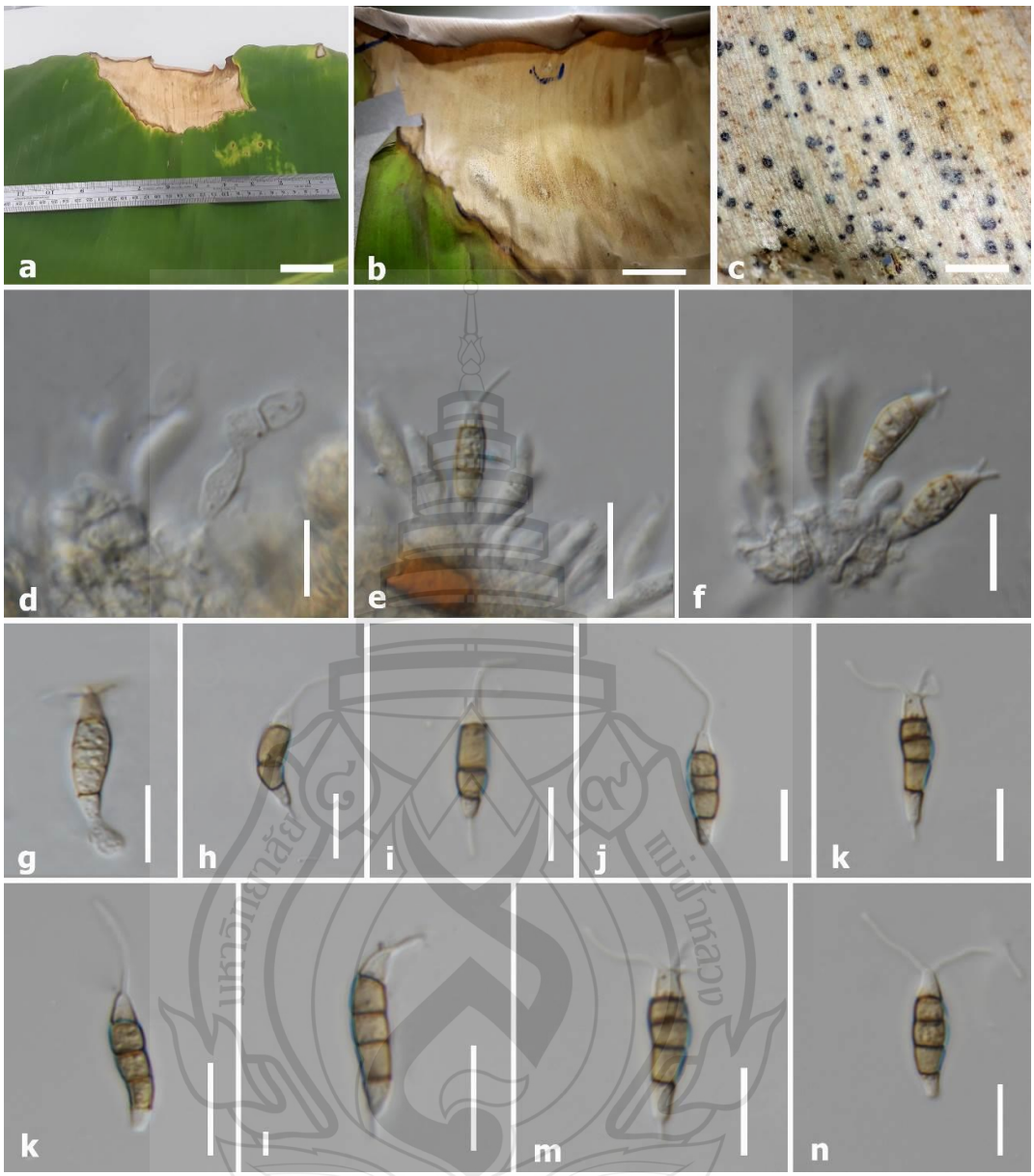
verruculose. *Three median cells* 4–5 × 2.5–3 μm ($\bar{x}$=4 × 2.6 μm, n=40), pale brown or brown, versicolored at maturity, septa and periclinal walls darker than the rest of the cells, verruculose. *Apical cell* 3–3.5 × 1–2 μm ($\bar{x}$=3 × 2 μm, n=10), short, also corn-shaped but broader than the basal cell, hyaline, sub-cylindrical. *Apical appendages* 20–26 × 0.5–1 μm ($\bar{x}$=24 × 0.8 μm, n=50), tubular, often 1–3, arising from the apex of the uppermost cell. *Basal appendages* 3–4.5 × 0.5–0.9 μm ($\bar{x}$=3.5 × 0.8 μm, n=40), comparatively short, straight, hyaline, cylindrical, arising from the base of the basal cell, sometimes absent.

Cultural characteristics — Colonies on PDA, white, fluffy and cottony, reaching 55 mm in 5 days at 25 °C, with a visible, aerial mycelium, lower surface is mostly smoke grey. Sporulation was very common at 25 °C as black glittering heads after 21 days.

Material examined — Thailand, Chiang Rai Province, Nang Lae, on a fresh leaf spot on *Musa* sp. (*Musaceae*), 14 May 2021, B.C. Samarakoon, 433C (MFLU 23-0306), culture MFLUCC 23-0247.

GenBank numbers — ITS= PP809111, *tub*2= PP840930, *tef*1= PP866298

Notes — In the multi-gene phylogeny of combined ITS, *tub*2 and *tef*1 sequence data, MFLUCC 23-0247 grouped with *Neopestalotiopsis clavispora* (ex-type: MFLUCC 12-0281) with a strong statistical support (ML=100%, BI=1.00) sister to *N. elipsospora* (Fig. 3.38). *Neopestalotiops clavispora* was recently reported as a pathogen causing leaf spots on *Musa* sp. at the pre-harvest stage in China (Qi et al., 2022). Our strain (MFLUCC 23-0247) was also isolated from leaf spots on *Musa* and the pathogenicity of the strains will be proven in future studies with accurate field trials. In addition, the pathogen was reported worldwide as causing leaf spots, blights, fruit rots, rot rots, crown rot and die back diseases in several agricultural crops (Biju et al., 2018; Jevremović et al., 2022; Prasannath et al., 2020; Shahriar et al., 2022). *Neopestalotiopsis clavispora* was previously reported from Thailand, causing flower blight on *Anthurium andraeanum* (Daengsuwan et al., 2021). This is the first report of the fungus associated with *Musa* leaf spots in Thailand.



Note a–b Leaf blotch on *Musa* sp. c Conidiomata on necrotic patches. d–f Conidial attachments and conidiogenesis. g–n Conidia. Scale bars: a, b=1000 μm, c=200 μm, d=10 μm, e–n=15 μm.

Figure 3.36 *Neopestalotiopsis clavispora* (MFLU 23-0306)

Neopestalotiopsis musae Norph. & K. D. Hyde, Fungal Diversity 80: 209 (2016)

Figure 3.37

Index Fungorum number: IF 552233; Facesoffungi number: FoF 02363

Associated with the leaf spot with yellow halo on *Musa* sp. Symptoms on the leaves were initially small, irregular, brown spots that gradually expanded to fusiform-shaped lesions with a yellow halo and eventually became necrotic. Sexual morph: Not observed. Asexual morph: *Conidiomata* 150–220 × 70–90 μm ($\bar{x}$=160 × 84 μm), acervulus, with basal stroma, rupturing the epidermis, sub-hyaline wall 1–3 cells thick, *textura angularis*. *Conidiophores* 7–9 × 2–3 μm ($\bar{x}$=7.5 × 2.6 μm, n=20), reduced to conidiogenous cells, enteroblastic, hyaline, ovate to filiform, simple, distinctly thick-walled. *Conidia* 30–38 × 8–10 μm ($\bar{x}$=34.5 × 9.5 μm), fusiform at maturity, ellipsoid or sub ellipsoid at immature stage, straight or curved, at maturity 4-septate, basal cell cone-shaped, hyaline, smooth-walled. *Basal cell* 8–9.5 × 3–4 μm ($\bar{x}$=8.5 × 3.6 μm, n=40), hyaline, elongated, cone-shaped, thin-walled and minutely verruculose, sometimes with a flat apex and acute base. *Three median cells* 23–25 × 9–12 μm ($\bar{x}$=23.8 × 10.2 μm, n=40), olivaceous-brown, versicolored at maturity, septa and periclinal walls darker than the rest of the cells, often verruculose, sometimes smooth. *Apical cell* 7–8 × 3–4 μm ($\bar{x}$=7.5 × 3.5 μm, n=40), short, also cone-shaped or flat, hyaline. *Apical appendages* 20–30 × 1–3 μm ($\bar{x}$=24 × 1.5 μm, n=50), tubular, often 1–3, arising from the apex of the uppermost cell, notably curved. *Basal appendages* 4–5 × 1–1.5 μm ($\bar{x}$=4.5 × 1.5 μm, n=40), comparatively short, straight, hyaline and cylindrical, arising from the base of the lower cell, sometimes absent.

Culture characteristics — Colonies on PDA, at 25 ºC reaching 55 mm diam. after 12 days, dense mycelium, circular, rough margin white, fluffy, concentric ring patterns sometimes present at immature stage, after 2 weeks the growth reduced, flat on the surface, pale brown discoloration occurs.

Material examined — Thailand, Chiang Mai, Chiang Dao, on a dead leaf of *Musa* sp. (*Musaceae*), 20 June 2021, B.C. Samarakoon, 447 (MFLU 23-0307), culture, MFLUCC 23-0282.

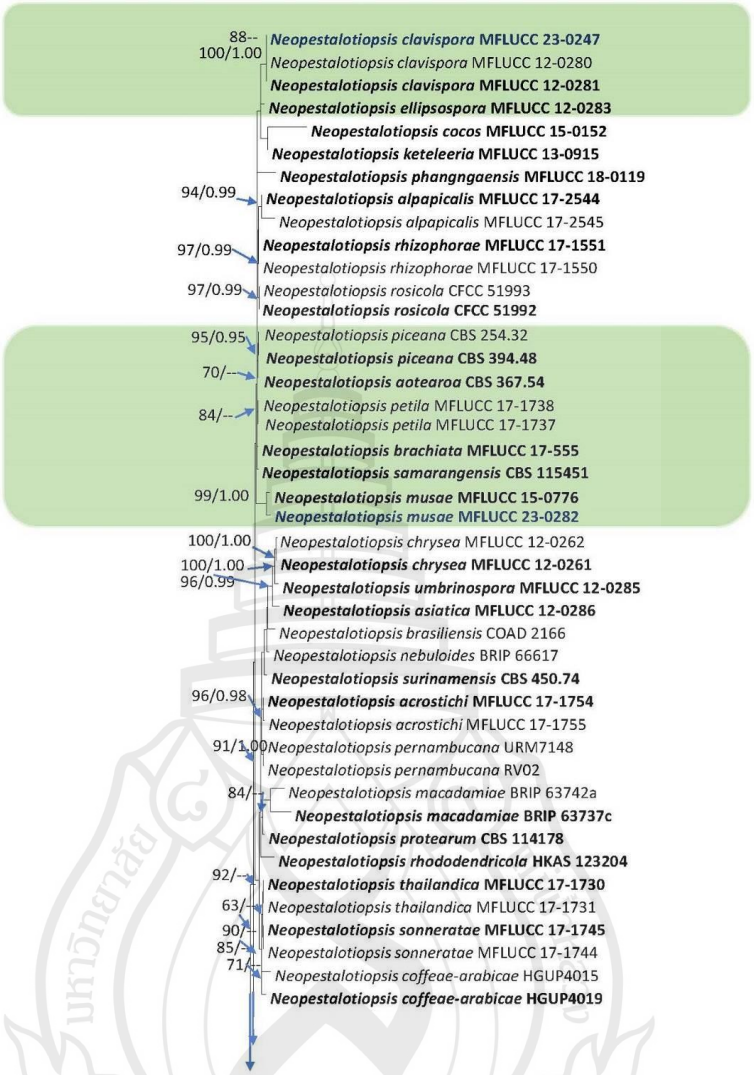
Notes — *Neopestalotiopsis musae* was described by Hyde et al. (2016) as a pathogen causing leaf spots on *Musa* sp. from Thailand. In the multi-gene phylogeny,

our strain (MFLUCC 23-0282.) and the ex-type strain of *N. musae* formed a distinct clade with ML=99% and BI=1.00 support values (Fig. 3.38). Morphologically, our new collection is similar to the holotype, except for the dimension of conidia, which may change with the environment. We report *N. musae* associated with the leaf spots on *Musa* sp. in Thailand.



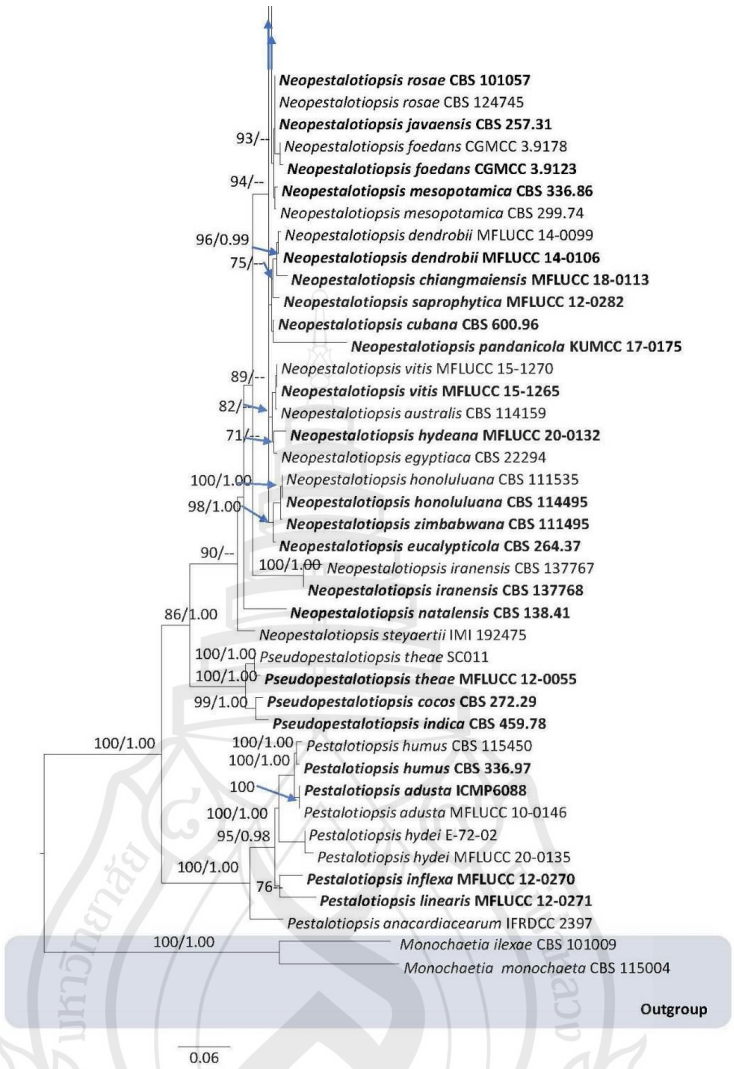
Note a–d Leaf spots lesions with yellow halo on *Musa*. e, f Colony on host. g Transverse section of the conidiomata. h–j Conidiogenesis and conidiophores with conidia. k–t Conidia. Scale bars: c, d, e =1000 μm, f=500 μm, g=50 μm, h–t=20 μm.

Figure 3.37 *Neopestalotiopsis musae* (MFLU 23-0307)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Monochaetia ilexae* (CBS 101009) and *M. monochaeta* (CBS 115004). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic positions of *Neopestalotiopsis clavispora* (MFLUCC 23-0282) and *N. musae* (MFLUCC 23-0247)

Figure 3.38 Maximum likelihood tree revealed by RAxML analyses of ITS, *tub*2 and *tef*1 sequence data of the taxa of *Sporocadaceae*



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Monochaetia ilexae* (CBS 101009) and *M. monochaeta* (CBS 115004). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.38 (continued)

Diaporthales Nannf.

Diaporthales accommodates pathogens, endophytes and saprobes in terrestrial and aquatic habitats (Senanayake et al., 2017, 2018). The sexual morph is characterized by papillate, solitary or aggregated perithecia, 2–32-spored, single-walled asci with conspicuous refractive rings (Senanayake et al., 2017). The asexual morph is mainly coelomycetous and sometimes hyphomycetous (Senanayake et al., 2018). Hyde et al. (2020) accepted 30 families and 181 genera in *Diaporthales*. Recently, several genera, such as *Pseudocryphonectria* (*Cryphonectriaceae*), *Phaeotubakia* (*Tubakiaceae*), *Pseudomastigosporella* (*Foliocryphiaceae*) and *Pseudophaeocytostroma* (*Diaporthaceae*) were included in the order (Huang et al., 2022; Monkai et al., 2022; Wang et al., 2022).

Diaporthaceae Höhn. ex Wehm.

The family was introduced and accommodated in *Diaporthales* by Höhnel (1917) and typified by *Diaporthe*. Most of the genera in the family are pathogens associated with commercial crops, causing cankers, fruit, root and seed decay, diebacks, leaf spots and blights (Gomes et al., 2013; Lamprecht et al., 2011). In addition, the genera exhibit endophytic and saprobic lifestyles (Abeywickrama et al., 2022; de Silva et al., 2021; Senanayake et al., 2017). Hyde et al. (2020) accepted 15 genera in the family and *Pseudophaeocytostroma* was recently included by Monkai et al. (2022). In this study, we introduce *Pseudophaeocytostroma sacchari* as an endophytic fungal taxon isolated from the fresh leaves of *Musa* sp. from Thailand.

Pseudophaeocytostroma Monkai & Phookamsak, Phytotaxa 571: 45 (2022)

Pseudophaeocytostroma was introduced by Monkai et al. (2022) in *Diaporthaceae* based on the phylogenetic positions of *P. bambusicola* and *P. sacchari*. *Pseudophaeocytostroma* has a similar morphology to *Phaeocytostroma*, which is characterized by the coelomycetous asexual morph, with uni- to multilocular conidiomata and dimorphic conidia. The alpha conidia are aseptate, sub-hyaline to brown and ellipsoid to fusiform. The beta conidia are fusiform and short or elongate (Lamprecht et al., 2011). This study reports the endophytic lifestyle of *Pseudophaeocytostroma sacchari* associated with *Musa* leaves in Thailand.

Pseudophaeocytostroma sacchari (Ellis & Everh.) B. Sutton, Mycol. Pap. 97: 26 (1964)

Figure 3.39

Index Fungorum number: IF 336098; Facesoffungi number: FoF 03819

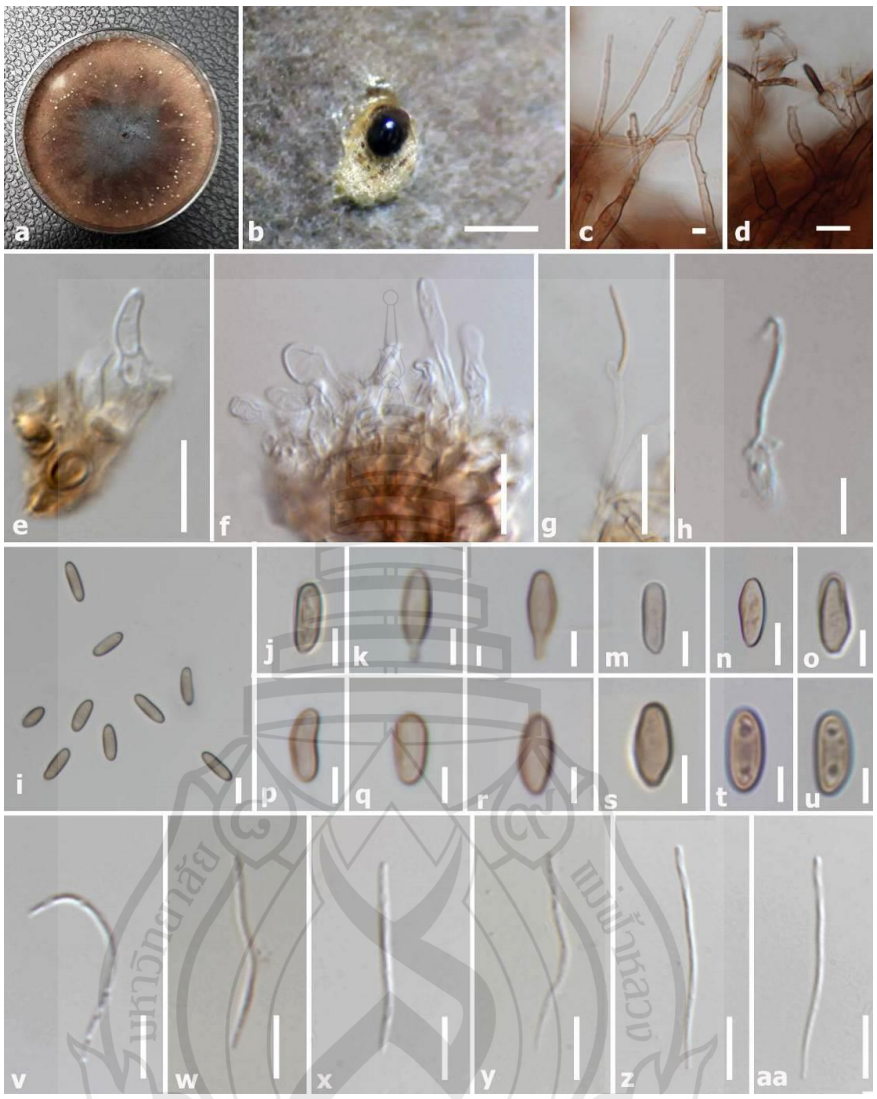
Endophytic on the fresh leaves of *Musa* sp. *Colonies* on PDA at 25 °C in light conditions, reaching 55 mm in 10 days, initially brownish gray with a filamentous to wavy margin, become blackish golden brown at maturity with a dull black center. *Pycnidia formation* initiates as white cottony raised hemi-spherical to spherical spots after one month of incubation at 25 °C in 12 hours of light and 12 hours of dark conditions. *Mycelium* 2–3.5 µm ($\bar{x}$=2.4 µm) wide, sparse, superficial, composed of septate, thick-walled, branched, rough, melanized hyphae with brownish exudates in old cultures. Sexual morph: Not observed. Asexual morph: Coelomycetous. *Conidiomata* 60–65 × 65–70 µm ($\bar{x}$ =63 × 68 µm, n=10) pycnidial, sporulating profusely, globose, unilocular or multilocular, brown, erumpent, blackish brown, shiny, conidial droplets exuding from central ostioles, walls consisting of 3–6 layers of medium brown *textura angularis* cells, hemispherical, surrounded by pale brown cottony web of mycelial outgrowths like a cushion, producing dimorphic conidia referred to here as α and β. *Paraphyses* (34–) 40–55 × 1–1.5 µm ($\bar{x}$ =49.5 × 1.2 µm, n=40), arranged in between conidiophores, broadly filiform, septate, hyaline, branched or unbranched, swollen at the base, obtuse at the apex. *Conidiophores of α conidia* 10–12 (−15) × 2–3.5 µm ($\bar{x}$=11 × 2.6 µm, n=20), short, hyaline to sub-hyaline, tightly aggregated, erect, clavate or straight, cylindrical, subcylindrical to ampulliform, aseptate, often unbranched. *Conidiogenous cells of α conidia* enteroblastic, phialidic, determinate, integrated, hyaline, rough-walled. *α conidia* 7–9 (–12) × 3–4 µm ($\bar{x}$=8.5 × 3.5 µm, n=40), brown to sub-hyaline, thick-walled, of various shapes, ovate, obovate, kidney-shaped, oblong to ellipsoid, obtuse at both ends, or sometimes with truncate base, septate, two distinct guttules observed in mature cultures. *Conidiophores of β conidia* 25–30 × 1.5–2 µm ($\bar{x}$=26.8 × 1.5 µm, n=30), comparatively narrow and elongated, sub-hyaline or often hyaline, arising singly and producing 3–4 branches from the middle, each sub-branch tapering towards the apex, clavate, cylindrical, smooth, thin to slightly thick-walled, producing two terminal conidiogenous cells on the apex of each branch, scars visible after

conidiophore secession. *β conidia* (26–) 30–35 (–38) × 0.7–1 μm ($\overline{x}$=34 × 0.85 μm, n=40), spindle-shaped, aseptate, smooth, hyaline, apex subacutely rounded, base truncate or rounded, tapering from towards apex, straight or flexuous, thin-walled, guttules absent. *Chlamydospores* formed in mature cultures. Sexual morph: Not observed.

Material examined — Thailand, Chiang Rai Province, Tap Tao, associated with a fresh leaf of *Musa* sp., 18 October 2021, B.C. Samarakoon, FC01 (MFLU 23-0308), culture MFLUCC 23-0231.

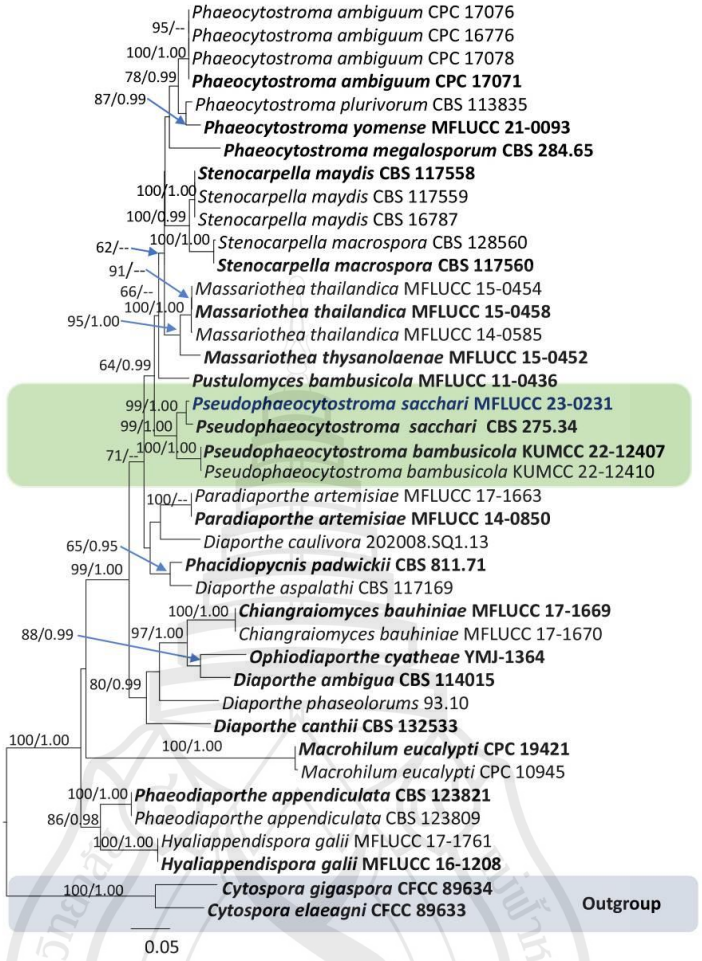
GenBank numbers — LSU= PP800443, ITS= PP809113

Notes — In the combined DNA sequence analyses of LSU, ITS and *tef*1, MFLUCC 23-0231 grouped with *Pseudophaeocytostroma sacchari* (CBS:275.34) with ML=99%, BI=1.00 statistical support (Fig. 3.40). *Pseudophaeocytostroma sacchari* is mainly associated with *Saccharum officinarum* as pathogen and saprobe (Lamprecht et al., 2011). Based on morphology and phylogenetic support, *Pseudophaeocytostroma sacchari* is presented herein as an endophytic species associated with fresh *Musa* sp. leaves from Thailand. This is the first report of the genus associated with *Musa* hosts and the first geographical occurrence in Thailand.



Note a Colony on PDA at 25 °C after 10 days. b Conidiomata on PDA. c, d Thick-walled mature mycelium. e–h Conidial attachments and conidiophores. i–u α conidia. v–aa β conidia. Scale bars: b=100 μm, c, d=3 μm, h–u=5 μm, e–g, v–aa=10 μm.

Figure 3.39 *Pseudophaeocytostroma sacchari* (MFLU 23-0308)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Cytospora elaeagni* (CFCC 89633) and *C. gigaspora* (CFCC 89634). The strain generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Pseudophaeocytostroma sacchari.*

Figure 3.40 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS and *tef*1 sequence data for the taxa of *Diaporthaceae*

Glomerellales Chadef. ex Réblová, W. Gams & Seifert

Réblová et al. (2011) validly proposed *Glomerellales* to accommodate *Australiascaceae*, *Glomerellaceae* and *Reticulascaceae* based on morpho-molecular data. The order accommodates five families and 32 genera (Hyde et al., 2020a).

Glomerellaceae Locq.

Glomerellaceae only accommodates *Colletotrichum*, and represents endophytic, saprobic, and parasitic lifestyles (Hyde et al., 2020a; Jayawardena et al., 2021). The sexual morphs of the family comprise solitary to aggregated ascomata; hyaline, septate, and basally branched paraphyses; 8-spored, unitunicate asci with a J- refractive ring; and uni- to biseriate, hyaline, with a variety of shapes of ascospores (Hyde et al., 2020a). The common asexual morph is coelomycetous, with acervular conidiomata that open by rupturing the host tissue. Setae may or may not be present, and the conidiogenous cells are enteroblastic. Conidia are hyaline, aseptate, with varying shapes (Cannon et al., 2012; Hyde et al., 2020a). As a specific feature, taxa of *Glomerellaceae* sometimes produce pale to dark brown appressoria as single or small groups (Cannon et al., 2012).

Colletotrichum Corda**,** Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3: 41 (1831)

Colletotrichum was introduced by Corda (1831) (Hyde et al., 2020a; Maharachchikumbura et al., 2015, 2016). Most of the species in the genus are cosmopolitan pathogens causing pre- and post-harvest diseases in economic crops and forest plants (Cai et al., 2009; Huang et al., 2013; Jayawardena et al., 2016, 2021; Than et al., 2009). In addition, the genus accommodates endophytic and saprobic fungi associated with different plant hosts (Jayawardena et al., 2016; Ma et al., 2018; Samarakoon et al., 2018; Vieira et al., 2014). Liu et al. (2022) accepted 280 *Colletotrichum* species in 16 species complexes and 13 species were further added by Alizadeh et al. (2022), Hassan et al. (2022) and Zheng et al. (2023).

Colletotrichum siamense Prihastuti, L. Cai & K. D. Hyde, Fungal Diversity 39: 98 (2009)

Figure 3.41

Index Fungorum number: IF 515410; Facesoffungi Number: FoF 03599

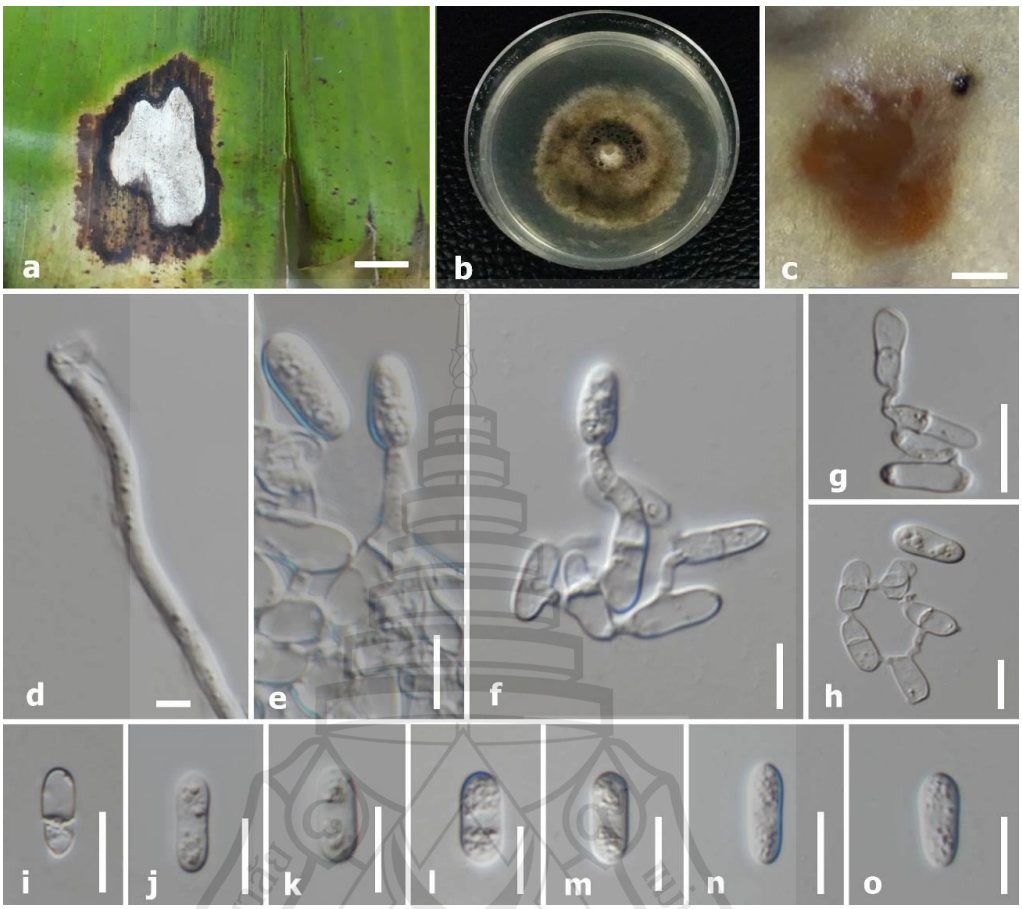
Associated with leaf spots on *Musa* sp. Symptoms on the leaves were initially small, irregular, black spots, the spot enlarges, the central lesions become necrotic surrouned with brown-black streak lesions. Sexual morph: Not observed. Asexual morph: Coelomycetous. *Colonies* on PDA at 25 °C, light, reaching 5 cm diameter in 4 days, initially white, mouse gray or grayish white or pinkish white or brownish, irregular or lobate margin. *Mycelium* initially cottony and flat, sparse at maturity, sometimes aerial, 3–6 µm ($\overline{x}$=3.5 µm) wide, septate, branched, rough-walled, often hyaline in the young colony, brown at maturity. *Sporulation* occurs from the inoculated point after 14 to 28 days, slimy and sticky, conidial masses were visible in salmon pink or orange, 25 °C, at light conditions forming acervulus, not abundant, reverse mouse gray or grayish white, *Sclerotia* present in some isolates. *Conidiophores* 20–28 µm × 2–7 µm ($\overline{x}$=24 × 4.7 µm, n=30), micronematous, hyaline, cylindrical, tapering toward the apex, erect and straight, sometimes slightly flexuous, unbranched, smooth, aseptate, arising from the mycelium, swollen at the base, pointed at the apex. *Conidiogenous cells* 1.5–2 × 1–2 µm ($\overline{x}$=1.7 × 1.5 µm, n=30), hyaline, monoblastic, terminal, cylindrical, having rounded apices, without collarette. *Conidia* 10–15 × 3–5 µm ($\overline{x}$=13 × 3.8 µm, n=40), abundant, smooth, hyaline, aseptate, oval, elliptical or cylindrical, sometimes elongated and flexuous, varying in shape, often with flat base, rounded apex. *Chlamydospores* 8–10 × 3–5 µm ($\overline{x}$=8.7 × 3.8 µm, n=40) visible in mature colonies.

Material examined — Thailand, Chiang Rai, Doi Mae Sa Long, associated with a leaf spot on fresh leaves of *Musa* sp., 17 June 2021, B. C. Samarakoon, 440A-42 (MFLU 23-0309), culture MFLUCC 23-0221.

GenBank numbers — ITS= PP809114, *gapdh*= PP866304, *chs*-1= PP866305, *act* = PP866302

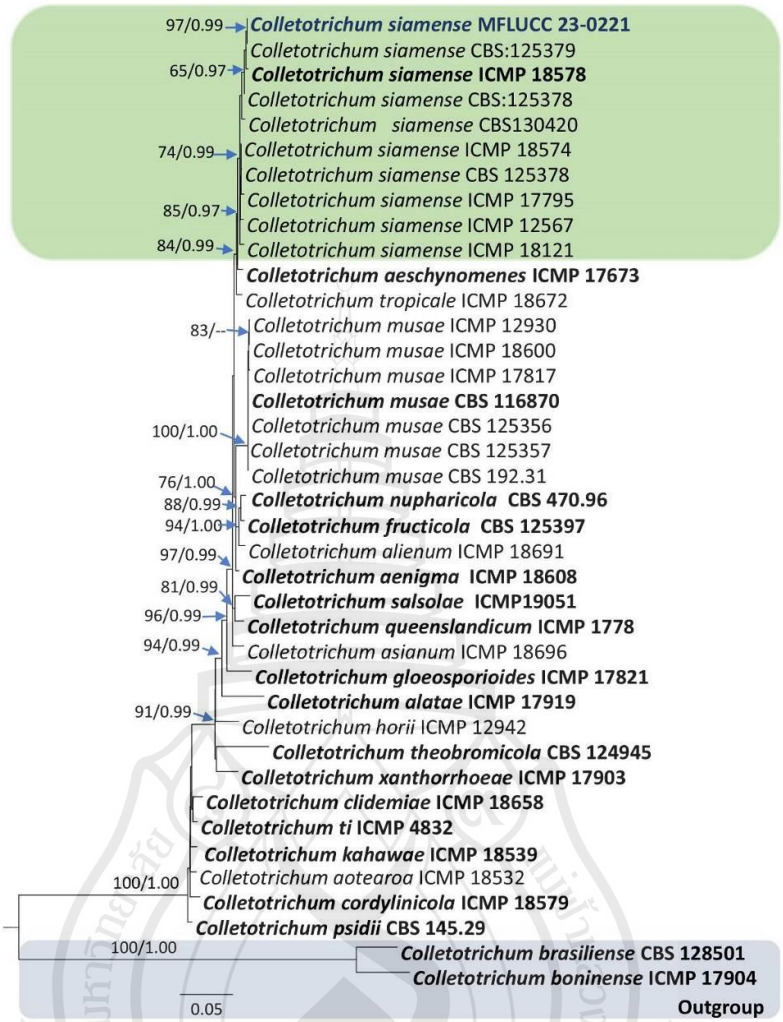
Notes — *Colletotrichum siamense* was introduced by Prihastuti et al. (2009) from Thailand on a berry of *Coffea arabica* and accommodated in the *C. gloeosporioides* species complex. The fungus has been frequently discovered in Asia, causing anthracnose in commercial fruit crops (*i.e.*, avocado, citrus, dragon fruit, papaya, peach, lychee, mango, and walnuts) (Dissanayake et al., 2021). Previously, *C. siamense* was reported in Thailand on *Azdirachta indica* (Udayanga et al., 2013), *Capsicum* (de Silva et al., 2019), *Coffeea arabica*, *Ficus* sp., *Mangifera indica*

(Udayanga et al., 2013), and *Selenicereus undatus* (Meetum et al., 2015). The fungus was previously identified from anthracnose lesions in banana fruits and was proven to be pathogenic in Brazil (Vieira et al., 2017) and Turkey (Uysal & Kurt, 2020). The pathogen has also been detected from the leaf spots of bananas in China (Huang et al., 2021) and India (Kumar et al., 2017). In the multi-gene phylogeny, our strain (MFLUCC 23-0221) grouped with *C. siamense* (CBS: 125379 and ICMP 18578) with ML=97%, BI=0.99 statistical support. Hence, based on morphology and phylogenetic support, we document the presence of *C. siamense* associated with the leaf spots on *Musa* in Thailand. However, the pathogenicity of our strain is yet to be confirmed in future studies.



Note a Leaf spots lesion on the leaf of *Musa acuminata*. b Colony on PDA after 4 weeks. c Salmon orange conidial masses. d Hyphae. e, f Conidiophores and the conidial attachments. g, h. Conidia fused by conidial anastomosis tubes. i-o Conidia. Scale bars: a=1 cm, c=100 μm, d=5 μm, e-o=10 μm.

Figure 3.41 *Colletotrichum siamense* (MFLU 23-0309)



Note ML bootstrap supports (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are given near the nodes, respectively. The tree is rooted with *C. boninense* (ICMP 17904) and *C. brasiliense* (CBS 128501). The strain generated in this study is indicated in bold blue. Ex-type strains are indicated in bold black. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Colletotrichum siamense.*

Figure 3.42 Maximum likelihood tree revealed by RAxML analyses of ITS, *gapdh, cmdA, act,* and *chs*-1 sequence data for selected taxa of the *Colletotrichum gloeosporioides* complex

Plectosphaerellaceae W. Gams, Summerb. & Zare

Zare et al. (2007) established *Plectosphaerellaceae* with *Plectosphaerella* as the type genus, and Maharachchikumbura et al. (2016) accepted the family in *Glomerellales*. At present, *Plectosphaerellaceae* consists of 24 genera exhibiting saprobic and pathogenic lifestyles in plant hosts (Hyde et al., 2020a). Several taxa in the family have bioactive properties (*i.e.*, alkaliphilic or alkalitolerant) (Grum-Grzhimaylo et al., 2016, 2018; Kozlova et al., 2019), and they are often discovered in soil and sometimes as human pathogens (Giraldo & Crous, 2019). The sexual morphs of the family produce flask-shaped perithecia, which are brown at the base with a paler, elongated neck. The asci are clavate and lateral apical thickening can be seen at the immature stage. When the asci become mature, a white mass of ascospores is released from the ostiole. In addition, the ascospores are often 2-celled, hyaline, and have a rough surface comprising several warts (Zare et al., 2007). The asexual morphs of *Plectosphaerellaceae* are phialidic hyphomycetes having verticillate or simple conidiogenous cells with 1–2-celled, ellipsoidal, smooth and hyaline conidia (Giraldo & Crous, 2019). *Acrostalagmus*, *Musicillium* and *Musidium* are reported on *Musa* spp., from different geographical localities around the world. In addition, most of *Musicillium* and *Musidium* have been discovered only from different plant parts of *Musa* spp. (Giraldo & Crous, 2019).

Gibellulopsis Bat. & H. Maia**,** Anais Soc. Biol. Pernambuco 16: 153 (1959)

Gibellulopsis was introduced by Batista and da Silva Maia (1959) and accommodated in *Plectosphaerellaceae* by Zare et al. (2007) with *G. piscis* as its type species. Eight species are accepted in the genus (Index Fungorum, 2023) from aquatic and terrestrial habitats (Giraldo & Crous, 2019). Majority of the taxa were found in soil and plant debris, but some were found in human body parts, moisture-damaged buildings, and insulator wool. Some taxa in the genus (*i.e.*, *G. nigrescens*) have been reported as pathogens causing wilts in commercial crops (Zare et al., 2007). *Gibellulopsis* has only been reported in Japan and India from the entire Asian region (with limited occurrence) and with no records in Thailand. However, the genus has been found in several geographical locations (*i.e.*, Argentina, Brazil, Canada, Cuba, Denmark, Finland, France, Germany, Netherlands, New Zealand, Russia, Sweden, and United Kingdom) (Farr & Rossman 2024; Giraldo & Crous, 2019). This study

presents the first occurrence of *Gibellulopsis* in Thailand as a new geographical record.

Gibellulopsis serrae (Maffei) Giraldo López & Crous, Stud. Mycol. 92: 250 (2018)

Figure 3.43

Index Fungorum number: IF 828040; Facesoffungi number: FoF 15206

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Mycelium* immersed, branched, septate, hyaline, thick-walled 1–2 μm wide. *Conidiophores* 350–450 × (4–) 10–16 μm ($\bar{x}$=410 × 12.5 μm, n=30), erect from hyphae with transparent slimy glistering heads of conidia, unbranched from the middle and base, sometimes branched at the apex, cylindrical and tapering towards the apex, septate, dark brown from the base and getting pale brown and sub-hyaline towards the apex, terminal hyaline, smooth. *Phialides* 30–65 × 3–7 μm ($\bar{x}$=45 × 5.5 μm, n=30), arising from the conidiophore, 3–4 present, hyaline, terminal, rough-walled, pointed, wider at the base and tapering towards the apex. *Conidia* 9–16 × 4–5 μm ($\bar{x}$=14.5 × 4.5 μm, n=40), ellipsoidal with rounded or acute ends, simple, hyaline, rough-walled, sometimes guttules present, conidial chains present.

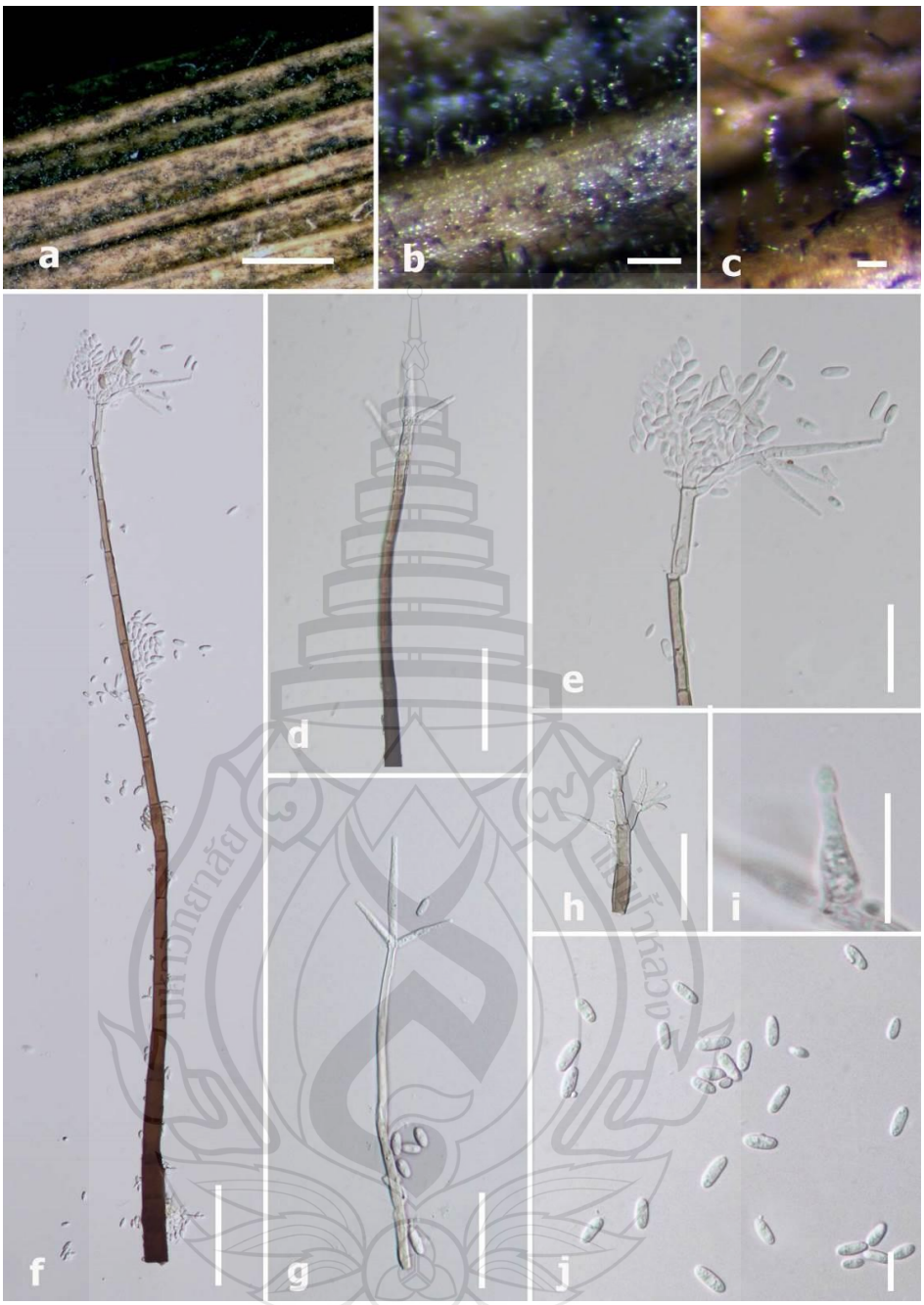
Cultural characteristics — Colonies on PDA, reaching 55 mm in 10 days at 25 °C, flat, white or mouse gray, concentric ring patterns that are slightly visible, irregular margined, reverse smoke grey. Sporulation was observed after 21 days at 25 °C.

Material examined — Thailand, Chiang Rai Province, Tap Tao, on the mid rib of a dead leaf of *Musa* sp., 14 August 2019, B. C. Samarakoon, BNS279 (MFLU 23-0310), culture MFLUCC 23-0308.

GenBank numbers — LSU= PP800445, ITS= PP809116, *tef*1= PP866301

Notes — *Gibellulopsis serrae* was previously reported on *Musa* sp. in India (Giraldo & Crous, 2019). There is no previous literature on the occurrence of the species from Thailand associated with any plant host. The species has been reported from *Abelmoschus esculentus* (Cuba), *Amaranthus tricolor* (Italy), *Beta vulgaris* (Canada) and *Solanum tuberosum* (Germany, Israel, and, Japan) (Giraldo & Crous, 2019). In addition, *G. serrae* was found in soil (Israel and Japan), human blood

(Greece), the eye (Italy) and the granuloma in goldfish (Brazil). Interestingly the fungus has also been documented as a fungicolus on *Cercospora beticola*, *Erysiphe* sp. and *Oidium* sp. in Russia (Giraldo & Crous, 2019). In the phylogenetic analyses of LSU, ITS, *rpb*2 and *tef*1 sequence data (Fig. 3.46), our strain MFLUCC 23-0308 grouped with *G. serrae* (CBS 175.75) with strong statistical support (ML=100%, BI=1.00). We present the first report of *Gibellulopsis* from Thailand with *G. serrae*, a new geographical record.



Note a–c Conidiophores on the host. c Slimy conidial mass with glistering transparent heads. d, e, f Conidiophores, phialides and conidia. g–i Conidiogenesis in phialides. j Conidia. Scale bars: a=200 μm, b, d, f=50 μm, c=10 μm, e, g, h=20 μm, i, j=15 μm.

Figure 3.43 *Gibellulopsis serrae* (MFLU 23-0310)

Musicillium Zare & W. Gams**,** Nova Hedwigia 85: 482 (2007)

Musicillium was introduced by Zare et al. (2007) to accommodate *Verticillium theobromae* (= *Stachylidium theobromae*), the causative agent of the cigar-end rot in bananas. Currently, three accepted species represent the genus with saprobic and pathogenic lifestyles (Giraldo & Crous, 2019; Index Fungorum, 2023). *Musicillium elettariae* and *M. tropicale* have been predominantly discovered in *Musa* species and a few other hosts (*Elettaria*, *Lactarius* and leaf litter). The asexual morph is a hyphomycetes with brown pigmented conidiophores, that verticillate in the upper nodes repeatedly. The conidia arise from the phialides as slimy heads. We report the sexual morph of *Musicillium elettariae* which exhibits the saprobic lifestyle, on *Musa* hosts in Thailand.

Musicillium elettariae Giraldo López & Crous, Stud. Mycol. 92: 267 (201

Figure 3.44

Index Fungorum Number: IF 828065; Facesoffungi Number: FoF 15207

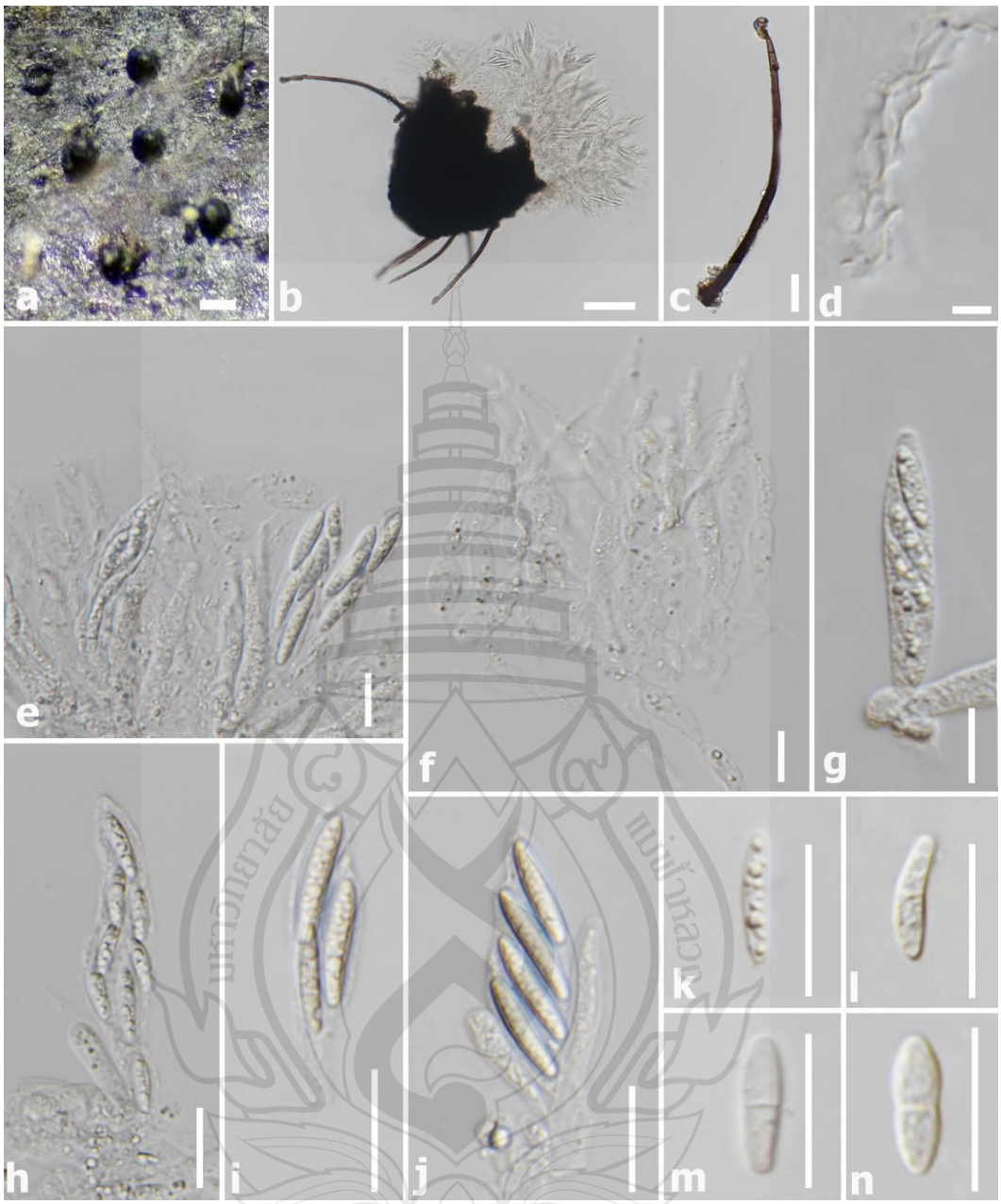
Saprobic on dead leaves of *Musa* sp. Sexual morph: *Ascomata* 70–100 μm ($\bar{x}$=80.5 μm, n=20) in diameter, solitary, mostly superficial, perithecial, black, papillate. *Papilla* central, black, conical, white masses of ascospores released from the ostiole. *Setae* 100–200 × 3–5 μm ($\bar{x}$=120 × 3.5 μm, n=20), elongated, tapering towards the apex, brown, septate, thick-walled. *Peridium* 4–7 μm ($\bar{x}$=5.8 μm, n=30) thick, made up of cells of *textura angularis*. *Paraphyses* 20–50 μm long ($\bar{x}$=36 μm, n=30), widest at base, tapering towards the apex, septate, notably constricted at septa, unbranched, first three cells from the base are elliptic, one cell 8–12 × 5–8 μm ($\bar{x}$=10 × 7 μm, n=20), apical cell 15–25 × 2–3.5 μm ($\bar{x}$=20 × 2.5 μm, n=20), tread-like. *Asci* 50–75 × 8–16 μm ($\bar{x}$=60 × 13.5 μm, n=30), 2–8 spored, unitunicate, cylindrical, straight or clavate, thin-walled, swollen in the center in squash mount, with a short pedicel, no positive reaction in the apical ring observed in Melzer's reagent. *Ascospores* 10–20 × 3–5 μm ($\bar{x}$=15 × 3.7 μm, n=30), uniseriate, overlapping or often biseriate, cylindrical with acute ends or elliptic, hyaline, sometimes swollen at the septum, one septum presents in mature spores, slightly constricted at septum, immature ascospores have several guttules, rough, mature ascospores slightly rough or smooth, gelatinous sheath visible. Asexual morph: Not observed.

Cultural characteristics — Colonies on PDA, reaching 55 mm in 10 days at 25 °C, flat, white, or mouse gray, concentric ring patterns are visible, irregular margined, reverse smoke grey. Sporulation was observed after 14 days at 25 °C.

Material examined — Thailand, Chiang Rai Province, Doi Chang, on a dead leaf of *Musa* sp., 23 June 2021, B. C. Samarakoon, MN27 (MFLU 23-0311), culture MFLUCC 23-0309.

GenBank numbers — LSU= PP800446, ITS= PP809117, *tef*1= PP866300

Notes — The asexual morph of *Musicillium elettariae* has been previously found on *Carex pendula* (Iran), *Elettaria cardamomum* (Rwanda) and *Musa acuminata* (Thailand) (Giraldo & Crous, 2019). Very few genera of *Plectosphaerellaceae* were discovered with the sexual morph (*i.e.*, *Furcasterigmium* and *Plectosphaerella*) (Giraldo & Crous, 2019; Monkai et al., 2020). We could not locate any *Musicillium* collection with its' sexual structures to compare with our specimen. However, our new collection is morphologically similar to the sexual morph of *Furcasterigmium furcatum* (host: *Magnolia liliifera*, Thailand) in Monkai et al. (2020) by having papillate ascomata and hyaline smooth-walled ascospores with a gelatinous sheath. In the multi-gene phylogeny of LSU, ITS, *rpb*2 and *tef*1 sequence data (Fig. 3.46), MFLUCC 23-0309 grouped with *M. elettariae* with ML=99%, BI=1.00 statistical support. We report the sexual morph of *M. elettariae* for the first time as a saprobe on *Musa* sp. in Thailand. In addition, this is the first discovery of the sexual morph of *Musicillium*.



Note a Ascomata on the host surface. b Ascomata in a wet mount slide by squashing. c Setae. d Peridium. e Paraphyses and asci. f Paraphyses. g–j Asci. k–n Ascospores. Scale bars: a=75 µm, b=50 µm, c=25 µm, e–n= 10 µm, d=5 µm.

Figure 3.44 *Musicillium elettariae* (MFLU 23-0311)

Musicillium tropicale Giraldo López & Crous, Stud. Mycol. 92: 268 (2018)

Figure 3 45

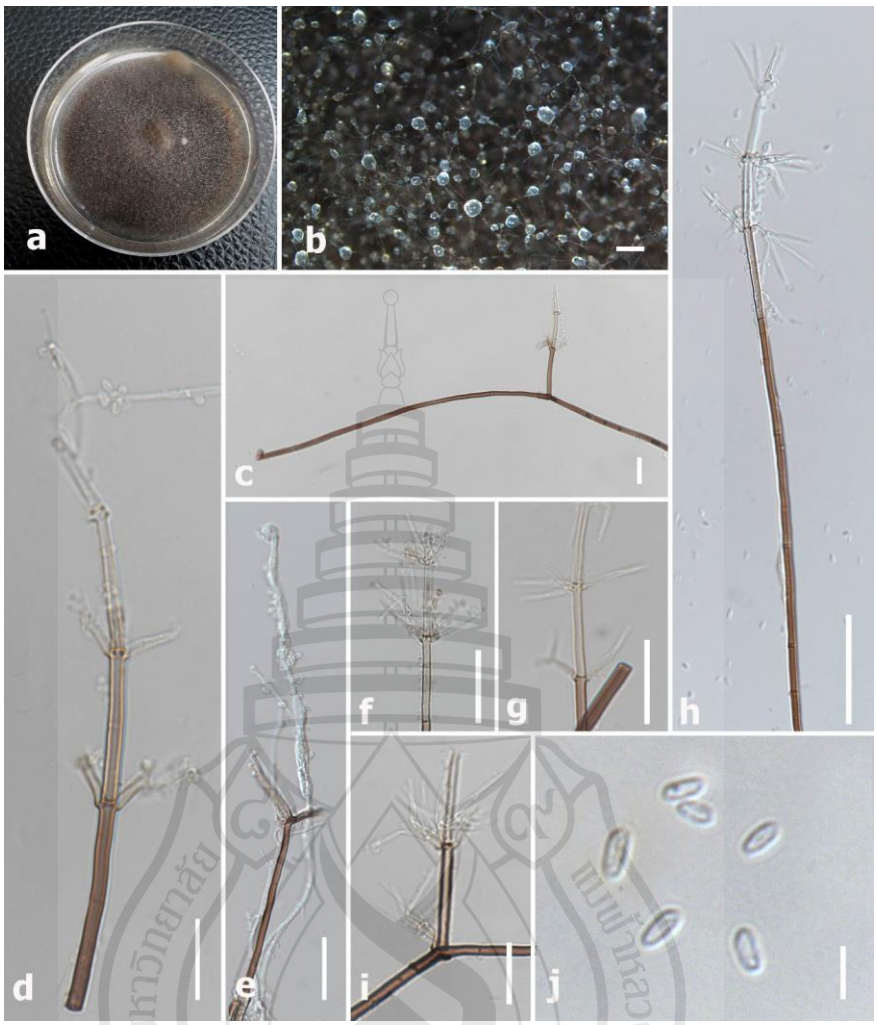
Index Fungorum Number: IF 828066; Facesoffungi Number: FoF 15208

Endophytic on a fresh leaf of *Musa* sp. Colonies on PDA at 25 °C, pinkish white after five days with entire margin, reaching 50 mm after 14 days, gradually becoming brownish black or mouse gray when conidiophores arise from the mycelium, flat, dusty, reverse grey, Sexual morph: Not observed. Asexual morph: Hyphomycetous. *Mycelium* branched, septate, smooth, hyaline at immaturity, gradually turning pale brown and then to dark brown at maturity, hyphae thin-walled at immature stage, notably thick-walled at maturity, 2–4 μm ($\bar{x}$=3.5 μm, n=20) wide. *Conidiophores* 200–700 × 3–5 μm ($\bar{x}$=400 × 3.5 μm, n=30), arising from the hyphae, erect, simple or branched or verticillate towards at the apex, bearing up to 5–8 whorls of 3–6 phialides, brown at the base and gradually becoming paler towards the apex and hyaline at terminal whorls, smooth or rough-walled, with thicker cell walls than the hyaline hyphae. *Phialides* 15–25 × 1–3 μm ($\bar{x}$=1.6 μm, n=30), solitary, tapering towards the end, pointed towards multiple directions, in whorls of 3–6, terminal, lateral, hyaline, thick- or smooth-walled. *Conidia* 2–5 × 1–2 μm ($\bar{x}$=4 μm, n=30), ellipsoidal, 1-celled, hyaline, thick-walled, arranged in slimy glistering heads at the apex of the conidiophore.

Material examined — Thailand, Chiang Rai Province, Doi Thung, associated with a fresh leaf of *Musa* sp., 20 September 2021, B. C. Samarakoon, BNE17 (MFLU 23-0312), culture MFLUCC 23-0232.

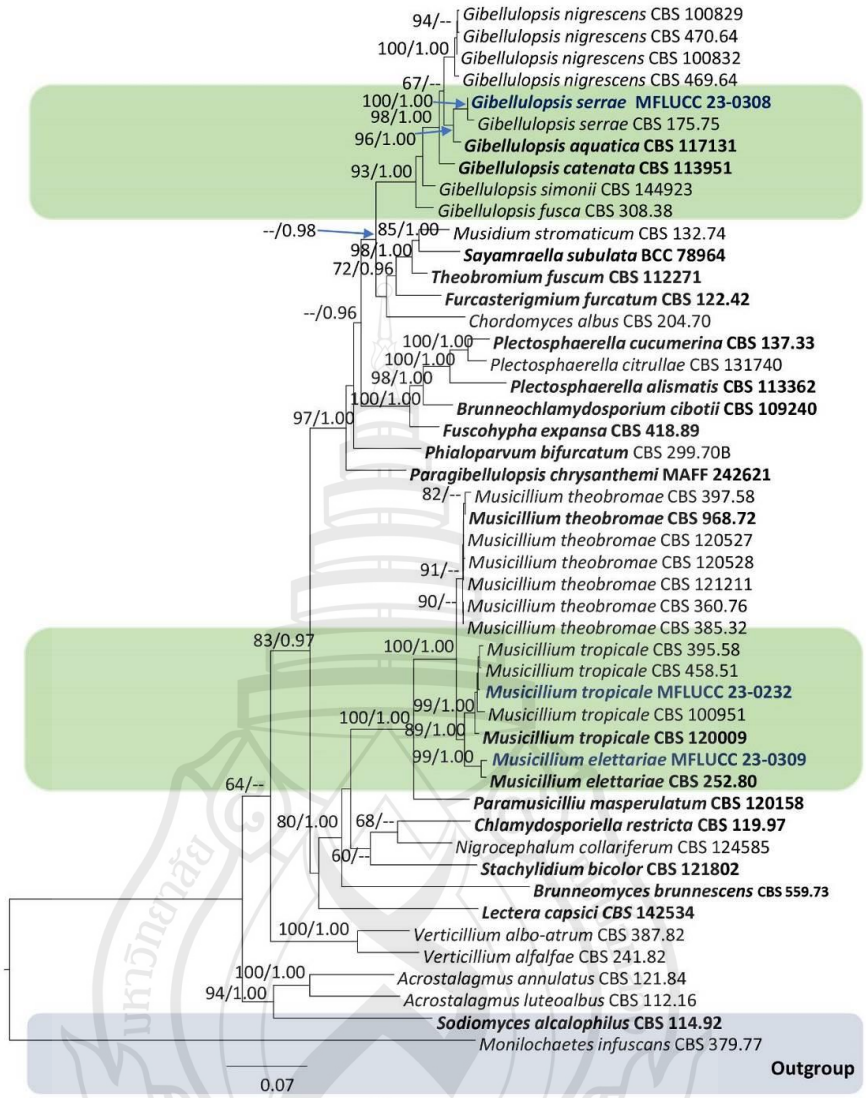
GenBank numbers — LSU= PP800444, ITS= PP809115, *rpb*2= PP840928, *tef*1= PP866300

Notes — *Musicillium tropicale* was described from a leaf of *Musa* sp. from Bangladesh by Giraldo and Crous (2019). Phylogenetic analysis analyses of combined LSU, ITS, *rpb*2 and *tef1* gene regions further validate the taxonomic position of our collection (MFLUCC 23-0232) along with *M. tropicale* with ML=99%, BI=1.00 statistical support. We report the first occurrence of *M. tropicale* from Southeast Asia and Thailand as an endophyte from the leaves of *Musa* spp.



Note a Sporulation of colonies on PDA after 28 days. b Conidiophores bear slimy conidial masses with glistering transparent heads. c, d, f–i Conidiophores, phialides and conidia. e Mycelium at an immature stage with conidiophores. j Conidia. Scale bars: b=150 µm, d, f=50 µm, d, g, h =15 µm, c, e, f, i=10 µm, j=2 µm.

Figure 3.45 *Musicillium tropicale* (MFLU 23-0312)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Monilochaetes infuscans* (CBS 379.77) and *Sodiomyces alcalophilus*(CBS 114.92). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.46 Maximum likelihood tree revealed by RAxML analyses of ITS, LSU, *rpb2* and *tef*1 sequence data of the taxa of *Plectosphaerellaceae*

Hypocreales Lindau

Hyde et al. (2020) accepted 303 genera and 14 families in *Hypocreales* based on morphology and molecular data. The order represents virulent plant and human pathogens (e.g., *Fusarium*), biocontrol agents (e.g., entomopathogenic fungi - *Trichoderma*), and producers of bio-active compounds (e.g., antibiotics - *Tolypocladium*), and potent mycotoxins (e.g., *Gibberella*) (Rossman, 1996).

Stachybotryaceae L. Lombard & Crous

Crous et al. (2014) erected *Stachybotryaceae* (*Hypocreales*) to accommodate *Myrothecium*, *Peethambara* and *Stachybotrys*. Lombard et al. (2016) provided a well-resolved phylogenetic backbone to *Stachybotryaceae* using LSU, ITS, *rpb*2, *cmdA*, *tef*1 and *tub*2 sequence data, and accepted 33 genera in *Stachybotryaceae*. Furthermore, *Melanopsamma*, *Memnoniella* and *Virgatospora* were resurrected in *Stachybotryaceae* (Lombard et al., 2016).

Albifimbria L. Lombard & Crous, Persoonia 36: 177 (2016)

Lombard et al. (2016) introduced *Albifimbria* to accommodate the ex-neotype strain of *A. verrucaria* (= *Myrothecium verrucaria*). In addition, *A. lateralis*, *A. terrestris* and *A. viridis* were introduced as novel taxa in the same study. *Albifimbria* is characterized by the production of verrucose setae around the sporodochia (Lombard et al., 2016). In addition, some *Albifimbria* species bear funnel-shaped mucoid appendages in conidia (Lombard et al., 2016). Currently, four species of *Albifimbria* are documented in Index Fungorum (2024).

Albifimbria was then discovered to exhibit all three lifestyles, occurring as an endophyte (Li et al., 2020; Wei et al., 2022), a plant pathogen (Rehman et al., 2021; Sharma et al., 2021) and a saprobe (Tulloch, 1972), with a cosmopolitan distribution. The genus has mostly been discovered with plant hosts in terrestrial habitats (Tulloch, 1972). However, it has also been reported from human blood (Masetti et al., 2020) and soil (Gurung et al., 2019). In this study, we present the endophytic occurrence of *A. verrucaria* associated with *Musa* leaves in Thailand. Samarakoon et al. (2022b) has reported the saprobic lifestyles of *A. verrucaria* on *Musa* sp. in Thailand.

Albifimbria verrucaria (Alb. & Schwein.) L. Lombard & Crous, Persoonia 36: 177 (2016)

Figure 3.47

Index Fungorum Number: IF 815927*;* Facesoffungi number: FoF04192

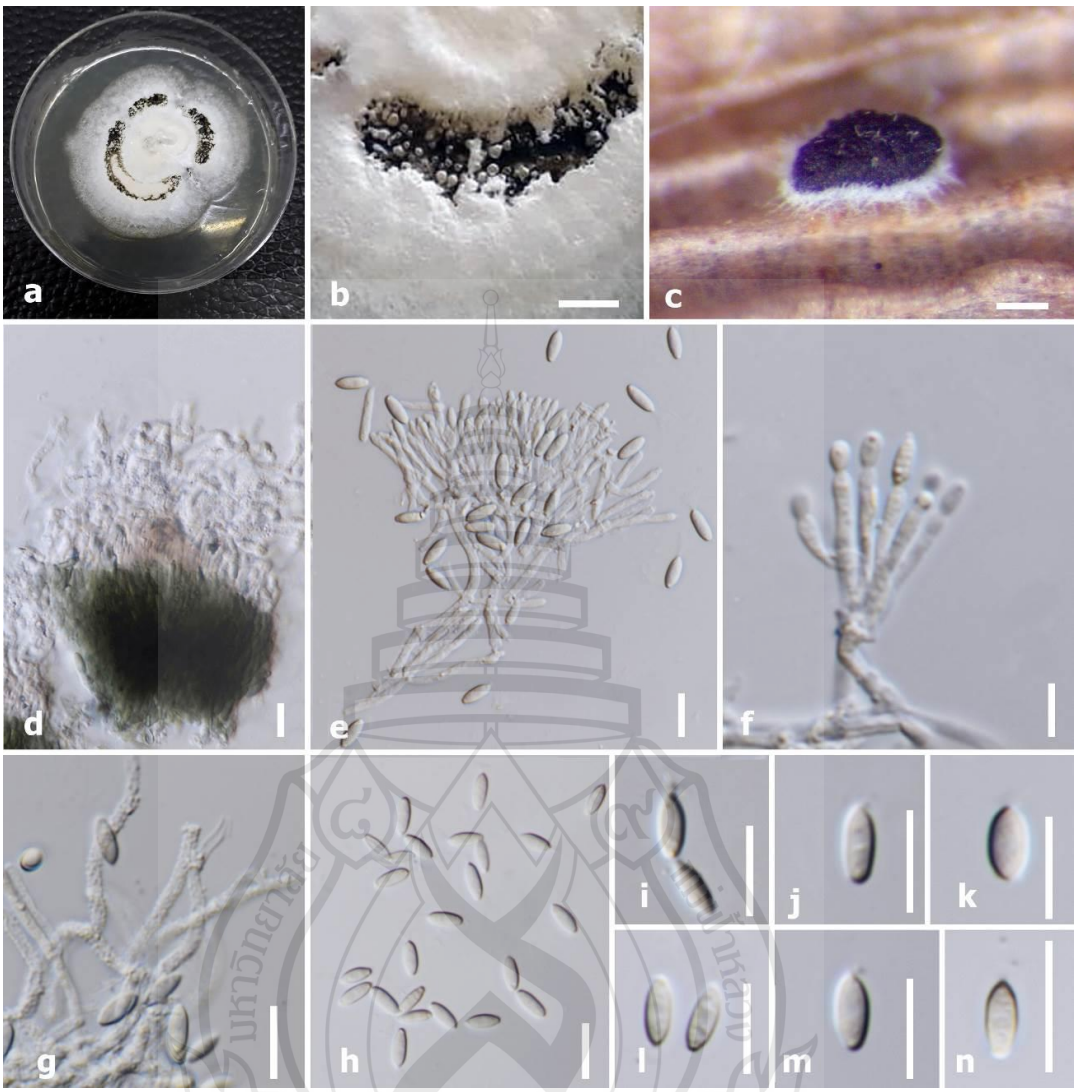
Endophytic on symptomless leaves of *Musa* sp. *Colonies* on PDA at 25 °C in light, reaching 55 cm in 10 days, initially white filamentous margin, becoming dense and white, raised with a cottony appearance, and sometimes radially striated at maturity. *Mycelium* 1–3.5 µm ($\bar{x}$=2.75 µm) wide, hyaline, superficial, composed of septate, branched, smooth or rough, thin-walled hyphae. Sexual morph: not observed. Asexual morph: *Sporodochia* 15–20 × 1–3 µm ($\bar{x}$=17 × 2.4 µm, n=20), visible after 2 weeks of incubation at 25 °C in light conditions, black, cup-shaped or disc-shaped, scattered or gregarious, irregular outline, conidial mass flattened. *Stroma* rarely developed, usually comprising a thin layer of isodiametric hyaline cells. *Setae* not observed. *Marginal hyphae* 3–4 µm ($\bar{x}$=3.3 µm, n=20) diam., hyaline, verrucose, septate, flexous, un-branched or frequently branched, septa unclear. *Conidiophores* 50–60 × 2–3 µm ($\bar{x}$=42.2 × 2.6 µm, n=30), erect from the stromatic layer, hyaline, smooth, dichotomously or unevenly branched, often 2–4 branches at each level, ultimate branches becoming *phialides*, producing numerous conidia. *Phialides* 10–15 × 1–2 µm ($\bar{x}$=13 × 1.7 µm, n=30) hyaline, rough-surfaced, tightly packed as a dense parallel layer, cylindrical, truncate base, rounded or acute apex, *Conidia* 6–8 × 3–4 µm ($\bar{x}$=7 × 3.5 µm, n=30), smooth, hyaline, broadly fusiform, acute apex, truncate or acute base.

Material examined — Thailand, Phayao, Chun, associated with fresh leaves of *Musa* sp., 12 November 2018, Binu Samarakoon, 29-2 (MFLU 23-0313), culture MFLUCC 23-0252. Doi Thung, on decaying leaves of *Musa* sp., 17 July 2021, Binu Samarakoon, MN25 (MFLU 23-0314), culture, MFLUCC 23-0251.

GenBank numbers — ITS= PP809119, *tub*2= PP840934

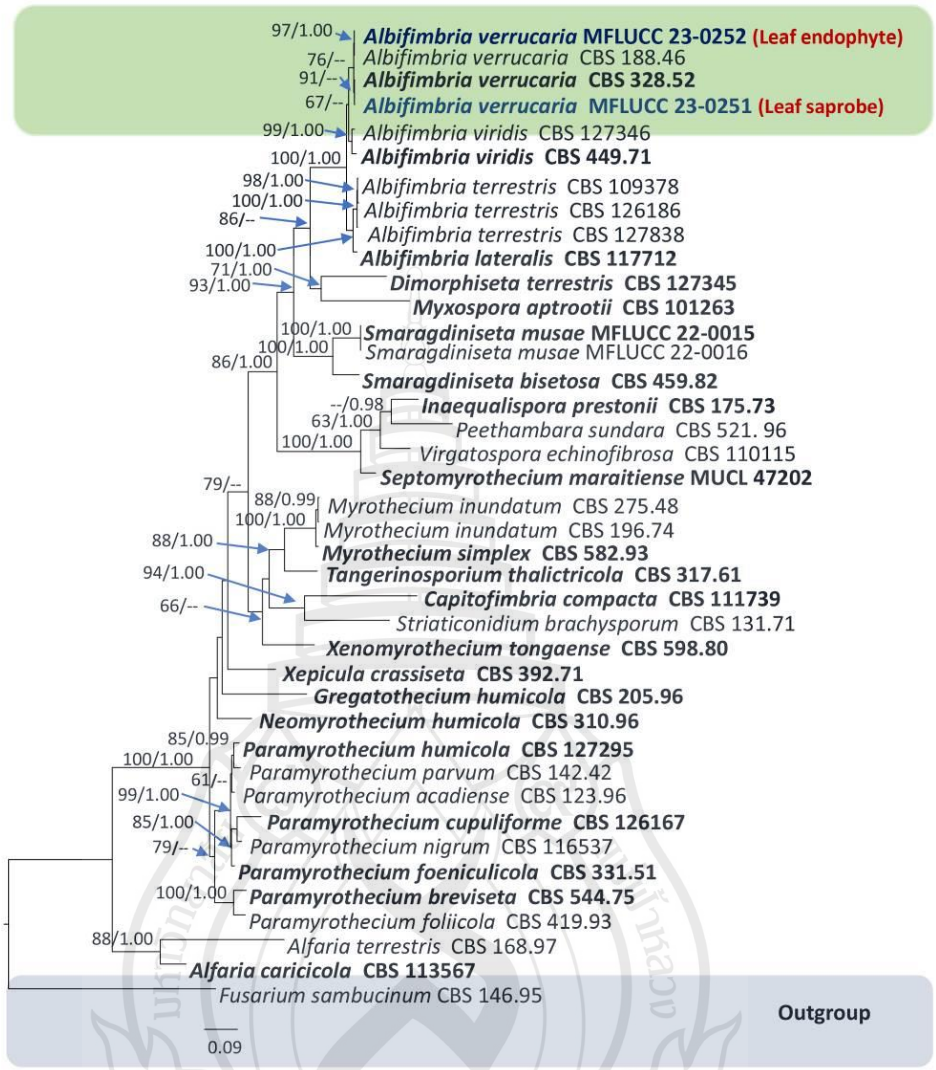
Notes — In the multi-gene phylogeny of ITS, *tub*2 and *rpb*2 sequence data, the endophytic strain (MFLUCC 23-0252) and the saprobic strain (MFLUCC 23-0251) grouped with *Albifimbria verrucaria* (CBS 188.46) with strong statistical support (Fig .3.48). This finding potentially supports the hypothesis of lifestyle transition of fungi in the same host or different hosts. However, we could not

accurately identify the species epithet of the host *Musa* plants of both the endophytic and saprobic isolates to further validate our finding. Herein, we present the endophytic occurrence of *Albifimbria verrucaria* associated with *Musa* leaves in Thailand, providing evidence for the different lifestyles of this species.



Note a Colony on PDA after 3 weeks (endophytic isolate), b sporodochia on PDA. c Sporodochia on the natural host as a saprobic lifestyle (MFLU 23-0314). d Squash mount of sporodochia of the saprobic collection. e Conidiophores and phialides in the endophytic isolate. f Phialides of the endophytic isolate. g Marginal hyphae of the endophytic isolate. h–n Conidia of the endophytic isolate. Scale bars b=500 μm, c=100 μm, d–n=10 μm.

Figure 3.47 *Albifimbria verrucaria* (MFLU 23-0313 and MFLU 23-0314)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Fusarium sambucinum* (CBS 146.95). The strains generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Albifimbria verrucaria.*

Figure 3.48 Maximum likelihood tree revealed by RAxML analyses of ITS, *rpb*2 and *tub*2 sequence data of some selected taxa of *Stachybotryaceae*

Stachybotrys Corda, Icon. fung. (Prague) 1: 21 (1837)

Stachybotrys was erected by Corda (1837) based on *S. atra* in *Hypocreales incertae sedis*. Lombard et al. (2016) transferred many previously accepted *Stachybotrys* to *Brevistachys*, *Globobotrys*, *Sirastachys* and *Striatibotrys*. There are 89 morphological species based on the Index Fungorum (2024), and 31 species have been reported with confirmed molecular data. The asexual morph of *Stachybotrys* has branched or unbranched conidiophores, bearing terminal, phialidic conidiogenous cells with unicellular conidia, in chains or slimy masses (Lombard et al., 2016; Wang et al., 2015). *Stachybotrys* is common in soil, marine habitats, air and plant materials rich with cellulose (*i.e.*, hay, straw, cereal grains, and decaying plant debris) (Lombard et al., 2016; Wang et al., 2015). In addition, *Stachybotrys* species have been detected on damp paper, cotton, linen and cellulose-based building materials (*i.e.*, drywalls, wall papers in indoor environments), water-damaged indoor buildings and air ducts (Wang et al., 2015). Most taxa of *Stachybotrys* are cellulytic saprobes (Samarakoon et al., 2021a) and have also been discovered as plant pathogens (Zhao et al., 2010) and endophytes (Zhang et al., 2019).

Stachybotrys subcylindrosporus C. Y. Jie, Y.L. Jiang, D. W. Li, McKenzie & Yong Wang bis**,** Mycol. Progr. 12: 695 (2013)

Figure 3 49

Index Fungorum Number: IF 821464; Facesoffungi number: FoF 15209

Saprobic on a dead leaf of *Musa* sp. Sexual morph: Not observed. Asexual morph*:* Hyphomycetous. Minute colonies observed as black shiny glistering heads on the top of the hyaline stipe. *Mycelium* often indiscernible, sometimes superficial, hyaline and septate. *Conidiophores* 45–58 × 3.5–4.5 μm ($\bar{x}$=55 × 3.7 μm, n=40), macronematous, mononematous, erect, simple, straight, slightly curved, unbranched, smooth or rough, thick-walled, septate, hyaline, cylindrical, with a notable, thick-walled globular base 2.5–4 × 3–3.5 μm ($\bar{x}$=2.8 × 3.2 μm, n=40) and a rounded apex, bearing a crown of phialides at the terminal end. *Conidiogenous cells* 5–6 × 2–3 μm ($\bar{x}$=5.4 × 2.6 μm, n=40), phialidic, discrete, determinate, obovoid, the outer ones somewhat curved, smooth or slightly rough, hyaline. *Conidia* 10–12.5 × 4–5.5 μm ($\bar{x}$=11 × 4.8 μm, n=40), unicellular, simple, truncated or rounded at base, curved, hyaline at immature stage, greenish brown or olivaceous brown at maturity,

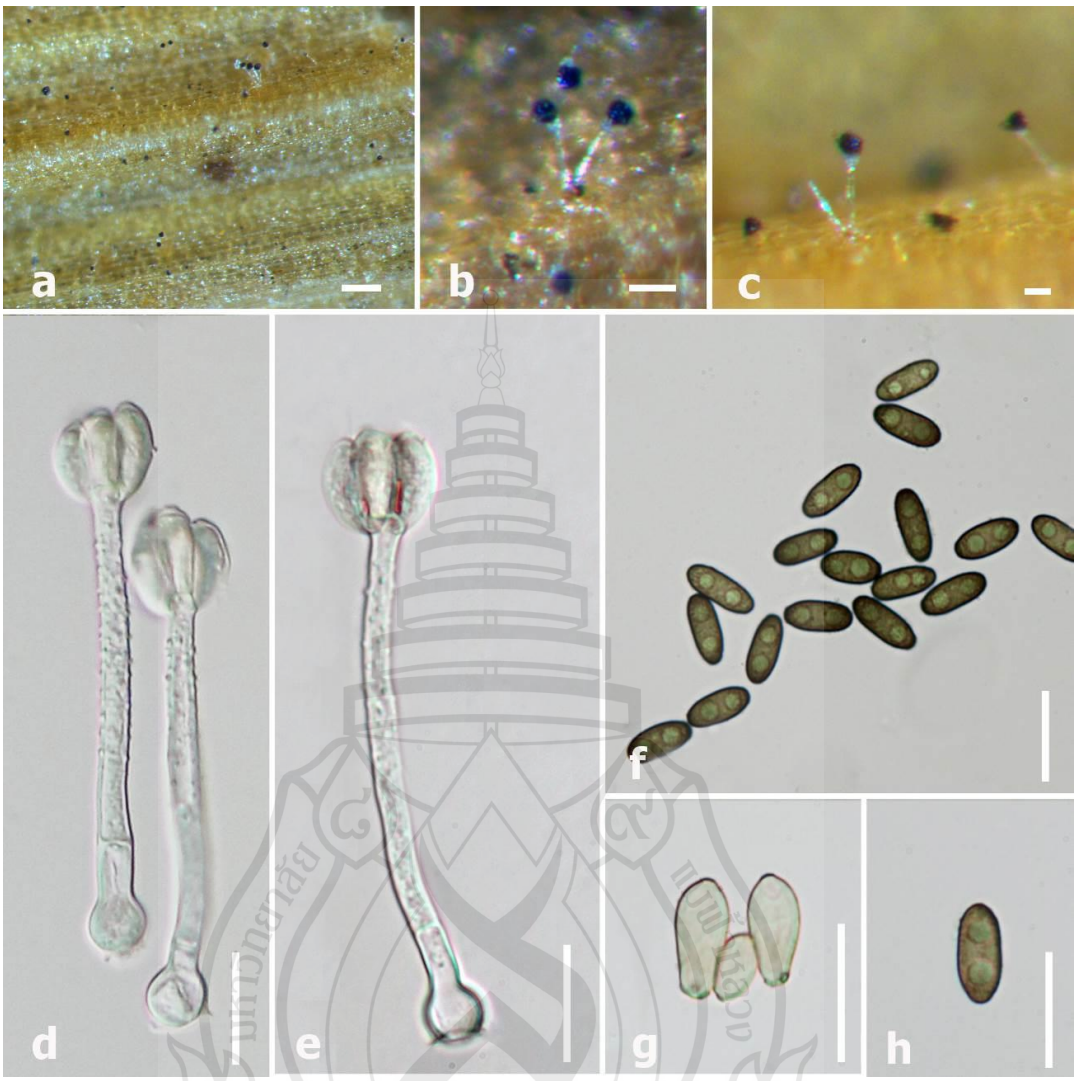
verruculose, often present 1 to 3 distinct oil drops at imature stage, some conidia are collarette and notably thick-walled at maturity.

Culture characteristics — Conidia germinating on PDA after 48 hours. Slow germination of conidia observed and colonies reaching 10–15 mm diameter after 7 days in the light conditions at 25 °C, flat, sparse, brownish or dirty pink, immersed lobate margin; reverse, blackish pink.

Material examined — Thailand, Chiang Rai, Nang Lae, Rattana Dormitory area, on dead petiole of *Musa* sp., 12 January 2019, Binu Samarakoon, BNS 202 (MFLU 23-0315), culture MFLUCC 23-0250.

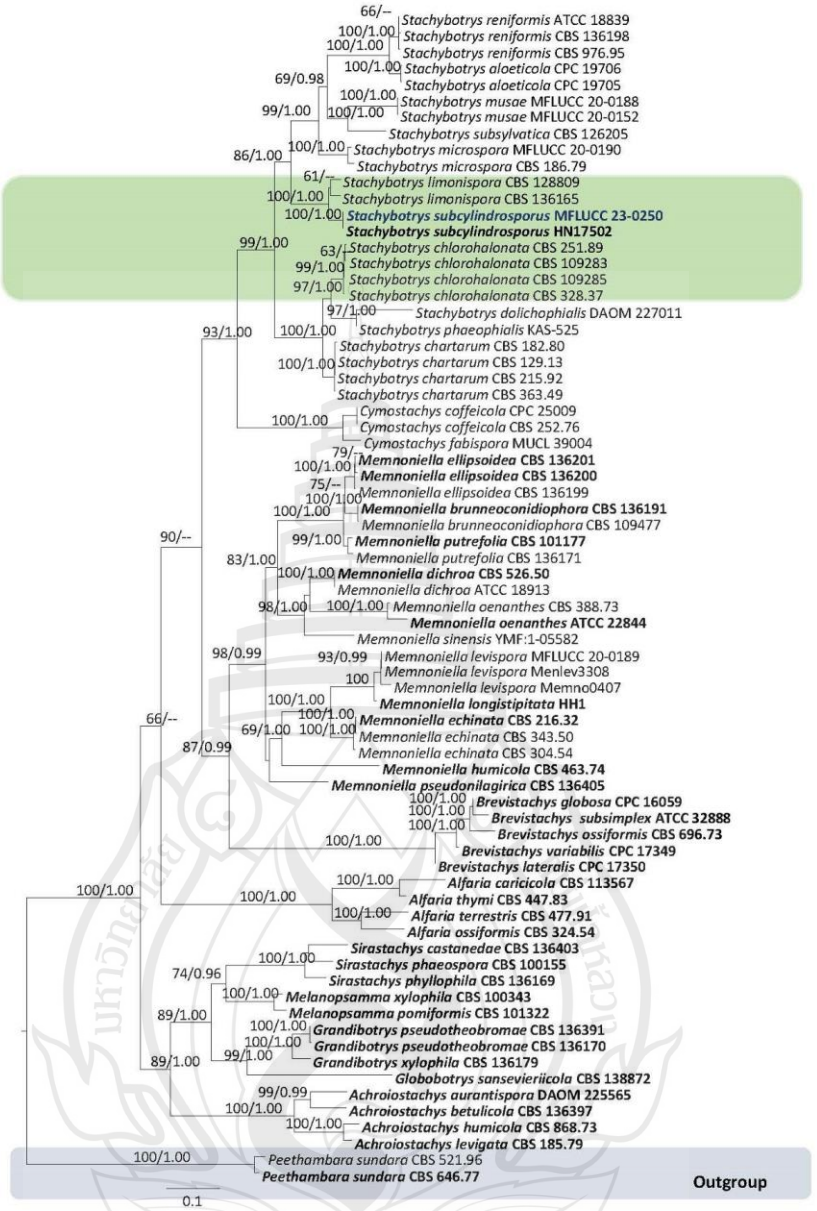
GenBank numbers — ITS= PP809118, *tub*2= PP840932

Notes — Photita et al. (2003a, b) and Farr and Rossman (2024) documented *Stachybotrys dichroa, S. nephrospora*, *S. ruwenzoriensis* and *S. theobromae* on *Musa* sp. as saprobes from Thailand. Photita et al. (2003a) introduced *S. suthepensis* as a saprobe on dead petioles of wild *Musa* sp. from Doi Suthep Pui National Park in Thailand. In addition, *S. chartarum* (Somalia) (Castellani & Ciferri, 1937), *S. globosa* (India) (Misra & Srivastava, 1982), *S. kampalensis* (Japan) (Kobayashi, 2007) were found on *Musa* spp. Samarakoon et al. (2021a) introduced *S. musae* as a saprobe of *Musa* sp. from China. In the multi-gene phylogenetic analyses of *cmdA*, ITS and *tub*2 data (Fig. 3.50), our strain (MFLUCC 23-0250) clustered with the type strain of *S. subcylindrosporus* (HGUP 0201) with ML=100%, BI=1.00 statistical support. *Stachybotrys subcylindrosporus* was previously reported from the soil of Hainan Province in China (Jie et al., 2013) and Thailand (Yasanthika et al., 2020). This is the first report of the species from a terrestrial plant host and the first occurrence on *Musa* sp. with the saprobic lifestyle in Thailand.



Note a–c Conidiophores and conidia with glistering heads on *Musa* sp. d, e Conidiophores and phialides. g Phialides, f, h Conidia. Scale bars: a=100 μm, b–h=10 μm.

Figure 3.49 *Stachybotrys subcylindrosporus* (MFLU 23-0315)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Peethambara sundara* (CBS 646.77 and CBS 521.96). Strains generated in this study are shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 3.50 Maximum likelihood tree revealed by RAxML analyses of *cmdA*, ITS, *rpb*2 and *tub*2 sequence data of the taxa of *Stachybotryaceae*, showing the phylogenetic position of *Stachybotrys subcylindrosporus*

Magnaporthales Thongk., Vijaykr. & K. D. Hyde

Magnaporthales represents necrotrophic or hemibiotrophic parasites infecting *Poaceae* and *Cyperaceae* (*e.g.*, *Pyricularia oryzae*, rice blast; *Gaeumannomyces graminis*, black spot on the sheath of rice) (Cannon, 1994; Thongkantha et al., 2009; Zhang et al., 2016). The order accommodates more than 200 species, the majority of which are pathogens on domesticated and wild monocotyledons (such as rice, maize, wheat, bluegrass, and *Digitaria*). According to Hyde et al. (2020), *Magnaporthales* are divided into five families and 36 genera (*Ceratosphaeriacea*e, *Magnaporthaceae*, *Ophioceraceae*, *Pseudohalonectriaceae*, and *Pyriculariaceae*). In addition, the order comprises several saprobic (*Ophioceraceae*) and endophytic (*Pyriculariaceae* and *Magnaporthaceae*) lifestyles (Feng et al., 2021; Jiang et al., 2021).

Pyriculariaceae Klaubauf, M. H. Lebrun & Crous

Pyriculariaceae was introduced by Klaubauf et al. (2014) as a sister family to *Ophioceraceae*, which includes species with pathogenic, endophytic and saprobic lifemodes, frequently associated with monocotyledons (Hyde et al., 2020a). The sexual morph of the taxa is found as immersed, perithecial ascomata. The asexual form is hyphomycetous and produces hyaline or brown, pyriform to elliptical, transversely septate conidia (Klaubauf et al., 2014). Notably, the family hosts destructive plant pathogens that cause major diseases in agricultural crops such as rice, wheat and millet (Klaubauf et al., 2014).

Neocordana Hern. -Restr. & Crous**,** Phytotaxa 205: 233 (2015)

Neocordana is a plant pathogenic and saprobic genus that causes leaf spots on *Musa* spp. The genus has been discovered in all the banana growing countries worldwide (Hernández-Restrepo et al., 2015; Samarakoon et al., 2019a). In addition, *N. versicolor* was found in the leaf spots of *Canna denudata* (Soares et al., 2005). The damage caused by the genus is severe and results in huge defoliation of *Musa* sp. (Hernández-Restrepo et al., 2015). *Neocordana* species were taxonomically classified under *Cordana* and were synonymized by Hernández-Restrepo et al. (2015) with the aid of molecular phylogeny. There are seven species epithets of *Neocordana* recoded in Index Fungorum (2024). The leaf spots caused by *Neocordana* species on *Musa* display characteristic concentric ring patterns at the gray centers of the necrotic areas. The lesions are big, pale brown, and fusiform to oval in shape (Jones, 2018). A

brilliant yellow chlorotic lesion surrounds the diseased area, dividing it from the rest of the healthy leaf tissue (Jones, 1999).

Neocordana musae (Zimm.) Hern. -Restr. & Crous, Phytotaxa 205: 234 (2015)

Figure 51

Index Fungorum Number: IF 811106; Faces of Fungi Number: FoF 15210

Associated with the necrotic area of the leaf spots on *Musa* sp. The necrotic patch is oval to diamond-shaped and pale brown with a yellow border, appear on the upper leaf side. Often spots merge, affecting large areas of the leaf, which turns brown and dries out. Sexual morph: Not observed. Asexual morph: *Mycelium* superficial or often immersed. *Hyphae* often smooth- walled, hyaline to pale brown. *Conidiophores* 70–180 × 3–7 μm ($\bar{x}$=119 × 5.8 μm, n=40), often brown or sometimes sub-hyaline or pale brown, smooth to rough, thin- to thick-walled, straight, or often clavate, septate, notably constricted at septa, spherical, globose or lobed base and rounded or bilobed apex, simple or aggregated, arising from the center of the necrotic patch or from the superficial mycelium. *Conidiogenous cells* often terminal or intercalary, denticulate; denticles up to 1 μm long. *Conidia* 12–20 × 6–10 μm ($\bar{x}$=16.6 × 8.5 μm, n=40) hyaline or sub- hyaline or pale brown, obclavate, pyriform, mostly obovoid, 1-septate, thick-walled, flat with rounded apex and pointed acute base.

Culture characteristics — Colonies on PDA reaching 45 mm diameter after 2 weeks at 25 °C, elevated, cottony, profuse, aerial, white with mouse grey zones or concentric rings, showing the sporulation, pale luteous exudates present, margin diffuse. Reverse black center, with concentric rings, luteous to ochreous.

Material examined — Thailand, Chiang Rai Province, Mae Fah Luang, on a fresh leaf spot on *Musa* sp. (*Musaceae*), 20 June 2021, B. C. Samarakoon, MN004 (MFLU23-0316), culture MFLUCC 23-0248.

GenBank numbers — LSU=PP800447, ITS=PP809121

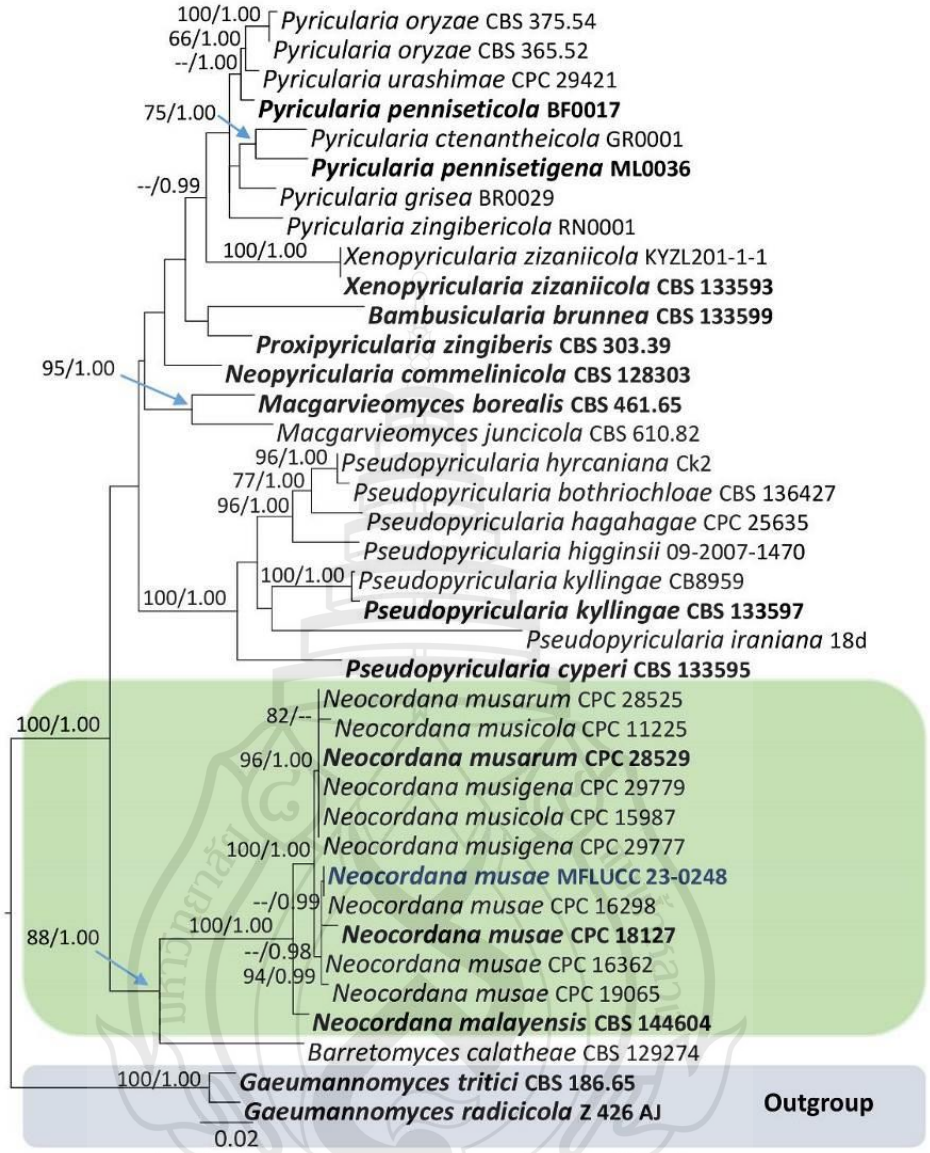
Notes — *Neocordana musae* (= *Cordana musae*) was discovered in several geographical localities in the tropics, causing leaf spots on *Musa* spp. (Adikaram & Yakandawala, 2020; Hernández-Restrepo et al., 2015). In the multi-gene phylogeny of combined LSU and ITS sequence data (Fig. 3.52), our strain MFLUCC 23-0248 grouped with *N. musae* with strong statistical support (ML=94%, PP=0.99). Giatgong

(1980) reported *N. musae* from Thailand as a pathogen on *Musa* leaves. Our isolate has been collected on a necrotic patch of a *Musa* leaf, and the pathogenicity of the strain should be confirmed on healthy *Musa* leaves in future studies. *Neocordana musae* has also been documented as an endophyte on *Musa* leaves in Thailand (Photita et al., 2001). In addition, Photita et al. (2004) documented that *N. musae* had been latent in the host tissue for a long time before causing the leaf spots. We confirm the occurrence of *N. musae,* which has been associated with leaf spots of *Musa* from Thailand, using morphology and molecular data.



Note a, b Diseased banana plants in the field with diamond shapedleaf spots. c, e Lower and upper surface of the leaf showing the eye-shaped leaf spot with distinct chlorotic, necrotic area and the healthy green area. d Conidiophores on the necrotic patch. f–o Conidiophores. p–u Conidia. Scale bars: c=10 cm, d=0.2 mm, e=10 µm, g=100 µm, f–p=20 µm, q–w=5 µm.

Figure 3.51 *Neocordana musae* (MFLU 23-0316)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Gaeumannomyces radicicola* (Z426AJ) and *G. tritici* (CBS186.65) (*Magnaporthaceae*). The strain generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Neocordana musae.*

Figure 3.52 Maximum likelihood tree revealed by RAxML analyses of LSU and ITS sequence data of the taxa of *Pyriculariaceae*

Savoryellomycetidae Hongsanan, K. D. Hyde & Maharachch.

*Pleurotheciale**s*** Réblová & Seifert

Pleurotheciales was introduced by Réblová et al. (2016) to accommodate *Pleurotheciaceae*. The order was previously placed in *Hypocreomycetidae* by Réblová et al. (2016). Hongsanan et al. (2017) have revealed that *Pleurotheciales* group together with *Conioscyphales*, *Fuscosporellales* and *Savoryellales* as a monophyletic lineage in *Sordariomycetes*. Hence, *Savoryellomycetidae* was introduced, with *Pleurotheciales* transferred therein based on molecular data. Currently, the order only accommodates *Pleurotheciaceae* with 13 genera (Hyde et al., 2020a).

Pleurotheciaceae Réblová & Seifert

Pleurotheciaceae was introduced by Réblová et al. (2016) and is typified by *Pleurothecium*. There are 13 genera accepted in the family, *i.e., Adelosphaeria, Anapleurothecium, Coleodictyospora, Dematipyriforma, Helicoascotaiwania, Melanotrigonum, Neomonodictys, Phaeoisaria, Phragmocephala, Pleurotheciella, Pleurothecium, Saprodesmium* and *Sterigmatobotrys* (Bao et al., 2022; Hyde et al., 2020a; Wijayawardene et al., 2022). The sexual morph of the family is characterized by dark, papillate, perithecial ascomata, and unitunicate asci with a non-amyloid apical annulus. The ascospores are hyaline, septate, and fusiform to ellipsoidal (Hyde et al., 2020a; Réblová et al., 2016). The asexual morphs of the family have different morphologies including acrodictys-like, helicoön-like, monodictys-like and dactylaria-like structures (Hyde & Yanna, 2002; Luo et al., 2018; Réblová et al., 2020). Taxa in the family are located with a global distribution from aquatic and terrestrial habitats (Luo et al., 2018; Réblová et al., 2020; Sun et al., 2017).

Dematipyriforma L. Yan Sun, Hai Y. Li, Xiang Sun & L. D. Guo, Cryptog. Mycol. 38: 345 (2017)

Dematipyriforma was described using *D. aquilaria*, which was found as a wood-inhabited endophyte of *Aquilaria crassna* (Sun et al., 2017). Previously, the genus was established in *Savoryellales* (Sun et al., 2017). Dong et al. (2021) transferred the genus to *Pleurotheciales* as a sister clade of *Rhexoacrodictys* and *Saprodesmium*. *Dematipyriforma* has similar phenotypic characters to *Neomonodictys* in *Pleurotheciales*. Bao et al. (2022) introduced *D. muriformis* from aquatic habitats

in Thailand as the second species in the genus. In addition, Bao et al. (2022) have synonymized *Rhexoacrodictys nigrospora* as *D. nigrospora* based on morphology and phylogeny. The genus has a saprotrophic and endophytic lifestyle and there has been no report of the genus associated with *Musa* sp. In this study, we introduce *Dematipyriforma terrestris* as a novel saprobic species isolated from the dead leaves of *Musa* sp. from Thailand.

Dematipyriforma terrestris Samarakoon, K.D. Hyde & Chomnunti, sp. nov.

Figure 3.53

Index fungorum number: IF901531; Facesoffungi number: FoF 15211

Holotype – MFLU 23-0317

Etymology – "*terrestris*" is the Latin word for "terrestrial"

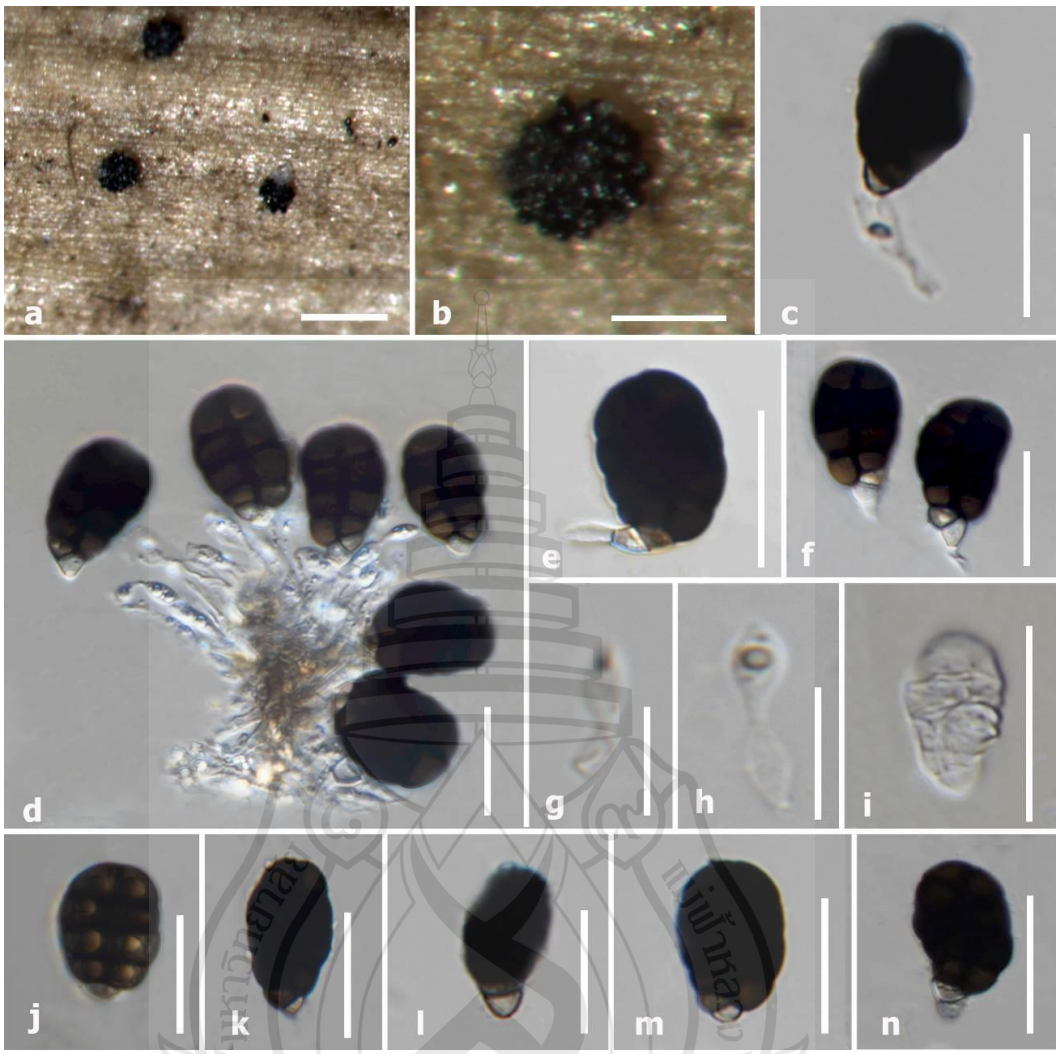
Saprobic on dead leaf petiole of *Musa* sp. Sexual morph: Not observed. Asexual morph: *Colonies* on host scattered or clustered, black, shining, superficial. *Mycelium* superficial or immersed, composed of sub-hyaline, pale brown or brown, branched, septate, thick-walled, hyphae. *Conidiophores* (8–) 10–13 (–15) × 1–3 μm ($\bar{x}$=12.5 × 2 μm, n=20), micronematous to semi-macronematous, mononematous, unbranched, hyaline, 2–3-septate, smooth, spherical, obovate or cylindrical, acute apex and truncate base, straight to flexuous, sometimes thread-like near the apex. *Conidiogenous cells* 5–6.5 × 2–3 μm ($\bar{x}$=5.5 × 2.5 μm, n=20), phialidic, monoblastic, integrated, terminal, determinate, hyaline to sub-hyaline, smooth to slightly rough surfaced, thin- to slightly thick-walled. *Conidia* (24–) 26–29 × 14–19 μm ($\bar{x}$=27 × 16 μm, n=40), acrogenous, solitary, smooth, thick-walled, golden brown to dark blackish brown, the single or two significant basal cells are notably hyaline or sub-hyaline and sometimes guttulate. Mature conidia are thick-walled and darker or black at the walls, obovate, muriform, rounded at apex, notabally pointed at the base, with 3–4 transverse septa, 1 longitudinal septum in all cells, vertical septum not reaching until the basal cells, notably constricted at septa, sometimes geniculate at the lowermost septum. Hyaline or subhyaline at immature stage. Conidial secession rhexolytic.

Culture characteristics — Colonies on PDA reaching 1 mm diam. after 3 weeks in the light condition at 25 °C, black, flat, sparse, mycelium completely immersed, radially striated, or wrinkled. Sporulation was observed after 2 months under light conditions.

Material examined — Thailand, Chiang Rai Province, Doi Chang, Doi Chang Temple Park, on dead leaf petiole of *Musa* sp., 24 June 2021, B. C. Samarakoon, MN28B (MFLU 23-0317, holotype), culture MFLUCC 23-0233.

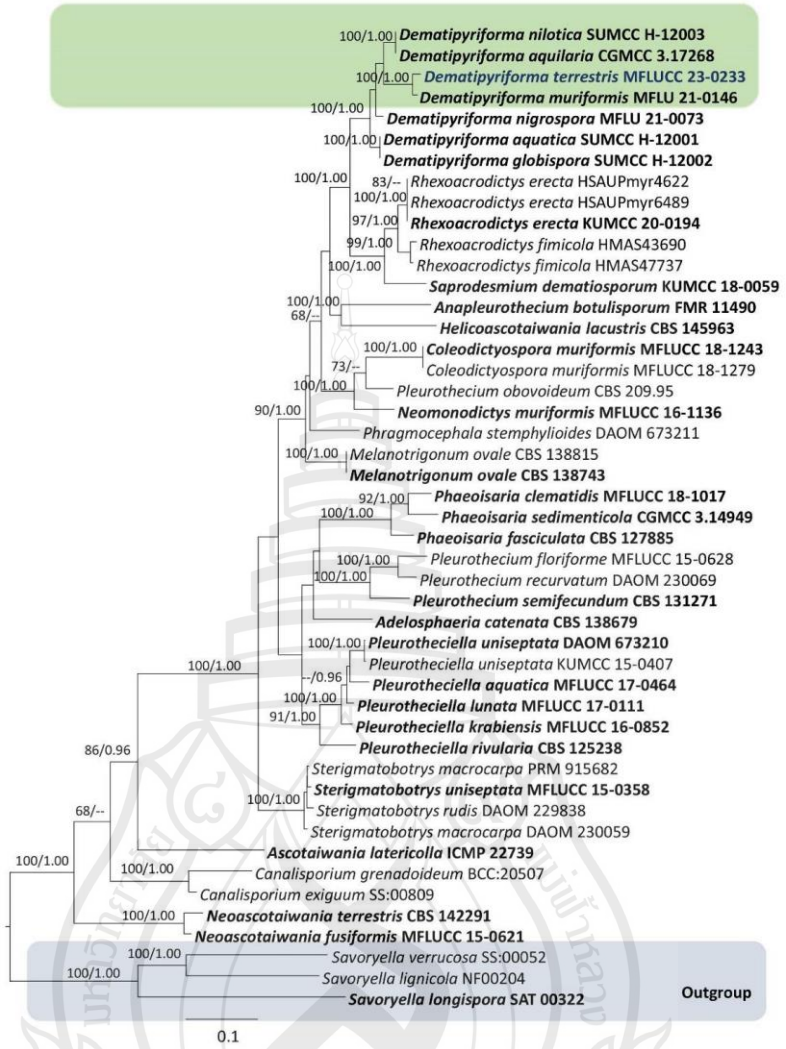
GenBank numbers — LSU=OQ981958, ITS=OQ981957, *tef*1= OR193000

Notes — In the multi-gene phylogeny of LSU, ITS and *tef*1 sequence data (Fig. 3.54), *Dematipyriforma terrestris* claded sister to *D. muriformis* (MFLUCC 21-0097) with ML=100%, BI=1.00 statistical support. *Dematipyriforma terrestris* has 2.27% (LSU=19/837), 2.63% (ITS=14/531) and (*tef*1=47/791) base pair differences with *D. muriformis* (MFLUCC 21-0097) without gaps. Our new species differs from *D. muriformis* by having geniculate, obovate conidia with a rounded apex and a notable pointed base. The conidia of *D. muriformis* are ellipsoidal and often have a comparatively rounded base. The conidial cells of the new species are more constricted at the septa when compared with *D. muriformis.* The two basal cells of *D. terrestris* are pale brown, sub-hyaline, or hyaline as compared to the median and apical cells, and have guttules when compared to *D. muriformis* (Bao et al., 2022). The conidiophores of our new taxon are wider and shorter as compared to those of *D. muriformis* (8–15 × 1–3 μm *vs.* 10–26.5 × 2–3 μm), but this feature is highly variable with the environmental adaptations. The phialidic conidiogenesis was observed in *D. terrestris* as a specific feature that was not found in *D. muriformis*. *Dematipyriforma aquilaria* differs from *D. terrestris* in having pyriform or elongated pyriform conidia (Sun et al., 2017). *Dematipyriforma nigrospora* differs from our new species by having globose to subglobose conidia where the septa have faded upon maturity (Boonmee et al., 2021). Based on morphology and phylogeny, *Dematipyriforma terrestris* is herein introduced as a novel hyphomycetous taxon from *Musa* sp. in Thailand. This is the first report of the genus on *Musaceae*.



Note a, b Colonies on *Musa* leaf petiole. c–f Conidial attachments. g–h Conidiogenesis. j–n Conidia. Scale bars: a=500µm, b=100µm, e, f, j–n=25µm, c, i=20µm, g, h=10µm.

Figure 3.53 *Dematipyriforma terrestris* (MFLU 23-0317, Holotype)



Note Supports for ML bootstrapping (≥60%) and Bayesian posterior probabilities (≥0.95 PP) are shown. The tree is rooted with *Savoryella lignicola* (NF00204), *S. longispora* (SAT 00322) and *S. verrucosa* (SS 00052). The strain generated in this study is shown in blue, with ex-type strains in bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Dematipyriforma terrestris* (MFLUCC 23-0233).

Figure 3.54 Maximum likelihood tree revealed by RAxML analyses of LSU, ITS and *tef*1 sequence data of the taxa of *Pleurotheciaceae*

3.4 Discussion

In the Asian region, various studies (Brown et al., 1998; Kobayashi, 2007; Lumyong et al., 2003; Wikee et al., 2013; Zakaria & Aziz, 2018) have investigated the systematics of fungi associated with different parts of *Musa*. Our research explores endophytic, pathogenic, and saprophytic lifestyles of fungi in both wild and cultivated *Musa* in Thailand, utilizing morpho-molecular taxonomy (Samarakoon et al., 2019, 2020, 2021, 2022). This marks the sixth installment in our manuscript series, presenting 30 species from 23 fungal families in *Dothideomycetes*, *Eurotiomycetes*, and *Sordariomycetes* (Fig. 3.55). Illustrated species mainly associate with various leaf parts, exhibiting associated, endophytic, and saprobic lifestyles (Figs. 3.56 and 3.57).

Seven endophytic fungal species were identified based on morphology and DNA sequence data: *Albifimbria verrucaria*, *Corynespora torulosa*, *Lasiodiplodia theobromae*, *Musicillium tropicale*, *Pseudophaeocytostroma sacchari*, *Pseudopithomyces chartarum*, *Setoarthopyrenia chromolaenae*. This study reports the first endophytic occurrences of *Albifimbria*, *Musicillium*, *Pseudophaeocytostroma*, *Pseudopithomyces* and *Setoarthopyrenia* associated with *Musa* hosts in Thailand. Some endophytic taxa found (*C. torulosa* and *L. theobromae*) are also known as pathogens on *Musa* leaves and fruits (Almenares & Pérez-Vicente, 2019; Meredith, 1961). There is a potential for these endophytic fungi to shift to a pathogenic lifestyle with environmental triggers and plant physiological changes (Bhunjun et al., 2024; Photita et al., 2001, 2004; Promputtha et al., 2007, 2010).

The study discovered taxonomically understudied genera of hyphomycetous saprobes, such as *Bahusandhika*, *Dictyoarthrinium*, and *Spegazzinia*. Additionally, it investigated the taxonomy and phylogeny of *Stachybotrys*, commonly known as "black mold" often found on dead *Musa* leaves. Bioactive secondary metabolites of many saprobic taxa were not investigated. However, the cultures of fungi capable of producing secondary metabolites are available at MFLUCC for future studies.

Notably, some saprobic species were discovered in *Musa* hosts that had previously been found in soil (*Albifimbria verrucaria*, *Gibellulopsis serrae*, and

Stachybotrys subcylindrosporus) (Giraldo & Crous, 2019; Gurung et al., 2019; Yasanthika et al., 2020; Zare et al., 2007). *Dematipyriforma* and *Neohelicosporium*, previously reported from aquatic habitats (Dong et al., 2021; Lu et al., 2018) were found in terrestrial habitats.

Many studies highlight fungi exhibiting multifunctional lifestyles associated with host plants (Barelli et al., 2016; Delaye et al., 2013; Rai & Agarkar, 2016; Ribeiro et al., 2020). Fungal endophytes are predicted to shift to a saprobic lifestyle upon host tissue senescence (Promputtha et al., 2007, 2010, 2014). Four taxa (*Albifimbria verrucaria*, *Corynespora torulosa*, *Lasiodiplodia theobromae*, and *Pseudopithomyces chartarum*) exhibiting endophytic and saprobic lifemodes are reported in this study. The phenotypic characters and DNA sequence data of these saprobes and endophytes are similar and occur on the same *Musa* host. This suggests that the latter endophytic fungi can become saprobes in response to host senescence (Promputtha et al., 2007). Further studies should evaluate these assumptions, such as the production patterns of degrading enzymes upon leaf death (Atsatt & Whiteside, 2014; Barelli et al., 2016; Bhunjun et al., 2024; Delaye et al., 2013; Rai & Agarkar, 2016; Promputtha et al., 2007, 2010, 2014).

Eight fungal taxa are reported on the leaf spots of fresh *Musa* spp. (*i.e.*, *Colletotrichum siamense, Curvularia umbiliciformis, Phaeosphaeria oryzae, Pyrenochaetopsis musae*, *Metulocladosporiella musae, Neocordana musae, Neopestalotiopsis clavispora, N. musae*). Among them, *Colletotrichum siamense, Metulocladosporiella musae, Neocordana musae,* and *Neopestalotiopsis clavispora* were reported as pathogens causing leaf spots on many agricultural crops, including *Musa* (Crous et al., 2006; Hernandez-Restrepo et al., 2015; Kumar et al., 2017; Qi et al., 2022). *Pyrenochaetopsis musae* (this study) and *N. musae* (Hyde et al., 2016) are originally described on *Musa* spp. The pathogenicity of *Curvularia umbiliciformis* and *Phaeosphaeria oryzae* has not been evaluated. This is the first occurrence where those species are associated with leaf spots in monocots. There is a high probability that the latter four taxa might have caused the leaf spots in *Musa* spp. However, the pathogenicity should be confirmed in future studies using *in vitro* and *in vivo* experiments.

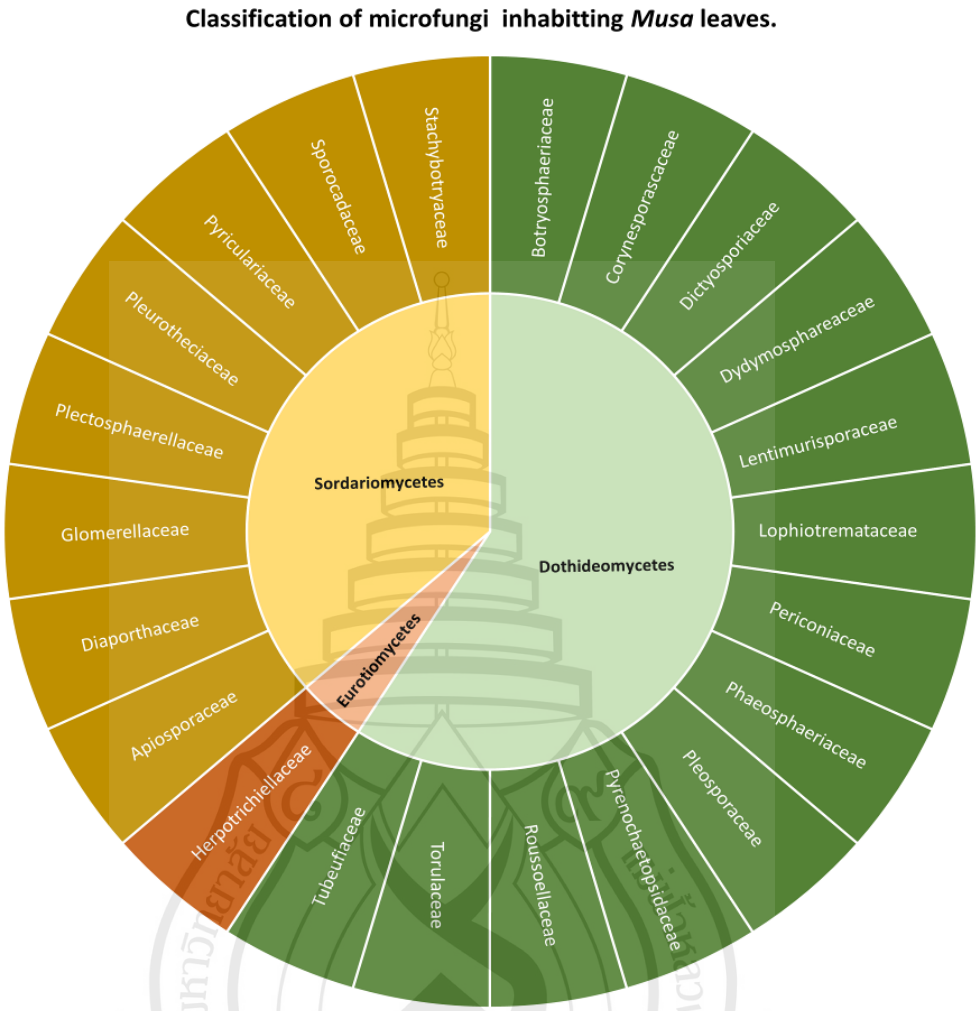
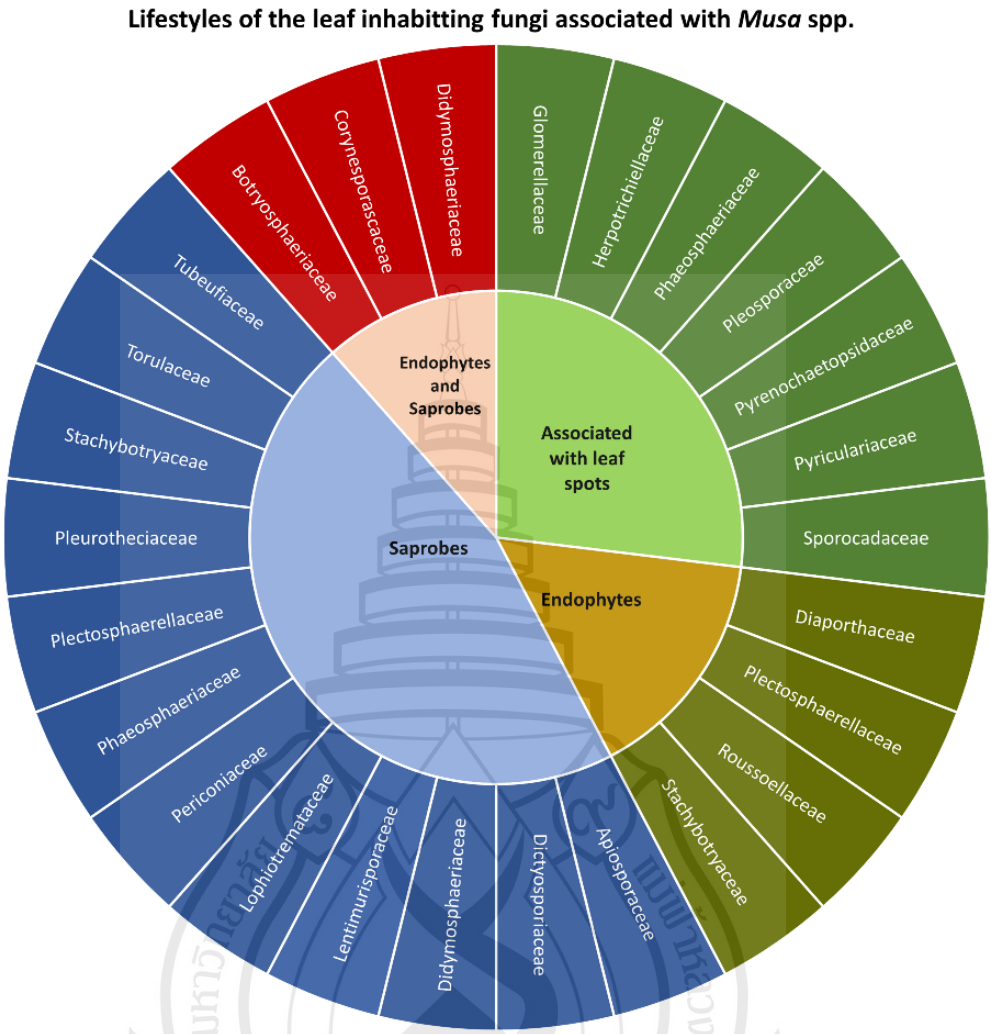


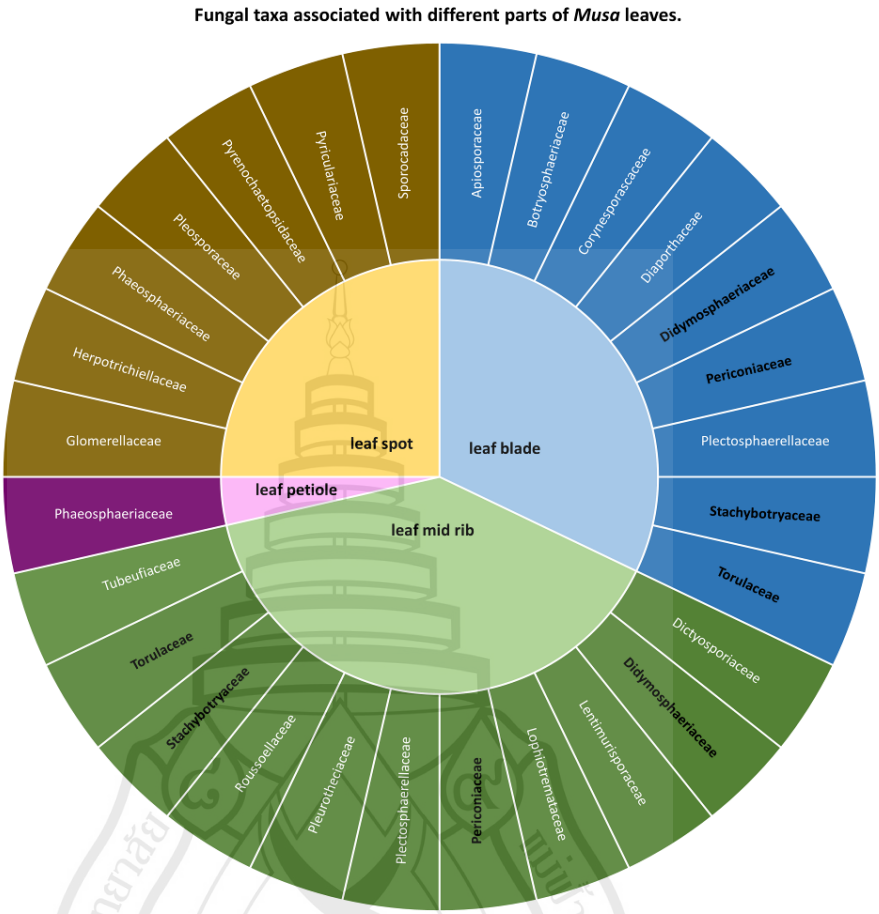
Figure 3.55 The familial distribution of selected genera of microfungi presented in this study, which inhabit the leaves of *Musa* in three sub-classes (*Dothideomycetes*, *Eurotiomycetes*, and *Sordariomycetes*)



Note The fungal families encountered, showing endophytic and saprobic lifestyles, are indicated in red columns.

Figure 3.56 The familial positions of micro-fungi exhibit different lifestyles associated with *Musa* leaves

The fungal taxa in *Botryosphaeriaceae* (*Lasiodiplodia theobromae*), *Didymosphaeraceae* (*Dictyoarthrinium musae, D. thailandica, Pseudopithomyces chartarum, Spegazzinia musae*), *Periconiaceae* (*Periconia echinochloae*), *Plectosphaerellaceae* (*Gibellulopsis serrae, Musicillium elettariae, M. tropicale*), *Stachybotryaceae* (*Albifimbria verrucaria, Stachybotrys subcylindrosporus*), and *Torulaceae* (*Torula mackenziei*) were often encountered on both the leaf blade and the midrib during the study (Fig. 3.56). Taxa of *Phaeosphaeriaceae* were found on leaf spots (*Phaeosphaeria oryzae*) and hard leaf petioles. We also noticed that the taxa of *Pyriculariaceae* (*Neocordana musae*) and *Herpotrichiellaceae* (*Metulocladosporiella musae*) are only restricted to leaf spots in all of our collections (data not shown). However, we could not conclude any noticeable distribution pattern of fungi associated with different tissue segments.



Note The common fungal families encountered in the midrib and the leaf blade are in bold black.

Figure 3.57 The familial positions of micro-fungi inhabiting different tissue parts of *Musa* leaves

The microfungi that inhabit *Musa* leaves are a diverse group, and rarely exhibit host-specificity. We have noted that the morphology of fungal structures has a significant deviation when they grow in artificial cultures compared to the natural substrate. Care should be taken for the accurate identification of the latter taxa and when delineating species based on morphological dimensions and shapes. We recommend using PDA, MEA, and WA (at 16 °C to 25 °C) to prepare single spore isolations and generate pure cultures. However, the most efficient culture media to obtain fruiting structures on the colony are OMA and PDA for the fungi associated with *Musa* tissues.

As an important highlight, it is recommended to observe the fresh or dead leaf specimens as soon as possible (around 24 to 72 hours) after they have been collected. This condition mostly applies to the sexual morphs of fungi, as the fruiting structures are minute and fragile. Those can be easily dehydrated in the artificial laboratory conditions and dried off or burst. When observing old leaf specimens (after one to two weeks), we could only locate a restricted number of fungal genera (*i.e.*, *Apiospora*, *Cladosporium*, *Stachybotrys*, and *Torula*). After one month, due to the high moisture of the leaves, the secondary growth of *Penicillium* and *Aspergillus* colonies develops, and the specimens become contaminated. The viability of the sexual spores only lasted for one to two weeks. The germination methods failed afterwards, and it was not possible to obtain pure cultures.

During the isolation of endophytes, the fast-growing cultures (*i.e.*, *Colletotrichum* and *Neopestalotiopsis*) lost viability after two to three months. Then the secondary growth of *Fusarium* or *Penicillium* is visible in the colonies as a contamination. Therefore, quick laboratory procedures for morphological observation should be conducted before the invasion of secondary contaminants. We could recover the pure cultures of saprobic fungi even after one year of storage at 7 °C and also from the PDA cubes stored in sterilized distilled water (16°C to 25°C). In addition, DNA was recovered from the PDA cubes of fungal cultures immersed in glycerol. The dead leaf parts, fresh leaves and the leaf spots host a lot of fungal contaminants, such as *Fusarium* and *Cladosporium* spores.

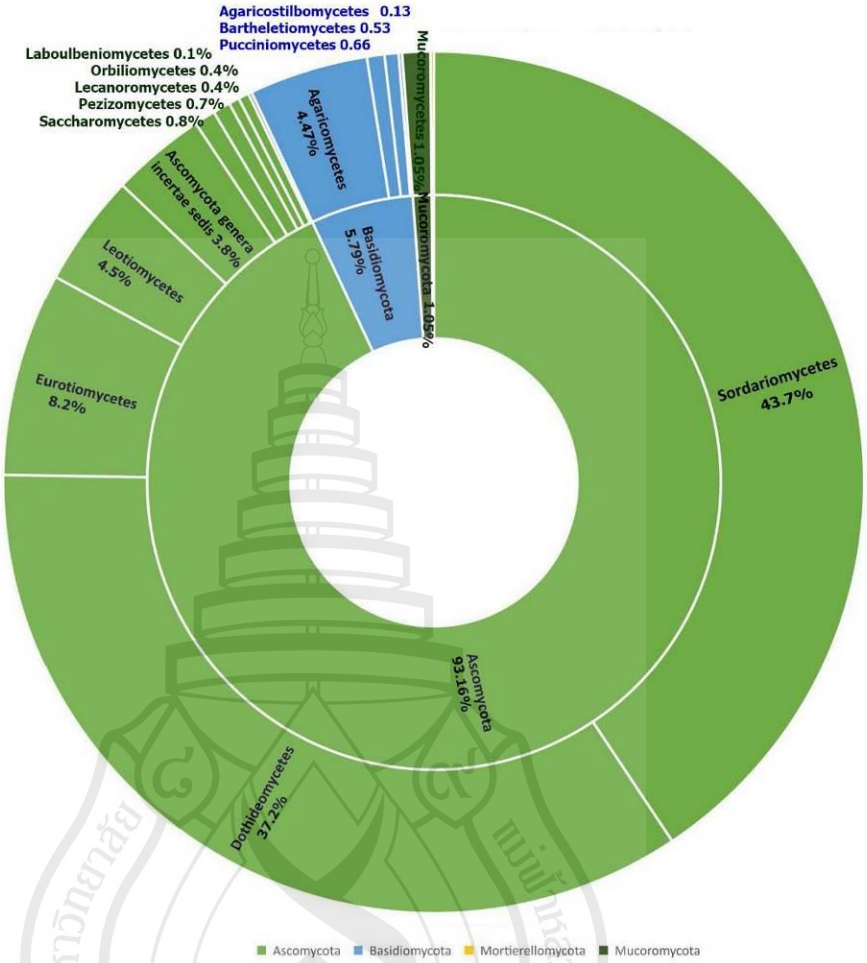


Figure 3.58 Percentage occurrence and the distribution of fungi associated with *Musa* hosts worldwide

Worldwide Checklist of Fungi Associated with *Musa*

The present study fills an important gap in the knowledge of *Musa*-associated fungi by compiling an updated and comprehensive checklist. Through a comprehensive review of international literature and databases, we have developed a catalog that refines the taxonomic classification of known fungi. This catalog also outlines their geographical distribution concerning a diverse range of *Musa* species, as summarized in Appendix A. Our investigation has revealed a diverse mycobiome, with 760 fungal species associated with *Musa* hosts. These species are categorized into four major phyla: *Ascomycota*, *Basidiomycota*, *Mortierellomycota* and *Mucoromycota*. *Ascomycota*, with 93% of the fungal taxa, emerges as the predominant phylum, suggesting its members have the most significant ecological and potentially pathogenic interactions with *Musa* hosts (Fig. 3.58). Within *Ascomycota*, *Sordariomycetes* (40.7%) and *Dothideomycetes* (34.6%) are the most represented classes, indicative of their extensive roles in *Musa* ecosystems (Fig. 3.58). *Eurotiomycetes* (7.6%) and minor fractions from other classes such as *Leotiomycetes* and *Pezizomycetes* also contribute to the ascomycetous diversity. *Basidiomycota*, which accounts for 6% of the fungal taxa, is led by the *Agaricomycetes* class, known for its wood-decaying members, hinting at a saprotrophic lifestyle on *Musa* debris. This is complemented by minor representations from other basidiomycetous classes, which may play roles yet to be fully elucidated in *Musa*-associated fungal ecology. *Mucoromycota*, while less prevalent, represents an important ecological component, with 1% of the fungi reported. The rare incidence of these taxa in *Musa*-related studies may point to a limited but specific ecological niche or a gap in current research efforts. *Mortierellomycota* is the least represented phylum, with only one species reported, opening avenues for further research into its role within the *Musa* biome. The significant majority of *Ascomycota* is a testament to the vast adaptability and ecological versatility of this phylum. The dominance of *Sordariomycetes* and *Dothideomycetes*, many of which are plant pathogens, underscores the importance of continued care in monitoring and managing *Musa* health.

The compilation of reported fungal species encompasses 340 genera across 132 families, highlighting the expansive variety of fungal interactions within *Musa* ecosystems. Remarkably, half of these genera are concentrated within just 11 families

(Fig. 3.60), with *Nectriaceae* (14%) and *Mycosphaerellaceae* (8%) at the forefront, followed by other significant contributors such as *Pleosporaceae* (5%), *Aspergillaceae* (4%), *Glomerellaceae* (4%), *Botryosphaeriaceae* (3%), *Phyllostictaceae* (3%), *Sporocadaceae* (3%), *Pyriculariaceae* (2%), *Plectosphaerellaceae* (2%) and *Stachybotryaceae* (2%). This distribution suggests a potential evolutionary or ecological preference that favors these families within *Musa* habitats. The genera *Aspergillus*, *Cladosporium* and *Colletotrichum*, among others, stand out as the most represented, which is a testament to their ecological success and adaptability. Specifically, *Fusarium*, with 8% of encounters, *Colletotrichum* and *Penicillium*, both at 3%, are noteworthy for their prominence and impact. At the species level, the prevalence of *Colletotrichum musae*, *Corynespora torulosa*, *Fusarium fujikuroi*, *Lasiodiplodia theobromae*, *Mycosphaerella musae*, *Neocordana musae*, *Pestalotiopsis leprogena*, *Phyllosticta musarum*, *Pseudocercospora musae* and *Sphaeropsis musarum* reflects their significant roles in *Musa* pathology and their adaptation to the *Musa* phytobiome. *Corynespora torulosa* emerges as the most frequently occurring species, followed closely by *Pestalotiopsis leprogena*, *Neocordana musae* and *Colletotrichum musae*, indicating a widespread presence and perhaps an ecological specialization that merits further investigation. These species, through their interactions with *Musa* plants, can offer insights into the complexities of host-pathogen dynamics and the environmental factors that drive fungal diversity and distribution.

Furthermore, the detailed geographical data provided for each fungal species found on *Musa* hosts. This enhances our understanding of the biogeographical patterns of *Musa*-associated fungi. This is crucial for the development of disease management strategies in *Musa* cultivation. These insights into the distribution of these species can inform both conservation efforts and agricultural practices, especially in regions where *Musa* crops are a staple and an economic cornerstone. From a biogeographical perspective, these fungi are not randomly scattered but show a distinct pattern of prevalence across 140 regions. A significant 62% of this diversity is attributed to merely 20 regions, with Thailand leading with 7% of total fungal records (Fig. 3.59). Following Thailand, China and Malaysia, each with a 6% share, underscoring the critical role of the Asia-Pacific region as a hub of fungal biodiversity

associated with *Musa*. The representation from Australia, Brazil, the United States, and India further illustrates the global nature of these interactions and the importance of understanding regional differences in fungal communities. The concentrated diversity within certain families and regions invites questions about the evolutionary pressures and ecological factors that shape these communities. It also emphasizes the need for continued exploration of fungal biodiversity in relation to *Musa* species. These efforts are essential for developing sustainable management practices and enhancing the understanding of global fungal ecology.

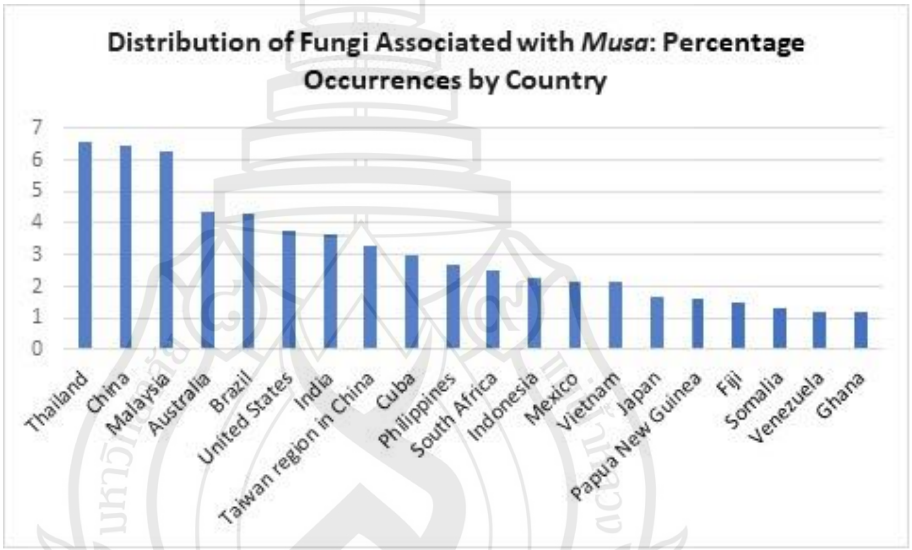


Figure 3.59 Distribution of fungi associated with *Musa*: Percentage of occurrences by country (including leading countries)

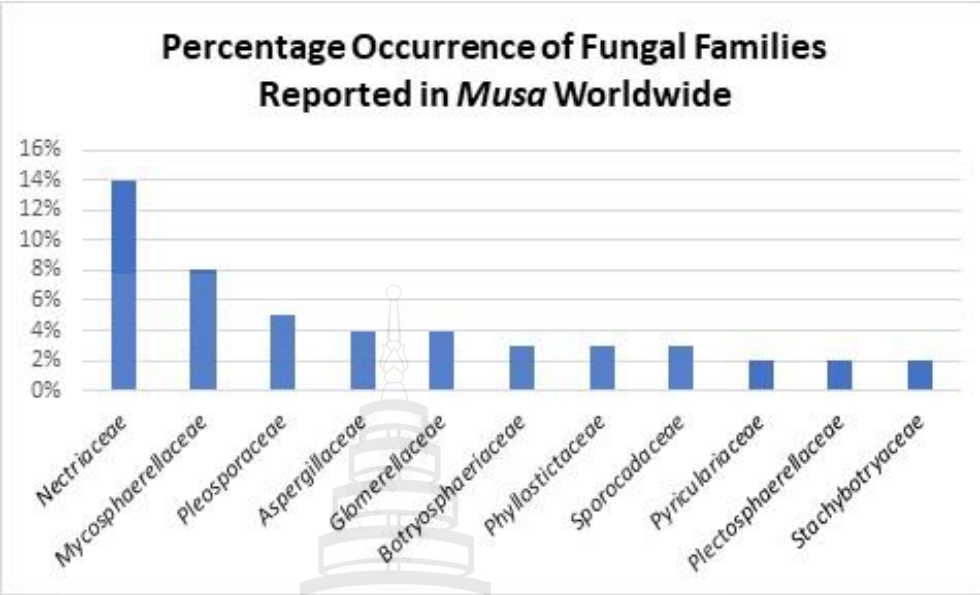


Figure 3.60 Percentage occurrences of the most common fungal families associated with *Musa* worldwide

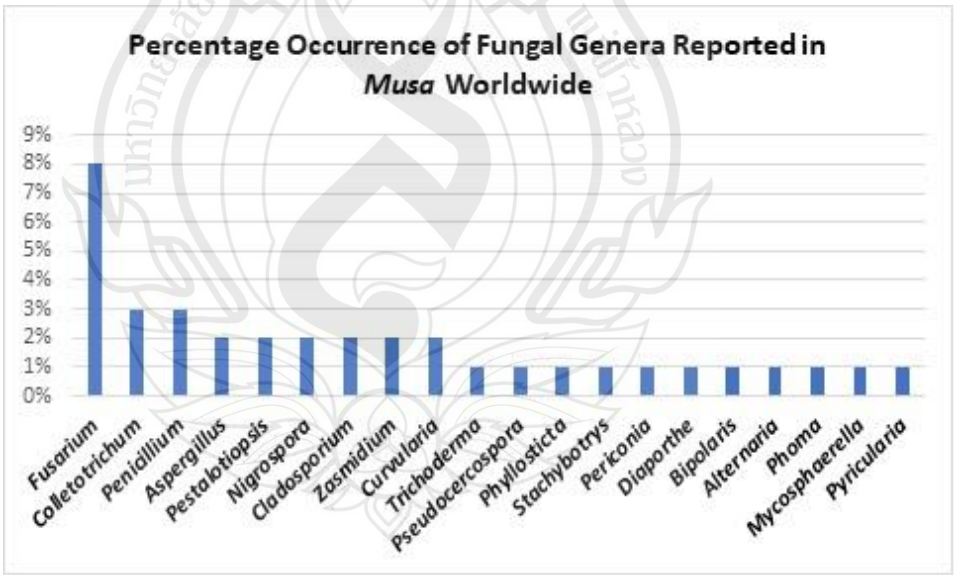


Figure 3.61 Percentage occurrences of the most common fungal genera associated with *Musa* worldwide

3.5 Conclusion

The culmination of this study presents an accurately curated, detailed and digitized list of microfungi associated with *Musa*. It showcases the wide spectrum of endophytic, pathogenic and saprobic lifestyles these fungi exhibit. This is significantly augmenting existing fungal databases, bolstering biodiversity conservation efforts, with a notable impact within Thailand. Through the use of precise fungal nomenclature and comprehensive morphological and phylogenetic analyses, we have laid a robust foundation for future research in taxonomy, plant pathology and biosecurity. The study has shown the interactions of fungi within *Musa* ecosystems, which are validated by strong morphological and phylogenetic evidence. It reveals how fungi can unknowingly cross international borders, potentially via banana leaf wrappers and related trade items. This underscores the need for strict crop security measures to protect global food supplies. One of the key discoveries includes previously uncharted saprobic fungal niches associated with *Musa*, now documented with their DNA sequences deposited in GenBank. This enriches the resource pool for future phylogenetic and taxonomic studies. Additionally, the exploration has led to the identification of novel endophytic fungal niches, some of which were hitherto unreported. These data collections are broadening our understanding of the *Musa* microbiome. These endophytic fungi capable of producing bioactive compounds, were isolated and preserved, for potential industrial and biotechnological applications. The insights derived from this research are significantly enhance the disease management strategies in *Musa* cultivation. This facilitates the proper identification, isolation, and control of fungal diseases associated with *Musa*. Furthermore, the data obtained will inform the development of quarantine regulations designed to prevent the spread of fungal diseases on an international scale. The extensive account of the diversity of *Musa*-associated fungi has profound implications for the management of *Musa* crops. It emphasizes the substantial role of *Ascomycota*, particularly classes like *Sordariomycetes* and *Dothideomycetes*, known for their pathogenicity and how they influence *Musa* plant health and productivity. Understanding the geographical and ecological distribution of these fungi is crucial for crafting targeted interventions to

reduce crop losses. This comprehensive study underscores the necessity to conserve *Musa* ecosystems as reservoirs of fungal biodiversity. These ecological niches play a significant role in the balance of worldwide floristic regions. The identification of novel fungal species is critical, as they have a high potential to be utilized in industrial applications. As *Musa* remains an essential global food resource, the understanding of its associated fungi is paramount for the sustainability of agricultural practices and the conservation of fungal biodiversity. Therefore, this study serves as an invaluable reference for mycological research and *Musa* crop management. The findings of this study further emphasize the necessity of exploring the ecological roles of fungi and their host associations. Additionally, the present study underscores the need to understand the biotic and abiotic factors that shape the fungal distribution on hosts.

CHAPTER 4

THE FIRST REPORT OF *Daldinia eschscholtzii* AS AN ENDOPHYTE FROM LEAVES OF *Musa* sp. (*Musaceae*) IN THAILAND

4.1 Introduction

Fungi exhibit various nutritional modes such as endophytes, saprobes and pathogens in different hosts and habitats (Hyde et al., 2018; Jayawardena et al., 2019; Tibpromma et al., 2018; Wang et al., 2005).

Endophytes inhabit living and healthy tissues without causing apparent disease symptoms (Schulz & Boyle, 2006). *Musa* sp. (banana) is a tropical monocotyledonous plant in family *Musaceae*. Several endophytic fungi have been recorded from *Musa* species in Australia (Brown et al., 1998), Brazil (Pereira et al., 1999), Central America (Pocasangre et al., 1999), China (Cao et al., 2002, 2003) and Hong Kong (Brown et al., 1998). *Acremonium* Link (Cao et al., 2003; Pocasangre et al., 1999), *Bipolaris* Shoemaker (Zakaria & Aziz, 2018), *Colletotrichum* Corda (Cao et al., 2003; Pocasangre et al., 1999), *Fusarium* Link, *Nigrospora* Zimm. (Brown et al., 1998), *Pestalotiopsis* Steyaert, *Phoma* Fr., *Trichoderma* Pers. and *Verticillium* Nees (Cao et al., 2003; Pocasangre et al., 1999) were the common genera that found as fungal endophytes from *Musa* sp. Cao et al. (2002) recorded *Alternaria* Nees, *Aspergillus* P. Micheli, *Aureobasidium* Viala & G. Boyer, *Cephalosporium* Corda, *Cladosporium* Link, *Deightoniella* S. Hughes, *Gloeosporium* Desm. & Mont., *Myxosporium* Link, *Sarcinella* Sacc., *Sphaceloma* de Bary and *Uncinula* Lév. from *Musa* sp.

Photita et al. (2001, 2004) documented fungal endophytes of wild *M. acuminata* from northern Thailand including *Guignardia* Viala & Ravaz and *Periconiella* Sacc. The pathogenicity of endophytic *Cladosporium musae* E.W. Mason, *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc., *Deightoniella torulosa*

(Syd.) M.B. Ellis, *Guignardia cocoicola* Punith., *Neocordana musae* (Zimm.) Hern. - Restr. & Crous and *Periconiella musae* Stahel ex M.B. Ellis was evaluated and *D. torulosa* was identified to cause disease symptoms in *Musa* leaves *in vitro* (Photita et al., 2004).

Daldinia (*Hypoxylaceae*) was introduced by Cesati and De Notaris (1863). Currently the genus accommodates around 50 taxa and distributed in terrestrial and marine habitats. The genus has frequently recorded from tropics compared to temperate regions with saprobic and endophytic nutritional modes (Guidot et al., 2003; Johannesson et al., 2001; Nugent, 2004; Stadler et al., 2014; Wijayawardene et al., 2017).

Traditionally *Daldinia* was accommodated in *Xylariaceae*. Stadler et al. (2014) provided a detailed comprehensive study on the genus using multiple taxonomic approaches including type material studies, sexual/asexual morphs and the cultural characteristics coupled with Scanning Electron Microscopic (SEM) observations. HPLC chemical profiles, UV visible spectroscopy, mass spectroscopy and 5.8S/ITS nrDNA phylogenetic studies also were used.

Wendt et al. (2018) constructed a multigene phylogeny for stromatic *Xylariales* species based on ITS, LSU, *rpb2* and *tub2* sequence data. As a result, *Xylariaceae* was segregated into many major clades and *Daldinia* was accommodated in *Hypoxylaceae*. The morphological characteristics such as stromatal pigments and nodulisporium-like asexual morphs further supported the placement of *Daldinia* in *Hypoxylaceae* by Wendt et al. (2018). After Stadler et al. (2014) the genus was updated with two more new species with *D. korfii* Sir & C. Lambert (Sir et al., 2016) and *D. subvernicosa* Srikit. (Wongkanoun et al., 2019).

Daldinia eschscholtzii was established in 1820 by Ehrenberg as *Sphaeria eschscholtzii*. Apart from the terrestrial plants, *D. eschscholtzii* has also been recorded in marine algae, mangroves, nails, skin and human blood (Helaly et al., 2018; Karnchanatat et al., 2007; Kongyen et al., 2015; Ng et al., 2016; Tarman et al., 2012; Zhang et al., 2008). The sexual morph of *D. eschscholtzii* appears as a turbinate to placentiform shaped stromata in warm and exposed habitats frequently on dead or decaying woody substrates of several angiosperms and few gymnosperms (Stadler et al., 2014). The asexual morph of *D. eschscholtzii* resembles hyaline hyphomycetes

and the conidiogenous structures of *D. eschscholtzii* represent a nodulisporium-like branching pattern (Stadler et al., 2014; Wijayawardene et al., 2017).

In this study, we collected fresh symptomless leaf samples of *Musa* sp. from Chiang Rai Phu Chi Fah and Phayao in northern Thailand and isolated three endophytic *D. eschscholtzii* strains. We present the first report of *D. eschscholtzii* as a foliicolous endophyte in *Musa* sp. In addition, this is the first endophytic report of genus *Daldinia* in *Musa* sp. and the first molecular and morphological justification of the occurrence of *D. eschscholtzii* in monocotyledons.

4.2 Materials and Methods

4.2.1 Fungal Isolation and Morphological Characterization

Symptomless fresh *Musa* leaves were collected from Chiang Rai, Phu Chi Fah and Phayao in northern Thailand. Small pieces (<5 mm^2) from the leaf tissues were separated using a sterilized scalpel, disinfected in 75% ethanol for 1 min, rinsed three times in sterile distilled water, dried and placed on potato dextrose agar (2% potato dextrose agar PDA). The plates were incubated at 25°C for at least 5 days until fungi developed. Hyphal tips were transferred to fresh PDA plates using a sterilized scalpel and incubated at 25°C temperature and light conditions. Asexual morphs were observed from the cultures after 14 days using a Motic SMZ 168 Stereo Zoom Microscope. Observed conidia were used for single spore isolations and incubated at 25°C. Growth rates and cultural characteristics were documented. Living and dry cultures were deposited in the Mae Fah Luang University Culture Collection (MFLUCC) and Mae Fah Luang University Herbarium (MFLU), Chiang Rai, Thailand respectively.

4.2.2 DNA Extraction and PCR Amplification

Fungal isolates were grown on potato dextrose agar (PDA) for 4 weeks at 25°C and total genomic DNA was extracted from 50 to 100 mg of axenic mycelium of the growing culture (Wanasinghe et al., 2018). Mycelium was ground to a fine powder with liquid nitrogen and fungal DNA was extracted using the Biospin Fungus Genomic DNA Extraction Kit-BSC14S1 (BioFlux, P.R. China) according to the

instructions of the manufacturer. Four gene regions as ITS, partial 28S large subunit (LSU), partial beta-tubulin (*tub2*) and partial second largest subunit of the DNA-directed RNA polymerase II (*rpb2*) were amplified using ITS5/ITS4 (White et al., 1990), LR0R/LR5 (Vilgalys & Hester 1990), T1/T2 (O'Donnell & Cigelnik, 1997) and fRPB2-5f/fRPB2-7cR (Liu et al., 1999) primers respectively.

A total volume of 26.5 µl PCR mixture contained TaKaRa E-Taq DNA polymerase 0.3 µl, 12.5 µl of 2 × PCR buffer with 2.5 µl of dNTPs, 1 µl of each primer, 9.2 µl of double-distilled water and 100–500 ng of DNA template followed by thermal cycle programs described by Wanasinghe et al. (2014) and Wendt et al. (2018). All the PCR products were visualized by staining with ethidium bromide (EtBr) on 1.2 % agarose gels. Successful PCR products were purified according to the manufacturer's instructions of a Qiagen purification kit (Qiagen, USA) and sequenced in Sunbiotech Company, Beijing, China.

4.2.3 Sequencing and Sequence Alignment

Obtained sequences were subjected to BLAST search in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi). BLAST search results and initial morphological studies have supported that our isolates have belonged to *Hypoxylaceae*. Other sequences used in the analyses were obtained from GenBank based on recently published data (Stadler et al., 2014; Wendt et al., 2018) (Table 1). The single gene alignments were automatically done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/index.html, Katoh et al., 2017) using the default settings and later refined where necessary, using BioEdit v. 7.0.5.2 (Hall, 1999).

4.2.4 Phylogenetic Analysis

Maximum likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis, 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution. A Bayesian analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronqvist, 2001) to evaluate Posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov Chain Monte Carlo sampling (BMCMC).

Table 4.1 Taxa that used in the phylogenetic analysis of *D. eschscholtzii* with the corresponding GenBank accession numbers

Species	Strain number	GenBank accession numbers			
		ITS	LSU	*rpb2*	*tub2*
Annulohypoxylon atroroseum	ATCC 76081	AJ390397	KY610422	KY624233	DQ840083
A. michelianum	CBS 119993	KX376320	KY610423	KY624234	KX271239
A. moriforme	CBS 123579	KX376321	KY610425	KY624289	KX271261
A. nitens	MFLUCC 12-0823	KJ934991	KJ934992	KJ934994	KJ934993
A. stygium	MUCL 54601	KY610409	KY610475	KY624292	KX271263
Daldinia andina^{T}	CBS 114736	-	KY610430	KY624239	KC977259
D. bambusicola^{T}	CBS 122872	KY610385	KY610431	KY624241	AY951688
D. caldariorum	MUCL 49211	AM749934	KY610433	KY624242	KC977282
D. concentrica	CBS 113277	AY616683	KY610434	KY624243	KC977274
D. dennisii^{T}	CBS 114741	JX658477	KY610435	KY624244	KC977262
D. eschscholtzii	MUCL 45435	JX658484	KY610437	KY624246	KC977266
D. eschscholtzii	CBS 113042	JX658497	-	-	-
D. eschscholtzii	CBS 113047	AY616684	-	-	-
D. eschscholtzii	CBS 116032	JX658500	-	-	-
D. eschscholtzii	CBS 116035	JX658498	-	-	-
D. eschscholtzii	CBS 116037	JX658492	-	-	-
D. eschscholtzii	CBS 116037(2)	JX658499	-	-	-
D. eschscholtzii	CBS 117735	JX658480	-	-	-
D. eschscholtzii	CBS 117740	JX658481	-	-	-
D. eschscholtzii	CBS 117741	JX658491	-	-	-
D. eschscholtzii	CBS 122876	JX658438	-	-	-
D. eschscholtzii	CBS 122877	JX658439	-	-	-
D. eschscholtzii	CBS 122878	JX658440	-	-	-
D. eschscholtzii	KC 1616	JX658496	-	-	-
D. eschscholtzii	KC1699	JX658490	-	-	-
D. eschscholtzii	MUCL 38740	JX658493	-	-	-
D. eschscholtzii	MUCL 41777	JX658486	-	-	-
D. eschscholtzii	MUCL 41778	JX658494	-	-	-
D. eschscholtzii	MUCL 43508	JX658495	-	-	-
D. eschscholtzii	MUCL 45434	JX658484	-	-	-
D. eschscholtzii	MUCL 47965	JX658482	-	-	-
D. eschscholtzii	**MFLUCC18-0177**	**MK587659**	**MK587746**	**MK625010**	**MK636689**
D. eschscholtzii	**MFLUCC19-0154**	**MK587660**	**MK587747**	**MK625011**	**MK636690**
D. eschscholtzii	**MFLUCC19-0153**	**MK587661**	**MK587748**	**MK625012**	**MK636691**
D. korfii^{T}	STMA14089	KY204020	-	-	-
D. loculatoides^{T}	CBS 113279	MH862918	KY610438	KY624247	KX271246
D. macaronesica^{T}	CBS 113040	KY610398	KY610477	KY624294	KX271266
D. petriniae^{T}	MUCL 49214	-	KY610439	KY624248	KC977261
D. placentiformis	MUCL 47603	AM749921	KY610440	KY624249	KC977278

Table 4.1 (continued)

Species	Strain number	GenBank accession numbers			
		ITS	LSU	*rpb2*	*tub2*
D. pyrenaica^{T}	MUCL 53969	KY610413	-	KY624274	KY624312
D. steglichii^{T}	MUCL 43512	KY610399	KY610479	KY624250	KX271269
D. theissenii^{T}	CBS 113044	KY610388	KY610441	KY624251	KX271247
D. vernicosa^{T}	CBS 119316	KY610395	KY610442	KY624252	KC977260
Entonaema liquescens	ATCC 46302	KY610389	KY610443	KY624253	KX271248
Hypoxylon carneum	MUCL 54177	KY610400	KY610480	KY624297	KX271270
H. cercidicola	CBS 119009	KC968908	KY610444	KY624254	KC977263
H. crocopeplum	CBS 119004	KC968907	KY610445	KY624255	KC977268
H. fendleri	MUCL 54792	KF234421	KY610481	KY624298	KF300547
H. fragiforme^{T}	MUCL 51264	KC477229	KM186295	KM186296	KX271282
H. fuscum^{T}	CBS 113049	KY610401	KY610482	KY624299	KX271271
H. griseobrunneum^{T}	CBS 331.73	KY610402	KY610483	KY624300	KC977303
H. haematostroma^{T}	MUCL 53301	KC968911	KY610484	KY624301	KC977291
H. howeanum	MUCL 47599	AM749928	KY610448	KY624258	KC977277
H. hypomiltum	MUCL 51845	KY610403	KY610449	KY624302	KX271249
H. investiens	CBS 118183	KC968925	KY610450	KY624259	KC977270
H. lateripigmentum^{T}	MUCL 53304	KC968933	KY610486	KY624304	KC977290
H. lenormandii	CBS 119003	KC968943	KY610452	KY624261	KC977273
H. monticulosum^{T}	MUCL 54604	KY610404	KY610487	KY624305	KX271273
H. musceum	MUCL 53765	KC968926	KY610488	KY624306	KC977280
H. papillatum^{T}	ATCC 58729	KC968919	KY610454	KY624223	KC977258
H. perforatum	CBS 115281	KY610391	KY610455	KY624224	KX271250
H. petriniae^{T}	CBS 114746	KY610405	KY610491	KY624279	KX271274
H. porphyreum	CBS 119022	KC968921	KY610456	KY624225	KC977264
H. pulicicidum^{T}	CBS 122622	JX183075	KY610492	KY624280	JX183072
H. rubiginosum^{T}	MUCL 52887	KC477232	KY610469	KY624266	KY624311
H. samuelsii^{T}	MUCL 51843	KC968916	KY610466	KY624269	KC977286
H. submonticulosum^{T}	CBS 115280	KC968923	KY610457	KY624226	KC977267
H ticinense	CBS 115271	JQ009317	KY610471	KY624272	AY951757
H. trugodes^{T}	MUCL 54794	KF234422	KY610493	KY624282	KF300548
Jackrogersella multiformis^{T}	CBS 119016	KC477234	KY610473	KY624290	KX271262
Pyrenopolyporus nicaraguensis	CBS 117739	AM749922	KY610489	KY624307	KC977272

Table 4.1 (continued)

Species	Strain number	GenBank accession numbers			
		ITS	**LSU**	***rpb2***	***tub2***
Rhopalostroma angolense	CBS 126414	KY610420	KY610459	KY624228	KX271277
Rostrohypoxylon terebratum^{T}	CBS 119137	DQ631943	DQ840069	DQ631954	DQ840097
Ruwenzoria pseudoannulata^{T}	MUCL 51394	KY610406	KY610494	KY624286	KX271278
Thamnomyces dendroidea	CBS 123578	FN428831	KY610467	KY624232	KY624313
Xylaria hypoxylon ^{T}	CBS 122620	KY610407	KY610495	KY624231	KX271279
X. polymorpha	MUCL 49884	KY610408	KY610464	KY624288	KX271280

Note *ATCC: American Type Culture Collection, Virginia, USA: CBS: Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, KC: Kew Culture Collection, United Kingdom, MFLUCC: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand, MUCL: Université Catholique de Louvain, Belgium, STMA: Personal Herbarium and Culture Collection of M. Stadler. Type strains are superscripted with T and newly generated strains are indicated bold.

Two parallel runs were conducted, using the default settings, but with the following adjustments: Four simultaneous Markov chains were run for 2,000,000 generations and trees were sampled every 100th generation and 20,000 trees were obtained. The first 4,000 trees, representing the burnin phase of the analyses and discarded. The remaining 16,000 trees were used for calculating PP in the majority rule consensus tree.

Phylograms were visualized with FigTree v1.4.0 program (Rambaut 2011) and reorganized in Microsoft power point.

4.3 Results

4.3.1 Phylogenetic Analysis of *D. eschscholtzii*

The combined LSU, ITS, *rpb2* and *tub2* matrix comprised 76 sequences including selected genera in *Hypoxylaceae*, *D. eschscholtzii* (MFLUCC 18-0177, MFLUCC 19-0154, MFLUCC 19-0153) strains and *Xylaria hypoxylon* (CBS 122620) and *X. polymorpha* (MUCL 49884) (*Xylariaceae*) as out group taxa (Fig. 4. 1). Four different alignments of each individual gene and a combined alignment of four genes

were analyzed in this study. A best scoring RAxML tree is shown in Fig. 4. 1 with a final ML optimization likelihood value of -35661.5741. The matrix had 1340 distinct alignment patterns, with 28.10% of undetermined characters or gaps. Estimated base frequencies were as follows; A=0.246955, C=0.244469, G=0.266113, T=0.242464; substitution rates AC=1.597317, AG=4.770781, AT=1.560157, CG=1.203822, CT=7.713893, GT=1.000000; proportion of invariable sites I=0.466559; gamma distribution shape parameter α=0.816750. All trees (ML and BYPP) were similar in topology and did not differ significantly (data not shown) at the generic relationships which agrees with previous study based on multi-gene phylogeny of Stadler et al. (2014) and Wendt et al. (2018). Bootstrap support (BS) values of ML (equal or greater than 60 % based on 1000 replicates) are shown on the upper branches with blue. Branches with Bayesian posterior probabilities (PP) greater than 0.95 from MCMC analyses are given in blue. Our isolates (MFLUCC 18-0177, MFLUCC 19-0154, MFLUCC 19-0153) were clustered with in *D. eschscholtzii* with a significant bootstrap support (ML=100%, PP=1.00).

4.3.2 Taxonomy

Daldnia eschscholtzii (Ehrenb.) Rehm

Index Fungorum Number: IF544992; Facesoffungi Number: FoF02990

Endophytic on fresh leaves of *Musa* sp. *Colonies* on PDA at 25°C temperature, light, reaching 7 cm in two weeks, initially white with a diffuse margin. Colonies become gray, with olive green and later become dull green spots. When mature purple pigmentation occurs from the center of the colony. Sexual morph: *Stromatic structures* arising from the surface after 8 weeks, convexly curved, swelled, sterile. Asexual morph: Sporulation after two to three weeks, under 25°C, entire surface after three weeks, becomes gray after four weeks, reverse black at the center and whitish gray at the periphery after two weeks. *Mycelium* 1–3.5 µm ($\bar{x}$=2.75 µm) wide, superficial, composed of septate, branched, rough, inflated, often have melanized hyphae with brownish exudates in old cultures. *Conidiophores* 0.8–2 µm long × 0.7–1.5 µm diam. ($\bar{x}$=1.5 × 1.3 µm, n=10) hyaline, mononematous synonymous, short, small, conidiogenous structure dichotomous or trichotomous with nodulisporium-like branching pattern, 1–3 conidiogenous cells arise from each terminus. *Conidiogenous*

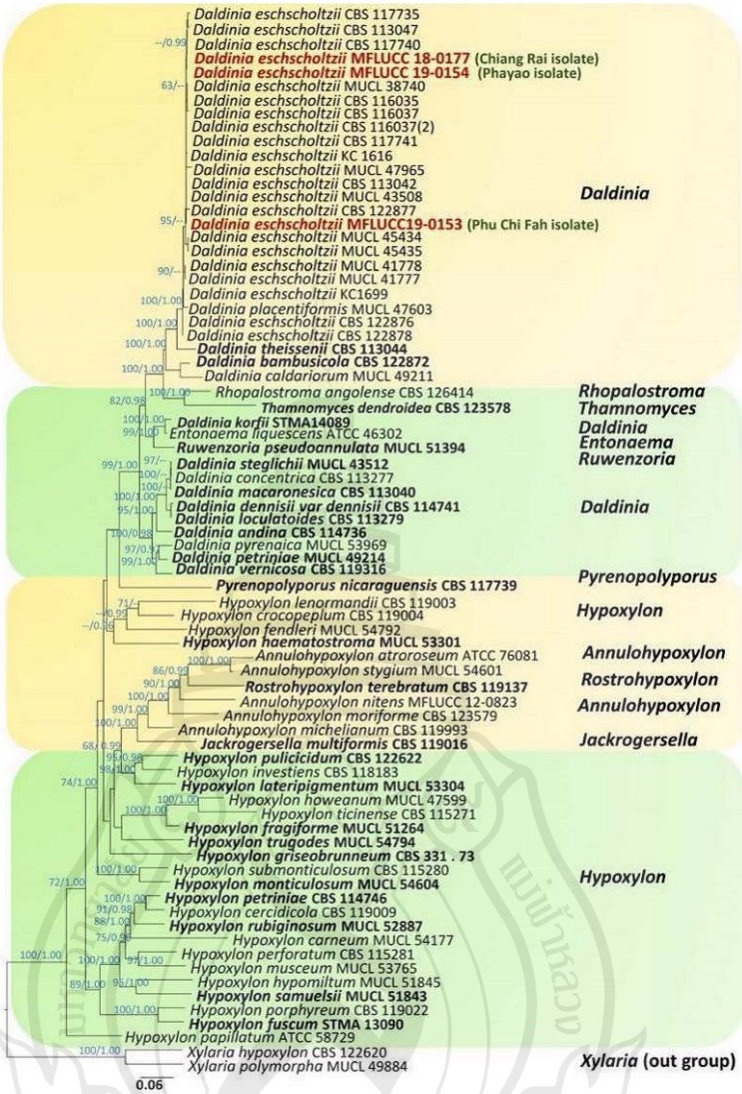
cells 2.8–4 ×1.7–5 µm ($\bar{x}$=3.4 × 2.1 µm, n=10), hyaline, holoblastic, terminal or intercalary, cylindrical, having rounded apices, texture, collaret or opening width. *Conidia* 3–5.5 µm × 2–3.5 µm ($\bar{x}$=4.6 × 2.5 µm, n=40), obovoid to ellipsoid, aseptate, hyaline, smooth often flat at the base.

Materials examined – Thailand, Chiang Rai, in symptomless fresh leaves of *Musa* sp., 15 October 2017, BC. Samarakoon, BN021 (5) (MFLU 19–0409), living culture MFLUCC 18–0177. Phayao, in symptomless fresh leaves of *Musa* sp., 23 January 2018, BC. Samarakoon, BNE003 (MFLU 19–0408), living culture MFLUCC 19–0154. Phu Chi Fah, in symptomless fresh leaves of *Musa* sp. 17 March 2018, BC. Samarakoon, BNE002 (MFLU 19–0407), living culture MFLUCC 19–0153.

4.4 Discussion

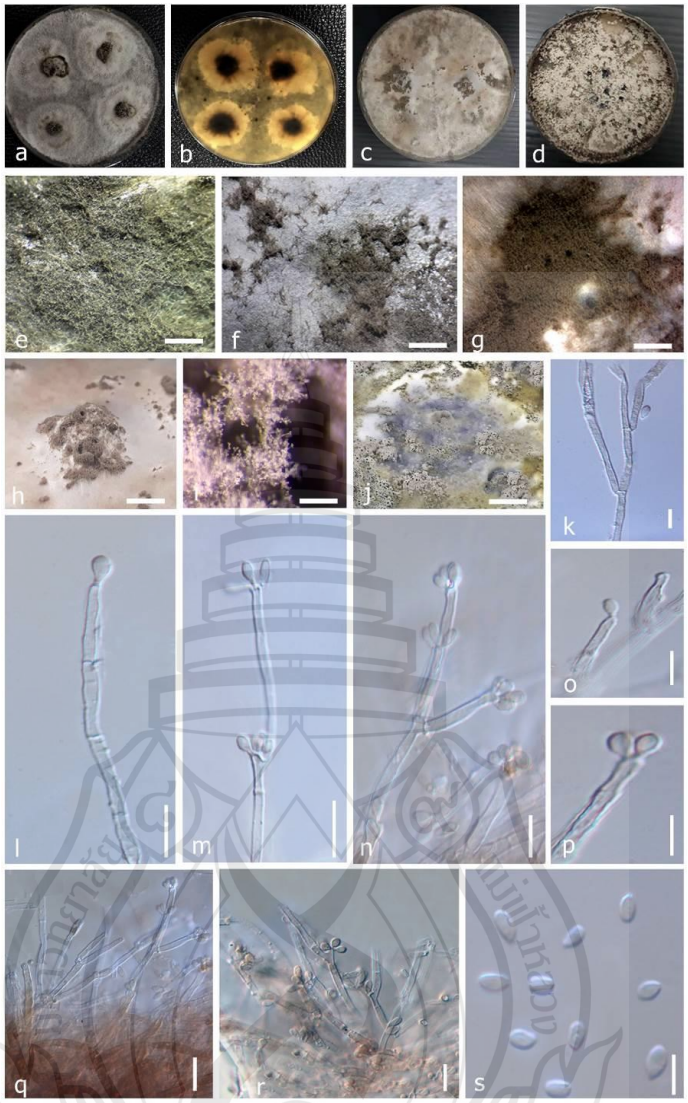
Studies about musaceous endophytes in Thailand were conducted by Photita et al. (2001, 2004) who isolated 61 fungal taxa from Doi Suthep Pui National Park, but did not conduct any molecular justification. To address this research gap, we are reinvestigating the fungi on *Musa* sp. in different geographic regions around the country, isolate them into a culture, and describe their morphology and phylogenetic relationships. During our study so far, we have isolated many taxa that have previously been recorded in Photita et al. (2001, 2004) with confirmed molecular data (not shown).

Few studies found that nonpathogenic endophytic strains of *Fusarium oxysporum* Schltdl. that have been isolated from healthy banana rhizomes can induce systemic resistance of the plant against *Radopholus similis* (pathogenic root nematode) in *Musa* sp. (Vu et al., 2006). In addition, endophytic *F. oxysporum* strains have controlled the nematode reproduction and damage (Sikora et al., 2008) and acted as potential growth promoters in *Musa* sp. (Ting et al., 2008). Therefore, the role of endophytic fungi in *Musa* sp. should be further investigated.



Note ML bootstrap supports (≥60 %) and Bayesian posterior probabilities (≥ 0.95 PP) are given. The tree was rooted with *Xylaria polymorpha* and *X. hypoxylon* (*Xylariaceae*). Strain generated in this study is indicated in red-boldface, and type strains are in black-bold. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Daldinia eschscholtzii.*

Figure 4.1 Maximum likelihood tree revealed by RAxML from an analysis of combined LSU-ITS- *rpb2* and *tub2* rDNA matrix of *Daldinia*



Note a, b immature colony on PDA after 3 weeks. c Immature colony on PDA after 2 weeks. d Colonies on PDA after 8 weeks bearing sterile stromatic structures showing sporulation in mouse gray. e greenish patches on PDA. f–i Sporulation of the colony. j Pigmentation on PDA and sterile stromatic structures. k Mycelium with nodulisporium-like branching pattern. l, m Conidial attachments and conidiogenous cells. n–r Nodulisporium-like branching pattern in the mycelium s Conidia. Scale bars: e–j = 200 µm, k–r = 10 µm, s = 2µm

Figure 4.2 *Daldinia eschscholtzii* (MFLU 19–0409)

CHAPTER 5

TAXONOMY AND PHYLOGENETIC APPRAISAL OF *Spegazzinia musae* SP. NOV. AND *S. deightonii* (*Didymosphaeriaceae*, *Pleosporales*) ON *Musaceae* FROM THAILAND

5.1 Introduction

Several taxonomic studies have been conducted to assess the saprobic fungal diversity in *Musa* species (Crous et al., 2016; Ellis, 1971, 1976; Hernández-Restrepo et al., 2015; Hyde et al., 2017; Matsushima, 1971; Photita et al., 2001; Somrithipol, 2007). Ellis (1971) described several species on *Musa* (i.e. *Arthrinium sacchari*, *Cladosporium musae*, *Cordana musae*, *Curvularia fallax*, *Deightoniella torulosa*, *Gliomastix elata*, *G. murorum* var. *polychroma*, *G. musicola*, *Gyrothrix hughesii*, *Haplobasidion musae*, *Memnoniella subsimplex*, *Periconia digitata*, *P. lateralis*, *Periconiella musae*, *Pithomyces sacchari*, *Pyriculariopsis parasitica*, *Spegazzinia tessarthra*, *Stachylidium bicolor*, *Tetraploa aristata*, *Zygosporium gibbum*, *Z. masonii* and *Z. minus*). Ellis (1976) also described *Bidenticula cannae*, *Chlamydomyces palmarum*, *Cordana johnstonii*, *Parapyricularia musae* and *Veronaea musae* on *Musa*.

Photita et al. (2001) identified 46 saprobic fungal taxa from *Musa acuminata* in Hong Kong. Most of the saprobes reported by Photita et al. (2001) belonged to the genera *Anthostomella*, *Deightoniella*, *Durispora*, *Hansfordia*, *Memnoniella*, *Nigrospora*, *Pyriculariopsis*, *Pseudopithomyces*, *Verticillium* and *Zygosporium*. In addition, *Dictyoarthrinium* (Somrithipol, 2007) and *Ramichloridium* (Kirschner & Piepenbring, 2014) were also recorded as saprobes on *Musa* sp. Considering the economic importance of *Musa* sp. there are not many studies on the saprobic fungal

populations associated with this host. Few studies have molecular data for the identified strains. To address this research gap, we are investigating the saprobic fungal diversity of *Musa* sp. in the Asian region where the fungi are highly diverse (Hyde et al., 2018).

Spegazzinia was established by Saccardo (1880) based on *S. ornata*. Currently 17 taxa are listed in Species Fungorum (2020). Based on morphology, the genus was placed in *Apiosporaceae* (*Sordariomycetes*) by Hyde et al. (1998). Based on SSU, LSU, ITS and *tef1-α* sequence data of *S. deightonii* and *S. tessarthra*, Tanaka et al. (2015) placed *Spegazzinia* in *Didymosphaeriaceae* (*Dothideomycetes*). This was supported by a phylogenetic analysis which placed *Spegazzinia* in a basal clade in *Didymosphaeriaceae* (Thambugala et al., 2017).

Hughes (1953) characterized *Spegazzinia* as a hypomycetous taxon with a unique basauxic conidiophore ontogeny (conidiophores that arise and elongate from a cup-shaped basal cell called a conidiophore mother cell). The conidia of *Spegazzinia* are brown to dark brown and dimorphic in most species, with a disc-shaped form and a stellate form (Ellis, 1971; Manoharachary & Kunwar, 2010). However, little molecular data for this genus is available in the GenBank (https://www.ncbi.nlm.nih.gov/). Therefore, for a better phylogenetic resolution of the genus in *Didymosphaeriaceae*, the previously identified taxa should be recollected to obtain DNA sequence data and morphological descriptions.

In this present study, we introduce *Spegazzinia musae* sp. nov. and report the first occurrence of *Spegazzinia deightonii* from *Musa* sp. in Thailand. We provide detailed morphological descriptions, illustrations and molecular justification for the introduction of *Spegazzinia musae* sp. nov. Our molecular analyses further support the phylogenetic placement of *Spegazzinia* in *Didymosphaeriaceae*.

5.2 Materials and Methods

5.2.1 Sample Collection, Morphological Studies and Isolation

Dead plant materials of *Musa* sp. (banana) were collected from Thailand during the dry season of 2018 to 2019. Specimens were transferred to the laboratory

in cardboard boxes. Samples were examined with a Motic SMZ 168 Series microscope. Powdery masses of conidia were mounted in water for microscopic studies and photomicrography. The taxa were examined using a Nikon ECLIPSE 80i compound microscope and photographed with a Canon 550D digital camera fitted to the microscope. Measurements were made with the Tarosoft (R) Image Frame Work program and images used for figures processed with Adobe Photoshop CS3 Extended version 10.0 software (Adobe Systems, USA).

Single spore isolation was carried out following the method described in Chomnunti et al. (2014). Germinated spores were individually transferred to potato dextrose agar (PDA) plates and grown at 25 °C in daylight. Colony characteristics were observed and measured after 3 weeks. Specimens were deposited in the Mae Fah Luang University (MFLU) Herbarium, Chiang Rai, Thailand. Living cultures were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC).

5.2.2 DNA Extraction and PCR Amplification

Fungal isolates were grown on PDA for 4 weeks at 25 °C and total genomic DNA was extracted from 50 to 100 mg of axenic mycelium of the growing cultures according to Wanasinghe et al. (2018). The mycelium was ground to a fine powder with liquid nitrogen and fungal DNA was extracted using the Biospin Fungus Genomic DNA Extraction Kit-BSC14S1 (BioFlux, P.R. China) according to the instructions of the manufacturer. Four gene regions, the internal transcribed spacer (ITS), partial 18S small subunit (SSU), partial 28S large subunit (LSU), and partial translation elongation factor 1-alpha gene (TEF1-α) were amplified using ITS5/ITS4 (White et al. 1990), NS1/NS4 (White et al., 1990), LR0R/LR5 (Vilgalys & Hester, 1990) and EF1-983F/EF1-2218R (Rehner, 2001) primers, respectively.

Polymerase chain reaction (PCR) was conducted according to the following protocol. The total volume of the PCR reaction was 25 µL containing 12.5 µL of 2 × Power Taq PCR MasterMix (a premix and ready to use solution, including 0.1 Units/ µL Taq DNA Polymerase, 500 µm dNTP Mixture each (dATP, dCTP, dGTP, dTTP), 20 mM Tris-HCL pH 8.3, 100 mM KCl, 3 mM MgCl2, stabilizer and enhancer), 1 µL of each primer (10 pM), 2 µL genomic DNA template and 8.5 µL double distilled water (ddH2O). The reaction was conducted by running for 40 cycles. The annealing

temperature was 56 °C for ITS and LSU, 57.2 °C for TEF1-α and 55 °C for SSU and initially 95 °C for 3 mins, denaturation at 95 °C for 30 seconds, annealing for 1 min, elongation at 72 °C for 30 seconds, and final extension at 72 °C for 10 mins for all gene regions. PCR amplification was confirmed on 1% agarose electrophoresis gels stained with ethidium bromide. The amplified PCR fragments were sent to a commercial sequencing provider (TsingKe Biological Technology (Beijing) Co., Ltd, China). The nucleotide sequence data acquired were deposited in GenBank.

5.2.3 Sequencing and Sequence Alignment

Obtained sequences were subjected to BLASTn search in GenBank (https://blast.ncbi. nlm.nih.gov/Blast.cgi). BLASTn search results and initial morphological studies supported that our isolates belonged to *Didymosphaeriaceae*. Other sequences used in the analyses were obtained from GenBank based on recently published data (Jayasiri et al., 2019; Tanaka et al., 2015) (Table 1). The single gene alignments were automatically done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/index.html, Katoh et al., 2019) using the default settings and later refined where necessary, using BioEdit v. 7.0.5.2 (Hall, 1999). The finalized alignment and tree were submitted to TreeBASE (submission ID: 25686, http://www.treebase.org)

5.2.4 Phylogenetic Analysis

Maximum likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis, 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution. Bootstrap support was obtained by running 1000 pseudo-replicates. Maximum likelihood bootstrap values (ML) equal or greater than 60% are given above each node in blue (Figure 5.1).

A Bayesian inference analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov chain Monte Carlo sampling (BMCMC). Two parallel runs were conducted, using the default settings, but with the following adjustments: four simultaneous Markov chains were run for 2,000,000 generations and trees were sampled every 100th generation and 20,000 trees

were obtained. The first 4,000 trees, representing the burning phase of the analyses were discarded. The remaining 16,000 trees were used for calculating PP in the majority rule consensus tree. Branches with Bayesian posterior probabilities (BYPP) greater than 0.95 are indicated above each node in blue (Figure 5. 1). Phylograms were visualized with FigTree v1.4.0 program (Rambaut, 2011) and reorganized in Microsoft Power Point.

Table 5.1 Taxa used in the phylogenetic analysis of *Spegazzinia* with the corresponding GenBank accession numbers

Species name	**Strain**	**GenBank accession number**			
		LSU	SSU	ITS	*tef1- α*
Alloconiothyrium aptrootii	CBS 980.95^{T}	JX496234	-	JX496121	-
Bimuria novae zelandiae	CBS 107.79^{T}	AY016356	AY016338	-	-
Dendrothyrium variisporum	CBS 121517^{T}	JX496143	-	JX496030	-
Deniquelata barringtoniae	MFLUCC 11-0422^{T}	JX254655	JX254656	JX254654	-
Didymocrea sadasivanii	CBS 438.65^{T}	DQ384103	DQ384066	-	-
Didymosphaeria rubi ulmifolii	MFLUCC 14-0023^{T}	KJ436586	KJ436588		-
Kalmusia spartii	MFLUCC 14-0560^{T}	KP744487	KP753953	KP744441	-
Karstenula rhodostoma	CBS 690.94	GU301821	GU296154	-	-
Laburnicola muriformis	MFLUCC 16-0290^{T}	KU743198	KU743199	KU743197	KU743213
Montagnula cirsii	MFLUCC 13-0680	KX274249	KX274255	KX274242	KX284707
M. graminicola	MFLUCC 13-0352^{T}	KM658315	KM658316	KM658314	-
Neokalmusia brevispora	KT 2313^{T}	AB524601	AB524460	-	AB539113
N. scabrispora	KT 2202	AB524594	AB524453	-	AB539107
Paracamarosporium hawaiiense	CBS 120025^{T}	JX496140	EU295655	JX496027	-
Paraconiothyrium cyclothyrioides	CBS 972.95^{T}	JX496232	AY642524	JX496119	-
Paramassariosphaeria clematidicola	MFLU 16-0172^{T}	KU743207	KU743208	KU743206	-
Paraphaeosphaeria michotii	MFLUCC 13-0349^{T}	KJ939282	KJ939285	KJ939279	-
Phaeodothis winteri	AFTOL-ID 1590	DQ678073	DQ678021	-	DQ677917
Pleospora herbarum	CBS 191.86T	GU238160	GU238232	-	KC584731
Pseudocamarosporium cotinae	MFLUCC 14-0624^{T}	KP744505	KP753964	KP744460	-

Table 5.1 (continued)

Species name	Strain	GenBank accession number			
		LSU	SSU	ITS	*tef1- α*
Pseudopithomyces chartarum	UTHSC 04-678	HG518065	-	HG518060	-
Spegazzinia bromeliacearum	JB 2019	MK809513	-	MK804501	-
S. deightonii	yone 212	AB807582	AB797292	-	AB808558
S. deightonii	yone 66	AB807581	AB797291	-	AB808557
S. intermedia	CBS 249.89	MH873861	-	MH862171	-
S. lobulata	CBS 361.58	MH869344	-	MH857812	-
S. neosundara	MFLUCC 15–0456	KX954397	KX986341	KX965728	
S. radermacherae	MFLUCC 17-2285	NG 066308	MK347848	NR 163331	MK360088
Spegazzinia sp.	yone 279	AB807583	AB797293	-	AB808559
S. tessarthra	SH 287	AB807584	AB797294	JQ673429	AB808560
Stemphylium botryosum	CBS 714.68T	KC584345	KC584603	KC584238	KC584729
Trematеia arundicola	MFLU 16-1275^{T}	KX274248	KX274254	KX274241	KX284706
T. guiyangensis	GZAAS01^{T}	KX274247	KX274253	KX274240	KX284705
Xenocamarosporium acaciae	CPC 24755^{T}	KR476759	-	KR476724	-

Note Abbreviations of culture collections: **AFTOL-ID**: Assembling the Fungal Tree of Life, **CBS**: Westerdijk Fungal Biodiversity Institute, Utrecht, Netherlands, **CPC**: Working collection of Pedro Crous housed at CBS, **GZAAS**: Guizhou Academy of Agricultural Sciences herbarium, China, **KT**: K. Tanaka, **MFLU**: Mae Fah Luang University, Chiang Rai, Thailand, **MFLUCC**: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand, **SH**: Academia Sinica People's Republic of China. Shanghai, **URM**: Universidade Federal de Pernambuco, **UTHSC**: Fungus Testing Laboratory, University of Texas Health Science Center, San Antonio, Texas, USA, **Yone**: H. Yonezawa. Type strains are superscripted with T and newly generated strains are indicated in bold.

5.3 Results

5.3.1 Phylogenetic Analysis

The combined SSU, LSU, ITS, TEF1-α matrix comprised 38 sequences including selected genera in *Didymosphaeriaceae*. A best scoring RAxML tree is

shown in Figure 5. 1. All trees (ML and BYPP) were similar in topology and did not differ (data not shown) at the generic relationships which agree with multi-gene phylogeny of Tanaka et al. (2015). All *Spegazzinia* strains analyzed here were clustered as a highly supported monophyletic clade (100% ML, 1.00 BYPP) in *Didymosphaeriaceae* (Figure 5. 1) sister to *Alloconiothyrium*, *Dendrothyrium*, *Laburnicola* and *Xenocamarosporium*. Our new species, *Spegazzinia musae* (MFLUCC 20-0001) clustered with *Spegazzinia* sp. (yone 279) and *S. deightonii* (yone 66, MFLUCC 20-0002, yone 212) with significant statistical support (77% ML, 0.99 BYPP). Strain MFLUCC 20-0002 grouped with *S. deightonii* (yone 66, yone 212) with high statistical support (96% ML, 0.99 BYPP).

5.3.2 Taxonomy

Spegazzinia deightonii (S. Hughes) Subram.

Figure 5. 2

Facesoffungi Number: FoF07238

Saprobic on dead leaves of *Musa* sp. Sexual morph Not observed. Asexual morph Hyphomycetous. *Sporodochia* powder like, dark, dense, dry, 1–3 mm diameter. *Conidiophore mother cells* 3.5–6.8 × 2.5–5.0 µm ($\bar{x}$ = 5.59 × 4.15 µm, n = 6), hyaline to light brown, sub spherical or doliiform. *Conidiophores* long or short and give rise to two types of conidia referred here as α and β. Conidiophores of α conidia up to 48–120 × 1–2 µm ($\bar{x}$ = 95.3 × 1.6 µm, n = 20), long, erect or flexuous, narrow, verruculose, unbranched, hyaline to golden-brown. Conidiophores of β conidia initially hyaline, light brown to brown at maturity, very short and slightly bent, 1.6–2 × 2.5–3 µm ($\bar{x}$ = 1.8 × 2.6 µm, n =10). *Conidiogenous cell development*; basauxic, forming a single, terminal holoblastic conidium at the apex of conidiophore. *Conidial development*; holoblastic. *Conidia*, solitary, two kinds: *α conidia*; stellate, 18–28 × 17–29 µm ($\bar{x}$ = 25.1 × 23.3 µm, n = 25), globose to variously shaped, with spines 4–6 µm long, 4–8-celled, frequently 4 and 6-celled, deeply constricted at the septa. *β conidia* are disc-shaped. At immature stage, hyaline. Light brown to dark brown at maturity, 8-celled, 16–21 × 11–14 µm ($\bar{x}$ = 19.2 × 14.6 µm, n = 25), flat from both sides with short and blunt spines. Always attached to conidiophore.

Culture characteristics - Conidia germinating on PDA within 13–14 h. Colonies growing on PDA, reaching a diameter of 55 mm after 14 d at 25 °C, raised, moderately dense, undulate margin, middle grey, periphery brownish grey and olive green at immature stage; reverse white to greyish white.

Material examined - Thailand, Chiang Rai Province, Doi Thun, on a dead leaf of *Musa* sp. (*Musaceae*), 7 December 2018, M.C. Samarakoon, BNS 072 (MFLU 19-2908), living culture MFLUCC 20-0002.

Notes - *Spegazzinia deightonii* MFLUCC 20-0002 clustered with *S. deightonii* (yone 66, yone 212) with significant statistical support (Figure 5. 1). All the strains of *S. deightonii* described in Elis (1971) and Tanaka et al. (2015) have similar morphological features with our strain such as dark brown, 8-celled, disked-shaped, spiny conidia. With morphological and multigene phylogenetic support, we report a new host record of *S. deightonii* from *Musa* sp.

Spegazzinia musae Samarakoon, Phookamsak, Wans., Chomnunti & K.D. Hyde, *sp. nov.*

Figure 5. 3

MycoBank number: MB 835298 Facesoffungi Number: FoF07237

Etymology. The name reflects the host genus, *Musa* (*Musaceae*).

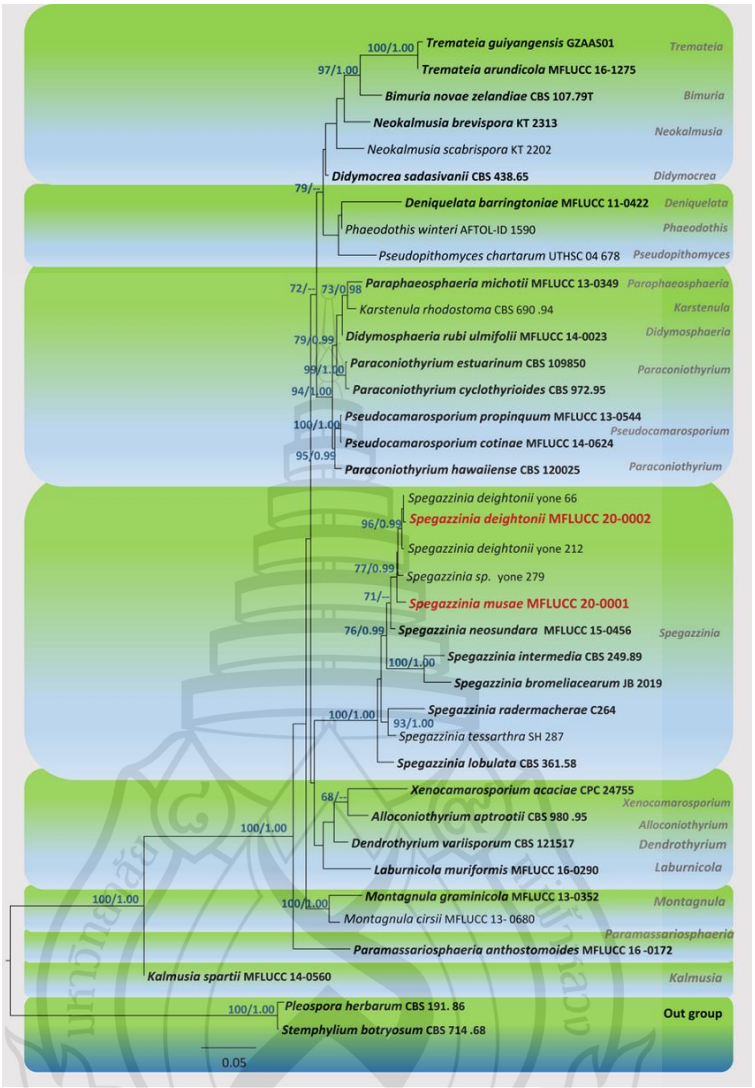
Holotype**.** MFLU 19-2907

Saprobic on a dead leaf of *Musa* sp. Sexual morph Not observed. Asexual morph Hyphomycetous. *Sporodochia* dark, dense, dry, powdery, velvety, 1–2 mm diameter. *Conidiophore mother cells* 3.4–5.8 × 3.7–4.7 μm ($\bar{x}$ = 4.6 × 4.1 μm, n = 10) sub hyaline or light brown, doliiform or sub spherical. *Conidiophores* usually have long ones and short ones that bear two kinds of conidia referred to here as α and β. Conidiophores of α conidia; up to 40–85 × 0.8–2.5 μm ($\bar{x}$ = 64 × 21.7 μm, n = 15), pale brown or dark golden brown, rough-walled, hyaline at bottom near the conidiophore mother cell, pale brown at middle, dark golden brown at top near conidial cells, erect or flexuous, narrow and long. Generally unbranched, rarely branched. Conidiophores of β conidia; 0.7–3.5 × 1.5–3 μm ($\bar{x}$ = 1.9 × 2.3 μm, n = 15), short, erect, unbranched, hyaline when immature, sub hyaline or hyaline at maturity. *Conidiogenous cell development*; basauxic, forming a single, terminal holoblastic conidium at the apex of conidiophore. *Conidial development*; holoblastic. *Conidia*

solitary, dry, two types. *α conidia*; stellate, 15–22.7 × 14.5–20.5 μm ($\bar{x}$ = 18.8 × 17.8 μm, n = 15), 4–6 celled, each cell globose to subglobose, deeply constricted at the septa, conspicuously spinulate, 4–6 spines, each 2–8 μm long arise from surface of each cell. *β conidia*; disc-shaped, initially hyaline, 4-celled, each cell slightly turbinate in shape, rough-walled, crossed septate, becoming brown to dark brown at maturity. Mature β conidia; 4-celled, each cell turbinate, crossed-septate, smooth-walled. Near septa at center; cells are light brown. At periphery in constricted areas, dark brown, 9.3–14.2 × 8.4–12.5 μm ($\bar{x}$ = 12.7 × 10.8 μm, n = 40), somewhat obovoid, deeply constricted at the septa, flat from side view. β conidia always attached to the conidiophore.

Culture characteristics - Conidia germinating on PDA within 12–15 h, germ tubes produced from one or several cells. Colonies growing on PDA, reaching a diameter of 46 mm after 14 d at 25 °C, greyish white, unevenly raised, surface rough, moderately dense, radially striated at center, margin crenulate; reverse white to greyish white.

Material examined - Thailand, Nan Province, on a dead leaf of *Musa* sp. (*Musaceae*), 12 September 2018, B.C. Samarakoon, BNS 069 (MFLU 19-2907, **holotype**), ex-type living culture MFLUCC 20-0001.Notes - Based on BLASTn search results of SSU, LSU, ITS and TEF1-α sequence data, *Spegazzinia musae* showed a high similarity (SSU = 98.24%, LSU = 98.92%, ITS = 96.91%, TEF1-α = 98.11%) to *S. neosundara* (MFLUCC 15-0456). In the multigene phylogeny, *S. musae* groups as a sister taxon to *S. deightonii* with strong statistical support (77% ML, 0.99 BYPP) (Figure 5. 1). Also, ITS sequence comparison revealed 3.75% base pair differences between *S. musae* and *S. deightonii*. Besides, *Spegazzinia musae* has contrasting morphological features to *S. deightonii* in both kinds of conidia. The disk-shaped conidia of *S. musae* are four-celled and do not bear spines at the periphery of cells, while the disc-shaped conidia of *S. deightonii* are 8-celled and spiny. Based on contrasting morphological differences and significant statistical support from our molecular phylogeny, *Spegazzinia musae* is introduced as a new species.



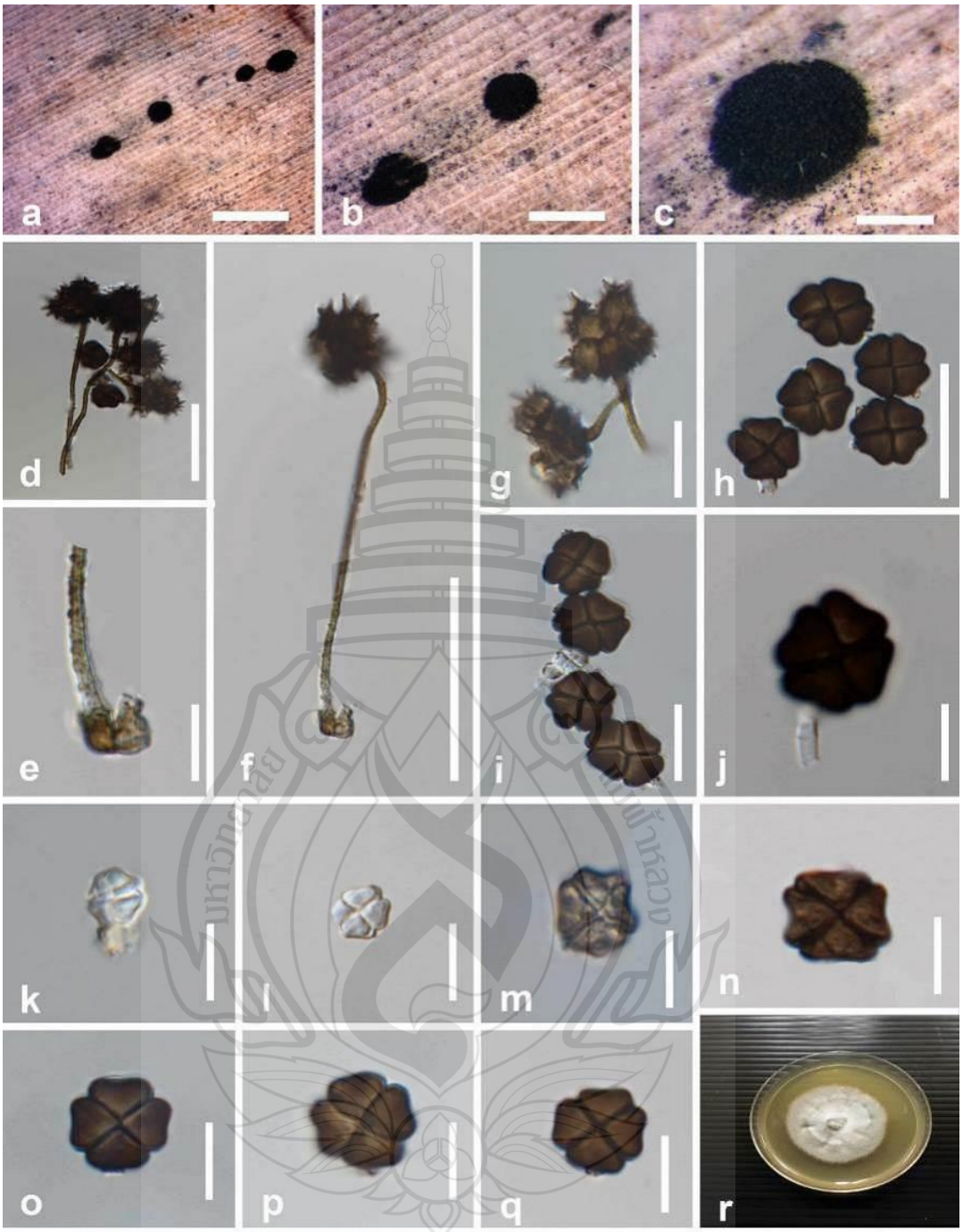
Note ML bootstrap supports (≥60 %) and Bayesian posterior probabilities (≥ 0.95 BYPP) are given above in the branches, respectively. The tree was rooted with *Pleospora herbarum* and *Stemphylium botryosum* (*Pleosporaceae*).

Figure 5.1 Maximum likelihood tree revealed by RAxML from an analysis of SSU, LSU and ITS and *tef1*-α sequence data of selected genera of family *Didymosphaeriaceae*, showing the phylogenetic position of *Spegazzinia musae* (MFLUCC 20-0001) and *S. deightonii* (MFLUCC 20-0002)



Note **a–c** fungal colonies on host surface **d** conidiophore mother cell of α conidia **e f g** α conidia **i** a developmental stage of β conidia **h k** conidia **l** colonies on PDA after 28 days showing sporulation **j, m–p** β conidia. Scale bars: 500μm (**a**), 200μm (**b**), 50 μm (**c**), 20μm (**e f g h**), 10μm (**d, k, m, n, o, p**), 5 μm (**i, j**).

Figure 5.2 *Spegazzinia deightonii* (MFLU 19-2908)



Note **a–c** fungal colonies on host surface **d** mature conidia **e** conidiophore of α conidia with the mother cell **f g** α conidia **h–q** β conidia **r** Colony on PDA after 28 days. Scale bars: 200 μm (**a b c**), 20 μm (**d e f g j**), 10 μm (**i h k–q**).

Figure 5.3 *Spegazzinia musae* (MFLU 19-2907, holotype)

5.4 Discussion

Spegazzinia is ubiquitous in the environment. Several taxa of *Spegazzinia* occur as saprobes on dead material of tropical, subtropical and temperate vascular plants (Bhat, 2010; Caretta et al., 1999; Delgado-Rodríguez et al., 2002; Ellis, 1971; Leão-Ferreira & Gusmão, 2010; Manoharachary & Kunwar, 2010; Subramanian, 1988). In addition, *Spegazzinia* was also recorded from soil (Ellis, 1971), dredged sediments of marine and brackish estuaries (Borut & Johnson, 1962) and grassland vegetation (Caretta et al., 1999). *Spegazzinia tessarthra* was recorded as an endophyte from lichens (Manish et al., 2014) and recently *S. bromeliacearum* was introduced as an endophyte from the leaves of *Tilandsia catimbauensis* (Crous et al., 2019). Damon (1953) considered *S. tessarthra* to be an important decomposer of monocotyledonous plants and other cellulose containing materials in tropical and subtropical areas. *Spegazzinia deightonii* was previously recorded on monocotyledons such as *Areca catechu* (China, Taiwan), *Cocos nucifera* (China) (Matsushima, 1980; Tianyu et al., 2009) and *Panicum maximum* (Hong Kong) (Lu et al., 2000). Our study presents the first report of *Spegazzinia deightonii* in *Musaceae* as a saprobe and introduces our new species, *S. musae*.

There does not appear to be any host-specificity as the genus is found on a wide range of hosts in various habitats and there are no records of a pathogenic lifestyle. Some *Spegazzinia* species (such as *S. tessarthra*) have been identified as saprobes and endophytes and therefore, the genus may have the potential of switching nutritional modes during the degradation of plant material (Promputtha et al., 2007).

Spegazzinia is a unique taxon among other dematiaceous hyphomycetes due to its conidial morphology and basauxic conidiogenesis. Most *Spegazzinia* species have contrasting morphological features in the shapes of α and β conidia. Some taxa bear spines in both types of conidia while some taxa do not bear spines. Simultaneously some species of *Spegazzinia* such as *S. radermacherae, S. tessarthra* show similar characters in morphology apart from dimensions of conidia. The length of conidiophores can be varied with the environmental stresses (Cole, 1974). Therefore,

the use of morphological data coupled with DNA sequence data (SSU, LSU, ITS and *tef-* α) will be crucial for better taxonomic resolutions in this genus.

Microfungal studies in *Musa* sp. are mostly oriented towards pathogens and endophytes due to the economic value of the fruit crop. Most of species that descriptively studied from *Musa* sp. are all pathogens such as *Colletotrichum, Fusarium, Mycosphaerella, Neocordana* and *Phyllosticta* (Churchill, 2011; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019; Wulandari et al., 2010). The endophytic fungal populations of *Musa* sp. were studied by Brown et al. (1998), Photita et al. (2001a, 2004) and Samarakoon et al. (2019). Few studies have documented the saprobic diversity of *Musa* sp. and as we believe, that there are saprobic niches associated with *Musa* sp. that are still unrevealed and taxonomists should investigate this hidden diversity for conservation purposes.

CHAPTER 6

MULTI-GENE PHYLOGENETIC EVIDENCE SUGGESTS *Dictyoarthrinium* BELONGS IN *Didymosphaeriaceae* (*Pleosporales, Dothideomycetes*) AND *Dictyoarthrinium musae* SP. NOV. ON *Musa* FROM THAILAND

6.1 Introduction

Hughes (1953) documented seven hyphomycete genera (*Arthrinium, Catenospegazzinia, Cordella, Dictyoarthrinium, Endocalyx, Pteroconium* and *Spegazzinia*) that had unique basauxic conidiogenous cell development. Hyde et al. (1998) accommodated *Dictyoarthrinium, Endocalyx, Scyphospora* (= *Arthrinium*) *and Spegazzinia* in *Apiosporaceae* (*Xylariales, Sordariomycetes*), based on morphological characteristics. Based on molecular phylogenetic data (LSU and ITS), *Cordella* and *Pteroconium* were synonymised under *Arthrinium* by Crous and Groenewald (2013) and *Arthrinium* was confirmed as the asexual morph of *Apiospora*. With the availability of molecular data (SSU, LSU, ITS and *tef*1-α), Tanaka et al. (2015) transferred *Spegazzinia* to *Didymosphaeriaceae*. Wijayawardene et al. (2018) and Hyde et al. (2020) accommodated *Arthrinium, Dictyoarthrinium* and *Endocalyx*, all with basauxic conidiogenous cell development, in *Apiosporaceae*.

Dictyoarthrinium was introduced by Hughes (1952) with *D. quadratum* as the type species. *Dictyoarthrinium africanum* was simultaneously introduced. Damon (1953) re-examined the type material, descriptions and illustrations of *Tetracoccosporium sacchari* (Johnston & Stevenson, 1917) and mentioned that *T. sacchari* was congeneric with *Dictyoarthrinium quadratum*. Therefore, Damon (1953) combined *T. sacchari* as *Dictyoarthrinium sacchari.* Damon (1953)

named *D. quadratum* as the heterotypic synonym of *D. sacchari*. Rao and Rao (1964) introduced *D. lilliputeum* and *D. microsporum*, while Kobayasi et al. (1971) introduced *D. rabaulense* as novel taxa to the genus. Somrithipol (2007) introduced *D. synnematicum* and currently seven epithets of *Dictyoarthrinium* are listed in Index Fungorum (2020). All *Dictyoarthrinium* species were introduced, based only on morphological data. Vu et al. (2019) sequenced *D. sacchari* (CBS 529.73) and submitted LSU data to GenBank as the only valid molecular record for the genus.

Dictyoarthrinium is characterised by basauxic conidiogenous cell development (Damon, 1953; Hughes, 1952; Matsushima, 1971). Basauxic development is demonstrated by conidiogenous cells in which elongation occurs at a basal growing point after formation of a single, terminal blastic conidium at its apex (Cole, 1976). Conidiophores of *Dictyoarthrinium* are minutely verruculose, subhyaline and transversely septate (Ellis, 1971). Usually, the septa are dark brown and appear as thick stripes on the conidiophore. Conidiophore mother cells are often hyaline or pale brown and cup-shaped (Hughes, 1952) or subspherical (Ellis, 1971). The length of conidiophores varies within the genus, but in some species, the dimensions are more or less similar. Conidia of *Dictyoarthrinium* arise from the conidiophore at terminal or lateral parts. Conidiogenesis is monoblastic or polyblastic and integrated (Ellis, 1971). Conidia are simple, solitary, dematiaceous and often four-celled. Some taxa (e.g. *D. africanum*) have 16-celled conidia (Hughes, 1952). The surface of conidia is verruculose and most species have warts on the surface. However, the conidia of *D. rabaulense* are densely echinulate with long spines (Kobayasi, 1971). The conidia vary in shape from square to spherical, subspherical or oblong. Most conidia appear flattened on one side. As a specific feature, only *D. synnematicum* possesses synnemata with filaments (Somrithipol, 2007). Stroma, setae and hyphopodia have not been observed in *Dictyoarthrinium*.

Many *Dictyoarthrinium* species are saprobes that colonise dead plant materials, although *D. rabaulense* was recorded even from soil and air (Ellis, 1976; Kobayasi et al., 1971). Most *Dictyoarthrinium* species occur on monocotyledonous plants. The genus is widely distributed across the tropics, mainly in terrestrial environments (Ellis, 1971, 1976). The sexual morph of *Dictyoarthrinium* is unknown.

Hosts, substrates and geographical distributions of extant *Dictyoarthrinium* species are listed in Table 1.

A study was undertaken to determine the saprobic fungi associated with *Musa* sp. (banana) in Thailand, during the dry season. Three hyphomycetous taxa that morphologically resembled *Dictyoarthrinium* were examined. According to our phylogenetic analyses of combined SSU, LSU, ITS and *tef*1-α sequence data, *Dictyoarthrinium* clustered in *Didymosphaeriaceae* (*Pleosporales*, *Dothideomycetes*) with strong statistical support, sister to *Spegazzinia.* Hence, we propose to transfer *Dictyoarthrinium* from *Apiosporaceae* (*Xylariales, Sordariomycetes*) to *Didymosphaeriaceae* (*Pleosporales, Dothideomycetes*) and introduce *Dictyoarthrinium musae* sp. nov. as a saprobe recorded from *Musa* sp. We also provide detailed morphological illustrations, descriptions and DNA sequence data for *D. sacchari,* recorded on *Musa* sp. from Thailand, which further validates the novel taxonomic placement of *Dictyoarthrinium* in *Didymosphaeriaceae*.

6.2 Materials and Methods

6.2.1 Sample Collection, Morphological Studies and Isolation

Dead leaves of *Musa* sp. were collected from Thailand during the dry season (December to March) of 2018 and 2019. Samples were examined with a Motic SMZ 168 Series microscope. Powder-like masses of fungal conidia were mounted in water for microscopic studies and photomicrography. The specimens were examined using a Nikon ECLIPSE 80i compound microscope and photographed with a Canon 550D digital camera fitted to the microscope. Measurements were made with the Tarosoft (R) Image Frame Work programme and images used for figures were processed with Adobe Photoshop CS3 Extended v. 10.0 software (Adobe Systems, USA). Single spore isolation was carried out following the method described in Chomnunti et al. (2014). Germinated spores were individually transferred to potato dextrose agar (PDA) plates and incubated at 25°C in daylight. Herbarium specimens were deposited in the Mae Fah Luang University (MFLU) Herbarium, Chiang Rai, Thailand. Living

cultures were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC).

Table 6.1 Hosts, substrates and geographical distribution of *Dictyoarthrinium* species

Species	Hosts/substrates	Geographical distribution	References
Dictyoarthrinium africanum S. Hughes	*Miscanthus*, *Panicum*, *Paspalum virgatum*, *Saccharum*, leaf litter of *Typha latifolia*	Argentina, Ghana, Solomon Islands, Venezuela	Ellis (1971), Hughes (1952), McKenzie and Jackson (1986), Tarda et al. (2019) and Urtiaga (1986)
D. lilliputeum P. Rag. Rao and D. Rao	Leaf litter of *Bambusae*	India	Rao and Rao (1964) and Sushma et al. (2020)
D. microsporum P. Rag. Rao and D. Rao	Dead leaves of *Borassus flabellifer*	India	Rao and Rao (1964)
D. rabaulense Matsush.	*Brassica campestris*, *Dendrocalamus strictus*, *Gossypium*, *Xylia xylocarpa*, air and soil	Bismarck Archipelago, Britain, Congo, India, New Caledonia, Nigeria, Tanzania.	Bhat (2010), Ellis (1976) and Kobayasi et al. (1971)
D. sacchari (J.A. Stev.) Damon = *D. quadratum* S. Hughes	Dead stems and leaves of *Ananas*, *Bambusa*, *Borassus*, *Cassia*, *Cosmos bipinnatus*, *Cymbopogon*, *Delonix elata*, *Dracaena*, *Erythrina*, *Lithachne pauciflora*, *Musa acuminata*, *M. paradisiaca*, *Neolitsea scrobiculata*, *Pandanus*, *Persea mechrantha*, *Phragmites*, *Prunus amygdalus*, *Saccharum* sp., *S. officinarum*, *S. spontanium*, *Zinnia*, leaf litter of *Typha latifolia*, decaying plant materials of dicots	Brazil, Cuba, Federated Ghana, India, Malaysia, Pakistan, Puerto Rico, Solomon Islands, Spain, States of Micronesia, Thailand, Venezuela, Zambia	Ahmad et al. (1997), Arnold (1986), Dennis (1970), Ellis (1971), Gene et al. (1990), Hughes (1952), Leão-Ferreira et al. (2010), Lumyong et al. (2003), Matsushima (1971), McKenzie and Jackson (1986), McKenzie and Jackson (1990), Nair and Tyagi (1961), Pande and Rao (1998), Paul and Singh (1986), Saravanan and Vittal (2007), Srivastava and Gupta (1981), Srivastava et al. (1964), Stevenson (1975), Subramanian (1952), and Tarda et al. (2019)
D. synnematicum Somrith.	Decaying leaves of *Musa* sp.	India, Thailand	Somrithipol (2007)

6.2.2 DNA Extraction, PCR Amplification and Sequencing

Fungal isolates grown on potato dextrose agar (PDA) for 4 weeks at 25°C were used to extract total genomic DNA. DNA was extracted from 50 to 100 mg of

axenic mycelium of the 4-weeks-old growing cultures. The mycelium was ground to a fine powder in liquid nitrogen and fungal DNA was extracted using the Biospin Fungus Genomic DNA Extraction Kit-BSC14S1 (BioFlux, P.R. China) according to the manufacturer's instructions. Four gene regions, the internal transcribed spacer (ITS), partial 18S small sub unit (SSU), partial 28S large sub unit (LSU) and partial translation elongation factor 1-alpha gene (*tef*1-α) were amplified using ITS5/ITS4 (White et al., 1990), NS1/NS4 (White et al., 1990), LR0R/LR5 (Vilgalys & Hester, 1990) and EF1-983F /EF1-2218R (Rehner, 2001) primers, respectively.

Polymerase chain reactions (PCR) were conducted according to the following protocol. The total volume of the PCR reaction was 25 µl and consisted of 12.5 µl of 2 × Power Taq PCR MasterMix (a premix and ready to use solution, including 0.1 Units/µlTaq DNA Polymerase, 500 µm dNTP Mixture each (dATP, dCTP, dGTP, dTTP), 20 mM Tris-HCl pH 8.3, 100 mMKCl, 3 mM $MgCl_2$, stabiliser and enhancer), 1 µl of each primer (10 pM), 2 µl genomic DNA extract and 8.5 µl double distilled water (ddH_2O). The reaction was conducted by running for 40 cycles. The annealing temperature was 56ºC for ITS and LSU, 57.2ºC for *tef*1-α and 55°C for SSU and initially 95°C for 3 min, denaturation at 95°C for 30 seconds, annealing for 1 min, elongation at 72°C for 30 seconds and final extension at 72°C for 10 min for all gene regions. PCR amplification was confirmed on 1% agarose electrophoresis gels stained with ethidium bromide. The amplified PCR fragments were sent to a commercial sequencing provider (TsingKe Biological Technology Co., Beijing, China). The nucleotide sequence data acquired were deposited in GenBank.

6.2.3 Sequence Alignment

Obtained sequences were subjected to BLAST search in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi). BLAST search results and initial morphological studies supported that our isolates belong to *Didymosphaeriaceae.* Other sequences used in the analyses were obtained from GenBank based on recently published papers (Jayasiri et al., 2019; Tanaka et al., 2015) (Table 2) and BLAST search results. The single gene alignments were done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/large.html; Katoh et al., 2019) using the default settings and later refined, where necessary, using BioEdit v. 7.0.5.2 (Hall, 1999).

6.2.4 Phylogenetic Analyses

Maximum Likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis, 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution. Bootstrap supports were obtained by running 1000 pseudo-replicates. Maximum Likelihood bootstrap values (ML) ≥ 60% are given above each node of the phylogenetic tree in brown (Figure 1).

A Bayesian analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov Chain Monte Carlo sampling (BMCMC). Two parallel runs were conducted, using the default settings, but with the following adjustments: four simultaneous Markov chains were run for 2,000,000 generations, trees were sampled every 100^{th} generation and 20,001 trees were obtained. The first 4,000 trees, representing the burn-in phase of the analyses, were discarded. The remaining 16,001 trees were used for calculating PP in the majority rule consensus tree. Branches with Bayesian posterior probabilities (BYPP) ≥ 0.95 are indicated above each node of the phylogenetic tree (Figure 6. 1). Phylogenetic trees were visualised with the FigTree v1.4.0 programme (Rambaut, 2011). Type strains are superscript with T and newly-generated strains are indicated in bold (Table 6.2).

Table 6.2 Selected taxa with their corresponding GenBank accession numbers in the family *Didymosphaeriaceae* that are utilised in the phylogenetic analyses

Taxa	Culture collection	ITS	LSU	SSU	*tef*1-α
Alloconiothyrium aptrootii	CBS 980.95^{T}	JX496121	JX496234	NA	NA
A. aptrootii	CBS 981.95^{T}	JX496122	JX496235	NA	NA
Austropleospora archidendri	CBS 168.77^{T}	JX496049	JX496162	NA	NA
A. keteleeriae	MFLUCC 18-1551^{T}	NR_163349	MK348021	MK347910	MK360045
Bambusistroma didymosporum	MFLU 15-0057^{T}	KP761733	KP761730	KP761737	KP761727
B. didymosporum	MFLU 15-0058	KP761734	KP761731	KP761738	KP761728
Bimuria novae zelandiae	CBS 107.79^{T}	MH861181	AY016356	AY016338	DQ471087

Table 6.2 (continued)

Taxa	Culture collection	ITS	LSU	SSU	*tef*1-*α*
C. thailandensis	MFLUCC 17-1510^{T}	MN325018	MN325006	MN325012	MN335651
Cylindroaseptospora leucaenae	MFLUCC 17-2424^{T}	NR_163333	NG_066310	MK347856	MK360047
Deniquelata barringtoniae	MFLUCC 11-0422^{T}	NR_111779	NG_042696	JX254656	NA
D. vittalii	NFCCI4249^{T}	MF406218	MF182395	MF622059	MF182398
Dictyoarthrinium musae	MFLUCC 20-0105^{T}	MT435617	MT482320	MT482326	MT495602
D. musae	MFLUCC 20-0106^{T}	MT482324	MT482321	MT482327	MT495603
D. sacchari	MFLUCC 20-0107	MT482325	MT482322	MT482328	NA
D. sacchari	CBS 529.73	NA	MH872479	NA	NA
Didymocrea sadasivanii	CBS 438.65^{T}	MH858658	DQ384103	NA	NA
Didymosphaeria rubi-ulmifolii	MFLUCC 14-0023^{T}	NA	KJ436586	NG_063557	NA
D. rubi-ulmifolii	MFLUCC 14-0024	NA	KJ436585	KJ436587	NA
Kalmusia italica	MFLUCC 14-0560^{T}	KP325440	KP325441	KP325442	NA
K. variisporum	CBS 121.517^{T}	NR_145165	JX496143	NA	NA
Kalmusibambusa triseptata	MFLUCC 13-0232^{T}	KY682697	KY682695	KY682696	NA
Karstenula rhodostoma	CBS 690.94	NA	GU301821	GU296154	GU349067
K. rhodostoma	CBS 691.94	LC014559	AB807531	AB797241	AB808506
Laburnicola hawksworthii	MFLUCC 13-0602^{T}	KU743194	KU743195	KU743196	NA
L. muriformis	MFLUCC 14-0921^{T}	KU743200	KU743201	KU743202	NA
Letendraea cordylinicola	MFLUCC 11-0150	KM213996	KM213999	KM214002	NA
L. cordylinicola	MFLUCC 11-0148^{T}	NR_154118	NG_059530	KM214001	NA
Montagnula bellevaliae	MFLUCC 14-0924^{T}	KT443906	KT443902	KT443904	KX949743
M. cirsii	MFLUCC 13-0680	KX274242	KX274249	KX274255	KX284707
M. scabiosae	MFLUCC 14-0954^{T}	KT443907	KT443903	KT443905	NA
Neokalmusia brevispora	KT 1466^{T}	LC014573	AB524600	AB524459	AB539112
N. scabrispora	KT 1023	LC014575	AB524593	AB524452	AB539106
Neptunomyces aureus	CMG12^{T}	MK912121	NA	NA	MK948000
N. aureus	CMG13	MK912122	NA	NA	MK948001
Paracamarosporium fagi	CPC 24890	KR611886	KR611904	NA	NA
P. fagi	CPC 24892^{T}	KR611887	KR611905	NA	NA
Paramassariosphaeria anthostomoides	CBS 615.86	MH862005	GU205223	GU205246	NA
P. anthostomoides	MFLU 16-0172^{T}	KU743206	KU743207	KU743208	NA
Paraphaeosphaeria rosae	MFLUCC 17-2549^{T}	MG828937	MG829046	MG829152	MG829223
P. rosicola	MFLUCC 15-0042^{T}	NR_157528	MG829047	MG829153	NA
Phaeodothis winteri	CBS 182.58	NA	GU301857	GU296183	NA
Pseudocamarosporium propinquum	MFLUCC 13-0544	KJ747049	KJ813280	KJ819949	NA

Table 6.2 (continued)

Taxa	Culture collection	ITS	LSU	SSU	*tef*1-α
P. pteleae	MFLUCC 17-0724^{T}	NR_157536	MG829061	MG829166	MG829233
Pseudopithomyces entadae	MFLUCC 17-0917^{T}	NA	NG_066305	MK347835	MK360083
P. rosae	MFLUCC 15-0035^{T}	MG828953	MG829064	MG829168	NA
Spegazzinia bromeliacearum	URM 8084^{T}	MK804501	MK809513	NA	NA
S. deightonii	MFLUCC 20-0002	MN956768	MN956772	MN956770	NA
S. intermedia	CBS 249.89^{T}	MH862171	MH873861	NA	NA
S. lobulata	CBS 361.58^{T}	MH857812	MH869344	NA	NA
S. musae	MFLUCC 20-0001^{T}	MN930512	MN930514	MN930513	NA
S. neosundara	MFLUCC 15-0456^{T}	KX965728	KX954397	KX986341	NA
S. radermacherae	MFLUCC 17-2285^{T}	MK347740	MK347957	MK347848	MK360088
S. tessarthra	SH 287	JQ673429	AB807584	AB797294	AB808560
Trematheia arundicola	MFLU 16-1275^{T}	KX274241	KX274248	KX274254	KX284706
T. guiyangensis	GZAAS01^{T}	KX274240	KX274247	KX274253	KX284705
T. murispora	GZCC 18-2787^{T}	NR_165916	MK972751	MK972750	MK986482
Verrucoconiothyrium nitidae	CBS:119209	EU552112	NA	NA	NA
Xenocamarosporium acaciae	CBS:139895	NR_137982	NG_058163	NA	NA
X. acaciae	MFLUCC 17-2432	MK347766	MK347983	MK347873	MK360093

Note *Abbreviations of culture collections: CBS: Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, CPC: Working collection of Pedro Crous housed at CBS, GZAAS: Guizhou Academy of Agricultural Sciences Herbarium, China, KT: K. Tanaka, MFLU: Mae Fah Luang University, Chiang Rai, Thailand, MFLUCC: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand, SH: Academia Sinica People's Republic of China. Shanghai, URM: Universidade Federal de Pernambuco. Type strains are provided as superscript T and newly-generated strains are indicated in bold.

6.3 Results

6.3.1 Phylogenetic Analyses

The combined SSU, LSU, ITS and *tef*1-α matrix comprised 61 sequences that represents the genera in *Didymosphaeriaceae.* The best scoring RAxML tree is shown

(Figure 6. 1) with a final ML optimisation likelihood value of -19278.64. The matrix had 1091 distinct alignment patterns, with 39.08% of undetermined characters or gaps. Estimated base frequencies were: A = 0.234095, C = 0.252628, G = 0.278053, T = 0.235224; substitution rates AC = 1.252730, AG = 2.198875, AT = 1.318760, CG = 0.953798, CT = 5.276095, GT = 1.000000; proportion of invariable sites I = 0.491333; gamma distribution shape parameter α = 0.446418. All trees (ML and BYPP) were similar in topology and did not differ at the generic relationships, which agree with multi-gene phylogeny of Tanaka et al. (2015) and Jayasiri et al. (2019). All *Dictyoarthrinium* strains analysed herein clustered as a highly-supported monophyletic clade (ML = 100%, BYPP = 1.00) in *Didymosphaeriaceae* (Figure 6. 1) sister to *Spegazzinia* (ML = 75%, BYPP = 0.98). We have included LSU sequence data of *D. sacchari* CBS 529.73 of Vu et al. (2019) in our phylogenetic analyses. According to GenBank, CBS 529.73 was classified in *Apiosporaceae* (*Sordariomycetes*). In our analyses, *D. sacchari* (CBS 529.73) clustered with MFLUCC 20-0105, MFLUCC 20-0106 and MFLUCC 20-0107 strains in *Didymosphaeriaceae* with a strong statistical support (ML = 100%, BYPP = 1.00). Our strain MFLUCC 20-0107 grouped with *D. sacchari* (CBS 529.73). The novel isolates of *D. musae* (MFLUCC 20-0105 and MFLUCC 20-0106) were sister to *D. sacchari* (CBS 529.73 and MFLUCC 20-0107) with strong statistical support (ML = 100%, BYPP = 1.00).



Note ML bootstrap supports (≥ 60%) and Bayesian posterior probabilities (≥ 0.95 BYPP) are given above the branches, respectively. The tree is rooted with *Bambusistroma didymosporum* (MFLU 15-0057 and MFLU 15-0058). The scale bar represents the expected number of nucleotide substitutions per site.

Figure 6.1 Maximum Likelihood tree revealed by RAxML from an analysis of SSU, LSU and ITS and *tef*1-α sequence data of the genera of *Didymosphaeriaceae*, showing the phylogenetic position of *Dictyoarthrinium musae* and *D. sacchari*

6.3.2 Taxonomy

Dictyoarthrinium musae Samarakoon, Chomnunti and K.D. Hyde, sp. nov. Figure 6.2

MycoBank No: 835764 Facesoffungi Number: FoF 08467

Etymology. Name reflects the host genus, *Musa* (*Musaceae*)

Holotype. MFLU 20-0437

Saprobic on dead leaves of *Musa* sp. Sexual morph: Not observed. Asexual morph: *Colonies* compact or effuse, black, often pulvinate. *Mycelium* superficial, a close network of branched and anastomosing hyphae. *Stromata* none. *Setae* and *hyphopodia* absent. *Conidiophores* 30–140 × 1–2 μm ($\bar{x}$ = 81.5 × 1.6 μm, n = 25), basauxic, arising usually singly from subspherical, subhyaline to light brown conidiophore mother cells, 4.5–4.8 × 4.3–4.5 μm ($\bar{x}$ = 4.6 × 4.4 μm, n = 10), macronematous, mononematous, straight or flexuous, narrow, cylindrical, rough, subhyaline to pale brown, with thick brown or dark brown transverse septa that appear as stripes with distances of 6.3–5.8 μm at apex and 2.3–3 μm at base of the conidiophore. *Conidiogenous cells* 4.1–4.5 × 4.3–4.7 μm ($\bar{x}$ = 4.4 × 4.5 μm, n = 10), blastic, integrated, terminal and intercalary, cylindrical, smooth, denticles absent, hyaline. *Conidia* 7.0–11.5 × 6.5–9.0 μm ($\bar{x}$ = 8.7 × 7.9 μm, n = 40), solitary, dry, acropleurogenous, simple, square, rounded at the corners, 4-celled, spherical or subspherical, often flattened in one plane, pale to dark brown at maturity, verrucose, with light brown to dark brown warts, immature conidia often 1-celled and subhyaline. Terminal conidium with four cells, sometimes absent or fallen before lateral conidia, mature conidia split along one line of the septa, most conidia arranged obliquely downwards on the conidiophore, conidial formation observed as a bunch starting after conidiophore 1–3 septate.

Culture characteristics - Conidia germinating on PDA within 18 hrs. Colonies on PDA reaching a diameter of 50 mm after 14 days at 25°C, slightly raised, hairy, filamentous, moderately dense, middle light grey, periphery white; reverse white to greyish-white.

Material examined - Thailand. Chiang Rai. On dead leaves of *Musa* sp. (*Musaceae*), 7 December 2018, M. C. Samarakoon, BNS265 (MFLU 20-0437, holotype), ex-type living culture (MFLUCC 20-0105); *ibid*. 20 February 2019, Binu

C. Samarakoon BNS2239 (MFLU 20-0438, paratype), ex-paratype living culture (MFLUCC 20-0106).

Notes - Based on BLAST search results of SSU, LSU, ITS and *tef*1-α sequence data, *Dictyoarthrinium musae* (MFLUCC 20-0105 and MFLUCC 20-0106) showed high similarity as follows: SSU = 99.15% to *Paraconiothyrium hawaiiense* (CBS 120025), LSU = 95.57% to *Cylindroaseptospora siamensis* (MFLUCC 17-2527), ITS = 98.24% to *Kalmusia italica* (isolate 5), *tef*1-α = 97.75% to *Spegazzinia neosundara* (MFLUCC 13-0211) with 100%, 100%, 87% and 99% query covers, respectively. In the multigene phylogeny, the *Dictyoarthrinium* clade was sister to *Spegazzinia* (ML = 75%, BYPP = 0.98). Within the *Dictyoarthrinium* clade, *D. musae* (MFLUCC 20-0105 and MFLUCC 20-0106) separated from the sister taxon, *D. sacchari* with strong statistical support (ML = 100%, BYPP = 1.00). ITS sequence comparison revealed 7.84% base pair differences between *D. musae* and *D. sacchari* (MFLUCC 20-0107). *Dictyoarthrinium musae* differs from *D. sacchari* by its unique conidial development in the apex. The terminal conidia of *D. musae* are always 4-celled and similar in colour to mature lateral conidia. In addition, the terminal conidia of *D. musae* are sometimes absent or fallen before the lateral conidia. In contrast, the terminal conidia of *D. sacchari* can be 2-celled or 4-celled, pale brown with respect to lateral mature conidia and always persist on the conidiophore. In addition, the mature conidia of *D. musae* split along one line of the septa and this specific feature is absent in *D. sacchari*. *Dictyoarthrinium musae* has a subhyaline, spherical conidiophore mother cell while *D. sacchari* has a distinct cup-shaped, brown conidiophore mother cell. Therefore, based on contrasting morphological differences to *D. sacchari* and strong statistical support from our molecular phylogeny, *D. musae* is herein introduced as a new species.

Dictyoarthrinium sacchari (J.A. Stev.) Damon, Bull.

Fig. 6. 3

Facesoffungi Number: FoF 08468

Saprobic on dead leaves of *Musa* sp. Sexual morph: Undetermined. Asexual morph: *Colonies* compact or effuse, black, often pulvinate. *Mycelium* superficial, a close network of branched and anastomosing hyphae. *Stromata* none. *Setae* and *hyphopodia* absent. *Conidiophores* 50–110 × 1–2 μm ($\bar{x}$ = 72.0 × 1.6 μm, n = 15),

basauxic, arising from cup-shaped, brown, distinct conidiophore mother cells, 3.4–4.4 × 2.9–4.7 μm ($\bar{x}$ = 4.0 × 3.7 μm, n = 10), macronematous, mononematous, usually straight or flexuous, narrow, cylindrical, rough-walled, subhyaline to pale brown, with dark brown transverse septa as stripes with distances of 6.3–5.8 μm at apex and 2.3–3 μm at base of the conidiophore. *Conidiogenous cells* 4.0–4.5 × 4.3–4.7 μm ($\bar{x}$ = 4.4 × 4.5 μm, n = 10), blastic, integrated, terminal and intercalary, cylindrical, smooth, hyaline. *Conidia* at maturity 8.5–11.5 × 8.5–10.0 μm ($\bar{x}$ = 9.9 × 9.3 μm, n = 40), solitary, dry, acropleurogenous, simple, square, rounded at the corners, 4-celled, but difficult to distinguish the cells due to their blackish-brown nature, spherical or subspherical, often flattened in one plane, blackish-brown at maturity, with brown warts on surface of the cells, terminal conidium always 4-celled or 2-celled, light brown when compared with lateral conidia, most conidia arranged perpendicular to the conidiophore, some directed obliquely upwards.

Culture characteristics - Conidia germinating on PDA within 18 hrs. Colonies on PDA reaching a diameter of 55 mm after 14 days at 25°C, raised, moderately dense, entire margined, brownish-grey at maturity; reverse white to greyish-white.

Material examined - Chiang Mai, Thailand. On mid-rib of a dead leaf of *Musa* sp. (*Musaceae*), S. Phongeun, 18 July 2018, BNS2287, (MFLU 20-0439), living culture MFLUCC. 20-0107.

Notes - Based on BLAST search results of SSU, LSU, ITS and *tef*1-α sequence data, our strain (MFLUCC 20-0107) showed high similarity to the taxa in GenBank as follows (SSU = 99.26% to *Paraconiothyrium brasiliense* (isolate GF1), LSU = 96.14% to *Alloconiothyrium aptrooti* (CBS 981.95), ITS = 93.00% to *Kalmusia italica* (MFLUCC 13–0066). In the multigene phylogeny, MFLUCC 20-0107 groups with *Dictyoarthrinium sacchari*, sister to *D. musae* with strong statistical support (ML = 100%, BYPP = 1.00). Our strain shares similar morphological features with *D. sacchari* (Ellis, 1971) and did not differ significantly. There are slight differences in conidial dimensions and the length of conidiophores of our collection and other *D. sacchari* collections by previous studies. Conidial dimensions and the length of conidiophores may differ due to diverse environmental effects and host associations. LSU sequence data of *D. sacchari* (CBS 529.73) are identical with our strain (MFLUCC 20-0107). Unfortunately, ITS, SSU and *tef*1-α sequence data of

CBS 529.73 are not available in GenBank to compare with our strain. LSU data of *Dictyoarthrinium musae* have 2.24% of base pair difference with *D. sacchari* (CBS 529.73 and MFLUCC 20-0107). *Dictyoarthrinium sacchari* was reported on *Musa* sp. from Thailand in Lumyong et al. (2003) without morpho-molecular justifications. In this study, we document *D. sacchari* with detailed morphological illustrations, description, herbarium material and a living culture coupled with DNA sequence data (SSU, LSU, ITS) for a better taxonomic resolution.

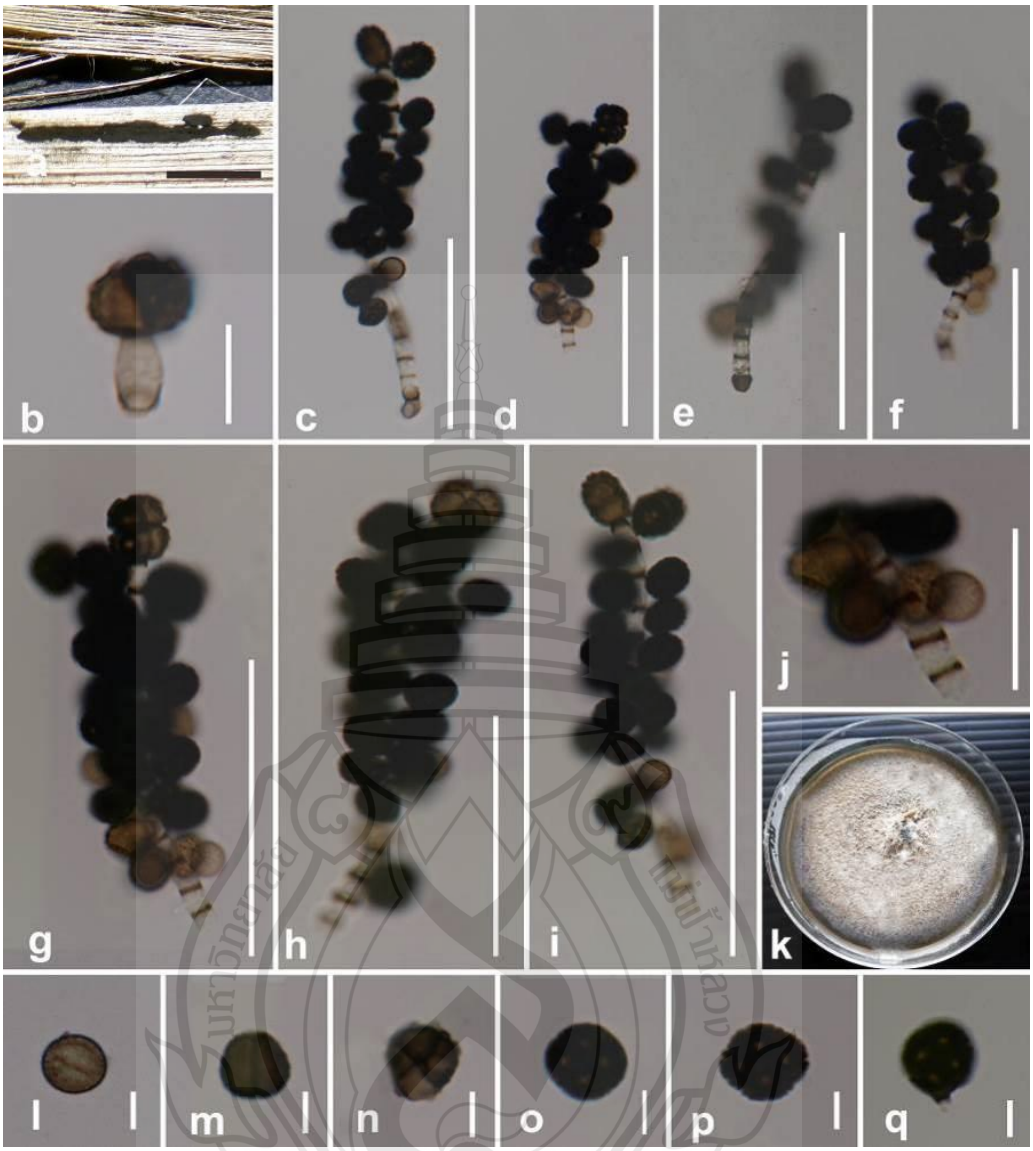
6.4 Discussion

Both *Dictyoarthrinium* and *Spegazzinia* are characterised by basauxic conidiophores (Ellis, 1971; Hughes, 1952; Tanaka et al., 2015). *Spegazzinia* often has stellate (α) and disc-shaped (β) conidia (Ellis, 1971; Tanaka et al., 2015). The conidia of *Dictyoarthrinium* (except *D. africanum*) share some similar characteristics with disc-shaped, β conidia of *Spegazzinia*. Both conidia are brown, 4-celled and constricted at the septa. Conidia of *Dictyoarthrinium* have characteristic hyaline or brown warts. Rarely, some taxa of *Spegazzinia*, for example, *S. deightonii*, also bear blunt ended spines. Most disc-shaped conidia of *Spegazzinia* are not warted. In addition, stellate conidia of *Spegazzinia* are always 4–5-celled and spinulose (Ellis, 1971; Tanaka et al., 2015). There are contrasting morphological features of the basauxic conidiophores of both genera. The conidiophores of *Dictyoarthrinium* are hyaline to subhyaline with septa that appear as dark brown or light brown stripes throughout the conidiophore. The conidiophores (in stellate conidia) of *Spegazzinia* are more elongated, narrow, aseptate and dematiaceous.



Notes a Conidia on the host; b. Conidiophore and conidia with conidiophore mother cell; c-f. Conidia with conidiophores on stalk; g. Developmental stage of an immature lateral conidium; h. Four-celled terminal conidium; i. Conidiophore; j. Conidiophores and conidia with terminal conidium; k, l. Conidiophores without terminal conidium; m. Attachment of a mature lateral conidium; n-q. Warted four-celled mature conidia; r, s. Mature conidia that split at septa; t. Colony on PDA after 21 days. Scale bars: 500 μm (a), 50 μm (b, c), 20 μm (d–g, i), 10 μm (h), 5 μm (j–s).

Figure 6.2 *Dictyoarthrinium musae* (MFLU 20-0437, holotype)



Note a Conidia on the host; b. Developmental stage of terminal conidium attached to the conidiophore; c–f. Conidiophores and conidia (e, with distinct mother cell); g, h. Mature conidiophores with four-celled terminal conidium; i. Conidiophore with two celled terminal conidium; j. Developmental stages of conidia on conidiophore; k. Colony on PDA after 21 days; l-q. Conidia. Scale bars: a = 1000 μm (a), 20 μm (b, j), 50 μm (c–i), 5 μm (l–q).

Figure 6.3 *Dictyoarthrinium sacchari* (MFLU 20-0439)

Dictyoarthrinium quadratum (type of *Dictyoarthrinium*) is the heterotypic synonym of *D. sacchari*. *Dictyoarthrinium quadratum* has a terminal mature conidium with one to two cells. As described in Hughes (1952), these 2-celled conidia remain on the conidiophore, even when other conidia fall off. This feature is absent in *D. musae*. The terminal conidium of *D. musae* always ends up with four cells. The conidia of *D. quadratum* are obliquely upwardly directed, whereas the conidia of *D. musae* are obliquely downwardly directed (Figure 2). The conidiophores of *D. quadratum* are erect and straight while *D. musae* has more curved conidiophores.

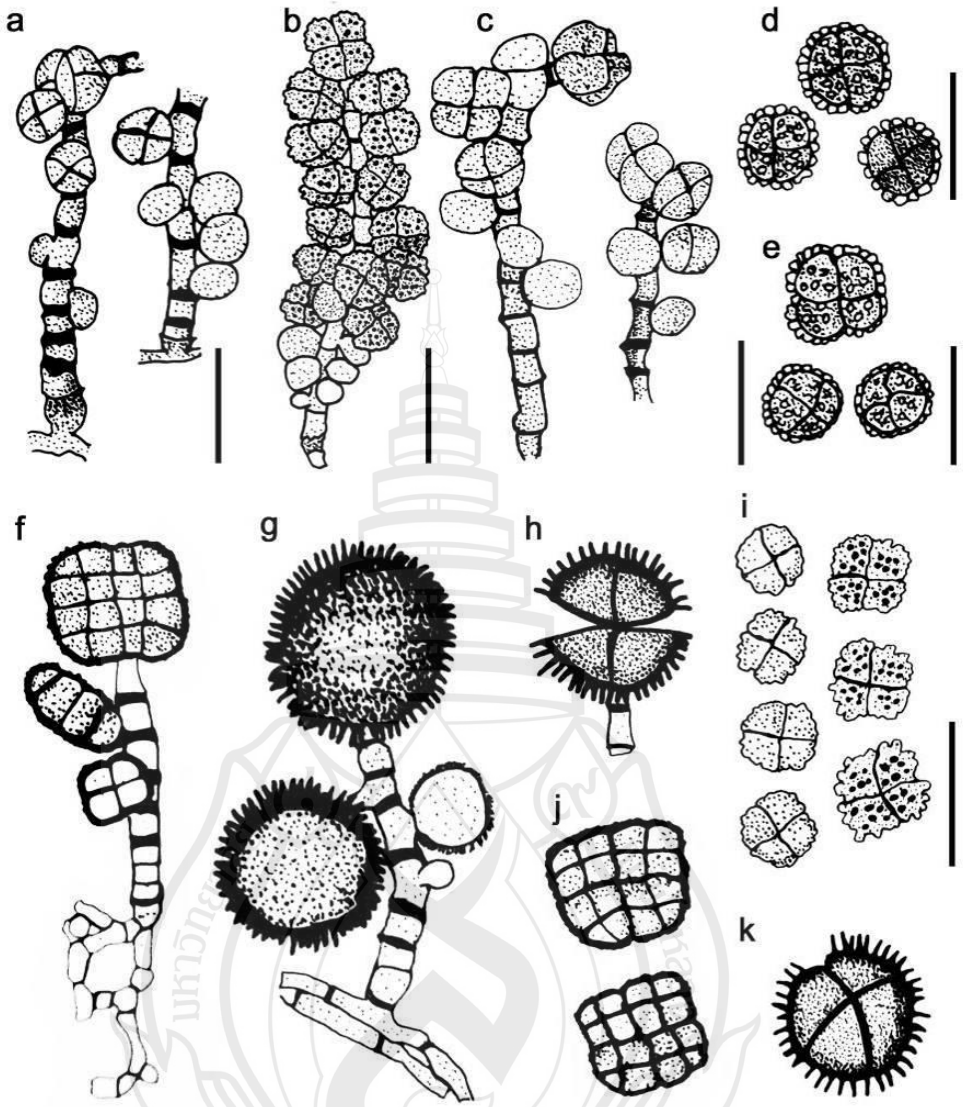
Dictyoarthrinium africanum differs significantly from *D. musae* by having 16-celled conidia. The conidia of *D. rabaulense* are completely black and densely echinulate with spines sometimes up to 4 μm long (Ellis, 1976). However, *D. musae* has brown warts on the surface of conidia, while *D. lilliputeum* has hyaline warts. *Dictyoarthrinium microsporum* has longer conidiophores (250 μm) than *D. musae*. Morphological features of *Dictyoarthrinium* species are illustrated in Figure 4. A key to the species of *Dictyoarthrinium* is provided below.

Key to the species of *Dictyoarthrinium*

1 Synnemata present *D. synnematicum*
1 Synnemata absent 2
2 Conidia 2- or 4-celled 3
2 Conidia 16-celled *D. africanum*
3 Conidia with brown warts 4
3 Conidia with hyaline warts *D. lilliputeum*
4 Conidiophores up to 130 μm long 5
4 Conidiophores up to 250 μm long *D. microsporum*
5 Terminal conidium always 4-celled, mature conidia split along one line of the septa *D. musae*
5 Terminal conidium 2- or 4-celled, mature conidia do not split along septa *D. sacchari*

To date, the taxonomy and phylogeny of most genera that have basauxic conidiogenesis (Hughes, 1952) have been resolved with their correct taxonomic placements. *Dictyoarthrinium* represented the sole unresolved genera. We transferred *Dictyoarthrinium* to *Didymosphaeriaceae* based on morphological and molecular evidence. This study uses multigene sequence data of SSU, LSU, ITS and *tef*1-α for the first time to confirm the taxonomic placement of *Dictyoarthrinium* in *Didymosphaeriaceae.*





Note a, d. *D. microsporum;* b, i. *D. synnematicum;* c, e. *D. lilliputeum;* f, j. *D. africanum;* g h, k. *D. rabaulense.* Scale bars: 20 μm (a, c, d, e), 10 μm (b, i). Magnification x 650 (f, g, h, j, k).

Source Rao and Rao (1964), Ellis (1971), Kobayasi et al. (1971) and Somrithipol (2007)

Figure 6.4 Morphology of conidia and conidiophores of previously described *Dictyoarthrinium* species

CHAPTER 7

NEW HOST AND GEOGRAPHIC RECORDS OF FIVE PLEOSPORALEAN HYPHOMYCETES ASSOCIATED WITH *Musa* SPP. (BANANA)

7.1 Introduction

Studies of fungi on *Musa* spp. have been conducted since the 19th century, especially in tropics and subtropics (Aptroot, 1995; Arnold, 1986; Ebbels & Allen, 1979; Ellis, 1971, 1976; Heredia-Abarca et al., 1997; Matsushima, 1971; Photita et al., 2001, 2002, 2003, 2004; Sawada, 1959; Shaw, 1984; Sivanesan, 1984; Somrithipol, 200). However, these studies were restricted to some fungal groups (e.g. hyphomycetous and endophytic fungi) and were based mostly on morphological characteristics. Hence, less novel species on *Musa* spp. were consequently introduced based on morphological characteristics coupled with phylogenetic analyses (Crous et al., 2016, 2017; Gao et al., 2014; Hernández-Restrepo et al., 2015; Liu et al., 2015; Samarakoon et al., 2019, 2021).

Many genera of fungi have been reported as endophytes, saprobes or pathogens on *Musa* spp. Worldwide. The most common species are from *Acremonium*, *Alternaria*, *Arthrobotryum*, *Bipolaris*, *Brevistachys*, *Chalara*, *Cladosporium*, *Coniothyrium*, *Corynespora*, *Cylindrocarpon*, *Dactylella*, *Diplodia*, *Dothiorella*, *Epicoccum*, *Helminthosporium*, *Lasiodiplodia*, *Leptosphaeria*, *Myrothecium*, *Nectria*, *Parapallidocercospora*, *Phaeodothis*, *Phaeosphaeria*, *Pseudoramularia*, *Pyricularia*, *Pyriculariopsis*, *Radaisiella*, *Scolecobasidium*, *Stagonospora*, *Torulopsis*, *Trichoderma*, *Trichothecium*, *Uwebraunia*, *Virgariella*, *Volutella*, *Wojnowicia*, *Zygophiala* and *Zasmidium* (Aptroot, 1995; Arnold, 1986; Cao et al., 2002; Gao et al., 2014; Hao et al., 2013; Heredia-Abarca et al., 1997; Photita et

al., 2001a, 2001b, 2002; Quaedvlieg et al., 2014; Shaw, 1984; Videira et al., 2017). However, few species among the latter genera have been identified based on DNA sequence data and the phylogenetic relationships of many taxa are not well investigated (Gao et al., 2014; Giraldo et al., 2017; Hao et al., 2013; Liu et al., 2015; Wikee et al., 2013).

Documentation of saprobic fungi on *Musa* spp. across the Asian region is also scanty (Matsushima, 1975; Photita et al., 2001, 2002, 2003; Samarakoon et al., 2020; Somrithipol, 2007). Based on morphology, Photita et al. (2001) reported 46 saprobes on *Musa acuminata* from Hong Kong and they belong to 40 genera in *Ascomycota* (*Anthostomella*, *Bipolaris*, *Chloridium*, *Colletotrichium*, *Corynesporopsis*, *Curvularia*, *Dactylaria*, *Dactylella*, *Deightoniella*, *Diaporthe*, *Dictyosporium*, *Didymosphaeria*, *Diplodia*, *Durispora*, *Glomerella*, *Hansfordia*, *Hyponectria*, *Leptosphaeria*, *Massarina*, *Memnoniella*, *Mycosphaerella*, *Nectria*, *Nigrospora*, *Ophioceras*, *Periconia*, *Periconiella*, *Phaeosphaeria*, *Phialocephala*, *Phoma*, *Phomatospora*, *Phomopsis*, *Pyriculariopsis*, *Stachybotrys*, *Stachylidium*, *Stemphylium*, *Tetraploa*, *Torula*, *Veronaea*, *Verticillium* and *Zygosporium*). In addition, *Cylindrocarpon* (Matsushima, 1975), *Dictyoarthrinium* (Samarakoon et al., 2020; Somrithipol, 2007), *Dictyosporium*, *Pseudopithomyces* (Photita et al., 2002), *Spegazzinia* (Samarakoon et al., 2020) and *Stachybotrys* (Photita et al., 2003) were also documented as fungal saprobes on *Musa* spp.

Periconia (*Periconiaceae*) was introduced by Tode (1791) and typified by *P. lichenoides* Tode. Both sexual and hyphomycetous asexual morphs are recorded in *Periconia* (Liu et al., 2017; Tanaka et al., 2015). The sexual morph has immersed or erumpent ascomata with an ostiolar neck. The eight ascospores are biseriate, hyaline and broadly fusiform with a gelatinous sheath (Tanaka et al., 2015). The asexual morph of *Periconia* has pale to dark brown branched or unbranched conidiophores (referred as stipe) (Tanaka et al., 2015). The conidiogenous cells are usually monoblastic or polyblastic which form at the terminal ends or intercalary parts of the conidiophore. In addition, the conidia of *Periconia* are usually catenate or solitary, pale to dark brown, spherical and aseptate (Ellis, 1971, 1976; Seifert & Gams, 2011).

The genus *Periconia* has been reported as plant pathogens, endophytes and as common saprobes in terrestrial and aquatic environments worldwide (Ellis, 1971,

1976; Liu et al., 2017; Markovskaja & Kačergius, 2014). Currently 187 epithets are listed in *Periconia* (Index Fungorum 2021). In addition, there are about 2575 DNA sequence data available for *Periconia* in GenBank (NCBI; https://www.ncbi.nlm.nih.gov/nuccore/?term=Periconia, accessed on January 10, 2021), which only restricted to 36 species. This suggests more than 150 species still need correct taxonomic placements based on molecular data, especially *P. lichenoides*, the generic type of *Periconia*.

Torula (*Torulaceae*) was introduced by Persoon (1975) and is typified by *T. herbarum* (Pers.) Link. The neotype of *T. herbarum* was designated by Crous et al. (2015). The genus is only known by its asexual morph and is characterized by doliiform to ellipsoid or clavate, cupulate conidiogenous cells which the walls are thick and heavily melanized at the base while thin at the apex. The conidia are subcylindrical, phragmosporous, brown, smooth to verrucose, and appear as branched or unbranched chains (Bhat, 2017; Crous et al., 2015; Crane & Miller, 2016; Ellis, 1971, 1976; Li et al., 2017, 2020). Previously, conidiogenesis was a key morphological feature used to delineate species in *Torula* (Crane & Schoknecht, 1977; Hughes, 1953; Li et al., 2020; Mason, 1941). Crous et al. (2015), Li et al. (2017, 2020) and Su et al. (2016, 2018) investigated the phylogenetic relationships of *Torula* using DNA sequence data (ITS, LSU, SSU, TEF, and RPB2). Currently, 17 species epithets have molecular data in GenBank (Hongsanan et al., 2020; Hyde et al., 2020a; Li et al., 2020), while more than 520 species are listed in Index Fungorum (2021). *Torula* is common on terrestrial and aquatic habitats mainly as a saprobe across tropical and temperate regions (Crous et al., 2015; Li et al., 2020; Su et al., 2018).

Most taxonomic studies have focused mostly on fungal pathogens on *Musa* spp. due to their diseases and agricultural losses (Carlier et al., 2002; Churchill, 2011; Dita et al., 2018; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019; Su et al., 2011; Wulandari et al., 2010; Zakaria et al., 2009). Therefore, the hidden saprobic and endophytic fungal diversity on *Musa* spp. are yet to be investigated as only 8% of fungi have possibly been described from the estimated fungal number of 2.2–3.8 million (Hyde et al., 2020b). In addition, a growing number of saprobic fungi recovered from *Musa* spp. need modern taxonomic

treatments (Marin-Felix et al., 2019; Maryani et al., 2019; Samarakoon et al., 2020, 2021).

We investigated the hidden saprobic fungi associated with different tissue types of *Musa* spp. (i.e. dead or fallen down leaves, leaf sheaths, pseudostems and decaying fruits) from different geographical localities across Asia. Fungi were identified based on morpho–molecular data and the taxonomic relationships were evaluated. In this study, we report *Periconia cortaderiae* (Thailand), *P. delonicis* (Thailand), *Torula chromolaenae* (Thailand), *T. fici* (Yunnan, China) and *T. masonii* (Taiwan, China) for the first time on *Musa* spp. with detailed morphological illustrations and DNA sequence data.

7.2 Materials and Methods

7.2.1 Fungal Collections, Isolation and Morphological Characterization

Dead leaves of *Musa* spp. were collected from China and Thailand. Specimens were transferred to the laboratory in cardboard boxes. Samples were examined with a Motic SMZ 168 Series microscope. Powder like masses of conidia of hyphomycetous taxa on *Musa* samples were mounted in water for microscopic studies and photomicrography. The hyphomycetous taxa were examined using a Nikon ECLIPSE 80i compound microscope and photographed with a Canon 550D digital camera fitted to the microscope. Measurements were made with the Tarosoft (R) Image Frame Work program and images used for figures processed with Adobe Photoshop CS6 Extended version 12.0 software (Adobe, USA).

Single spore isolation was carried out following the method described in Senanayake et al. (2020). Germinated spores were individually transferred to potato dextrose agar (PDA) plates and grown at 25°C in normal light. Colony characteristics were observed and measured after 3 weeks. The specimens are deposited at the Mae Fah Luang University (MFLU) Herbarium, Chiang Rai, Thailand. Living cultures are deposited at the Culture Collection of Mae Fah Luang University (MFLUCC). Faces of fungi numbers are registered as in Jayasiri et al. (2015).

7.2.2 DNA Extraction and PCR Amplification

Fungal isolates derived from single spore cultures were grown on potato dextrose agar (PDA) for 4 weeks at 25°C and the axenic mycelia (50–100 mg) of each isolate were scrapped off for DNA extraction purposes. Mycelia were ground to a fine powder with liquid nitrogen and fungal DNA was extracted using the Biospin Fungus Genomic DNA Extraction Kit–BSC14S1 (BioFlux®, P.R. China) according to the instructions of the manufacturer. Five gene regions were used for the polymerase chain reaction (PCR) amplification, including partial 18S small subunit rDNA (SSU), partial 28S large subunit rDNA (LSU), internal transcribed spacer (ITS), RNA polymerase II second largest subunit (RPB2) and partial translation elongation factor 1–alpha gene (TEF) using the primers NS1/NS4 (White et al. 1990), LR0R/LR5 (Vilgalys & Hester, 1990), ITS5/ITS4 (White et al., 1990), fRPB2–5f/fRPB2–7cR (Liu et al., 1999) and EF1–983F/EF1–2218R (Rehner, 2001), respectively.

The final volume of the PCR reaction was 25 µl, consisting of 2 µl of DNA template, 1 µl of each forward and reverse primer, 12.5 µl of 2×Easy Taq PCR SuperMix (mixture of EasyTaqTM DNA Polymerase, dNTPs, and optimized buffer, Beijing TransGen Biotech Co., Ltd., Beijing, P.R. China) and 8.5 µl of the sterilized double–distilled water (ddH_2O). The thermal cycle programs were set up following the procedures described by Samarakoon et al. (2019, 2020b) for the respective genes. The amplified PCR fragments were sent to a commercial sequencing provider (TsingKe Biological Technology (Beijing) Co., Ltd, China) for PCR purification and sequencing. The Sanger DNA sequences obtained from this study were deposited in GenBank (Tables 1, 2).

7.2.3 Sequence Alignment

Obtained sequences were subjected to BLASTn search tool in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi) for finding the closely related taxa. BLASTn search results and initial morphological studies have supported that our isolates belong to *Periconiaceae* and *Torulaceae*. Other sequences used in the analyses were obtained from GenBank (Tables 1, 2) based on recently published data (Hongsanan et al., 2020; Hyde et al., 2020a; Jayasiri et al., 2019; Li et al., 2020). The single gene alignments were done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/large.html;

Katoh et al., 2019) using the default settings and refined where necessary, using BioEdit v. 7.0.5.2 (Hall, 1999). Type strains are superscripted with "T" and newly generated strains are indicated in black bold in Table 7.1.

Table 7.1 Taxa used in the phylogenetic analyses of *Periconiaceae* with the corresponding GenBank accession numbers

Taxa	Culture collection/ Voucher no.	GenBank accession numbers			
		LSU	SSU	ITS	TEF
Flavomyces fulophazii	CBS 135761^{T}	KP184040	KP184082	KP184001	NA
F. fulophazii	MF09	MN515261	NA	MN537663	MN535259
Helminthosporium dalbergiae	H 4628	AB807521	AB797231	LC014555	AB808497
Massarina cisti	CBS 266.62^{T}	AB807539	AB797249	NA	AB808514
Noosia banksiae	CPC:17282	JF951167	NA	JF951147	NA
N. banksiae	CBS 129526	MH878062	NA	NA	NA
Periconia aquatica	MFLUCC 16-0912^{T}	KY794705	NA	KY794701	KY814760
P. byssoides	MFLUCC 18–1548	MK348013	MK347902	MK347794	MK360070
P. caespitosa	LAMIC_110_16	MH051907	NA	MH051906	NA
P. cortaderiae	MFLUCC 15-0457^{T}	NG_068238	NG_068373	NR_165853	KY310703
P. cortaderiae	MFLUCC 15-0451	KX954403	KX986346	KX965734	KY429208
P. cortaderiae	**MFLUCC 20–0236**	**MW406971**	**MW406969**	**MW406973**	**MW422156**
P. cyperacearum	CPC:32138^{T}	NG_064549	NA	NR_160357	MH327882
P. delonicis	MFLUCC 17-2584^{T}	MK347941	MK347832	NA	MK360071
P. delonicis	**MFLUCC 20–0235**	**MW406970**	**MW406968**	**MW406972**	**MW422155**
P. digitata	CBS 510.77	AB807561	AB797271	NA	AB808537
P. epilithographicola	CBS 144017^{T}	NA	NA	NR_157477	NA
P. epilithographicola	PL5-1B	NA	NA	MF422162	NA
P. homothallica	HHUF 29105	NG_059397	NG_064851	NR_153446	AB808541
P. homothallica	KT 916	AB807565	AB797275	AB809645	NA
P. igniaria	CBS 379.86	AB807566	AB797276	LC014585	AB808542
P. igniaria	CBS 845.96	AB807567	AB797277	LC014586	AB808543
P. macrospinosa	CBS 135663	KP184038	KP184080	KP183999	NA
P. neobrittanica	CPC 37903^{T}	NG_068342	NA	NR_166344	NA
P. palmicola	MFLUCC 14-0400^{T}	NG_068917	MN648319	NA	MN821070
P. pseudobyssoides	DUCC 0850	MG333494	NA	MG333491	MG438280
P. pseudobyssoides	H 4151	AB807568	AB797278	LC014587	AB808544
P. pseudobyssoides	H 4790	AB807560	AB797270	LC014588	AB808536
P. salina	MFLU 19-1235^{T}	MN017846	MN017912	MN047086	NA

Table 7.2 Taxa used in the phylogenetic analyses of *Torulaceae* with the corresponding GenBank accession numbers

Taxa	Culture collection/ Voucher no.	ITS	LSU	SSU	RPB2	TEF
Dendryphion aquaticum	MFLUCC 15–0257^{T}	KU500566	KU500573	KU500580	NA	NA
D. comosum	CBS 208.69^{T}	MH859293	MH871026	NA	NA	NA
D. europaeum	CPC 23231	KJ869145	KJ869202	NA	NA	NA
D. hydei	KUMCC 18-0009^{T}	MN061343	MH253927	MH253929	NA	NA
Neotorula aquatica	MFLUCC 15–0342^{T}	KU500569	KU500576	KU500583	NA	NA
N. submersa	HKAS 92660	NR_154247	KX789217	NA	NA	NA
Rostriconidium aquaticum	KUMCC 15-0297	MG208165	MG208144	NA	MG207975	MG207995
R. aquaticum	MFLUCC 16–1113^{T}	MG208164	MG208143	NA	MG207974	MG207994
R. pandanicola	KUMCC 17-0176^{T}	MH275084	MH260318	MH260358	MH412759	MH412781
Roussoella nitidula	MFLUCC 11–0182^{T}	KJ474835	KJ474843	NA	KJ474859	KJ474852
R. scabrispora	MFLUCC 11–0624^{T}	KJ474836	KJ474844	NA	KJ474860	KJ474853
Roussoellopsis tosaensis	KT1659	NA	AB524625	AB524484	AB539104	AB539117
Rutola graminis	CPC 33267	MN313814	MN317295	NA	NA	NA
R. graminis	CPC 33695	MN313815	MN317296	NA	NA	NA
R. graminis	CPC 33715^{T}	MN313816	MN317297	NA	NA	NA
Sporidesmioides thailandica	MFLUCC 13–0840	MN061347	NG_059703	NG_061242	KX437761	KX437766
S. thailandica	KUMCC 16-0012^{T}	MN061348	KX437758	KX437760	KX437762	KX437767
Thyridaria broussonetiae	TB1	KX650569	NA	KX650515	KX650586	KX650539
Thyridariella mahakoshae	PUFD17-99^{T}	MG020435	MG020438	MG020441	MG020446	MG023140
Th. mangrovei	PUFD17-98^{T}	MG020434	MG020437	MG020440	MG020445	MG020443
Torula acaciae	CPC 29737^{T}	NR_155944	NG_059764	NA	KY173594	NA
T. aquatica	DLUCC 0550	MG208166	MG208145	NA	MG207976	MG207996
T. aquatica	MFLUCC16–1115^{T}	MG208167	MG208146	NA	MG207977	NA
T. breviconidiophora	KUMCC 18-0130^{T}	MK071670	MK071672	MK071697	NA	MK077673
T. camporesii	KUMCC 19-0112^{T}	MN507400	MN507402	MN507401	MN507404	MN507403
T. chiangmaiensis	KUMCC 16-0039^{T}	MN061342	KY197856	KY197863	NA	KY197876

Table 7.2 (continued)

Taxa	Culture collection/ Voucher no.	ITS	LSU	SSU	RPB2	TEF
T. chromolaenae	**MFLUCC 20–0237**	**MW412524**	**MW412518**	**MW412515**	**MW422161**	**MW422158**
T. fici	CBS 595.96^{T}	KF443408	KF443385	KF443387	KF443395	KF443402
T. fici	KUMCC 15-0428	MG208172	MG208151	NA	MG207981	MG207999
T. fici	KUMCC 16-0038	MN061341	KY197859	KY197866	KY197872	KY197879
T. fici	**MFLUCC 20–0238**	**MW412525**	**MW412519**	**MW412516**	**NA**	**MW422159**
T. gaodangensis	MFLUCC 17–0234^{T}	MF034135	NG_059827	NG_063641	NA	NA
T. goaensis	MTCC 12620^{T}	NR_159045	NG_060016	NA	NA	NA
T. herbarum	CPC 24414	KR873260	KR873288	NA	NA	NA
T. hollandica	CBS 220.69	NR_132893	NG_064274	KF443389	KF443393	KF443401
T. hydei	KUMCC 16-0037^{T}	MN061346	MH253926	MH253928	NA	MH253930
T. mackenziei	MFLUCC 13–0839^{T}	MN061344	KY197861	KY197868	KY197874	KY197881
T. masonii	CBS 245.57^{T}	NR_145193	NG_058185	NA	NA	NA
T. masonii	DLUCC 0588	MG208173	MG208152	NA	MG207982	MG208000
T. masonii	**MFLUCC 20–0239**	**MW412523**	**MW412517**	**MW412514**	**MW422160**	**MW422157**
T. pluriseptata	MFLUCC 14–0437^{T}	MN061338	KY197855	KY197862	KY197869	KY197875
T. polyseptata	KUMCC 18-0131^{T}	MK071671	MK071673	MK071698	NA	MK077674

Note Abbreviations of culture collections: **CBS**: Westerdijk Fungal Biodiversity Institute, Utrecht, Netherlands, **CPC**: Working collection of Pedro Crous housed at CBS, **GZAAS**: Guizhou Academy of Agricultural Sciences herbarium, China, **H**: University of Helsinki, Helsinki, Finland, **KT**: K. Tanaka, **MFLU**: Mae Fah Luang University, Chiang Rai, Thailand, **MFLUCC**: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand, **S**: Swedish Museum of Natural History, Stockholm, Sweden, **SH**: Academia Sinica People's Republic of China. Shanghai, **URM**: Universidade Federal de Pernambuco.

7.2.4 Phylogenetic Analyses

Phylogenetic analyses were preformed based on maximum likelihood (ML) and Bayesian inference (BI) criteria. The phylogenetic trees showing relationships of

taxa in *Periconiaceae* and *Torulaceae* were generated separately. Data matrixes used in these analyses were followed as; *Periconiaceae* (Analysis 1): the combined SSU, LSU, ITS and TEF data matrix comprised 35 sequences of representative taxa in *Periconiaceae*. *Helminthosporium dalbergiae* (MAFF 243853) and *Massarina cisti* (CBS 266.62) were selected as outgroup taxa. *Torulaceae* (Analysis 2): the combined SSU, LSU, ITS, TEF and RPB2 matrix comprised 40 sequences of selected genera in *Torulaceae*. Taxa in *Roussoellaceae* were selected as the outgroup taxa viz. *Roussoella nitidula* (MFLUCC 11–0182), *R. scabrispora* (MFLUCC 11–0624) and *Roussoellopsis tosaensis* (KT 1659).

Maximum likelihood (ML) trees were generated using the RAxML–HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution and 1,000 replicates of rapid bootstrap. Bayesian inference (BI) analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov Chain Monte Carlo sampling (BMCMC). Two parallel runs were conducted, using the default settings, but with the following adjustments: four simultaneous Markov chains were run for 2,000,000 generations (Analysis 1, 2) and trees were sampled every 100th generation and 20,000 trees were obtained. The first 4,000 trees, representing the burn–in phase of the analyses were discarded. The remaining 16,000 trees were used for calculating PP in the 50% majority rule consensus tree.

Phylograms were visualized with FigTree v1.4.0 program (Rambaut, 2011) and reorganized in Microsoft PowerPoint (2007, USA) and converted to jpeg file in Adobe Photoshop CS6 Extended version 12.0 software (Adobe, USA). The final trees and data matrixes were submitted in TreeBASE (https://www.treebase.org/), submission ID: 27468 for *Periconiaceae* and 27469 for *Torulaceae*.

7.3 Results

7.3.1 Phylogenetic Analyses

Analysis 1: *Periconiaceae*

The best scoring RAxML tree resulted from the combined gene analysis of SSU, LSU, ITS and TEF sequence data is shown in Fig. 1 with a final ML optimization likelihood value of –9645.86. The matrix had 561 distinct alignment patterns, with 26.15% of undetermined characters or gaps. Estimated base frequencies were as follows; A = 0.233866, C = 0.256179, G = 0.274088, T = 0.235866; substitution rates AC = 2.126081, AG = 2.703293, AT = 1.718216, CG = 1.412442, CT = 10.292987, GT = 1.000000; proportion of invariable sites I =0.624461; gamma distribution shape parameter α = 0.615919. Bayesian posterior probabilities (BYPP) from MCMC were evaluated with a final average standard deviation of split frequencies was 0.008. All trees (ML & BI) were similar in topology and did not differ significantly with respects to generic placements and this agrees with previous studies based on multi–gene phylogeny (Hongsanan et al., 2020; Hyde et al., 2020; Jayasiri et al., 2019). Our MFLUCC 20–0235 strain is sister to *Periconia delonicis* (MFLUCC 17−2584) and grouped with *P. palmicola* (MFLUCC 14−0400) and *P. verrucosa* (MFLUCC 17−2158) with a strong statistical support (ML = 98%, BYPP =1.00; Fig. 1). The MFLUCC 20–0236 strain grouped with *P. cortaderiae* (MFLUCC 15−0457, MFLUCC 15−0451) with high support (ML = 100%, BYPP = 1.00), and has close phylogenetic affinity to *Noosia banksiae* (CPC: 17282, CBS 129526) and *Periconia homothallica* (KT 916, HHUF 29105). Therefore, we identify MFLUCC 20–0235 as *P. delonicis* and MFLUCC 20–0236 as *P. cortaderiae*, respectively.

Analysis 2: *Torulaceae*

The best scoring RAxML tree (Fig. 2) has a final ML optimization likelihood value of –19754.05. The matrix had 1189 distinct alignment patterns, with 31.37% of undetermined characters or gaps. Estimated base frequencies were as follows; A = 0.241559, C = 0.263242, G = 0.273563, T = 0.221637; substitution rates AC = 1.375308, AG = 2.974871, AT = 1.345285, CG = 0.922655, CT = 6.841524, GT = 1.000000; proportion of invariable sites I = 0.486989; gamma distribution shape parameter α = 0.482115. Bayesian posterior probabilities (BYPP) from MCMC were evaluated with a final average standard deviation of split frequencies was 0.005. All the phylogenetic trees (ML & BI) were similar in topology and no considerable difference at the generic level and similar with the phylogenetic analyses of and Hyde et al. (2020), Li et al. (2017, 2020), and Su et al. (2018). Our isolate (MFLUCC 20–

0237) formed a clade with *Torula chromolaenae* (KUMCC 16–0036) with high support (ML = 100%, BYPP = 1.00), and clustered with *T. breviconidiophora* (KUMCC 18–0130) and *T. mackenziei* (MFLUCC 13−0839). The MFLUCC 20–0238 strain clustered with *T. fici* (CBS 595.96, KUMCC 15–0428, KUMCC 16–0038) with moderate support in ML analysis (ML = 80%) and not significant support in BI analysis and has a close relationship with *T. hydei* (KUMCC 16–0037; ML 98%, BYPP = 1.00). The MFLUCC 20–0239 strain clustered with *T. masonii* (CBS 245.57, DLUCC 0588, KUMCC 16–0033) with high support (ML = 100%, BYPP = 1.00), and also close to *T. acaciae* (CPC 29737). We therefore identify MFLUCC 20–0237 as *T. chromolaenae*, MFLUCC 20–0238 as *T. fici* and MFLUCC 20–0239 as *T. masonii*, respectively.

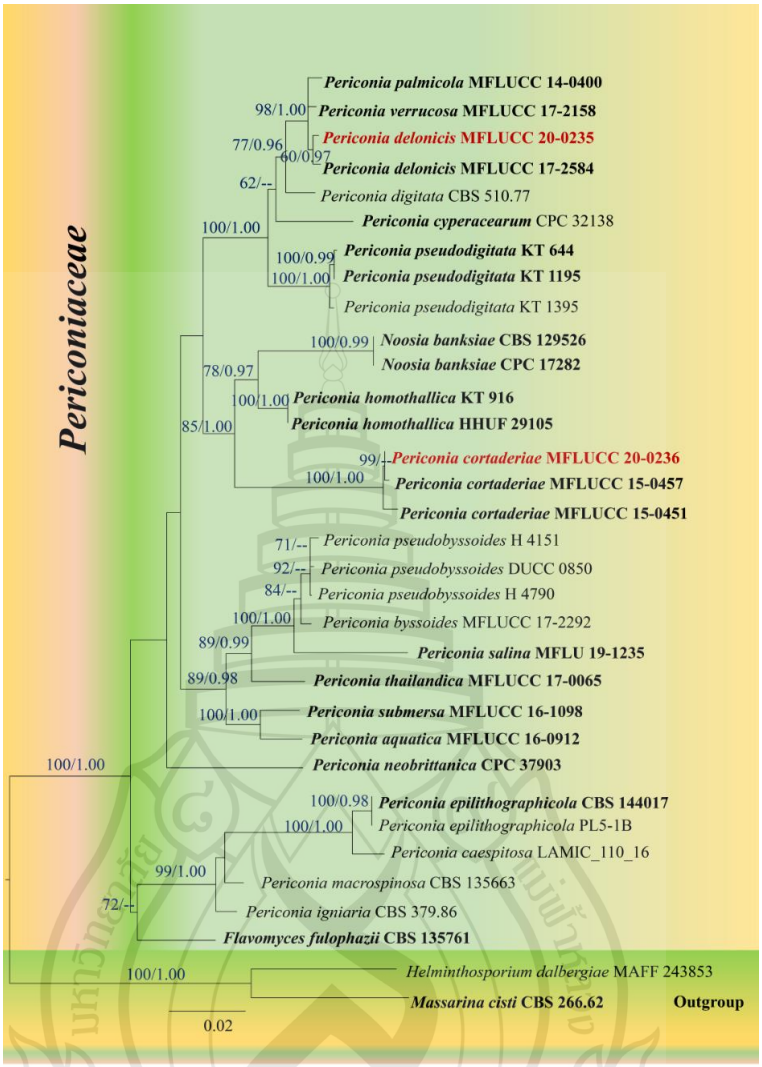
7.3.2 Taxonomy

Periconia delonicis Jayasiri, E.B.G. Jones & K.D. Hyde

Figure 7. 3

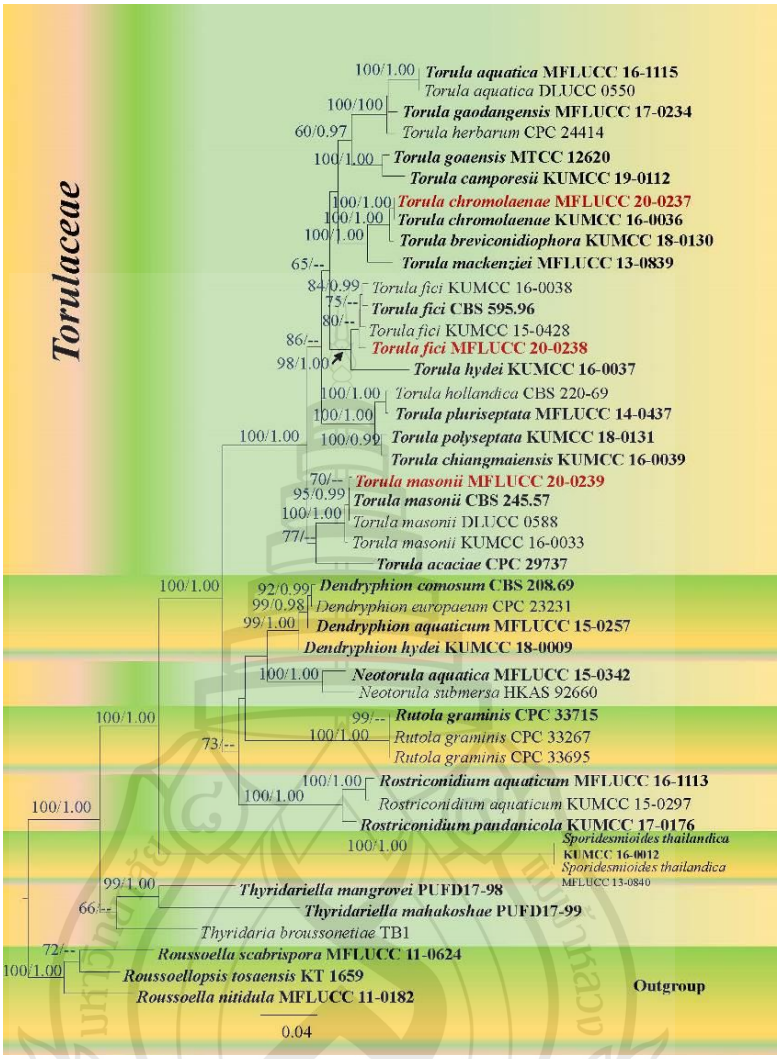
Index Fungorum number: IF555562; Facesoffungi number: FoF 05268

Saprobic on a dead leaf of *Musa* sp. Sexual morph: Undetermined. Asexual morph: hyphomycetous. *Conidiophores* 320−400 × 8−12 μm ($\bar{x}$ = 365 × 9.5 μm, n = 10) macronematous, rarely micronematous. Macronematous conidiophores and conidia resembled a stipe and a globular head. *Stipe of the Conidiophores* unbranched, straight or flexuous from the middle, septate, pale to dark brown, often appearing black, smooth, globular heads shining by reflected light. *Conidiogenous cells* 4−7.5 × 3.4−7.4 μm ($\bar{x}$ = 5.5 × 5.3 μm, n = 15) monoblastic or polyblastic, discrete on the stipe, determinate, ellipsoidal, pale brown to brown. *Conidia* 4−8 × 4−6 μm ($\bar{x}$ = 5.6 × 5.4 μm, n =15), catenate, in chains, arising at one or more points on the curved surface of the conidiogenous cell, simple, usually spherical or subspherical, pale to dark brown, smooth to minutely veruculose, aseptate.



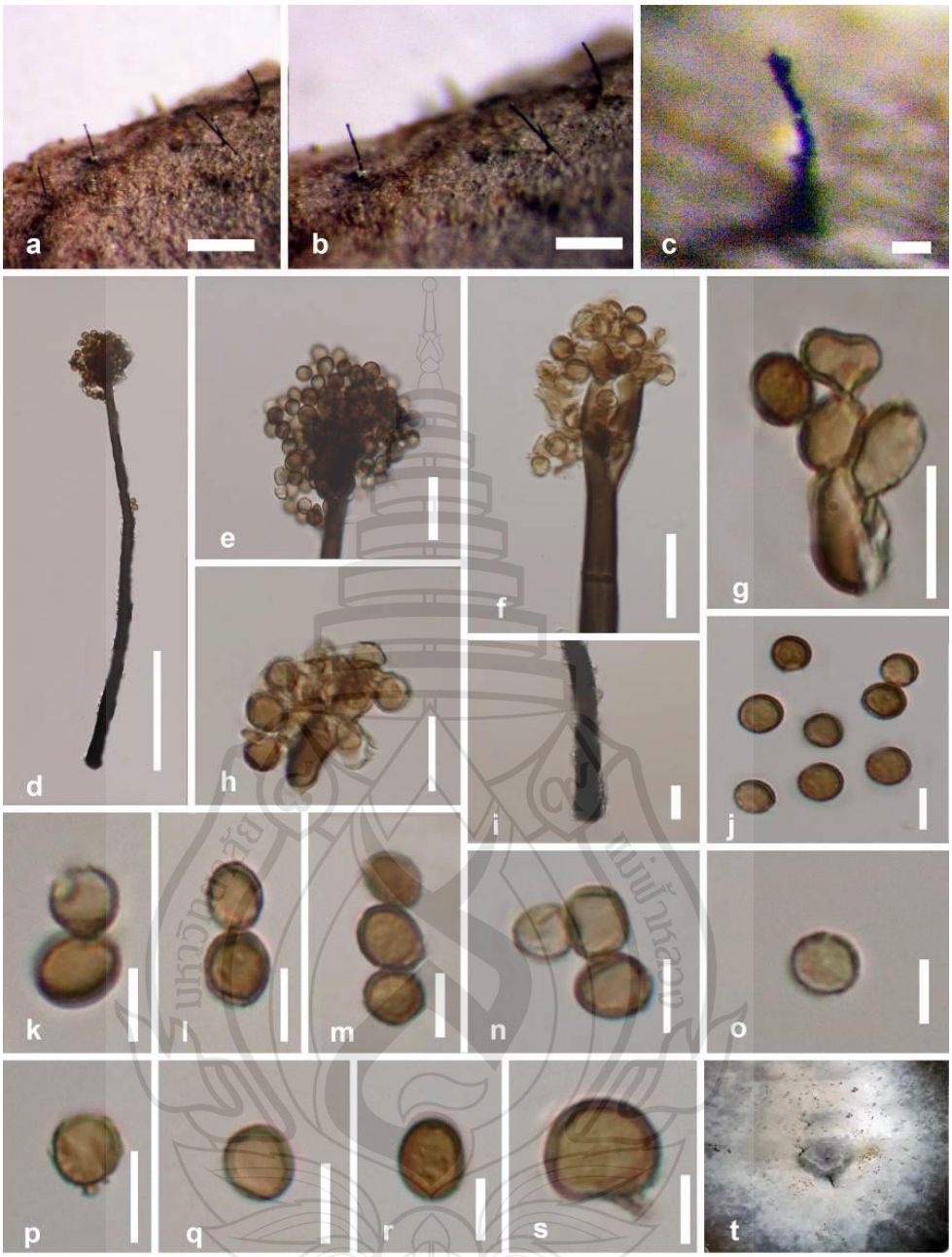
Note ML bootstrap supports (≥ 60%) and Bayesian posterior probabilities (≥ 0.95 BYPP) are given above the branches as ML/BYPP. The tree is rooted with *Helminthosporium dalbergiae* (MAFF 243853) and *Massarina cisti* (CBS 266.62). Strains generated in this study are indicated in red bold. Ex–type strains are indicated in black bold. The scale bar 0.02 represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Periconia delonicis* (MFLUCC 20–0235) and *P. cortaderiae* (MFLUCC 20–0236).

Figure 7.1 Maximum likelihood tree revealed by RAxML from an analysis of a concatenated SSU, LSU, ITS and TEF sequence dataset of the species in *Periconiaceae*



Note ML bootstrap supports (≥ 60%) and Bayesian posterior probabilities (≥ 0.95 BYPP) are given above the branches as ML/BYPP. The tree is rooted with *Roussoella nitidula* (MFLUCC 11–0182), *R. scabrispora* (MFLUCC 11–0624) and *Roussoellopsis tosaensis* (KT 1659). Strains generated in this study are indicated in red bold. Ex–type strains are indicated in black bold. The scale bar 0.04 represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Torula chromolaenae*, *T. fici* and *T. masonii.*

Figure 7.2 Maximum likelihood tree (RAxML) revealed by an analysis of a concatenated SSU, LSU, ITS, *tef*-1 and *rpb2* sequence dataset of the species in *Torulaceae*



Note a−c Conidiophores bearing conidia on host. d−f Conidia and conidiophores. g, h Conidiogenous cells bearing conidia. i Base of the conidiophore. j−s Mature and immature conidia. t Colonies on PDA after 14 days. Scale bars: a, b = 500 µm, c, d = 100 µm, e, f, i = 20 µm, g, h = 10 µm, j−s = 5 µm.

Figure 7.3 *Periconia delonicis* (MFLU 20−0696)

Culture characteristics – Conidia germinated on PDA within 48 hrs, reaching 40 mm diam. in 2 weeks at 25°C. Colonies on PDA with sparse, pinkish white mycelia on the surface, circular and flattened. Surface is smooth, with small, brown granular–like, powdery masses at maturity. The reverse of the colony is dark brown and yellow in the center with a white margin. Conidia and conidiophores are not observed in mature colonies.

Material examined – Thailand, Chiang Mai Province, Mae Taeng District, on a dead leaf of *Musa* sp. (*Musaceae*), 22 September 2018, B.C. Samarakoon, BNS012 (MFLU 20–0696), living culture MFLUCC 20–0235.

Known hosts & distribution – on pods of *Delonix regia* (*Fabaceae*, Dicotyledon) from Thailand (Jayasiri et al., 2019); on dead leaf of *Musa* sp. (*Musaceae*, *Monocotyledon*) from Thailand (this study).

Notes – Based on BLASTn search results of SSU, LSU, ITS, TEF sequence data, our strain (MFLUCC 20−0235) showed high identity to the taxa in GenBank as follows; SSU = 99.75% similarity to *Periconia palmicola* (MFLUCC 14−0400), LSU = 99.88% similarity to *P. delonicis* (MFLUCC 17−2584), ITS = 99.20% similarity to *P. palmicola* (MFLUCC 14−0400). Multi–loci phylogenetic analysis (Fig. 1) showed that the new strain MFLUCC 20–0235 forms a clade together with *P. palmicola* (MFLUCC 14−0400) and *P. verrucosa* (MFLUCC 17−2158) with high statistical support (ML = 98%, BYPP = 1.00).

Our strain (MFLUCC 20–0235) shares similar morphology to the type of *Periconia delonicis* in having macronematous, unbranched conidiophores, with monoblastic, terminal conidiogenous cells and brown, globose to subglobose, aseptate, veruculose conidia (Jayasiri et al., 2019). Our strain (MFLUCC 20−0235) also shares similar size range of conidiophores (320−400 × 8−12 μm vs. 360−420 × 8−12 μm) and conidia (4−8 × 4−6 μm vs. 5.5−7 μm diam.). Based on recommendations by Jeewon & Hyde (2016), we also compare the nucleotide bases of TEF region for our new strain and the type strain of *P. delonicis*. MFLUCC 20−0235 differs from *P. delonicis* (MFLUCC 17−2584) in 5/746 bp (0.67%).

In our phylogenetic analyses, MFLUCC 20−0235 and ex–type stain of *Periconia delonicis* (MFLUCC 17−2584) showed a close phylogenetic affinity to *P. palmicola* (MFLUCC 14−0400) and *P. verrucosa* (MFLUCC 17−2158). The

conidiophores, conidiogenous cells and the conidia of MFLUCC 20−0235 shares similar morphology with the holotype illustration of *P. palmicola* in Hyde et al. (2020a) (i.e. dark brown to black conidiophores, hyaline conidiogenous cells, subglobose to globose conidia). However, *P. palmicola* differs from MFLUCC 20−0235 in having comparatively short conidiophores (151–188 × 5.6–8 μm vs. 320−400 × 8−12 μm) which were branched at apex. The conidiophores of MFLUCC 20−0235 are unbranched and comparatively long with respect to *P. palmicola*. A nucleotide base pair comparison of TEF region showed that MFLUCC 20−0235 differs from *P. palmicola* (MFLUCC 14−0400) in 4/746 (0.53%). MFLUCC 20−0235 also has similar morphology to *P. verrucosa* (MFLUCC 17−2158) but differs in having longer conidiophores (320−400 × 8−12 μm vs. 170–296 × 10–12 μm) and smaller conidia (4−8 × 4−6 μm. vs. 7–15 μm diam.) (Phukhamsakda et al., 2020). A nucleotide base comparison of ITS and TEF regions showed that MFLUCC 20−0235 differs from *P. verrucosa* (MFLUCC 17−2158) in 7/501 bp (1.39%) of ITS and 4/746 bp (0.53%) of TEF. Based on morphological comparison with the types of *P. delonicis*, *P. palmicola* and *P. verrucosa*, a nucleotide base comparison of ITS and TEF regions and phylogenetic evidence, we thus identify our new collection as *P. delonicis*. In this study, we report *P. delonicis* on *Musa* sp. (*Musaceae*, monocotyledon) for the first time.

Periconia cortaderiae Thambugala & K.D. Hyde

Figure 7. 4

Index Fungorum number: IF553165; Facesoffungi number: FoF 03226

Saprobic on a dead leaf of *Musa* sp. Sexual morph: Undetermined. Asexual morph: hyphomycetous. *Colonies* on host effuse, powdery, gregarious, with a black, conidial masses on the host. *Mycelium* composed of cottony, branched, hyphae forming dark clusters with conidia scattered on the host surface. *Conidiophores* 40–120 × 1−6 μm ($\bar{x}$ = 58.5 × 3.5 μm, n = 15), macronematous, mononematous, single or rarely 2–3 together, erect, thick–walled, brown to dark brown, septate, rough, 4–5 μm wide at base, and 1–2 μm wide at apex; base shoe–shaped, distinct. *Conidiogenous cells* 2.5–4.5 μm × 2.5–3.5 μm ($\bar{x}$ = 3.5 × 2.8 μm, n = 10), annellidic, monoblastic, discrete on stipe, percurrent proliferations present as scars at the apex of conidiophore. *Conidia* 4–7.6 × 4–6.5 μm ($\bar{x}$ = 6.5 × 5.9 μm, n = 40), catenate,

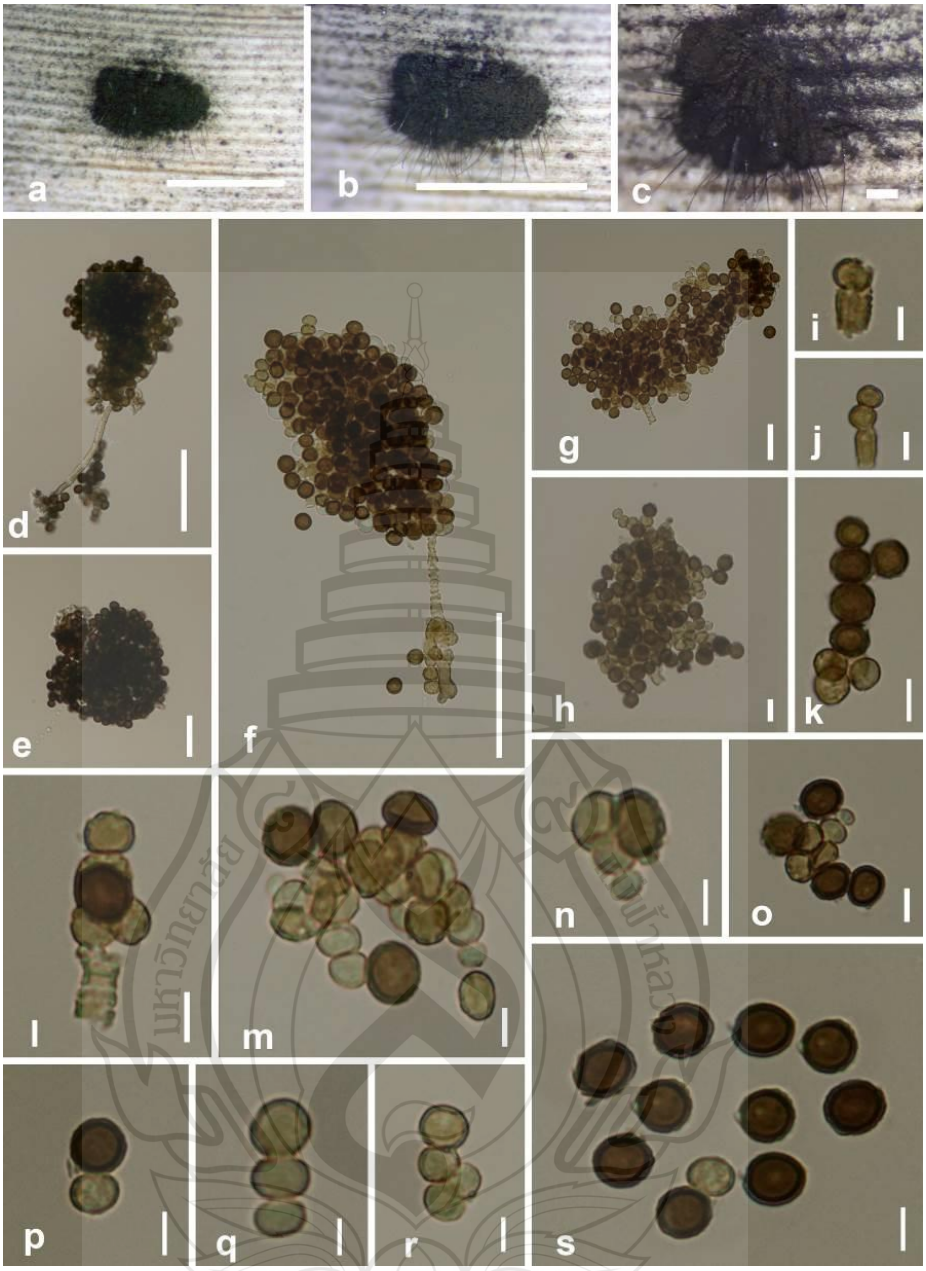
globose, one–celled, hyaline to pale brown when immature, becoming brown to dark brown, smooth or minutely verruculose.

Culture characteristics – Conidia germinating on PDA within 48 hrs. Colonies growing on MEA, reaching a diameter of 20 mm after 14 days at 25°C, flat when immature, raised at maturity with unevenly distributed radial furrows or linear marks, surface is smooth at immature stage and notably rough at maturity with crenulate to crenate margin. Colony is initially white, moderately dense and completely black at maturity with the sporulation, reverse white to black.

Material examined – Thailand, Nan Province, Nai Wiang, on a dead leaf of *Musa* sp. (*Musaceae*), 1 March 2019, B.C. Samarakoon, BNS100 (MFLU 20−0697), living culture MFLUCC 20−0236.

Known hosts & distribution – on *Cortaderia* sp. (*Poaceae*, Monocotyledon) from Thailand (Thambugala et al., 2017); on *Caragana arborescens* (*Fabaceae*, Dicotyledon) from Yunnan, China (Phookamsak et al., 2019); on *Musa* sp. (*Musaceae*, Monocotyledon) from Thailand (this study).

Notes – Based on BLASTn search results of SSU, LSU, ITS sequence data, our strain (MFLUCC 20−0236) showed high identity to the taxa in GenBank as follows; SSU = 99.76%, LSU = 99.88%, ITS = 99.80% similarities to *Periconia cortaderiae* (MFLUCC 15−0457). The morphology of our strain is similar to the holotype of *P. cortaderiae* (Thambugala et al., 2017), except the length of the conidiophores. Our strain has short conidiophores with respect to the holotype (40–120 × 1−6 μm vs. 400–800 × 4–9.4 μm). A nucleotide base comparison of ITS and TEF regions showed that MFLUCC 20−0236 differs from *P. cortaderiae* (MFLUCC 15−0457) in 1/493 bp (0.2%) of ITS and 1/829 bp (0.12%) of TEF. In addition, our MFLUCC 20−0236 strain differs from *P. cortaderiae* (MFLUCC 15−0451) in 2/493 bp (0.4%) of ITS and 2/872 bp (0.2%) of TEF. Therefore, we identify our new collection as *P. cortaderiae*, and this is reported from *Musa* sp. (monocotyledon) from Thailand for the first time.



Note a−c Colonies on host substrate.d, f Conidiophores bearing conidia. e, g, h Conidial masses. i, j, m−o Conidiogenesis from terminal mother cells. l Monoblastic, annellidic conidiogenous cells bearing conidial chains. k, p, q, r Conidial chains. s Conidia. Scale bars: a = 3 mm, b = 3.5 mm, c = 50 µm, d, f = 50 µm, e, g = 20 µm, h−s = 5 µm.

Figure 7.4 *Periconia cortaderiae* (MFLU 20−0697)

Torula chromolaenae Jun F. Li, Phook., Mapook & K.D. Hyde

Figure 7. 5

Index Fungorum number: IF819536; Facesoffungi number: FoF 02713

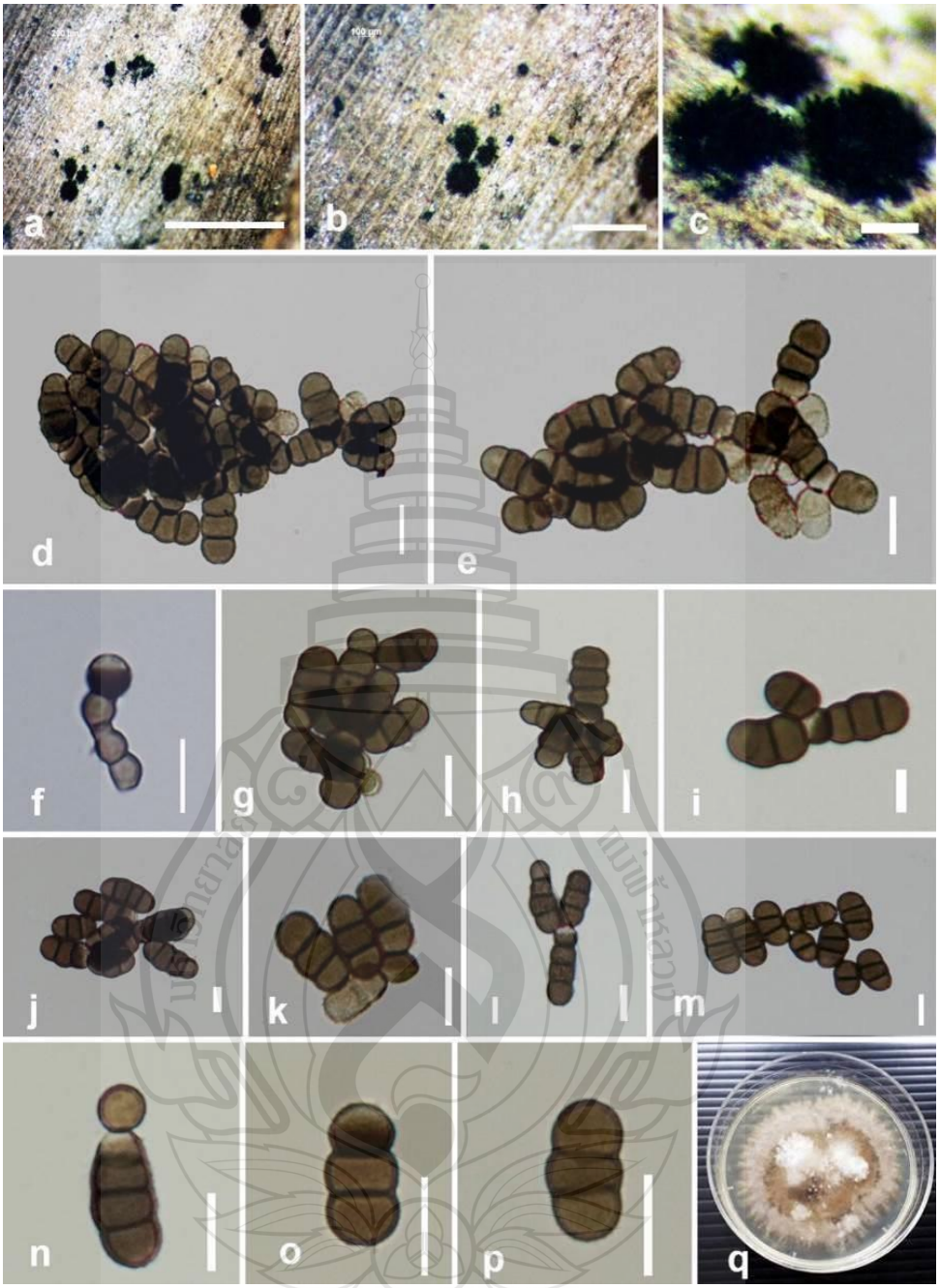
Saprobic on a dead leaf vein of *Musa* sp. (*Musaceae*). Sexual morph: Undetermined. Asexual morph: hyphomycetous. *Colonies* effuse, black, powdery, thread–like on host. *Mycelium* slightly immersed, septate, unbranched, smooth, pale brown hyphae. *Conidiophores* 2–5 × 2–4 μm ($\bar{x}$ = 3.8 × 3.3 μm, n = 10), micronematous or semi–macronematous, unbranched, straight or flexuous, subhyaline or pale brown, smooth or minutely verruculose. *Conidiogenous cells* 2–6 × 2–4.5 μm ($\bar{x}$ = 4.5 × 3.7 μm, n =10), polyblastic or sometimes monoblastic, integrated, terminal, discrete, determinate, usually spherical, smooth, distal fertile part thin–walled, subhyaline to pale brown, proximal sterile part dark brown, thick–walled, produced conidia in multiple planes. *Conidia* 10–15 × 5–7 μm ($\bar{x}$ = 11.4 × 6.2 μm, n = 40) dry, in simple or branched chains arising from the surface of the upper half of the characteristic conidiogenous cells, cylindrical with rounded ends, ellipsoidal or subspherical, brown or dark brown, minutely verruculose, 1–3 transverse septa, usually strongly constricted at the septa; conidial chains arranged in multiple planes.

Culture characteristics – Conidia germinating on PDA within 18 hrs and germ tubes produced from the tip cell. Colonies growing on PDA, reaching 50 mm diam. in 14 days at 25°C. Mycelium partly immersed to superficial, slightly effuse, and hairy, with dentate margin, pale pink at periphery golden brown in the middle with whitish hairy mycelial clumps. Sporulation was not observed in mature cultures.

Material examined – Thailand, Chiang Mai Province, Mae Taeng District, on a dead leaf vein of *Musa* sp. (*Musaceae*), 15 February 2019, B.C. Samarakoon, BNS083 (MFLU 20−0698), living culture MFLUCC 20−0237.

Known hosts & distribution – on *Chromolaena odorata* (*Asteraceae*, Dicotyledon) from Thailand (Mapook et al., 2020; Li et al., 2017); on *Clematis fulvicoma*, (*Ranunculaceae*, Dicotyledon) from Thailand (Phukhamsakda et al., 2020); on *Pandanus tectorius* (*Pandanaceae*, Monocotyledon) from Yunnan, China (Tibpromma et al., 2018); on herbaceous litter (Dicotyledon) from Yunnan, China (Hyde et al., 2020); *Musa* sp. (Monocotyledon) from Thailand (this study).

Notes – The BLASTn search results of SSU, LSU, ITS and TEF sequence data, indicated that our strain (MFLUCC 20−0237), showed a high identity to *Torula chromolaenae* (KUMCC 16–0036) as follows; SSU = 100.00%, LSU = 100.00%, ITS = 100.00%, TEF = 99.5% similarities. Morphological comparison with the type specimen of *T. chromolaenae* showed that our new collection (MFLU 20−0698/ MFLUCC 20−0237) is typical to *T. chromolaenae* in having brown or dark brown, minutely verruculose, 1–3–septate conidia. However, our collection (MFLU 20−0698) has slightly smaller conidiophores (2–5 × 2–4 μm vs. 5–6.3 × 3.5–4.6 μm) and conidia (10–15 × 5–7 μm vs. 2.1–16.5 × (3.6–) 4.1–5 μm) with respect to Li et al. (2017). A nucleotide base comparison of ITS, TEF and RPB2 regions also showed that MFLUCC 20–0237 is conspecific with *T. chromolaenae* (KUMCC 16–0036) (0/502 bp of ITS, 0/787 bp of TEF, and 0/817 bp of RPB2). We thus identify our new collection (MFLU 20–0698) as *T. chromolaenae*. Previously, *T. chromolaenae* was reported as a saprobe on dicotyledonous and monocotyledonous hosts from China and Thailand, indicating that the species is not specific on hosts and normally found in tropical region.



Note a−c Colonies on leaf vein of *Musa* sp. d, e Conidia arranged in multi planes. f Conidiophore and conidiogenous cell. g−p Conidia and the formation of immature conidia. q Colonies on PDA after 21 days. Scale bars a = 1000 µm, b = 500 µm, c = 50 µm, d−h, k, o, p = 10 µm, l−n, i, j = 5 µm.

Figure 7.5 *Torula chromolaenae* (MFLU 20–0698)

Torula fici Crous

Figure 7.6

Index Fungorum number: IF816154; Facesoffungi number: FoF 02712

Saprobic on dead leaf vein of *Musa* sp. (*Musaceae*). Sexual morph: Undetermined. Asexual morph: hyphomycetous. *Colonies* superficial, black, appearing as powdery masses on the host. *Mycelium* slightly immersed, septate, smooth, pale brown. *Conidiophores* 1–6 × 1.5–3 μm ($\bar{x}$ = 4.8 × 1.8 μm, n = 10), micronematous or semi–macronematous, unbranched, straight or slightly flexuous, subhyaline or pale grayish brown, verruculose. *Conidiogenous cells* 3.5–4 × 2.5–3.5 μm ($\bar{x}$ = 3.2 × 2.7 μm, n = 10) polyblastic or sometimes monoblastic, terminal, discrete, determinate, brown to dark brown, usually spherical, thin–walled, veruculose, having rough distal fertile part and a notably thick–walled, proximal sterile part. Base of sterile part of the conidiogenous cells that arise from mycelium is notably flat. *Conidia* (4–) 10–25(–75) × 3.5–4.5 μm ($\bar{x}$ = 24.8 × 3.8 μm, n = 40) dry, in simple or branched chains arising from the surface of the upper half of the characteristic conidiogenous cells, cylindrical with rounded ends, ellipsoidal or subspherical, brown or dark brown, notably verruculose, 1–3 transverse septa, slightly constricted at the septa, immature conidia hyaline to subhyaline, comparatively thin–walled, mature conidia notably thick–walled.

Culture characteristics – Conidia germinating on PDA within 20 hrs and germ tubes produced from the tip cell. Colonies growing on PDA, reaching 50 mm diam. in 14 days at 25°C, mycelium partly immersed to superficial, slightly effuse, hairy, with dentate to irregular margin, pinkish white.

Material examined – China, Yunnan, Xishuangbanna, on a dead leaf vein of *Musa* sp. (*Musaceae*), 20 December 2018, D.N Wanasinghe, BNSWN5 (MFLU 20–0699), living culture MFLUCC 20–0238.

Known hosts & distribution – on *Chromolaena odorata* (*Asteraceae*, Dicotyledon) from Thailand (Li et al., 2017, Mapook et al., 2020); on *Ficus religiosa* (*Moraceae*, Dicotyledon) from Cuba (Crous et al., 2015); on *Garcinia* sp. (*Clusiaceae*, Dicotyledon) from Thailand (Jayasiri et al., 2019); on *Magnolia grandiflora* (*Magnoliaceae*, Dicotyledon) from Yunnan, China (Jayasiri et al., 2019); on *Olea europaea* (*Oleaceae*, Dicotyledon) from South Africa (Spies et al., 2020); on

Pandanus sp. (*Pandanaceae*, Monocotyledon) from Thailand (Tibpromma et al., 2018); on submerged decaying wood in Yunnan, China (Su et al., 2018); on *Musa* sp. (*Musaceae*, Monocotyledon) from Yunnan, China (this study).

Notes – The BLASTn search results of SSU, LSU, ITS and TEF sequence data, indicated that our strain (MFLUCC 20–0238), has a high identity to *Torula fici* (KUMCC 16–0038) as follows; SSU = 99.88%, LSU = 100.00%, ITS = 98.99%, TEF = 98.53% similarities. Our new collection (MFLU 20–0699) is morphologically similar to *T. fici* in having short conidiophores, or reduced to conidiogenous cells, mono– to polyblastic, brown, verruculose conidiogenous cells and brown or dark brown, 1–3–septate conidia (Crous et al., 2015). However, our collection has slightly smaller conidiogenous cells (3.5–4 × 2.5–3.5 μm vs. (5–) 6(–8) × 5(–7) μm) and overlapped size of conidia (4–16 × 3.5–4.5 μm vs. (12–) 13–14(–15) (–19) × 5(–6) μm; Crous et al. 2015). A nucleotide base comparison of ITS and *tef* regions also showed that MFLUCC 20–0238 differs from *T. fici* (CBS 595.96, type strain) in 7/467 bp (1.49%) of ITS and 16/776 bp (2.06%) of TEF. In addition, our strain MFLUCC 20–0238 differs from the strains KUMCC 15–0428 and KUMCC 16–0038 in 3/429 bp (0.69%) and 5/494 bp (1.01%) of ITS, and 15/808 bp (1.8%) and 11/813 bp (1.35%) of TEF, respectively. Nevertheless, our new strain (MFLUCC 20–0238) shows a high variation of TEF sequence with the type strain of *T. fici* (CBS 595.96; 2.06%) and strain KUMCC 15–0428 (1.8%). Based on current phylogenetic results (Fig. 2), we thus identify our new collection (MFLU 20–0699/ MFLUCC 20–0238) as *T. fici*. The conspecific of these strains is needed to be clarified in further studies. In this study, we report *T. fici* on *Musa* sp. (Monocotyledon) from Yunnan, China for the first time.



Note a–c Colonies on dead leaf of *Musa* sp. d–n Conidiogenesis. o, p Conidial masses. q Conidia (in chain). r–u Disposed conidia. v Colonies on PDA after 28 days. Scale bars: a = 500 μm, b = 100 μm, c = 20 μm, d–u = 5 μm.

Figure 7.6 *Torula fici* (MFLU 20–0699)

Torula masonii Crous

Figure 7. 7

Index Fungorum number: IF812806; Facesoffungi number: FoF 02711

Saprobic on a dead leaf of *Musa* sp. (*Musaceae*). Sexual morph: Undetermined. Asexual morph: hyphomycetous. *Colonies* superficial, appearing as black, powdery masses on the host. *Mycelium* slightly immersed, septate, smooth, grayish brown. *Conidiophores* 3–6.5 × 4–5 μm ($\bar{x}$ = 5.4 × 4.3 μm, n = 10), micronematous or semi–macronematous, unbranched, straight or slightly flexuous, pale grayish brown to brown, subcylindrical, septate, or reduced to conidiogenous cells. *Conidiogenous cells* 5.5–6.5 × 4.5–6 μm ($\bar{x}$ = 6.3 × 5.3 μm, n = 10) polyblastic or sometimes monoblastic, terminal, discrete, determinate, grayish brown to dark brown, darker than the conidiophores or conidia, spherical, cup–shaped, or inverted cup–shaped, thin–walled, smooth, pale brown of distal fertile part and subhyaline or pale grayish brown of proximal sterile part. *Conidia* 8–25 × 4–6.5 μm ($\bar{x}$ = 18.3 × 5.6 μm, n = 40), dry, in simple or branched chains arising from the surface of the upper half of the characteristic conidiogenous cells, cylindrical with rounded ends, ellipsoidal or subspherical in each cell, grayish brown to dark brown, (2–) 3–5(–12) transverse septa, notably constricted at the septa, verruculose, arranged in different planes with respect to the main axis.

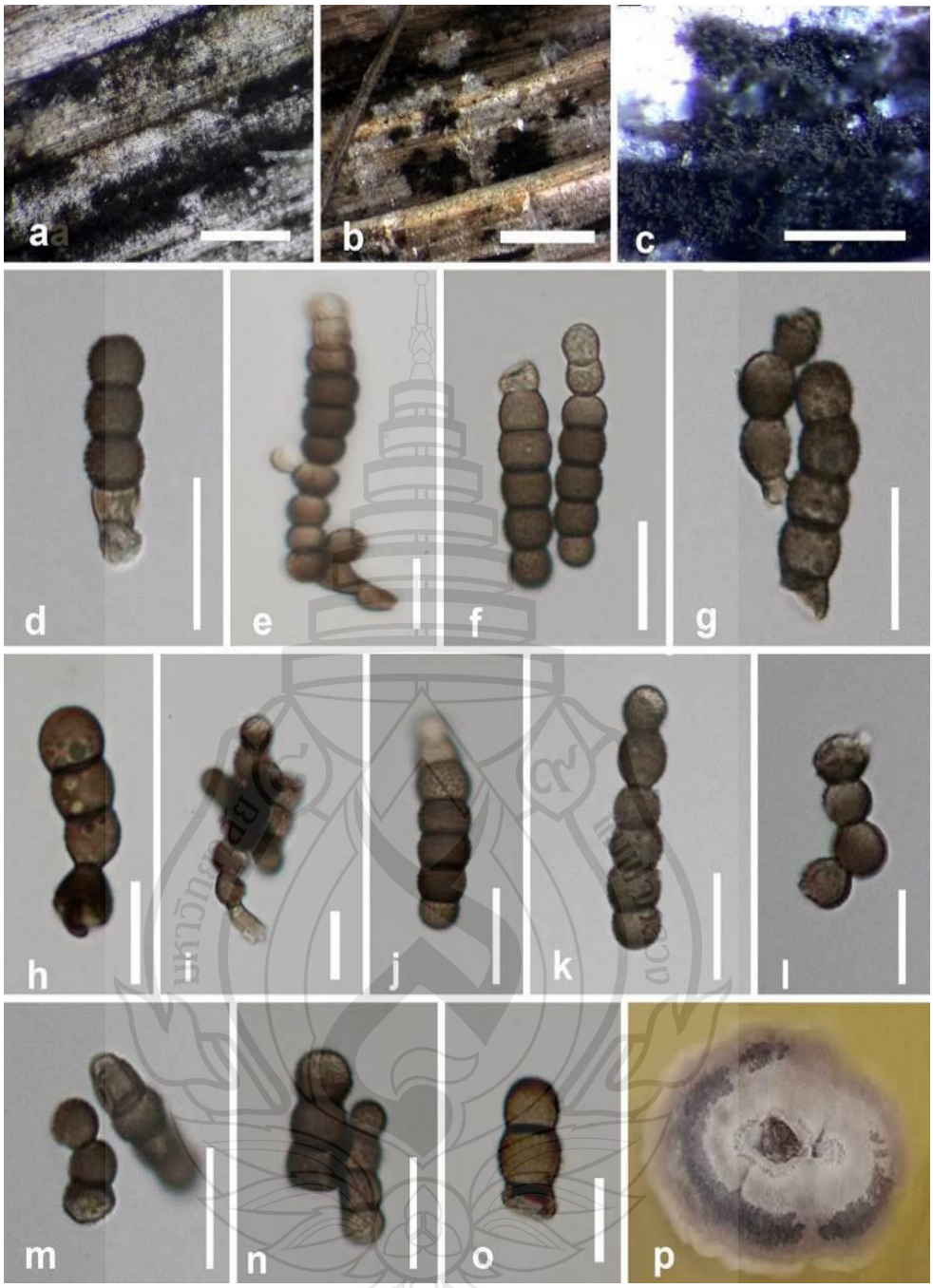
Culture characteristics – Conidia germinating on PDA within 14 hrs and germ tubes produced from the apex. Colonies growing on PDA, reaching 50 mm diam. in 15 days at 25°C, mycelium partly immersed to superficial, slightly effuse and hairy. Colonies medium dense, circular, flattened, slightly raise, surface smooth, with edge entire to sinuate margin, hairy at the center and margin, with dense, floccose to cottony at the middle, three distinct colour zones present in the culture. Periphery pinkish white, middle gray and grayish white next.

Material examined – China, Taiwan region, Alishan, on a dead leaf of *Musa* sp. (*Musaceae*), 20 September 2018, D.S. Tennakoon, BNS023 (MFLU 20–0700), living culture MFLUCC 20–0239.

Known host & distribution – on *Brassica* sp. (*Brassicaceae*, Dicotyledon) from United Kingdom (Crous et al., 2015); *Iris germanica* (*Iridaceae*, Monocotyledon) from Italy (Li et al., 2017); on submerged decaying wood

(Dicotyledon) from Yunnan, China (Su et al., 2018); on *Musa* sp. (*Musaceae*, Monocotyledon) from Taiwan (this study).

Notes – The BLASTn search results of SSU, LSU, ITS, TEF and RPB2 sequence data, showed that our strain (MFLUCC 20−0239), is similar to taxa in GenBank as follows; SSU = 99.87% similarity to *Torula chromolaenae* (MFLUCC 17−1514), LSU = 100.00% similarity to *T. masonii* (CBS 245.57), ITS = 99.88% similarity to *T. masonii* (KUMCC 16–0033), TEF = 100% and RPB2 = 99.75% similarities to *T. masonii* (DLUCC 0588). Comparing with the type specimen, our new isolate (MFLU 20–0700) is morphologically similar to *T. masonii*; however, the type of *T. masonii* has slightly larger size of conidiophores and conidia. The conidia of the type of *T. masonii* are predominantly 6–septate, but also vary in conidial septation from 2– to 12–septate (Crous et al., 2015), whereas the conidia of our new isolate are predominantly 3–5–sepate, occasionally 2– to 12–septate. A nucleotide base pair comparison of ITS showed that our strain (MFLUCC 20−0239) differs from other *T. masonii* strains (CBS 245.57, DLUCC 0588 and KUMCC 16–0033) in 8/509 (1.57%), 2/441 (0.45%) and 1/508 (0.19%). Our strain MFLUCC 20−0239 also differs from the strains DLUCC 0588 and KUMCC 16–0033 in 2/798 bp (0.25%) and 2/830 (0.34%) of RPB2 but has no different nucleotide base in TEF gene region. We identify our new isolate as *T. masonii*, based on phylogenetic evidence, although there is more than 1.5% variation in the ITS DNA regions as compared to the type strain (CBS 245.57). We document *T. masonii* on *Musa* sp. for the first time. This is the first geographical record of *T. masonii* from Taiwan.



Note a Colonies on dead leaf of *Musa* sp. b, c Masses of conidia on host surface. d–h, j–o Conidia. i Conidiophore, conidiogenous cell and budding of conidia. p Colonies on PDA after 28 days. Scale bars: a = 50 μm, b = 500 μm, c = 1000 μm, d, f–o = 10 μm, e = 5 μm.

Figure 7.7 *Torula masonii* (MFLU 20–0700)

7.4 Discussion

Many *Torula* and *Periconia* species have been reported on *Musa* spp. worldwide. *Torula herbarum* has been reported on *Musa* spp. from Papua New Guinea, Somalia, Taiwan, Thailand, and Zambia (Castellani & Ciferri, 1937; Matsushima, 1971, 1980; Photita et al., 2001a, 2003b; Riley, 1956). *Periconia byssoides* (Venezuela, Cuba, and Somalia) (Delgado-Rodriguez & Mena-Portales, 2004; Matsushima, 1971; Urtiaga, 1986), *P. digitata* (Thailand, Malaysia) (Photita et al., 2001b; Williams & Liu, 1976), *P. lateralis* (Thailand) (Photita et al., 2001b) and *P. minutissima* (Ghana) (Hughes, 1953) have also been reported o. *Musa* spp. The identification of the latter taxa on *Musa* spp. was solely based on morphology and molecular data were not integrated. Therefore, more taxon sampling of saprobic and endophytic fungi on *Musa* spp. should be carried out by integrating morpho–molecular data in taxonomy.

Some *Periconia* species have been reported as plant pathogens (i.e., *P. cicirnata*, *P. digitata* and *P. macrospinosa*) on leaves, roots and stems of economically important crops such as maize, sorghum and pointed gourd (Sarkar et al., 2019; Stojkov et al., 1996). In addition, *P. keratitis* has been reported as a human pathogen from India (Gunasekaran et al., 2020). *Periconia* produce some economically important bioactive compounds with antimicrobial activities (Bhilabutra et al., 2007; Hongsanan et al., 2020; Kim et al., 2004). It is interesting to note that *P. delonicis* and *P. cortaderiae* may also produce bioactive compounds which were discovered from taxa in the same genus. In addition, some species of *Torula* also produce chemically active compounds (i.e., Dichlorinated Aromatic Lactones and erythritol) which have a wide range of applications in the food industry (Chunyu et al., 2018). Mapook et al. (2020) also reported that *T. chromolaenae*, *T. fici* and *T. polyseptata* showed antimicrobial activity against *Bacillus subtilis*, *Escherichia coli* and *Mucor plumbeus* on their preliminary screening of antimicrobial activity of fungi on *Chromolaena odorata*. Therefore, it will be interesting to know whether *T. chromolaenae* and *T. fici* from *Musa* spp. will have the same biological ability.

Recent taxonomic studies integrated DNA sequence data on the introduction of novel taxa in *Periconia* and *Torula* (Crous et al., 2015; Hyde et al., 2020; Jayasiri et al., 2019; Li et al., 2017, 2020; Liu et al., 2017; Mapook et al., 2020; Phukhamsakda et al., 2020; Su et al., 2016, 2018). Protein–coding genes revealed to be good phylogenetic markers in species delineation of *Periconia* and *Torula* (Hyde et al., 2020a; Jayasiri et al., 2019; Li et al., 2017, 2020; Mapook et al., 2020; Phukhamsakda et al., 2020; Su et al., 2016, 2018). Corresponding protein–coding sequences (RPB2 and TEF) with ribosomal DNA (SSU, LSU and ITS) sequence dataset can provide well–resolved tree topologies for the taxa in *Periconiaceae* and *Torulaceae*. However, several taxa of *Periconiaceae* and *Torulaceae* lack protein–coding DNA sequences in GenBank. Therefore, many *Periconia* and *Torula* taxa need to be recollected so that valid sequence data are provided to GenBank for better taxonomic resolutions.

Phylogenetic tree of *Periconiaceae* (Fig. 1) showed that *Periconia delonicis* does not form a well–separated clade with *P. palmicola* (MFLUCC 14−0400) and *P. verrucosa* (MFLUCC 17−2158). The tree topology showed that they are conspecific, and this result is also supported by a nucleotide base comparison of ITS and TEF regions. However, *P. delonicis* is phylogenetically well–resolved and is distinct from *P. verrucosa* in Phukhamsakda et al. (2020), indicating that ITS and TEF regions are not good phylogenetic markers for some species in *Periconiaceae*. *Periconia delonicis* was not included in phylogenetic analyses of *Periconiaceae* when Hyde et al. (2020) introduced *P. palmicola* as a new species. The conspecific of *P. delonicis* and *P. palmicola* is therefore questionable and should be reinvestigated in future studies.

Phylogenetic tree of *Torulaceae* (Fig. 2) showed that *Torula chromolaenae*, *T. fici* and *T. masonii* form well–resolved subclades within *Torulaceae*. However, the four strains (including type strain) of *T. fici* and *T. masonii* formed insignificantly separated branch lengths in this analysis and this phylogenetic result is also supported by Hongsanan et al. (2020), Hyde et al. (2020), Li et al. (2020), Mapook et al. (2020), and Phukhamsakda et al. (2020). This may be the result of a high variation (>1.5%) in the TEF region (see notes under *T. fici* and *T. masonii*). Further studies on the

conspecific or complexity of these species are needed for their clarification based on the reliable protein coding genes.

Documentation of fungi from new hosts and geographical locations supports the accurate estimates and taxonomic establishments of fungal diversity and distribution. In addition, new occurrences of fungi from various hosts and habitats further provide insights to determine host jumping patterns, host shift speciation and the adaptations of fungi during their life cycle (Hyde et al., 2020). Taxonomy and phylogeny of fungal pathogens on *Musa* spp. (i.e., *Colletotrichum*, *Fusarium*, *Mycosphaerella*, *Neocordana* and *Phyllosticta*) have been well–studied worldwide (Churchill, 2011; Giatgong, 1980; Guarnaccia et al., 2017; Marin-Felix et al., 2019; Maryani et al., 2019; Wulandari et al., 2010). The detailed taxonomic works on endophytic fungi in *Musa* spp. were previously conducted by Brown et al. (1998), Photita et al. (2001, 2004), Samarakoon et al. (2019) and Zakaria & Aziz (2018). Still the saprobic fungal niches on *Musa* spp. remain unrevealed and many more taxa are yet to be discovered. Hence the morpho–molecular data of this study will be further useful in future taxonomic works of fungi.

CHAPTER 8

Stachybotrys musae SP. NOV., *S. microsporus*, AND *Memnoniella levispora* (*Stachybotryaceae*, *Hypocreales*) FOUND ON BANANAS IN CHINA AND THAILAND

8.1 Introduction

During the past three decades, there have been several studies on the saprobic fungi associated with tropical monocotyledonous hosts (Bhilabutra et al., 2010; Dai et al., 2017; Hyde et al., 1998; Konta et al., 2020; Liu et al., 2014; Phookamsak et al., 2015; Thambugala et al., 2017; Thongkantha et al., 2008; Tibpromma et al., 2018; Wong & Hyde, 2001). In addition, detailed taxonomic studies have been conducted to describe and document saprobic fungi on *Musa* across South and South East Asia (Photita et al., 2001, 2003, 2004; Samarakoon et al., 2019, 2020, 2021; Somrithipol, 2007).

Stachybotryaceae accommodates 39 genera (including *Memnoniella* and *Stachybotrys*) in the *Hypocreales* (Hyde et al., 2020; Wijayawardene et al., 2020). The taxonomic history of *Memnoniella* and *Stachybotrys* are detailed in Wang et al. (2015) and Lombard et al. (2016). An updated phylogeny for *Stachybotryaceae* was provided by Lombard et al. (2016) using LSU, ITS, *rpb*2, cmdA, *tef*1 and *tub*2 sequence data. Previously, Smith (1962) and Wang et al. (2015) stated that *Memnoniella* and *Stachybotrys* are congeneric. However, Lombard et al. (2016) resurrected *Memnoniella* as a distinct genus in *Stachybotryaceae*. Doilom et al. (2017), Hyde et al. (2020), Lin et al. (2016), and Mapook et al. (2020) further supported the observations of Lombard et al. (2016) and treated *Memnoniella* and *Stachybotrys* as two distinct genera. Hyde et al. (2020) documented nine species of *Memnoniella* with DNA sequence data. Index Fungorum (2021) documented 19 records of the *Memnoniella*, but ten were transferred to other genera in

Stachybotryaceae (i.e., *Stachybotrys* and *Brevistachys*) (Hyde et al., 2020; Mapook et al., 2020; Zheng et al., 2019). Hyde et al. (2020) listed 88 species of *Stachybotrys* based on Species Fungorum (2020). Currently 30 taxa of *Stachybotrys* have DNA sequence data in GenBank.

The asexual morph of *Stachybotrys* has branched or unbranched, erect conidiophores, bearing terminal, phialidic conidiogenous cells with unicellular conidia, in chains or slimy masses (Ellis, 1971; Lombard et al., 2016; Seifert et al., 2011; Wang et al., 2015). *Memnoniella* also shares similar morphology with *Stachybotrys* (Gond et al., 2013; Lombard et al., 2016; Wang et al., 2015; Zheng et al., 2019) even though they are phylogenetically distinct. The conidia of *Memnoniella* occur to the surface as dry chains, while in *Stachybotrys*, the conidia occur as slimy masses (Lombard et al., 2016). However, much research has disregarded this dry or wet conidial disposition pattern while distinguishing *Memnoniella* and *Stachybotrys* (Hyde et al., 2020; Lombard et al., 2016; Smith, 1962; Zheng et al., 2019).

Stachybotrys is common in soil, plant litter (hay, straw, cereal grains and decaying plant debris), marine habitats, and air (Lin et al., 2016; Lombard et al., 2016; Mapook et al., 2020; Wang et al., 2015; Zheng et al., 2019). In addition, *Stachybotrys* has been detected on damp paper, cotton, linen, cellulose-based building materials (drywalls, wall papers in indoor environments), water-damaged indoor buildings, and air ducts (Ellis, 1971, 1976; Hyde et al., 2020; Izabel et al., 2010; Jie et al., 2013; Tang et al., 2003; Thongkantha et al., 2008; Wang et al., 2015; Whitton et al., 2001). Most *Stachybotrys* species are cellulolytic saprobes (Li & Jiang, 2011) and are also plant pathogens (Pathak & Chauhan, 1976; Zhao et al., 2010) and endophytes (Busby et al., 2016; Cao et al., 2009; Raghavendra et al., 2013; Yang et al., 2020; Zhang et al., 2019). *Memnoniella* species exhibit saprobic lifestyles and have been reported from dead plant materials and soil (Lombard et al., 2016; Zheng et al., 2019). Some of *Memnoniella* and *Stachybotrys* taxa (*M. ehinata* and *S. chartarum*) co-exist in similar ecological habitats such as indoor environments (Zhang et al., 2019). Mainly, *S. chartarum* and few other species (i.e. *S. elegans* and *S. microspora*) of *Stachybotrys* have veterinary and medical importance as they produce several mycotoxins (Hossain et al., 2004; Hyde et al., 2019; Jarvis et al., 1995; Mason et al., 1998; Rosenblum et al., 2010).

Many species of *Memnoniella* and *Stachybotrys* have been documented from China and Thailand. Lin et al. (2016) provided a check list of *Stachybotrys* species recorded from different hosts and substrates in Thailand (*S. albipes*, *S. bambusicola*, *S. chartarum*, *S. elegans*, *S. microspora*, *S. nephrospora*, *S. palmae*, *S. parvispora*, *S. renispora*, *S. ruwenzoriensis*, *S. sansevieriae*, *S. suthepensis*, and *S. theobromae*). *Stachybotrys aksuensis* (Xinjiang), *S. biformis* (Shaanxi), *S. littoralis* (Guangdong), and *S. yushuensis* (Qinghai) were introduced from soil habitats in different geographic localities of China (Pan et al., 2014). In addition, *S. nielamuensis* (Tibet; Wu & Zhang, 2009), *S. subcylindrospora* (Hainan; Jie et al., 2013), *S. variabilis* (Qinghai; Wang et al., 2009), *S. yunnanensis* (Yunnan; Kong, 1997), and *S. zhangmuensis* (Tibet; Wu & Zhang, 2009) were also described from China. In addition, *Memnoniella chromolaenae*, *M. echinate*, and *M. sinensis* were reported from Yunnan Province, China and Thailand (Liu & Zhang, 2004; Mapook et al., 2020; Zhang et al., 2019).

Photita et al. (2002, 2003), and Farr and Rossman (2015) documented *S. nephrospora*, *S. ruwenzoriensis* and *S. theobromae* as saprobes on *Musa* in Thailand. Photita et al. (2003a) introduced *S. suthepensis*, which was saprobic on dead petioles of *Musa acuminata* from Chiang Mai, Thailand. In addition, *S. chartarum* (Somalia; Castellani & Ciferri, 1937), *S. globosa* (India; Misra & Srivastava, 1982), and *S. kampalensis* (Japan; Kobayashi, 2007) were found on *Musa*. *Memnoniella dichroa* (Thailand), *M. echinata* (Honduras, Japan) and *M. subsimplex* (Bermuda, Ghana, New Zealand, Sierra Leone) were also recorded on *Musa* (Ellis, 1971; Matsushima, 1975; McGuire & Crandall, 1967; Photita et al., 2003b).

Most *Stachybotrys* and a few *Memnoniella* species were introduced based only on morphology (Wang et al., 2015). The limitation of DNA sequence data in GenBank has restricted the delineation of species based on phylogenetic species concepts. Wang et al. (2015) and Lombard et al. (2016) tried to address these research gaps and highlighted many taxa that were invalidly published. The toxicological health effects of *S. chartarum* are widely researched, but other taxa in the genus are not as well-studied. Therefore, the need for more comprehensive morpho-molecular taxonomic work on *Stachybotrys* and *Memnoniella* is recommended in recent studies (Hyde et al., 2020; Lombard et al., 2016; Wang et al., 2015).

We are studying fungi associated with *Musa* (Samarakoon et al., 2019, 2020, 2021). The present study concentrates on saprobic *Stachybotrys* and *Memnoniella* niches on *Musa* from China and Thailand. We introduce *Stachybotrys musae* sp. nov. on *Musa* from China (Yunnan Province) and also report *Memnoniella levispora* on *Musa* from China (Yunnan) for the first time. *Stachybotrys microspora* is also reported on *Musa* from Chiang Rai Province, Thailand. Multi-locus phylogenetic analyses, morphological illustrations, and taxonomic discussions are provided for these taxa.

8.2 Materials and Methods

8.2.1 Sample Collection, Morphological Studies and Isolation

Decaying leaves of an undetermined species of *Musa* with fungal structures were collected from Yunnan Province, China and Thailand during the dry seasons of 2018 and 2019. Plant materials were transferred to the laboratory in small cardboard boxes and treated as outlined in Senanayake et al. (2020).

Single spore isolation was conducted following the methods outlined in Senanayake et al. (2020). Herbarium specimens were deposited in the Mae Fah Luang University Herbarium (Herb. MFLU), Chiang Rai, Thailand. Living cultures of each strain were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC). Faces of Fungi (Jayasiri et al., 2015) and MycoBank numbers (http://www.MycoBank.org) were obtained for the novel taxon.

8.2.2 DNA Extraction, PCR Amplification and Sequencing

DNA extraction, PCR amplification, sequencing, sequence alignment, and phylogenetic analyses follow the methods as outlines in Dissanayake et al. (2020). Five gene regions, including the internal transcribed spacer (ITS), partial calmodulin (cmdA), partial β-tubulin (*tub*2), translation elongation factor 1-alpha (*tef*1) and partial second largest subunit of the DNA-directed RNA polymerase II (*rpb*2) were amplified using primers ITS5/ITS4 (White et al., 1990), CAL-228F/CAL2Rd (Carbone & Kohn, 1999; Groenewald et al., 2013), Bt2a and Bt2b (Glass &

Donaldson, 1995), EF1-728F/EF2 (Carbone and Kohn, 1999; O'Donnell et al., 1998), and fRPB2-5f/fRPB2-7cR (Liu et al., 1999), respectively.

The total volume of the PCR reaction was 25 μL and consisted of 12.5 μL of 2 × Power Taq PCR MasterMix (a premix and ready to use solution, including 0.1 Units/μl Taq DNA Polymerase, 500 μm dNTP Mixture each (dATP, dCTP, dGTP, dTTP), 20 mMTris-HCL pH 8.3, 100 mMKCl, 3 mM $MgCl_2$, stabilizer and enhancer), 1 μL of each primer (10pM), 2 μL genomic DNA template, and 8.5 μL sterilized double distilled water (ddH2O). The reaction was conducted by running for 40 cycles. The annealing temperatures followed Lombard et al. (2016) and Samarakoon et al. (2019, 2020a). The amplified PCR fragments were sent to a commercial sequencing provider (TsingKe Biological Technology (Beijing) Co., China). Nucleotide sequence data obtained were deposited in GenBank.

8.2.3 Sequence Alignment

Obtained sequence data were primarily checked with BLAST searches in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi). BLAST search results and initial morphological studies revealed that our isolates belong to *Stachybotryaceae*. Other sequences used in the analyses were obtained from GenBank based on recently published papers (Lin et al., 2016; Lombard et al., 2016; Wang et al., 2015) and BLAST search results. The single gene alignments were made by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/large.html; Katoh et al., 2019) using the default settings and later refined where necessary using BioEdit v. 7.0.5.2 (Hall, 1999).

8.2.4 Phylogenetic Analyses

Maximum likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis, 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution. Bootstrap supports were obtained by running 1000 pseudo-replicates. Maximum likelihood bootstrap values equal to or greater than 60% are given above each node of the phylogenetic tree (Figure 8.1).

A Bayesian analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (PP) (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov chain Monte Carlo sampling (BMCMC).

Two parallel runs were conducted using the default settings but with the following adjustments: four simultaneous Markov chains were run for 2,000,000 generations, trees were sampled every 100th generation, and 20001 trees were obtained in total. The first 4,000 trees, representing the burn-in phase of the analyses, were discarded to enter the high probability region, where the states of the Markov chain are more representative of the sampling distribution. The remaining 16,001 trees were used for calculating PP in the majority rule consensus tree. Branches with Bayesian posterior probabilities (BYPP) equal to or greater than 0.95 are indicated above each node of the phylogenetic tree (Fig. 1). Phylogenetic trees were visualized with the FigTree v1.4.0 program (Rambaut, 2011) and reorganized in Microsoft PowerPoint

8.3 Results

8.3.1 Phylogenetic Analyses

The combined ITS, cmdA, *rpb*2, *tub*2, and *tef*1 matrix comprised 70 sequences that represent selected genera in *Stachybotryaceae*. The best scoring RAxML tree is presented (Fig. 1) with a final ML optimization likelihood value of -38213.091. The matrix had 1833 distinct alignment patterns with 35.79% of undetermined characters or gaps. Estimated base frequencies were: A=0.229585, C=0.291579, G=0.254548, T=0.224288; substitution rates AC=1.228527, AG=3.573013, AT=1.331197, CG=0.93385, CT=5.411134, GT=1.0; proportion of invariable sites I=0.400993; and gamma distribution shape parameter α=1.130129. All trees (ML and BYPP) obtained from combined ITS, cmdA, *rpb*2, *tub*2 and *tef*1 data set were equal in topology and did not show any notable deviation from Lin et al. (2016) and Lombard et al. (2016). Isolates of the new species, *Stachybotrys musae* (MFLUCC 20-0152 and MFLUCC 20-0188) claded sister to *S. subsylvatica* (CBS12620) as a monophyletic clade with strong statistical support (ML=100%, BYPP=1.00). The new strains MFLUCC 20-0190 and MFLUCC 20-0189 constituted strongly supported monophyletic lineages with *S. microspora* (CBS 186.79) (ML=100%, BYPP=1.00) and *Memnoniella levispora* (Menlev3308 and Memno0407) (ML= 91%), respectively.

8.3.2 Taxonomy

Stachybotrys musae sp. nov. Samarakoon & Chomnunti, sp. nov.

Figure 8.2

MycoBank No —MB838529 FoF Number — FoF 09574

Etymology — Name reflects the host genus *Musa*

Holotype — MFLU 20-0626

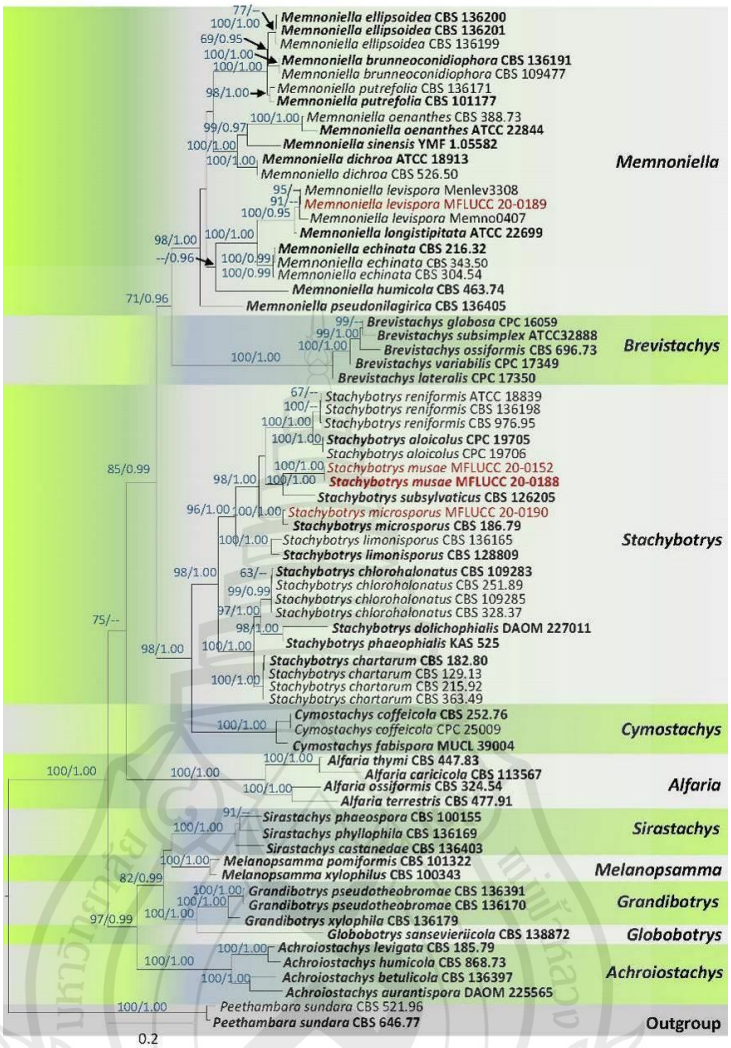
Saprobic on dead leaves of *Musa* sp. *Sexual morph*: Undetermined. *Asexual morph*: *Colonies* effuse, usually black or blackish green. *Mycelium* superficial, with light brown, septate, 5.6–7.4 (x̄=6.5µm, n=30) wide, hyphae sometimes forming ropes. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* 45–94×2.6–3.9µm (x̄=71.4×3.2µm, n=30) macronematous, mononematous, usually unbranched, rarely branched; often with distinct sub-hyaline shoe-shaped base 7–9×3–5.7µm (x̄=8.4×5.2µm, n=20). *Conidiophores* usually straight or flexuous, often curved near the base, straight towards the tip, multi-septate, often with 1–7 septa, sometimes more than 7-septate, hyaline or sub-hyaline at base, pale olive brown towards apex, smooth or slightly verrucose at maturity, sometimes sub-hyaline, granulate on the surface, terminating with a crown of phialides at apex. *Conidiogenous cells* monophialidic, 10–13×3–5µm (x̄=11.8×4.4µm, n=20), discrete, in groups of 4–6 at the apex of each conidiophore, broadly fusiform, with minute collarette at the tip. *Conidia* simple, unicellular, smooth, aggregated in large, slimy, often black and glistening heads. *Immature conidia* hyaline, acute at one end, rounded at another end, spherical. *Mature conidia* 5–7.5×4–7µm (x̄=7.1×5.6µm, n=40), ellipsoidal, acute or rounded at both ends dark brown, blackish brown or black, smooth or verrucose, sometimes covered with dark granules.

Culture characteristics — Conidia germinating on PDA after 48 hours, germ tubes produced from germ pores. Colonies growing on PDA reaching 2 cm diam. after 3 weeks in light conditions at 25 °C, mostly immersed mycelium, slimy and minutely dense, middle of the colony orange and pinkish orange at the periphery. Radially or unevenly striated, colonies have a wrinkled appearance from the top. Conidial formation was observed only in mature cultures rarely and minutely.

Material examined — China, Yunnan Province, Xishuangbanna on a dead leaf of undetermined *Musa* sp., 19 December 2018, D.N. Wanasinghe, BNSWN8 (MFLU

20-0626, holotype), living cultures (MFLUCC 20-0188 and MFLUCC 20-0152) as ex-type strains.

Notes — Based on BLASTn searches of ITS, cmdA, *rpb*2 and *tub*2 sequence data, *Stachybotrys musae* showed a high similarity (cmdA=84.34%, ITS=94.29%, *tub*2=89.13 % and *rpb*2=90.07%) to *S. subsylvatica* (CBS 126205). In the multigene phylogeny, *S. musae* clustered sister to *S. subsylvatica* with ML=100%, BYPP=1.00 statistical support (Fig. 1). Also, ITS sequence comparison revealed 4.94% base pair differences (without gaps) between *S. musae* and *S. subsylvatica*. *Stachybotrys musae* has contrasting morphological features to *S. subsylvatica* in having notably curved hyaline to olivaceous brown conidiophores. However, the conidiophores of *S. subsylvatica* are straight to slightly flexuous and most of the conidiophores are hyaline to subhyaline (Lombard et al., 2016). The conidiophores of *S. subsylvatica* are usually 1–4-septate, whereas the conidiophores of *S. musae* are 1–7-septate or even more than 7-septate. In addition, *S. musae* has distinct sub-hyaline shoe-shaped conidiophore bases that are absent in *S. subsylvatica.* The apex of phialidic conidiogenous cells of *S. subsylvatica* are sub-hyaline to pale olivaceous brown, while *S. musae* has completely hyaline phialides. When considering the culture characteristics, the colonies on PDA of *S. subsylvatica* are buff to pale luteous, whereas *S. musae* produces characteristic pinkish orange colonies on PDA. In our multigene analysis, *S. musae* has a close phylogenetic affinity to *S. aloeticola* and *S. reniformis.* However, *S. aloeticola* has allantoid to fusiform conidia containing 1–2 oil droplets (Crous et al., 2014). *Stachybotrys reniformis* bears tuberculate and often globose conidia (Wang et al., 2015). These specific features are absent in *S. musae.* Based on distinct morphological characteristics and significant statistical support from our molecular phylogenetic studies, *S. musae* is introduced herein as a new species on *Musa* from Yunnan Province, China.



Note Maximum likelihood bootstrap supports (≥60%) and Bayesian posterior probabilities (≥ 0.95 BYPP) are given above the branches, respectively. The tree is rooted with *Peethambara sundara* (CBS 646.77 and CBS 521.96) (*Stachybotryaceae*). Strains generated in this study are indicated in red. Ex-type strains are indicated in black bold. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 8.1 Maximum likelihood tree revealed by RAxML analyses of ITS, cmdA, *rpb*2, *tub*2, and *tef*1 sequence dataset of selected genera in *Stachybotryaceae* showing the phylogenetic position of *Stachybotrys musae* (MFLUCC 20-0152, MFLUCC 20-0188), *S. microspora* (MFLUCC 20-0190), and *Memnoniella levispora* (MFLUCC 20-0189)



Note a. Conidiophores on the host surface, b–d, g, h, j, m. Conidiophores with attached conidia, e, f. Conidiophores, i. Conidiophore with monophialidic conidiogenous cells, k. Mycelium, l. Mass of conidia and conidiophores, n. Conidia, o. Colonies on PDA after 8 weeks, Scale bars: a=500µm, j=200µm, c–i, l, m=50µm, b, f, g=25µm, n, k=5µm.

Figure 8.2 *Stachybotrys musae* (MFLU 20–0626, holotype)

Stachybotrys microsporus (B.L. Mathur & Sankhla) S.C. Jong & E.E. Davis

Figure 8. 3

Saprobic on dead leaf petiole of *Musa* sp. *Sexual morph*: Undetermined. *Asexual morph:* Hyphomycetous. *Colonies* on host are black and hairy. *Conidiophores* macronematous, mononematous, often simple, erect, straight or mostly flexuous, irregularly or sympodially branched, 20–50× 1.3–3.1µm ($\bar{x}$=32.4×2µm, n=20) at the base, tapering to 0.6–1.4µm wide ($\bar{x}$=0.94µm, n=20) near the apex, smooth, thick-walled, septate, hyaline at base, olivaceous brown at apex, bearing a crown of phialides at the tip. *Conidiogenous cells* 3.7–7.1×2.5–3.1µm ($\bar{x}$=5.3×2.8µm, n=20), monophialidic, discrete, determinate, terminal, obovoid, with peripheral ones somewhat curved, smooth, sub-hyaline. *Conidia* 7.7–14.2×5.1–9.8µm ($\bar{X}$=9.3×7.5µm, n=40) unicellular, simple, often aggregated as large glistening heads in black, when young elliptical, rounded at both ends, becoming globose, and often having pointed ends at maturity, roughened at surface, dark brown to black.

Culture characteristics — Conidia germinating on PDA after 36 to 48 hours. Colonies growing on PDA reaching 2–2.5 cm diam. after 3 weeks in the light condition at 25 °C, slow growing, flat, sparse, mycelium is completely immersed, pink, radially striated or wrinkled. Sporulation not observed in cultures.

Material examined — Thailand, Chiang Rai Province, Mae Sai District, on dead leaf petiole of *Musa* sp., 20 April 2019, B. Samarakoon, BNS 30 (MFLU 20-0628), living culture MFLUCC 20-0190.

Known distribution — soil (China and India), on *Arachis hypogaea* (Nigeria), decaying wood and subshrubs (karst areas in Thailand), *Solanum lycopersicum* (Canada) (Johnston et al., 2017; Lin et al., 2016; Lombard et al., 2016; Wang et al., 2015).

Notes — *Stachybotrys microsporus* (strain MFLUCC 20-0190) grouped with *S. microspora* (strain CBS 186.79) with strong statistical support (Fig. 1). All the strains of *S. microspora* described in Wang et al. (2015) and Lin et al. (2016) have similar morphology (i.e., hyaline, sympodially or irregularly branched conidiophores with tapering apices) with our collection (MFLU20-0628). Based on DNA sequence data, Santos (2015) reported that *S. globosa* is conspecific with *S. microsporus*. Previously, *S. globosa* was documented on *Musa* from India without molecular

justifications (Misra & Srivastava, 1982). Hence, in this study, we report *S. microsporus* (= *S. globosa*) on *Musa* from Thailand with morphological evidence and DNA sequence data.

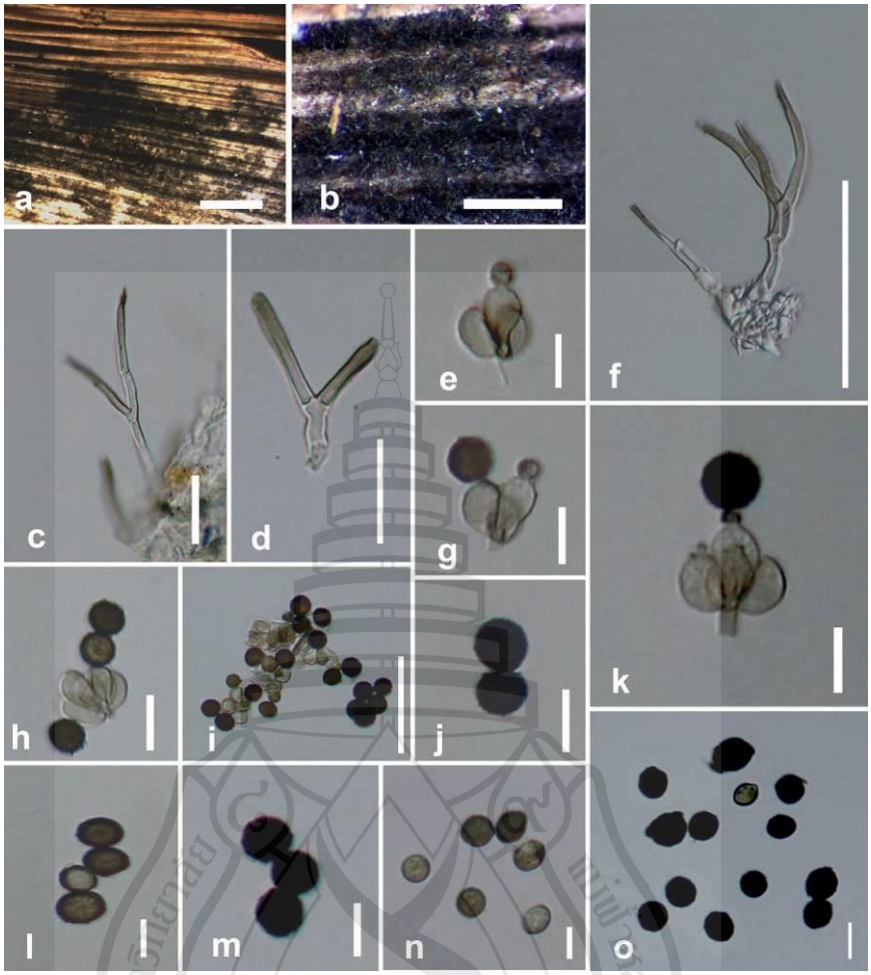
Memnoniella levispora Subram.

Figure 8.4

Saprobic on dead leaf petiole of *Musa* sp. *Sexual morph*: Undetermined. *Asexual morph*: *Colonies* on host, gregarious, scattered, superficial, black, powdery and bouquet-like. *Conidiophores* 43.6–60×2.5–4.7μm ($\bar{x}$=48.7×3.7 μm, n=20) at the base, 5–7μm wide at swollen apex, straight or flexuous, macronematous, unbranched, bearing a crown of phialides at the apex, minutely verrucose at base, often covered in part with dark granules to black olivaceous at lower half, thick-walled, 1–3-septate, *Conidiogenous cells* 4–6.9×2.3–3.1μm ($\bar{x}$=5.8×2.6μm, n=20) phialidic, sub-hyaline, short and narrow at apex, clavate, ampulliform, cylindrical or broadly fusiform, without collarettes. *Conidial heads* arising from conidiogenous cells, convex, round at apex and flat at base, black. *Conidia* 2.5–4.3×1.5–3.6μm ($\bar{x}$=3.5×2.2μm, n=20), in chains, simple, spherical to subspherical, often flattened in a plane or hemispherical, grey, dark brown to black and smooth.

Culture characteristics — Conidia germinating on PDA after 24 hours. Germ tubes produced from germ pores. Colonies growing on PDA reaching 16–21 mm diam. after 3 weeks in light conditions at 25 °C, slow growing, crenated, flat or effuse, moderately fluffy, medium sparse, aerial, white from above, pale yellowish from below.

Material examined — China, Yunnan Province, Xishuangbanna, on dead leaf of *Musa* sp., 18 December 2018, D.N. Wanasinghe, BNSWN6 (MFLU 20-0627), living culture MFLUCC 20-0189.



Note a, b. Conidiophores on the host surface. c, d, f. Conidiophores. e, g–i, k. Conidiogenous cells with attached conidia, j, l–o. Conidia. Scale bars: a, b=500µm, f=30µm, i=50µm, e, g, h =20µm, c, d, j–m=15µm, n–o=10µm

Figure 8.3 *Stachybotrys microspora* (MFLU 20–0628)

Known distribution — on *Morus* (India), *Oryza sativa* (Cuba), *Roystonea regia* (Cuba), *Sanchezia* (India, Pakistan), *Tectona grandis* (Thailand) (Arnold, 1986; Barrios & Perez, 2005; Doilom et al., 2017; Ellis, 1971; Wang et al., 2015).

Notes — Our strain MFLUCC 20-0189 grouped with *Memnoniella levispora* (Menlev3308 and Memno0407) with moderate statistical support (ML=91%) (Fig. 1). The morphological illustrations of *M. levispora* described in Wang et al. (2015) and Doilom et al. (2017) share similar features such as bouquet-like fungal colonies and catenate, numerous conidia, with our strain. *Memnoniella levispora* was documented on *Musa* sp. from India by Munjal and Kapoor (1969) using only morphological data. We report *M. levispora* as a saprobe on *Musa* sp. for the first time from Yunnan, China as a new geographical record using morpho-molecular data.

8.4 Discussion

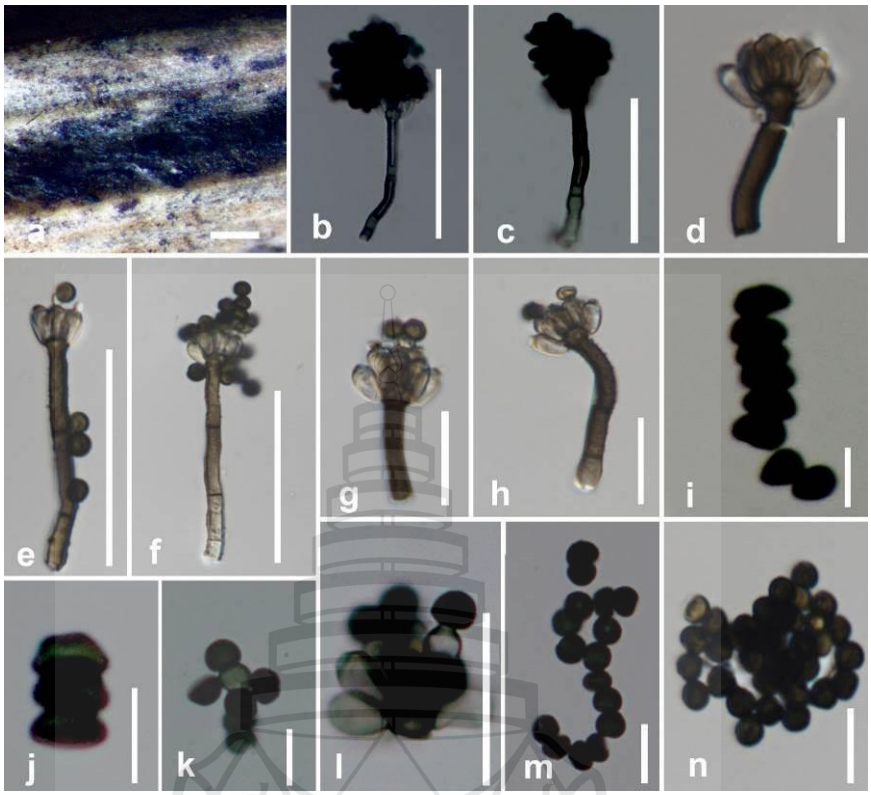
Taxonomic evidence for the new species is further strengthened by a comparison of *Stachybotrys* taxa previously described from *Musa* based only on morphology. *Stachybotrys suthepensis* was introduced on a dead petiole of *Musa acuminata* by Photita et al. (2003a). However, *S. suthepensis* differs from *S. musae* in having significantly verruculose, ellipsoid to cylindrical conidia which are rounded at the ends. Conidia of our new strain are not verruculose and ellipsoidal in shape with acute ends. In addition, the conidiophore of *S. musae* is notably curved when compared with *S. suthepensis*. Molecular data of *S. suthepensis* are not available in GenBank to compare with our collection.

Stachybotrys chartarum, S. kampalensis, S. nephrospora, and *S. theobromae* are distinct from our strain by morpho-molecular data. However, *S. ruwenzoriensis* does not have DNA sequence data in GenBank but differs from *S. musae* in having obovoid phialides and notably verrucose, globose to subglobose conidia. *Stachybotrys yunnanensis* was recorded from the same geographical region (Yunnan, China) where our new strain was identified, but it differs in morphology and DNA sequence data.

The wall of the conidiophores of *S. bambusicola* (Rifai, 1964) are similar to *S. musae* but differ in having pink conidia. *Stachybotrys longispora* (Lombard et al.,

2016) has a distinct conidiophore base but differs from *S. musae* by having a globular shape in the conidiophore base. The conidiogenous cells of *S. longispora* do not have collarettes when compared to *S. musae*. The conidiophore base of *S. nephrodes* in McKenzie (1991) is similar to *S. musae*, but *S. nephrodes* is different from our species in conidial shape. *Stachybotrys reniverrucosa* in Whitton et al. (2001) also has notably curved conidiophores like *S. musae*, but they can be easily differentiated by the conidial shape.

Many *Stachybotrys* taxa lack ex-type strains and holotypes are often difficult to locate. Sequence data for several species are lacking in GenBank. Some species were established, described, and identified based on ITS sequence data. However, constructing phylogenies only based on ITS data will not result in good tree topologies in *Stachybotrys*. Multiple sequence alignments combined with protein coding regions result in well-resolved phylogenies with well- separated clades for *Memnoniella* and *Stachybotrys* (Fig. 1). We have noted the lack of other protein coding gene regions (i.e., cmdA, *rpb*2, *tub*2, and *tef*1) in GenBank for many extant species of *Stachybotrys*. Differentiating *Memnoniella* and *Stachybotrys* has been problematic for over 50 years, and it was finally resolved by Lombard et al. (2016). Several genera of *Stachybotryaceae* are similar in morphology but have different molecular data (Lombard et al., 2016). Therefore, further taxa of *Stachybotryaceae* should be collected, isolated, and new sequence data should be generated for better taxonomic resolution.



Note a. Conidiophores on the host surface, b–g. Conidiophores and conidia, h, l. Conidiogenous cells and conidia, i–k, m, n. Conidia. Scale bars: a = 500 μm, b, c, e, f = 50 μm, d, g, h, l = 20 μm, i, j, k, m, n = 10 μm.

Figure 8.4 *Memnoniella levispora* (MFLU 20–0627)

CHAPTER 9

TAXONOMY AND PHYLOGENY OF *Smaragdiniseta musae* SP. NOV. AND *Albifimbria verrucaria* (*Hypocreales, Stachybotryaceae*) ON *Musa* FROM THAILAND

9.1 Introduction

Crous et al. (2014) established *Stachybotryaceae* and Lombard et al. (2016) further revised the family based on phenotypic characteristics and molecular analyses of LSU, ITS, *rpb2, cmdA, tef*1 and *tub*2 sequences. These arguments were accepted in the recent classifications of *Sordariomycetes* by Hyde et al. (2020) and Wijayawardene et al. (2020). The polyphyletic nature of *Myrothecium* (Chen et al., 2016) was further justified by Lombard et al. (2016) who established 13 new genera in *Stachybotryaceae* with myrothecium-like morphology viz. *Albifimbria, Capitofimbria, Dimorphiseta, Gregatothecium, Inaequalispora, Myxospora, Neomyrothecium, Paramyrothecium, Parvothecium, Smaragdiniseta, Striaticonidium, Tangerinosporium* and *Xenomyrothecium*. *Smaragdiniseta* was erected to accommodate *S. bisetosa* (=*Myrothecium bisetosum*) which is characterized by cup-shaped sporodochia with straight, hyaline, smooth-walled peripheral setae (Lombard et al., 2016; Rao & De Hoog, 1983). The setae grow rapidly from sporodochia and are soon covered by a weft of emerald green, echinulate marginal hyphae (Rao & De Hoog, 1983). The sexual morph of *Smaragdiniseta* is yet to be determined.

The taxonomic placement of *M. bisetosum* was doubted by Rao and De Hoog (1983) as it is morphologically resembling *Sarcopodium* by the formation of setae (Ehrenberg, 1818). However, Rao and De Hoog (1983) distinguished *M. bisetosum* from *Sarcopodium* by the macroscopic colour of the conidiomata. They interpreted the new collection that was similar in morphology to *Sarcopodium* and *Myrothecium*.

In the phylogenetic analyses of Lombard et al. (2016), *M. bisetosum* formed a monophyletic lineage sister to *Albifimbria* that was well separated from *Myrothecium*. *Smaragdiniseta* still remains monotypic (Index Fungorum 2022), since no additional taxonomic work has been conducted since Lombard et al. (2016).

In Lombard et al. (2016), the ex-neotype strain of *Myrothecium verrucaria* formed another highly supported monophyletic clade in *Stachybotryaceae*. *Albifimbria* was introduced to classify this lineage and *M. verrucaria* was synonymized and typified under *Albifimbria*. In addition, *A. lateralis, A. terrestris,* and *A. viridis* were introduced as novel taxa (Lombard et al., 2016). *Albifimbria* is characterized by the production of verrucose setae around the sporodochia (Lombard et al., 2016). In addition, some *Albifimbria* species bear funnel-shaped mucoid appendages in conidia (Lombard et al., 2016). Currently, four species of *Albifimbria* are listed in Index Fungorum (2022).

We are studying the saprobic fungi associated with *Musa* spp. from Thailand with the intention of providing a better understanding of their taxonomy based on both morphology and phylogeny (Samarakoon et al., 2020a, 2020b, 2021a, 2021b). This study is aimed to document two myrothecium-like taxa in *Stachybotryaceae* isolated from the dead leaves of *Musa*. Based on morphological illustrations, descriptions and phylogenetic analyses, we introduce one of our collections as *Smaragdiniseta musae* sp. nov. from Mae Sai, Chiang Rai, Thailand. This is the second species in *Smaragdiniseta* which further validates the taxonomic establishment of Lombard et al. (2016) and breaks the monotypic nature of the genus. In addition, we report *Albifimbria verrucaria* on *Musa* sp. as a new country record to Thailand.

9.2 Materials and Methods

9.2.1 Sample Collection, Morphological Studies, and Isolation

Dead leaves of *Musa* with characteristic sporodochia were collected from Thailand during January to October 2019. Specimens were transferred to the laboratory in small cardboard boxes. Fungi were observed using a Motic SMZ 168

series microscope (Motic Asia, Kowloon, Hong Kong). Conidiomata were mounted on glass slides in tap water and lactoglycerol for examination and photomicrography. The specimens were further observed using a Nikon ECLIPSE 80i compound microscope (Nikon Instruments Inc., Melville, NY, USA) and photographed using a Canon 550D digital camera (Canon Inc., Ota, Tokyo, Japan). Measurements were taken with the aid of Tarosoft (R) Image Frame Work program. More than 20 measurements were made for the structures. The images were further arranged using Adobe Photoshop CS6 Extended version 10.0 software (Adobe Systems, USA).

Single spore isolations for the samples were conducted according to Senanayake et al. (2020). Germinated conidia were individually transferred to potato dextrose agar (PDA) plates and incubated at 25 °C. Colony characters were examined after a month. Dried herbarium specimens were deposited in the Mae Fah Luang University Herbarium (Herb. MFLU), Chiang Rai, Thailand. Living cultures in PDA were deposited in the Culture Collection of Mae Fah Luang University (MFLUCC). Faces of fungi numbers (Jayasiri et al., 2015) and MycoBank numbers (http://www.MycoBank.org) were received for the isolates. The illustrations and descriptions were submitted to the GMS MICROFUNGI (gmsmicrofungi.org) database (Chaiwan et al., 2021).

9.2.2 DNA Extraction, PCR Amplification, and Sequencing

DNA was extracted from the mycelium of 14 days old cultures. The mycelium was crushed using a plastic pestle and DNA was extracted using Biospin Fungus Genomic DNA Extraction Kit-BSC14S1 (BioFlux, P.R. China) following manufacturer guidelines. Three gene regions; viz. internal transcribed spacer (ITS), partial β-tubulin (*tub*2) and partial second largest subunit of the DNA-directed RNA polymerase II (*rpb*2), were amplified using ITS5/ITS4 (White et al., 1990), Bt2a and Bt2b (Glass & Donaldson, 1995) and fRPB2-5f/fRPB2-7cR (Liu et al., 1999) respectively.

Polymerase chain reaction (PCR) was conducted using the following protocol. The total volume of the PCR reaction was 25 µL and comprised 12.5 µL of 2 × Power Taq PCR MasterMix (a premix and ready to use solution, including 0.1 Units/µl Taq DNA Polymerase, 500 µm dNTP Mixture each (dATP, dCTP, dGTP, dTTP), 20

mMTris-HCL pH 8.3, 100 mMKCl, 3 mM $MgCl_2$, stabilizer and enhancer), 1 μL of each primer (10pM), 2 μL genomic DNA and 8.5 μl of deionized water. The total reaction comprised 35 cycles. The annealing temperatures were according to Lombard et al. (2016) and Samarakoon et al. (2021b). The amplified PCR fragments were sent to TsingKe Biological Technology (Beijing) Co., China for sequencing. DNA sequence data obtained were deposited in GenBank (https://www.ncbi.nlm.nih.gov/).

9.2.3 Sequence Alignment

Newly generated sequence data of different gene regions were subjected to BLAST searches using BLASTn in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi) to retrieve similar sequences. The results and initial morphology indicated that our strains belong to *Stachybotryaceae* (Hypocreales). The collection numbers for these similar sequences (Table 9.1) were then downloaded from GenBank based on BLASTn results and Lombard et al. (2016). Single gene alignments were made by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/large.html; Katoh et al., 2019) using the default settings and later refined as necessary using BioEdit v. 7.0.5.2 (Hall, 1999).

9.2.4 Phylogenetic Analyses

Maximum likelihood (ML) trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis et al., 2008; Stamatakis, 2014) in CIPRES Science Gateway platform (Miller et al., 2010) with GTR+I+G model of evolution for single and multi-gene alignments. Bootstrap supports were gained by running 1000 pseudo-replicates. Maximum likelihood (ML) bootstrap values equal to or greater than 60% are given above each node of the phylogenetic tree (Figure 1).

A Bayesian analysis was conducted with MrBayes v. 3.1.2 (Huelsenbeck & Ronquist, 2001) to evaluate posterior probabilities (Rannala & Yang, 1996; Zhaxybayeva & Gogarten, 2002) by Markov chain Monte Carlo sampling (BMCMC). Two parallel runs were conducted, using the default settings and with the adjustments as follows; four simultaneous Markov chains were run for 2,500,000 generations and trees were sampled every 100^{th} generation and 20001 trees were obtained. The first 4,000 trees, of the burn-in phase, were discarded. The remaining 16,001 trees were taken for calculating PP in the majority rule consensus tree. Branches with Bayesian

posterior probabilities (BYPP) equal to or greater than 0.95 are written above each node of the multigene tree (Figure 9.1). The trees were displayed with FigTree v1.4.0 (Rambaut, 2011) and rearranged in Microsoft PowerPoint. Type strains are superscripted with T and new collections are in bold black (Table 9.1).

Table 9.1 Names, culture collection numbers, and their respective GenBank accession numbers of the *Stachybotryaceae* taxa that have been subjected to phylogenetic analyses

Species	**Strain**	**GenBank Accession Numbers**		
		ITS	***rpb2***	***tub***
Albifimbria lateralis	CBS 117712^{T}	KU845881	KU845919	KU845957
A. terrestris	CBS 109378	KU845882	KU845920	KU845958
A. terrestris	CBS 126186	KU845883	KU845921	KU845959
A. terrestris	CBS 127838	KU845884	KU845922	KU845960
A. verrucaria	CPC 30056	KU845885	KU845923	KU845961
A. verrucaria	CBS 328.52^{T}	KU845886	KU845924	KU845962
A. verrucaria	CBS 188.46	KU845888	KU845926	KU845964
A. verrucaria	**MFLUCC 22-0017**	**ON563487**	NA	**ON586153**
A. viridis	CBS 449.71^{T}	KU845898	KU845936	KU845974
A. viridis	CBS 127346	KU845899	KU845937	KU845975
Alfaria caricicola	CBS 113567^{T}	KU845983	KU846001	KU846014
Alf. terrestris	CBS 168.97	KU845987	KU846005	KU846018
Capitofimbria compacta	CBS 111739^{T}	KU846287	KU846349	KU846404
Dimorphiseta terrestris	CBS 127345^{T}	KU846314	KU846375	KU846431
Fusarium sambucinum	CBS 146.95	NA	KM232381	NA
Gregatothecium humicola	CBS 205.96^{T}	KU846315	KU846376	KU846432
Inaequalispora prestonii	CBS 175.73^{T}	KU846316	KU846377	KU846433
Myrothecium inundatum	CBS 196.74^{T}	KU846451	NA	KU846532
M. simplex	CBS 582.93^{T}	KU846456	NA	KU846537
Myxospora aptrootii	CBS 101263^{T}	KU846458	KU846496	KU846539
Neomyrothecium humicola	CBS 310.96^{T}	KU846467	KU846505	NA
Pa. breviseta	CBS 544.75^{T}	KU846289	KU846351	KU846406
Pa. cupuliforme	CBS 126167^{T}	KU846290	KU846352	KU846407
Pa. foeniculicola	CBS 331.51^{T}	KU846292	KU846354	KU846409
Pa. foliicola	CBS 419.93	KU846293	KU846355	KU846410
Pa. humicola	CBS 127295^{T}	KU846295	KU846356	KU846412
Pa. nigrum	CBS 116537	KU846296	KU846357	KU846413
Pa. parvum	CBS 142.42	KU846297	KU846358	KU846414

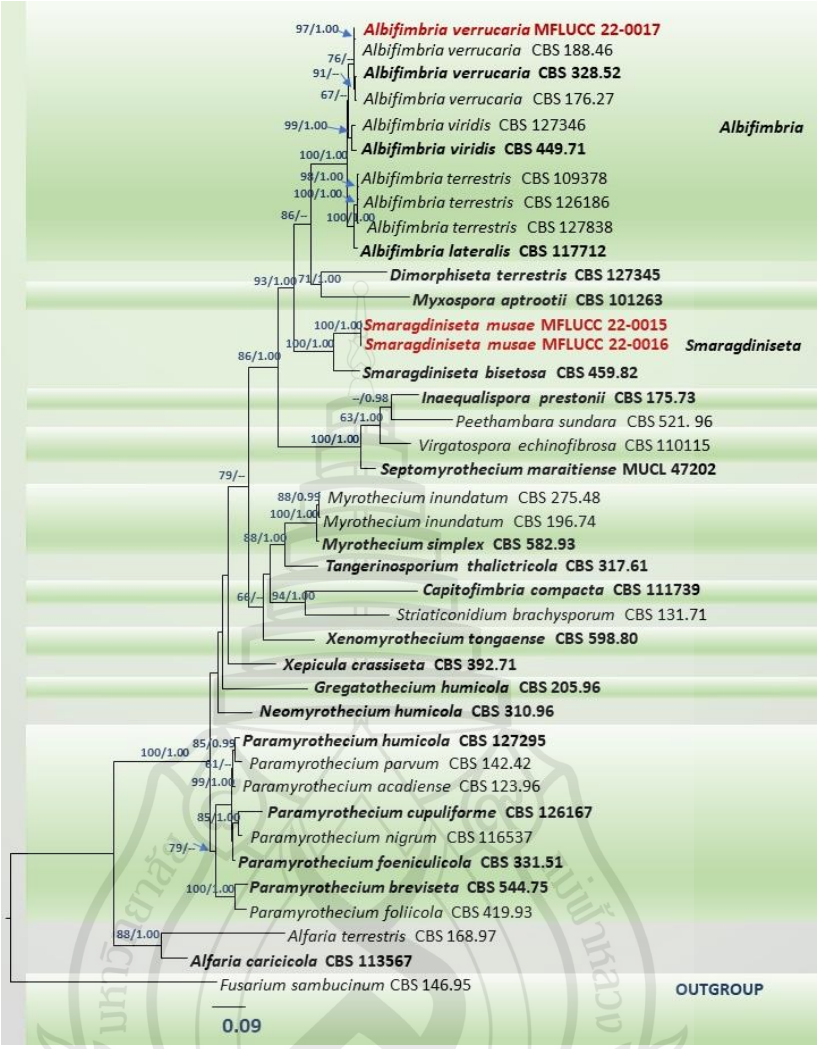
Table 9.1 (continued)

Species	Strain	GenBank Accession Numbers		
		ITS	***rpb2***	***tub***
Peethambara sundara	CBS 521.96	KU846470	KU846508	KU846550
Septomyrothecium maraitiense	MUCL 47202^{T}	NA	KU846510	NA
Smaragdiniseta bisetosa	CBS 459.82^{T}	KU847229	KU847281	KU847319
S. musae	**MFLUCC 22-0015^{T}**	**ON563485**	**ON586151**	**ON572191**
S. musae	**MFLUCC 22-0016**	**ON563486**	**ON586152**	**ON572192**
Striaticonidium brachysporum	CBS 131.71	KU847230	KU847282	KU847320
Tangerinosporium thalitricola	CBS 317.61^{T}	KU847243	NA	KU847333
Virgatospora echinofibrosa	CBS 110115	KU847244	KU847293	KU847334
Xenomyrothecium tongaense	CBS 598.80^{T}	KU847246	KU847295	KU847336
Xepicula crassiseta	CBS 392.71^{T}	KU847247	KU847296	KU847337

9.3 Results

9.3.1 Phylogenetic Analyses

The combined ITS, *rpb*2 and *tub*2 gene alignment was composed of 40 sequences that represented some of the selected taxa in *Stachybotryaceae*. The best scoring RAxML tree is presented (Figure 9.1) with a final ML optimization likelihood value of -21969.93. The matrix had 1136 distinct alignment patterns with 35.79% of undetermined characters or gaps. Estimated base frequencies were: A=0.239280, C=0.284737, G=0.251988, T=0.223995; substitution rates AC=1.282296, AG=4.565113, AT=1.367959, CG=1.092959, CT=7.305206, GT=1.0; proportion of invariable sites I=0.459148; gamma distribution shape parameter α=0.920614. All trees (ML and BI) resulting from the multi-gene alignment were equal in topology, without notable differences from Lombard et al. (2016). *Smaragdiniseta musae* (MFLUCC 22-0015, MFLUCC 22-0016) formed an independent lineage sister to *S. bisetosa* (CBS 459.82) (ML=100%, BYPP=1.00) with strong statistical support. In addition, MFLUCC 22-0017 grouped with *Albifimbria verrucaria* (CBS 188.46) (ML=97%, BYPP=1.00) respectively.



Note ML bootstrap supports (≥60%) and Bayesian posterior probabilities (≥0.95 BYPP) are given above the nodes, respectively. The tree is rooted with *Fusarium sambucinum* (CBS146.95) (*Nectriaceae*). Strains generated in this study are indicated in bold red. Ex-type strains are indicated in bold black. The scale bar represents the expected number of nucleotide substitutions per site. The tree is showing the phylogenetic position of *Albifimbria verrucaria* (MFLUCC 22-0017) and *Smaragdiniseta musae* (MFLUCC 22-0015, MFLUCC 22-0016).

Figure 9.1 Maximum likelihood tree revealed by RAxML analyses of ITS, *rpb*2 and *tub*2 sequence data of selected genera of *Stachybotryaceae*

9.3.2 Taxonomy

Smaragdiniseta musae Samarakoon & Chomnunti, sp. nov.

Figure 9.2

MycoBank Number: MB844095 Facesoffungi Number: FoF 10846

Etymology: The species epithet reflects the host genus, *Musa*

Holotype: MFLU 22-0047

Saprobic on dead leaves of *Musa* sp. Sexual morph: Undetermined. Asexual morph: *Sporodochia* 0.2–0.35 mm diam., cup-shaped, scattered, solitary, circular with an entire margin, initially emerald green, later becoming black, composed of hyaline, erect conidiophores, surrounded by filamentous white marginal hyphae and setae at periphery. *Fungal hyphae* parallelly arranged like a palisade layer, compacted, verrucose, olivaceous brown or hyaline, sometimes warticulate, septate, branched, irregularly thick-walled, with ultimate hyphal cell rounded at apex and flat at base; hyphal cells: 10–14×0.8–2.5µm ($\bar{x}$=13.3×1.6µm, n=30). Aggregated hyphae hyaline or emerald green when immature, tan brown at maturity. *Setae* fast growing from marginal hyphae, numerous, aggregating as a pale gray brush, elongated, straight or slightly curved, tapering towards apex, hyaline, septate, unbranched, apiculate at apex, sometimes caudate, truncate or rounded, swollen to globose to ovate or rounded at base, setae wall 0.4–1.5µm ($\bar{x}$=0.8µm, n=30) thick, often smooth, sometimes rough with hyaline acellular coatings, 60–250×0.8–2.8µm ($\bar{x}$=126.4×1.6µm, n=30); septa 4–8µm apart. *Marginal hyphae* often coiling or growing around the setae or projecting out, forming a wefty cover around setae, 95–125µm ($\bar{x}$=106µm, n=30) wide. *Conidiophores* 4–14×1.3–2.5µm ($\bar{x}$=12.9 ×1.7µm, n=30), macronematous, hyaline, smooth, thin-walled, arising from sub hyaline or pale brown, with slightly thickened and swollen basal cells, often with a narrow truncate base, wider in the middle, tapering to rounded at apex, 3–4×5–6µm ($\bar{x}$=3.5 ×5.5µm, n=10), septate, rarely unbranched, mostly branched and with 2–3 conidiogenous sub-branches at each node. *Conidiogenous cells* phialidic, rough or thin-walled, rod-shaped, elongated or ovate, 4–9×1–3µm ($\bar{x}$=6.8 ×1.9µm, n=20), without a collarette, pinching off simple conidia at the apex of each phialide. *Conidia* simple, hyaline, smooth, thin-walled, elliptic or slightly ovate, rounded at one end and acute at other end, with two distinct guttules at vertical ends, sometimes with 3–5 guttules, 6–10×2–3.5µm ($\bar{x}$=8.3×2.7µm, n=10).

Culture characteristics - Conidia germinating on PDA after 48 hours, germ tubes were produced from the acute end. Colonies growing on PDA reaching 20 mm diam. after 2 weeks in the light conditions at 25 °C, mycelium mostly immersed, not slimy, cottony, pinkish-white, dense in the middle and comparatively sparse at the periphery. Radially and unevenly striated, colonies have a slightly wrinkled appearance from the top. The formation of sporodochia was not observed in mature colonies.

Material examined - Thailand, Chiang Rai Province, Mae Sai, on a dead leaf of *Musa* sp., 16 June 2019, Binu Samarakoon, BNS264 (MFLU 22-0047, **holotype**), ex-type MFLUCC 22-0015. Living culture MFLUCC 22-0016.

Notes - Based on BLASTn search results of ITS, *tub2*, *rpb2* sequence data, *Smaragdiniseta musae* showed a high percentage identity (ITS=97.23%, *tub2*=89.16% and *rpb2*=91.10%) to *S. bisetosa* (CBS 459.82). In the multigene phylogeny, *S. musae* clustered with *S. bisetosa* in having strong statistical support (100% ML, 1.00 BYPP) (Figure 1). The base pair comparison of ITS, *tub2* and *rpb2* of our new taxon revealed 3.14% (17/540), 12.36% (35/283) and 9.34% (63/674) nucleotide differences with *S. bisetosa*. Besides, *S. musae* differs from *S. bisetosa* by the conidial morphology. The conidia of *S. musae* have two distinct guttules at the vertical poles. In addition, some conidia bear minute guttules at the center. However, the taxonomic illustration and description of *S. bisetosa* did not indicate the guttule formation in the conidia (Rao & Hoog, 1983). Moreover, the conidia of *S. bisetosa* are obclavate, narrowly ellipsoidal or rod-shaped, whereas our new taxon has elliptic or slightly ovate-shaped conidia with a rounded top and an acute base. Both ends of the conidia of *S. bisetosa* are rounded or sometimes are found with a truncate base (Rao & Hoog, 1983). We have not observed a truncate base in the conidia of *S. musae*. Furthermore, the marginal hyphae of *S. musae* often coil or grow around the setae but never have overgrown. The marginal hyphae always reach around 95–125µm of the setae and terminate at a point. According to the description of Rao and Hoog (1983), in *S. bisetosa,* the marginal hyphae always covered the entire setae. Our new collection is similar in morphology to the other genera in *Stachybotryaceae* in having conidiophores where the ultimate branches become phialides (Lombard et al., 2016). This feature phenotypically justifies the placement of our new collection in

Stachybotryaceae. Based on distinct morphological characteristics and strong statistical support from our molecular phylogeny, *Smaragdiniseta musae* is therefore herein introduced as a new species on *Musa* sp. from Chiang Rai Province, Thailand. This is the first report of *Smaragdiniseta* on *Musaceae* and from Southeast Asia. In addition, *S. musae* is the second taxon that is being described in this genus.

Albifimbria verrucaria (Alb. & Schwein.) L. Lombard & Crous

Figure 9.3

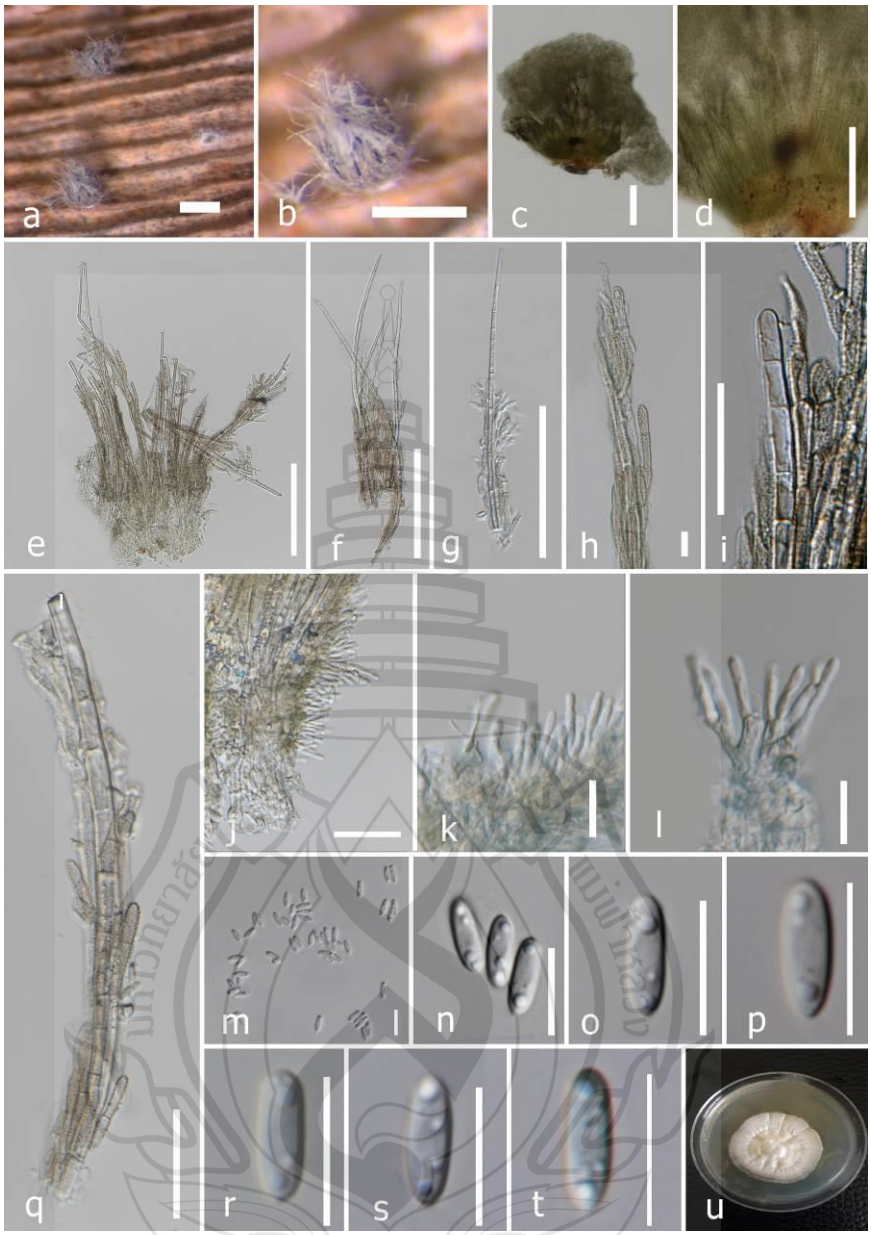
MycoBank Number: 815927 Facesoffungi Number: FoF 04192

Saprobic on dead leaves of *Musa* sp. Sexual morph: Undetermined. Asexual morph: *Sporodochia* cupulate or discoid, scattered or gregarious, having irregular or rounded outline composed of white marginal hypha, with conidial mass flattened or convex, pale olivaceous green at immature stage, black and shiny at maturity, 10–18×0.8–3μm ($\bar{x}$=12.3×2.4μm, n=20). *Stroma* rarely well-developed, usually with a thin layer of isodiametric or elongate hyaline cells 15–25 ($\bar{x}$=16.8μm, n=10). *Setae*: not observed. *Marginal hyphae* hyaline, usually verrucose, septate, curling and coiling, some branched, rounded or blunt at apex, 1.5–3.8 ($\bar{x}$=3.3, n=20) in diam. *Conidiophores* arising from thin stromatic layer, hyaline, smooth, 30–48×1–2μm ($\bar{x}$=42.2 ×1.7μm, n=30) septate, branching repeatedly, forming 2–4 branches at each level, with ultimate branches becoming *phialides*, which give rise to numerous conidia, conidiophores sometimes also arising from the hyphae. *Phialides* hyaline, rough-walled 30–48×1–2μm ($\bar{x}$=42.2×1.7μm, n=30), 3–7 in a whorl, closely packed in a dense parallel layer, cylindrical, hyaline, collate at base, rounded or acute at apex, sometimes slightly tapering towards apex, 8–16×1–3.5μm ($\bar{x}$=12.2×1.8μm, n=30). *Conidia* broadly fusiform, always pointed at one end, mostly truncate or rounded at the other end, hyaline, sometimes sub hyaline, smooth, 5–9.5×2–3.5μm ($\bar{x}$=7.6×3.0μm, n=30).

Culture characteristics - Conidia germinating on PDA after 12 hours. Colonies growing on PDA reaching 40 mm diam. after 2 weeks in the light conditions at 25 °C, mycelium mostly immersed, not slimy, cottony, white, dense in the middle and comparatively sparse at the periphery, fast-growing. Sporodochia formed after 12 days at the center as a black uneven ring.

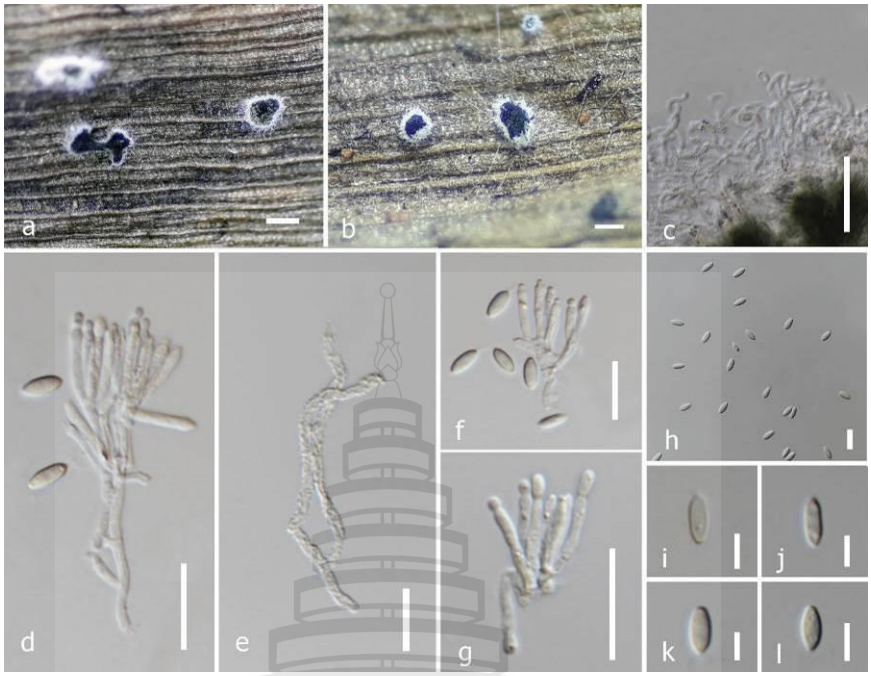
Material examined - Thailand, Chiang Rai Province, Mae sai, on a dead leaf of *Musa* sp., 25 June 2019, Binu Samarakoon, BNS292 (MFLU 22-0048), living culture MFLUCC 22-0017.

Notes - Based on BLASTn search results of ITS, *tub2*, *rpb2* sequence data, our stain (MFLUCC 22-0017) showed a high similarity (ITS=100% *tub2*=100% and *rpb2*=99%) to *Albifimbria verrucaria* (CBS 188.46). In the multigene phylogeny, MFLUCC 22-0017 grouped with *A. verrucaria* strains with strong statistical supports (97% ML, 1.00 BYPP) (Figure 9.1). Morphologically, our collection is similar to the descriptions of Lombard et al. (2016) and Tulloch (1972). *Albifimbria verrucaria* has previously been reported from *Musa* sp. as a saprobe in Venezuela (Dennis, 1970). This is the first report of *Albifimbria* from Thailand. MFLUCC 22-0017 is the first saprobic *A. verrucaria* strain found in Thailand. In addition, this is the second report of *Albifimbria* on *Musaceae*.



Note **a, b** sporodochia on the host **c, d** cupulate sporodochia **e-i, q** setae and marginal hyphae **j-l** attachments of conidiophores and phialides **m-t** conidia **u** colony on PDA after 8 weeks. Scale bars: 400µm (**a, b**); 100µm (**c, d, i, q**); 50µm (**e-h**); 20µm (**j**); 10µm (**k-t**).

Figure 9.2 *Smaragdiniseta musae* (MFLU 22-0047, holotype)



Note **a b** sporodochia on the host **c e** marginal hyphae **d f g** conidiophores and phialides **h-l** conidia. Scale bars: 400µm (**a, b**); 100µm (**i-j**); 50µm (**c**); 10µm (**d-h**); 5µm (**i-l**).

Figure 9.3 *Albifimbria verrucaria* (MFLU 22-0048)

9.4 Discussion

Smaragdiniseta has been previously documented as a saprobe only from terrestrial habitats (Rao & De Hoog, 1983). There were no reports on pathogenic, and endophytic lifestyles or sexual morphs that represent the genus. *Smaragdiniseta* was only discovered in India, while no other reports have been published on the occurrence worldwide. *Albifimbria* was subsequently discovered to show all three nutritional modes viz. as endophytes (Li et al., 2020; Wei et al., 2022), as pathogens (Gilardi et al., 2020; Herman et al., 2020; Rehman et al., 2021; Sharma et al., 2021) and as saprobes (Tulloch, 1972). However, *Albifimbria* has mostly been discovered from plant hosts in terrestrial habitats (Tulloch, 1972). In addition, the genus has also been reported in human blood (Masetti et al., 2020) and soil (Gurung et al., 2019; Murgia et al., 2019). Several genera of *Stachybotryaceae* such as *Albifimbria,*

Memnoniella, *Myrothecium* and *Stachybotrys* are capable of producing bioactive compounds (Li et al., 2020; Pervez et al., 2015; Sun et al., 2020; Wang et al., 2015).

Albifimbria verrucaria has been reported as a plant pathogen that causes stem necrosis and leaf spots on various crops such as *Glycine latifolia* (Herman et al., 2020), leafy vegetables (Matić et al., 2019; Rehman et al., 2021), ornamental crops (Matić et al., 2019), tomato (Gilardi et al., 2020). In addition, *A. verrucaria* was also reported as an antagonistic agent on grapevine pathogens (Li et al., 2020). Also, *A. verrucaria* has been applied as bio-pesticide to many weeds and nematodes (Assaf, 2020). *Albifimbria verrucaria* can produce many lytic enzymes (viz. lipase, protease, and kinase) which can degrade the cuticles of insects and thus, can be used as an insecticide (Assaf, 2020; Weaver et al., 2021). Chemical screening of *Smaragdiniseta* isolates has not been conducted so far and still, the profiles remain undiscovered. Hence, apart from the taxonomic treatments, the chemical profiles of these genera also can be investigated as they are excellent sources of secondary metabolites. In addition, *A. verrucaria* was reported as a human pathogen causing keratomycosis (Liu et al., 2021; Moreno-Flores et al., 2020). Hence there are opportunities for taxonomists to conduct sampling, isolation, and identification of these hidden taxa from various hosts and provide baseline data for future research work.

CHAPTER 10

THE PLANT PATHOGENIC GENUS *Neocordana*

10.1 Introduction

Fungi are the organisms that play various ecological roles in the environment, including decomposition of organic matter and recycling of nutrients, exhibit pathogenic and endophytic lifestyles (Treseder et al., 2015). The asexual genus, *Neocordana* was established by Hernández-Restrepo et al. (2015) and accommodated in the family *Pyriculariaceae*, order *Magnaporthales*. *Neocordana musae* (Zimm.) Hern. -Restr. & Crous was considered as the type species (Wijayawardene et al., 2017) and six plant pathogenic taxa (Index Fungorum, 2024) represents the genus at present from limited number of hosts (*Musaceae* and *Cannaceae*) worldwide (Crous et al., 2016; Hernandez-Restrepo et al., 2015; Jones, 1998) (Table 10.1). Several studies have reported that fungi can alter their lifestyles as endophytes, saprobes or pathogens (Promputtha et al., 2007). *Neocordana* is an excellent example for a fungal genus that represents all three modes of ecological strategies, notably, as plant pathogen, saprobe (Hernández-Restrepo et al., 2015; Wijayawardene et al., 2017), as well as an endophyte (Photitia et al., 2001).

As plant pathogens, the overwhelming majority of species causes leaf spots on *Musa* sp. (banana) (Allen & Dettmann, 1990; Fan et al., 2012; Jones, 1999). In addition, *N. versicolor* harms the leaves of a common ornamental plant, *Canna denudate* in Brazil (Soares et al., 2005). The damage caused by the pathogens is severe, resulting in huge defoliation (Hernández-Restrepo et al., 2015) and minimizing the potential of photosynthesis in the host plant. Generally, the leaf spots, resulting from the pathogenic attack can affect the productivity, quality and the market value of the commodity (Gaikwad et al., 2017) and contribute to a considerable economic loss in agriculture.

The objectives of this study are to, 1) Provide an updated account of the diversity, distribution and morpho-molecular taxonomy of the genus *Neocordana.* 2) Reinvestigate intergeneric relationships of *Neocordana* based on LSU and ITS sequence data. 3) Discuss the potential of pathogenicity, disease control, and endophytic nature of *Neocordana.*

10.2 Diversity, Distribution and Morphology

The sexual morph of the genus is still unknown (Wijayawardene et al., 2017) and the asexual morph resembles brown hyphomycetes with differentiated conidiophores which are straight, and erected. Conidiophores bear pale brown conidia that arise from terminal and intercalary conidiogenous cells (Hernández-Restrepo et al., 2015). Colonies are usually grown on potato dextrose agar. The mycelia are superficial, hairy and grey to brown in color. This mycelial growth has also been recorded on the cuticle of host plants. The septate mycelia are hyaline and become brown with age (Hernández-Restrepo et al., 2015). The morphological features of the type specimen are illustrated in Figure 10.1. The main morphological characters (especially conidial size and shape) differentiating species of genus *Neocordana* are outlined in Table 10.2.

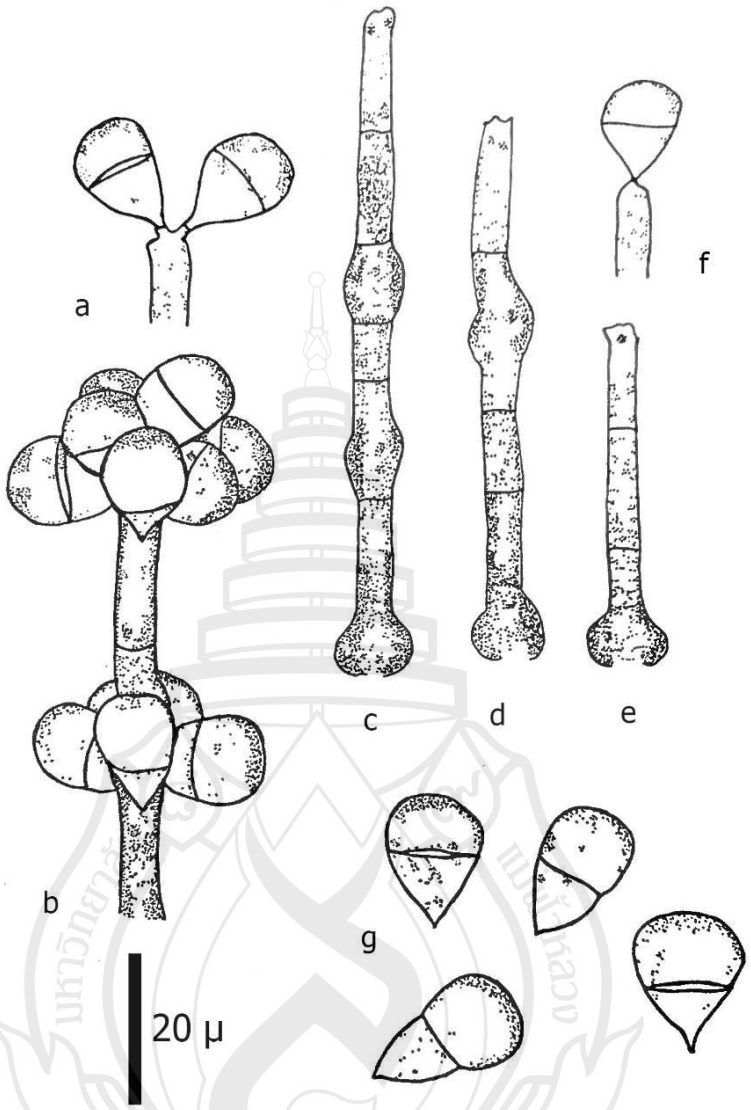
Neocordana versicolor can be delineated with respect to *N. musae* in terms of conidial shape, colour and size (Table 10.3) while *N. johnstonii*, *N. versicolor* also bear some morphological dissimilarities in the conidiophore (Table 10.4). With respect to *N. musae* and *N. johnstonii*, the conidiophores of both taxa are brown, erect, straight, septate and denticulate. The conidiophores arise as single small groups and paler towards the apex in color. Conidia of both organisms are two celled, smooth and pale brown to hyaline. A thickened hylum can be seen in conidia. Colonies are hypophyllous, effuse to hairy and dark brown. The size of conidiophores and conidia are different from each other as listed in Table 10.5 (Jones, 1999).

Table 10.1 Recorded species of *Neocordana*, hosts and distribution

Species	Host	Distribution	Reference
Neocordana johnstonii (M.B. Ellis) Hern. -Restr. & Crous	*Musa sapientum*	Australia, Indonesia Malaysia, Philippines, Tonga.	Hernandez-Restrepo et al. (2015)
Neocordana musae (Zimm.) Hern. -Restr. & Crous	*Musa sapientum*	Has been recorded around the tropical region	Hernandez-Restrepo et al. (2017)
	Musa sp.		
Neocordana musarum Crous	*Musa* sp.	France	Crous et al. (2016)
Neocordana musicola Hern. -Restr. & Crous	*Musa* sp.	Mauritius, Mexico	Hernandez-Restrepo et al. (2015)
Neocordana musigena Crous	*Musa* sp.	Morocco	Crous et al. (2017)
Neocordana versicolor (D.J. Soares & R.W. Barreto) Hern. -Restr. & Crous	*Canna denudate*	Brazil	Hernandez-Restrepo et al. (2015)

Table 10.2 Comparison of the size and the shape of conidia in the genus *Neocordana*

Species	Shape of the conidia	Size of the conidia	Reference
Neocordana musae	Obclavate to pyriform	14–18 × 8–10 µm	Hernandez-Restrepo et al. (2015)
Neocordana johnstonii	Ellipsoidal to subglobose	19–26 ×14–16 µm	Hernandez-Restrepo et al. (2015)
Neocordana musarum	Oblong to obovoid	15–20 × 9–13 µm,	Crous et al. (2016)
Neocordana musicola	Oblong to obovoid	14.5–20 × 6.5–9.5	Hernandez-Restrepo et al. (2015)
Neocordana musigena	Oblong to obovoid	conidia 15–18 × 7–9 µm	Crous et al. (2017)
Neocordana versicolor	Ellipsoidal	15–25 × 10–15 µm	Hernandez-Restrepo et al. (2015)



Note a, b, f, Conidiophores with attached conidia c, d, e, Conidiophores from which conidia are detached g, Conidia.

Source Meredith (1962b)

Figure 10.1 *Neocordana musae*

Table 10.3 Distinct morphological differences between *N. musae* and *N. versicolor*

Character	***Neocordana musae***	***Neocordana versicolor***
Conidia	Large and broadly ellipsoid	Small and obovoid to pyriform
Germ tube	End with amulliform	Shaped a boxing glove
Appressoria	Dark grey	Dark brown
Family of the host	*Musaceae*	*Cannaceae*

Table 10.4 Distinct features of the conidiophore between *N. johnstonii* and *N. versicolor*

Character of the conidiophore	***Neocordana johnstonii***	***Neocordana versicolor***
Apical and intercalary part	Not swollen	Becomes bulbous and swollen
Presence of denticles	More than one denticle at the swollen parts	One denticle per swell

Table 10.5 Comparison of conidia and conidiophores of *N. musae* and *N. johnstonii*

Character	***Neocordana musae***	***Neocordana johnstonii***
Conidiophore	Often nodose	Often twisted in the basal part
	Up to 150 µm long	Up to 300 µm long
	4-6 µm in diameter	5-9 µm in diameter
Conidia	Short and not much wide	Longer and wider than *N. Musae*

Crous et al. (2016) mentioned that *N. musarum* resembles *N. musae*. Size of the conidia can be used to differentiate between the two species, given that *N. musarum* have wider conidia than *N. musae.* According to Crous et al. (2017), *N. musigena* is similar to *N. musicola* but phylogenetically distinct. Cultural characters of species in the genus are almost similar and only few contrasting features were noticed and these are detailed in Table 10.6.

10.3 History and Taxonomy of *Neocordana*

Earlier *Neocordana* species were taxonomically classified under the asexual dematiaceous hyphomycetes genus *Cordana* Preuss. Later the later was synonymized by Hernández-Restrepo et al. (2015) to *Neocordana*. *Cordana* was established by Preuss (1851) with *C. pauciseptata* Preuss as the type specimen. With DNA sequence data and phylogenetic concepts, pathogens such as *C. musae*, *C. johnstonii* and *C. versicolor* were placed in order Magnaporthales, family *Pyriculariaceae* and accommodated in *Neocordana.*

In this study (Hernández-Restrepo et al., 2015) a phylogenetic tree was constructed based on analyses of the LSU and ITS sequence data of *N. musae* and *N. musicola* isolates with the other taxa of *Magnaporthales*. The isolates of *N. musae* and *N. musicola* were from different localities such as Australia, Mauritius, Malaysia and Mexico (Hernández-Restrepo et al., 2015). With a high bootstrap support, *Neocordana* isolates were clearly separated as a monophyletic clade in *Pyriculariaceae*. DNA sequence data of *N. versicolor* and *N. johnstoni* are not available and therefore not included in phylogenetic analysis.

Based on the morphological data and host pathogenic interactions, *N. versicolor* and *N. johnstoni* were included in the genus. Crous et al. (2016) has introduced *N. musarum* as a new species with the help of descriptive, morphological and molecular data (LSU). Next species introduced by Crous et al. (2017) is *N. musigena*. The taxonomic placement of four species of the genus (*N. musae, N. musicola, N. musarum* and *N. musigena* are supported by molecular data but taxonomic placement of two species (*N. versicolor* and *N. johnstoni*) are still uncertain due to the lack of molecular data. Currently LSU, ITS, ACT and RPB1 genes sequences are available in GenBank for the recently introduced above mentioned four species. The published record for *N. versicolor* was provided by Soares et al. (2005) and its establishment was mainly based on morphology, plant family of the host and pathogenicity.

10.4 Taxonomic Placement of the Genus *Neocordana* in the Family *Pyriculariaceae*

In this study, we present the updated tree of family Pyriculariaceae by using all the available LSU and ITS sequences. Multiple alignments were automatically done by MAFFT v. 7.036 (http://mafft.cbrc.jp/alignment/server/index.html; Katoh & Standley, 2013) using BioEdit v. 7.0.5.2 (Hall, 1999).

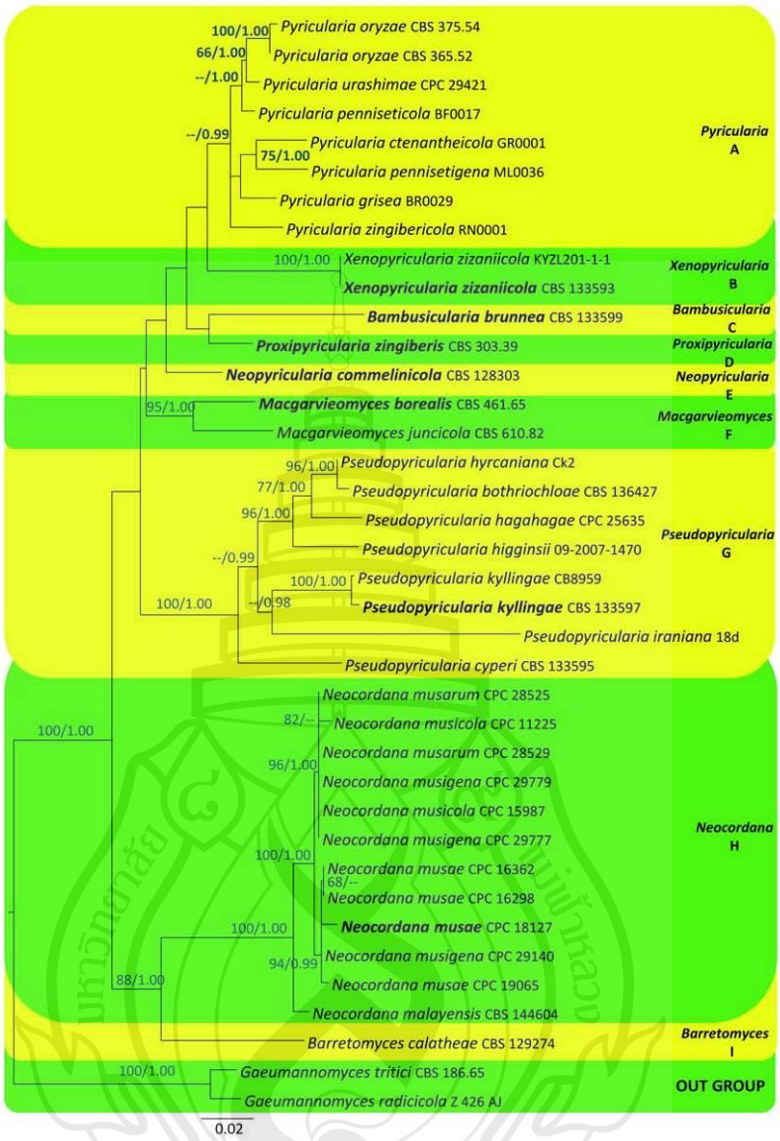
Table 10.6 Comparison of culture characteristics in the genus *Neocordana*

Species	Colonies on Malt Extract Agar (MEA)		Reference
	Upper surface of the plate	Lower surface of the plate	
Neocordana johnstonii	*In vitro* cultures are not available	*In vitro* cultures are not available	Hernandez-Restrepo et al. (2015)
Neocordana musae	Elevated and cottony, aerial mycelium is white, mouse gray zones represents the sporulation, having a defuse margin	Centre is black, have concentric rings, isabelline to umber or luteous to ochreous in colour	Hernandez-Restrepo et al. (2015)
Neocordana musicola	Cottony, aerial mycelium is white and mouse grey towards the edge that shows the sporulation, having a diffuse margin	Fuscous black in the centre, luteous at the edge	Hernandez-Restrepo et al. (2015)
Neocordana versicolor	*In vitro* cultures are not available	*In vitro* cultures are not available	Hernandez-Restrepo et al. (2015)
Neocordana musarum	Colonies are flat and spreading, aerial mycelium is moderate and smooth, having even margins, dirty white in colour	Pale luteous in colour	Crous et al. (2016)
Neocordana musigena	Colonies flat, spreading, with moderate aerial mycelium, and feathery margins	Luteous in colour	Crous et al. (2017)

Maximum likelihood trees were generated using the RAxML-HPC2 on XSEDE (8.2.8) (Stamatakis, 2014) in the CIPRES Science Gateway platform (Miller et al., 2010) using GTR+I+G model of evolution. Bayesian analysis was conducted according to (Wanasinghe et al., 2017). Phylograms were visualized with FigTree v1.4.0 program (Rambaut, 2012) and reorganized in Microsoft power point (2010).

Table 10.7 Taxa used in the phylogenetic analysis of the family *Pyriculariaceae* and their corresponding GenBank accession numbers

Species	Culture accession numbers	Gene bank accession numbers	
		LSU	ITS
Bambusicularia brunnea	**CBS 133599**	**KM484948**	**KM484830**
Barretomyces calatheae	CBS 129274	KM484950	KM484831
Gaeumannomyces radicicola	Z 426 AJ	KM484966	KM484849
Gaeumannomyces tritici	CBS 186.65	KM484955	KM484838
Macgarvieomyces borealis	**CBS 461.65**	**DQ341511**	MH858669
Macgarvieomyces juncicola	CBS 610.82	KM484970	KM484855
Neocordana musae	**CPC 18127**	**LN713290**	**NR_154265**
Neocordana musae	CPC 16362	LN713289	LN713281
Neocordana musae	CPC 16298	LN713288	LN713282
Neocordana musae	CPC 19065	LN713291	LN713276
Neocordana musarum	CPC 28529	KY173516	KY173425
Neocordana musarum	CPC 28525	KY173515	KY173424
Neocordana musicola	CPC 15987	LN713287	LN713283
Neocordana musicola	CPC 11225	LN713286	NR_154266
Neocordana musigena	CPC 29779	KY979805	KY979750
Neocordana musigena	CPC 29777	KY979804	KY979749
Neocordana musigena	CPC 29140	KY979803	KY979748
Neopyricularia commelinicola	**CBS 128303**	**KM484982**	**KM484868**
Proxipyricularia zingiberis	**CBS:303.39**	**KM484989**	**KM484871**
Pseudopyricularia bothriochloae	CBS 136427	KF777238	KF777186
Pseudopyricularia cyperi	CBS 133595	KM484990	KM484872
Pseudopyricularia hagahagae	CPC 25635	KT950865	KT950851
Pseudopyricularia higginsii	09_2007_1470	KM484991	KM484875
Pseudopyricularia hyrcaniana	Ck2	KY457266	NA
Pseudopyricularia iraniana	18d	KY457269	KY465726
Pseudopyricularia kyllingae	**CBS 133597**	**KM484992**	**KM484876**
Pseudopyricularia kyllingae	CB8959	KM484993	KM484877
Pyricularia ctenantheicola	GR0001	KM484994	KM484878
Pyricularia grisea	BR0029	KM484995	KM484880
Pyricularia oryzae	CBS 365.52	KM485000	KM484890
Pyricularia oryzae	CBS 375.54	KM485001	KM484891
Pyricularia penniseticola	BF0017	KM485031	KM484925
Pyricularia pennisetigena	ML0036	NA	KM484935
Pyricularia urashimae	CPC 29421	KY173529	KY173439
Pyricularia zingibericola	RN0001	KM485037	KM484941
Xenopyricularia zizaniicola	**CBS 133593**	-	**KM484947**



Note ML bootstrap supports (≥60 %) and Bayesian posterior probabilities (≥0.9PP) support are given above or below the branches respectively. The tree is rooted to *Gaeumannomyces radicicola* and *G. tritici* (*Magnaporthaceae*). Type strains of genera are in black-boldface. The scale bar represents the expected number of nucleotide substitutions per site.

Figure 10.2 Maximum likelihood tree revealed by RAxML from an analysis of combined LSU and ITS partial sequence data of the genera of family *Pyriculariaceae*, showing the phylogenetic position of the genus *Neocordana*

The combined LSU and ITS gene dataset comprised 37 taxa from selected genera of family *Pyriculariaceae* and the matrix had 387 distinct alignment patterns, with 16.02% of undetermined characters or gaps. Estimated base frequencies were as follows; A = 0.250125, C = 0.256305, G = 0.288899, T = 0.204671; substitution rates AC = 2.522715, AG = 1.852404, AT = 2.850883, CG = 1.187014, CT = 6.056856, GT = 1.000000; proportion of invariable sites I = 0.552858; gamma distribution shape parameter α = 0.495129. The best scoring RAxML has a final ML optimization likelihood value of -6274.840484. Type species of each genera are in black bold fronts. Type species of each genera are in black bold fronts in Table 10.7.

A total of 35 in group taxa corresponding to 9 monophyletic clades (ML = 100 %, PP = 1.00), within the *Pyriculariaceae* is presented herein (Figure 10.2). Nine genera previously recognized, namely *Bambusicularia* (clade F), *Barretomyces* (clade I, ML = 91% / PP = 0.99), *Macgarvieomyces* (clade E, ML = 91% / PP = 1.00), *Neocordana* (clade H, ML = 100% / PP = 1.00), *Neopyricularia* (clade D), *Proxipyricularia* (clade C), *Pseudopyricularia* (clade G, ML= 100%, PP = 1.00), *Pyricularia* (clade A) and *Xenopyricularia* (clade B, ML = 100% / PP =1.00) are given here. The genus *Neocordana* constitutes a well-supported monophyletic clade (Clade H), sister to *B. calatheae* (clade I). We have not seen any significant separation of the *Neocordana* taxa with in the clade.

10.5 Biology and the Pathogenicity of the Genus *Neocordana*

Neocordana pathogens only target the leaves of the hosts. No published records regarding the disease's occurrence in other plant parts such as fruits roots or stem are known. Cross infectivity and alteration of hosts are still not recorded. The leaf spots on *Musa* sp. are very common in the field and result a significant loss (Jones, 1999). It was observed that the penetration and the invasion of the *Neocordana* pathogens are very common during humid environmental conditions (Jones, 1999). The severity of the damage depends on the age, nutritional deficiency or the occurrence of previous wounds in the plant. Environmental conditions that the plant is being exposed also significantly affect the severity of the damage.

Neocordana leaf spots on *Musa* sp. have distinct concentric ring patterns at the gray centers of the necrotic areas. The necrotic lesions are pale brown, large and having an oval to fusiform shape. Around the brown necrotic area, a bright yellow chlorotic lesion is present and it separates the diseased area of the leaf from the healthy area (Jones, 1999). The lesions also can be observed in the places where other pathogens had previously invaded. The penetration of the *Neocordana* pathogens occur at leaf margins and the nutrient deficiencies triggers the invasion (Cooke et al., 2009; Jones, 1999). The disease symptoms in *Canna* caused by *N. versicolor* are also somewhat similar to above. Eye shaped lesions can be seen in the leaf. They are widely distributed on the surface and finally results the complete necrosis of the leaf (Soares et al., 2005).

Violent conidial discharge of *N. musae* under decreasing vapor pressure at Jamaican plantations of *Musa* sp. was recorded by Meredith (1962a). In an infected leaf when the relative humidity is lower than 95%, conidial formation was not occurred. During dry climatic conditions, conidia formation was only recorded at night. During rain when the leaf surface got wet, the dispersal of conidia was accelerated. Meredith (1962a) has concluded that the rain, humidity and irrigation can increase the conidial concentration on the leaf. Meredith (1962b) discussed that the discharge of conidia is independent from light. As a result of drying, water evaporates from conidia and the conidiophores. A negative pressure was developed soon after the water evaporation. Finally, the walls are drawn inward and a tension builds up. As a result of releasing the tension, conidia shoot away from the conidiophores. The gaseous phase of the terminal cell might provide the energy for the discharge of conidia (Meredith, 1962b).

Allen and Dettmann (1990) observed the production of conidia and the appressoria formation of *N. johnstonii in vitro* and was considered as a pathogen causing leaf spots. As recorded in this study *Neocordana* leaf spots were severe in cold locations. Sporulation was rapid at moist weather on the abaxial surface of the leaf. Compared to dead leaves, high sporulation was recorded on living leaves. In young leaf spots the sporulation was highly recorded. The spores had a short lifespan on dry leaf surfaces. Production of conidia has recorded when the leaf spots are subjected to moisture. The sporulation continues at a constant rate at least for five

days. The optimum temperature for spore production was 21 °C – 22 °C. The lowest temperature requirement for the production of spores was 10 °C on wet leaves. Rate of conidia production was recorded as 0.04 conidia mm^{-2} of lesion h^{-1} on dead leaves. Appressoria was formed under 22 °C – 25 °C on detached leaves. In addition, the production of spores had a low optimum temperature with respect to *Mycosphaerella musae* and *M. musicola* (Allen & Dettmann, 1990).

10.6 Disease Formation of *N. musae*

Disease formation has been widely studied only on *N. musae*. Pathogen can penetrate on living and dead cells of the host. Penetration of the pathogen depends on the health of the tissue hence *N. musae* was recorded as a weak pathogen. The penetration is wound induced. Invasion usually occurs at leaf margins and the places where the leaf lamina got tear off. Effect of senescence, nutritional deficiencies, adverse environmental conditions, wounds and the lesions cause by other pathogens can enhance the invasion of *N. musae* (Jhonns, 1999)

Conidia of *N. musae* can be germinated on a moisture film on the leaf surface. Within 8 hours after the deposition, appressoria formation starts. The appressoria next give rise to the infection peg. Infection peg penetrates the epidermal cell. After that, one or few fungal cells are formed and fill the epidermal cell. The infection peg starts to swell next. Finally, the epidermal cells face necrotic cell death and results pale brown lesions (Jhonns, 1999).

Another study (Jhonns, 1999) has concluded that *N. johnstonii* was more adapted to cooler environments than *N. musae*. Leaf spots of *N. johnstonii* also found to be smaller, more regular in outline and more tapered than *N. musae*. The leaf spots of *N. musae* were recorded as large, elliptical and oval with respect to *N. johnstonii* (Jhonns, 1999).

Fungicides used for Sigatoka leaf disease and black streak disease in *Musa* sp. can be used to control *Neocordana* leaf spots (Jhons, 1999). Addition of oil with the systemic fungicides use in controlling Sigatoka leaf disease in *Musa* sp. can enhance the severity of *Neocordana* spots and no specific controlling method was indicated in

this study (Ploetz et al., 2003). Biological control was applied on *N. musae* using *Jatropa* plant extracts to reduce leaf spot diseases in *Musa* sp. (Torre et al., 2008). Extracts of several parts of *Jatropa* plant such as seeds, young fruits, roots and leaves are very effective to control *N. musae*. Alvindia (2012) observed the impact of *in vitro* application of several bio control agents on the mycelium growth of *N. musae*. Selected extracts of plant oils, inorganic salts, *Trichoderma harzianum, Bacillus amyloliquefaciens*, and Serenade ASO (*B. subtilis* 1.34% EC) totally controlled the mycelium development of *N. musae* in 10 weeks (Alvindia, 2012). In addition to that, Piper betel oil (60%), Potassium bicarbonate (28%), Garlic oil and Capsicum oil (20%) could limit the mycelium growth by different percentages. Jalander and Gachande (2013) studied the *in vitro* efficacy of two fungicides named Captasul (capton-50) and Ridomil gold on mycelium growth of *N. musae*. Different concentrations (50ppm, 100ppm, 150ppm, 200 ppm, 250 ppm, and 300 ppm) were used against the pathogen and Captasul (300ppm) was reported as highly toxic and very effective to control *N. musae*. Recently Samuelian (2016) investigated antagonistic activities of *T. harzianum* against growth of *N. musae* as an integrated disease management approach. *T. harzianum* was identified and confirmed by DNA sequence data. At present, almost all the biological control methods are applied on *N. musae*, but similar studies are needed to be performed on other *Neocordana* pathogens.

10.7 Isolation, Culturing, Identification and Biological Characteristics

Limited amount of studies was conducted on isolation, culturing and biological characters of the genus and only restricted to *N. musae*. In Gakwad et al. (2017) the fungus was isolated from the diseased leaves of *Musa* sp. and grown in different media. The culture morphology and colony diameter were observed with respect to the media that have been used in this study. Potato Dextrose Agar media (PDA), Malt Extract Agar media (MEA), Czapeks dox agar media, Asthana & Hawkars agar, Richard agar, Kings agar and host leaf extract agar media were used. Among all tested mycelia growth was not observed in Asthana & Hawkars agar media

and Richard agar media. On other media the colony is gray to white in colour. Distinct concentric to circular rings at periphery were observed in PDA and King's agar media. A compact growth was observed in Czapeks dox agar and Kings Agar media. When the organism has grown on MEA and Czapek's dox agar media, a sparse growth was seen. Sporulation was observed at MEA media from the periphery of the concentric rings. Highest radial growth was recorded on PDA and MEA while the lowest was observed at Czapeks dox agar media. Pure cultures were taken from the single spore isolation. Molecular data were not used to confirm the organism. Pathogenicity test was not conducted during the study. For the other *Neocordana* members, detailed studies of the cultures were not conducted yet. Colony characteristics were recorded in Crous et al. (2016, 2017) and Hernandez-Restrepo et al. (2015).

Pathogenic nature of *N. musae* was also studied at Yunnan (Fan et al., 2012). Morphological observations of the pathogen conducted on leaf spots and optimum favorable temperature for the pathogenic growth was recorded as 28 °C and the pH was recorded as 7. Whole light treatment was identified as a good source for mycelium growth while the mycelium grows better in sucrose and carbon rich environments. Yeast extract was figured out as better sources for nitrogen in the media. Pathogen showed a profuse growth on PDA and PSA media and optimum temperature was recorded as 25 °C for the sporulation on above media. The lethal temperature for the mycelium of *N. musae* was recorded as 70 °C and the time of exposure was 30 minutes (Fan et al., 2012).

10.8 Endophytic Nature of *Neocordana* Members and Association with *Mycosphaerella* sp.

Neocordana musae was recorded as an endophyte in Thailand (Photitia et al., 2001). In-depth study regarding the endophyte was again conducted by Photita et al. (2004). Pathogenic nature (leaf spots formation) of the endophyte was checked on detached *Musa* leaves. The isolates that used were unable to cause the disease on leaves. Photita et al. (2004) concluded that *N. musae* is latent in the host tissue for

long time before causing the disease. There are no published records on the endophytic nature of other *Neocordana* members.

Neocordana musae was recorded around the lesions as a result of *M. musicola*, *M. fijiensis* and another *Mycosphaerella* sp. which is responsible for Septoria leaf spot disease (Jhonns, 1999). Another study was conducted in northern Thailand by Kaewjan (2012) on *Mycosphaerella* species and fungi associated with diseases of *Musa* sp. which recovered *N. musae* as an endophyte. The authors clearly state that *N. musae* can be a weak pathogen which causes diseases at stressed conditions. The pathogen can stay latent during long period of time inside the host. Tsigbey (1996) reported that black sigatoka symptoms were associated with lot of conidia and conidiophores of *N. musae* but unable to collect the spores of *M. fijiensis*. Tsigbey (1996) also observed *N. musae* at the centers and margins of necrotic leaf tissues and stated that future studies are warranted on the pathogenic roles of *N. musae* and its link to severity of black sigatoka disease on *Musa* sp.

10.9 Antagonistic Activity of *N. musae*

Antagonistic activity of *N. musae* was investigated *in vitro* on the growth of *Colletotrichum musae* (Nuangmek et al., 2008). *Neocordana musae* was recorded as an endophyte from a wild variety of *Musa* sp. which significantly reduces the radial growth of mycelium of *C. musae*. In addition, this inhibition occurred due to the competitive nature and faster growth of *N. musae*. As a result, the growth of the mycelium of *C. musae* is also inhibited. Production of secondary metabolites by *N. musae* and a related antagonistic activity was not recorded in this study.

10.10 Possible Future Studies

Limited number of studies have been conducted on *Neocordana* when compared to other plant pathogenic genera such as, *Colletotrichum*, *Fusarium* and *Mycosphaerella* which cause diseases in *Musa* sp. Detailed studies were not conducted and few studies could be included in this paper. Host and pathogenic

interactions, natural disease resistance mechanisms such as induced systemic resistance (ISR), Systemic Acquired Resistance (SAR) and the associated chemical and physiological changes in host plants, can be studied for the genus. Postharvest physiology of infected commodities by *Neocordana* pathogens can be investigated. The infection process was studied in the past but no recent report found on this aspect. As *Musa* sp. is one of the major fruit crops, it will be useful to investigate more on its pathogenesis, disease cycle and the epidemiology. It is necessary to come up with more biological control strategies such as integrated pest management approaches in future to cut down *Neocordana* leaf spots.

There are only six species discovered at present but very likely that this genus harbors many more species. We have observed the establishment of new species based on minute morphological differences which are not conclusive to differentiate species. According to Jeewon and Hyde (2016) phenotypic variations such as the size or shape of conidia must be considered with caution as they can be varying with several environmental factors. Therefore, more molecular studies are warranted for a better understanding of species relationships and reveal the potential of species complexes in future. There are possibilities for investigations on the potential of whether *Neocordana* endophytes can switch to pathogenic and saprobic life styles. We suggest to undertake proteomic studies to characterize proteins associated with pathogenicity and disease formation that will be useful in future for better taxonomic resolutions and disease control.

CHAPTER 11

TAXONOMIC AND PHYLOGENETIC ASSESSMENT OF SELECTED FUNGAL PATHOGENS ASSOCIATED WITH BANANA FRUITS IN THE LOCAL MARKETS OF NORTHERN THAILAND

11.1 Introduction

Bananas (*Musa* spp.) are highly traded worldwide due to their abundance of essential nutrients, such as antioxidants, fiber, vitamins, and minerals. These nutritional properties offer numerous health benefits to consumers (Kumar et al., 2012). However, bananas are susceptible to various diseases both before and after harvest, primarily caused by fungi (Anthony et al., 2004; Jones, 2019; Maswada, 2017; Raut & Ranade, 2004; Supriya et al., 2009; Xie et al., 2022). The post-harvest deterioration of bananas significantly reduces the shelf-life, market quality, and local preference, leading to substantial financial losses in the commercial banana industry (Amin & Hossain, 2012; Mohapatra et al., 2010).

More than 20 distinct fungal infections have been identified in both pre-harvest banana bunches and throughout the post-harvest handling chain (Alvindia et al., 2002; Jones, 2019). Anthracnose is a significant and destructive disease that has been reported in post-harvest bananas during transportation, storage, and marketing (Simmonds, 1941). The symptoms are characterized by black sunken lesions with orange to salmon pink spore masses, or acervuli, on the fruit (Simmonds, 1941; Zakaria et al., 2021). In addition, the pathogen invasion occurs at the pre-harvest stage and remains dormant until ripening (Muirhead & Deverall, 1981; Simmonds, 1941; Swinburne & Brown, 1983). The effective penetration of the fungus into the fruit's

epidermis is hindered by the accumulation of phytoalexins until the fruit ripens (Brown & Swinburne, 1981).

Several species of *Colletotrichum* (*Glomerellaceae*, *Glomerellales*, *Sordariomycetes*) (Wijayawardene et al., 2022), mostly *C. musae*, have been identified as the causative agents of the disease (Simmonds, 1941; Zakaria et al., 2021; Zhimo et al., 2017). In addition, *C. chrysophilum* (Mexico; Fuentes-Aragón et al., 2021), *C. gloeosporioides* (Ecuador, Malaysia, Pakistan, Alam et al., 2021; Intan-Sakinah et al., 2013; Riera et al., 2019), *C. karstii*, *C. paxtonii* (China; Huang et al., 2021), *C. scovillei* (China; Zhou et al., 2017), *C. siamense* (Turkey; Uysal & Kurt, 2020), *C. theobromicola* and *C. tropicale* (Brazil; Vieira et al., 2017) were also reported as anthracnose pathogens in banana fruits. Among them, the pathogenicity of *C. theobromicola* and *C. tropicale* is yet to be confirmed (Vieira et al., 2017).

Fruit speckles on bananas are also known as *Deightoniella* spots, pin-spotting, salt and pepper spots, and swamp spots (Jones, 2019). This disease was found on all cultivars of bananas, with Lady-finger being notably more susceptible than others (Jones, 2019). The symptoms appear on the fruit skin at the pre-harvest stage as superficial, reddish to black minute spots, often with water-soaked margins (Almenares & Pérez-Vicente, 2019; Jones, 2019; Pasberge-Gauhl, 2002; Vawdrey, 2008). Several pathogens can cause fruit speckles, and the etiology of the disease has become complex (Jones, 2019; Pasberg-Gauhl, 2000; Vawdrey & Campagnolo, 2000). However, Meredith (1961) first described the symptoms caused by *Corynespora torulosa* (*Corynesporascaceae*, *Pleosporales*, *Dothideomycetes*) (Wijayawardene et al., 2022) in Jamaica. The pathogen was also subsequently reported in Australia (Vawdrey, 2008) and Cuba (Almenares & Pérez-Vicente, 2019). Some of the speckle symptoms on banana fruits were different from those caused by *C. torulosa* which onsets broader lesions (Pasberg-Gauhl, 2000; Vawdrey & Campagnolo, 2000). Therefore, the identification of the true causative agents of banana fruit speckles becomes challenging, necessitating further investigations (Jones, 2019; Pasberg-Gauhl, 2000; Vawdrey & Campagnolo, 2000).

Thailand is the second-largest banana exporter in the ASEAN region (Suvittawa, 2014; Termpitipong, 2021), hosting approximately 50 varieties (Anupunt, 2002). Bananas are a significant part of local Thai cuisine and play a vital role as raw

materials for various economic products (Bansiddhi, 2003). Three clones, namely Kluai Hom Thon (*Musa acuminata*; AAA genomic group; Gros Michel), Kluai Khai (*M. acuminata*; AA genomic group; Sucrier), and Kluai Namwa (*M. acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak), are commercially grown in northern Thailand for their high yield and adaptability (Anupunt, 2002; Bansiddhi, 2003). Many studies have investigated fungal pathogens in Hom Thon bananas (Gros Michel) due to their high availability in commercial markets. However, there is a lack of research on post-harvest fungal diseases in Namwa and Khai bananas in Thailand. This study aims to fill a research gap by investigating the fungal pathogens associated with anthracnose and speckles in Namwa and Khai fruits in the northern region.

Bananas were collected from local markets in Chiang Mai, Chiang Rai, and Nan provinces in northern Thailand from 2018 to 2022. A total of 56 fungal isolates were obtained during the study. The latter were categorized into three primary groups based on cultural characteristics and microscopic morphology. From these, nine were selected for DNA extraction based on the severity of the initial symptoms where the cultures were isolated. Phylogenetic relationships were established for the pathogens and morphological illustrations and descriptions were provided. This is the first report of *Corynespora torulosa* causing fruit speckles on Namwa bananas in Thailand. We identified *Colletotrichum siamense* from the post-harvest anthracnose lesions on Khai bananas with confirmed pathogenicity tests for the first time in Thailand. Additionally, *C. musae* was also recognized as causing anthracnose on Namwa fruits in northern Thailand.

11.2 Materials and Methods

11.2.1 Sample Collection and Isolation of Fungi

Two banana clones, viz., Kluai Khai (*Musa acuminata*; AA genomic group; Sucrier clone) and Kluai Namwa (*M. acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak clone), were selected for the study. Post-harvest banana bunches (peel colour: natural green to yellow with brown spots; 13 to 16 weeks old after the formation of the inflorescence) were randomly sampled. The collection sites were the

local markets in Chiang Mai, Chiang Rai, and Nan provinces in northern Thailand. During 2018–2022, two main seasons in the region were selected for the study: the dry season (November–May) and the rainy season (June–October). Clones were chosen based on their availability, public preference, and continuous year-round fruit supply to local markets.

Besides research significance, clone selection also incorporated input from cultivators and sellers, along with reliable information on fruit physiology and age.

Based on the Von Loesecke ripening scale (Companhia de Entrepostos e Armazéns Gerais de São Paulo, 2006), the ripening stages of bananas were divided into seven categories: Stage 1 = entirely green peel; Stage 2 = green peel with traces of yellow; Stage 3 = more green than yellow peel; Stage 4 = more yellow than green peel; Stage 5 = yellow peel with traces of green; Stage 6 = entirely yellow peel; Stage 7 = yellow peel with brown spots. Additionally, the maturity of the banana specimens was documented in collaboration with both the commercial seller and the cultivator. The days were counted in weeks since the formation of the banana inflorescence.

Anthracnose symptoms were characterized by black, sunken lesions on the fruit, often with spore masses or acervuli on the necrotic surface (Abayasekara et al., 2013). Twenty banana bunches showing the latter symptoms (10 from each clone) were collected. The specimens were next classified into three main categories based on the severity of disease symptoms, as followed by Table 11.1. Subsequently, ten bunches of Namwa bananas showing speckles (superficial, minute black to brown spots with water-soaked margins; Vawdrey, 2008) were collected.

The categorization and symptom assessment of the diseased fruits were conducted according to Table 11.2. All the specimens were taken in sealed polythene bags to the laboratory. Next the disease symptoms were recorded and photographed. The symptomatic fruits were separated from the bunches where necessary.

The cumulative details of the post-harvest physiology of the specimens, collection sites, climatic conditions, and symptom evaluation are attached in the supplementary material section (Appendix B).

Table 11.1 Characterization of anthracnose symptoms of collected samples based on disease severity (Disease severity index)

Group number	Peel color	Severity of the Disease	Symptoms
Category 1	Yellow peel with brown spots	Mild	Brown to black spots, rounded, irregular or diamond shape, no sporulation
Category 2	Yellow peel with brown spots	Moderate	Orange to salmon pink spore masses on the black sunken lesions, unaffected pulp
Category 3	Yellow peel with brown spots	Severe	Black sunken lesions, conidial droplets fusing with adjacent diseased areas, yellow fruit peel, multiple infections on the peel, and fruit pulp affected

Table 11.2 Characterization of speckle symptoms of collected samples based on disease severity (Disease severity index)

Group number	Peel colour	Severity of the disease	Symptoms
Category 5	Entirely green to entirely yellow	Mild	Minute reddish-brown spots, surrounded by a water-soaked margin, dispersed and covered 2% of the fruit
Category 6	Entirely green to entirely yellow	Moderate	Spots were distinct, black and cover 15% of the fruit, sometimes with water-soaked margins
Category 7	Entirely green to entirely yellow	Severe	Spots were distinct as tiny necrotic patches, that covered 50% of the fruit

Fungi were isolated from a total of 98 selected infected lesions (58 anthracnose symptoms and 40 speckles) in different banana specimens (Appendix B). Tissue segments were separated from the advancing edges of anthracnose lesions (5 × 5 mm ^{2}) and speckles (2 × 2 mm ^{2}) on banana skins using a sterilized blade. Infected pieces were surface sterilized using 70% ethanol and 1% sodium hypochlorite (NaClO) for one to three minutes, followed by rinsing twice in sterile distilled water (Senanayake et al., 2020). The additional chemicals were removed by drying them on sterile filter paper. Tissue segments (four per plate) were transferred onto PDA plates boosted with 50 $\mu g/mL^{-1}$ tetracycline to inhibit bacterial growth under aseptic conditions and incubated at 25 °C for seven days.

A total of 183 isolates were obtained from the initial plates. Among these, 56 isolates were selected, transferred to new PDA plates, and then incubated for 10–14 days at 25 °C under light conditions. Pure cultures were grouped into three categories (CGA = *Colletotrichum* group A, CGB = *Colletotrichum* group B, and CORGC = *Corynespora* group C) (Appendix B). This was based on colony characters and microscopic features (i.e., the morphology of conidia and conidiophores). Subsequent identification revealed that CGA is *Colletotrichum musae*, CGB is *C. siamense*, and CORGC is *Corynespora torulosa*. Morphological identification (Appendix B) followed comparisons with reference specimens: *C. musae* (epitype = CBS 116870; Su et al., 2011), *C. siamense* (holotype = MFLU 090230; Prihastuti et al., 2009), and *C. torulosa* (epitype = CBS H-21456; Crous et al., 2013).

The colony characteristics were examined after 21 days. To prepare herbarium specimens, cultures were grown in water agar with 1.5% glycerol and kept for sporulation under light conditions. The plates were placed on the aluminium tray with silica gel and kept in a desiccator. Dried cultures were stored in wax paper bags with silica gel and deposited in the Fungarium of Mae Fah Luang University (Herb. MFLU), Chiang Rai, Thailand. For further study, living cultures were submitted to the Culture Collection Unit of Mae Fah Luang University (MFLUCC).

11.2.2 DNA Extraction, PCR Amplification and Sequencing

Out of the initial 56 isolates, nine fungal cultures were chosen, with three coming from each group (CGA, CGB, and CORGC) to extract DNA. These selections represented mild (1/5), moderate (2/6), and severe (3/7) disease categories (Figure 11.1). The isolates that were selected to generate molecular data are bolded in Appendix B. Mycelium scrapings from fourteen-day-old cultures were crushed using metal beads with TissueLyser LT (QIAGEN Sample and Assay Technologies; Miami, Florida, United States). The DNA extraction was performed using the column-based PureDireX Genomic DNA Isolation Kit (Blood/Cultured Cell/Fungus; New Taipei City, Taiwan) following the manufacturer's guidelines.

DNA sequence data were generated for eight gene regions: Internal transcribed spacer (ITS), partial 28S large ribosomal subunit (LSU), actin (*act*), beta-tubulin 2 (*tub2*), chitin synthase (*chs-1*), glyceraldehyde-3-Phosphate dehydrogenase

(*gapdh*), the second largest subunit of the DNA-directed RNA polymerase II (*rpb*2), translation elongation factor 1-alpha gene (*tef1-α*). The sequencing methodology followed Jayawardena et al., (2021) for *Colletotrichum* and Voglmayr and Jaklitsch, (2017) for *Corynespora*.

Specific primers were used to amplify the gene regions, including ITS5/ITS4 (White et al., 1990), LR0R/LR5 (Vilgalys & Hester, 1990), ACT512F/ACT783R (Carbone & Kohn, 1999), Bt2a/Bt2b (Glass & Donaldson, 1995), CHS-79F/CHS345R (Carbone & Kohn, 1999) and GDF1/GDR1 (Templeton et al., 1992). Polymerase chain reaction (PCR) was conducted following the protocol of Samarakoon et al., (2021), with a total of 40 cycles. The annealing temperatures for the different gene regions ranged from 53 °C (ITS and LSU), 54 °C (*act*), 56 °C (*chs-1*) and 58.5 °C (*gapdh* and *tub2*) with a 1-minute annealing time. The amplified PCR fragments were sent to SolGent Co., Ltd. South Korea, for sequencing. The sequence data have been generated and deposited in GenBank for further analysis and reference.

11.2.3 Pathogenicity Tests

Three isolates (MFLUCC 23-0032, MFLUCC 23-0033, and MFLUCC 23-0027) were used for pathogenicity tests. A banana grower and a sanitized cultivation from the Rattana dormitory area (Nang Lae village, Chiang Rai) were selected for the fruit supply. The age of the banana inflorescences was monitored. Uniformly sized banana hands, specifically 12–13 weeks old (ripening stage 1 = entirely green peel; based on the Von Loesecke ripening scale), were selected for artificial inoculation. These banana hands were chosen from both Namwa and Khai clones. Fruits with blemishes and disease symptoms were excluded. The banana hands were washed with running water and surface-sterilised with 70% ethanol. Next, the fruits were rinsed with sterilized distilled water and air-dried for 3–6 hours. Fingers were not separated from the hands, and the crown area was sealed with parafilm to reduce water loss and secondary pathogen invasion.

In the preparation of the conidial suspension, the mycelia were scraped, mixed with distilled water, and filtered through sterilized glass wool. The final concentration of conidia was set to 1×10^6 mL^{-1} using a haemocytometer (Neubauer Counting

Chamber, Kyrios-Soter Scientific; made in Germany). Twenty microliters of the conidial suspension from each fungal isolate were applied to three evenly spaced sites along the sterilized, none-wounded (data has shown) and wounded fruit skin. The suspension was applied from the stem end to the blossom end of the fruits (Figure 11.8). Nine replicates of fruits were used for each fungal isolate from the respective cultivar. Twenty microliters of sterilized distilled water were inoculated on fruits as a control treatment. Artificially inoculated fruits were incubated in separate moisture chambers at 28–30 °C. The treatments were examined daily, and the onset of disease symptoms was recorded and compared with those of the original diseased fruits. Fungal pathogens were re-isolated from the diseased symptoms of the fruit skins on PDA. Cultural characteristics and conidial morphology were compared with those of the original isolates used during the challenged inoculation. The originality has been further confirmed with molecular data. Two parallel sets of experiments were conducted. The results of the experiment are attached herein as Figure 11.8.

11.2.4 Sequence Alignment and Phylogenetic Analyses

The DNA sequences generated in the study were checked with a BLAST search in GenBank (httpps://blast.ncbi.nlm.nih.gov/Blast.cgi). This revealed that our isolates belong to the *Colletotrichum gloeosporioides* species complex (Jayawardena et al., 2021; Weir et al., 2012) and *Corynesporascaceae* (Voglmayr & Jaklitsch, 2017). Additional sequences used in the analyses were obtained from GenBank based on recent publications (Talhinhas & Baroncelli, 2021; Voglmayr & Jaklitsch, 2017) (Tables 11.1 and 11.2). The single- and multi-gene alignments were generated, and phylogenetic analysis (Maximum likelihood trees and Bayesian analysis) was conducted following the parameters outlined by Samarakoon et al., (2021). Branches with Bayesian posterior probabilities (PP) equal to or greater than 0.95 are indicated above each node of the phylogenetic trees (Figure 5 and 7).

11.3 Results

11.3.1 Isolation Summary

Fungi were isolated from a total of 98 selected infected lesions (58 anthracnose symptoms and 40 speckles) in different banana specimens (Appendix B). A total of 56 fungal isolates were selected for further investigation (Appendix B, Column 17). Among these, 24 cultures were obtained from the anthracnose symptoms of Namwa bananas.

Table 11.3 The taxa of the *Colletotrichum gloeosporioides* species complex that were used in the phylogenetic analyses, along with their names, culture collection numbers, and respective GenBank accession numbers

Species	**Strain**	**Gene bank accession numbers**				
		ITS	***gapdh***	***cmdA***	***act***	***chs-1***
Colletotrichum aenigma	ICMP 18608*	JX010244	JX010044	JX009683	JX009443	JX009774
C. aeschynomenes	ICMP 17673*	JX010176	JX009930	JX009721	JX009483	JX009799
C. alatae	CBS 304.67*	JX010190	JX009990	JX009738	JX009471	JX009837
C. alienum	IMI 313842	JX010217	JX010018	JX009664	JX009580	JX009754
C. aotearoa	ICMP 18532	JX010220	JX009906	JX009614	JX009544	JX009764
C. asianum	IMI 313839	JX010192	JX009915	JX009723	JX009576	JX009753
C. boninense	CBS 123755*	JX010292	JX009905	JQ005674	JX009583	JX009827
C. brasiliense	CBS 128501	JQ005235	JQ005322	JQ005756	JQ005583	JQ005409
C. clidemiae	ICMP 18658*	JX010265	JX009989	JX009645	JX009537	JX009877
C. cordylinicola	MFLUCC 090551*	JX010226	JX009975	HM470238	HM470235	JX009864
C. fructicola	CBS 125397*	JX010173	JX010032	JX009674	JX009581	JX009874
C. gloeosporioides	CBS 112999*	JX010152	JX010056	JX009731	JX009531	JX009818
C. horii	ICMP 12942	GQ329687	GQ329685	JX009603	JX009533	JX009748
C. kahawae	ICMP 18539*	JX010230	JX009966	JX009635	JX009523	JX009800
C. musae	ICMP 17817	JX010142	JX010015	JX009689	JX009432	JX009815
C. musae	ICMP 17817	JX010142	JX010015	JX009689	JX009432	JX009815
C. musae	ICMP 18600	JX010144	JX010038	JX009686	JX009556	JX009848
C. musae	ICMP 12930	JX010141	JX009986	JX009685	JX009566	JX009881
C. musae	CBS 116870*	JX010146	JX010050	JX009742	JX009433	JX009896
C. musae	**MFLUCC 23-0032**	**OR186193**	**OR192994**	**NA**	**OR209335**	**OR192988**
C. musae	**MFLUCC 23-0219**	**OR186194**	**OR192995**	**NA**	**OR209336**	**OR192989**
C. musae	**MFLUCC 23-0220**	**OR186195**	**OR192996**	**NA**	**OR209337**	**OR192990**
C. nupharicola	CBS 470.96*	JX010187	JX009972	JX009663	JX009437	JX009835
C. nupharicola	CBS 470.96*	JX010187	JX009972	JX009663	JX009437	JX009835
C. nupharicola	CBS 470.96*	JX010187	JX009972	JX009663	JX009437	JX009835
C. psidii	CBS 145.29*	JX010219	JX009967	JX009743	JX009515	JX009901

Table 11.3 (continued)

Species	Strain	Gene bank accession numbers				
		ITS	***gapdh***	***cmdA***	***act***	***chs-1***
C. queenslandicum	ICMP 1778*	JX010276	JX009934	JX009691	JX009447	JX009899
C. salsolae	ICMP 19051*	JX010242	JX009916	JX009696	JX009562	JX009863
C. siamense	ICMP 12567	JX010250	JX009940	JX009697	JX009541	JX009761
C. siamense	ICMP 18574	JX010270	JX010002	JX009707	JX009535	JX009798
C. siamense	ICMP 18121	JX010245	JX009942	JX009715	JX009460	JX009845
C. siamense	CBS 130417*	JX010171	JX009924	FJ917505	FJ907423	JX009865
C. siamense	ICMP 17795	JX010162	JX010051	JX009703	JX009506	JX009805
C. siamense	**MFLUCC 23-0033**	**OR186196**	**OR192997**	**NA**	**OR209338**	**OR192991**
C. siamense	**MFLUCC 23-0034**	**OR186197**	**OR192998**	**NA**	**OR209339**	**OR192992**
C. siamense	**MFLUCC 23-0222**	**OR186198**	**OR192999**	**NA**	**OR209340**	**OR192993**
C. siamense	CBS 125378*	JX010278	JX010019	JX009709	GQ856775	GQ856730
C. siamense	CBS 130420*	HM131511	HM131497	JX009713	HM131507	JX009895
C. theobromicola	CBS 124945*	JX010294	JX010006	JX009591	JX009444	JX009869
C. ti	ICMP 4832*	JX010269	JX009952	JX009649	JX009520	JX009898
C. tropicale	ICMP 18672	JX010275	JX010020	JX009722	JX009480	JX009826
C. xanthorrhoeae	CBS 127831*	JX010261	JX009927	JX009653	JX009478	JX009823

Note Abbreviations of culture collections **CBS**: CentraalbureauvoorSchimmelcultures, Utrecht, The Netherlands **ICMP**: The International Collection of Micro-organisms from Plants, Landcare Research, Manaaki Whenua **IMI:** CABI Genetic Resource Collection, United Kingdom **MFLUCC**: Culture Collection, Mae Fah Luang University Chiang Rai, Thailand, **MUCL**: Agriculture and Agri-Food Canada; Mycothèque de l'Université Catholique de Louvain, NA: Sequence data were unable to retrieve from GenBank. *=ex-types, ex-epitypes and reference strains, Bold = specimens of present study.

The latter were identified as *Colletotrichum musae* and categorized as group CGA (Appendix B). Out of these, 21 were identified based solely on their morphology, while three (MFLUCC 23-0032; MFLUCC 23-0219; MFLUCC 23-0220) were confirmed using both morphology and phylogeny (Figure 1, 3 and 5). Sixteen isolates were identified as *C. siamense*, with 13 confirmed only from morphology and three (MFLUCC 23-0033; MFLUCC 23-0034; MFLUCC 23-0222) identified using both morpho-molecular data (Figure 11.1, 11.4 and 11.5). These

isolates were obtained from the anthracnose symptoms of Khai Bananas and represented group CGB (Appendix B).

Table 11.4 The taxa of *Corynesporascaceae* and associated species used in the phylogenetic analyses

Species	Gene bank accession numbers		
	Strain	**LSU**	**ITS**
Corynespora cambrensis	IVF092001	NA	OM802325
C. cambrensis	IVF102517	NA	OM802326
C. cassiicola	CBS 100822	GU301808	NA
C. cassiicola	UM 591	NA	KU990882
C. cassiicola	CBS:161.60	MH869486	MH857942
C. cassiicola	CBS:127095	NA	MH864416
C. citricola	CABI 211585	NA	FJ852593
C. citricola	CBS 169.77	NA	FJ852594
C. encephalarti	CBS 145555*	NG_067878	NR_165556
C. lignicola	MFLUCC 16-1301*	NG_073787	MN860549
C. ligustri	SN40	NA	MH782602
C. ligustri	JYNZ	NA	MF428395
C. proliferata	CBS112393	NA	FJ852596
C. pseudocassiicola	CPC 31708*	NG_064538	MH327794
C. smithii	CABI 5649b	GU323201	FJ852597
C. smithii	L139	KY984300	KY984300
C. submersa	MFLUCC 16-1101*	MN860553	MN860548
C. thailandica	CBS:145089*	NG_066298	NR_161145
C. torulosa	CPC 15989	KF777207	KF777154
C. torulosa	CATAS-XJCT99	MZ734297	MZ736144
C. torulosa	CATAS-XJCT98	MZ734296	MZ736143
C. torulosa	CATAS-XJCT97	MZ734295	MZ736142
C. torulosa	CBS:136419	MH877634	MH866095
C. torulosa	**MFLUCC 23-0027**	**OR198899**	**OR198902**
C. torulosa	**MFLUCC 23-0028**	**OR198900**	**OR198903**
C. torulosa	**MFLUCC 23-0029**	**OR198901**	**OR198904**
Cyclothyriella rubronotata	CBS 141486*	KX650544	KX650544
C. rubronotata	CBS 121892	KX650541	KX650541
Helminthosporium juglandinum	CBS 136922*	KY984319	KY984319
H. massarinum	CBS 139690*	AB807524	AB809629

Table 11.4 (continued)

Species	Gene bank accession numbers		
	Strain	**LSU**	**ITS**
Massarina cisti	CBS 266.62*	AB807539	LC014568
Periconia pseudodigitata	HHUF 29370*	NG_059396	NR_153490
P. homothallica	HHUF 29105	NG_059397	NR_153446

Note Abbreviations of culture collections: **CABI:** CABI Genetic Resource Collection, United Kingdom **CBS**: Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, **CPC:** Culture collection, Pedro Crous, housed at the CBS, Utrecht, Netherlands **MFLUCC**: Culture Collection of Mae Fah Luang University, Chiang Rai, Thailand, **MUCL**: Agriculture and Agri-Food Canada; Mycothèque de l'Université Catholique de Louvain, NA: DNA sequences are not available.*=ex-types, ex-epitypes and reference strains, Bold = specimens of present study

A total of 14 *Corenespora torulosa* isolates were selected from speckles in the Namwa bananas. Among them, three (MFLUCC 23-0027; MFLUCC 23-0028; MFLUCC 23-0029) were identified based on morphology (Figure 11.1 and 11.6) coupled with molecular data (Figure 11.7). And the remaining 11 were identified solely through morphology. These isolates hosted the CORGC group in Appendix B.

11.3.2 Post-Harvest Anthracnose in Banana Fruits

Pathogenicity test

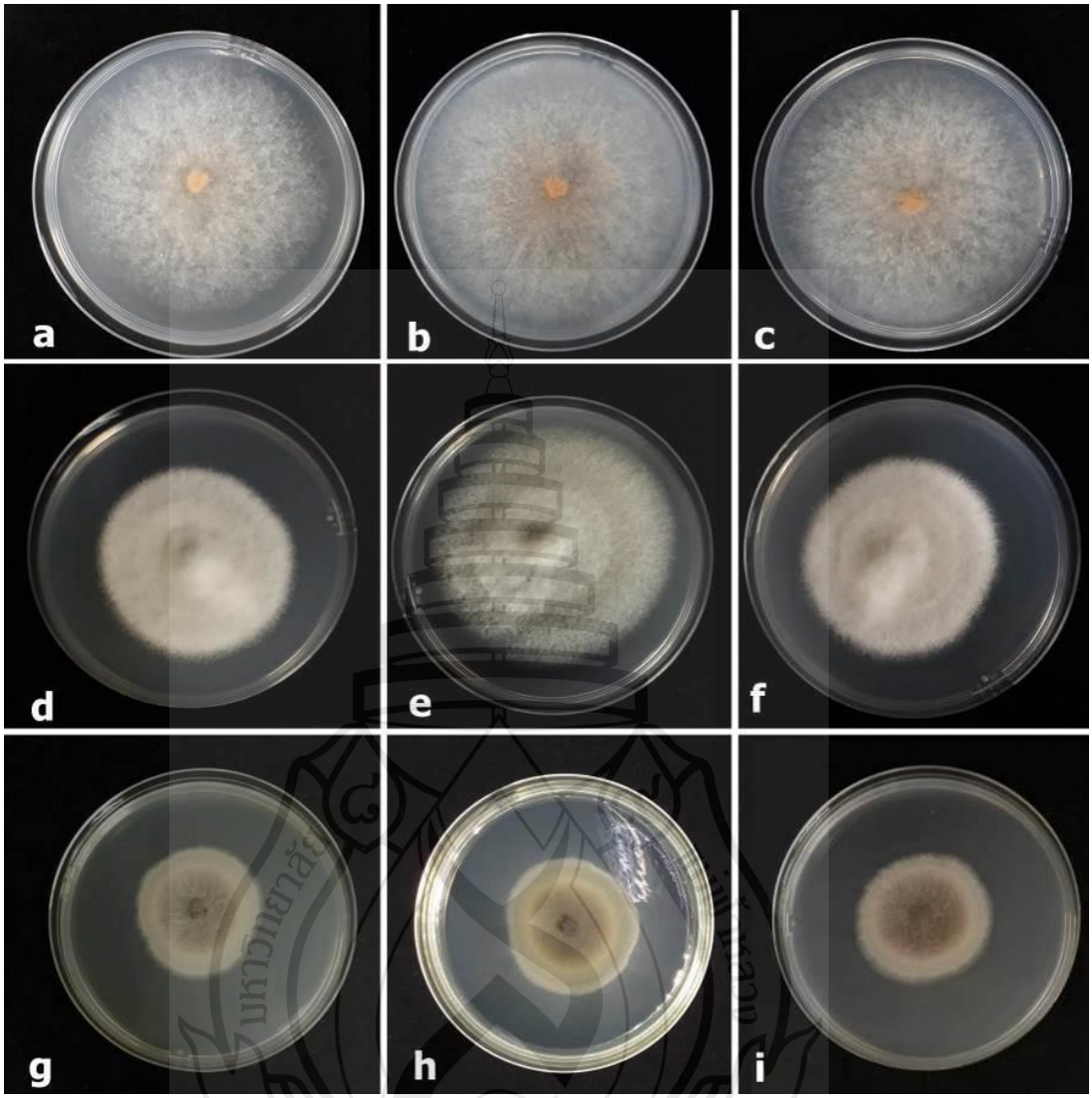
Two *Colletotrichum* species (*viz*., MFLUCC 23-0032 = *C. musae* and MFLUCC 23-0033 = *C. siamense*) were able to cause typical anthracnose lesions on the none-wounded fruit surface after 4–6 days of the artificial inoculation. At first, the symptoms appeared as minute reddish-brown pinholes and later turned into black sunken necrotic patches (Figure 11.8, h–r) on the fruits of ripening index 3 and 4. After 7 days of the inoculation, the anthracnose symptoms were notably identical to the original symptoms from which the latter *Colletotrichum* species were first isolated (Figure 11.2, a–f). The control fruits did not develop any disease symptoms. Fungi were re-isolated from the disease areas to establish Koch's postulates. The conidial

and colony morphologies of the re-isolated pathogens were similar to those of the initial isolates used for inoculation. On the wounded peel, symptoms appeared after 2–4 days of artificial inoculation, similar to those observed on the non-wounded method. *Colletotrichum musae* (MFLUCC 23-0032) provoked symptoms in ripening stages 1 and 2 (entirely green peel and green with traces of yellow peel) on the wounded fruit surface after 2 days. In addition, *C. siamense* (MFLUCC 23-0033) initiated symptoms on more yellow than green, wounded fruits (ripening stage 4) after 3 days.

Symptom development observed on the collected fruits during the study

The anthracnose infection caused by *Colletotrichum musae* initially appeared as brown to black spots of 0.5–0.8 cm in diameter on the skin (ripening stage 6 and 7) (Figure 11.2, a). The lesions were initially rounded or irregular in shape and sometimes took on a diamond shape (Figure 11.2, b) at the curved fruit shoulders. The size of the lesions has increased to 2–3 cm. The fruit tissue has sunken and appears black upon ripening. However, the pulp remained unaffected. Sporulation (Figure 11.2, b, c) and white mycelial exudates were detected after 2 to 4 days of the first symptom onset on the skin. The spores were orange to salmon pink and located as slimy, sticky droplets or masses on the mature necrotic tissue. When overripe (16 weeks old), the sunken lesions, together with conidial droplets, started fusing with the adjacent diseased areas (Figure 11.2, c). In addition, the infection was spreading through the peripheral tissues of the fruit pulp. Multiple infections were observed after ripening stage 7 (16 to 17 weeks old) from different angles of the fruit. The decay had started, and the skin tissues were completely deteriorated. The infection had invaded the entire fruit after 8–10 days of ripening stage 7. Further, the fruit was completely covered with conidial masses with a salmon-pink to orange appearance.

Colletotrichum siamense infection also causes black, sunken anthracnose lesions that are often rounded and merged with adjacent diseased tissues (Figure 11.2 d, e, f). The symptoms were recorded on the fruit skins of Khai bananas at the post-harvest stage. Invasion and symptom onset were comparatively slow with respect to *C. musae*. The appearance of the first symptom on the skin was noted after 7–8 days of complete ripening (stage 7) with a diameter of 0.3–0.4 cm.



Note **a-c** *Colletotrichum musae* (a = MFLUCC 23-0032; b = MFLUCC 23-0219; c = MFLUCC 23-0220); **d-f** *Colletotrichum siamense* (d = MFLUCC 23-0033; e = MFLUCC 23-0034; f = MFLUCC 23-0222); **g-i** *Corynespora torulosa* (g = MFLUCC 23-0027; h = MFLUCC 23-0028; i = MFLUCC 23-0029).

Figure 11.1 Fungal colonies grow on the PDA after 7 days'

The lesions expanded upon aging to 1–1.5 cm and coalesced later. Sporulation started on the lesion after 8–10 days of complete ripening. Slimy and sticky spore masses were visible in blackish-salmon pink and were sparse compared to the *C. musae* infection. When the fruit has overripened (15.5 to 16.5 weeks old), the sunken lesions on Khai banana fruit skins display a concentric ring pattern (Figure 11.2, f), dividing the necrotic area into 2–3 distinct zones. The invasion of *C. siamense* was comparatively slow when compared to *C. musae*. The decay of the fruits was notably slow and started after 9–11 days of ripening stage 7. When the necrotic regions began to merge at the final stage (16 to 17 weeks old), the fruit pulp had already been infected (Figure 11.2, f).

Taxonomy of *Colletotrichum*

Colletotrichum musae (Berk. & M.A. Curtis) Arx 1957

Index Fungorum: IF295348, Facesoffungi Number: FoF12141

Figure 11.3

Pathogenic on ripened fruits Namwa bananas. *Colonies* on PDA at 25 °C, light conditions, reach 5 cm diameter in 4 days, initially greyish white, irregular or entire or wavy margin. *Mycelium* initially flat and dense in the middle, sparse at periphery, when mature entire culture is sparse or abundant, fluffy, aerial *Fungal hyphae* 1.5–4.5 µm ($\overline{x}$ = 2.7 µm) in width, septate, smooth to rough, inflated, often hyaline at immaturity, branched, orange exudates present in mature mycelia. *Sporulation* occurs from the centre after 6 to 7 days and speeded to periphery under 25 °C, salmon pink or orange, slimy, sticky, well-developed conidial masses observed at the entire colony after 8 to 9 days, reverse pinkish orange, *Sclerotia* absent. *Setae* absent. *Conidiophores*, 10–30 µm long × 2–5 µm diam. ($\overline{x}$ = 20.5 × 3.8 µm, n = 30) micronematous, hyaline, cylindrical, tapered toward the apex, erect and straight, sometimes slightly flexuous, unbranched, aseptate, arising from the mycelium, base swollen and globose, irregularly shaped, apex pointed. *Conidiogenous cells* 2–4 × 1–3 µm ($\overline{x}$ = 3.7 × 1.8 µm, n = 20), hyaline, monoblastic, terminal, cylindrical, having rounded apices, no collarette. *Conidia* 10–15 × 7–4 µm ($\overline{x}$ = 13.4 × 5.33 µm, n = 40), abundant, hyaline, aseptate, guttulate, oval, elliptical or cylindrical, sometimes elongated and flexuous, often with acute base, rounded apex. Sexual morph: Not observed.

Materials examined: Thailand, Chiang Rai, Nang Lae, Fah Thai local market, associated with an anthracnose lesion of ripened fruit skin of Namwa bananas, 15 October 2021, Binu C. Samarakoon, SM30 (MFLU 23-0279), living culture MFLUCC 23-0032. Thailand, Chiang Rai, Ban Du municipality market, on anthracnose lesion of a fruit bunch of Namwa bananas, 23 November 2021, Binu C. Samarakoon, SM31 (MFLU 23-0280), living culture MFLUCC 23-0219. Thailand, Chiang Mai, Saraphi, associated with anthracnose lesions of Namwa bananas, 16 April 2022, Binu C. Samarakoon, SM33 (MFLU 23-0281), living culture MFLUCC 23-0220.

GenBank accession numbers**:** MFLUCC 23-0032: ITS = OR186193, *act* = OR209335, *chs*-1 = OR192988, *gapdh* = OR192994; MFLUCC 23-0219: ITS = OR186194, *act* = OR209336, *chs*-1 = OR192989, *gapdh* = OR192995; MFLUCC 23-0220*:* ITS = OR186195, *act* = OR209337, *chs*-1 = OR192990, *gapdh* = OR192996.

Notes**:** According to the BLASTn search results of ITS, *gapdh, act,* and *chs-1* sequences, MFLUCC 23-0032, MFLUCC 23-0219 and MFLUCC 23-0220 showed a 100% similarity to *Colletotrichum musae* (ICMP12930). In the multigene phylogeny, our strains were grouped with *C. musae* with strong statistical support (100% ML; 1.00 BYPP) (Figure 11.5). Based on morpho-molecular support, we report the occurrence of *Colletotrichum musae* on the anthracnose lesions of Namwa bananas in Thailand.

Colletotrichum siamense Prihastuti, L. Cai & K.D. Hyde

Index Fungorum number: IF515410, Facesoffungi Number: FoF 03599

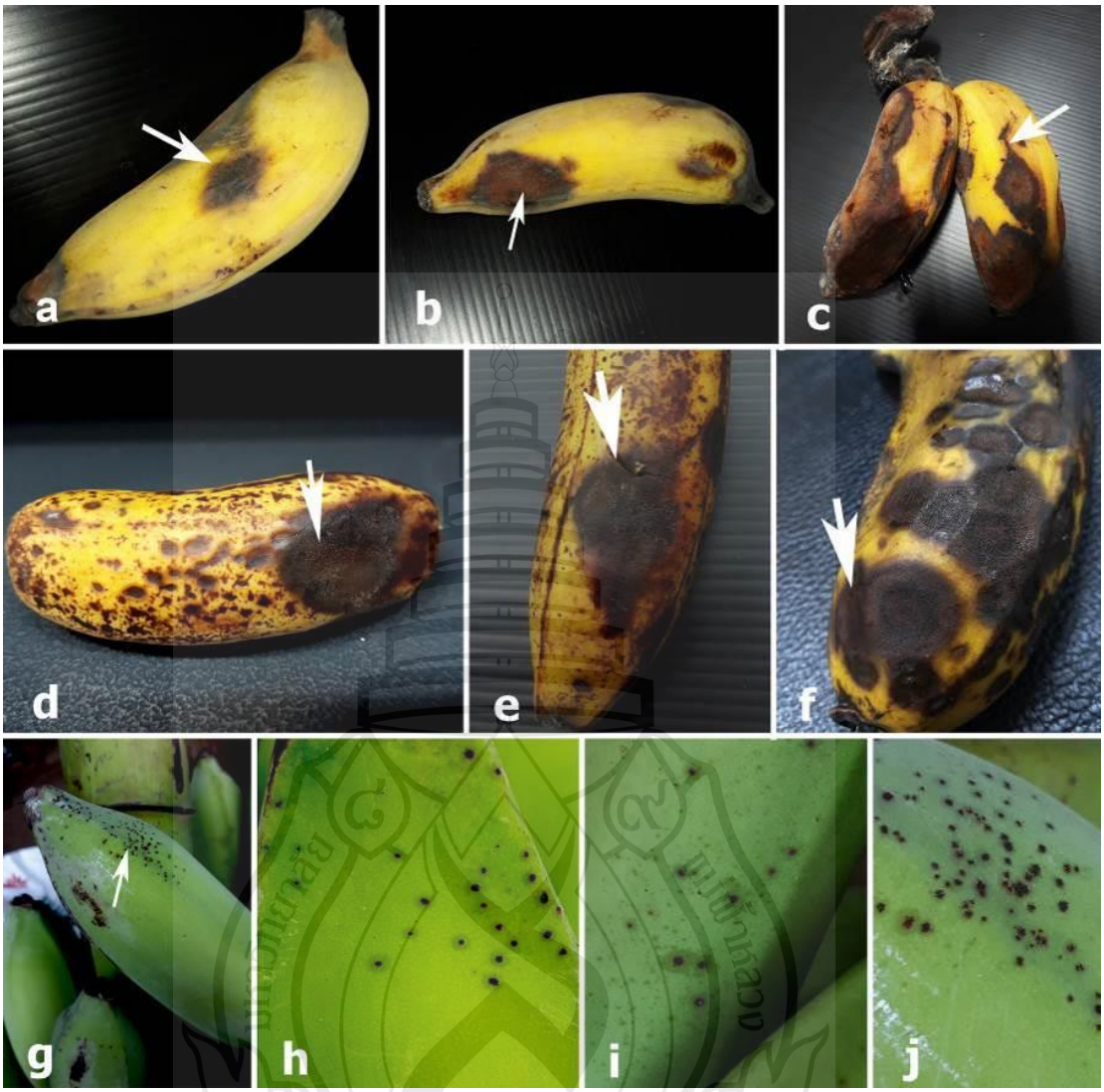
Figure 11.4

Pathogenic on ripened fruits of Khai banana. *Colonies* on PDA at 25 °C, light conditions, reach 5 cm diameter in 4 days, initially white, mouse grey or greyish white or pinkish-white or brownish, irregular or lobate margin. *Mycelium* initially cottony and flat, when mature sparse, aerial, 3–6 µm ($\bar{x}$ = 3.5 µm) wide, septate, branched, rough, inflated, often hyaline at immature stage, brown exudates present at maturity. *Sporulation* occurs from the inoculated point after 14 to 28 days, few conidial masses were visible 25 °C, salmon pink or orange, slimy, sticky, reverse mouse gray or greyish white, *Sclerotia* present in some isolates. *Setae* not observed. *Conidiophores* 10–25– (40)– (55) µm long × 2–7 µm diam. ($\bar{x}$ = 15.4 × 4.7 µm, n =

30) micronematous, hyaline, cylindrical, tapered toward the apex, erect and straight, sometimes slightly flexuous, unbranched, smooth, aseptate, arising from the mycelium, swollen at the base, pointed at apex. *Conidiogenous cells* 1.5–2 × 1–2 µm ($\overline{x}$ = 1.8 × 1.4 µm, n = 30), hyaline, monoblastic, terminal, cylindrical, having rounded apices, no collarette. *Conidia* 10–18 × 3–5 µm ($\overline{x}$ = 15.4 × 3.8 µm, n = 40), abundant, smooth, hyaline, aseptate, oval, elliptical or cylindrical, sometimes elongated and flexuous, varying in shape, often with a flat base, rounded apex. Sexual morph: Not observed.

Material examined: Thailand, Chiang Rai, Nang Lae, Fah Thai local market, associated with an anthracnose lesion of ripened fruit skin of Khai banana, 22 June 2021, Ruvishika S. Jayawardena, SM35 (MFLU 23-0282), living culture MFLUCC 23-0033. Thailand, Chiang Rai, Mae Chan municipality market, on anthracnose lesion of fruit bunch of Khai banana, 4 December 2021, Binu C. Samarakoon, SM42 (MFLU 23-0283), living culture MFLUCC 23-0034. Thailand, Chiang Rai, Ban Du municipality market, associated with anthracnose lesions of Khai banana fruit, 19 June 2022, Binu C. Samarakoon, SM36 (MFLU 23-0284), living culture MFLUCC 23-0222.

GenBank accession numbers: MFLUCC 23-0033: ITS = OR186196, *act* = OR209338, *chs*-1 = OR192991, *gapdh* = OR192997; MFLUCC 23-0034: ITS = OR186197, *act* = OR209339; *chs*-1 = OR192992; *gapdh* = OR192998; MFLUCC 23-0222: ITS = OR186198; *act* = OR209340; *chs*-1 = OR192993; *gapdh* = OR192999.



Note **a** Initiation of anthracnose symptoms caused by *Colletotrichum musae* (fruits of Namwa banana); **b, c** Diamond-shaped necrotic patches and severe symptoms with salmon orange spore masses (in the fruits of Namwa banana) caused by *C. musae*; **d, e, f** Necrotic lesions and the severe symptoms in the skin with round necrotic patches, concentric rings and salmon pink spore masses caused by *C. siamense* in Khai banana fruits; **g-j** Green Namwa banana fruits displaying speckle symptoms; **h, i** Necrotic spots surrounded by water-soaked margins. The notable symptoms are indicated by an arrow.

Figure 11.2 Anthracnose and speckle symptoms that have been reported in the study

Notes**:** The BLASTn search results of ITS, *gapdh*, *act*, and *chs-1* sequences suggest that our stains (MFLUCC 23-0033; MFLUCC 23-0034; MFLUCC 23-0222) have a high similarity (ITS = 99.62%, 99.62%, 99.81%; *gapdh* = 100%, 100%, 99.56%, *act* = 100%, 100%, 100%, and *chs-1* = 100%, 100%, 100%), excluding gaps to *C. siamense* (ICMP 12567, ICMP 18574, ICMP 18121) with query covers of 99% to 100%. In the multigene phylogeny, our strains (MFLUCC 23-0033; MFLUCC 23-0034; MFLUCC 23-0222) clustered with *C. siamense* with strong statistical support (85% ML, 0.99 BYPP) (Figure 11.5). Morphologically, our collection is similar to the illustrations of Prihastuti et al., (2009) and Weir et al., (2012) in conidial morphology and conidiophores. Based on morpho-molecular support, we document *C. siamense* causing anthracnose in Khai bananas in Thailand. During the artificial inoculation of *C. siamense*, noticeable black blemish development was observed. This was significant when the fruit reached ripening stage 7. The latter spots were identified as a post-harvest physiological disorder on the fruit peel. This is due to chlorophyll degradation and stomatal cell death in ripening skin (Pongprasert et al., 2021).

11.3.3 Speckle in Banana Fruits

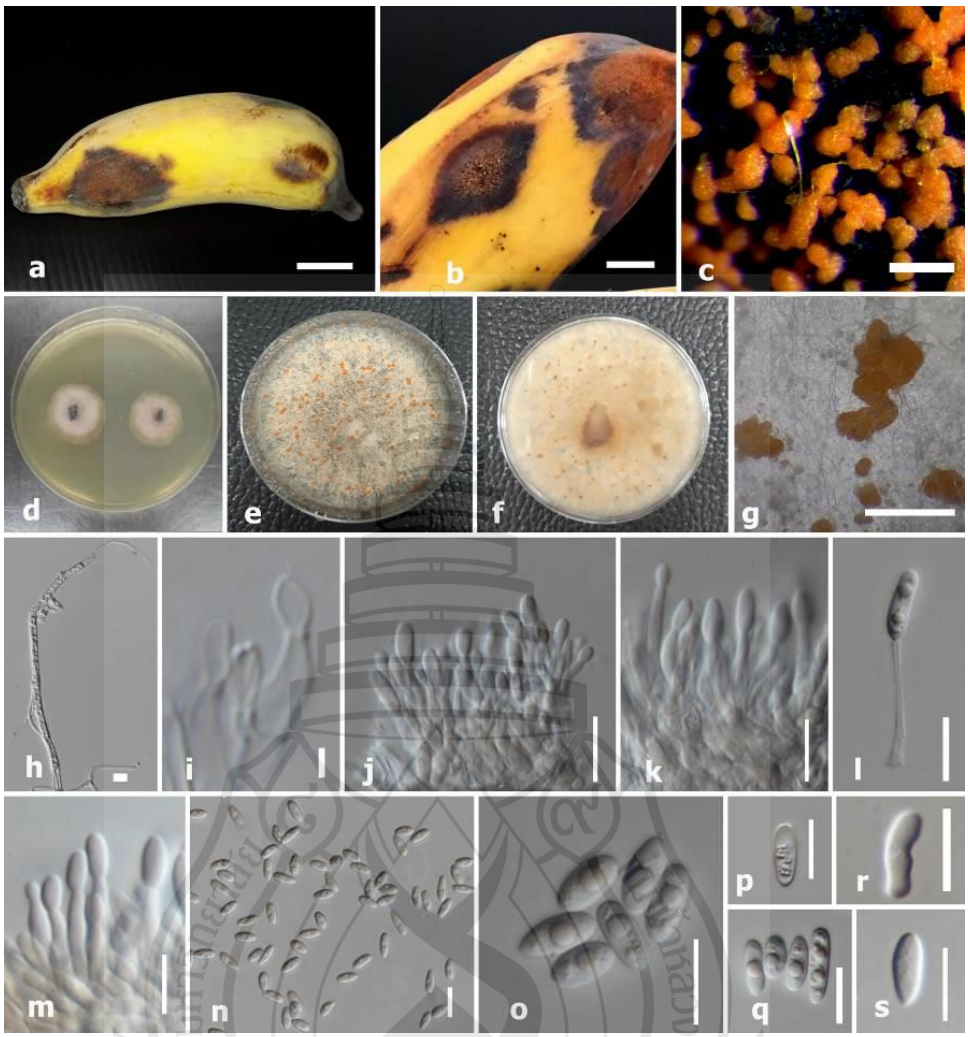
Pathogenicity test

The isolates of MFLUCC 23-0027, MFLUCC 23-0028 and MFLUCC 23-0029 were identified as *Corynespora torulosa* based on phylogeny and morphology (Figure 11.6 and 11.7). After 3 days of artificial inoculations, *C. torulosa* strains caused minute necrotic halos in the inoculated areas on the non-wounded fruit peel at ripening stage 2 (peel colour: entirely green with yellow traces) (Figure 11.8, a). After 6 days of inoculation, the infection and the halos expanded the diameter of the necrotic patch to 1.5 cm. The fruits were at ripening stages 3, 4, and 5. At the same time, the fungal mycelium has been released from the diseased tissue with conidial proliferation. When the fruits reached ripening stage 6 (entirely yellow peel), the necrotic patches became more distinct, and the decay of the peel was initiated. Disease symptoms were not observed in control fruits. The challenge-inoculated fruits display identical disease symptoms with the original Namwa banana specimens in which the fungus has been isolated (Figure 11.2, g–j). To establish Koch's postulates, the pathogen was re-isolated from the infected areas and confirmed with morphology

and DNA. On the wounded peel, symptoms appeared after 2 days of inoculation, similar to those observed on the non-wounded method.

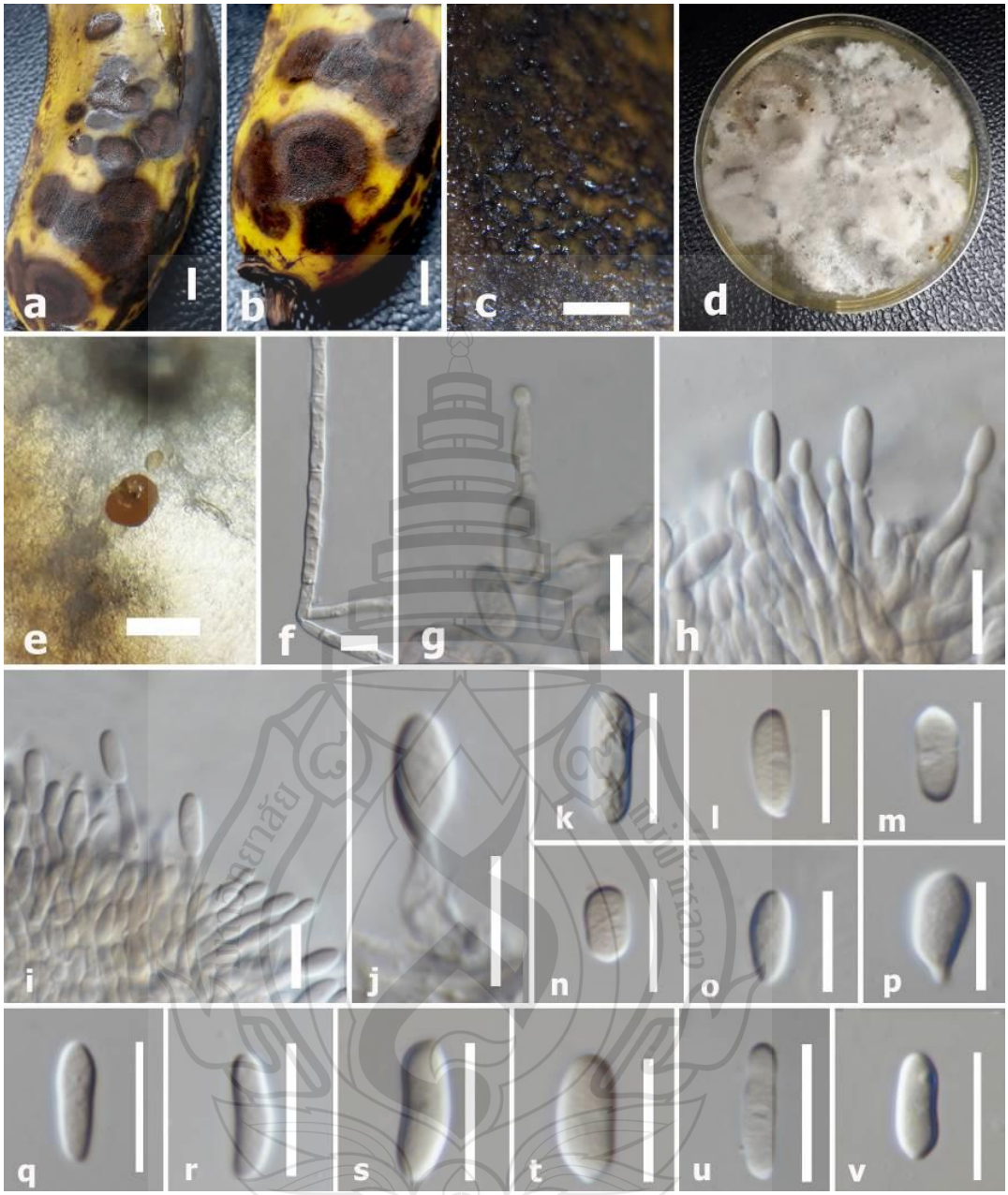
11.3.4 Symptom Development of the Collected Fruits

Speckles caused by *Corynespora torulosa* were recorded and collected from green banana bunches (ripening stage 1) and ripened fruits (stage 3 to 6) of Namwa bananas (Figure 11.2 g–j and Figure 11.6 a–e). Symptoms are comprised of tiny reddish-brown to black spots (0.5 mm to 1 mm) in diameter on banana skin. The speckles were scattered throughout the fruit surface, but they were sometimes dense and aggregated at the stalk end area and blossom end. The spots in the green banana bunches were surrounded by a water-soaked margin (Figure 11.2, h, i). The spots did not expand at the post-harvest stage. When the ripening started, the speckles became more distinct as tiny necrotic patches on a yellow background (Figure 11.6, a–e). Banana skin has only been affected by the pathogen and the infection has not penetrated the fruit pulp.



Note **a, b** Anthracnose lesions on ripened banana skin; **c** Salmon orange conidial masses; **d** Colony on PDA formed from isolated diseased tissues after 3 days'; **e f** Colonies on PDA after 10 days'; **g** Conidial masses on PDA; **h** Fungal hyphae **i-m** Attachments of conidiophores and conidia; **n-s** Conidia. Scale bars: 10 mm **(a, b)**; 200 µm **(c, g)**; 20 µm **(j, k)**; 15 µm **(l-s)**; 5 µm **(h, i)**.

Figure 11.3 *Colletotrichum musae* (MFLU 23-0279)



Note **a, b** Anthracnose lesions on ripened banana skin; **c** Salmon orange conidial masses; **d** Colony on PDA 14 days'; **e** Conidial masses on PDA f Fungal hyphae; **g-j** Attachments of conidia; **k-v** Conidial morphology. Scale bars: 1 cm (**a, b**); 500 μm (**c, e**); 15 μm (**g-v**); 5 μm (**f**).

Figure 11.4 *Colletotrichum siamense* (MFLU 23-0282)

Taxonomy of *Corynespora*

Corynespora torulosa (Syd. & P. Syd.) Crous

Index Fungorum number: IF805829, Facesoffungi Number: FoF 35566 Figure 11.6

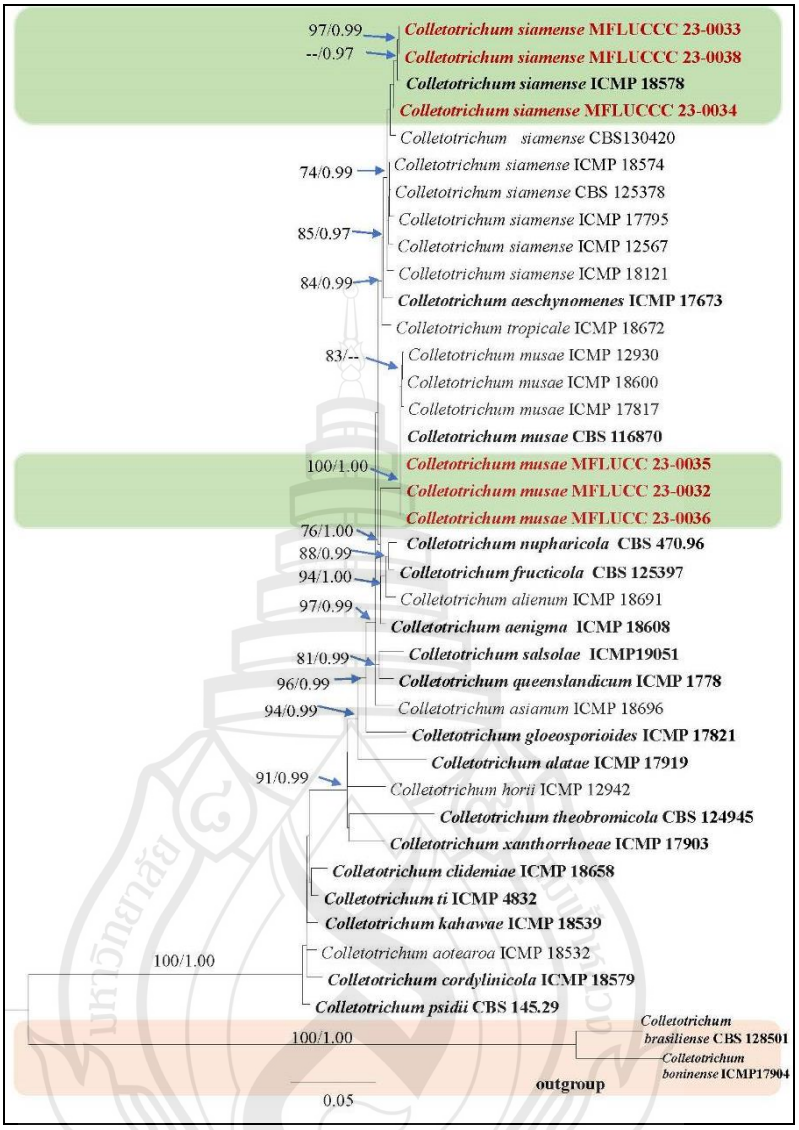
Pathogenic on fruits of Namwa banana. *Colonies* on PDA at 25 °C, light conditions, reach 5 cm diameter in 6 days, at immature stage, greyish-white, mouse grey or white and later becomes brownish-black at maturity. Filamentous, or rhizoid form, raised. Margin entire, lobate or ciliate, *Stroma* none. *Mycelium* aerial 4.5–7.5 µm ($\overline{x}$ = 6 µm) in width, septate, branched, subhyaline and smooth at an immature stage, rough and pale to dark brown at a mature stage, swollen at septa where branches initiated. *Sporulation* initiated after 10 days on PDA, long single or 3-4 conidial clusters arise from mycelium, and showing brown to black appearance on colony; reverse completely black after sporulation. *Conidiophores* erect from the mycelium, 110–370 µm × 1–14 µm ($\overline{x}$ = 290.5 × 9 µm, n = 40) tapering towards apex, 9–12 µm wide at the base, 1–3 µm near the apex, arising singly or more often in dense tufts from superficial hypha, simple, torsive, straight or flexuous, branched or un-branched, pale brown to dark brown, septate, 4–5 thin flange of tissue parts appearing as wings on the surface, having corn shaped or clavate base and a rounded or flat apex. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, doliiform, collarette, producing hyaline spherical immature conidia at terminal end. *Conidia* (50)–150–200– (300) µm × 2–17 µm ($\overline{x}$ = 170.55 × 12.5 µm, n = 50) with blackish-brown scar at the base, formed singly, cylindrical, straight or notably curved, tapering towards rounded apex, mature conidia have a globose, or doliform shaped swollen distinct base, in 10–13 µm × 8–9 µm ($\overline{x}$ = 12.5 × 8.3 µm, n =20), pale brown or golden brown, smooth to verruculose, with 0, 1, 2, 3 or more transverse pseudosepta, thin flange of tissue part attached to the surface of conidia like a wing.

Materials examined: Thailand, Chiang Rai, Nang Lae, Fatay local market, associated with speckle spots of ripened fruit skin of Namwa bananas, 17 January 2022, Binu C. Samarakoon, B01 (MFLU 23-0321), living culture MFLUCC 23-0027. Thailand, Nan, local banana stall at Nan city area, on black spots of ripened Namwa bananas, 4 December 2018, Binu C. Samarakoon, Nan2018 (MFLU 23-0322), living culture: MFLUCC 23-0028. Thailand, Chiang Mai, Chiang Dao, speckles of unripen

Namwa bunch, 10 May 2021, Binu C. Samarakoon, B02 (MFLU 23-0323), living culture MFLUCC 23-0029.

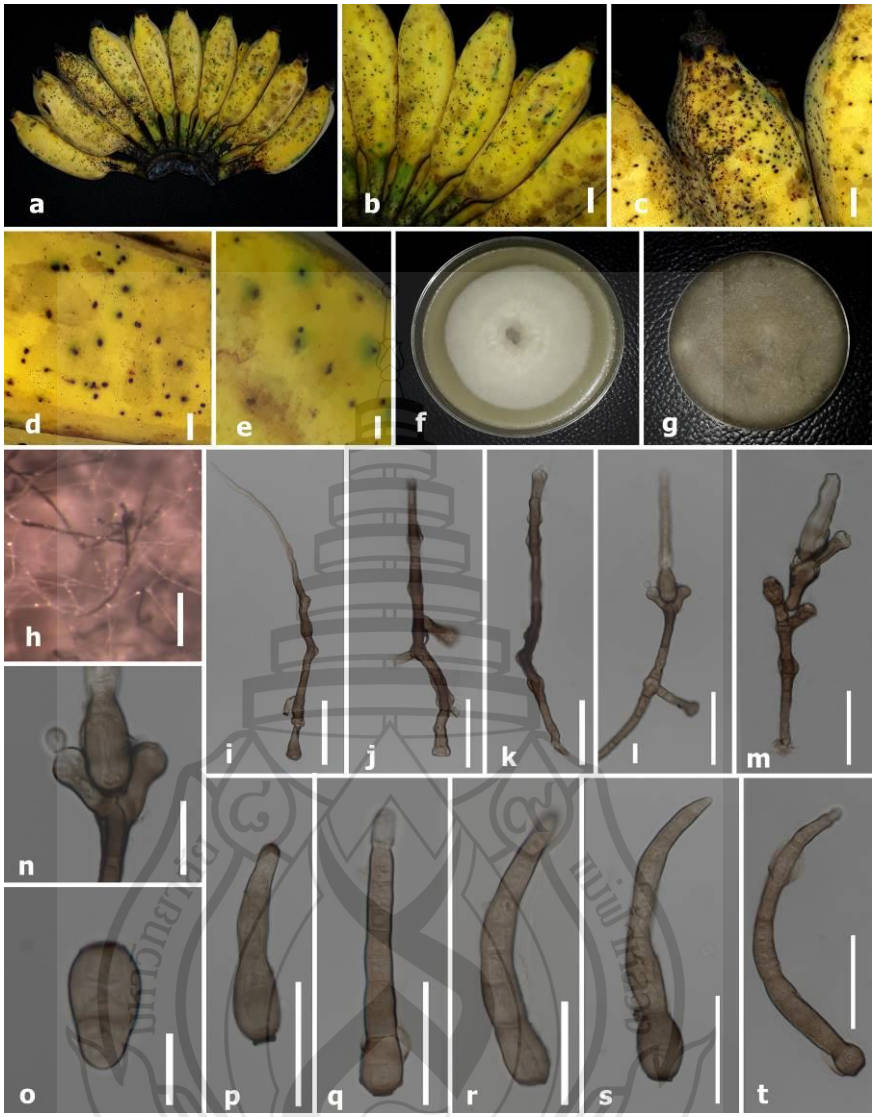
GenBank accession numbers**:** MFLUCC 23-0027: ITS: OR198902, LSU: OR198899; MFLUCC 23-0028: ITS: OR198903, LSU: OR198900; MFLUCC 23-0029: ITS: OR198904, LSU: OR198901.

Notes**:** *Corynespora torulosa* was previously known as *Deightoniella torulosa* (= *Brachysporium torulosum*). In the multigene phylogeny (LSU and ITS Figure 11.7), our isolates were grouped with *C. torulosa* isolates with strong statistical support. The morphology of our strains is similar to the illustrations of Elis (1971) and Crous et al., (2013) in conidia and conidiophores. Hence, on the basis of morphology and phylogeny, we document the first occurrence of *C. torulosa* causing the speckles of Namwa banana fruits in Thailand.



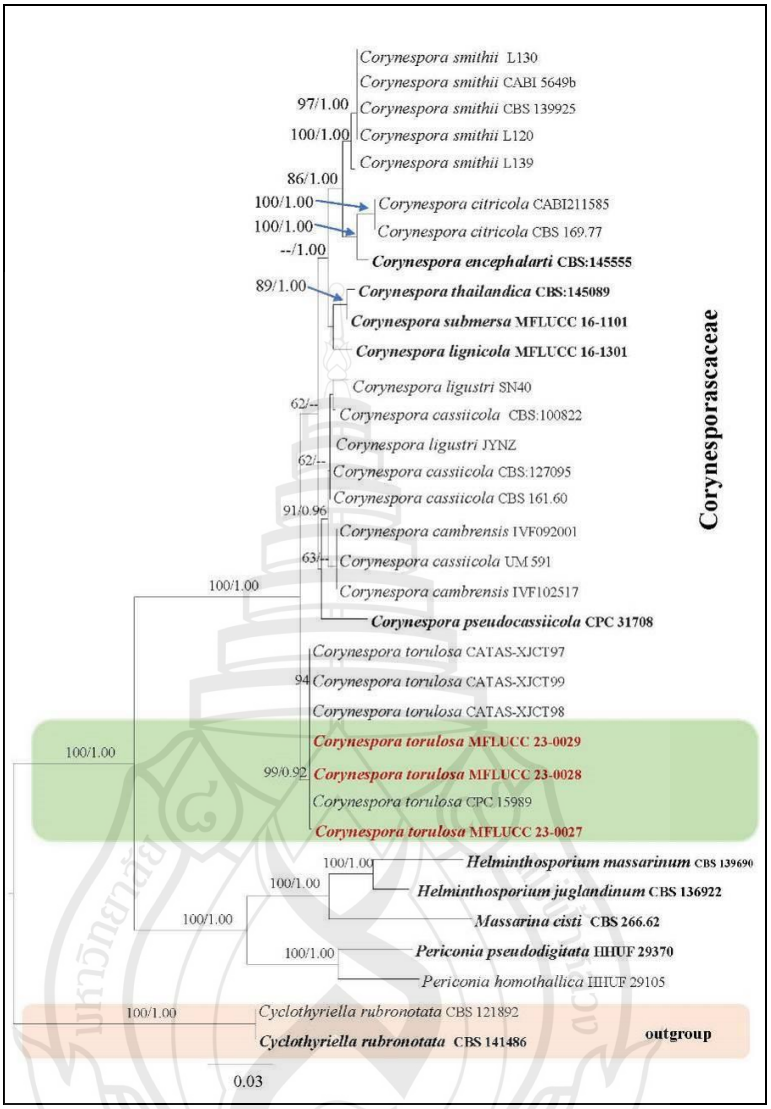
Note Bootstrap supports (≥70%) and posterior probabilities (≥0.95 PP) are displayed above the nodes. The roots of the phylogenetic tree are *C. boninense* (ICMP 17904) and *C. brasiliense* (CBS 128501). Strains generated in this study are bold and indicated in red. Ex-types, ex-epitypes and reference strains are bold and black-indicated. The scale bar shows the expected number of nucleotide substitutions per site.

Figure 11.5 Maximum likelihood tree generated by RAxML analyses of ITS, *gapdh*, *cmdA*, *act*, and *chs-1* sequence data for the selected taxa of the *Colletotrichum gloeosporioides* complex



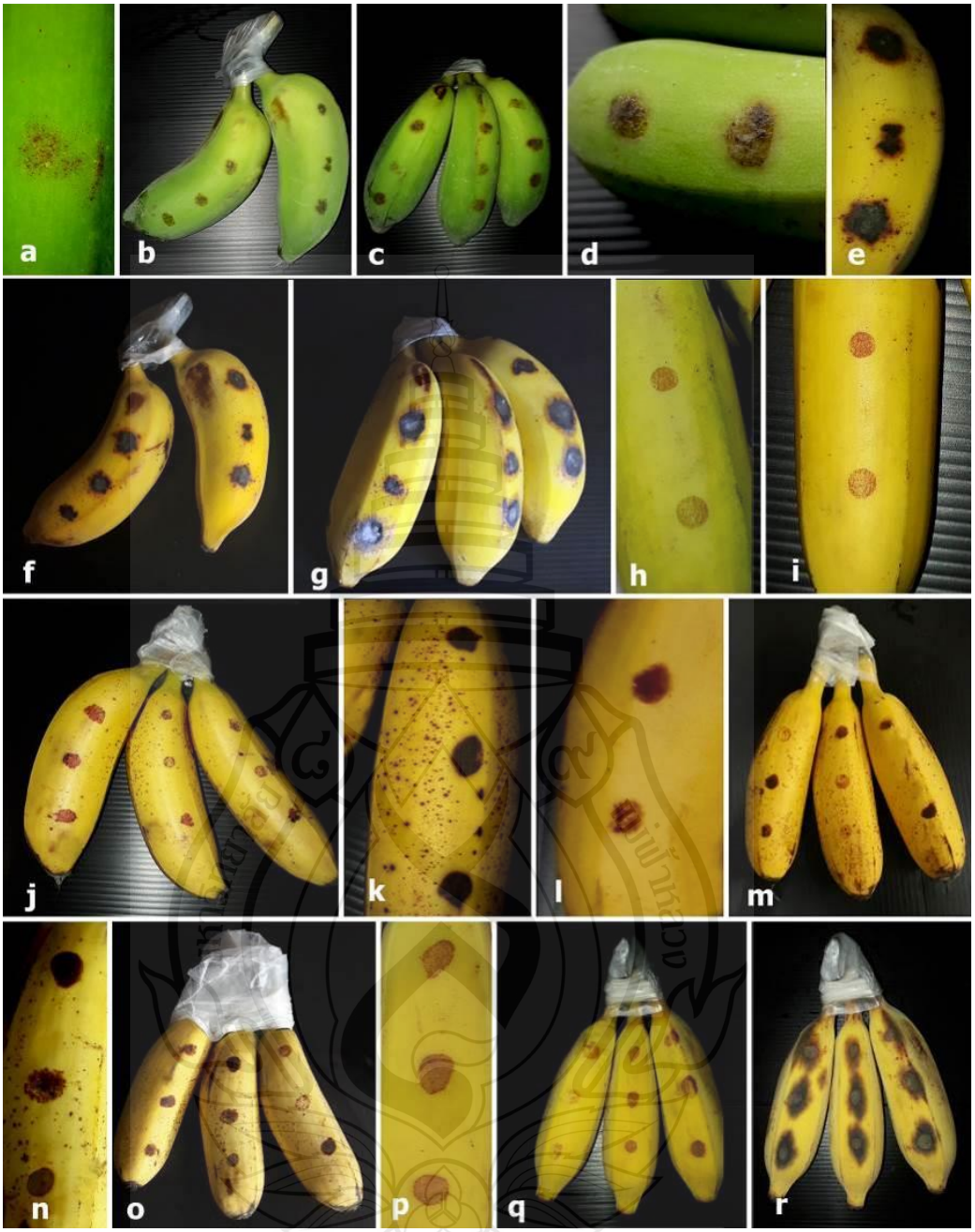
Note **a, b, c** Speckle symptoms on ripened banana skin; **d, e** Minute halos with water-soaked margins; **f** Colony on PDA after 14 days'; **g** Colony on PDA after 21 days'; **h** Sporulation on mycelium; **i-k** Conidiophores; **l-n** Attachment of conidia; **o-t** Conidia. Scale bars: 0.5 cm (**b, c, d, e**); 100 μm (**q, t**); 50 μm (**i, j, k-m, o, p**); 5 μm (**f**).

Figure 11.6 *Corynespora torulosa* (MFLU 23-0321)



Note The Bootstrap supports (≥60% ML) and the posterior probabilities (≥0.95 PP) are indicated on the nodes. *Cyclothyriella rubronotata* (CBS 141486 and CBS 121892) is used to root the tree.

Figure 11.7 Maximum likelihood tree constructed by RAxML analyses of LSU and ITS, sequence data for selected taxa in *Pleosporales*, showing the phylogenetic placement of *Corynespora torulosa*



Note **a-f** Development of diseased symptoms caused by *Corynespora torulosa* in Namwa banana; h-o Anthracnose symptoms after the inoculation of *Colletotrichum siamense* in Khai bananas; p-r Artificial inoculation of *C. musae* on Namwa bananas.

Figure 11.8 Results of the pathogenicity test

11.4 Discussion

Banana fruits can be infected by anthracnose pathogens during the pre-harvest stage in the field throughout the growing season (Jones, 2019). The spores are produced on the decaying or senescing banana tissue (i.e., leaves, discharged fruits, stem parts) and dislocate via water (Simmonds & Mitchell, 1940). The accumulated conidia in plant debris reach the unripen fruits by rain splash or irrigation water until the packing house. At optimal temperature conditions, the conidia attach to the fruit surface and germination is initiated (Jones, 2019). Signal molecules induce defensive responses in the plants and restrict the successful penetration of the fungus into the fruit skin (Abayasekara et al., 2013). However, the physiological changes in the host that occur during the ripening (i.e., reduction of phytoalexins and inducible defense responses) help the fungal pathogens switch to aggressive growth as necrotrophs (Alkan & Fortes, 2015). This results in deteriorated fruit tissue and a lesion (Prusky et al., 2013). In addition to the field conditions, fungal penetration can occur through the natural openings and wounds of the banana fruits during the post-harvest handling chain (Jones, 2019).

Anthracnose affects fruits in all dessert banana cultivars (Jones, 2019). Gros Michel (AAA) is less susceptible to green fruit-wound anthracnose than Cavendish (AAA) (Stover, 1972). Plantain (AAB) fruits are also known to be resistant to anthracnose pathogens (Stover, 1972). *Colletotrichum siamense* was identified in anthracnose lesions in bananas in Brazil (Vieira et al., 2017) and Turkey (Uysal & Kurt, 2020). The pathogen has also been found in leaf spots of bananas in China (Huang et al., 2021) and India (Kumar et al., 2017). Udayanga et al. (2013) documented the fungus associated with anthracnose lesions in bananas in Thailand, but the pathogenicity of the isolates was not confirmed.

Pre-harvested banana fruit bunches in the field exhibit speckle symptoms due to various abiotic and biotic stresses. Fungicides and agrochemicals, including leaf fertilizers, result in speckle-like symptoms on damaged fruits (Jones, 2019). Unharvested fruits are susceptible to insect feeding, egg deposition and fungal penetration. This induces physiological reactions and causes necrotic flecks (Jones,

2019). However, *Corynespora* speckles can be distinguished from flower thrip damage by the absence of raised bumps on necrotic patches (Jones, 2019).

Previous studies identified 16 fungal species in different genera associated with pre-harvest banana speckles (i.e., *Cephalosporium, Colletotrichum, Corynespora, Cylindrocarpon, Fusarium, Penicillium,* and *Trichoderma*) (Jones, 2019). Artificial inoculation revealed that only a few taxa (*Colletotrichum musae, Corynespora torulosa, Cephalosporium* spp., *Fusarium semitectum* and *F. tricinctum*) produced the speckle symptoms. Specifically, *C. musae* causes larger necrotic patches, forming sunken black areas with salmon-pink spores (Jones, 2019; Ocfemia, 1924). Affected fruits ripened prematurely, leading to rot and eventual wrinkling (Jones, 2019; Ocfemia, 1924). All the banana cultivars are susceptible to speckle disease at the pre-harvest stage (Jones, 2019). In addition, *C. torulosa* was also isolated from black leaf spots on banana leaves in India, Jamaica and Thailand (Jones, 2019; Koné et al., 2008; Meredith, 1961; Tongsri et al., 2017; Vardhana, 2017).

The infection of *Corynespora torulosa* begins with the dead plant leaves, and the inoculum is generated during the rain or dew (Meredith, 1961). An aggressive conidial discharge occurs when the humidity drops and conidia become airborne. Conidia germinate on the fruit skin in moist conditions, producing appressoria. The penetration is indicated by a reddish-brown discoloration (Figure 11.8, a) on the green fruit skin and produces speckles after three days (Meredith, 1961). We have isolated *C. torulosa* strains from the speckled symptoms of ripened banana fruits available in the municipal markets at the post-harvest stage. However, we believe that the pathogen infected the fruits at the pre-harvest stage and symptomatic unripen fruits might have been transferred to the local sellers. Additionally, we isolated *C. torulosa* strains from green banana bunches at the same local counters, further confirming our findings.

During the dry season in northern Thailand, we could not locate many *Corynespora torulosa*-associated speckle symptoms. However, after heavy rainfall in the wet season, the pathogen was successfully isolated from freshly harvested banana bunches. Many post-harvest green banana bunches in the Nang Lae area (Fah Thai local market, Chiang Rai) displayed *C. torulosa* speckles during this wet period. However, the fungus disappeared from the fruits when the environment dried up.

Further research is required to confirm the etiology of *C. torulosa*-associated speckle disease and the seasonal changes.

As a future direction, our research includes a subsequent study that documents the endophytic and saprobic lifestyles of the isolated pathogens. The outcomes of this investigation will be presented in upcoming publications. Bananas are a major crop in Thailand, economically significant and deeply rooted in Thai culture. They are a staple dessert and cooking fruit, widely available in local markets. Research on post-harvest fungal diseases in the fruit is crucial for enhancing disease management in Thailand, benefiting agriculture, food security, public health, and quarantine policies.

11.5 Conclusion

Colletotrichum musae was identified as a post-harvest pathogen causing anthracnose in Namwa bananas. The pathogenicity of *C. siamense* that cause post-harvest anthracnose of Khai bananas was confirmed in Thailand for the first time. *Corynespora torulosa* was identified as causing fruit speckles in Namwa bananas as the first report in Thailand. The morphological and phylogenetic studies of the ITS, LSU, *act, cmdA, tub2, chs-1*, and *gapdh* sequences were used to identify the fungi. Fresh and unripe banana fruits were infected with the identified strains to prove Koch's postulates, which confirmed their pathogenicity.

CHAPTER 12

OVERALL CONCLUSIONS

12.1 The Microfungal Groups found in *Musa* and the Challenges

Based on morphological and molecular taxonomic approaches, the overall study could document sixty-seven ascomycetous fungal species in fifty-one different genera that range in thirty-four families and thirteen orders in *Dothideomycetes*, *Eurotiomycetes*, and *Sordariomycetes*. The latter taxa represent endophytic, pathogenic, and saprobic lifestyles and were collected from different tissue parts of *Musa* plants. Among them, forty-four fungal species were morphologically illustrated, and the phylogenetic relationships were investigated and presented here in the dissertation (Table 12.2).

In addition, twenty fungal taxa (five endophytes and fifteen saprobes) were able to be recognized at the generic level with the support of DNA sequence data and morphology (Table 12.1). Those fungal groups mainly belonged to some of the taxonomically unresolved groups in *Diaporthales*, *Hypocreales*, *Magnaporthales*, and *Sordariales*. Most taxa showed 85% to 95% similarity during the BLAST search results in the Gene Bank to the closest hits with contrasting morphology. We can come across predictions, as the taxa can be new findings with novel familial or generic positions. Moreover, they can also be the previously identified species by past scientists only with morphology.

For example, the herbarium code MN02 (saprobic on the dead leaves of *Musa*) has a very low percentage of similarity in BLAST searches to the extant taxa in *Chaetosphaeriales*, *Ophiostomatales*, and *Sordariales*. However, in-depth morphological investigation found that our new collection is identical to *Durispora musae* in Photita et al. (2000), which is currently accommodated in *Valsaceae*

(*Diaporthales*). However, a precise and careful phylogenetic investigation should be conducted to determine the accurate taxonomic position of *Durispora musae*. Before concluding, multiple taxon sampling of the strains in the respective orders should be conducted to avoid erroneous taxonomic identifications. Similar to the above strain, three isolated taxa in *Hypocreales* (MN14, MN23A, and MT10) and one species (MN49) in *Magnaporthales* need intensive and comprehensive phylogenetic analyses before coming to the conclusions of the taxonomic establishments. Hence, those problematic taxa could not be presented with the dissertation due to the limited time period.

In addition, DNA sequence data for a few representative endophytic taxa from *Botryosphaeriales* (*Phyllosticta*), *Capnodiales* (*Cladosporium*), *Glomerellales* (*Colletotrichum*), *Hypocreales (Fusarium),* and *Mycosphaerellales* (*Pseudocercospora*) were also able to be generated. However, species-level identification was unable to be presented with the dissertation due to the comprehensive phylogenetic analyses. Due to the unavoidable circumstances during the COVID-19 pandemic period, a considerable amount of lab time was lost during the study. However, the challenges were able to be overcome, and we were able to generate DNA sequences for the requested gene regions. Thus, the time was limited to construct multigene phylogenetic trees and investigate the taxonomic relationships for the latter twenty genera. The microfungal study has been oriented mainly towards three different lifestyles of fungi (Table 12.2). Three different fungal groups had their own patterns of growing conditions and lifespans. In addition, the collecting methods, isolation, preservation, and laboratory handling procedures were independent of each fungal group. A huge collection of cultures had to be handled carefully for five years and preserved until molecular facilities were available.

12.2 Endophytic Fungal Study

The study has been identified seventeen genera of endophytic fungi (*viz. Albifimbria, Alternaria, Colletotrichum, Corynespora, Curvularia, Daldinia, Diaporthe, Epicoccum, Fusarium, Lasiodiplodia, Musicillium, Neopestalotiopsis,*

Pestalotiopsis, Phyllosticta, Pseudophaeocytostroma, Pseudopithomyces, Spegazzinia) that colonized fresh leaves of *Musa* were identified based on morphology and DNA sequence data. Among them, eight taxa are illustrated and described here in with confirmed molecular phylogeny (i.e., *Albifimbria verrucaria, Stachybotryaceae; Daldinia eschscholtzii, Hypoxylaceae; Musicillium tropicale, Plectosphaerellaceae; Pseudophaeocytostroma sacchari, Diaporthaceae; Setoarthopyrenia chromolaenae, Roussoellaceae*). This is the first endophytic reports of *Albifimbria, Daldinia, Musicillium, Pseudophaeocytostroma, Pseudopithomyces, Setoarthopyrenia* and *Spegazzinia* associated *Musa* hosts.

Table 12.1 Fungal taxa that identified during the study to the generic level based on morphology and molecular data of the ITS region

Order	Family	Original code	Genus	Percentage similarity of BLAST search results (ITS region)
Amphisphaeriales	*Sporocadaceae*	BNS003	*Pestalotiopsis microspora*	100%
Botryosphaeriales	*Phyllosticta*	BF01	*Phyllosticta capitalensis*	100%
Capnodiales	*Cladosporiaceae*	BNS14	*Cladosporium cladosporioides*	100%
Diaporthales	*Diaporthaceae*	EN30	*Diaporthe hongkongnensis*	99%
Diaporthales	*Diaporthaceae*	MN052	*Diaporthe toxicodendri*	95%
Glomerellales	*Glomerellaceae*	BNS240-2	*Colletotrichum capsici*	100%
Hypocreales	*Bionectriaceae*	BNS19	*Clonostachys rosea*	99%
Hypocreales	*Hypocreaceae*	BNS277	*Acrostalagmus luteoalbus*	100%
Hypocreales	*Bionectriaceae*	MN23A	*Gliomastix polychroma*	90%
Hypocreales	*Nectriaceae*	F1	*Fusarium musae*	99%
Hypocreales	*Nectriaceae*	MT10	*Thyronectria sinopica*	86%
Hypocreales	*Stachybotryaceae*	MN14	*Koorchaloma bambusae*	99%
Hypocreales	Uncertain	MN16	*Lasionectria sansevieriae*	86%
Magnaporthales	Uncertain	MN49	*Ophioceras aquaticus*	85%
Mycosphaerellales	*Mycosphaerellaceae*	P003	*Pseudocercospora musae*	99%
Pleosporales	*Didymellaceae*	BNS206	*Epicoccum nigrum*	99%
Pleosporales	*Pleosporaceae*	BNS262	*Curvularia lunata*	100%
Pleosporales	*Pleosporaceae*	BNP07A	*Alternaria alternata*	100%
Pleosporales	*Hermatomycetaceae*	MN505	*Hermatomyces tectonae*	100%
Pleosporales	*Didymosphaeriaceae*	MN24	*Kalmusia italica*	100%
Diaporthales/ /Sordariales	Uncertain	MN02	*Durispora musae* Photita et al. (2003)	83%

Table 12.2 Fungal taxa that identified during the study to the species level based on morphology and phylogeny

Order	Family	Species	Life style	The finding
Botryosphaeriales	*Botryosphaeriaceae*	*Lasiodiplodia theobromae*	Saprobic and endophytic life styles	Evidence for the multi-functional life styles of the fungi on *Musa*
Pleosporales	*Corynesporascaceae*	*Corynespora torulosa*	Saprobic Pathogenic and endophytic life styles	First report of the species in Thailand causing fruit speckles on Namwa banana fruits and Evidence for the multi-functional life styles of the fungi on *Musa*
Pleosporales	*Dictyosporiaceae*	*Dendryphiella vinosa*	Saprobe	New host record
Pleosporales	*Didymosphaeriaceae*	*Pseudopithomyces chartarum*	Saprobic and endophytic life styles	Evidence for the multi-functional life styles of the fungi on *Musa*
Pleosporales	*Didymosphaeriaceae*	*Dictyoarthrinium musae* Samarakoon & Chomnunti, sp. Nov.	Saprobe	New collection
Pleosporales	*Didymosphaeriaceae*	*Dictyoarthrinium sacchari*	Saprobe	New host record
Pleosporales	*Didymosphaeriaceae*	*Dictyoarthrinium thailandica*	Saprobe	New host record
Pleosporales	*Didymosphaeriaceae*	*Spegazzinia musae* Samarakoon & Chomnunti, sp. Nov.	Saprobe	New species, first report of the genus on *Musa*
Pleosporales	*Didymosphaeriaceae*	*Spegazzinia radermacherae*	Saprobe	New host record
Pleosporales	*Didymosphaeriaceae*	*Spegazzinia deightonii*	Saprobe	New host record
Pleosporales	*Lentimurisporaceae*	*Bahusandhika indica*	Saprobe	New host record, country record
Pleosporales	*Lophiotremataceae*	*Lophiotrema hydei*	Saprobe	New species, first geographical occurrence of in Thailand and *Musaceae*
Pleosporales	*Periconiaceae*	*Periconia cortaderiae*	Saprobe	New host record
Pleosporales	*Periconiaceae*	*Periconia delonicis*	Saprobe	New host record

Table 12.2 (continued)

Order	Family	Species	Life style	The finding
Pleosporales	*Periconiaceae*	*Periconia echinochloae*	Saprobe	New host and geographical record
Pleosporales	*Phaeosphaeriaceae*	*Phaeosphaeria oryzae*	Associated with leaf spots	New host record and reported on leaf spot
Pleosporales	*Pleosporaceae*	*Curvularia umbiliciformis*	Associated with leaf spots	New host record, new country record Thailand, on leaf spots
Pleosporales	*Pyrenochaetopsidaceae*	*Pyrenochaetopsis musae* Samarakoon, K. D. Hyde & Chomnunti, sp. Nov.	Associated with leaf spots	New species and reported on leaf spot, *Pyrenochaetopsis* in *Musaceae*
Pleosporales	*Roussoellaceae*	*Setoarthopyrenia chromolaenae*	Endophyte	New host record, first report of the genus
Pleosporales	*Torulaceae*	*Torula fici*	Saprobe	New host record
Pleosporales	*Torulaceae*	*Torula chromolaenae*	Saprobe	New host record
Pleosporales	*Torulaceae*	*Torula masonii*	Saprobe	New host record
Pleosporales	*Torulaceae*	*Torula mackenziei*	Saprobe	New host record
Tubeufiales	*Tubeufiaceae*	*Neohelicosporium terrestris* Samarakoon, K. D. Hyde & Chomnunti, sp. Nov.	Saprobe	New species, A terrestrial report, first report of the genus on *Musa*
Chaetothyriales	*Herpotrichiellaceae*	*Metulocladosporiella musae*	Associated with leaf spots	New collection associated with leaf spot
Amphisphaeriales	*Apiosporaceae*	*Apiospora locuta-pollinis*	Saprobe	New host and country
Amphisphaeriales	*Apiosporaceae*	*Nigrospora sphaerica*	Saprobe	New collection
Amphisphaeriales	*Sporocadaceae*	*Neopestalotiopsis clavispora*	Associated with leaf spots	Associated with leaf spots
Amphisphaeriales	*Sporocadaceae*	*Neopestalotiopsis musae*	Associated with leaf spots	Associated with leaf spots

Table 12.2 (continued)

Order	Family	Species	Life style	The finding
Diaporthales	*Diaporthaceae*	*Pseudophaeocytostroma sacchari*	Endophyte	First report of the genus on *Musa*
Glomerellales	*Glomerellaceae*	*Colletotrichum musae*	Saprobe, pathogen and endophyte	Causing banana anthracnose in Namwa banana, Evidence for the multi-functional life styles of the fungi on *Musa*
Glomerellales	*Glomerellaceae*	*Colletotrichum siamense*	Pathogen and associated with leaf spots	Causing banana anthracnose in Khai banana and associated with leaf spots
Glomerellales	*Plectosphaerellaceae*	*Musicillium tropicale*	Endophyte	First occurrence from Southeast Asia
Glomerellales	*Plectosphaerellaceae*	*Gibellulopsis serrae*	Saprobe	First report of the genus in Thailand.
Glomerellales	*Plectosphaerellaceae*	*Musicillium elettariae*	Saprobe	First record of the sexual morph
Hypocreales	*Stachybotryaceae*	*Albifimbria verrucaria*	Endophyte and a saprobe	Evidence for the multi-functional life styles of the fungi on *Musa*, New geographical record
Hypocreales	*Stachybotryaceae*	*Memnoniella levispora*	Saprobe	New collection
Hypocreales	*Stachybotryaceae*	*Smaragdiniseta musae* Samarakoon & Chomnunti, sp. Nov.	Saprobe	New species
Hypocreales	*Stachybotryaceae*	*Stachybotrys microsporus*	Saprobe	New collection
Hypocreales	*Stachybotryaceae*	*Stachybotrys musae* Samarakoon & Chomnunti, sp. Nov.	Saprobe	New species
Hypocreales	*Stachybotryaceae*	*Stachybotrys subcylindrosporus*	Saprobe	First saprobic report on a plant host, new host record
Magnaporthales	*Pyriculariaceae*	*Neocordana musae*	Associated with leaf spots	Associated with leafspots
Pleurotheciales	*Pleurotheciaceae*	*Dematipyriforma teristiris* Samarakoon, K. D. Hyde & Chomnunti, sp. Nov.	Saprobe	New species, first report of the genus on *Musa*

Table 12.2 (continued)

Order	Family	Species	Life style	The finding
Xylariales	*Hypoxylaceae*	*Daldinia eschscholtzii*	Endophyte	New host record, First report of the genus on *Musa*

Most of the endophytic taxa found in this study are also reported as pathogens on *Musa* (i.e., *Colletotrichum musae*, *Corynespora torulosa*, *Lasiodiplodia theobromae*, *Neopestalotiopsis musae*, and *Phyllosticta capitalensis*). There is a possibility that those endophytic fungi can be latent in the host and shift to a pathogenic lifestyle with environmental triggers and the physiological changes (i.e., alternation of defensive mechanisms upon host senescence) of the plant (Photita et al., 2004). In addition, few taxa that has the ability to produce bioactive compounds also reported during the study such as *A. verrucaria, C. torulosa, D. eschscholtzii* and *L. theobromae.*

The most common genera encountered in banana leaves and fruits were *Colletotrichum, Daldinia,* and *Neopestalotiopsis*. These three fungal groups were often isolated in the rainy and dry seasons. Other groups of fungi had a limited occurrence and were discovered from time to time throughout the year.

Sporulation of the endophytes can be observed from five days to three months after the first sub-culture at 16 °C to 25 °C under light conditions. For the fast-growing asexual morphs like *Colletotrichum, Corynespora, Daldinia, Fusarium, Neopestalotiopsis,* and *Lasiodiplodia* strains, PDA was suitable to generate fruiting structures. However, slow-growing cultures, OMA is recommended, especially to observe the sporulation of *Albifimbria* and *Phyllosticta*. Interestingly, the conidiogenesis and the conidiogenous cells were easily located in the seven- to seven-day-old sporulation cultures when compared to the mature cultures.

Most of the isolated endophytic strains during the study lost viability after three months. Then the subculture failed and was unable to regenerate a new batch of isolates. Hence, immediate actions should be taken for morphological examinations, preservation, and industrial purposes such as secondary metabolite extraction. As we have seen, many fast-growing endophytic cultures were contaminated by the

secondary invasions of *Fusarium* and *Penicillium* colonies. Therefore, the culture morphology should be recorded continuously, and the subculture process will otherwise give rise to an erroneous secondary fungal strain. Even for DNA extraction, it is recommended to use seven- to ten-day-old pure cultures rather than old strains to avoid contaminated sequences or chromatograms with noise. If the molecular procedures take some time, as an additional step, we preserved the seven- to ten-day-old PDA cubes in 15% glycerol. These cubes were used for the DNA extraction after 3 years of incubation at low temperatures (4° C), and the results were 100% accurate.

Most endophytic strains terminate their lives, and dehydration can be a reason. The cultures stored on 9 cm.-diameter plastic plates were contaminated or dried off faster than the 55-mm PDA plates. The larger surface area of the plate might be contributing to higher water losses. Hence, using PDA slants in screw-cap tubes or mini and micro centrifuge tubes was most effective in the preservation of cultures without losing viability for at least eight months.

12.3 The Study of Saprobic Microfungi on *Musa*

The morpho-molecular data revealed the occurrence of 48 genera of saprobic fungi *viz. Acrostalagmus, Albifimbria, Alternaria, Apiospora, Bahusandhika, Cladosporium, Clonostachys, Colletotrichum, Corynespora, Curvularia, Dematipyriforma, Dendryphiella, Diaporthe, Dictyoarthrinium, Durispora, Epicoccum, Fusarium, Gibellulopsis, Gliomastix, Hermatomyces, Kalmusia, Koorchaloma, Lasiodiplodia, Lasionectria, Lophiotrema, Memnoniella, Musicillium, Nectria, Neocordana, Neohelicosporium, Neopestalotiopsis, Nigrospora, Ophioceras, Periconia, Pestalotiopsis, Phaeosphaeria, Phyllosticta, Plectosphaerella, Pseudocercospora, Pseudophaeocytostroma, Pseudopithomyces, Pyrenochaetopsis, Setophoma, Smaragdiniseta, Spegazzinia, Stachybotrys* and *Torula* on *Musa* substrates. Among them, 33 species *viz. Albifimbria verrucaria* (*Stachybotryaceae*), *Apiospora locuta-pollinis* (*Apiosporaceae*), *Bahusandhika indica* (*Lentimurisporaceae*), *Colletotrichum musae* (*Glomerellaceae*), *Corynespora torulosa* (*Corynesporascaceae*), *Dematipyriforma teristiris* (*Pleurotheciaceae*),

Dendryphiella vinosa (*Dictyosporiaceae*), *Dictyoarthrinium musae, D. thailandica, D. sacchari* (*Didymosphaeriaceae*), *Gibellulopsis serrae* (*Plectosphaerellaceae*), *Lasiodiplodia theobromae* (*Botryosphaeriaceae*), *Lophiotrema hydei* (*Lophiotremataceae*), *Memnoniella levispora* (*Stachybotryaceae*), *Musicillium elettariae* (*Plectosphaerellaceae*), *Neocordana musae* (*Pyriculariaceae*), *Neohelicosporium terrestris* (*Tubeufiaceae*), *Nigrospora sphaerica* (*Apiosporaceae*), *Periconia cortaderiae, P. delonicis, P. echinochloae* (*Periconiaceae*), *Pseudopithomyces chartarum* (*Didymosphaeriaceae*), *Smaragdiniseta musae* (*Stachybotryaceae*), *Spegazzinia deightonii, S. musae, S. radermacherae* (*Didymosphaeriaceae*), *Stachybotrys microsporus, S. musae, S. subcylindrosporus* (*Stachybotryaceae*), *Torula chromolaenae, T. fici, T. mackenziei,* and *T. masonii* (*Torulaceae*) are included in the thesis with full descriptions, illustrations and molecular phylogeny.

As a research gap, the majority of saprobic fungal genera on *Musa* substrates were not well investigated during previous research works with detailed morphology and phylogeny. However, the current study could increase the saprobic fungal numbers associated with the host. The genera *Albifimbria, Apiospora, Bahusandhika, Clonostachys, Dematipyriforma, Dendryphiella, Gliomastix, Hermatomyces, Koorchaloma, Lophiotrema, Ophioceras, Neohelicosporium, Neopestalotiopsis, Setophoma,* and *Smaragdiniseta* were reported as the first occurrences of genera on *Musa* as saprobes.

During the study, some taxonomically understudied and rare genera of hyphomycetous saprobes, such as *Bahusandhika*, *Dictyoarthrinium, Smaragdiniseta,* and *Spegazzinia,* were able to be discovered. We could transfer *Dictyoarthrinium* to *Dydymosphareaceae* (*Dothideomycetes*) from *Apiosporaceae* (*Sordariomycetes*) with the support of morphology and phylogeny. In addition, the taxonomy and the phylogeny of the taxa of *Stachybotrys,* also referred to as black molds," that were often found on dead *Musa* leaves were investigated. It was noted that the bioactive secondary metabolites of many saprobic taxa have not been investigated. Hence, the living cultures were made available for the toxicological studies (*Stachybotrys*) and the other investigations of biochemical applications.

Interestingly, some saprobic species were able to be discovered from *Musa* hosts that previously colonized soil (i.e., *Albifimbria verrucaria, Gibellulopsis serrae, and Stachybotrys subcylindrosporus*). *Dematipyriforma* and *Neohelicosporium* were previously reported from aquatic habitats and could be discovered in terrestrial habitats. Notably, many genera of saprobic niches were able to be discovered in wild *Musa* in forest ecosystems compared to cultivated roadside vegetation. Some genera that inhabited leaf litter in forest ecosystems (i.e., *Apiospora Hermatomyces, Memnoniella, Ophioceras Periconia, Nigrospora, and Stachybotrys*) (Tennakoon et al., 2022) were able to be discovered in *Musa* substrates in forest vegetation.

The sexual morphs of banana saprobes are well grown and most of the time located as producing hyaline ascospores. The fruiting structures are minute compared to the fungi that were isolated from the other plant hosts, and the isolation process was a bit challenging when locating the correct spore. This resulted in accurate, pure cultures without contamination. As with the sexual ascomycetes, the coelomycetous conidia were also found to be minute and hyaline, with most conidiophores reduced to conidiogenous cells and phialidic. There have been exceptions for *Lasiodiplodia,* which produces brown, larger spores, and *Phyllosticta,* which produce enlarged spores with hyaline sheaths.

Musa provides an excellent substrate for hyphomycetous fungi. During the study, hyphomycetous taxa with different morphologies were able to be recorded. Basauxic conidiophores were observed in *Apiospora* (*Arthrinium*), *Dictyoarthrinium,* and *Spegazzinia*. Discrete, acropleurogenous, and solitary conidia were observed in *Corynespora*, *Neocordana*, and *Nigrospora*. In addition, *Pseudopithomyces* has solitary, pleurogenous, or acropleurogenous muriform conidia. *Periconia* produces unbranched conidial chains on the phialidic or annellidic apex of the conidiophores. *Cladosporium* has long, branched, catenate conidia on the stipe. *Gibellulopsis* and *Musicillium* pose stipe that verticillate towards the apex and produce whorls of phialides. *Memnoniella* and *Stachybotrys* also bear phialides at the apex of the conidiophores.

Acrostalagmus is synnematous and monophialidic, while *Albifimbria* produces sporodochia. *Smaragdiniseta* also produces sporodochia but is covered with numerous setae. *Dendryphiella* and *Curvularia* have polytretic conidiogenous cells, while

Bahusandhika has monotretic cells. Geniculate conidia were discovered in *Curvularia,* while *Spegazzinia* produces disk-shaped and stellate-shaped conidia. *Epicoccum* produces muriform conidia that erect from a stroma with a protuberant basal stalk cell. *Torula* poses a multiseptate conidium in which the terminal cells always become conidiogenous. Similar to *Torula, Bahusandhika* produces terminal conidiogenous cells at the apex of the conidiophores and also at the top of the cells of the conidia. This usually produces one to three conidia and links the individual conidia as chains. *Hermatomyces* has an interesting conidial morphology, muriform and lenticular in shape, where pale peripheral cells surround the central dematiaceous cells.

12.4 The Study of Microfungi Associated with Leaf Spots

Eight fungal taxa, *viz*. *Colletotrichum siamense* (*Glomerellaceae*), *Curvularia umbiliciformis* (*Pleosporaceae*), *Metulocladosporiella musae* (*Herpotrichiellaceae*), *Neocordana musae* (*Pyriculariaceae*), *Neopestalotiopsis clavispora*, *N. musae* (*Sporocadaceae*), *Phaeosphaeria oryzae* (*Phaeosphaeriaceae*) and *Pyrenochaetopsis musae* (*Pyrenochaetopsidaceae*), associated with *Musa* leaf spots, are reported. Among them, *Colletotrichum siamense*, *Metulocladosporiella musae*, *Neocordana musae* and *Neopestalotiopsis clavispora* were previously reported as pathogens causing leaf spots on many agricultural crops, including *Musa* (Crous et al., 2006; Hernandez-Restrepo et al., 2015; Kumar et al., 2017; Qi et al., 2022). *Pyrenochaetopsis musae* (this study) and *Neopestalotiopsis musae* (Hyde et al., 2016) are originally described on *Musa* spp. The pathogenicity of *Curvularia umbiliciformis* and *Phaeosphaeria oryzae* on *Musa* leaves has not been evaluated in previous studies. This is the first occurrence where those species are being associated with leaf spots in monocots. There is a high probability that the latter taxa might have caused those leaf spots in *Musa* spp. However, the pathogenicity of these isolates (*C. umbiliciformis* and *P. oryzae*) on *Musa* should be confirmed in future studies using both *in vitro* and *in vivo* experiments. It is also possible that these fungal groups are secondary invaders of the necrotic tissue at the leaf spot, acting as saprobes.

In addition, each leaf spot has a unique shape in the chlorotic region and the necrotic patch. leaf spot-associated *Neocordana musae* was isolated from the eye-shaped lesions, while *Neopestalotiopsis* spp. were found in necrotic tissue with concentric ring patterns. *Phaeosphaeria oryzae* (leaf spot-associated) was recovered from the rounded to elliptic lesions. Those spots were with a distinct, thick black line that surrounded the necrotic region and demarcates it from the region where chlorosis generates. *Curvularia umbiliciformis* (leaf spot-associated) was detected from the square to irregular-shaped leaf spots with a comparatively pale brown necrotic area and a thin black line that separates regions. *Metulocladosporiella musae* (leaf spot-associated) rises from the thick, irregularly shaped patches that are always detected near the midrib of the leaf. *Pyrenochaetopsis musae* (leaf spot-associated) produced the fruiting structures on white necrotic patches with a considerably small chlorotic region. However, both regions were demarcated by a thick black line in the necrotic patch. *Colletotrichum siamense* has been isolated from diseased leaf tissue with black striations that originated from the center of the necrotic patch. Similar to the saprobes, these leaf spots also host a lot of contaminants, such as *Fusarium* and *Cladosporium* spores, together with molds and mycelia. Additional precautions should be taken when isolating the fungi to avoid contamination.

The overall findings of the fungi associated with leaf spots on *Musa* will provide insights in to the identification of pre-harvest banana diseases in Thailand. Future studies will be able to prove the pathogenicity of the isolates and contribute to the pre-harvest disease management of *Musa* in Thailand.

12.5 Pathogenic Fungi on *Musa* Fruits

Two banana fruit diseases, anthracnose and speckle, were investigated during the study. Both symptomatic banana fruits were collected from the local markets in Northern Thailand's three different provinces (Chiang Mai, Chiang Rai, and Nan). *Colletotrichum musae* and *C. siamense* were identified from the post-harvest anthracnose lesions in Namwa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) and Khai bananas (*M. acuminata*; AA genomic group; Sucrier).

In addition, *Corynespora torulosa* was found in the speckles of Namwa bananas (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak). To establish Koch's postulates, fresh and unripe banana fruits were artificially inoculated with the identified strains, which confirmed their pathogenicity. This is the first confirmed occurrence of *Cory. torulosa* causing banana fruit speckles in Thailand. In addition, the presence of *C. siamense* causing post-harvest anthracnose in Khai bananas was reported.

With the updated molecular tree for the *Pyriculariaceae*, a thorough review of the plant pathogenic genus *Neocordana* that causes leaf spots on *Musa* was also conducted. The findings of this study contribute to a better understanding of post-harvest disease control in the commercial banana industry in Thailand. The findings of the overall pathogenic fungal study contribute to a better understanding of post-harvest banana diseases and address the present related challenges. Additionally, the results will further support the post-harvest disease management and control of the commercial banana industry in Thailand.

12.6 Different Life Styles of the Same Fungi Found on *Musa* Leaves and Fruits

Three fungal taxa (*Albifimbria verrucaria, Stachybotryaceae; Lasiodiplodia theobromae, Botryosphaeriaceae; Pseudopithomyces chartarum, Didymosphaeriaceae*) are identified to be exhibiting both endophytic and saprobic lifestyles on the leaves of cultivated banana ABB Group (*Musa acuminata* × *Musa balbisiana*). Interestingly, the endophytic, pathogenic, and saprobic lifestyles of *Colletotrichum musae* (*Glomerellaceae*) and *Corynespora torulosa* (*Corynesporascaceae*) were able to be recorded during the study in cultivated banana ABB Group banana leaves and fruits. The results were confirmed with pathogenicity tests combined with molecular evidence. Many studies witness fungi exhibiting multi-functional lifestyles associated with host plants (Barelli et al., 2016; Fisher & Petrini, 1992; O'Connell et al., 2022; Rai & Agarkar, 2016; Ribeiro et al., 2020). It has been predicted that fungal endophytes shift to a saprobic nutritional mode upon the senescence of host tissues

(Okane et al., 2010; Promputtha et al., 2007, 2010, 2014). In addition, these endophytes might colonize the leaf or fruit and stay latent until the plant defense responses break downs and manifest in to the aggressive pathogenic lifestyle (Hilário & Gonçalves, 2023; Okane et al., 2010). During the host decay, next these fungal pathogens can project out from the diseased host tissue and produce fruiting structures as saprobes (O'Connell et al., 2012). However in-depth studies are necessary to conduct and verify the life style transition of fungi using transcriptomics and proteomics studies (Hilário & Gonçalves, 2023; Okane et al., 2010). The interchangeable lifestyles of fungi may be triggered by various host, fungal, or environmental factors. It is interesting, and further research is necessary to investigate the effects of climate change on the lifestyle transitions of fungi. The data generated during the study can be implemented in future research works.

12.7 Comparison of Results

Research biases were noted in the study of saprobic fungal groups, and the endophytic fungal groups were not extensively investigated. For the endophytic fungi, a subset of isolates was selected due to limited molecular facilities. Only taxa with unique morphologies were chosen from the primary isolation batch to represent each genus, and molecular data were generated for these selected taxa. This is the reason for the low number of endophytic isolates.

Only three pathogenic fungal taxa (*Colletotrichum musae, C. siamense* and *Corynespora torulosa*) were selected for a comprehensive five-year study. The pathogenicity of leaf spot fungi was not evaluated due to the lack of access to field trials. Consequently, we did not observe multiple occurrences of many fungi associated with leaf spots. These occurrences were infrequent, with isolates being found only once or twice and in limited numbers. In an attempt to fulfill Koch's first postulate, we were unable to obtain multiple isolates from a single strain throughout the year, resulting in insufficient data to conclusively identify these isolates as pathogens.

During this study, a random sampling approach was employed. However, diversity indices were not applied to compare the diversity of each fungal group, preventing a detailed comparative analysis of our isolation data. Nonetheless, we identified some specific characteristics of the different fungal groups on a limited scale.

Due to the limited duration of the study, samples were not collected from the rhizomes, roots, flowers, or pre-harvest rachis and fruit bunches of *Musa*. Instead, fungi were primarily isolated from the leaf blade, midrib, sheath, sucker, and pseudo stem. Additionally, post-harvest fruits were collected for fungal isolation. The results of the current study indicate the presence of different fungal genera in each tissue type of the collected leaf samples. For example, in fresh leaf samples, the genus *Phyllosticta* was very common, characterized by the production of masses of white conidial exudates. *Colletotrichum* fruiting bodies were also observed on mature leaves. However, sexual fruiting bodies and hyphomycetous fungi were not prominently visible on fresh leaf parts such as the blade, midrib, petiole, and sheath.

In contrast, diseased banana leaves exhibited several sexual fruiting bodies on leaf spots or blotches before detachment from the plant in the natural environment. Ascomata with mature asci were visible on the leaf spots, with fungal groups such as *Phaeosphaeria* and *Mycosphaerella* being prevalent on these spots and streaks. *Colletotrichum, Diaporthe, Didymella, Neopestalotiopsis, Phoma*, and various coelomycetous fungal groups with hyaline-spores were visible on necrotic patches. Hyphomycetous fungal groups, including, *Cercospora*-like taxa, *Fusarium, Metulocladosporiella, Neocordana*, and *Pseudocercospora*, were commonly observed on spots, blotches, and streaks. As endophytes, *Phyllosticta, Colletotrichum, Corynespora, Daldinia, Fusarium, and Lasiodiplodia* were the most commonly encountered genera in various leaf tissue parts. When considering banana fruits, the most commonly isolated endophytic fungi were *Colletotrichum* and *Daldinia*, with *Corynespora* and *Fusarium* being the next most frequently found.

In dead banana tissues, the midrib of the leaf harbors several saprobic fungi. These groups can produce sexual fruiting structures or coelomycetes, primarily on the lower surface of the midrib and sometimes on the upper surface in folded leaves. *Colletotrichum, Diaporthe* and *Lasiodiplodia* were the most commonly observed

fungal taxa on the midrib. It has been noticed that the midrib area hosts diverse groups of well-known and rarely studied hyphomycetous genera. Among the most frequently encountered fungal groups were *Corynespora*, *Dictyoarthrinium*, *Nigrospora*, *Periconia*, *Pseudopithomyces*, *Stachybotrys*, and *Torula*.

Upon decay, most fungal groups become visible on the dead leaf blade, with the most commonly observed groups being *Corynespora*, *Nigrospora* and *Pseudopithomyces*. Interestingly, *Corynespora* occurs in clusters on dead pseudo stem tissue parts as a prevalent fungal group. *Lasiodiplodia* taxa were notably common in rigid areas of the leaf sheaths. In dead or decaying fruits, *Colletotrichum* (mostly *C. musae*) was the predominant saprobic fungus, while *Fusarium* and *Penicillium*-like taxa emerged as secondary invaders.

Based on the findings, comparison of collecting sites revealed differences in the diversity of saprobic fungi in *Musa* tissues. Samples from commercial banana fields and roadside vegetation primarily hosted genera such as *Colletotrichum*, *Corynespora*, *Fusarium*, *Pseudopithomyces*, *Stachybotrys*, and *Torula*. In contrast, wild *Musa* cultivations and banana plants within forest ecosystems harbored a wider range of saprobic fungal genera. Particularly noteworthy was the significant hypomycetous diversification observed in wild *Musa* (Table 12.1). Wild *Musa* plants exhibited a higher diversity of fungal saprobes compared to cultivated varieties, especially evident in leaf spots where numerous sexual genera were encountered in the thicker leaf blades of wild *Musa* plants. In cultivated vegetation, on diseased leaves, genera such as *Pseudocercospora*, *Phyllosticta*, *Colletotrichum*, and *Neopestalotiopsis* were frequently found. Additionally, interesting endophytic fungi were discovered in wild *Musa* leaves (Table 12.1), including *Albifimbria verrucaria* and *Musicillium tropicale*.

In this study, fungal taxa traditionally thought to be specific to bananas such as *Colletotrichum musae*, *Metulocladosporiella musae*, and *Neocordana musae* were indeed confirmed. However, other fungal taxa isolated from *Musa* plants during the study were also found to be present in a diverse array of plant hosts.

During the dry season, only a limited number of saprobic fungal genera are typically reported. Commonly identified genera during this period include *Arthrinium*, *Colletotrichum*, *Corynespora*, *Fusarium*, *Lasiodiplodia*, *Nigrospora*, *Periconia*,

Stachybotrys, and Torula. However, our findings indicate a diverse range of saprobic genera during the rainy season or immediately after rainfall. The humid conditions following rain promote the proliferation of hyphomycetous fungi, particularly from dead tissues.

For fungi associated with leaf spots, the humid post-rain environment triggers the formation of fruiting bodies on necrotic patches, often with numerous spore masses. During the dry season, many hyphomycetous fruiting structures fall and become less visible. Sexual morphs may appear on the midrib area during this time, but in many samples, the asci and ascospores are often ruptured or desiccated, making them difficult to locate.

In summary, the rainy season favors the growth of hyphomycetous fungi and promotes the development of fungal fruiting bodies in humid conditions post-rainfall, contrasting with the reduced visibility of such structures during the dry season.

12.8 Global Checklist of Fungi Associated with *Musa*

The present study fills an important gap in the knowledge of *Musa*-associated fungi by compiling an updated and comprehensive checklist. Through a comprehensive review of international literature and databases, we have developed a catalog that refines the taxonomic classification of known fungi. This catalog also outlines their geographical distribution concerning a diverse range of *Musa* species, as summarized in Appendix B. Our investigation has revealed a diverse mycobiome, with 760 fungal species associated with *Musa* hosts. These species are categorized into four major phyla: *Ascomycota, Basidiomycota, Mortierellomycota* and *Mucoromycota*. *Ascomycota*, with 93% of the fungal taxa, emerges as the predominant phylum, suggesting its members have the most significant ecological and potentially pathogenic interactions with *Musa* hosts. Furthermore, the detailed geographical data provided for each fungal species found on *Musa* hosts. This enhances our understanding of the biogeographical patterns of *Musa*-associated fungi. This is crucial for the development of disease management strategies in *Musa* cultivation. These insights into the distribution of these species can inform both

conservation efforts and agricultural practices, especially in regions where *Musa* crops are a staple and an economic cornerstone.

From a biogeographical perspective, these fungi are not randomly scattered but show a distinct pattern of prevalence across 140 regions. A significant 62% of this diversity is attributed to merely 20 regions, with Thailand leading with 7% of total fungal records. Following Thailand, China and Malaysia, each with a 6% share, underscoring the critical role of Asia-Pacific region as a hub of fungal biodiversity associated with *Musa*. The representation from Australia, Brazil, the United States, and India further illustrates the global nature of these interactions and the importance of understanding regional differences in fungal communities. The concentrated diversity within certain families and regions invites questions about the evolutionary pressures and ecological factors that shape these communities. It also emphasizes the need for continued exploration of fungal biodiversity in relation to *Musa* species. These efforts are essential for developing sustainable management practices and enhance the understanding of global fungal ecology.

As a special note, the lifestyles of the fungal taxa reported in the checklist, including their epiphytic nature, could not be fully included due to limited access to historical literature. Some studies did not specify whether the fungi were endophytic, saprobic, pathogenic, or epiphytic in nature. Therefore, for many species, this information remains unknown or difficult to ascertain.

12.9 Advantages and Outcomes of this Research

The documentation of this study was able to generate a detailed, digitized collection of micro fungi associated with *Musa* representing endophytic, pathogenic and saprobic life styles. This will be further contributed to the incensement of fungal numbers and further enhance the value of the conservation of biodiversity in Thailand. The correct fungal nomenclature, morphological review, phylogenetic evaluation and the laboratory-based research experience will provide strong platforms to the future research works of taxonomists, pathologists, and quarantine systems.

These intimate associations of different lifestyles of fungi associated with *Musa* were studied with morphological and phylogenetic evidences. Those hidden lifestyles of fungi can be crossing boarders via the banana leaf wrappers and other banana related ornaments. The documentation of the different lifestyles of the same fungi will contribute to the international crop security and food protection.

The hidden saprobic fungal niches associated with *Musa* were revealed and the DNA sequence data were deposited in GenBank for future phylogenetic analyses and nomenclature procedures. The new endophytic fungal niches were able to document which has been not previously identified. The potential endophytic fungal groups which produces bioactive compounds were identified, isolated and made available in the culture collection institutes for industrial use.

As the major finding, the new fungal incidents of post-harvest fungal diseases (anthracnose and speckle) on *Musa* fruits in Thailand were able to report. In addition, the fungal taxa that might have a potential of causing pre-harvest leaf diseases (mainly leaf spots) were revealed with the correct identifications that will be further useful in pre-harvest disease management and control of commercial banana industry.

Living cultures are preserved in the culture collection of Mae Fah Luang University (MFLUCC) for future industrial applications. The herbarium materials of all the fungal collections are deposited in the Fungarium of Mae Fah Luang University (Herb. MFLU) for future reference. These living cultures can be used in future chemical research and act as good sources of fungi with bioactive properties and toxicological studies. In addition, the isolates can be used in the future as aids or living tools for polyphasic taxonomic approaches such as chemotaxonomy.

The outcome of this research work will contribute to the advanced pre-harvest productivity and improved post-harvest quality of the commercial *Musa* industry. The information that generate from this study will be implemented in disease identification, management and control. In addition, the results will be further utilized in establishing quarantine regulations and prevent the international spread of fungal diseases associated with *Musa*.

The global checklist of fungi associated with *Musa* provides a standardized framework for taxonomic clarity, disease management, and scientific research. The precise identification of different fungal groups, their geographical distribution, and

the host species enables early preventive strategies to identify and control the diseases on *Musa* crops worldwide. This simultaneously enhances agricultural productivity and food security and further supports the risk assessment and early detection of emerging fungal threats, associated with *Musa* cultivation systems.

The data curation of this study presents an accurately curated, detailed and digitized list of microfungi associated with *Musa*. It showcases the wide spectrum of endophytic, pathogenic and saprobic lifestyles these fungi exhibit. This is significantly augmenting existing fungal databases, bolstering biodiversity conservation efforts, with a notable impact within Thailand. Through the use of precise fungal nomenclature and comprehensive morphological and phylogenetic analyses, the study laid a robust foundation for future research in taxonomy, plant pathology and biosecurity.

12.10 Future Directions

The pathogenicity of the fungal taxa, *viz*. *Colletotrichum siamense*, *Curvularia umbiliciformis*, *Metulocladosporiella musae*, *Neocordana musae*, *Neopestalotiopsis clavispora*, *N. musae*, *Phaeosphaeria oryzae*, and *Pyrenochaetopsis musae*, that are associated with *Musa* leaf spots, can be conducted in the future. The field trials should be conducted on the respective strains with the tissue-cultured plants of the accurate banana cultivar. In addition, the crown rot disease of *Musa* fruits is necessary to study, and the systematics of the fungal complex should be investigated. The cigar end rot of *Musa* inflorescence and the fruits (the pre-harvest disease) is crucial to investigate in future studies. In addition, there have been many pre-harvest leaf diseases associated with *Musa* leaf and the pseudo-stem. The disease-causing agents with confirmed morpho-molecular evidence will be studied in the future.

The bioactive properties of the identified fungal strains in *Corynesporascaceae*, *Hypoxylaceae*, *Phaeosphaeriaceae*, *Plectosphaerellaceae*, and *Tubeufiaceae* are recommended for future research. In addition, the toxicological profiles of fungi in *Stachybotryaceae* (*Albifimbria verrucaria*, *Memnoniella levispora*,

Smaragdiniseta musae, Stachybotrys microspores, and S. musae) can be screened as a future research project.

In addition, the taxonomy and phylogeny of the fungal taxa that have been identified at the generic level (Table 12.1) will be investigated in the future. This will result in few taxonomic novelties from family level to species level with the detailed morphological justifications together with phylogenetic evidence.

12.11 Publications Generated from the Thesis

This data in this dissertation could generate nine first author (8 published, 1 accepted) publications and 8 co-author publications in peer reviewed journals as follows;

First author publications

1. Samarakoon, B. C., Wanasinghe, D. N., Samarakoon, M. C., Bundhun, D., Jayawardena, R., Hyde, K. D., . . . Chomnunti, P. (2024). Exploring fungi: A taxonomic and phylogenetic study of leaf-inhabiting *Ascomycota* in *Musa* species from northern Thailand, with a global checklist. *Mycosphere, (Accepted).*

2. Samarakoon, B. C., Samarakoon, M. C., Wanasinghe, D. N., Jayawardena, R. S., Hyde, K. D., & Chomnunti, P. (2024). Taxonomic and phylogenetic assessment of selected fungal pathogens associated with banana fruits in the local markets of northern Thailand. *European Journal of Plant Pathology*, 1-20. https://doi.org/10.1007/s10658-024-28

3. Samarakoon, B. C., Wanasinghe, D., Bhat, J., & Chomnunti, P. (2022). Taxonomy and phylogeny of *Smaragdiniseta musae* sp. nov. and *Albifimbria verrucaria* (*Hypocreales*, *Stachybotryaceae*) on *Musa* from Thailand. *Biodiversity Data Journal*, *10*, Article e89360.

4. Samarakoon, B. C., Wanasinghe, D. N., Phookamsak, R., Bhat, J., Chomnunti, P., Karunarathna, S. C., . . . Lumyong, S. (2021). *Stachybotrys musae* sp. nov., *S. microsporus*, and *Memnoniella levispora* (*Stachybotryaceae*, *Hypocreales*) found on bananas in China and Thailand. *Life*, *11*, 323.

5. Samarakoon, B. C., Phookamsak, R., Karunarathna, S. C., Jeewon, R., Chomnunti, P., Xu, J. C., . . . Li, Y. J. (2021). New host and geographic records of five pleosporalean hyphomycetes associated with *Musa* spp. (Banana). *Studies in Fungi*, *6*, 92–115.

6. Samarakoon, B. C., Wanasinghe, D. N., Samarakoon, M. C., Phookamsak, R., McKenzie, E. H. C., Chomnunti, P., Hyde, K. D., Lumyong, S., & Karunarathna, S. C. (2020). Multi-gene phylogenetic evidence suggests *Dictyoarthrinium* belongs in *Didymosphaeriaceae* (*Pleosporales*, *Dothideomycetes*) and *Dictyoarthrinium musae* sp. nov. on *Musa* from Thailand. *MycoKeys*, *71*, 101–118.

7. Samarakoon, B. C., Phookamsak, R., Wanasinghe, D. N., Chomnunti, P., Hyde, K. D., McKenzie, E. H. C., Promputtha, I., Xu, J. C., & Li, Y. J. (2020). Taxonomy and phylogenetic appraisal of *Spegazzinia musae* sp. nov. and *S. deightonii* (*Didymosphaeriaceae*, *Pleosporales*) on *Musaceae* from Thailand. *MycoKeys*, *70*, 19–37. https:// doi.org/10. 3897/mycokeys.70.52043

8. Samarakoon, B. C., Samarakoon, M. C., Aluthmuhandiram, J. V. S., Wanasinghe, D. N., & Chomnunti, P. (2019). The first report of *Daldinia eschscholtzii* as an endophyte from leaves of *Musa sp.* (*Musaceae*) in Thailand. *Asian Journal of Mycology*, *2*, 183–197. https://doi.org/10.5943/ajom/2/1/9

9. Samarakoon, B. C., Wanasinghe, D. N., Jeewon, R., Tian, Q., Jayawardena, R. S., & Chomnunti, P. (2019). The plant pathogenic genus *Neocordana*. *Plant Pathology & Quarantine*, *9*, 139–151. https://doi.org/10.5943/ppq/9/1/12

Co-author publications

10. Chethana, K. W. T., Rathnayaka, A. R., Samarakoon, B. C., Wu, N., Wijesinghe, S. N., Yasanthika, W. A. E., Sysouphanthong, P., Thiyagaraja, V., Armand, A., Lestari, A. S., Madagammana, A. D., Ediriweera, A. N., Prematunga, C., Li, C. J.-Y., Tennakoon, D. S., Gomdola, D., Marasinghe, D. S., Bundhun, D., Pem, D., Ren, G., . . . Hyde, K. D. (2023). AJOM new records and collections of fungi: 151–200. *Asian Journal of Mycology*, *6*, 89–243.

11. Chethana, K. W. T., Niranjan, M., Dong, W., Samarakoon, M. C., Bao, D. F., Calabon, M. S., Chaiwan, N., Chuankid, B., Dayarathne, M. C., de Silva, N. I., Devadatha, B., Dissanayake, A. J., Goonasekara, I. D., Huanraluek, N., Jayawardena, R. S., Karunarathna, A., Luo, Z. L., Marasinghe, D. S., Ma, X. Y.,. . . Hyde, K. D.

(2021). AJOM new records and collections of fungi: 101–150. *Asian Journal of Mycology*, *4*, 113–260. https://doi.org/10.5943/ajom/5/1/11

12. Hyde, K. D., Norphanphoun, C., Maharachchikumbura, S. S. N., Bhat, D. J., Jones, E. B. G., Bundhun, D., Chen, Y. J., Bao, D. F., Boonmee, S., Calabon, M. S., Chaiwan, N., Chethana, K. W. T., Dai, D. Q., Dayarathne, M. C., Devadatha, B., Dissanayake, A. J., Dissanayake, L. S., Doilom, M., Dong, W.,. . . Xiang, M. M. (2020). Refined families of *Sordariomycetes*. *Mycosphere*, *11*, 305–1059. https://doi.org/10.5943/mycosphere/11/1/7

13. Hyde, K. D., Xu, J., Rapior, S., Jeewon, R., Lumyong, S., Niego, A. G. T., Abeywickrama, P. D., Aluthmuhandiram, J. V. S., Brahamanage, R. S., Brooks, S., Chaiyasen, A., Chethana, K. W. T., Chomnunti, P., Chepkirui, C., Chuankid, B., de Silva, N. I., Doilom, M., Faulds, C., Gentekaki, E., . . . Stadler, M. (2019). The amazing potential of fungi: 50 ways we can exploit fungi industrially. *Fungal Diversity*, *97*, 1–136. https://doi.org/10.1007/s13225-019-00431-1

14. Jayawardena, R. S., Hyde, K. D., Gomes de Farias, A. R., Bhunjun, C. S., Ferdinandez, H. S., Manamgoda, D. S., Udayanga, D., Herath, I. S., Thambugala, K. M., Manawasinghe, I. S., Gajanayake, A. J., Samarakoon, B. C., Bundhun, D., Gomdola, D., Huanraluek, N., Sun, Y., Tang, X., Promputtha, I., Silva, N. I, . . . Thines, M. (2021). What is a species in fungal plant pathogens? *Fungal Diversity*, *109*, 239–266. https://doi.org/10.1007/s13225-020-00455-0

15. Jayawardena, R. S., Hyde, K. D., Wang, S., Sun, Y.-R., Suwannarach, N., Sysouphanthong, P., Abdel-Wahab, M. A., Abdel-Aziz, F. A., Abeywickrama, P. D., Abreu, V. P., Armand, A., Aptroot, A., Bao, D.-F., Begerow, D., Bellanger, J.-M., Bezerra, J. D. P., Bundhun, D., Calabon, M. S., Cao, T., . . . Wang, Y. (2022). Fungal diversity notes 1512–1610: Taxonomic and phylogenetic contributions on genera and species of fungal taxa. *Fungal Diversity*, *117*, 1–272. https://doi.org/ 10.1007/s13225-022-00500-1

16. Jayawardena, R. S., Hyde, K. D., Aumentado, H. D. R., Abeywickarama, P. D., Avasthi, S., Dissanayake, A. J., Gautam, A. K., Gayanayake, A. J., Armand, A., Balendres, M. A. O., Calabon, M. S., Cheng, Y. J., Chethana, K. W. T., Ferdinandez, H. S., Gomdola, D., Jose, P. A., Kowalski, T., Kularathnage, N. D., Kumar, S., Lan, Y., . . . Wang, Y. (2024). One Stop Shop V: Taxonomic update

with molecular phylogeny for important phytopathogenic genera: 101-125. Fungal Diversity. (In review).

17. Yasanthika, E., Dissanayake, L. S., Wanasinghe, D. N., Karunarathna, S. C., Mortimer, P. E., Samarakoon, B. C., . . . Hyde, K. D. (2020). *Lonicericola fuyuanensis* (*Parabambusicolaceae*) a new terrestrial pleosporalean ascomycete from Yunnan Province, China. *Phytotaxa, 446*, 103–113. https://doi.org/10.11646/phytotaxa.446.2.3

18. Yasanthika, W. A., Wanasinghe, D. N., Karunarathna, S. C., Bhat, D. J., Samarakoon, B. C., Ren, G. C., . . . Hyde, K. D. (2020). Two new *Sordariomycetes* records from forest soils in Thailand. *Asian Journal of Mycology*, *3*, 456–471.

REFERENCES

REFERENCES

Abayasekara, C. L., Adikaram, N. K. B., Wanigasekara, U. W. N. P., & Bandara, B. M. R. (2013). *Phyllosticta musarum* infection-induced defenses suppress anthracnose disease caused by *Colletotrichum musae* in banana fruits cv 'Embul'. *The Plant Pathology Journal*, *29*, 77.

Abd-Alla, M. A., El-Gamal, N. G., El-Mougy, N. S., & Abdel-Kader, M. M. (2014). Post harvest treatments for controlling crown rot disease of Williams banana fruits (*Musa acuminata* L) in Egypt. *Plant Pathology and Quarantine, 4*, 1–12.

Abd-Elsalam, K. (2009). First report of *Fusarium thapsinum* on imported banana fruits into Saudi Arabia. *Pest Technology, 3*, 25–27.

Abeywickrama, P. D., Camporesi, E., Jayawardena, R. S., Hyde, K. D., Yan, J., Zhang, W., . . . Li, X. (2022). Novel and surprising host associations of *Diaporthe* (*Diaporthaceae, Diaporthales*) species from Italy. *Chiang Mai Journal of Science, 49*, 223–247.

Acabal, B. D., Dalisay, T. U., Groenewald, J. Z., Crous, P. W., & Cumagun, C. J. R. (2019). *Athelia rolfsii* (= *Sclerotium rolfsii*) infects banana in the Philippines. *Australasian Plant Disease Notes, 14*, 1–3.

Adikaram, N. K. B., & Yakandawala, D. M. D. (2020). A checklist of plant pathogenic fungi and *Oomycota* in Sri Lanka. *Ceylon Journal of Science, 49*, 93–123.

Ahmad, S. (1969). *Fungi of west Pakistan. Biological Society of Pakistan Monograph, 5*, 1–110.

Ahmad, S., Iqbal, S. H., & Khalid, A. N. (1997). *Fungi of Pakistan*. Sultan Ahmad Mycological Society of Pakistan.

Akello, J., Dubois, T., Coyne, D., & Kyamanywa, S. (2008). Endophytic *Beauveria bassiana* in banana (*Musa* spp.) reduces banana weevil (*Cosmopolites sordidus*) fitness and damage. *Crop Protection, 27,* 1437–1441.

Alam, M. W., Malik, A., Rehman, A., Hameed, A., Tahir, U., Sarwar, M., . . . Shafeeq, T. (2021). First record of *Colletotrichum gloeosporioides* causing anthracnose of banana in Pakistan. *Plant Disease, 105,* 2013.

Albu, S., Schneider, R. W., Price, P. P., & Doyle, V. P. (2016). *Cercospora cf. flagellaris* and *Cercospora cf. sigesbeckiae* are associated with Cercospora leaf blight and purple seed strain on soybean in north America. *Phytopathology, 106,* 1376–1385.

Alexopoulos, C. J. (1940). Some fungi from Greece. *Mycologia, 32,* 336–358.

Alfieri, S. A., Langdon, K. R., Wehlburg, C., & Kimbrough, J. W. (1984). *Index of plant diseases in Florida (Revised)*. Florida Department of Agriculture and Consumer Services.

Ali, M. S., & Saikia, U. N. (1997). Coelomycetes of Assam. *Indian Phytopathology, 50,* 200–205.

Alizadeh, A., Javan-Nikkhah, M., Nourmohammadi, N. R., Liu, F., Fotouhifar, K., & Damm, U. (2022). New species of *Colletotrichum* from wild *Poaceae* and *Cyperaceae* plants in Iran. *Mycologia, 114,* 89–113.

Alizadeh, A., Javan-Nikkhah, M., Zare, R., Fotouhifar, K. B., Damm, U., & Stukenbrock, E. H. (2015). New records of *Colletotrichum* species for the *mycobiota* of Iran. *Mycologia Iranica, 2,* 95–109.

Alkan, N., & Fortes, A. M. (2015). Insights into molecular and metabolic events associated with fruit response to post-harvest fungal pathogens. *Frontiers in Plant Science, 6,* 889.

Allen, R., & Dettmann, E. (1990). Production of *conidia* and *appressoria* by *Cordana johnstonii* on banana. *Mycological Research, 94,* 815–818.

Almenares, M., & Pérez-Vicente, L. (2019). Speckle by *Corynespora torulosa* Syd., Crous: A pre-harvest fruit disease of *Musa* spp. in Cuba. *Rev Protección Veg*, *34*, Article e06.

Altomare, C., Petrini, O., Logrieco, A., & Bottalico, A. (1997). Taxonomic relationships among the toxigenic species *Fusarium acuminatum*, *Fusarium sporotrichioides*, *Fusarium sporotrichioides*, and *Fusarium tricinctum* by isozyme analysis and RAPD assay. *Canadian Journal of Botany*, *75*, 1674–1684.

Alvarez, M. G. (1976). *Primer catalogo de enfermedades de plantas Mexicanas* [First catalog of mexican plant diseases], *Fitofilo*, *71*, 1–169.

Alvindia, D. G. (2012). Inhibitory influence of biocontrol agents, plant oils and an inorganic salt on *Mycosphaerella fijiensis* and *Cordana musae*, the causal pathogen of black sigatoka and leaf spot of banana. *African Journal of Microbiology Research*, *6*, 4179–4184.

Alvindia, D. G., & Yuuri, H. (2011). Identification of *Clonostachys* and *Trichoderma* spp. from banana fruit surfaces by cultural, morphological, and molecular methods. *Mycology*, *2*, 109–115.

Alvindia, D. G., Kobayashi, T., Yaguchi, Y., & Natsuaki, K. T. (2002). Pathogenicity of fungi isolated from "Non-Chemical Bananas". *Japanese Journal of Tropical Agriculture, 46*, 215–223.

Amani, M. (2011). Identification of fungal pathogens on banana (*Musa acuminata*) in Sistan & Bluchestan province. *Journal of Novel Researches on Plant Protection, 3,* 158–145.

Amani, M., & Avagyan, G. (2014). Isolation and identification of fungal pathogens on banana trees (*Musa acuminata L.*) in Iran. *International Journal of Agri Science, 4*, 409–413.

Amano, K. (1986). *Host range and geographical distribution of the powdery mildew fungi*. Japan Science Society Press.

Amin, M. N., & Hossain, M. M. (2012). Reduction of postharvest loss and prolong the shelf-life of banana through hot water treatment. *Journal of Chemical Engineering*, *27*, 42–47.

Andersen, B., Kroger, E., & Roberts, R. G. (2001). Chemical and morphological segregation of *Alternaria alternata*, *A. gaisen*, and *A. longipes*. *Mycological Research*, *105*, 291–299.

Anikster, Y. (1984). Contribution to the knowledge of nuclear history in some *Pucciniaceae*. *Tottori Mycological Institute*, *22*, 120–123.

Anikster, Y. (1986). Teliospore germination in some rust fungi. *Phytopathology*, *76*, 1026–1030.

Anupunt, P. (2002). Banana in Thailand. *Advancing Banana and Plantain R&D in Asia and the Pacific*, *11*, 149.

Aptroot, A. (1995). Redisposition of some species excluded from *Didymosphaeria* (*Ascomycotina*). *Nova Hedwigia*, *60*, 325–379.

Araujo, N. A. F., Pasqual, M., Pio, L. A. S., Alves, E., Moura, N. M., & Costa, S. (2017). Identification and aggressiveness of four isolates of *Fusarium oxysporum* f. sp. *cubense* from Latundan banana in Brazil. *Journal of Phytopathology*, *165*, 257–264.

Ariyawansa, H. A., Maharachchikumbura, S. S., Karunarathna, S. C., Chukeatirote, E., Bahkali, A. H., Kang, J. K., . . . Hyde, K. D. (2013). *Deniquelata barringtoniae* gen. et sp. nov., associated with leaf spots of *Barringtonia asiatica*. *Phytotaxa*, *105*, 11–20.

Ariyawansa, H. A., Tanaka, K., Thambugala, K. M., Phookamsak, R., Tian, Q., Camporesi, E., . . . Hyde, K. D. (2014). A molecular phylogenetic reappraisal of the *Didymosphaeriaceae = Montagnulaceae*. *Fungal Diversity, 68,* 69–104.

Ariyawansa, H. A., Thambugala, K. M., Manamgoda, D. S., Jayawardena, R., Camporesi, E., Boonmee, S., . . . Hyde, K. D. (2015). Towards a natural classification and backbone tree for *Pleosporaceae*. *Fungal Diversity*, *71*, 85–139.

Arnold, G. R. W. (1986). *Lista de Hongos Fitopatogenos de Cuba* [List of phytopathogenic fungi of Cuba]. Ministerio de Cultura Editorial Cientifico-Tecnica.

Arzanlou, M., & Crous, P. W. (2006). *Phaeosphaeriopsis musae* M. Arzanlou and Crous, sp. nov. *Fungal Planet: A Global Initiative to Promote the Study of Fungal Biodiversity*, *9*, 398.

Arzanlou, M., Groenewald, J. Z., Fullerton, R. A., Abeln, E. C., Carlier, J., Zapater, M. F., . . . Crous, P. W. (2008). Multiple gene genealogies and phenotypic characters differentiate several novel species of *Mycosphaerella* and related anamorphs on banana. *Persoonia*, *20*, 19–37.

Arzanlou, M., Groenewald, J. Z., Gams, W., Braun, U., Shin, H. D., & Crous, P. W. (2007). Phylogenetic and morphotaxonomic revision of *Ramichloridium* and allied genera. *Studies in Mycology*, *58*, 57–93.

Ashby, S. F. (1913). *Bulletin of the Department of Agriculture of Jamaica*, *2*, 118.

Assaf, L. H. (2020). Molecular identification and insecticidal activity of *Albifimbria verrucaria* isolated from cucurbit plants and soil in Iraq. *Journal of Duhok University*, *23*, 106–113.

Assunção, M. M. C., Cavalcanti, M. D. Q., & Menezes, M. (2010). *Schizophyllum commune* isolated from banana leaves (*Musa* spp.) as endophytic fungi in Pernambuco, Brazil. *Agrotrópica*, *22*, 67–70.

Atienza, V., Hawksworth, D. L., & Pérez-Ortega, S. (2021). *Verrucoccum* (*Dothideomycetes, Dictyosporiaceae*) – A new genus of lichenicolous fungi on *Lobaria s. lat.* for the *Dothidea hymeniicola* species complex. *Mycologia, 113*, 1233–1252.

Atsatt, P. R., & Whiteside, M. D. (2014). Novel symbiotic protoplasts formed by endophytic fungi explain their hidden existence, lifestyle switching, and diversity within the plant kingdom. *PLoS One, 9*, Article e95266.

Aveskamp, M. M., de Gruyter, J., Woudenberg, J. H. C., Verkley, G. J. M., & Crous, P. W. (2010). Highlights of the *Didymellaceae*: A polyphasic approach to characterise *Phoma* and related pleosporalean genera. *Studies in Mycology, 65*, 1–60.

Bahcecioglu, Z., & Kabaktepe, S. (2012). Checklist of rust fungi in Turkey. *Mycotaxon*, *119*, 494.

Bainier, G., & Sartory, A. (1912). Étude d'un *Penicillium* nouveau *Penicillium musae* (n sp) [Study of a new *Penicillium, Penicillium musae* (new species)], *Annales Mycologici*, *10*, 398.

Baker, R. E. D., & Dale, W. T. (1951). Fungi of Trinidad and Tobago. *Mycological Papers*, *33*, 1–123.

Bansiddhi, K. (2003). Current status and prospects of banana R & D in Thailand. In *Advancing Banana and Plantain R & D in Asia and the Pacific, 12*, 111.

Bao, D. F., Bhat, D. J., Boonmee, S., Hyde, K. D., Luo, Z. L., & Nalumpang, S. (2022). Lignicolous freshwater ascomycetes from Thailand: Introducing *Dematipyriforma muriformis* sp. nov., one new combination, and two new records in *Pleurotheciaceae*. *MycoKeys*, *93*, 57–79.

Barelli, L., Moonjely, S., Behie, S. W., & Bidochka, M. J. (2016). Fungi with multifunctional lifestyles: Endophytic insect pathogenic fungi. *Plant Molecular Biology*, *90*, 657–664.

Barnes, I., Roux, J., Wingfield, B. D., Dudzinski, M. J., Old, K. M., & Wingfield, M. J. (2003). *Ceratocystis pirilliformis*, a new species from *Eucalyptus nitens* in Australia. *Mycologia*, *95*, 865–871.

Barrios, L. M., & Pérez, I. O. (2005). Nuevos registros de hongos en semillas de *Oryza sativa* en Cuba. *Manejo Integrado de Plagas y Agroecología*, *75*, 64–67.

Bashar, M. A., Shamsi, S., & Hossain, M. (2012). Fungi associated with rotten fruits in Dhaka metropolis. *Bangladesh Journal of Botany*, *41*, 115–117.

Batista, A. C. (1959). *Monografia dos fungos Micropeltaceae* [Monograph of the *Micropeltaceae* fungi]. Universidade do Recife Inst Micologia.

Batista, A. C., & Ciferri, R. (1962). The *Chaetothyriales*. *Beiträge zur Kenntnis der Pilze Mitteleuropas*, *3*, 1–129.

Batista, A. C., & Vital, A. F. (1952). Monografia das espécies de *Phyllosticta* em Pernambuco. *Boletín del Secretariado de Industria y Comercio de la República Argentina*, *19*, 1–80.

Batista, A. C., Falcão, R. G., & Bezerra, J. L. (1963). Some phytopathological hyphomycetes. *Revista de Agricultura*, *3*, 48–59.

Batista, E., Lopes, A., & Alves, A. (2020). *Botryosphaeriaceae* species on forest trees in Portugal: Diversity, distribution, and pathogenicity. *European Journal of Plant Pathology*, *158*, 693–720.

Batista, E., Lopes, A., & Alves, A. (2021). What do we know about *Botryosphaeriaceae*? An overview of a worldwide cured dataset. *Forests*, *12*, 313.

Bauer, R., Lutz, M., Begerow, D., Piatek, M., Vanky, K., Bacigalova, K., . . . Oberwinkler, F. (2008). Anther smut fungi on monocots. *Mycological Research*, *112*, 1297–1306.

Bechem, E. T., & Afanga, Y. A. (2017). Morphological and molecular identification of fungi associated with corm rot and blight symptoms on plantain (*Musa paradisiaca*) in macro-propagators. *International Journal of Biological and Chemical Sciences*, *11*, 2793–2808.

Benjamin, C. R., & Slot, A. (1969). Fungi of Haiti. *Sydowia*, *23*, 125–163.

Bensch, K., Braun, U., Groenewald, J. Z., & Crous, P. W. (2012). The genus *Cladosporium*. *Studies in Mycology*, *72*, 1–401.

Bensch, K., Groenewald, J. Z., Braun, U., Dijksterhuis, J., Yanez-Morales, M., & Crous, P. W. (2015). Common but different: The expanding realm of *Cladosporium*. *Studies in Mycology*, *82*, 23–74.

Bensch, K., Groenewald, J. Z., Dijksterhuis, J., Starink-Willemse, M., Andersen, B., Summerell, B. A., . . . Crous, P. W. (2010). Species and ecological diversity within the *Cladosporium cladosporioides* complex (*Davidiellaceae, Capnodiales*). *Studies in Mycology*, *67*, 1–96.

Bentley, S., Pegg, K. G., & Dale, J. L. (1995). Genetic variation among a worldwide collection of isolates of *Fusarium oxysporum* f. sp. *cubense* analyzed by RAPD-PCR fingerprinting. *Mycological Research*, *99*, 1378–1384.

Bhat, D. J. (2010). *Fascinating micro-fungi (hyphomycetes) of Western Ghats – India*. Broadway Publishing House.

Bhilabutra, W., McKenzie, E. H. C., Hyde, K. D., & Lumyong, S. (2010). Fungi on the grasses, *Thysanolaena latifolia* and *Saccharum spontaneum*, in northern Thailand. *Mycosphere*, *1*, 301–314.

Bhilabutra, W., Techowisan, T., Peberdy, J. F., & Lumyong, S. (2007). Antimicrobial activity of bioactive compounds from *Periconia siamensis* CMUGE015. *Research Journal of Microbiology, 2*, 749–755.

Bhuiyan, M. A. B., Islam, S. M. N., Bukhari, M. A. I., Kader, M. A., Chowdhury, M. Z. H., Alam, M. Z., . . . Jenny, F. (2022). First report of *Pestalotiopsis microspora* causing leaf blight of banana in Bangladesh. *Plant Disease, 106*, 1518.

Biju, C. N., Mohammed, F. P., & Rajan, G. (2018). Identification and characterization of *Neopestalotiopsis clavispora* associated with leaf blight of small cardamom (*Elettaria cardamomum* Maton). *Journal of Phytopathology, 166*, 532–546.

Bills, G. F., Gonzalez-Menendez, V., Platas, G., & Fournier, J. (2012). *Hypoxylon pulicicidum* sp. nov. (*Ascomycota, Xylariales*), a pantropical insecticide-producing endophyte. *PLoS One, 7*, Article e46687.

Bitzer, J., Laessøe, T., Fournier, J., Kummer, V., Decock, C., Tichy, H. V., . . . Stadler, M. (2008). Affinities of *Phylacia* and the daldinoid *Xylariaceae*, inferred from chemotypes of cultures and ribosomal DNA sequences. *Mycological Research, 112*, 251–270.

Boedijn, K. B. (1959). The *Uredinales* of Indonesia. *Nova Hedwigia, 1*, 463–496.

Boonmee, S., D'souza, M. J., Luo, Z., Pinruan, U., Tanaka, K., Su, H., . . . Hyde, K. D. (2016). *Dictyosporiaceae* fam. nov. *Fungal Diversity, 80*, 457–482.

Boonmee, S., Rossman, A. Y., Liu, J. K., Li, W. J., Dai, D. Q., Bhat, J. D., . . . Hyde, K. D. (2014). *Tubeufiales* ord. nov. integrating sexual and asexual generic names. *Fungal Diversity, 68*, 239–298.

Boonmee, S., Wanasinghe, D. N., Calabon, M. S., Huanraluek, N., Chandrasiri, S. K., Jones, G. E., . . . Hyde, K. D. (2021). Fungal diversity notes 1387–1511: Taxonomic and phylogenetic contributions on genera and species of fungal taxa. *Fungal Diversity, 111*, 1–335.

Booth, C. (1964). Studies of *Pyrenomycetes* VII. *Mycological Papers, 94*, 1–16.

Booth, C., & Stover, R. H. (1974). *Cylindrocarpon musae* sp. nov., commonly associated with burrowing nematode (*Radopholus similis*) lesions on bananas. *Transactions of the British Mycological Society, 63*, 506.

Borut, S. Y., & Johnson, T. W. (1962). Some biological observations on fungi in estuarine sediments. *Mycologia, 54*, 181–193.

Bragança, C. A. D., Damm, U., Baroncelli, R., Massola, N. S., & Crous, P. W. (2016). Species of the *Colletotrichum acutatum* complex associated with anthracnose diseases of fruit in Brazil. *Fungal Biology, 120*, 547–561.

Braithwaite, K. S., Irwin, J. A. G., & Manners, J. M. (1990). Ribosomal DNA as a molecular taxonomic marker for the group species *Colletotrichum gloeosporioides*. *Australian Systematic Botany, 3*, 733–738.

Braun, U. (1982). Die Rostpilze (*Uredinales*) der Deutschen Demokratischen Republik [The rust fungi (*Uredinales*) of the German Democratic Republic], *Feddes Repertorium, 93*, 213–334.

Braun, U., Crous, P. W., & Nakashima, C. (2014). Cercosporoid fungi (*Mycosphaerellaceae*) 2. Species on monocots (*Acoraceae* to *Xyridaceae*, excluding *Poaceae*). *IMA Fungus, 5*, 203–390.

Braun, U., & Sivapalan, A. (1999). Cercosporoid hyphomycetes from Brunei. *Fungal Diversity, 3*, 1–27.

Brayford, D. (1987). *Cylindrocarpon musae*. *CMI Descriptions of Pathogenic Fungi and Bacteria, 927*, 1–2.

Brown, A. E., & Swinburne, T. R. (1981). Influence of iron and iron chelators on the formation of progressive lesions by *Colletotrichum musae* on banana fruits. *Transactions of the British Mycological Society, 77*, 119–142.

Brown, K. B., Hyde, K. D., & Guest, D. I. (1998). Preliminary studies on endophytic fungal communities of *Musa acuminata* species complex in Hong Kong and Australia. *Fungal Diversity, 1*, 27–51.

Bulletin of the Société d'histoire naturelle de l'Afrique du nord. (1917). *Take huitième, Année 1917 – Siège de la Société, Faculté de Sciences d'Alger, Alger*. Société d'histoire naturelle de l'Afrique du nord.

Burgess, T. I., Barber, P. A., Mohali, S., Pegg, G., de Beer, W., & Wingfield, M. J. (2006). Three new *Lasiodiplodia* spp. from the tropics recognized based on DNA sequence comparisons and morphology. *Mycologia, 98*, 423–435.

Burgess, T. I., Tan, Y. P., Garnas, J., Edwards, J., Scarlett, K. A., Shuttleworth, L. A., . . . Jami, F. (2019). Current status of the *Botryosphaeriaceae* in Australia. *Australasian Plant Pathology, 48*, 35–44.

Busby, P. E., Ridout, M., & Newcombe, G. (2016). Fungal endophytes: Modifiers of plant disease. *Plant Molecular Biology, 90*, 645–655.

Bussaban, B., Lumyong, S., Lumyong, P., Seelanan, T., Park, D. C., McKenzie, E. H. C., . . . Hyde, K. D. (2005). Molecular and morphological characterization of *Pyricularia* and allied genera. *Mycologia, 97*, 1002–1011.

Butler, S., Young-Kelly, H., Raper, T., Cochran, A., Jordan, J., Shrestha, S., . . . Shelby, P. (2016). First report of target spot caused by *Corynespora cassiicola* on cotton in Tennessee. *Plant Disease, 100*, 535.

Cai, L., Hyde, K. D., Taylor, P. W. J., & Weir, B. (2009). A polyphasic approach for studying *Colletotrichum*. *Fungal Diversity, 39*, 183–204.

Calpouzos, L. (1955). *Studies on the Sigatoka disease of bananas and its fungus pathogen.* Atkins Garden and Research Lab, Cienfuegos, Cuba.

Cannon, P. F. (1994). The newly recognized family *Magnaporthaceae* and its inter-relationships. *Systema Ascomycetum, 13*, 25–42.

Cannon, P. F., Damm, U., Johnston, P. R., & Weir, B. S. (2012). *Colletotrichum*: current status and future directions. *Studies in Mycology, 73*, 181–213.

Cannon, P. F., & Hawksworth, D. L. (1982). A re-evaluation of *Melanospora* Corda and similar *Pyrenomycetes*, with a revision of the British species. *Botanical Journal of the Linnean Society, 84*, 115–160.

Cantone, F. A., & Vandenberg, J. D. (1998). Intraspecific diversity in *Paecilomyces fumosoroseus*. *Mycological Research, 102*, 209–215.

Cao, L. X., Tian, X. L., & Zhou, S. N. (2003). Isolation of endophytic fungi and *Actinomycetes* from banana (*Musa paradisiaca*) plants. *Acta Scientiarum Naturalium Universitatis Sunyatseni, 2*, 20–23.

Cao, L., You, J., & Zhou, S. (2002). Endophytic fungi from *Musa acuminata* leaves and roots in South China. *World Journal of Microbiology and Biotechnology, 18*, 169–171.

Cao, R., Liu, X., Gao, K., Mendgen, K., Kang, Z., Gao, J., . . . Wang, X. (2009). Mycoparasitism of endophytic fungi isolated from reed on soilborne phytopathogenic fungi and production of cell wall-degrading enzymes in vitro. *Current Microbiology, 59*, 584–592.

Carbone, I., & Kohn, L. M. (1999). A method for designing primer sets for speciation studies in filamentous ascomycetes. *Mycologia, 91*, 553–556.

Caretta, G., Piontelli, E., Picco, A. M., & Del Frate, G. (1999). Some filamentous fungi on grassland vegetation from Kenya. *Mycopathologia, 145*, 155.

Carlier, J., De Waele, D., & Escalant, J. V. (2002). *Global evaluation of Musa germplasm for resistance to Fusarium wilt, Mycosphaerella leaf spot diseases and nematodes*. INIBAP Technical Guidelines.

Carter, E., & Boudreaux, C. (2004). Fatal cerebral phaeohyphomycosis due to *Curvularia lunata* in an immunocompetent patient. *Journal of Clinical Microbiology, 42*, 5419–5423.

Cash, E. K. (1952). *A record of the fungi named by J. B. Ellis (Part 1).* U.S.D.A. Special Publication.

Castellani, E., & Ciferri, R. (1937). *Prodromus Mycoflorae Africae Orientalis Italicae* [Prodrome of the mycoflora of Italian East Africa]. Istituto Agricolo Coloniale Italiano, Firenze.

Castellani, E., & Ciferri, R. (1950). *Mycoflora Erythraea Somala et Aethiopica, Suppl. 1* [Mycoflora of Erythrea, Somalia, and Ethiopia, supplement 1]. Atti dell'Istituto Botanico della Università di Pavia, Laboratorio di Crittografia.

Cesati, V., & De Notaris, G. (1863). Schema di classificazione degle sferiacei italici aschigeri piu' o meno appartenenti al genere *Sphaeria* nell'antico significato attribuitoglide Persono [Classification scheme of Italian ash-colored sphaeraceous fungi more or less belonging to the genus *Sphaeria* in the ancient sense attributed to Person], *Commentario della Società Crittogamologica Italiana*, *1*, 177–420.

Ceylon Department of Agriculture. (1915). *Annals of the Royal Botanic Gardens, Peradeniya*. Colombo Skien Publishers.

Ceylon Department of Agriculture. (1917). *Annals of the Royal Botanic Gardens, Peradeniya*. Colombo Skien Publishers.

Chaiwan, N., Jeewon, R., Pem, D., Jayawardena, R. S., Nazurally, N., Mapook, A., . . . Hyde, K. D. (2022). Fungal species from *Rhododendron* sp., *Discosia rhododendricola* sp. nov., *Neopestalotiopsis rhododendricola* sp. nov., and *Diaporthe nobilis* as a new host record. *Journal of Fungi, 8*, 907.

Chandrasiri, S. K., Liu, Y. L., Huang, J. E., Samarakoon, M. C., Boonmee, S., Calabon, M. S., . . . Hu, D. M. (2021). *Veronaea aquatica* sp. nov. (*Herpotrichiellaceae, Chaetothyriales, Eurotiomycetes*) from submerged bamboo in China. *Biodiversity Data Journal, 9,* Article e64505.

Charlton, N. D., Carbone, I., Tavantzis, S. M., & Cubeta, M. A. (2008). Phylogenetic relatedness of the M2 double-stranded RNA in *Rhizoctonia* fungi. *Mycologia, 100*, 555–564.

Chehri, K., Salleh, B., & Zakaria, L. (2014). *Fusarium virguliforme*, a soybean sudden death syndrome fungus in Malaysian soil. *Australasian Plant Disease Notes, 9*, 128.

Chen, C. H. (2017). *Fungi on banana in northern Taiwan* (doctoral dissertation). National Central University, Taiwan.

Chen, C. H., Hsieh, S. Y., Yeh, Y. H., & Kirschner, R. (2020). *Cladocillium musae*, a new genus and species of cercosporoid fungi (*Mycosphaerellaceae*) on wild banana in Taiwan. *Mycological Progress, 19*, 837–843.

Chen, Y., Ran, S. F., Dai, D. Q., Wang, Y., Hyde, K. D., Wu, Y. M., . . . Jiang, Y. (2016). Mycosphere Essays 2. *Myrothecium*. *Mycosphere, 7*, 64–80.

Chethana, C. S., Chowdappa, P., Biju, C. N., Praveena, R., & Sujatha, A. M. (2016). Molecular and phenotypic characterization revealed six *Colletotrichum* species responsible for anthracnose disease of small cardamom in South India. *European Journal of Plant Pathology, 146*, 465–481.

Chethana, K. T., Manawasinghe, I. S., Hurdeal, V. G., Bhunjun, C. S., Appadoo, M. A., Gentekaki, E., . . . Hyde, K. D. (2021). What are fungal species and how to delineate them?. *Fungal Diversity, 109*, 1–25.

Chethana, K. W. T., Niranjan, M., Dong, W., Samarakoon, M. C., Bao, D. F., Calabon, M. S., . . . Hyde, K. D. (2021). AJOM new records and collections of fungi, 101–150. *Asian Journal of Mycology, 4*, 113–260.

Chi, P., Jiang, Z., & Xiang, M. (2007). *Flora Fungorum Sinicorum*, *Phomopsis* [Flora of fungi in China, *Phomopsis*]. Science Press, Beijing.

Chittarath, K., Mostert, D., Crew, K. S., Viljoen, A., Kong, G., Molina, A. B., . . . Thomas, J. E. (2018). First report of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (VCG 01213/16) associated with Cavendish bananas in Laos. *Plant Disease, 102*, 449–450.

Cho, W. D., & Shin, H. D. (2004). *List of plant diseases in Korea* (4th ed.). Korean Society of Plant Pathology.

Chomnunti, P., Hongsanan, S., Hudson, B. A., Tian, Q., Peršoh, D., Dhami, M. K., . . . Hyde, K. D. (2014). The sooty moulds. *Fungal Diversity, 66*, 1–36.

Chunyu, W. X., Zhao, J. Y., Ding, Z. G., Wang, Y. X., Han, X. L., Li, M. G., . . . Wen, M. L. (2018). A new dichlorinated aromatic lactone from the tin mine tailings-derived fungus *Torula* sp. YIM DT 10072. *Chemistry of Natural Compounds, 54*, 432–434.

Chupp, C. (1954). *Monograph of the fungus genus Cercospora*, Ithaca, NY.

Churchill, A. C. (2011). *Mycosphaerella fijiensis*, the black leaf streak pathogen of banana: Progress towards understanding pathogen biology and detection, disease development, and the challenges of control. *Molecular Plant Pathology, 12*, 307–328.

Ciferri, R. (1929). *Micoflora Domingensis, Lista de los hongos hasta la fecha indicados en Santo Domingo* [Mycoflora of Santo Domingo, list of fungi indicated up to date]. Agricultural institution of Moca.

Ciferri, R. (1961). *Mycoflora Domingensis Integrata* [Integrated mycoflora of Santo Domingo], *Quaderno, 19*, 1–539.

Cole, G. T. (1974). Conidiophore and conidium ontogeny in *Spegazzinia tessarthra*. *Canadian Journal of Botany, 52*, 1259–1264.

Cole, G. T. (1986). Models of cell differentiation in conidial fungi. *Microbiological Reviews, 50*, 95–132.

Companhia de Entrepostos e Armazéns Gerais de São Paulo. (2006). *Programa brasileiro para a modernização da horticultura e produção integrada de frutas. Normas de classificação de banana* [Brazilian program for the modernization of horticulture and integrated fruit production. Standards for banana classification]. São Paulo: CEAGESP.

Conner, K. N., Hagan, A. K., & Zhang, L. (2013). First report of *Corynespora cassiicola*-incited target spot on cotton in Alabama. *Plant Disease, 97*, 1379–1379.

Cooke, M. C. (1878). Ravenel's American fungi. *Grevillea, 6*, 129–146.

Cooke, M. C., & Massee, G. (1874). *Grevillea, 3*. Williams and Norgate Publishers.

Cooke, M. C., & Massee, G. (1883). *Grevillea, 12*. Williams and Norgate Publishers.

Cooke, M. C., & Massee, G. (1887). *Grevillea, 16*. Williams and Norgate Publishers.

Cooke, T., Persley, D., & House, S. (2009). *Diseases of fruit crops in Australia*. CSIRO Publishing.

Corbett, D. C. M. (1964). A supplementary list of plant diseases in Nyasaland. *Mycological Papers, 95*, 1–16.

Costa, J. F. O., Kamei, S. H., Silva, J. R. A., Miranda, A. R. G. S., Netto, M. B., da Silva, S. J. C., . . . Assunção, I. P. (2019). Species diversity of *Colletotrichum* infecting *Annona spp.* in Brazil. *European Journal of Plant Pathology, 153*, 1119–1130.

Crane, J. L., & Miller, A. N. (2016). Studies in genera similar to *Torula*: *Bahusaganda*, *Bahusandhika*, *Pseudotorula*, and *Simmonsiella* gen. nov. *IMA Fungus, 7*, 29–45.

Crane, J. L., & Schoknecht, J. D. (1977). Revision of *Torula* species. *Rutola*, a new name for *Torula graminis*. *Canadian Journal of Botany, 55*, 3013–3019.

Crane, J. L., & Shearer, C. A. (1991). A nomenclator of *Leptosphaeria* V. Cesati & G. DeNotaris. *Illinois Natural History Survey Biological Notes, 34*, 1–355.

Crous, P. W. (2002). *Taxonomy and pathology of Cylindrocladium (Calonectria) and allied genera*. American Phytopathological Society (APS Press).

Crous, P. W., & Braun, U. (1996). *Cercosporoid* fungi from South Africa. *Mycotaxon, 57*, 233–321.

Crous, P. W., & Braun, U. (2003). *Mycosphaerella and its anamorphs: 1. Names published in Cercospora* and *Passalora*. Centraalbureau voor Schimmelcultures.

Crous, P. W., & Groenewald, J. Z. (2013). A phylogenetic re-evaluation of *Arthrinium*. *IMA Fungus, 4*, 133–154.

Crous, P. W., & Mourichon, X. (2002). *Mycosphaerella eumusae* and its anamorph *Pseudocercospora eumusae* spp. nov., causal agent of *eumusae* leaf spot disease of banana. *Sydowia, 54*, 35–43.

Crous, P. W., Allegrucci, N., Arambarri, A. M., Cazau, M. C., Groenewald, J. Z., & Wingfield, M. J. (2005). *Dematiocladium celtidis* gen. et sp. nov. (*Nectriaceae*, *Hypocreales*), a new genus from *Celtis* leaf litter in Argentina. *Mycological Research, 109*, 833–840.

Crous, P. W., Braun, U., Wingfield, M. J., Wood, A. R., Shin, H. D., Summerell, B. A., & Groenewald, J. Z. (2009). Phylogeny and taxonomy of obscure genera of microfungi. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 22*, 139–161.

Crous, P. W., Carlier, J., Roussel, V., & Groenewald, J. Z. (2021). *Pseudocercospora* and allied genera associated with leaf spots of banana (*Musa* spp.). *Fungal Systematics and Evolution, 7*, 1–19.

Crous, P. W., Carris, L. M., Giraldo, A., Groenewald, J. Z., Hawksworth, D. L., Hemández-Restrepo, M., . . . Wood, A. R. (2015). The genera of fungi-fixing the application of the type species of generic names-G 2: *Allantophomopsis*, *Latorua*, *Macrodiplodiopsis*, *Macrohilum*, *Milospium*, *Protostegia*, *Pyricularia*, *Robillarda*, *Rotula*, *Septoriella*, *Torula*, and *Wojnowicia*. *IMA Fungus, 6*, 163–198.

Crous, P. W., Groenewald, J. Z., Risede, J. M., Simoneau, P., & Hyde, K. D. (2006). *Calonectria* species and their *Cylindrocladium* anamorphs, species with clavate vesicles. *Studies in Mycology, 55*, 213–226.

Crous, P. W., Groenewald, J. Z., Shivas, R. G., Edwards, J., Seifert, K. A., Alfenas, A. C., . . . Quaedvlieg, W. (2011). Fungal Planet description sheets 69–91. *Persoonia, 26*, 108–156.

Crous, P. W., Osieck, E. R., Jurjevi, Ž., Boers, J., Van Iperen, A. L., Starink-Willemse, M., . . . Siepe, K. (2021). Fungal Planet description sheets, 1284–1382. *Persoonia–Molecular Phylogeny and Evolution of Fungi, 47*, 178–374.

Crous, P. W., Phillips, A. J. L., & Baxter, A. P. (2000). *Phytopathogenic fungi from South Africa*. University of Stellenbosch, Department of Plant Pathology Press.

Crous, P. W., Quaedvlieg, W., Sarpkaya, K., Can, C., & Erkilic, A. (2013). *Septoria*-like pathogens causing leaf and fruit spot of pistachio. *IMA Fungus, 4*, 187–199.

Crous, P. W., Schroers, H. J., Groenewald, J. Z., Braun, U., & Schubert, K. (2006). *Metulocladosporiella* gen. nov for the causal organism of *Cladosporium* speckle disease of banana. *Mycological Research, 110*, 264–275.

Crous, P. W., Schroers, H. J., Groenewald, J. Z., Braun, U., & Schubert, K. (2006). *Metulocladosporiella* gen. nov. for the causal organism of *Cladosporium* speckle disease of banana. *Mycological Research, 110*, 264–275.

Crous, P. W., Schubert, K., Braun, U., De Hoog, G. S., Hocking, A. D., Shin, H. D., . . . Groenewald, J. Z. (2009). Opportunistic human-pathogenic species in the *Herpotrichiellaceae* are phenotypically similar to saprobic or phytopathogenic species in the *Venturiaceae*. *Studies in Mycology, 64*, 123–133.

Crous, P. W., Schumacher, R. K., Akulov, A., Thangavel, R., Hernandez–Restrepo, M., Carnegie, A. J., . . . Groenewald, J. Z. (2019). New and interesting fungi 2. *Fungal Systematics and Evolution, 3*, 57–134.

Crous, P. W., Schumacher, R. K., Wingfield, M. J., Akulov, A., Denman, S., Roux, J., . . . Groenewald, J. Z. (2018). New and interesting Fungi 1. *Fungal Systematics and Evolution, 1*, 169–215.

Crous, P. W., Shivas, R. G., Quaedvlieg, W., van der Bank, M., Zhang, Y., Summerell, B. A., Guarro, J., Wingfield, M. J., Wood, A. R., Alfenas, A. C., Braun, U., Cano-Lira, J. F., García, D., Marin-Felix, Y., Alvarado, P., Andrade, J. P., Armengol, J., Assefa, A., den Breeÿen, A., . . . Groenewald, J. Z. (2014). Fungal planet description sheets, 214–280. *Persoonia, 32*, 184–306.

Crous, P. W., Wingfield, M. J., Burgess, T. I., Carnegie, A. J., Hardy, G. E. S. J., Smith, D., Summerell, B. A., Cano-Lira, J. F., Guarro, J., Houbraken, J., Lombard, L., Martín, M. P., Sandoval-Denis, M., Alexandrova, A. V., Barnes, C. W., Baseia, I. G., Bezerra, J. D. P., Guarnaccia, V., May, T. W., . . . Groenewald, J. Z. (2017). Fungal planet description sheets 625–715. *Persoonia, 39*, 270–467.

Crous, P. W., Wingfield, M. J., Burgess, T. I., Hardy, G. E. S. J., Gené, J., Guarro, J., Baseia, I. G., García, D., Gusmão, L. F. P., Souza-Motta, C. M., Thangavel, R., Adamčík, S., Barili, A., Barnes, C. W., Bezerra, J. D. P., Bordallo, J. J., Cano-Lira, J. F., de Oliveira, R. J. V., Ercole, E., . . . Groenewald, J. Z. (2018). Fungal planet description sheets 716–784. *Persoonia, 40*, 240–393.

Crous, P. W., Wingfield, M. J., Burgess, T. I., Hardy, G. E., Crane, C., Barrett, S., Cano-Lira, J. F., Le Roux, J. J., Thangavel, R., Guarro, J., Stchigel, A. M., Martín, M. P., Alfredo, D. S., Barber, P. A., Barreto, R. W., Baseia, I. G., Cano-Canals, J., Cheewangkoon, R., Ferreira, . . . Groenewald, J. Z. (2016). Fungal planet description sheets 469–557. *Persoonia, 37*, 218–403.

Crous, P. W., Wingfield, M. J., Guarro, J., Cheewangkoon, R., van der Bank, M., Swart, W. J., Stchigel, A. M., Cano-Lira, J. F., Roux, J., Madrid, H., Damm, U., Wood, A. R., Shuttleworth, L. A., Hodges, C. S., Munster, M., de Jesús Yáñez-Morales, M., Zúñiga-Estrada, L., Cruywagen, E. M., . . . Groenewald, J. Z. (2013). Fungal planet description sheets 154–213. *Persoonia, 31*, 188–296.

Crous, P., Carlier, J., Roussel, V., & Groenewald, J. Z. (2020). *Pseudocercospora* and allied genera associated with leaf spots of banana (*Musa* spp.). *Fungal Systematics and Evolution, 7*, 1–19.

Da Cunha, K. (2014). *Phenotypic and molecular characterization of clinical isolates of Bipolaris, Curvularia, Exserohilum, and Pithomyces* (doctoral dissertation), Universitat Rovira, Virgili.

Dade, H. A. (1940). A revised list of Gold Coast fungi and plant diseases. *Bulletin of Miscellaneous Information, 6*, 205–247.

Daengsuwan, W., Wonglom, P., Arikit, S., & Sunpapao, A. (2021). Morphological and molecular identification of *Neopestalotiopsis clavispora* causing flower blight on *Anthurium andraeanum* in Thailand. *Horticultural Plant Journal, 7*, 573–578.

Dahal, G., Amatya, P., & Manandhar, H. (1992). Plant diseases in Nepal. *Review of Plant Pathology, 71*, 797–807.

Dai, D. Q., Phookamsak, R., Wijayawardene, N. N., Li, W. J., Bhat, D. J., Xu, J. C., . . . Chukeatirote, E. (2017). Bambusicolous fungi. *Fungal Diversity, 82*, 1–105.

Damm, U., Cannon, P. F., Woudenberg, J. H. C., & Crous, P. W. (2012). The *Colletotrichum acutatum* species complex. *Studies in Mycology, 73*, 37–113.

Damm, U., Cannon, P. F., Woudenberg, J. H. C., Johnston, P. R., Weir, B. S., Tan, Y. P., . . . Crous, P. W. (2012). The *Colletotrichum boninense* species complex. *Studies in Mycology, 73*, 1–36.

Damm, U., Sato, T., Alizadeh, A., Groenewald, J. Z., & Crous, P. W. (2019). The *Colletotrichum dracaenophilum*, *C. magnum*, and *C. orchidearum* species complexes. *Studies in Mycology, 92*, 1–46.

Damm, U., Sun, Y. C., & Huang, C. J. (2020). *Colletotrichum eriobotryae* sp. nov. and *C. nymphaeae*, the anthracnose pathogens of loquat fruit in central Taiwan and their sensitivity to azoxystrobin. *Mycological Progress, 19*, 367–380.

Damodaran, T., Mishra, V. K., Jha, S. K., Gopal, R., Rajan, S., & Ahmed, I. (2019). First report of Fusarium wilt in banana caused by *Fusarium oxysporum* f. sp. *cubense* tropical race 4 in India. *Plant Disease, 103*, 1022–1023.

Damon, S. C. (1953). Notes on the hyphomycetous genera *Spegazzinia*, Sacc., and *Isthmospora*. *Bulletin of the Torrey Botanical Club, 80*, 155–165.

Daranagama, D. A., Camporesi, E., Tian, Q., Liu, X., Chamyuang, S., Stadler, M., . . . Hyde, K. D. (2015). *Anthostomella* is polyphyletic comprising several genera in *Xylariaceae*. *Fungal Diversity, 73*, 203–238.

De Beer, Z. W., Duong, T. A., Barnes, I., Wingfield, B. D., & Wingfield, M. J. (2014). Redefining *Ceratocystis* and allied genera. *Studies in Mycology, 79*, 187–219.

De Gruyter, J., Woudenberg, J. H. C., Aveskamp, M. M., Verkley, G. J. M., Groenewald, J. Z., & Crous, P. W. (2010). Systematic reappraisal of species in *Phoma* section *Paraphoma*, *Pyrenochaeta*, and *Pleurophoma*. *Mycologia, 102*, 1066–1081.

De Gruyter, J., Woudenberg, J. H. C., Aveskamp, M. M., Verkley, G. J. M., Groenewald, J. Z., & Crous, P. W. (2013). Redisposition of *Phoma*-like anamorphs in *Pleosporales*. *Studies in Mycology, 75*, 1–36.

De Hoog, G. S. (1977). *Rhinocladiella* and allied genera. *Studies in Mycology*, *15*, 1–140.

De Melo, M. P., da Silva-Matos, K., & Júnior, J. E. A. B. (2016). *Thielaviopsis musarum* causes postharvest crown and fruit rot of banana in northeastern Brazil. *Tropical Plant Pathology, 41*, 258–263.

De Silva, D. D., Ades, P. K., Crous, P. W., & Taylor, P. W. J. (2017). *Colletotrichum* species associated with chili anthracnose in Australia. *Plant Pathology, 66*, 254–267.

De Silva, N. I., Maharachchikumbura, S. S. N., Thambugala, K. M., Bhat, D. J., Karunarathna, S. C., Tennakoon, D. S., . . . Hyde, K. D. (2021). Morpho-molecular taxonomic studies reveal a high number of endophytic fungi from *Magnolia candolli* and *M. garrettii* in China and Thailand. *Mycosphere, 11*, 163–237.

De Silva, N. I., Phillips, A. J., Liu, J. K., Lumyong, S., & Hyde, K. D. (2019). Phylogeny and morphology of *Lasiodiplodia* species associated with *Magnolia* forest plants. *Scientific Reports, 9*, 1–11.

De Sousa, M. R., & Lucas, M. T. (1978). Fungi Lusitaniae. *Agronomia Lusitana, 38*, 285–295.

Deighton, F. C. (1936). Preliminary list of fungi and diseases of plants in Sierra Leone and list of fungi collected in Sierra Leone. *Bulletin of Miscellaneous Information, 1936*, 397–424.

Deighton, F. C. (1960). African Fungi I. *Mycological Papers, 78*, 1–42.

Deighton, F. C. (1972). Four leaf-spotting hyphomycetes from Africa. *Transactions of the British Mycological Society, 59*, 419–427.

Delaye, L., García-Guzmán, G., & Heil, M. (2013). Endophytes versus biotrophic and necrotrophic pathogens - are fungal lifestyles evolutionarily stable traits?. *Fungal Diversity*, *60*, 125–135.

Delgado, G. (2011). Nicaraguan fungi, a checklist of hyphomycetes. *Mycotaxon*, *115*, 534–580.

Delgado-Rodriguez, G., & Mena-Portales, J. (2004). Hifomicetos (*hongos anamorficos*) de la reserva ecologica "alturas de banao" (Cuba) [Hyphomycetes (anamorphic fungi) from the ecological reserve 'Alturas de Banao' (Cuba)], *Boletin de la Sociedad Micológica de Madrid, 28*, 115–124.

Delgado-Rodriguez, G., Mena-Portales, J., & Mercado-Sierra, A. (2003). Nuevos registros de hifomicetos (*hongos anamorficos*) en las alturas de Trinidad (Cuba) [New records of hyphomycetes (anamorphic fungi) in the highlands of Trinidad (Cuba)], *Boletin de la Sociedad Micológica de Madrid, 27*, 49–54.

Delgado-Rodriguez, G., Mena-Portales, J., Calduch, M., & Decock, C. (2002). Hyphomycetes (*hongos mitosporicos*) del area protegida mil cumbres, Cuba Occidental [Hyphomycetes (mitosporic fungi) from the Mil Cumbres Protected Area, western Cuba], *Cryptogamie Mycologie*, *23*, 277–293.

Deltour, P., Franca, S. C., Heyman, L., Pereira, O. L., & Hofte, M. (2018). Comparative analysis of pathogenic and nonpathogenic *Fusarium oxysporum* populations associated with banana on a farm in Minas Gerais, Brazil. *Plant Pathology*, *67*, 707–718.

Demiray, S. T., Akçalı, E., Uysal, A., & Kurt, Ş. (2020). First report of *Thielaviopsis paradoxa* causing main stalk rot on banana in Turkey. *Plant Disease, 104*, 2733.

Denchev, C. M. (1995). Bulgarian *Uredinales*. *Mycotaxon, 55*, 405–465.

Denchev, C. M. (2001). Class *Ustomycetes* (Orders *Tilletiales*, *Ustilaginales*, and *Graphiolales*). *Fungi Bulgaricae, 4*, 1–286.

Deng, H., Xing, J., & Luo, D. (2011). Metabolites of endophytic fungus *Pestalotiopsis clavispora* isolated from the stem of *Bruguiera sexangula*. *Mycosystema, 30*, 263–267.

Dennis, R. W. G. (1970). *Kew Bulletin Additional Series III. Fungus Flora of Venezuela and Adjacent Countries*. Verlag von J. Cramer.

Diao, Y. Z., Zhang, C., Liu, F., Wang, W. Z., Liu, L., Cai, L., . . . Liu, X. L. (2017). *Colletotrichum* species causing anthracnose disease of chili in China. *Persoonia, 38*, 20–37.

Dickinson, C. H. (1968). *Gliomastix Guéguen*. *Mycological Papers, 115*, 1–115.

Dingley, J. M., Fullerton, R. A., & McKenzie, E. H. C. (1981). *Survey of agricultural pests and diseases. Technical report volume 2: Records of fungi, bacteria, algae, and angiosperms pathogenic on plants in Cook Islands, Fiji, Kiribati, Niue, Tonga, Tuvalu, and Western Samoa*. FAO.

Dissanayake, A. J., Bhunjun, C. S., Maharachchikumbura, S. S. M., & Liu, J. K. (2020). Applied aspects of methods to infer phylogenetic relationships amongst fungi. *Mycosphere, 11*, 2652–2676.

Dissanayake, A. J., Phillips, A. J. L., Hyde, K. D., Yan, J. Y., & Li, X. H. (2017). The current status of species in *Diaporthe*. *Mycosphere, 8*, 1106–1156.

Dissanayake, D. M. S., Adikaram, N. K. B., Yakandawala, D. M. D., & Jayasinghe, L. (2021). Molecular phylogeny-based identification of *Colletotrichum endophytica* and *C. siamense* as causal agents of avocado anthracnose in Sri Lanka. *Ceylon Journal of Science, 50*, 449–458.

Dita, M., Barquero, M., Heck, D., Mizubuti, E. S., & Staver, C. P. (2018). *Fusarium* wilt of banana: Current knowledge on epidemiology and research needs toward sustainable disease management. *Frontiers in Plant Science, 9*, 1468.

Doidge, E. M. (1950). The South African fungi and lichens to the end of 1945. *Bothalia, 5*, 1–1094.

Doilom, M., Dissanayake, A. J., Wanasinghe, D. N., Boonmee, S., Liu, J. K., Bhat, D. J., . . . Hyde, K. D. (2017). Microfungi on *Tectona grandis* (Teak) in northern Thailand. *Fungal Diversity, 82*, 107–182.

Dong, W., Wang, B., Hyde, K. D., McKenzie, E. H., Raja, H. A., Tanaka, K., . . . Zhang, H. (2020). Freshwater *Dothideomycetes*. *Fungal Diversity, 105*, 319–575.

Douanla-Meli, C., Unger, J. G., & Langer, E. (2018). Multi-approach analysis of the diversity in *Colletotrichum cliviae* sensu lato. *Antonie Van Leeuwenhoek, 111*, 423–435.

Du, M., Schardl, C. L., Nuckles, E., & Vaillancourt, L. J. (2005). Using mating-type gene sequences for improved phylogenetic resolution of *Collectotrichum* species complexes. *Mycologia, 97*, 641–658.

Du, Y. X., Chen, F. R., Shi, N. N., & Ruan, H. C. (2017). First report of *Fusarium chlamydosporum* causing banana crown rot in Fujian province, China. *Plant Disease, 101*, 1048–1049.

Dudka, I. O., Heluta, V. P., Tykhonenko, Y. Y., Andrianova, T. V., Hayova, V. P., Prydiuk, M. P., . . . Dzhagan, V. V. (2004). *Fungi of the Crimean Peninsula.* M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine.

Dugan, F. M., Braun, U., Groenewald, J. Z., & Crous, P. W. (2008). Morphological plasticity in *Cladosporium sphaerospermum*. *Persoonia, 21*, 9–16.

Dugan, F. M., Schubert, K., & Braun, U. (2004). Check-list of *Cladosporium* names. *Schlechtendalia, 11*, 1–103.

Ebbels, D. L., & Allen, D. J. (1979). A supplementary and annotated list of plant diseases, pathogens, and associated fungi in Tanzania. *Phytopathology Papers, 22*, 1–89.

Ehrenberg, C. G. (1818). *Sylvae mycologicae Berolinenses*. Formis Theophili Bruschcke.

El-Buni, A. M., & Rattan, S. S. (1981). *Check list of Libyan fungi*. Al Faateh University Faculty of Science Department of Botany, Tripoli.

Ellis, J. B., & Everhart, B. M. (1889). New and rare species of north American fungi. *Journal of Mycology, 5*, 145–157.

Ellis, M. B. (1957a). *Haplobasidion, Lacellinopsis,* and *Lacellina*. *Mycological Papers, 67*, 1–15.

Ellis, M. B. (1957b). Some species of *Deightoniella*. *Mycological Papers, 66,* 1–12.

Ellis, M. B. (1960). Dematiaceous hyphomycetes I. *Mycological Papers, 76*, 1–36.

Ellis, M. B. (1967). Dematiaceous hyphomycetes VIII: *Periconiella*, *Trichodochium*, etc. *Mycological Papers, 111*, 1–46.

Ellis, M. B. (1971a). *Dematiaceous hyphomycetes*. Commonwealth Mycological Institute, Kew, Surrey, England.

Ellis, M. B. (1971b). Dematiaceous hyphomycetes XI. *Mycological Papers, 131*.

Ellis, M. B. (1976). *More dematiaceous Hyphomycetes.* Commonwealth Mycological Institute, Kew, Surrey, England.

Engkhaninun, J., Chatasiri, S., To–anun, C., Visarathanonth, N., Kakishima, M., & Yoshitaka, O. (2005). New geographical distribution and host records of rust fungi from northern Thailand. *Mycoscience, 46*, 137–142.

Ershad, D. (2000). *Vankya*, a new genus of smut fungi. *Rostaniha*: *Botanical Journal of Iran, 1*, 65–72.

Erwin, D. C., & Ribeiro, O. K. (1996). *Phytophthora diseases worldwide*. APS Press, Minnesota.

Faedda, R., Agosteo, G. E., Schena, L., Mosca, S., Frisullo, S., Magnano di San Lio, G., . . . Cacciola, S. O. (2011). *Colletotrichum clavatum* sp. nov. identified as the causal agent of olive anthracnose in Italy. *Phytopathologia Mediterranea, 50*, 283–302.

Fan, B., Dewapriya, P., Li, F., Blümel, M., & Tasdemir, D. (2020). Pyrenosetins A-C, new decalinoylspirotetramic acid derivatives isolated by bioactivity-based molecular networking from the seaweed-derived fungus *Pyrenochaetopsis* sp. FVE–001. *Marine Drugs, 18*, 47.

Fan, H., Yang, P., Guo, Z., & Zeng, L. (2012). Pathogen and biological characteristics on *Cordana* leaf spot of banana. *Southwest China Journal of Agricultural Sciences, 25*, 2089–2092.

Farr, D. F., & Rossman, A. Y. (n.d.). *Fungal Databases. US National Fungus Collections, ARS USDA.* Retrieved October 15, 2023, from https://ntars–gringov/fungaldatabases/.

Farr, M. L. (1973). An annotated list of Spegazzini's fungus taxa, Vol. 1. *Bibliotheca Mycologica, 35*, 1–823.

Farr, M. L., & Stevenson, J. A. (1963). Eine erganzungsliste bolivianischer pilze. *Sydowia, 17*, 37–69.

Feng, J., Liu, W. T., Chen, J. J., & Zhang, C. L. (2021). Biogeography and ecology of *Magnaporthales*: A case study. *Frontiers in Microbiology, 12*, 654380.

Feng, Y. R., Liu, B. S., & Sun, B. B. (2014). First report of leaf blotch caused by *Pestalotiopsis clavispora* on *Rosa chinensis* in China. *Plant Disease, 98*, 1009–1009.

Firman, I. D. (1972). A list of fungi, plant parasitic bacteria, viruses, and nematodes in Fiji. *Phytopathology Papers, 15*, 1–36.

Fischer, G. W. (1953). *Manual of the north American smut fungi*. Ronald Press Company, New York.

Fortune, M. P., Gosine, S., Chow, S., Dilbar, A., Hill, A., Gibbs, H., . . . Rambaran, N. (2004). First report of black sigatoka disease (causal agent *Mycosphaerella fijiensis*) from Trinidad. *New Disease Reports, 10*, 246.

Fournier, J., Stadler, M., Hyde, K. D., & Duong, L. M. (2010). The new genus *Rostrohypoxylon* and two new *Annulohypoxylon* species from northern Thailand. *Fungal Diversity, 40*, 23–36.

Fresenius, G. (1850). *Beiträge zur Mykologie* [Contributions to mycology]. Frankfurt a. M, Bei H. L. Brönner.

Fuentes-Aragon, D., Juarez-Vazquez, S. B., Vargas-Hernandez, M., & Silva-Rojas, H. V. (2018). *Colletotrichum fructicola*, a member of *Colletotrichum gloeosporioides* sensu lato, is the causal agent of anthracnose and soft rot in avocado fruits cv. "Hass". *Mycobiology, 46*, 92–100.

Fuentes-Aragón, D., Rebollar-Alviter, A., Osnaya-Gonzalez, M., Enciso-Maldonado, G. A., Gonzalez-Reyes, H., & Silva-Rojas, H. V. (2021). Multilocus phylogenetic analyses suggest the presence of *Colletotrichum chrysophilum* causing banana anthracnose in Mexico. *Journal of Plant Diseases and Protection, 128*, 589–595.

Fullerton, R. A., & Casonato, S. G. (2019). The infection of the fruit of 'Cavendish' banana by *Pseudocercospora fijiensis*, caused by black leaf streak (black Sigatoka). *European Journal of Plant Pathology, 155*, 779–787.

Gaikwad, C. B., Thorat, B. S., & Bhokare, K. R. (2017). Isolation, culturing and identification of the fungus *Cordana musae* (Zimm) Hohn causing leaf spot of banana. *Journal of Entomology and Zoology Studies, 5*, 1646–1648.

Ganesan, S., Singh, H. S., Petikam, S., & Biswal, D. (2017). Pathological status of *Pyricularia angulata* causing blast and pitting disease of banana in Eastern India. *Plant Pathology Journal, 33*, 9–20.

Gao, L., Ma, Y., Zhao, W., Wei, Z., Gleason, M. L., Chen, H., . . . Zhang, R. (2015). Three new species of *Cyphellophora* (*Chaetothyriales*) associated with sooty blotch and flyspeck. *Plos One, 10*, 1–22.

Gao, L., Wei, Z., Wang, B., Gleason, M. L., Zhang, R., & Sun, G. (2015). A new species of *Scleroramularia* associated with sooty blotch and flyspeck in southern China. *Phytotaxa, 226*, 261–268.

Gao, L., Zhang, M., Zhao, W., Hao, L., Chen, C., Zhang, R., . . . Sun, G. (2014). Molecular and morphological analysis reveals five new species of *Zygophiala* associated with flyspeck signs on plant hosts from China. *Plos One, 9*, 1–12.

Garcia, R. O., Rivera-Varas, V., Ploetz, R., Correll, J. C., & Irish, B. M. (2018). Characterization of *Fusarium* spp. isolates recovered from bananas (*Musa spp.*) affected by Fusarium wilt in Puerto Rico. *European Journal of Plant Pathology, 152*, 599–611.

Garcia-Bastidas, F. A., Ordonez, N., Konkol, J., Al-Qasim, M., Naser, Z., Abdelwali, M., . . . Kema, G. H. J. (2014). First report of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 associated with Panama disease of banana outside southeast Asia. *Plant Disease, 98*, 694.

Garcia-Bastidas, F. A., Quintero-Vargas, J. C., Ayala-Vasquez, M., Schermer, T., Seidl, M. F., Santos-Paiva, M., . . . Kema, G. H. J. (2020). First report of Fusarium wilt tropical race 4 in Cavendish bananas caused by *Fusarium odoratissimum* in Colombia. *Plant Disease, 104*, 994.

Garcke, A. (1833). *Linnaea: Ein Journal für die Botanik in ihrem ganzen Umfange*. Berlin F. Dümmler.

Garoé, N. T., Cabrera, R., Andreea, C., Martín Toledo, T., & Cristina, G. (2013). Survey of banana endophytic fungi isolated in artificial culture media from an applied viewpoint. *Journal of Horticulture and Forestry Biotechnology, 17*, 22–25.

Ge, Q., Chen, Y., & Xu, T. T. (2009). *Flora fungorum sinicorum, Pestalotiopsis*. Science Press, Beijing.

Gene, J., Cano, J., & Guarro, J. (1990). Contribution to the study of the Spanish hyphomycetes XI. *Revista Iberoamericana de Micología, 7*, 31–33.

Gerlach, W., & Ershad, D. (1970). Beitrag zur Kenntnis der *Fusarium*- und *Cylindrocarpon*-Arten in Iran [Contribution to the knowledge of *Fusarium* and *Cylindrocarpon* species in Iran], *Nova Hedwigia, 20*, 725–784.

Giatgong, P. (1980). *Host Index of Plant Diseases in Thailand* (2nd ed.). Plant Pathology and Microbiology Division, Department of Agriculture and Cooperatives, Thailand.

Gilardi, G., Matic, S., Luongo, I., Gullino, M. L., & Garibaldi, A. (2020). First report of stem necrosis and leaf spot of tomato caused by *Albifimbria verrucaria* in Italy. *Plant Disease, 104*, 2026.

Gilbertson, R. L., Bigelow, D. M., Hemmes, D. E., & Desjardin, D. E. (2002). Annotated check list of wood-rotting *Basidiomycetes* of Hawaii. *Mycotaxon, 82*, 215–239.

Ginns, J. H. (1986). *Compendium of plant disease and decay fungi in Canada 1960–1980*. Research Branch Canada Agriculture Publication.

Giraldo, A., & Crous, P. W. (2019). Inside *Plectosphaerellaceae*. *Studies in Mycology, 92*, 227–286.

Giraldo, A., Crous, P. W., Schumacher, R. K., Cheewangkoon, R., Ghobad-Nejhad, M., & Langer, E. (2017). The genera of fungi – G3: *Aleurocustis*, *Blastacervulus*, *Clypeophysalospora*, *Licrostroma*, *Neohendersonia*, and *Spumatoria*. *Mycological Progress, 16*, 325–348.

Giraldo, A., Gené, J., Sutton, D. A., Wiederhold, N., & Guarro, J. (2017). New *Acremonium*-like species in the *Bionectriaceae* and *Plectosphaerellaceae*. *Mycological Progress, 16*, 349–368.

Gjaerum, H. B., & Hansen, A. (1990). Additions to the rust flora of the Greek islands. *Annals of the Goulandris Museum, 8*, 81–96.

Glass, N. L., & Donaldson, G. C. (1995). Development of primer sets designed for use with the PCR to amplify conserved genes from filamentous ascomycetes. *Applied and Environmental Microbiology, 61*, 1323–1330.

Glienke, C., Pereira, O. L., Stringari, D., Fabris, J., Kava-Cordeiro, V., Galli-Terasawa, L., . . . Crous, P. W. (2011). Endophytic and pathogenic *Phyllosticta* species, with reference to those associated with Citrus Black Spot. *Persoonia*, *26*, 47–56.

Gomes, L. I. S., Douhan, G. W., Bibiano, L. B. J., Maffia, L. A., & Mizubuti, E. S. G. (2013). *Mycosphaerella musicola* identified as the only pathogen of the Sigatoka disease complex present in Minas Gerais State, Brazil. *Plant Disease*, *97*, 1537–1543.

Gomes, R. R., Glienke, C., Videira, S. I. R., Lombard, L., Groenewald, J. Z., & Crous, P. W. (2013). *Diaporthe*, a genus of endophytic, saprobic, and plant pathogenic fungi. *Persoonia, 31*, 1–41.

Gómez, O. C., Moreira, D. M., & Luiz, B. J. H. H. (2021). Medicinal potentialities and pathogenic profile of *Lasiodiplodia* genus. *World Journal of Microbiology and Biotechnology, 37*, 1–12.

Gond, A. K., Patel, R., Patel, S., Jamaluddin, J., & Pandy, A. (2013). New record of *Memnoniella levispora subram* on *Ficus carica* L. from India. *Journal of Nematology and Biological Control Reports, 2*, 272–274.

Gonzalez, M. S., & Pons, N. (2000). Characteristics of developmental stages in mitospore production of *Pseudocercospora musae*. *Mycological Research, 104*, 1507–1517.

Goos, R. D., & Cox, E. A. (1961). *Botryodiplodia theobromae* and its association with *Musa* species. *Mycologia, 53*, 262–277.

Goos, R. D., & Gowing, D. P. (1992). Type specimens of fungi maintained at herbarium pacificum, Bernice P. Bishop Museum, Honolulu. *Mycotaxon*, *43*, 177–198.

Gorter, G. J. M. A. (1977). Index of plant pathogens and the diseases they cause in cultivated plants in South Africa. *Republic South Africa Department of Agriculture Technical Services Plant Protection Research Institute Science Bulletin*, *392*, 1–177.

Gostinčar, C., Turk, M., Zajc, J., & Gunde-Cimerman, N. (2019). Fifty *Aureobasidium pullulans* genomes reveal a recombining polyextremotolerant generalist. *Environmental Microbiology*, *21*, 3638–3652.

Groenewald, J. Z., Nakashima, C., Nishikawa, J., Shin, H. D., Park, J. H., Jama, A. N., . . . Crous, P. W. (2013). Species concepts in *Cercospora*: spotting the weeds among the roses. *Studies in Mycology*, *75*, 115–170.

Grum-Grzhimaylo, A. A., Falkoski, D. L., van den Heuvel, J., Valero-Jiménez, C. A., Min, B., Choi, I. G., & Debets, A. J. (2018). The obligate alkalophilic soda-lake fungus *Sodiomyces alkalinus* has shifted to a protein diet. *Molecular Ecology*, *27*, 4808–4819.

Grum-Grzhimaylo, A. A., Georgieva, M. L., Bondarenko, S. A., Debets, A. J., & Bilanenko, E. N. (2016). On the diversity of fungi from soda soils. *Fungal Diversity*, *76*, 27–74.

Guarnaccia, V., Groenewald, J. Z., Polizzi, G., & Crous, P. W. (2017). High species diversity in *Colletotrichum* associated with citrus diseases in Europe. *Persoonia*, *39*, 32–50.

Guatimosim, E., Schwartsburd, P. B., Barreto, R. W., & Crous, P. W. (2016). Novel fungi from an ancient niche: Cercosporoid and related sexual morphs on ferns. *Persoonia*, *37*, 106–141.

Guatimosim, E., Schwartsburd, P. B., Crous, P. W., & Barreto, R. W. (2016). Novel fungi from an ancient niche: Lachnoid and chalara-like fungi on ferns. *Mycological Progress, 15*, 1239–1267.

Guba, E. F. (1961). *Monograph of Monochaetia and Pestalotia*. Harvard University Press, Cambridge.

Guidot, A., Johannesson, H., Dahlberg, A., & Stenlid, J. (2003). Parental tracking in the postfire wood decay ascomycete *Daldinia loculata* using highly variable nuclear gene loci. *Molecular Ecology*, *12*, 1717–1730.

Gunasekaran, R., Janakiraman, D., Rajapandian, S. G. K., Appavu, S. P., Venkatesh, P. N., & Prajna, L. (2021). *Periconia* species-An unusual fungal pathogen causing mycotic keratitis. *Indian Journal of Medical Microbiology*, *39*, 36–40.

Guo, L. (1988). The genera *Ustilago* and *Liroa* in China. *Mycosystema, 1*, 211–240.

Guo, Yl. (1999). Fungal flora of tropical Guangxi, China. Hyphomycetes I. *Mycotaxon*, *72*, 349–358.

Gupta, D., Chowdhry, P. N., & Padhi, B. (1983). Some phytopathogenic fungi of ornamental plants from India. *Indian Phytopathology*, *36*, 244–246.

Gupta, P. C. (2023). Bioanalytical studies on fungal pathogens originating from spoiled Alpan banana (*Musa Paradisiaca*). *Biosciences Biotechnology Research Asia*, *20*. Article 3.

Gurunath, R. V. (1966). An account of the market and storage diseases of fruits and vegetables in Bombay-Maharashtra, India. *Mycopathologia et Mycologia Applicata, 28*, 165–176.

Gurung, S. K., Adhikari, M., Kim, S. W., Lee, H. G., Jun, J. H., Gwon, B. H., . . . Lee, Y. S. (2019). First report of *Albifimbria verrucaria* and *Deconica coprophila* (Syn: *Psylocybe coprophila*) from field soil in Korea. *The Korean Journal of Mycology, 47*, 209–218.

Gutner, L. S. (1941). *The smut fungi*. State Publication House, Moscow, Leningrad.

Hafez, M., Abdelmagid, A., Adam, L. R., & Daayf, F. (2020). Specific detection and identification of *Fusarium graminearum* sensu stricto using PCR–RFLP tool and specific primers targeting the translational elongation factor 1(alpha) gene. *Plant Disease, 104*, 1076–1086.

Hall, T. A. (1999). BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series, 41*, 95–98.

Hanlin, R. T. (1992). Index to genera and species of ascomycetes described by A. P. Viegas. *Mycotaxon, 43*, 207–230.

Hao, L., Chen, C., Zhang, R., Zhu, M., Sun, G., & Gleason, M. L. (2013). A new species of *Scolecobasidium* associated with the sooty blotch and flyspeck complex on banana from China. *Mycological Progress, 12*, 489–495.

Hao, Y., Aluthmuhandiram, J. V. S., Chethana, K. W. T., Manawasinghe, I. S., Li, X., Liu, M., . . . Zhang, W. (2020). *Nigrospora* species associated with various hosts from Shandong Peninsula, China. *Mycobiology, 48*, 169–183.

Hashimoto, A., Matsumura, M., Hirayama, K., & Tanaka, K. (2017). Revision of *Lophiotremataceae* (*Pleosporales*, *Dothideomycetes*): *Aquasubmersaceae*, *Cryptocoryneaceae* and *Hermatomycetaceae* fam. nov. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 39*, 51–73.

Hassan, O., Kim, J. S., Romain, B. B. N. D., & Chang, T. (2022). An account of *Colletotrichum* species associated with anthracnose of *Atractylodes ovata* in South Korea based on morphology and molecular data. *PLOS ONE, 17*, Article e0263084.

Hattori, Y., Nakano, L., & Nakashima, C. (2023). Taxonomic re-examination of Japanese isolates of the genus *Lasiodiplodia*. *Mycoscience*, *64*, 74–82.

He, J., Li, D. W., Cui, W. L., & Huang, L. (2024). Seven new species of *Alternaria* (*Pleosporales, Pleosporaceae*) associated with Chinese fir, based on morphological and molecular evidence. *MycoKeys*, *101*, 1.

Heidarian, Z., Arzanlou, M., & Ahmadpour, A. (2020). Molecular phylogeny and morphology differentiate several new records and novel hosts for *Curvularia* species in Iran. *Nova Hedwigia*, *111*, 151–171.

Helaly, S. E., Thongbai, B., & Stadler, M. (2018). Diversity of biologically active secondary metabolites from endophytic and saprotrophic fungi of the ascomycete order *Xylariales*. *Natural Product Reports, 35*, 992–1014.

Hemphill, C. F., Daletos, P. G., Liu, Z., Lin, W., & Proksch, P. (2016). Polyketides from the mangrove–derived fungal endophyte *Pestalotiopsis clavispora*. *Tetrahedron Letters, 57*, 2078–2083.

Hennen, J. F., Figueiredo, M. B., de Carvalho, A. A. Jr., & Hennen, P. G. (2005). *Catalogue of the species of plant rust fungi* (*Uredinales*) *of Brazil*. Jardim Botânico do Rio de Janeiro.

Heredia-Abarca, G., Mena, P. J., Mercado, S. A., & Reyes, E. M. (1997). Tropical hyphomycetes of Mexico II. Some species from the tropical biology station "Los Tuxtlas," Veracruz, Mexico. *Mycotaxon, 64*, 203–223.

Herman, T., Pawlowski, M. L., Domier, L. L., & Hartman, G. L. (2020). First report of *Albifimbria verrucaria* causing leaf spot on *Glycine latifolia*. *Plant Disease, 104*, 576.

Hernandez-Restrepo, M., Groenewald, J. Z., & Crous, P. W. (2015). *Neocordana* gen. nov., the causal organism of Cordana leaf spot on banana. *Phytotaxa, 205*, 229–238.

Hernandez-Restrepo, M., Groenewald, J. Z., & Crous, P. W. (2016). Taxonomic and phylogenetic re-evaluation of *Microdochium*, *Monographella*, and *Idriella*. *Persoonia*, *36*, 57–82.

Herrera, C. S., Rossman, A. Y., Samuels, G. J., Lechat, C., & Chaverri, P. (2013). Revision of the genus *Corallomycetella* with *Corallonectria* gen. nov. for *C. jatrophae* (*Nectriaceae, Hypocreales*). *Mycosystema, 32*, 518–544.

Herron, D. A., Wingfield, M. J., Wingfield, B. D., Rodas, C. A., Marincowitz, S., & Steenkamp, E. T. (2015). Novel taxa in the *Fusarium fujikuroi* species complex from *Pinus* spp. *Studies in Mycology, 80*, 131–150.

Heslop-Harrison, J. S., & Schwarzacher, T. (2007). Domestication genomics and the future for banana. *Annals of Botany, 100*, 1073–1084.

Hill, R., Buggs, R. J., Vu, D. T., & Gaya, E. (2022). Lifestyle transitions in fusarioid fungi are frequent and lack clear genomic signatures. *Molecular Biology and Evolution, 39*, Article msac085.

Hill, R., Llewellyn, T., Downes, E., Oddy, J., MacIntosh, C., Kallow, S., & Gaya, E. (2021). Seed banks as incidental fungi banks: Fungal endophyte diversity in stored seeds of banana wild relatives. *Frontiers in Microbiology, 12*, Article 643731.

Hirata, T., Kimishima, E., Aoki, T., Nirenberg, H. I., & O'Donnell, K. (2001). Morphological and molecular characterization of *Fusarium verticillioides* from rotten banana imported into Japan. *Mycoscience, 42*, 155–166.

Hirayama, K., & Tanaka, K. (2011). Taxonomic revision of *Lophiostoma* and *Lophiotrema* based on reevaluation of morphological characters and molecular analyses. *Mycoscience, 52*, 401–412.

Ho, M. H. M., Castaneda-Ruiz, R. F., Dugan, F. M., & Jong, S. C. (1999). *Cladosporium* and *Cladophialophora* in culture: Descriptions and an expanded key. *Mycotaxon, 72*, 115–157.

Holevas, C. D., Chitzanidis, A., Pappas, A. C., Tzamos, E. C., Elena, K., Psallidas, P. G., . . . Varveri, C. (2000). Disease agents of cultivated plants observed in Greece from 1981 to 1990. *Benaki Phytopathological Institute, 19*, 1–96.

Honger, J. O., Offei, S. K., Oduro, K. A., Odamtten, G. T., & Nyaku, S. T. (2014). Identification and species status of the mango biotype of *Colletotrichum gloeosporioides* in Ghana. *European Journal of Plant Pathology, 140*, 455–467.

Hongsanan, S., Hyde, K. D., Phookamsak, R., Wanasinghe, D. N., McKenzie, E. H. C., Sarma, V. V., Boonmee, S., Lücking, R., Bhat, D. J., Liu, N. G., Tennakoon, D. S., Pem, D., Karunarathna, A., Jiang, S. H., Jones, E. B. G., Phillips, A. J. L., Manawasinghe, I. S., Tibpromma, S., Jayasiri, S. C.,. . . Xie, N. (2020). Refined families of *Dothideomycetes*: *Dothideomycetidae* and *Pleosporomycetidae*. *Mycosphere*, *11*, 1553–2107.

Hongsanan, S., Maharachchikumbura, S. S. N., Hyde, K. D., Samarakoon, M. C., Jeewon, R., Zhao, Q., . . . Bahkali, A. H. (2017). An updated phylogeny of *Sordariomycetes* based on phylogenetic and molecular clock evidence. *Fungal Diversity*, *84*, 25–41.

Hossain, M. A., Ahmed, M. S., & Ghannoum, M. A. (2004). Attributes of *Stachybotrys chartarum* and its association with human disease. *Journal of Allergy and Clinical Immunology*, *113*, 200–208.

Hou, L. W., Liu, F., Duan, W. J., & Cai, L. (2016). *Colletotrichum aracearum* and *C. camelliae-japonicae*, two holomorphic new species from China and Japan. *Mycosphere*, *7*, 1111–1123.

Hsieh, H. M., Ju, Y. M., & Rogers, J. D. (2005). Molecular phylogeny of *Hypoxylon* and closely related genera. *Mycologia*, *97*, 844–865.

Hsieh, W. H., & Goh, T. K. (1990). *Cercospora and similar fungi from Taiwan*. Maw Chang Book Co., Taipei.

Hu, H., He, M., Wu, Y., Long, S., Zhang, X., Liu, L., . . . Li, Q. (2023). Taxonomic and phylogenetic characterisations of six species of *Pleosporales* (in *Didymosphaeriaceae, Roussoellaceae* and *Nigrogranaceae*) from China. *MycoKeys*, *100*, 123.

Huang, F., Groenewald, J. Z., Zhu, L., Crous, P. W., & Li, H. (2015). Cercosporoid disease of Citrus. *Mycologia, 107*, 1151–1171.

Huang, H. Y., Huang, H. H., Zhao, D. Y., Shan, T. J., & Hu, L. L. (2022). *Pseudocryphonectria elaeocarpicola* gen et sp. nov., *Cryphonectriaceae*, *Diaporthales*, causing stem blight of *Elaeocarpus* spp. in China. *MycoKeys, 91*, 67–84.

Huang, J., Xu, J., Wang, Z., Khan, D., Niaz, S. I., Zhu, Y., & Liu, L. (2017). New lasiodiplodins from mangrove endophytic fungus *Lasiodiplodia* sp. *Natural product research, 31*, 326–332.

Huang, R., Sun, W., Wang, L., Li, Q., Huang, S., Tang, L., . . . Hsiang, T. (2021). Identification and characterization of *Colletotrichum* species associated with anthracnose disease of banana. *Plant Pathology, 70*, 1827–1837.

Huang, S. L., Yan, B., Wei, J. G., Yan, W. H., Cen, Z. L., & Yang, T. (2007). First report of plantain zonate leaf spot caused by *Pestalotiopsis menezesiana* in China. *Australasian Plant Disease Notes, 2*, 61–62.

Huang, S. P., Wei, J. G., Guo, T. X., Li, Q. L., Tang, L. H., Mo, J. Y., . . . Yang, X. B. (2019). First report of sheath rot caused by *Fusarium proliferatum* on Pisang Awak banana (*Musa* ABB) in China. *Journal of Plant Pathology, 101*, 1271–1272.

Huelsenbeck, J. P., & Ronquist, F. (2001). MRBAYES: Bayesian inference of phylogenetic trees. *Bioinformatics, 17*, 754–755.

Hughes, S. J. (1952a). Fungi from the Gold Coast I. *Mycological Papers, 48*, 1–91.

Hughes, S. J. (1952b). Fungi from the Gold Coast. 11. *Mycological Papers, 50*, 1–104.

Huguenin, B. (1966). *Micromycetes* de Nouvelle-Caledonie [Micromycetes of New Caledonia], *Cahiers ORSTOM, Serie Biologie, 1*, 61–91.

Hung, T. N., Hung, N. Q., Mostert, D., Viljoen, A., Chao, C. P., & Molina, A. B. (2018). First report of Fusarium wilt on cavendish bananas caused by *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (VCG 01213/16) in Vietnam. *Plant Disease, 102*, 448.

Hyde, K. D. (1995). Two new interesting ascomycetes from Irian Jaya and Papua New Guinea. *Mycotaxon, 55*, 275–282.

Hyde, K. D., & Alcorn, J. L. (1993). Some disease-associated microorganisms on plants of Cape York Peninsula and Torres Strait Islands. *Australasian Plant Pathology*, *22*, 73–83.

Hyde, K. D., de Silva, N. I., Jeewon, R., Bhat, D. J., Phookamsak, R., Doilom, M., Boonmee, S., Jayawardena, R. S., Maharachchikumbura, S. S. N., Senanayake, I. C., Manawasinghe, I. S., Liu, N. G., Abeywickrama, P. D., Chaiwan, N., Karunarathna, A., Pem, D., Lin, C. G., Sysouphanthong, P., Luo, Z. L., . . . Bulgakov, T. S. (2020). AJOM new records and collections of fungi: 1–100. *Asian Journal of Mycology*, *3*, 22–294.

Hyde, K. D., Fröhlich, J., & Taylor, J. E. (1998). Fungi from palms XXXVI: Reflections on unitunicate ascomycetes with apiospores. *Sydowia, 50*, 21–80.

Hyde, K. D., Hongsanan, S., Jeewon, R., Bhat, D. J., McKenzie, E. H. C., Jones, E. B. G., Phookamsak, R., Ariyawansa, H. A., Boonmee, S., Zhao, Q., Abdel-Aziz, F. A., Abdel-Wahab, M. A., Banmai, S., Chomnunti, P., Cui, B.-K., Daranagama, D. A., Das, K., Dayarathne, M. C., de Silva, N. I., . . . Zhu, L. (2016). Fungal diversity notes 367–490: Taxonomic and phylogenetic contributions to fungal taxa. *Fungal Diversity, 80*, 1–270.

Hyde, K. D., & Hyde, Y. (2002). New saprobic fungi on fronds of palms from northern Queensland, Australia. *Australian Systematic Botany, 15*, 755–764.

Hyde, K. D., Jeewon, R., Chen, Y. J., Bhunjun, C. S., Calabon, M. S., Jiang, H. B., . . . Tibpromma, S. (2020). The numbers of fungi: Is the descriptive curve flattening? *Fungal Diversity, 103*, 219–271.

Hyde, K. D., Jones, E. B. G., Liu, J. K., Ariyawansa, H., Boehm, E., Boonmee, S., Braun, U., Chomnunti, P., Crous, P. W., Dai, D. Q., Diederich, P., Dissanayake, A., Doilom, M., Doveri, F., Hongsanan, S., Jayawardena, R., Lawrey, J. D., Li, Y. M., Liu, Y. X., . . . Zhang M. (2013). Families of *Dothideomycetes*. *Fungal Diversity, 63*, 1–313.

Hyde, K. D., Nilsson, R. H., Alias, S. A., Ariyawansa, H. A., Blair, J. E., Cai, L., de Cock, A. W. A. M., Dissanayake, A. J., Glockling, S. L., Goonasekara, I. D., Gorczak, M., Hahn, M., Jayawardena, R. S., van Kan, J. A. L., Laurence, M. H., Lévesque, C. A., Li, X., Liu, J. K., Maharachchikumbura, S. S. N., . . . Zhou, N. (2014). One stop shop: Backbones trees for important phytopathogenic genera I. *Fungal Diversity, 67*, 21–125.

Hyde, K. D., Norphanphoun, C., Abreu, V. P., Bazzicalupo, A., Chethana, K. W. T., Clericuzio, M., Dayarathne, M. C., Dissanayake, A. J., Ekanayaka, A. H., He, M. Q., Hongsanan, S., Huang, S. K., Jayasiri, S. C., Jayawardena, R. S., Karunarathna, A., Konta, S., Kušan, I., Lee, H., Li, J. F., . . . Mortimer, P. E. (2017). Fungal diversity notes 603–708: Taxonomic and phylogenetic notes on genera and species. *Fungal Diversity, 87*, 1–235.

Hyde, K. D., Norphanphoun, C., Chen, J., Dissanayake, A. J., Doilom, M., Hongsanan, S., . . . Stadler, M. (2018). Thailand's amazing diversity: Up to 96% of fungi in northern Thailand may be novel. *Fungal Diversity, 93*, 215–239.

Hyde, K. D., Norphanphoun, C., Maharachchikumbura, S. S. N., Bhat, D. J., Jones, E. B. G., Bundhun, D., Chen, Y. J., Bao, D. F., Boonmee, S., Calabon, M. S., Chaiwan, N., Chethana, K. W. T., Dai, D. Q., Dayarathne, M. C., Devadatha, B., Dissanayake, A. J., Dissanayake, L. S., Doilom, M., Dong, W., . . . Xiang, M. M. (2020). Refined families of *Sordariomycetes*. *Mycosphere, 11*, 305–1059.

Hyde, K. D., Norphanphoun, C., Ma, J., Yang, H. D., Zhang, J. Y., Du, T. Y., . . . Zhao, Q. (2023). Mycosphere notes 387-412-novel species of fungal taxa from around the world. *Mycosphere, 14*, 663–744.

Ibrahim, N. F., Mohd, M. H., Nor, N. M. I. M., & Zakaria, L. (2016). *Fusarium fujikuroi* causing fusariosis of pineapple in peninsular Malaysia. *Australasian Plant Disease Notes, 11*, 21.

Index Fungorum. (2024). *Index Fungorum*. Partnership: Landcare Research–NZ and RBG Kew: Mycology. Available online at: http://www.indexfungorum.org, accessed April 25, 2023.

Imperial Mycological Institute (Great Britain), Commonwealth Mycological Institute (Great Britain), & International Mycological Institute. (1954). *Index of fungi 1*. United Kingdom.

Imperial Mycological Institute (Great Britain), Commonwealth Mycological Institute (Great Britain), & International Mycological Institute. (1957). *Index of fungi.* United Kingdom.

Imperial Mycological Institute (Great Britain), Commonwealth Mycological Institute (Great Britain), & International Mycological Institute. (1963). *Index of fungi 2.* United Kingdom.

Imperial Mycological Institute (Great Britain), Commonwealth Mycological Institute (Great Britain), & International Mycological Institute. (1972). *Index of fungi 3*. United Kingdom.

Imperial Mycological Institute (Great Britain), Commonwealth Mycological Institute (Great Britain), & International Mycological Institute. (1981). *Index of fungi 4*. United Kingdom.

Intan-Sakinah, M. A., Suzianti, I. V., & Latiffah, Z. (2013). First report of *Colletotrichum gloeosporioides* causing anthracnose of banana (*Musa* spp.) in Malaysia. *Plant Disease, 97*, 991.

Ioos, R., Hubert, J., Abadie, C., Dufeal, D., Opdebeeck, G., & Iotti, J. (2011). First report of black sigatoka disease in banana caused by *Mycosphaerella fijiensis* on Martinique Island. *Plant Disease, 95*, 359.

Irandegani, Y., Pirnia, M., Taheri, A., Khaledi, N., Keykhasaber, M., & Sarani, S. (2023). Phylogenetic analyses of *Fusarium oxysporum* species complex on banana in Iran and evaluation of some essential oils on the growth, sporulation, and spore germination of the fungus. *European Journal of Plant Pathology, 167*, 183–195.

Irish, B. M., Goenaga, R., & Ploetz, R. C. (2006). *Mycosphaerella fijiensis*, causal agent of black sigatoka of *Musa* spp., found in Puerto Rico and identified by polymerase chain reaction. *Plant Disease, 90*, 684.

Ivic, D., Voncina, D., Sever, Z., Simon, S., & Pejic, I. (2013). Identification of *Colletotrichum* species causing bitter rot of apple and pear in Croatia. *Journal of Phytopathology, 161*, 284–286.

Izabel, T. D. S. S., Cruz, A. C. R. D., Barbosa, F. R., Ferreira, S. M. L., Marques, M. F. O., & Gusmão, L. F. P. (2010). The genus *Stachybotrys* (anamorphic fungi) in the semi-arid region of Brazil. *Revista Brasileira de Botânica, 33*, 479–487.

Jacobs, A., Van Wyk, P. S., Marasas, W. F. O., Wingfield, B. D., Wingfield, M. J., & Coutinho, T. A. (2010). *Fusarium ananatum* sp. nov. in the *Gibberella fujikuroi* species complex from pineapples with fruit rot in South Africa. *Fungal Biology, 114*, 515–527.

Jaklitsch, W. M., Gardiennet, A., & Voglmayr, H. (2016). Resolution of morphology–based taxonomic delusions: *Acrocordiella, Basiseptospora, Blogiascospora, Clypeosphaeria, Hymenopleella, Lepteutypa, Pseudapiospora, Requienella, Seiridium,* and *Strickeria*. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 37*, 82–105.

Jalander, V., & Gachande, B. D. (2013). In vitro efficacy of fungicides against the growth of leaf spot pathogen (*Cordana musae* Zimm. Hohn.) of banana. *Science Research Reporter, 3*, 4–6.

Jarvis, B. B., Salemme, J., & Morals, A. (1995). *Stachybotrys* toxins. 1. *Natural Toxins, 3*, 10–16.

Jayasiri, S. C., Hyde, K. D., Ariyawansa, H. A., Bhat, J., Buyck, B., Cai, L., . . . Jeewon, R. (2015). The Faces of fungi database: Fungal names linked with morphology, molecular, and human attributes. *Fungal Diversity, 74*, 3–18.

Jayasiri, S. C., Hyde, K. D., Jones, E. B. G., & Lu, Y. Z. (2017). *Neohelicosporium fusisporum* sp. nov., *Tubeufiaceae*, and the first report of a sexual morph for the genus. *Studies in Fungi, 21*, 210–217.

Jayasiri, S. C., Hyde, K. D., Jones, E. B. G., McKenzie, E. H. C., Jeewon, R., Phillips, A. J. L., . . . Karunarathna, S. C. (2019). Diversity, morphology, and molecular phylogeny of *Dothideomycetes* on decaying wild seed pods and fruits. *Mycosphere, 10*, 1–186.

Jayawardena, R. S., Bhunjun, C. S., Hyde, K. D., Gentekaki, E., & Itthayakorn, P. (2021). *Colletotrichum*: Lifestyles, biology, morpho-species, species complexes, and accepted species. *Mycosphere, 12*, 519–669.

Jayawardena, R. S., Huang, J. K., Jin, B. C., Yan, J. Y., Li, X. H., Hyde, K. D., . . . Zhang, G. Z. (2016). An account of *Colletotrichum* species associated with strawberry anthracnose in China based on morphology and molecular data. *Mycosphere, 7*, 1147–1163.

Jayawardena, R. S., Hyde, K. D., Chethana, K. W. T., Daranagama, D. A., Dissanayake, A. J., Goonasekara, I. D., . . . Yan, J. Y. (2018). Mycosphere notes 102–168: Saprotrophic fungi on *Vitis* in China, Italy, Russia, and Thailand. *Mycosphere, 9*, 1–114.

Jayawardena, R. S., Hyde, K. D., Jeewon, R., Ghobad-Nejhad, M., Wanasinghe, D. N., Liu, N., Phillips, A. J. L., Oliveira-Filho, J. R. C., da Silva, G. A., Gibertoni, T. B., Abeywikrama, P., Carris, L. M., Chethana, K. W. T., Dissanayake, A. J., Hongsanan, S., Jayasiri, S. C., McTaggart, A. R., Perera, R. H., Phutthacharoen, K., . . . Kang, J.C. (2019). One stop shop II: Taxonomic update with molecular phylogeny for important phytopathogenic genera: 26–50. *Fungal Diversity, 94*, 41–129.

Jeewon, R., Ittoo, J., Mahadeb, D., & Jaufeerally-Fakim, Y. (2013). DNA based identification and phylogenetic characterization of endophytic and saprobic fungi from *Antidesma madagascariense*, a medicinal plant in Mauritius. *Journal of Mycology, 2013*, 1–10.

Jeewon, R., Liew, E. C. Y., & Hyde, K. D. (2003). Molecular systematics of the *Amphisphaeriaceae* based on cladistic analyses of partial LSU rDNA gene sequences. *Mycological Research, 107*, 1392–1402.

Jevremović, D., Vasić, T., Živković, S., Vasilijević, B., Marić, M., Vojvodić, M., . . . Bulajić, A. (2022). *Neopestalotiopsis clavispora*, a causal agent of twig dieback on highbush blueberries in Serbia. *Journal of Plant Diseases and Protection, 129*, 1–7.

Jiang, H. B., Hyde, K. D., Jayawardena, R. S., Doilom, M., Xu, J., & Phookamsak, R. (2019). Taxonomic and phylogenetic characterizations reveal two new species and two new records of *Roussoella* (*Roussoellaceae, Pleosporales*) from Yunnan, China. *Mycological Progress, 18*, 577–591.

Jiang, H. B., Hyde, K. D., Yang, E. F., Kakumyan, P., Bahkali, A. H., Elgorban, A. M., . . . Lumyong, S. (2021). Morphological and phylogenetic appraisal of *Ophioceras* (*Ophioceraceae, Magnaporthales*). *PLoS One, 16,* Article e0253853.

Jiang, H. B., Jeewon, R., Karunarathna, S. C., Phukhamsakda, C., Doilom, M., Kakumyan, P., . . . Lumyong, S. (2021). Reappraisal of *Immotthia* in *Dictyosporiaceae, Pleosporales*, Introducing *Immotthia bambusae* sp. nov. and *Pseudocyclothyriella clematidis* comb. et gen. nov. Based on Morphology and Phylogeny. *Frontiers in Microbiology, 12*, 656235.

Jiang, N., Zhu, Y. Q., Xue, H., Piao, C. G., & Li, Y. (2023). *Phaeotubakia lithocarpicola* gen. et sp. nov. (*Tubakiaceae, Diaporthales*) from leaf spots in China. *MycoKeys, 95*, 15–25.

Jie, C. Y., Geng, K., Jiang, Y. L., Xu, J. J., Hyde, K. D., McKenzie, E. H. C., . . . Wang, Y. (2013). *Stachybotrys* from soil in China, identified by morphology and molecular phylogeny. *Mycological Progress, 12*, 693–698.

Jin-Hyeuk, K., Jae-San, R., Tran Thi, P. C., Shun-Shan, S., & Okhee, C. (2012). Soft rot of *Rhizopus oryzae* as a postharvest pathogen of banana fruit in Korea. *Mycobiology, 40*, 214–216.

Johannesson, H., Laessøe, T., & Stenlid, J. (2000). Molecular and morphological investigation of the genus *Daldinia* in northern Europe. *Mycological Research, 104*, 275–280.

Johannesson, H., Vasiliauskas, R., Dahlberg, A., Penttilä, R., & Stenlid, J. (2001). Genetic differentiation in Eurasian populations of the postfire ascomycete *Daldinia loculata*. *Molecular Ecology, 10*, 1665–1677.

Johnston, A. (1960). A supplement to a host list of plant diseases in Malaya. *Mycological Papers, 77*, 1–30.

Johnston, J. R., & Stevenson, J. A. (1917). Sugar cane fungi and diseases of Porto Rico. *Journal of the Department of Agriculture, Porto Rico, 1*, 177–264.

Johnston-Monje, D., Loewen, S., & Lazarovits, G. (2017). Mycobiomes of tomato plants with vine decline. *Canadian Journal of Plant Pathology, 39*, 184–200.

Jones, D. R. (1999). *Diseases of banana, Abacá, and Enset*. CABI Publishing.

Jones, D. R. (2019). Fungal diseases of banana fruit. In *Handbook of Diseases of Banana, Abaca and Enset*. CABI Publishers.

Jones, E. G., Klaysuban, A., & Pang, K. L. (2008). Ribosomal DNA phylogeny of marine anamorphic fungi, *Cumulospora varia*, *Dendryphiella* species, and *Orbimyces spectabilis*. *The Raffles Bulletin of Zoology, 19*, 11–18.

Jorstad, I. (1958). *Uredinales* of the Canary Islands. *Matematisk-Naturvitenskapelig Klasse, 2*, 1–182.

Jorstad, I. (1962). Investigations on the *Uredinales* and other parasitic fungi in Mallorca and Menorca. *Matematisk-Naturvitenskapelig Klasse, 2*, 1–73.

Jorstad, I., & Nannfeldt, J. A. (1958). Additions and corrections to Enumeratio Uredinearum Scandinavicarum. *Botaniska Notiser, 111*, 306–318.

Junior, C. A. S., Marcon, J., Andrade, P. A. M., Silva, J. A., Faraldo, M. I. F., Verdi, M. C. Q., . . . Azevedo, J. L. (2018). Endophytic bacterial and fungi associated with banana leaves (*Musa* spp.) cultivated under organic management. *Journal of Agricultural Science, 10*, 460.

Kaewjan, P., Sittikul, C., Cheewangkoon, R., Hyde, K. D., & Akarapisan, A. (2012). *Mycosphaerella* and other fungi associated with banana leaf diseases from northern Thailand. *Chiang Mai University Journal of Natural Sciences, 11*, 25–32.

Kaiserl, K. (1907). *Sitzungsberichte Abt. 1 Mineralogie, Krystallographie, Botanik, Physiologie der Pflanzen, Zoologie, Paläontologie, Geologie, physische Geographie und Reisen* [Proceedings Section 1: Mineralogy, crystallography, botany, plant physiology, zoology, paleontology, geology, physical geography, and travels]. K-K Hof- und Staatsdruckerei in Kommission bei A. Hölder.

Kamal. (2010). *Cercosporoid fungi of India*. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.

Kapur, J. N. (1968). New microfungi from India. *Transactions of the British Mycological Society, 51*, 328–333.

Kar, A. K., & Mandal, M. (1975). New *Cercospora* species from West Bengal (India): V. *Norwegian Journal of Botany, 22*, 105–110.

Karangwa, P., Mostert, D., Ndayihanzamaso, P., Dubois, T., Niere, B., zum Felde, A., . . . Viljoen, A. (2018). Genetic diversity of *Fusarium oxysporum f. sp. cubense* in East and Central Africa. *Plant Disease, 102*, 552–560.

Karnchanatat, A., Petsom, A., Sangvanich, P., Piaphukiew, J., Whalley, A. J., Reynolds, C. D., . . . Sihanonth, P. (2007). Purification and biochemical characterization of an extracellular beta-glucosidase from the wood–decaying fungus *Daldinia eschscholzii* (Ehrenb.) Rehm. *FEMS Microbiology Letters, 270*, 162–170.

Karunarathna, A., Phookamsak, R., Jayawardena, R. S., Cheewangkoon, R., Hyde, K. D., & Kuo, C. H. (2019). The holomorph of *Neoroussoella alishanense* sp. nov. (*Roussoellaceae, Pleosporales*) on *Pennisetum purpureum* (*Poaceae*). *Phytotaxa, 406*, 218–236.

Katoh, K., Rozewicki, J., & Yamada, K. D. (2019). MAFFT online service: Multiple sequence alignment, interactive sequence choice, and visualization. *Briefings in Bioinformatics, 20*, 1160–1166.

Katoh, K., Rozewicki, J., & Yamada, K. D. (2017). MAFFT online service: Multiple sequence alignment, interactive sequence choice and visualization. *Briefings in Bioinformatics, bbx108*.

Ketabchi, M. (2014). First report of banana fruit rot by *Pestalotiopsis theae*. *Iranian Journal of Plant Pathology, 50*, 103–104.

Khan, I. H., & Javaid, A. (2020). First report of *Curvularia lunata* causing postharvest fruit rot of banana in Pakistan. *International Journal of Agriculture and Biology, 24*, 1621–1624.

Khan, N. A., Asaf, S., Ahmad, W., Jan, R., Bilal, S., Khan, I., . . . Harrasi, A. (2023). Diversity, lifestyle, genomics, and their functional role of *Cochliobolus*, *Bipolaris*, and *Curvularia* species in environmental remediation and plant growth promotion under biotic and abiotic stressors. *Journal of Fungi, 9*, 254.

Kim, S., Shin, D. S., Lee, T., & Oh, K. B. (2004). *Periconicins*, two new fusicoccane diterpenes produced by an endophytic fungus *Periconia* sp. with antibacterial activity. *Journal of Natural Products, 67*, 448–450.

Kimunye, J. N., Were, E., Mussa, F., Tazuba, A., Jomanga, K., Viljoen, A., . . . Mahuku, G. (2020). Distribution of *Pseudocercospora* species causing Sigatoka leaf diseases of banana in Uganda and Tanzania. *Plant Pathology, 69*, 50–59.

Klaubauf, S., Tharreau, D., Fournier, E., Groenewald, J. Z., Crous, P. W., de Vries, R. P., . . . Lebrun, M. H. (2014). Resolving the polyphyletic nature of *Pyricularia*. *Studies in Mycology, 79*, 85–120.

Kobayashi, T. (2007). *Index of fungi inhabiting woody plants in Japan: Host, Distribution, and Literature*. Zenkoku-Noson-Kyoiku Kyokai Publishing Co., Ltd.

Kobayashi, T., & Kubono, T. (1986). Materials for the fungus flora of Japan. *Transactions of the Mycological Society of Japan, 27*, 29–32.

Kobayasi, Y. (1971). Mycological reports from New Guinea and the Solomon Islands. *Bulletin of the National Museum of Nature and Science, 1*, 1–11.

Kodsueb, R., Dhanasekaran, V., Aptroot, A., Lumyong, S., McKenzie, E. H. C., Hyde, K. D., . . . Jeewon, R. (2006). The family *Pleosporaceae*, intergeneric relationships and phylogenetic perspectives based on sequence analyses of partial 28S rDNA. *Mycologia, 98*, 571–583.

Kolombia, Y. A., Alakonya, A. E., Ortega-Beltran, A., Amah, D., Agogbua, J., Mahuku, G., . . . Swennen, R. (2023). First report of *Lasiodiplodia theobromae* causing dieback symptoms on plantain (*Musa AAB* subgroup) in Nigeria. *Plant Disease, 107*, 943.

Koné, D., Ji, P., Fonsah, G. E., & Csinos, A. S. (2008). First report of black leaf spot of banana caused by *Deightoniella torulosa* in Georgia. *Plant Disease, 92*, 1470–1470.

Kong, H. Z. (1997). *Stachybotrys yunnanensis* sp. nov. and *Neosartorya delicata* sp. nov. isolated from Yunnan, China. *Mycotaxon, 62*, 427–433.

Kongyen, W., Rukachaisirikul, V., Phongpaichit, S., & Sakayaroj, J. (2015). A new hydronaphthalenone from the mangrove-derived *Daldinia eschscholtzii* PSU-STD57. *Natural Product Research, 29*, 1995–1999.

Konta, S., Hyde, K. D., Eungwanichayapant, P., Karunarathna, S. C., Samarakoon, M. C., Xu, J., . . . Tibpromma, S. (2021). Multigene phylogeny reveals *Haploanthostomella elaeidis* gen. et sp. nov. and familial replacement of *Endocalyx* (*Xylariales, Sordariomycetes, Ascomycota*). *Life, 11*, 486.

Konta, S., Maharachchikumbura, S. S. N., Senanayake, I. C., McKenzie, E. H. C., Stadler, M., Boonmee, S., . . . Eungwanichayapant, P. D. (2020). A new genus *Allodiatrype*, five new species and a new host record of diatrypaceous fungi from palms (*Arecaceae*). *Mycosphere, 11*, 239–268.

Koorders, S. H. (1907). *Botanische Untersuchungen über einige in Java vorkommende Pilze, besonders über Blätter bewohnende parasitisch auftretende Arten* [Botanical investigations on some fungi occurring in Java, especially species parasitically inhabiting leaves]. Amsterdam.

Koyyappurath, S., Atuahiva, T., Le-Guen, R., Batina, H., Le-Squin, S., Gautheron, N., . . . Grisoni, M. (2016). *Fusarium oxysporum* f. sp. *radicis-vanillae* is the causal agent of the root and stem rot of vanilla. *Plant Pathology, 65*, 612–625.

Kozlova, M. V., Bilanenko, E. N., Grum-Grzhimaylo, A. A., & Kamzolkina, O. V. (2019). An unusual sexual stage in the alkalophilic ascomycete *Sodiomyces alkalinus*. *Fungal Biology, 123*, 140–150.

Kranz, J. (1962). A list of fungi new to Cyrenaica (Libya). *Sydowia, 16*, 125–134.

Kranz, J. (1963). Fungi collected in the Republic of Guinea. Collections from the Kindia area in 1962. *Sydowia, 17*, 174–185.

Kranz, J. (1965a). A list of plant pathogenic and other fungi of Cyrenaica (Libya). *Phytopathological Papers, 6*, 1–24.

Kranz, J. (1965b). Fungi collected in the Republic of Guinea. III. Collections from the Kindia area in 1963/64 and host index. *Sydowia, 19*, 92–107.

Kruse, J., Kummer, V., & Thiel, H. (2014). Noteworthy records of phytopathogenic micromycetes. *Zeitschrift für Mykologie, 80*, 593–626.

Kuhnert, E., Fournier, J., Peršoh, D., Luangsa-ard, J. J. D., & Stadler, M. (2014). New *Hypoxylon* species from Martinique and new evidence on the molecular phylogeny of *Hypoxylon* based on ITS rDNA and β-tubulin data. *Fungal Diversity*, *64*, 181–203.

Kumar, K. S., Bhowmik, D., Duraivel, S., & Umadevi, M. (2012). Traditional and medicinal uses of banana. *Journal of Pharmacognosy and Phytochemistry, 1*, 51–63.

Kumar, S., Singh, R., & Kamal. (2021). Global diversity and distribution of distoseptosporic micromycete *Corynespora* Güssow (*Corynesporascaceae*) - an updated checklist with current status. *Studies of Fungi, 6*, 1–63.

Kumar, V. S., Nair B. A., Nair P. V. R., Annamalai A., Jaishanker R., Umamaheswaran K., . . . Peethambaran C. K. (2017). First report of *Colletotrichum siamense* causing anthracnose of cliff banana in India. *Plant Disease, 101*, 390.

Kurera, W. M. S., Adikaram, N. K. B., Yakandawala, D. M. D., Maharachchikumbura, S. S., Jayasinghe, L., & Samarakoon, K. (2023). Molecular and phenotypic characterization of *Colletotrichum plurivorum* and *Colletotrichum musae* causing banana anthracnose disease in the Central Province of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka, 51*.

Kwon, J. H., Ryu, J. S., Chi, T. T. P., Shen, S. S., & Choi, O. (2012). Soft rot of *Rhizopus oryzae* as a postharvest pathogen of banana fruit in Korea. *Mycobiology, 40*, 214–216.

Laboratoire de cryptogamie (1971). *Revue de mycologie*. Muséum national d'histoire naturelle, Paris.

Lamprecht, S. C., Crous, P. W., Groenewald, J. Z., Tewoldemedhin, Y. T., & Marasas, W. F. (2011). *Diaporthaceae* associated with root and crown rot of maize. *IMA Fungus, 2*, 13–24.

Larter, L. N. H., & Martyn, E. B. (1943). A preliminary list of plant diseases in Jamaica. *Mycological Papers, 8*, 1–16.

Le Thi, L., Mertens, A., Vu, D. T., Vu, T. D., Minh, P. L. A., Duc, H. N., . . . Janssens, S. B. (2022). Diversity of *Fusarium* associated banana wilt in northern Viet Nam. *MycoKeys, 87*, 53.

Leão-Ferreira, S. M., & Gusmão, L. F. P. , Conidial fungi from the semi-arid Caatinga biome of Brazil: New species of *Endophragmiella* and *Spegazzinia* with new records for Brazil, South America, and Neotropica. *Mycotaxon, 111*, 1–10.

Li, H. Y., Sun, G. Y., Zhai, X. R., Batzer, J. C., Mayfield, D. A., Crous, P. W., . . . Gleason, M. L. (2012). *Dissoconiaceae* associated with sooty blotch and flyspeck on fruits in China and the United States. *Persoonia, 28*, 113–125.

Li, J. F., Phookamsak, R., Jeewon, R., Bhat, D. J., Mapook, A., Camporesi, E., . . . Hyde, K. D. (2017). Molecular taxonomy and morphological characterization reveal new species and new host records of *Torula* species (*Torulaceae, Pleosporales*). *Mycological Progress, 16*, 447–461.

Li, J., Jeewon, R., Mortimer, P. E., Doilom, M., Phookamsak, R., & Promputtha, I. (2020). Multigene phylogeny and taxonomy of *Dendryphion hydei* and *Torula hydei* spp. nov. from herbaceous litter in northern Thailand. *PloS ONE, 15,* Article e0228067.

Li, Q. R., & Jiang, Y. L. (2011). *Stachybotrys subreniformis*, new from soil in China. *Mycotaxon, 115*, 171–173.

Li, W. J., McKenzie, E. H. C., Liu, J. K., Bhat, D. J., Dai, D. Q., Camporesi, E., . . . Hyde, K. D. (2020). Taxonomy and phylogeny of hyaline-spored coelomycetes. *Fungal Diversity, 100,* 279–801.

Li, Z., Chang, P., Gao, L., & Wang, X. (2020). The endophytic fungus *Albifimbria verrucaria* from wild grape as an antagonist of *Botrytis cinerea* and other grape pathogens. *Phytopathology, 110*, 843–850.

Liang, C., Jayawardena, R. S., Zhang, W., Wang, X., Liu, M., Liu, L., . . . Zhao, K. (2016). Identification and characterization of *Pseudocercospora* species causing grapevine leaf spot in China. *Journal of Phytopathology, 164*, 75–85.

Liang, J., Li, G., Zhao, M., & Cai, L. (2019). A new leaf blight disease of turfgrasses caused by *Microdochium poae* sp. nov. *Mycologia, 111*, 265–273.

Lichtenstein, J. H. R., Molina, R. M., Donaghey, T. C., Amuzie, C. J., Pestka, J. J., Coull, B. A., . . . Brain, J. D. (2010). Pulmonary responses to *Stachybotrys chartarum* and its toxins: Mouse strain affects clearance and macrophage cytotoxicity. *Toxicological Sciences, 116*, 113–121.

Liddle, R. L., Akinsanmi, O. A., & Galea, V. J. (2019). Non-host specificity of *Botryosphaeriaceae* on macadamia and blueberry. *Australasian Plant Pathology, 48*, 65–73.

Lima, C. S., Pfenning, L. H., Costa, S. S., Abreu, L. M., & Leslie, J. F. (2012). *Fusarium tupiense* sp. nov., a member of the *Gibberella fujikuroi* complex that causes mango malformation in Brazil. *Mycologia, 104*, 1408–1419.

Lin, C. G., McKenzie, E. H. C., Bhat, D. J., Ran, S. F., Chen, Y., Hyde, K. D., . . . Wang, Y. (2016). Stachybotrys-like taxa from karst areas and a checklist of Stachybotrys-like species from Thailand. *Mycosphere, 7*, 1273–1291.

Lin, S. H., Huang, S. L., Li, Q. Q., Hu, C. J., Fu, G., Qin, L. P., . . . Yan, W. H. (2011). Characterization of *Exserohilum rostratum*, a new causal agent of banana leaf spot disease in China. *Australasian Plant Pathology, 40*, 246–259.

Lin, T. Y. (1970). Maladies des taches foliaires de Bananiers provoquees a Formose par trois champignons nouveaux [Diseases of leaf spot in banana trees caused in Formosa by three new fungi], *Revue de Mycologie, 35*, 317–327.

Linnean Society of London. (1869). *The Journal of the Linnean Society, 10*, 523.

Linnean Society of London. (1875). *The Journal of the Linnean Society, 14*, 87.

Litzenberger, S. C., Farr, M. L., & Lip, H. T. (1962). *A preliminary list of Cambodian plant diseases.* USAID, Ministry of Agriculture, Cambodia.

Liu, C., Wang, H., Hou, X., Zeng, R., Ye, H., Gao, Q., . . . Zhou, H. (2023). First report of *Epicoccum latusicollum* causing leaf spot disease on banana in China. *Plant Disease*, *107*, 2553.

Liu, F., Bonthond, G., Groenewald, J. Z., Cai, L., & Crous, P. W. (2019). *Sporocadaceae*, a family of coelomycetous fungi with appendage-bearing conidia. *Studies in Mycology*, *92*, 287–415.

Liu, F., Cai, L., Crous, P. W., & Damm, U. (2014). The *Colletotrichum gigasporum* species complex. *Persoonia, 33,* 83–97.

Liu, F., Ma, Z. Y., Hou, L. W., Diao, Y. Z., Wu, W. P., Damm, U., . . . Cai, L. (2022). Updating species diversity of *Colletotrichum* with a phylogenomic overview. *Studies in Mycology, 101,* 1–56.

Liu, F., Weir, B. S., Damm, U., Crous, P. W., Wang, Y., Liu, B., . . . Cai, L. (2015). Unravelling *Colletotrichum* species associated with *Camellia*, employing ApMat and GS loci to resolve species in the *C. gloeosporioides* complex. *Persoonia, 35,* 63–86.

Liu, H., & Zhang, T. (2004). A preliminary report of soil dematiaceous hyphomycetes from the Yellow river delta I. *Mycosystema, 23,* 338–344.

Liu, H., Lei, X., Chen, L., Hu, S., Li, G., & Deng, Z. (2021). Keratomycosis caused by a rare pathogen, *Myrothecium verrucaria*. *Mycopathologia, 186,* 893–895.

Liu, J. K., Hyde, K. D., Jones, E. B. G., Ariyawansa, H. A., Bhat, D. J., Boonmee, S., Maharachchikumbura, S. S. N., McKenzie, E. H. C., Phookamsak, R., Phukhamsakda, C., Shenoy, B. D., Abdel-Wahab, M. A., Buyck, B., Chen, J., Chethana, K. W. T., Singtripop, C., Dai, D. Q., Dai, Y. C., Daranagama, D. A., . . . Wisitrassameewong, K. (2015). Fungal diversity notes 1–110: Taxonomic and phylogenetic contributions to fungal species. *Fungal Diversity, 72,* 1–197.

Liu, J. K., Phookamsak, R., Dai, D. Q., Tanaka, K., Jones, E. G., Xu, J. C., . . . Hyde, K. D. (2014). *Roussoellaceae*, a new pleosporalean family to accommodate the genera *Neoroussoella* gen. nov., *Roussoella*, and *Roussoellopsis*. *Phytotaxa, 181,* 1–33.

Liu, N. G., Hongsanan, S., Yang, J., Bhat, D. J., Liu, J., Jumpathong, J., . . . Liu, Z. (2017). *Periconia thailandica* (*Periconiaceae*), a new species from Thailand. *Phytotaxa, 323,* 253–263.

Liu, N. G., Hongsanan, S., Yang, J., Lin, C. G., Bhat, D. J., Liu, J. K., . . . Liu, Z. Y. (2018). *Dendryphiella fasciculata* sp. nov. and notes on other *Dendryphiella* species. *Mycosphere, 8*, 1575–1586.

Liu, N. G., Lin, C. G., Liu, J. K., Samarakoon, M. C. H., Hongsanan, S., Bhat, D. J., . . . Jumpathong, J. (2019). *Lentimurisporaceae*, a new Pleosporalean family with divergence times estimates. *Cryptogamie Mycologie*, *39*, 259–282.

Liu, P. S. W. (1977). A supplement to a host list of plant diseases in Sabah, Malaysia. *Phytopathological Papers, 21*, 1–49.

Liu, X. J., & Guo, Y. L. (1998). *Flora Fungorum Sinicorum*, Vol. 9: *Pseudocercospora*. Science Press, Beijing.

Liu, Y. J., Whelen, S., & Hall, B. D. (1999). Phylogenetic relationships among ascomycetes: Evidence from an RNA polymerase II subunit. *Molecular Biology and Evolution, 6*, 1799–1808.

Lombard, L., Houbraken, J., Decock, C., Samson, R. A., Meijer, M., Réblová, M., . . . Crous, P. W. (2016). Generic hyper-diversity in *Stachybotriaceae*. *Persoonia, 36*, 156–246.

Lombard, L., Sandoval-Denis, M., Lamprecht, S. C., & Crous, P. W. (2019). Epitypification of *Fusarium oxysporum*; clearing the taxonomic chaos. *Persoonia*, *43*, 1–47.

Lombard, L., Serrato-Diaz, L. M., Cheewangkoon, R., French-Monar, R. D., Decock, C., & Crous, P. W. (2014). Phylogeny and taxonomy of the genus *Gliocephalotrichum*. *Persoonia, 32*, 127–140.

Lombard, L., van der Merwe, N. A., Groenewald, J. Z., & Crous, P. W. (2015). Generic concepts in *Nectriaceae*. *Studies in Mycology*, *80*, 189–245.

Lombard, L., van Doorn, R., & Crous, P. W. (2019). Neotypification of *Fusarium chlamydosporum* – A reappraisal of a clinically important species complex. *Fungal Systematics and Evolution, 4*, 183–200.

Lopes, R. B., Mesquita, A. L. M., Tigano, M. S., Souza, D. A., Martins, I., & Faria, M. (2013). Diversity of indigenous *Beauveria* and *Metarhizium* spp. in a commercial banana field and their virulence toward *Cosmopolites sordidus* (*Coleoptera: Curculionidae*). *Fungal Ecology, 6*, 356–364.

Lu, B., Hyde, K. D., Ho, W. H., Tsui, K. M., Taylor, J. E., Wong, K. M., . . . Zhou, D. (2000). *Checklist of Hong Kong Fungi*. Fungal Diversity Press, Hong Kong.

Lu, Y. Z., Boonmee, S., Liu, J. K., Hyde, K. D., McKenzie, E. H. E., & Kang, J. C. (2018). Multi-gene phylogenetic analyses reveal *Neohelicosporium* gen. nov. and five new species of helicosporous hyphomycetes from aquatic habitats. *Mycological Progress, 17*, 631–646.

Lu, Y. Z., Liu, J. K. J., Hyde, K. D., Jeewon, R., Kang, J. C., Fan, C., . . . Eungwanichayapant, P. D. (2018). A taxonomic reassessment of *Tubeufiales* based on multi-locus phylogeny and morphology. *Fungal Diversity, 92*, 131–344.

Lumbsch, H. T., & Hindemith, R. (2001). Major lineages of *Dothideomycetes* (*Ascomycota*) inferred from SSU and LSU rDNA sequences. *Mycological Research, 105*, 901–908.

Lumyong, P., Photita, W., McKenzie, E. H. C., Hyde, K. D., & Lumyong, S. (2002). A new *Dictyosporium* species from *Musa acuminata* in Thailand. *Mycotaxon, 82*, 415–419.

Lumyong, P., Photita, W., McKenzie, E. H. C., Hyde, K. D., & Lumyong, S. (2003). Saprobic fungi on dead wild banana. *Mycotaxon, 85*, 345–346.

Luo, D. Q., Deng, H. Y., Yang, X. L., Shi, B. Z., & Zhang, J. Z. (2011). Oleanane-type triterpenoids from the endophytic fungus *Pestalotiopsis clavispora* isolated from the Chinese mangrove plant *Bruguira sexangula*. *Helvetica Chimica Acta, 94*, 1041–1047.

Luo, J., & Zhuang, W.Y. (2010). New species and new Chinese records of *Bionectriaceae* (*Hypocreales, Ascomycota*). *Mycological Progress, 9*, 17–25.

Luo, Z. L., Hyde, K. D., Bhat, D. J., Jeewon, R., Maharachchikumbura, S. S. N., Bao, D. F., . . . Su, H. Y. (2018). Morphological and molecular taxonomy of novel species *Pleurotheciaceae* from freshwater habitats in Yunnan, China. *Mycological Progress, 17*, 511–530.

Ma, X., Nontachaiyapoom, S., Jayawardena, R. S., Gentekaki, E., Zhou, S., Qian, Y., . . . Kang, J. (2018). Endophytic *Colletotrichum* species from *Dendrobium* spp. in China and northern Thailand. *MycoKeys, 43*, 23.

Madrid, H., Cano, J., Gene, J., & Guarro, J. (2011). Two new species of *Cladorrhinum*. *Mycologia, 103*, 795–805.

Maharachchikumbura, S. S. N., Hyde, K. D., Groenewald, J. Z., Xu, J., & Crous, P. W. (2014). *Pestalotiopsis* revisited. *Studies Mycology, 79*, 121–186.

Maharachchikumbura, S. S. N., Hyde, K. D., Jones, E. B. G., McKenzie, E. H. C., Bhat, J. D., Dayarathne, M. C., . . . Wijayawardene, N. N. (2016). Families of *Sordariomycetes*. *Fungal Diversity, 79*, 1–317.

Maharachchikumbura, S. S. N., Wanasinghe, D. N., Cheewangkoon, R., & Al-Sadi, A. M. (2021). Uncovering the hidden taxonomic diversity of fungi in Oman. *Fungal Diversity, 106*, 229–268.

Maharachchikumbura, S. S., Chen, Y., Ariyawansa, H. A., Hyde, K. D., Haelewaters, D., Perera, R. H., . . . Stadler, M. (2021). Integrative approaches for species delimitation in *Ascomycota*. *Fungal Diversity, 109*, 155–179.

Maharachchikumbura, S. S., Guo, L. D., Chukeatirote, E., Bahkali, A. H., & Hyde, K. D. (2011). *Pestalotiopsis*: Morphology, phylogeny, biochemistry and diversity. *Fungal Diversity, 50*, 167–187.

Male, M. F. B., Tan, Y. P., Vawdrey, L. L., & Shivas, R. G. (2011). Elucidation of the taxonomy and pathological status of *Pyricularia* associated with banana blast in Australia. *Australasian Plant Disease Notes, 6*, 22–25.

Manamgoda, D. S., Cai, L., Bahkali, A. H., Chukeatirote, E., & Hyde, K. D. (2011). *Cochliobolus*: An overview and current status of species. *Fungal Diversity, 51*, 3–42.

Manamgoda, D. S., Rossman, A. Y., Castlebury, L. A., Crous, P. W., Madrid, H., Chukeatirote, E., . . . Hyde, K. D. (2014). The genus *Bipolaris*. *Studies Mycology, 79*, 221–288.

Manamgoda, D. S., Rossman, A., Castlebury, L. A., & Chukeatirote, E. (2015). A taxonomic and phylogenetic re-appraisal of the genus *Curvularia* (*Pleosporaceae*): Human and plant pathogens. *Phytotaxa, 212*, 175–198.

Manawasinghe, I. S., Zhang, Y. X., Liao, C. F., Xiong, Y. R., Kularathnage, N. D., Luo, M., . . . Gafforov, Y. S. (2022). Mycosphere notes 345–386. *Mycosphere, 13*, 454–557.

Maneval, W. E. (1937). A list of the Missouri fungi. *University of Missouri Studies in Science, Series 12*.

Manish, T., Gupta, R. C., & Yogesh, J. (2014). *Spegazzinia tessarthra* isolated as a true endophyte from lichen *Heterodermia flabellata*. *Indian Phytopathology, 67*, 109–110.

Manoharachary, C., & Kunwar, I. K. (2010). *Taxonomy and Ecology of Indian fungi*. IK Internat Pvt. Ltd.

Manzo-Sanchez, G., Orozco-Santos, M., Islas-Flores, I., Martinez-Bolanos, L., Guzman-Gonzalez, S., Leopardi-Verde, C. L., . . . Canto-Canche, B. (2019). Genetic variability of *Pseudocercospora fijiensis*, the black Sigatoka pathogen of banana (*Musa* spp.) in Mexico. *Plant Pathology, 68*, 513–522.

Mapook, A., Hyde, K. D., McKenzie, E. H. C., Jones, E. B. G., Bhat, D. J., Jeewon, R., . . . Purahong, W. (2020). Taxonomic and phylogenetic contributions to fungi associated with the invasive weed *Chromolaena odorata* (Siam weed). *Fungal Diversity, 101*, 1–175.

Marasas, W. F. O., Rheeder, J. P., Logrieco, A., Van Wyk, P. S., & Juba, J. H. (1998). *Fusarium nelsonii* and *F. musarum*, two new species in section *Arthrosporiella* related to *F. camptoceras*. *Mycologia, 90*, 505–513.

Marin, D. H., Sutton, T. B., Blankenship, S. M., & Swallow, W. H. (1996). Pathogenicity of fungi associated with crown rot of bananas in Latin America on Grande Naine and disease-resistant hybrid bananas. *Plant Disease, 80*, 525–528.

Marin-Felix, Y., Hernandez-Restrepo, M., & Crous, P. W. (2020). Multi-locus phylogeny of the genus *Curvularia* and description of ten new species. *Mycological Progress, 19*, 559–588.

Marin-Felix, Y., Hernandez-Restrepo, M., Iturrieta-Gonzalez, I., Garcia, D., Gene, J., Groenewald, J. Z., . . . Crous, P. W. (2019). Genera of phytopathogenic fungi (GOPHY) 3. *Studies in Mycology, 94*, 1–124.

Marin-Felix, Y., Hernandez-Restrepo, M., Wingfield, M. J., Akulov, A., Carnegie, A. J., Cheewangkoon, R., . . . Crous, P. W. (2019). Genera of phytopathogenic fungi (GOPHY) 2. *Studies in Mycology, 92*, 47–133.

Markovskaja, S., & Kačergius, A. (2014). Morphological and molecular characterisation of *Periconia pseudobyssoides* sp. nov. and closely related *P. byssoides*. *Mycological Progress, 13*, 291–302.

Martyn, E. B. (1945). A note on banana leaf speckle in Jamaica and some associated fungi. *Mycological Papers, 13*, 1–5.

Maryani, N., Lombard, L., Poerba, Y. S., Subandiyah, S., Crous, P. W., & Kema, G. H. J. (2019). Phylogeny and genetic diversity of the banana *Fusarium* wilt pathogen *Fusarium oxysporum* f. sp. *cubense* in the Indonesian center of origin. *Studies in Mycology, 92*, 155–194.

Masel, A. M., Irwin, J. A. G., & Manners, J. M. (1993). Mini-chromosomes of *Colletotrichum* spp. infecting several host species in various countries. *Mycological Research, 97*, 852–856.

Masetti, R., Prodi, A., Liberatore, A., Carfagnini, F., Cappelletti, E., Leardini, D., . . . Cricca, M. (2020). Occurrence of *Albifimbria verrucaria* in the blood of a female child with neuroblastoma. *Frontiers in Medicine, 7*, 13.

Mason, C. D., Rand, T. G., Oulton, M., MacDonald, J. M., & Scott, J. E. (1998). Effects of *Stachybotrys chartarum* (atra) conidia and isolated toxin on lung surfactant production and homeostasis. *Natural Toxins, 6*, 27–33.

Mason, E. W. (1925). *Fungi received at the Imperial Bureau of Mycology*. Bureau, United States.

Mason, E. W. (1941). Annotated account of fungi received at the Imperial Mycological Institute. List 2. Fasc. 3 (special part). *Commonwealth Mycological Papers, 5*, 1–144.

Maswada, H. F. (2017). Etiology and ecology of fungi causing postharvest diseases of banana fruits in Egypt. *Plant Archives, 17*, 1463–1468.

Mathur, R. S. (1979). *The coelomycetes of India*. Bishen Singh Mahendra Pal Singh, Delhi, India.

Matić, S., Gilardi, G., Gullino, M. L., & Garibaldi, A. (2019). Emergence of leaf spot disease on leafy vegetable and ornamental crops caused by *Paramyrothecium* and *Albifimbria* species. *Phytopathology, 109*, 1053–1061.

Matsumura, M., Mortimer, P. E., Rambold, G., Randrianjohany, E., Sato, G., Sri-Indrasutdhi, V., . . . Camporesi, E. (2015). Fungal diversity notes 1–110: Taxonomic and phylogenetic contributions to fungal species. *Fungal Diversity*, *72*, 1–197.

Matsushima, T. (1971). *Microfungi of the Solomon Islands and Papua–New Guinea*. Nippon Printing Publishing Co., Osaka.

Matsushima, T. (1975). *Icones microfungorum a Matsushima lectorum*. Nippon Printing Publishing Co., Osaka.

Matsushima, T. (1980). *Matsushima Mycological Memoirs No. 1: Saprophytic microfungi from Taiwan, Part 1, Hyphomycetes.* Kobe, Japan.

Matsushima, T. (1981). *Matsushima Mycological Memoirs No. 2.* Kobe, Japan.

Matsushima, T. (1985). *Matsushima Mycological Memoirs No 4.* Kobe, Japan.

Matsushima, T. (1987). *Matsushima Mycological Memoirs No. 5.* Kobe, Japan.

Maymon, M., Shpatz, U., Harel, Y. M., Levy, E., Elkind, G., Teverovski, E., . . . Freeman, S. (2018). First report of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 causing Fusarium wilt of Cavendish bananas in Israel. *Plant Disease, 102*, 2655–2656.

Mbenoun, M., De Beer, Z. W., Wingfield, M. J., Wingfield, B. D., & Roux, J. (2014). Reconsidering species boundaries in the *Ceratocystis paradoxa* complex, including a new species from oil palm and cacao in Cameroon. *Mycologia, 106*, 757–784.

McDowell, J. M. (2013). Genomic and transcriptomic insights into lifestyle transitions of a hemi-biotrophic fungal pathogen. *New Phytologist, 197*, 1032–1034.

McGuire Jr, J. U., & Crandall, B. S. (1967). *Survey of insect pests and plant diseases of selected food crops of Mexico, Central America, and Panama.* International Agricultural Development Service, ARS, USDA, AID.

McKenzie, E. C. (1991). Dematiaceous hyphomycetes on *Freycinetia* (*Pandanaceae*). I, *Stachybotrys*. *Mycotaxon, 41*, 179–188.

McKenzie, E. H. C. (1996). *Fungi, Bacteria, and pathogenic Algae on plants in American Samoa.* South Pacific Commission.

McKenzie, E. H. C., & Jackson, G. V. H. (1986). The fungi, bacteria and pathogenic algae of Solomon Islands. *Strengthening Plant Protection and Root Crops Development in the South Pacific. RAS/83/001, Field Document 11*. Suva, Fiji.

McKenzie, E. H. C., & Jackson, G. V. H. (1990). The fungi, bacteria and pathogenic algae of the Federated States of Micronesia. *SPC Technical Paper, 199*, 67.

McKenzie, E. H. C., & Vanky, K. (2001). Smut fungi of New Zealand – An introduction and list of recorded species. *New Zealand Journal of Botany, 39*, 501–515.

McMaster, C. A., Tran-Nguyen, L. T. T., Voutsinos, M. Y., Cook, S. E., Conde, B. D., West, S. J., . . . Liberato, J. R. (2020). Outbreak of freckle disease (*Phyllosticta cavendishii*) on Cavendish bananas in Australia and the initial biosecurity response. *Plant Pathology, 69*, 38–49.

Meeboon, J., Hidayat, I., To-anun, C., & Nakashima, C. (2008). Cercosporoid fungi from Thailand II: New species of *Cercospora* and *Passalora*. *Sydowia, 60*, 253–260.

Meetum, P., Leksomboon, C., & Kanjanamaneesathian, M. (2015). First report of *Colletotrichum aenigma* and *C. siamense*, the causal agents of anthracnose disease of dragon fruit in Thailand. *Journal of Plant Pathology, 97*, 402–402.

Mendes, M. A. S., da Silva, V. L., & Dianese, J. C. (1998). *Fungos em plants no Brasil.* Embrapa-SPI/Embrapa-Cenargen.

Mercado-Sierra, A. (1984). *Hifomicetes demaciaceos de Sierra del Rosario, Cuba.* Editorial Academica, Havana.

Mercado-Sierra, A., & Heredia, G. (1994). Hyphomycetes associated with plant litter from the State of Veracruz, Mexico. *Revista Mexicana de Micología, 10,* 33–48.

Mercado-Sierra, A., Gené, J., Figueras, M. J., Rodríguez, K., & Guarro, J. (1998). New or rare hyphomycetes from Cuba. IX. Some species from Pinar del Rio Province. *Mycotaxon, 67,* 417–426.

Meredith, D. S. (1961). Fruit-spot speckle of Jamaican bananas caused by *Deightoniella torulosa* Syd. Ellis III: Spore formation, liberation, and dispersal. *Transactions of the British Mycological Society, 44,* 391.

Meredith, D. S. (1962a). Some fungi on decaying banana leaves in Jamaica. *Transactions of the British Mycological Society, 45,* 335–347.

Meredith, D. S. (1962b). Dispersal of conidia of *Cordana musae* (Zimm.) Höhnel in Jamaican banana plantations. *Annals of Applied Biology, 50,* 263–267.

Meredith, D. S. (1962c). Spore discharge in *Cordana musae* (Zimm.) Höhnel and *Zygosporium oscheoides*. *Annals of Botany, 26,* 233–241.

Meredith, D. S. (1963). Tip rot of banana fruits in Jamaica. *Transactions of the British Mycological Society, 46,* 473–481.

Meredith, D. S. (1969). Fungal diseases of bananas in Hawaii. *Plant Disease Reporter, 53,* 63–66.

Meredith, D. S. (1970). Banana leaf spot disease (Sigatoka) caused by *Mycosphaerella musicola* Leach. *Phytopathological Papers, 11,* 1–147.

Meredith, D. S., & Lawrence, J. S. (1969). Black leaf streak disease of bananas (*Mycosphaerella fijiensis*): Symptoms of disease in Hawaii and notes of the conidial state of the causal fungus. *Transactions of the British Mycological Society, 52*, 459–476.

Meredith, D. S., Aragaki, M., & Holtzmann, O. V. (1968). *Deightoniella torulosa* on bananas in Hawaii. *Plant Disease Reporter, 52*, 405.

Meyer, L., Sanders, G. M., Jacobs, R., & Korsten, L. (2006). A one-day sensitive method to detect and distinguish between the citrus black spot pathogen *Guignardia citricarpa* and the endophyte *Guignardia mangiferae*. *Plant Disease, 90*, 97–101.

Miles, A. K., Tan, Y. P., Tan, M. K., Drenth, A., Ghalayini, A., & Donovan, N. J. (2013). *Phyllosticta* spp. on cultivated Citrus in Australia. *Australasian Plant Pathology, 42*, 461–467.

Miller, J. W. (1991). *Bureau of plant pathology*. Division of Plant Industry, Florida.

Miller, M. A., Pfeiffer, W., & Schwartz, T. (2010, November). Creating the CIPRES Science Gateway for inference of large phylogenetic trees. In *2010 gateway computing environments workshop (GCE)*, 1–8.

Mingot-Ureta, C., Lopez-Moya, F., & Lopez-Llorca, L. V. (2020). Isolates of the nematophagous fungus *Pochonia chlamydosporia* are endophytic in banana roots and promote plant growth. *Agronomy, 10*, 1299.

Misra, P. C., & Srivastava, S. K. (1982). Two undescribed *Stachybotrys* species from India. *Transactions of the British Mycological Society, 78*, 556–559.

Mo, J., Zhao, G., Li, Q., Solangi, G. S., Tang, L., Guo, T., . . . Hsiang, T. (2018). Identification and characterization of *Colletotrichum* species associated with mango anthracnose in Guangxi, China. *Plant Disease, 102*, 1283–1289.

Mohali, S., Burgess, T. I., & Wingfield, M. J. (2005). Diversity and host association of the tropical tree endophyte *Lasiodiplodia theobromae* revealed using simple sequence repeat markers. *Forest Pathology, 35*, 385–396.

Mohapatra, D., Mishra, S., & Sutar, N. (2010). Banana post-harvest practices: Current status and future prospects: A review. *Agricultural Reviews, 31*, 56–62.

Monkai, J., Jayawardena, R. S., Maharachchikumbura, S. S., & Hyde, K. D. (2020). Sexual morph of *Furcasterigmium furcatum* (*Plectosphaerellaceae*) from *Magnolia liliifera* collected in northern Thailand. *Phyton, 89*, 765.

Monkai, J., Phookamsak, R., Xu, S., Xu, J., Mortimer, P. E., Karunarathna, S. C., . . . Lumyong, S. (2022). *Pseudophaeocytostroma bambusicola* gen. et. sp. nov. (*Diaporthaceae*) from bamboo in Yunnan, PR China. *Phytotaxa, 571*, 1–9.

Morelet, M. (1969). *Mycromycetes* du Var et d'ailleurs (2me Note). *Annales de la Société des Sciences Naturelles et d'Archéologie de Toulon et du Var, 21*, 104–106.

Moreno-Flores, A., Álvarez-Reguera, A., Álvarez-Fernández, M., & Alastruey-Izquierdo, A. (2020). *Albifimbria verrucaria* keratitis: A case report. *Enfermedades Infecciosas y Microbiologia Clinica (English Ed.), 38*, 398–399.

Moriwaki, J., Sato, T., & Tsukiboshi, T. (2003). Morphological and molecular characterization of *Colletotrichum boninense* sp. nov. from Japan. *Mycoscience, 44*, 47–53.

Mostert, D., Molina, A. B., Daniells, J., Fourie, G., Hermanto, C., Chao, C. P., . . . Viljoen, A. (2017). The distribution and host range of the banana *Fusarium* wilt fungus *Fusarium oxysporum* f. sp. *cubense* in Asia. *PLoS One, 12*, Article e0181630.

Mouchacca, J., & Horak, E. (1998). Annotated checklist of New Caledonian *Basidiomycota*. II. Rusts and Smuts. *Mycotaxon, 69*, 13–30.

Muirhead, I. F., & Deverall, B. (1981). Role of appressoria in latent infection of banana fruits by *Colletotrichum musae*. *Physiological Plant Pathology, 19*, 77–84.

Mulder, J. L., & Stover, R. H. (1976). *Mycosphaerella* species causing banana leaf spot. *Transactions of the British Mycological Society, 67*, 77–82.

Mulenko, W., Majewski, T., & Ruszkiewicz-Michalska, M. (2008). *A preliminary checklist of* Micromycetes *in Poland.* W. Szafer Institute of Botany, Polish Academy of Sciences.

Munjal, R. L., & Kapoor, J. N. (1969). Some hyphomycetes from Himalayas. *Mycopathologia et Mycologia Applicata, 39*, 121–128.

Murgia, M., Fiamma, M., Barac, A., Deligios, M., Mazzarello, V., & Paglietti, B. (2019). Biodiversity of fungi in hot desert sands. *MicrobiologyOpen, 8*, Article e00595.

Museo Nacional de Buenos Aires. (1909). *Anales del Museo Nacional de Buenos Aires*. Buenos Aires, Imprenta de Juan A. Alsina.

Museo Nacional de Buenos Aires. (1910). *Anales del Museo Nacional de Buenos Aires, 20*, 453.

Museo Nacional de Buenos Aires. (1911). *Anales del Museo Nacional de Buenos Aires, 13*. Buenos Aires, Imprenta de Juan A. Alsina.

Myllys, L., Stenroos, S., & Thell, A. (2002). New genes for phylogenetic studies of lichenized fungi: Glyceraldehyde-3-phosphate dehydrogenase and beta-tubulin genes. *Lichenologist, 34*, 237–246.

Nag Raj, T. R. (1993). *Coelomycetous anamorphs with appendage-bearing conidia.* Mycologue Publications, Waterloo, Ontario.

Nag Raj, T. R., & Kendrick, B. (1975). *A Monograph of Chalara and Allied Genera.* Wilfrid Laurier University Press, Ontario.

Nair, M. C., & Tyagi, P. D. (1961). Notes on some hyphomycetes-I. *Proceedings of the Indian Academy of Sciences, 54*, 269–275.

Nakashima, C., Motohashi, K., Chen, C. Y., Groenewald, J. Z., & Crous, P. W. (2016). Species diversity of *Pseudocercospora* from Far East Asia. *Mycological Progress, 15*, 1093–1117.

Nam, M. H., Park, M. S., Kim, H. S., Kim, T. I., & Kim, H. G. (2015). *Cladosporium cladosporioides* and *C. tenuissimum* cause blossom blight in strawberry in Korea. *Mycobiology, 43*, 354–359.

Narisawa, K., Hambleton, S., & Currah, R. S. (2007). *Heteroconium chaetospira*, a dark septate root endophyte allied to the *Herpotrichiellaceae* (*Chaetothyriales*) obtained from some forest soil samples in Canada using bait plants. *Mycoscience, 48*, 274–281.

Nattrass, R. M. (1961). Host lists of Kenya fungi and bacteria. *Mycological Paper, 81*, 1–46.

Nelson, A., Vandegrift, R., Carroll, G. C., & Roy, B. A. (2020). Double lives: Transfer of fungal endophytes from leaves to woody substrates. *PeerJ, 8*, Article e9341.

Ng, K. P., Chan, C. L., Yew, S. M., Yeo, S. K., Toh, Y. F., Looi, H. K., . . . Kuan, C. S. (2016). Identification and characterization of *Daldinia eschscholtzii* isolated from skin scrapings, nails, and blood. *PeerJ, 4*, Article e2637.

Nguanhom, J., Cheewangkoon, R., Groenewald, J. Z., Braun, U., To-anun, C., & Crous, P. W. (2015). Taxonomy and phylogeny of *Cercospora* spp. from northern Thailand. *Phytotaxa, 233*, 27–48.

Nirenberg, H. I., & O'Donnell, K. (1998). New *Fusarium* species and combinations within the *Gibberella fujikuroi* species complex. *Mycologia, 90*, 434–458.

Nitani, T., Akai, K., Hasegawa, R., Ayukawa, Y., Garcia, R. R., Chitose, A., . . . Komatsu, K. (2018). Panama disease of banana occurred in Miyakojima Island, Okinawa, Japan. *Journal of General Plant Pathology, 84*, 165–168.

Nogawa, T., Kato, N., Shimizu, T., Okano, A., Futamura, Y., Takahashi, S., . . . Osada, H. (2018). Wakodecalines A and B: New decaline metabolites isolated from a fungus *Pyrenochaetopsis* sp. RK10–F058. *The Journal of Antibiotics, 71*, 123–128.

Norphanphoun, C., Hongsanan, S., Gentekaki, E., Chen, Y. J., Kuo, C. H., & Hyde, K. D. (2020). Differentiation of species complexes in *Phyllosticta* enables better species resolution. *Mycosphere, 11*, 2542–2628.

Norse, D. (1974). Plant diseases in Barbados. *Phytopathological Paper, 18*, 1–38.

Nozawa, S., Seto, Y., Takata, Y., Narreto, L. A., Valle, R. R., Okui, K., . . . Watanabe, K. (2023). *Fusarium mindanaoense* sp. nov., a new *Fusarium* wilt pathogen of cavendish banana from the Philippines belonging to the *F. fujikuroi* species complex. *Journal of Fungi, 9*, 443.

Nuangmek, W., McKenzie, E. H. C., & Lumyong, S. (2008). Endophytic fungi from wild banana (*Musa acuminata* Colla.) works against anthracnose disease caused by *Colletotrichum musae*. *Research Journal of Microbiology, 3*, 368–374.

Nugent, L. K. (2004). *Latent invasion by Xylariaceous fungi* (doctoral dissertation). Liverpool John Moores University, Liverpool, United Kingdom.

O'Donnell, K., & Cigelnik, E. (1997). Two divergent intragenomic rDNA ITS2 types within a monophyletic lineage of the fungus *Fusarium* are nonorthologous. *Molecular Phylogenetics and Evolution, 7*, 103–116.

Ocfemia, G. O. (1927). Notes on some economic plant diseases new in the Philippine islands. *Philippine Agriculture, 13*, 163–165.

O'Donnell, K., Cigelnik, E., & Nirenberg, H. I. (1998). Molecular systematics and phylogeography of the *Gibberella fujikuroi* species complex. *Mycologia, 90*, 465–493.

O'Donnell, K., Ward, T. J., Geiser, D. M., Kistler, H. C., & Aoki, T. (2004). Genealogical concordance between the mating type locus and seven other nuclear genes supports formal recognition of nine phylogenetically distinct species within the *Fusarium graminearum* clade. *Fungal Genetics and Biology, 41*, 600–623.

Okane, I., Lumyong, S., Nakagiri, A., & Ito, T. (2003). Extensive host range of an endophytic fungus, *Guignardia endophyllicola* (anamorph *Phyllosticta capitalensis*). *Mycoscience, 44*, 353–363.

O'Neill, W. T., Henderson, J., Pattemore, J. A., O'Dwyer, C., Perry, S., Beasley, D. R., . . . Tan, Y. P. (2016). Detection of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 strain in northern Queensland. *Australasian Plant Disease Notes, 11*, 33.

Ordonez, N., Garcia-Bastidas, F., Laghari, H. B., Akkary, M. Y., Harfouche, E. N., Awar, B. N., . . . Kema, G. H. J. (2016). First report of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 causing Panama disease in Cavendish bananas in Pakistan and Lebanon. *Plant Disease, 100*, 209–210.

Orieux, L., & Felix, S. (1968). List of plant diseases in Mauritius. *Phytopathological Paper, 7*, 1–48.

Ortega-Acosta, S. A., Hernández-Morales, J., Ochoa-Martínez, D. L., & Ayala-Escobar, V. (2015). First report of *Corynespora cassiicola* causing leaf and calyx spot on roselle in Mexico. *Plant Disease, 99*, 1041–1041.

Osorio, J. A., Wingfield, M. J., De Beer, Z. W., & Roux, J. (2015). *Pseudocercospora mapelanensis* sp. nov. associated with a fruit and leaf disease of *Barringtonia racemosa* in South Africa. *Australasian Plant Pathology, 44*, 349–359.

Ozkıılınç, H., Rotondo, F., Pryor, B. M., & Peever, T. L. (2018). Contrasting species boundaries between sections *Alternaria* and *Porri* of the genus *Alternaria*. *Plant Pathology, 67*, 303–314.

Padwick, G. W. (1939). The genus *Fusarium*. I. Known occurrence in India. *Indian Journal of Agricultural Sciences, 9*, 171–184.

Pan, H., Kong, J., Xu, J., Zhang, Y., & Hang, T. (2014). Four new species of *Stachybotrys* and a key to species of the genus known from soil in China. *Mycosystema, 33*, 785–792.

Pande, A. (2008). *Ascomycetes of Peninsular India*. Scientific Publishers, India.

Pande, A., & Rao, V. G. (1998). *A compendium of fungi on legumes from India*. Scientific Publishers, India.

Pando, F., & Hernandez, J. C. (2002). Bases Corológicas de Flora Micologica Iberica. Numeros 1766–1932. *Cuadernos de Trabajo de Flora Micológica Ibérica, 17*, 1–124.

Pantidou, M. E. (1973). *Fungus-host index for Greece*. Benaki Phytopathological Institute, Kiphissia, Athens.

Pantou, M. P., Strunnikova, O. K., Shakhnazarova, V. Y., Vishnevskaya, N. A., Papalouka, V. G., & Typas, M. A. (2005). Molecular and immunochemical phylogeny of *Verticillium* species. *Mycological Research, 109*, 889–902.

Paparu, P., Dubois, T., Gold, C. S., Adipala, E., Niere, B., & Coyne, D. (2004). Inoculation, colonization, and distribution of fungal endophytes in *Musa* tissue culture plants. *Uganda Journal of Agricultural Sciences, 9*, 583–599.

Papizadeh, M., van Diepeningen, A. D., Zamanizadeh, H. R., Saba, F., & Ramezani, H. (2018). *Fusarium ershadii* sp. nov., a pathogen on *Asparagus officinalis* and *Musa acuminata*. *European Journal of Plant Pathology, 151*, 689–701.

Parkunan, V., Li, S., Fonsah, E. G., & Ji, P. (2013). First report of *Alternaria* leaf spot of banana caused by *Alternaria alternata* in the United States. *Plant Disease, 97*, 1116.

Pathak, P. D., & Chauhan, R. K. S. (1976). Leaf spot disease of *Crotolaria juncea* L. caused by *Stachybotrys atra* Corda. *Current Science, 45*, 567–567.

Paul, N. C., Lee, H. B., Lee, J. H., Shin, K. S., Ryu, T. H., Kwon, H. R., . . . Kim, Y. K. (2014). Endophytic fungi from *Lycium chinense* Mill and characterization of two new Korean records of *Colletotrichum*. *International Journal of Molecular Sciences, 15*, 15272–15286.

Paul, Y. S., & Singh, B. M. (1986). Addition to fungi of India. *Indian Phytopathology, 39*, 748–751.

Paul, Y. S., & Thakur, V. K. (2006). *Indian Erysiphaceae*. Scientific Publishers (India), Jodhpur.

Pearce, C. A., & Hyde, K. D. (2006). *Phyllachoraceae of Australia*. Fungal Diversity Press, Hong Kong.

Pem, D., Jeewon, R., Chethana, K. W. T., Hongsanan, S., Doilom, M., Suwannarach, N., . . . Hyde, K. D. (2021). Species concepts of *Dothideomycetes*: Classification, phylogenetic inconsistencies, and taxonomic standardization. *Fungal Diversity, 109*, 283–319.

Peregrine, W. T. H., & Ahmad, K. B. (1982). Brunei: A first annotated list of plant diseases and associated organisms. *Phytopathological Paper, 27*, 1–87.

Peregrine, W. T. H., & Siddiqi, M. A. (1972). A revised and annotated list of plant diseases in Malawi. *Phytopathological Papers, 16*, 1–51.

Pereira, J. O., Vieira, M. C., & Azevedo, J. L. (1999). Endophytic fungi from *Musa acuminata* and their reintroduction into axenic plants. *World Journal of Microbiology and Biotechnology, 15*, 37–40.

Perez Sierra, A., Termorshiuzen, A., & Otieno, W. (2003). Characterization of *Armillaria* isolates from tea (*Camellia sinensis*) in Kenya. *Mycologia*, *95*, 160–175.

Pervez, M. R., Musaddiq, M., Thakare, P. V., & Kumar, A. (2015). Characterization of bioactive compound isolated from *Myrothecium* spp. with UV, FTIR and HPLC analysis. *Indian Journal of Pharmaceutical and Biological Research, 3*, 1.

Petrak, F. (1944). *List of New Species and Varieties of Fungi, New Combinations and New Names Published 1932–1935.* Commonwealth Mycological Institute.

Petrak, F. (1950). *List of New Species and Varieties of Fungi, New Combinations and New Names Published 1936–1939.* Commonwealth Mycological Institute.

Pfenning, L. H., de Melo, M. P., Costa, M. M., Reis, A., Cabral, C. S., Lima, C. S., . . . Abreu, L. M. (2019). *Fusarium udum* revisited: A common but poorly understood member of the *Fusarium fujikuroi* species complex. *Mycological Progress, 18*, 107–117.

Pfister, D. H. (1991). A redescription of *Peziza bananicola* and comments on some similar tropical species. *Mycotaxon*, *41*, 505–507.

Phengsintham, P., Braun, U., McKenzie, E. H. C., Chukeatirote, E., Cai, L., & Hyde, K. D. (2013). Monograph of *Cercosporoid* fungi from Thailand. *Plant Pathology & Quarantine*, *3*, 67–138.

Phengsintham, P., Chukeatirote, E., Bahkali, A. H., Moslem, M. A., Hyde, K. D., & Braun, U. (2010). *Cercospora* and allied genera from Laos 3. *Cryptogamie Mycologie*, *31*, 305–322.

Phillips, A. J. L., Alves, A., Abdollahzadeh, J., Slippers, B., Wingfield, M. J., Groenewald, J. Z., . . . Crous, P. W. (2013). The *Botryosphaeriaceae*: Genera and species known from culture. *Studies in Mycology*, *76*, 51–167.

Phillips, A. J., Hyde, K. D., Alves, A., & Liu, J. K. J. (2019). Families in *Botryosphaeriales*: A phylogenetic, morphological, and evolutionary perspective. *Fungal Diversity, 94*, 1–22.

Phookamsak, R., Hyde, K. D., Jeewon, R., Bhat, D. J., Jones, E. G., Maharachchikumbura, S. S., . . . Xu, J. (2019). Fungal diversity notes 929–1035: Taxonomic and phylogenetic contributions on genera and species of fungi. *Fungal Diversity, 95*, 1–273.

Phookamsak, R., Jiang, H., Suwannarach, N., Lumyong, S., Xu, J., Xu, S., . . . Chomnunti, P. (2022). Bambusicolous fungi in *Pleosporales*: Introducing four novel taxa and a new habitat record for *Anastomitra beculia*. *Journal of Fungi, 8*, 630.

Phookamsak, R., Wanasinghe, D. N., Hongsanan, S., Phukhamsakda, C., Huang, S. K., Tennakoon, D. S., . . . Mortimer, P. E. (2017). Towards a natural classification of *Ophiobolus* and *Ophiobolus*-like taxa, introducing three novel genera: *Ophiobolopsis*, *Paraophiobolus*, and *Pseudoophiobolus* in *Phaeosphaeriaceae* (*Pleosporales*). *Fungal Diversity, 87*, 299–339.

Phookamsak, R., Norphanphoun, C., Tanaka, K., Dai, D. Q., Luo, Z. L., Liu, J. K., . . . Mortimer, P. E. (2015). Towards a natural classification of *Astrosphaeriella*-like species; introducing *Astrosphaeriellaceae* and *Pseudoastrosphaeriellaceae* fam. nov. and *Astrosphaeriellopsis*, gen. nov. *Fungal Diversity, 74*, 143–197.

Photita, W., Lumyong, P., McKenzie, E. H. C., Hyde, K. D., & Lumyong, S. (2003a). *Memnoniella* and *Stachybotrys* species from *Musa acuminata*. *Cryptogamie Mycologie, 24*, 147–152.

Photita, W., Lumyong, P., McKenzie, E. H. C., Hyde, K. D., & Lumyong, S. (2003b). Saprobic fungi on dead wild banana. *Mycotaxon, 85*, 345–356.

Photita, W., Lumyong, S., & Lumyong, P. (2001). Endophytic fungi of wild banana (*Musa acuminata*) at Doi Suthep Pui National Park, Thailand. *Mycological Research, 105*, 1508–1513.

Photita, W., Lumyong, S., Lumyong, P., & Hyde, K. D. (2000). *Durispora musae*, a new species of ascomycetes from banana in Hong Kong. *Nova Hedwigia, 71*, 101–105.

Photita, W., Lumyong, S., Lumyong, P., Ho, W. H., McKenzie, E. H. C., & Hyde, K. D. (2001). Fungi on *Musa acuminata* in Hong Kong. *Fungal Diversity, 6*, 99–106.

Photita, W., Lumyong, S., Lumyong, P., Hyde, K. D., & McKenzie, E. H. C. (2002). Index of fungi described from the *Musaceae*. *Mycotaxon, 81*, 491–503.

Photita, W., Lumyong, S., Lumyong, P., McKenzie, E. H. C., & Hyde, K. D. (2004). Are some endophytes of *Musa acuminata* latent pathogens? *Fungal Diversity, 16*, 131–140.

Phukhamsakda, C., McKenzie, E. H. C., Phillips, A. J. L., Jones, E. B. G., Bhat, D., Stadler, M., . . . Hyde, K. D. (2020). Micro fungi associated with *Clematis* (*Ranunculaceae*) with an integrated approach to delimiting species boundaries. *Fungal Diversity, 102*, 1–203.

Piatek, M., Lutz, M., & Chater, A. O. (2013). Cryptic diversity in the *Antherospora vaillantii* complex on *Muscari* species. *IMA Fungus, 4*, 5–19.

Piepenbring, M. (2006). Checklist of fungi in Panama. Preliminary version. *Puente Biológico, 1*, 1–190.

Pintos, Á., & Alvarado, P. (2021). Phylogenetic delimitation of *Apiospora* and *Arthrinium*. *Fungal Systematics and Evolution, 7*, 197–221.

Pirozynski, K. A. (1962). *Circinotrichum* and *Gyrothrix*. *Mycological Papers, 84*, 1–28.

Pirozynski, K. A., & Morgan-Jones, G. (1968). Notes on microfungi. III. *Transactions of the British Mycological Society, 51*, 185–206.

Ploetz, R. C. (2003). *Diseases of tropical fruit crops*. CABI Publishing.

Ploetz, R. C. (2004). First report of black sigatoka of banana caused by *Mycosphaerella fijiensis* on Grand Bahama Island. *Plant Disease, 88*, 772.

Ploetz, R. C., & Mourichon, X. (1999). First report of black sigatoka in Florida. *Plant Disease, 83*, 300.

Ploetz, R. C., & Shepard, E. S. (1988). Fusarial wilt of banana in south Florida. *Plant Disease, 72*, 994.

Pocasangre, L., Sikora, R. A., Vilich, V., & Schuster, R. P. (1999). Survey of banana endophytic fungi from Central America and screening for biological control of *Radopholus similis*. In *II ISHS Conference on Fruit Production in the Tropics and Subtropics*, *531*, 283–290.

Pollack, F. G. (1987). An annotated compilation of *Cercospora* names. *Mycological Memoirs, 12*, 1–212.

Pongprasert, N., Srilaong, V., & Sunpapao, A. (2021). Postharvest senescent dark spot development mechanism of *Musa acuminata* ("Khai" banana) peel associated with chlorophyll degradation and stomata cell death. *Journal of Food Biochemistry, 45*, Article e13745.

Powell, M. J., & Koch, W. J. (1977). Morphological variations in a new species of *Entophlyctis* I: The species concept. *Canadian Journal of Botany, 55*, 1668–1685.

Prasannath, K., Galea, V. J., & Akinsanmi, O. A. (2020). Characterization of leaf spots caused by *Neopestalotiopsis clavispora* and *Colletotrichum siamense* in macadamia in Australia. *European Journal of Plant Pathology*, *156*, 1219–1225.

Prasher, I. B., & Verma, R. K. (2012). Two hyphomycetes new to Himalayas. *Plant Sciences Feed, 28*, 122–124.

Pratibha, J., Prabhugaonkar, A., Hyde, K. D., & Bhat, D. J. (2014). Phylogenetic placement of *Bahusandhika*, *Cancellidium*, and *Pseudoepicoccum* (Asexual *Ascomycota*). *Phytotaxa, 176*, 68–80.

Preuss, G. T. (1851). Synopsis fungorum cognitorum praesertim prope Hoyerswerda. *Linnaea, 24*, 101–153.

Prihastuti, H., Cai, L., Chen, H., McKenzie, E. H., & Hyde, K. D. (2009). Characterization of *Colletotrichum* species associated with coffee berries in northern Thailand. *Fungal Diversity, 39*, 89–109.

Promputtha, I., Hyde, K. D., McKenzie, E. H., Peberdy, J. F., & Lumyong, S. (2010). Can leaf degrading enzymes provide evidence that endophytic fungi become saprobes? *Fungal Diversity, 41*, 89–99.

Promputtha, I., Lumyong, S., Dhanasekaran, V., McKenzie, E. H. C., Hyde, K. D., & Jeewon, R. (2007). A phylogenetic evaluation of whether endophytes become saprotrophs at host senescence. *Microbial Ecology, 53*, 579–590.

Prusky, D., Alkan, N., Mengiste, T., & Fluhr, R. (2013). Quiescent and necrotrophic lifestyle choice during postharvest disease development. *Annual Review of Phytopathology*, *51*, 155–176.

Punithalingam, E. (1983). *Phaeoseptoria musae*. *CMI Descriptions of Pathogenic Fungi and Bacteria, 772*, 1–2.

Qi, Y. X., Zhang, H., Peng, J., Zeng, F. Y., Xie, Y. X., Yu, Q. F., . . . Zhang, X. (2023). First report of *Neopestalotiopsis clavispora* causing leaf spot disease on banana *Musa acuminata* in China. *Plant Disease, 107*, 220.

Qi, Y. X., Zhang, X., Pu, J. J., Xie, Y. X., Zhang, H. Q., & Huang, S. L. (2008). Race 4 identification of *Fusarium oxysporum* f. sp. *cubense* from Cavendish cultivars in Hainan province, China. *Australasian Plant Disease Notes*, *3*, 46–47.

Qi, Y., Fu, Y., Peng, J., Zeng, F., Wang, Y., Xie, Y. X., . . . Zhang, X. (2022). First report of Banana *Musa acuminata* cv. Formosana leaf spot disease caused by *Curvularia geniculata* in China. *Plant Disease, 106*, 1758.

Qi, Y., Peng, J., Zeng, F., Xie, Y., Xie, P., Yu, Q., . . . Zhang, X. (2022). First report of *Curvularia pseudobrachyspora* causing leaf spot on banana in China. *Journal of Plant Pathology, 104*, 1181.

Quaedvlieg, W., Binder, M., Groenewald, J. Z., Summerell, B. A., Carnegie, A. J., Burgess, T. I., . . . Crous, P. W. (2014). Introducing the consolidated species concept to resolve species in the *Teratosphaeriaceae*. *Persoonia, 33*, 1–40.

Quan, Y., Muggia, L., Moreno, L. F., Wang, M., Al-Hatmi, A., da Silva Menezes, N., . . . de Hoog, S. (2020). A re-evaluation of the *Chaetothyriales* using criteria of comparative biology. *Fungal Diversity, 103*, 47–85.

Raabe, R. D., Conners, I. L., & Martinez, A. P. (1981). *Checklist of plant diseases in Hawaii*. Hawaii Institute of Tropical Agriculture and Human Resources.

Ragazzi, A., & Marino, M. (1990). II genere *Cercospora* in Africa, con particolare riferimento alla *Cercospora angolensis* [The genus *Cercospora* in Africa, with particular reference to *Cercospora angolensis*], *Rivista di Agricoltura Subtropicale e Tropicale, 84*, 171–184.

Raghavendra, A. K. H., & Newcombe, G. (2013). The contribution of foliar endophytes to quantitative resistance to *Melampsora* rust. *New Phytologist, 197*, 909–918.

Rai, M., & Agarkar, G. (2016). Plant-fungal interactions: What triggers the fungi to switch among lifestyles? *Critical Reviews in Microbiology, 42*, 428–438.

Rai, R. N., & Lal, B. (1984). A new variety of *Chaetosphaeropsis truncata* causing fruit rot of banana. *Indian Phytopathology, 37*, 566–568.

Rajeshkumar, K. C., Verma, R. K., Boonmee, S., Chandrasiri, S., Hyde, K. D., Ashtekar, N., . . . Wijayawardene, N. N. (2021). *Paradictyocheirospora tectonae*, a novel genus in the family *Dictyosporiaceae* from India. *Phytotaxa, 509*, 259–271.

Rambaut, A. (2011). *FigTree: Tree figure drawing tool* (Version 1.3.1) [Computer software]. Institute of Evolutionary Biology, University of Edinburgh. http://tree.bio.ed.ac.uk/software/figtree/

Ramos, J. B., Braganca, C. A. D., Rocha, L. S., Oliveira, A. da S., Cordeiro, Z. J. M., . . . Haddad, F. (2018). First report of black sigatoka of banana caused by *Mycosphaerella fijiensis* in Bahia, Brazil. *Plant Disease, 102*, 2035.

Rampadarath, S., Bandhoa, K., Puchooa, D., Jeewon, R., & Bal, S. (2018). Metatranscriptomics analysis of mangroves habitats around Mauritius. *World Journal of Microbiology and Biotechnology, 34*, 59

Rana, S., Baghela, A., & Singh, S. K. (2017). Morphology and phylogeny of *Microdochium fisheri*, a new record from India. *Plant Pathology & Quarantine, 7*, 191–200.

Rannala, B., & Yang, Z. H. (1996). Probability distribution of molecular evolutionary trees: A new method of phylogenetic inference. *Journal of Molecular Evolution, 43*, 304–311.

Rao, P. R., & Rao, D. (1964). Some allied dematiaceae-dictyosporae from India. *Mycopathologia, 23*, 23–28.

Rao, V. G. (1969). The Genus *Alternaria* from India. *Nova Hedwigia, 17*, 219–258.

Rao, V., & De Hoog, G. S. (1983). A new species of *Myrothecium*. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 12*, 99–101.

Rashmi, M., Kushveer, J. S., & Sarma, V. V. (2019). A worldwide list of endophytic fungi with notes on ecology and diversity. *Mycosphere, 10*, 798–1079.

Rathnayaka, A. R., Chethana, K. W. T., Manawasinghe, I. S., Wijesinghe, S. N., de Silva, N. I., Tennakoon, D. S., . . . Jones, E. B. G. (2023). *Lasiodiplodia*: Generic revision by providing molecular markers, geographical distribution and haplotype diversity. *Mycosphere, 14*, 1254–1339.

Raut, S. P., & Ranade, S. (2004). *Diseases of Fruits and Vegetables*. Springer, Dordrecht.

Raza, M., Zhang, Z. F., Hyde, K. D., Diao, Y. Z., & Cai, L. (2019). Culturable plant pathogenic fungi associated with sugarcane in southern China. *Fungal Diversity, 99*, 1–104.

Reblova, M., Gams, W., & Seifert, K. A. (2011). *Monilochaetes* and allied genera of the *Glomerellales* and a reconsideration of families in the *Microascales*. *Studies in Mycology, 68*, 163–191.

Réblová, M., Hernández-Restrepo, M., Fournier, J., & Nekvindová, J. (2020). New insights into the systematics of *Bactrodesmium* and its allies, and introducing new genera, species, and morphological patterns in the *Pleurotheciales* and *Savoryellales* (*Sordariomycetes*). *Studies in Mycology, 95*, 415–466.

Réblová, M., Seifert, K. A., Fournier, J., & Štěpánek, V. (2016). Newly recognized lineages of perithecial ascomycetes: The new orders *Conioscyphales* and *Pleurotheciales*. *Persoonia, 37*, 57–81.

Rehman, A., Mehboob, S., Alam, M. W., & Naz, S. (2021). First report of leaf spot caused by *Albifimbria verrucaria* on spinach in Pakistan. *Journal of Plant Pathology, 103*, 715.

Rehner, S. A. (2001). *Primers for Elongation Factor 1-alpha (EF1-alpha)*. Retrieved from http://ocid.nacse.org/research/deephyphae/EF1primer.pdf

Reinking, O. A. (1918). Philippine economic plant diseases. *Philippine Journal of Science, 13*, 165–274.

Reinking, O. A. (1919). Higher *Basidiomycetes* from the Philippines and their hosts. I. *Philippine Journal of Science, 15*, 479–490.

Ren, G., Wanasinghe, D. N., de Farias, A. R. G., Hyde, K. D., Yasanthika, E., Xu, J., . . . Gui, H. (2022). Taxonomic novelties of woody litter fungi (*Didymosphaeriaceae, Pleosporales*) from the Greater Mekong Subregion. *Biology, 11*, 1660.

Resplandy, R., Chevaugeon, J., Delassus, M., & Luc, M. (1954). Première liste annotée de champignons parasites de plantes cultivées en Côte d'Ivoire. *Annales de l'Épiphytie, 1*, 1–61.

Revue mycologique. (1886). Toulouse, Bureaux de la redaction. Author unknown.

Revue mycologique. (1889). Toulouse, Bureaux de la redaction. Author unknown.

Ribeiro, T. H. C., Fernandes-Brum, C. N., de Souza, C. R., Dias, F. A. N., Almeida-Junior, O. D., & Chalfun-Junior, A. (2020). Transcriptome analyses suggest that changes in fungal endophyte lifestyle could be involved in grapevine bud necrosis. *Scientific Reports, 10*, 9514.

Richardson, M. J. (1990). *An annotated list of seed-borne diseases.* International Seed Testing Association, Zurich.

Riera, N., Ramirez-Villacis, D., Barriga-Medina, N., Alvarez-Santana, J., Herrera, K., Ruales, C., . . . Leon-Reyes, A. (2019). First report of banana anthracnose caused by *Colletotrichum gloeosporioides* in Ecuador. *Plant Disease, 103*, 763.

Rieux, A., Hostachy, B., De Lapeyre de Bellaire, L., Martin, Y., Maratchia, G., Dupuis, A. S., . . . Hubert, J. (2019). First report of black Sigatoka disease in banana caused by *Mycosphaerella fijiensis* on Reunion Island. *New Disease Reports, 39*, 12.

Rifai, M. A. (1964). *Stachybotrys bambusicola* sp. nov. *Transactions of the British Mycological Society, 47*, 269–272.

Riley, E. A. (1956). A preliminary list of plant diseases in northern Rhodesia. *Mycological Papers, 63*, 1–28.

Riley, E. A. (1956). A preliminary list of plant diseases in northern Rhodesia. *Mycological Papers, 63*, 1–28.

Riley, E. A. (1960). A revised list of plant diseases in Tanganyika Territory. *Mycological Papers, 75*, 1–42.

Riolo, M., Aloi, F., Faedda, R., Cacciola, S. O., & Pane, A. (2020). First report of postharvest fruit rot caused by *Fusarium sacchari* on lady finger banana in Italy. *Plant Disease, 104*, 2290.

Romero, R. A., & Sutton, T. B. (1998). Characterization of benomyl resistance in *Mycosphaerella fijiensis*, cause of black Sigatoka of banana, in Costa Rica. *Plant Disease, 82*, 931–934.

Rong, I. H., & Gams, W. (2000). The hyphomycete genera *Exochalara* and *Monilochaetes*. *Mycotaxon, 76*, 451–462.

Rossman, A. Y. (1996). Morphological and molecular perspectives on systematics of the *Hypocreales*. *Mycologia, 88*, 1–19.

Roux, J., & Wingfield, M. J. (2013). *Ceratocystis* species on the African continent, with particular reference to *Ceratocystis albofundus*, an African species in the *Ceratocystis fimbriata* sensu lato species complex. *CBS Biodiversity Series*, 131–138.

Roux, J., Wingfield, M. J., & Morris, M. J. (1997). *Botryosphaeria dothidea*, a pathogen of *Acacia mearnsii* in South Africa. *South African Journal of Science, 93*, 12.

Saccardo, P. A. (1877a). *Michelia*, 2. Patavii, Typis Seminarii.

Saccardo, P. A. (1877b). *Michelia*, 1. Patavii, Typis Seminarii.

Saccardo, P. A. (1886). *Sylloge Fungorum*, *4*, 537.

Saccardo, P. A., & Saccardo, D. (1906). *Sylloge Fungorum*, *18*, 274–581.

Saccardo, P. A., & Sydow, P. (1902). *Sylloge Fungorum*, *16*, 877.

Saccardo, P. A., Saccardo, D., Traverso, J. B., & Trotter, A. (1931). *Sylloge Fungorum*, 25, 557.

Saccardo, P. A., Traverso, G. B., & Trotter, A. (1887). *Sylloge fungorum omnium hucusque cognitorum*. Patavii, sumptibus auctoris.

Sakayaroj, J., Preedanon, S., Phongpaichit, S., Buatong, J., Chaowalit, P., & Rukachaisirikul, V. (2012). Diversity of endophytic and marine-derived fungi associated with marine plants and animals. In *Marine Fungi* (pp. 291–328). Berlin, Germany.

Salaemae, N., Srilaong, V., Pongprasert, N., Boonyaritthongchai, P., Wongs-Aree, C., Shigyo, M., . . . Kaewsuksaeng, S. (2022). Alterations in morphological and biochemical properties in 'Namwa' banana associated with freckles caused by *Lasiodiplodia theobromae* in Thailand. *Physiological and Molecular Plant Pathology*, *117*, 101783.

Salem, N. M., Almomany, A. M., Tahat, M. M., & Aldakil, H. (2020). First report of *Fusarium verticillioides* causing banana fruit rot in Jordan. *Plant Disease, 104*, 3255.

Salunkhe, V. N., Gawande, S. P., Nagrale, D. T., Hiremani, N. S., Gokte–Narkhedkar, N., & Waghmare, V. N. (2019). First report of *Corynespora* leaf spot of cotton caused by *Corynespora cassiicola* in Central India. *Plant Disease, 103*, 1785.

Salvatore, M. M., Andolfi, A., & Nicoletti, R. (2020). The thin line between pathogenicity and endophytism: The case of *Lasiodiplodia theobromae*. *Agriculture, 10*, 488.

Samarakoon, B. C., Phookamsak, R., Karunarathna, S. C., Jeewon, R., Chomnunti, P., Xu, J. C., . . . Li, Y. J. (2021). New host and geographic records of five pleosporalean hyphomycetes associated with *Musa* spp. (Banana). *Studies in Fungi*, *6*, 92–115.

Samarakoon, B. C., Phookamsak, R., Wanasinghe, D. N., Chomnunti, P., Hyde, K. D., McKenzie, E. H. C., . . . Li, Y. J. (2020). Taxonomy and phylogenetic appraisal of *Spegazzinia musae* sp. nov. and *S. deightonii* (*Didymosphaeriaceae, Pleosporales*) on *Musaceae* from Thailand. *MycoKeys, 70*, 19–37.

Samarakoon, B. C., Samarakoon, M. C., Aluthmuhandiram, J. V. S., Wanasinghe, D. N., & Chomnunti, P. (2019). The first report of *Daldinia eschscholtzii* as an endophyte from leaves of *Musa* sp. (*Musaceae*) in Thailand. *Asian Journal of Mycology, 2*, 183–197.

Samarakoon, B. C., Wanasinghe, D. N., Jeewon, R., Tian, Q., Jayawardena, R. S., & Chomnunti, P. (2019). The plant pathogenic genus *Neocordana*. *Plant Pathology and Quarantine, 9*, 139–151.

Samarakoon, B. C., Wanasinghe, D. N., Phookamsak, R., Bhat, J., Chomnunti, P., Karunarathna, S. C., . . . Lumyong, S. (2021). *Stachybotrys musae* sp. nov., *S. microsporus*, and *Memnoniella levispora* (*Stachybotryaceae, Hypocreales*) Found on Bananas in China and Thailand. *Life, 11*, 323.

Samarakoon, B. C., Wanasinghe, D. N., Samarakoon, M. C., Phookamsak, R., McKenzie, E. H. C., Chomnunti, P., . . . Karunarathna, S. C. (2020). Multi-gene phylogenetic evidence suggests *Dictyoarthrinium* belongs in *Didymosphaeriaceae* (*Pleosporales, Dothideomycetes*) and *Dictyoarthrinium musae* sp. nov. on *Musa* from Thailand. *MycoKeys, 71*, 101–118.

Samarakoon, B. C., Wanasinghe, D., Bhat, J., & Chomnunti, P. (2022). Taxonomy and phylogeny of *Smaragdiniseta musae* sp. nov. and *Albifimbria verrucaria* (*Hypocreales, Stachybotryaceae*) on *Musa* from Thailand. *Biodiversity Data Journal, 10*, Article e89360.

Samarakoon, M. C., Hyde, K. D., Maharachchikumbura, S. S., Stadler, M., Jones, E. B., Promputtha, I., . . . Liu, J. K. (2022). Taxonomy, phylogeny, molecular dating, and ancestral state reconstruction of *Xylariomycetidae* (*Sordariomycetes*). *Fungal Diversity, 112*, 1–88.

Samarakoon, M. C., Peršoh, D., Hyde, K. D., Bulgakov, T. S., Manawasinghe, I. S., Jayawardena, R. S., . . . Promputtha, I. (2018). *Colletotrichum acidae* sp. nov. from northern Thailand and a new record of *C. dematium* on *Iris* sp. *Mycosphere, 9*, 583–597.

Samuelian, S. (2016). Potential of *Trichoderma harzianum* for control of banana leaf fungal pathogens when applied with a food source and an organic adjuvant. *3 Biotech, 6*, 1–11.

Samuels, G. J., Doi, Y., & Rogerson, C. T. (1990). Contributions toward a mycobiota of Indonesia: *Hypocreales*. *Memoirs of the New York Botanical Garden archives, 59*, 6–108.

Sandoval-Denis, M., Guarnaccia, V., Polizzi, G., & Crous, P. W. (2018). Symptomatic Citrus trees reveal a new pathogenic lineage in *Fusarium* and two new *Neocosmospora* species. *Persoonia, 40*, 1–25.

Sandoval-Denis, M., Lombard, L., & Crous, P. W. (2019). Back to the roots, a reappraisal of *Neocosmospora*. *Persoonia*, *43*, 90–185.

Sandoval-Denis, M., Swart, W. J., & Crous, P. W. (2018). New *Fusarium* species from the Kruger National Park, South Africa. *MycoKeys, 34*, 63–92.

Sangeetha, G., Anandan, A., & Rani, S. U. (2012). Morphological and molecular characterization of *Lasiodiplodia theobromae* from various banana cultivars causing crown rot disease in fruits. *Archives of Phytopathology and Plant Protection, 45*, 475–486.

Santos, J. E. Á., Silva, D. E. M. D., Vieira, R. F. B. D. S., Cordeiro, M. V. M., Almeida, M. M. M., Lima, M. A. S., . . . Silva, C. D. F. B. D. (2023). First report of *Lasiodiplodia brasiliensis* causing crown rot on banana in Brazil. *Plant Disease*, Article e4098.

Santos, J. E. A., Silva, D. E. M., Vieira, R. F. B. S., Carvalho, A. M. S., Schurt, D. A., Lima, M. A. S., . . . Silva, C. F. B. D. (2023). First report of *Fusarium kalimantanense* causing Fusarium wilt on banana tree in Brazil. *Plant Disease, 107*, 227.

Santos, T. A. B. (2015). Relações filogenéticas dos complexos *Stachybotrys-Memmoniella* e *phalangispora-speiropsis-wiesneriomyces*. Universidade Federal de Pernambuco, Brazil.

Saravanan, T., & Vittal, B. P. R. (2007). Some rare and interesting hyphomycetes from eastern Ghats in Tamil Nadu, India. *Kavaka, 35*, 21–44.

Sarbhoy, A. K., & Agarwal, D. K. (1990). *Descriptions of Tropical Plant Pathogenic Fungi Set 1*. Malhotra Publications House, New Delhi.

Sarbhoy, A. K., Lal, G., & Varshney, J. L. (1971). *Fungi of India (1967–71)*. Navyug Traders, New Delhi.

Sarkar, S., Girisham, S., & Reddy, S. M. (2013). Identification of three fruit–rot fungi of banana by 28S ribosomal DNA sequencing. *International Journal of Bioassays, 2*, 422–429.

Sarkar, S., Girisham, S., & Reddy, S. M. (2014). Some new post-harvest fungal diseases of banana. *Annals of Plant Sciences, 2*, 149–152.

Sarkar, T., Chakraborty, P., Karmakar, A., Saha, A., & Saha, D. (2019). First report of *Periconia macrospinosa* causing leaf necrosis of pointed gourd in India. *Journal of Plant Pathology, 101*, 1281–1281.

Savani, A. K., Bhattacharyya, A., Boro, R. C., Dinesh, K., & Jc, N. S. (2021). Exemplifying endophytes of banana (*Musa paradisiaca*) for their potential role in growth stimulation and management of *Fusarium oxysporum* f. sp. cubense causing Panama wilt. *Folia Microbiologica, 66*, 317–330.

Savchenko, K. G., Heluta, V. P., Wasser, S. P., & Nevo, E. (2014). Rust fungi (*Pucciniales*) of Israel II: The genus *Uromyces*. *Nova Hedwigia, 98*, 393–407.

Sawada, K. (1959). Descriptive catalogue of Taiwan (Formosan) fungi XI. *Special Publication College of Agriculture National Taiwan University, 8*, 1–268.

Scauflaire, J., Gourgue, M., & Munaut, F. (2011). *Fusarium temperatum* sp. nov. from maize, an emergent species closely related to *Fusarium subglutinans*. *Mycologia, 103*, 586–597.

Schena, L., Mosca, S., Cacciola, S. O., Faedda, R., Sanzani, S. M., Sergeeva, V., . . . Magnano, G. (2014). Species of the *Colletotrichum gloeosporioides* and *C. boninense* complexes associated with olive anthracnose. *Plant Pathology, 63*, 437–446.

Schilling, A. G., Moller, E. M., & Geiger, H. H. (1995). Molecular differentiation and diagnosis of the cereal pathogens *Fusarium culmorum* and *F. graminearum*. *Sydowia, 48*, 71–82.

Scholz, H., & Scholz, I. (1988). Die Brandpilze Deutschlands (*Ustilaginales*). *Englera, 8*, 1–691.

Schroers, H. J., Baayen, R. P., Meffert, J. P., De Gruyter, J., Hooftman, M., & O'Donnell, K. (2004). *Fusarium foetens*, a new species pathogenic to begonia (*Begonia x hiemalis*) and the sister taxon of the *Fusarium oxysporum* species complex. *Mycologia, 96*, 393–406.

Schubert, K., Greslebin, A., Groenewald, J. Z., & Crous, P. W. (2009). New foliicolous species of *Cladosporium* from South America. *Persoonia, 22*, 111–122.

Schubert, K., Groenewald, J. Z., Braun, U., Dijksterhuis, J., Starink, M., Hill, C. F., . . . Crous, P. W. (2007). Biodiversity in the *Cladosporium herbarum* complex (*Davidiellaceae, Capnodiales*) with standardization of methods for *Cladosporium* taxonomy and diagnostics. *Studies in Mycology, 58*, 105–156.

Schulz, B., & Boyle, C. (2006). *Microbial root endophytes.* Springer, Berlin, Heidelberg.

Seaver, F. J., & Waterston, J. M. (1941). Contributions to the mycoflora of Bermuda – II. *Mycologia, 33,* 313.

Seifert, K. A. (1979). *Blistum musae*: A new species of synnematal hyphomycete. *Mycotaxon, 10*, 233–240.

Seifert, K. A. (1985). A monograph of *Stilbella* and some allied Hyphomycetes. *Studies in Mycology, 27*, 1–234.

Seifert, K. A., & Gams, W. (2011). The genera of Hyphomycetes-2011 update. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 27*, 119–129.

Semer, C. R., Mitchell, D. J., Mitchell, M. E., Martin, F. N., & Alfenas, A. C. (1987). Isolation, identification and chemical control of *Cylindrocladium musae* sp. nov. associated with toppling disease of banana. *Phytopathology, 77*, 1729.

Senanayake, I. C., Crous, P. W., Groenewald, J. Z., Maharachchikumbura, S. S. N., Jeewon, R., Phillips, A. J. L., . . . Tangthirasunun, N. (2017). Families of *Diaporthales* based on morphological and phylogenetic evidence. *Studies in Mycology, 86*, 217–296.

Senanayake, I. C., Jeewon, R., Chomnunti, P., Wanasinghe, D. N., Norphanphoun, C., Karunarathna, A., . . . Karunarathna, S. C. (2018). Taxonomic circumscription of *Diaporthales* based on multigene phylogeny and morphology. *Fungal Diversity*, *93*, 241–443.

Senanayake, I. C., Maharachchikumbura, S. S., Hyde, K. D., Bhat, J. D., Jones, E. G., McKenzie, E. H., . . . Camporesi, E. (2015). Towards unraveling relationships in *Xylariomycetidae* (*Sordariomycetes*). *Fungal Diversity*, *73*, 73–144.

Senanayake, I. C., Rossi, W., Leonardi, M., Weir, A., McHugh, M., Rajeshkumar, K. C., . . . Song, J. (2023). Fungal diversity notes 1611–1716: Taxonomic and phylogenetic contributions on fungal genera and species emphasis in south China. *Fungal Diversity*, *122*, 161–403.

Senwanna, C., Mapook, A., Samarakoon, M. C., Karunarathna, A., Wang, Y., Tang, A. M. C., . . . Cheewangkoon, R. (2021). *Ascomycetes* on Para rubber *(Hevea brasiliensis*). *Mycosphere*, *12*, 1334–1512.

Shahriar, S. A., Nur-Shakirah, A. O., & Mohd, M. H. (2022). *Neopestalotiopsis clavispora* and *Pseudopestalotiopsis camelliae-sinensis* causing grey blight disease of tea (*Camellia sinensis*) in Malaysia. *European Journal of Plant Pathology*, *162*, 709–724.

Sharma, A., Kumar, A., & Javeria, S. (2021). Pathogenic association of *Albifimbria terrestris* with rice seeds. *Indian Phytopathology*, *74*, 849–850.

Sharma, G., & Shenoy, B. D. (2014). *Colletotrichum fructicola* and *C. siamense* are involved in chili anthracnose in India. *Archives of Phytopathology and Plant Protection*, *47*, 1179–1194.

Sharma, G., Kumar A., & Shenoy, B. D. (2015). Resolving the *Colletotrichum siamense* species complex using ApMat marker. *Fungal Diversity*, *71*, 247–264.

Shaw, C. G. (1973). Host fungus index for the Pacific northwest-hosts. *Washington State University Agricultural Experiment Station Bulletin*, *765*, 1–121.

Shaw, D. E. (1984). Microorganisms in Papua New Guinea. *Department of Primary Industries Research Bulletin*, *33*, 1–344.

Shenoy, B. D., Jeewon, R., Lam, W. H., Bhat, D. J., Than, P. P., Taylor, P. W. J., . . . Hyde, K. D. (2007). Morpho-molecular characterization and epitypification of *Colletotrichum capsici* (*Glomerellaceae*, *Sordariomycetes*), the causative agent of anthracnose in chili. *Fungal Diversity*, *27*, 197–211.

Sherwood, M. A. (1980). Taxonomic studies in the *Phacidiales*: The genus *Coccomyces* (*Rhytismataceae*). *Occasional Papers of the Farlow Herbarium of Cryptogamic Botany*, *15*, 1–120.

Shivas, R. G. (1989). Fungal and bacterial diseases of plants in western Australia. *Journal of the Royal Society of Western Australia*, *72*, 1–62.

Shivas, R. G., Grice, K. R. E., & Young, A. J. (2011). *Ramichloridium* spp. on *Musa* in northern Queensland, introducing *Ramichloridium ducassei* sp. nov. on leaf streaks of Ducasse banana. *Australasian Plant Pathology*, *40*, 61–65.

Shivas, R. G., Tan, Y. P., Edwards, J., Dinh, Q., Maxwell, A., Andjic, V., . . . Coates, L. M. (2016). *Colletotrichum* species in Australia. *Australasian Plant Pathology*, *45*, 447–464.

Shoemaker, R. A., & Babcock, C. E. (1989). *Phaeosphaeria*. *Canadian Journal of Botany*, *67*, 1500–1599.

Sikora, R. A., Pocasangre, L., zum Felde, A., Niere, B., Vu, T., & Dababat, A. A. (2008). Mutualistic endophytic fungi and in-planta suppressiveness to plant parasitic nematodes. *Biological Control*, *46*, 15–23.

Silva, D. E. M. D., Vieira, R. F. B. D. S., Inokuti, E. M., Almeida, M. M. M., Cordeiro, M. V. M., Lima, C. S., . . . Silva, C. D. F. B. D. (2023). First report of *Lasiodiplodia iraniensis* causing crown rot on banana fruits in Brazil. *Plant Disease,* Article e37392029.

Silva, M., Barreto, R. W., Pereira, O. L., Freitas, N. M., Groenewald, J. Z., & Crous, P. W. (2016). Exploring fungal mega-diversity. *Pseudocercospora* from Brazil. *Persoonia, 37,* 142–172.

Silva, M., Mendonça, H. L., Barreto, R. W., & Pereira, O. L. (2008). First report of leaf spots on banana in Brazil caused by *Bipolaris sacchari*. *Australasian Plant Disease Notes*, *3,* 10–11.

Simmonds, J. H. (1941). Latent infection in tropical fruit discussed in relation to the part played by species of *Gloeosporium* and *Colletotrichum*. *Proceedings of the Royal Society of Queensland, 52*, 92–120.

Simmonds, J. H. (1966). *Host index of plant diseases in Queensland*. Queensland Department of Primary Industries, Brisbane.

Simmonds, J. H., & Mitchell, R. S. (1940). Black end and anthracnose of the banana. *Bulletin of the Council for Scientific and Industrial Research, Australia, 131,* 63.

Simonyan, S. A. (1981). *Mycoflora of Botanical gardens and arboretums of the Armenian SSR*. Publishing House of the Academy of Sciences.

Singtripop, C., Hongsanan, S., Li, J., de Silva, N. I., Phillips, A. J. L., Jones, E. B., . . . Hyde, K. D. (2016). *Chaetothyrina mangiferae* sp. nov., a new species of *Chaetothyrina*. *Phytotaxa*, *255*, 21–33.

Sir, E. B., Lambert, C., Wendt, L., Hladki, A. I., Romero, A. I., & Stadler, M. (2016). A new species of *Daldinia* (*Xylariaceae*) from northwestern Argentina recognized on the basis of morphological, chemotaxonomic and molecular phylogenetic evidence. *Mycological Progress*, *15*, 1–13.

Sivanesan, A. (1984). *The bitunicate Ascomycetes and their anamorphs*. Cramer, Vaduz Publishers.

Sivanesan, A. (1987). Graminicolous species of *Bipolaris*, *Curvularia*, *Drechslera*, *Exserohilum*, and their teleomorphs. *Mycological Papers*, *158*, 1–261.

Skovgaard, K., Rosendahl, S., O'Donnell, K., & Nirenberg, H. I. (2003). *Fusarium commune* is a new species identified by morphological and molecular phylogenetic data. *Mycologia*, *95*, 630–636.

Slippers, B., Crous, P. W., Jami, F., Groenewald, J. Z., & Wingfield, M. J. (2017). Diversity in the *Botryosphaeriales*: Looking back, looking forward. *Fungal Biology*, *121*, 307–321.

Small, W. (1928). On *Rhizoctonia bataticola* (Taub.) Butler as a cause of root disease in the tropics. *Transactions of the British Mycological Society*, *34*, 17–18.

Smith, G. (1951). Some new species of moulds and some new British records. *Transactions of the British Mycological Society*, *34*, 195.

Smith, G. (1962). Some new and interesting species of micro-fungi. *Transactions of the British Mycological Society, 45*, 387–394.

Soares, D. J., Nechet, K. L., & Barreto, R. W. (2005). *Cordana versicolor* sp. nov., dematiaceous hyphomycete causing leaf-spot on *Canna denudata* (*Cannaceae*) in Brazil, with observations on *Cordana musae*. *Fungal Diversity*, *18*, 147–155.

Société mycologique de France, & Société botanique de France. (1885). *Bulletin de la Société mycologique de France* [Bulletin of the mycological society of France]. Epinal, La Société.

Société mycologique de France, & Société botanique de France. (1892). *Bulletin de la Société mycologique de France* [Bulletin of the mycological society of France]. Epinal, La Société.

Société mycologique de France. (1913). *Bulletin trimestriel de la Société mycologique de France* [Bulletin of the mycological society of France]. Paris, La Société.

Société mycologique de France. (1972). *Bulletin trimestriel de la Société mycologique de France* [Bulletin of the mycological society of France]. Paris, La Société.

Somrithipol, S. (2007). A synnematous species of *Dictyoarthrinium* from Thailand. *Mycologia, 99*, 792–796.

Sonah, H., Deshmukh, R. K., Parida, S. K., Chand, S., & Kotasthane, A. (2009). Morphological and genetic variation among different isolates of *Magnaporthe grisea* collected from Chhattisgarh. *Indian Phytopathology, 62*, 469–477.

Spies, C. F. J., Mostert, L., Carlucci, A., Moyo, P., Van Jaarsveld, W. J., Plessis, I. L., . . . Halleen, F. (2020). Dieback and decline pathogens of olive trees in South Africa. *Persoonia: Molecular Phylogeny and Evolution of Fungi, 45*, 196–220.

Srivastava, M. P., Tandon, R. N., Bilgrami, K. S., & Ghosh, A. K. (1964). Study on fungal diseases of some tropical fruits: A list of fungi isolated from fruits and fruit trees. *Phytopathology, 50*, 250–251.

Srivastava, R. N., & Gupta, J. S. (1981). Seed mycoflora from Indian seed lots of *Cosmos bipinnatus* and their control. *Indian Phytopathology, 34*, 383–385.

Stadler, M., Læssøe, T., Vasilyeva, L., Fournier, J., Decock, C., Schmieschek, B., . . . Peršoh, D. (2005). A polythetic approach to the taxonomy of the *Daldinia childiae* complex. *Studies in Mycology, 52*, 1–47.

Stamatakis, A. (2014). RAxML version 8: A tool for phylogenetic analysis and post–analysis of large phylogenies. *Bioinformatics, 30*, 1312–1313.

Stamatakis, A., Hoover, P., & Rougemont, J. (2008). A Rapid Bootstrap Algorithm for the RAxML Web Servers. *Systematic Biology, 57*, 758–771.

Stauber, L., Prospero, S., & Croll, D. (2020). Comparative genomics analyses of lifestyle transitions at the origin of an invasive fungal pathogen in the genus *Cryphonectria*. *mSphere*, *5*, Article e00737-20.

Stevens, F. L. (1925). Hawaiian Fungi. *Bernice P. Bishop Museum Bulletin*, *19*, 1–189.

Stevenson, J. A. (1975). Fungi of Puerto Rico and the American Virgin Islands. *Contributions from the Reed Herbarium*, *23*, 743.

Stevenson, J. A., & Wellman, F. L. (1944). A preliminary account of the plant diseases of El Salvador. *Journal of the Washington Academy of Sciences*, *34*, 259–268.

Stewart, J. E., Kim, M. S., Ota, Y., Sahashi, N., Hanna, J. W., Akiba, M., . . . Dann, E. K. (2020). Phylogenetic and population genetic analyses reveal three distinct lineages of the invasive brown root-rot pathogen *Phellinus noxius*, and bioclimatic modeling predicts differences in associated climate niches. *European Journal of Plant Pathology*, *156*, 751–766.

Stojkov, S., Levic, J., Ignjatovic, D., Ivanovic, D., & Pencic, V. (1996). *Periconia* pathogens on Maize root and stalk. *Zastita bilja*, *47*, 217.

Stover, R. H. (1966). Fungi associated with nematode and non-nematode lesions on banana roots. *Canadian Journal of Botany*, *44*, 1703–1710.

Stover, R. H. (1972). *Banana, Plantain and Abaca Diseases*. Commonwealth Mycological Institute.

Stover, R. H. (1983). Effet de la luttez intégrée sur le controle de la cercosporiose noire des feuilles du bananier. *Fruits*, *38*, 449–466.

Stukenbrock, E. H., Quaedvlieg, W., Javan-Nikkhah, M., Zala, M., Crous, P. W., & McDonald, B. A. (2012). *Zymoseptoria ardabiliae* and *Zymoseptoria pseudotritici*, two progenitor species of the *Septoria tritici* leaf blotch fungus *Zymoseptoria tritici* (synonym *Mycosphaerella graminicola*). *Mycologia, 104,* 1397–1407.

Su, H. J., Hwang, S. C., & Ko, W. H. (1986). Fusarial wilt of Cavendish bananas in Taiwan. *Plant Disease, 70,* 814–818.

Su, H. Y., Hyde, K. D., Maharachchikumbura, S. S. N., Ariyawansa, H. A., Luo, Z., Promputtha, I., . . . Chai, H. (2016). The families *Distoseptisporaceae* fam. nov., *Kirschsteiniotheliaceae, Sporormiaceae* and *Torulaceae,* with new species from freshwater in Yunnan province, China. *Fungal Diversity, 80,* 375–409.

Su, X. J., Luo, Z. L., Jeewon, R., Bao, D. F., Li, W. L., & Hyde, K. D. (2018). Morphology and multigene phylogeny reveal new genus and species of *Torulaceae* from freshwater habitats in northwestern Yunnan, China. *Mycological Progress, 17,* 531–545.

Su, Y. Y., Noireung, P., Liu, F., Hyde, K. D., Moslem, M. A., Bahkali, A. H., . . . Cai, L. (2011). Epitypification of *Colletotrichum musae,* the causative agent of banana anthracnose. *Mycoscience, 52,* 376–382.

Subramanian, C. V. (1952). Fungi imperfecti from Madras-II. *Proceedings of the Indian Academy of Sciences Section B, 34,* 160–168.

Subramanian, C. V. (1988). A new species of *Spegazzinia* from Western Australia. *Proceedings: Plant Sciences, 98,* 160–167.

Subramanian, D. (1956). Role of trace element chelation in the *fusarium* wilt of cotton. *Proceedings: Indian Academy of Sciences, 43,* 302–307.

Summerell, B. A., Leslie, J. F., Liew, E. C. Y., Laurence, M. H., Bullock, S., Petrovic, T., . . . Burgess, L. W. (2011). *Fusarium* species associated with plants in Australia. *Fungal Diversity, 46*, 1–27.

Sun, J. M., Zhang, Y., Zhang, J. Z., Lan, X., & Lu, J. (2016). First report of freckle disease of banana caused by *Phyllosticta capitalensis* in Guangxi, Southwest China. *Journal of Plant Pathology*, *98*, 175.

Sun, L. Y., Li, H. Y., Sun, X., & Guo, L. D. (2017). *Dematipyriforma aquilaria* gen. et sp. nov, a new hyphomycetous taxon from *Aquilaria crassna*. *Cryptogamie Mycologie*, *38*, 341–351.

Sun, T. T., Zhu, H. J., & Cao, F. (2020). The fungal *Myrothecium* genus as a source of bioactive secondary metabolites. *Studies in Natural Products Chemistry, 65*, 195–237.

Sung, G. H., Sung, J. M., Hywel-Jones, N. L., & Spatafora, J. W. (2007). A multi-gene phylogeny of *Clavicipitaceae* (*Ascomycota, Fungi*): Identification of localized incongruence using a combinational bootstrap approach. *Molecular Phylogenetics and Evolution, 44*, 1204–1223.

Supriya, S., Girisham, S., & Reddy, S. M. (2009). Incidence of post-harvest fungal diseases of banana fruit in Warangal market. *Indian Phytopathology*, *62*, 103–105.

Surridge, A. K. J. (2002). *Mycosphaerella leaf spot diseases of bananas: Present status and outlook*. International Network for the Improvement of Banana and Plantain.

Surridge, A. K. J., Viljoen, A., Crous, P. W., & Wehner, F. C. (2003). Identification of the pathogen associated with Sigatoka disease of banana in South Africa. *Australasian Plant Pathology, 32*, 27–31.

Sushma, P. I. B., & Verma, R. K. (2020). Some interesting hyphomycetous fungi from India. *Vegetos, 33*, 74–82.

Suvittawa, A. (2014). Thailand's banana supply chain management: Export success factors. *International Journal of Business and Management Science, 3*, 6–11.

Swinburne, T. R., & Brown A. E. (1983). Appressoria development and quiescent infections of banana fruit by *Colletotrichum musae*. *Transactions of the British Mycological Society*, *80*, 176–178.

Sydow, H., & Petrak, F. (1931). *Micromycetes* Philippinenses. *Annals of Mycology*, *29*, 145–279

Sydow, H., & Sydow, P. (1912). Novae fungorum species – VII. *Annales Mycologici*, *10*, 84.

Sydow, H., Sydow, P., & Butler, E. J. (1916). *Fungi Indiae orientalis* [Fungi of eastern India]. *Annales Mycologici*, *14*, 200.

Tai, F. L. (1979). *Sylloge fungorum Sinicorum*. Sci Press, Academia Sinica.

Takashima, M., Suh, S., & Nakase, T. (1995). *Bensingtonia musae* sp. nov. isolated from a dead leaf of *Musa paradisiaca* and its phylogenetic relationship among Basidiomycetous yeasts. *Journal of General and Applied Microbiology*, *41*, 143–151.

Talhinhas, P., & Baroncelli, R. (2021). *Colletotrichum* species and complexes: Geographic distribution, host range and conservation status. *Fungal Diversity*, *110*, 109–198.

Tamura, K., Stecher, G., Peterson, D., Filipski, A., & Kumar, S. (2013). *MEGA6: Molecular evolutionary genetics analysis version 6.0* [Computer software]. *Molecular Biology and Evolution*, *30*, 2725–2729.

Tan, Y. P., Crous, P. W., & Shivas, R. G. (2018). Cryptic species of *Curvularia* in the culture collection of the Queensland plant pathology herbarium. *MycoKeys*, *35*, 1–25.

Tan, Y. P., Shivas, R. G., Marney, T. S., Edwards, J., Dearnaley, J., Jami, F., . . . Burgess, T. I. (2019). Australian cultures of *Botryosphaeriaceae* held in Queensland and Victoria plant pathology herbaria revisited. *Australasian Plant Pathology*, *48*, 25–34.

Tanaka, K., & Harada, Y. (2004). Bambusicolous fungi in Japan 1: Four *Phaeosphaeria* species. *Mycoscience*, *45*, 377–382.

Tanaka, K., Hirayama, K., Yonezawa, H., Hatakeyama, S., Harada, Y., Sano, T., . . . Hosoya, T. (2009). Molecular taxonomy of bambusicolous fungi: *Tetraplosphaeriaceae*, a new pleosporalean family with *Tetraploa*-like anamorphs. *Studies in Mycology, 64*, 175–209.

Tanaka, K., Hirayama, K., Yonezawa, H., Sato, G. (2015). Revision of the *Massarineae*, *Pleosporales*, *Dothideomycetes*. *Studies in Mycology*, *82*, 75–136.

Tang, A. M. C., Hyde, K. D., & Corlett, R. T. (2003). Diversity of fungi on wild fruits in Hong Kong. *Fungal Diversity, 14*, 165–185.

Tang, A. M. C., Jeewon, R., & Hyde, K. D. (2005). Succession of endophytes from leaf, stem and root tissues of *Tripterygium wilfordii*. *Fungal Diversity, 19*, 105–122.

Tarda, A. S., Saparrat, M. C. N., & Gómez, N. (2019). Assemblage of dematiaceous and Ingoldian fungi associated with leaf litter of decomposing *Typha latifolia* L. (*Typhaceae*) in riverine wetlands of the Pampean plain (Argentina) exposed to different water quality. *Journal of Environmental Management, 250*, 109–409.

Tarnowski, T. L., Pérez-Martínez, J. M., & Ploetz, R. C. (2010). Fuzzy pedicel: A new postharvest disease of banana. *Plant Disease*, *94*, 621–627.

Tarr, S. A. J. (1963). A supplementary list of Sudan fungi and plant diseases. *Mycological Papers*, *85*, 1–31.

Teixeira, M. D. M., Moreno, L. F., Stielow, B. J., Muszewska, A., Hainaut, M., Gonzaga, L., . . . de Hoog, G. S. (2017). Exploring the genomic diversity of black yeasts and relatives (*Chaetothyriales*, *Ascomycota*). *Studies in Mycology, 86*, 1–28.

Tejerina, J. C., Meriles, G., Stover, R. H., Ploetz, R. C., & Romanoff, S. (1997). First report of black sigatoka in Bolivia. *Plant Disease, 81*, 1332.

Templeton, A. R., Crandall, K. A., & Sing, C. F. (1992). A cladistic analysis of phenotypic associations with haplotypes inferred from restriction endonuclease mapping and DNA sequence data III. Cladogram estimation. *Genetics, 132*, 619–633.

Tennakoon, D. S., Hyde, K. D., Wanasinghe, D. N., Bahkali, A. H., Camporesi, E., Khan, S., . . . Phookamsak, R. (2016). Taxonomy and phylogenetic appraisal of *Montagnula jonesii* sp. nov. (*Didymosphaeriaceae, Pleosporales*). *Mycosphere, 7*, 1346–1356.

Tennakoon, D. S., Kuo, C. H., Maharachchikumbura, S. S., Thambugala, K. M., Gentekaki, E., Phillips, A. J., . . . Hyde, K. D. (2021). Taxonomic and phylogenetic contributions to *Celtis formosana, Ficus ampelas, F. septica, Macaranga tanarius*, and *Morus australis* leaf litter-inhabiting microfungi. *Fungal Diversity, 108*, 1–215.

Tennakoon, D. S., Thambugala, K. M., Wanasinghe, D. N., Gentekaki, E., Promputtha, I., Kuo, C. H., . . . Hyde, K. D. (2020). Additions to *Phaeosphaeriaceae* (*Pleosporales*): *Elongaticollum* gen. nov., *Ophiosphaerella taiwanensis* sp. nov., *Phaeosphaeriopsis beaucarneae* sp. nov., and a new host record of *Neosetophoma poaceicola* from *Musaceae*. *MycoKeys, 70*, 59–88.

Teodoro, N. G. (1937). *An enumeration of Philippine fungi.* Department of Agriculture and Commerce, Manila.

Termpitipong, R. (2021). *Banana by-products in Thailand: Exploring its feasibility as bioplastics feedstock for food packaging* (Master's thesis). Faculty of Engineering, Lund University.

Thambugala, K. M., Wanasinghe, D. N., Phillips, A. J. L., Camporesi, E., Bulgakov, T. S., Phukhamsakda, C., . . . Hyde, K. D.(2017). Mycosphere notes 1–50: Grass (*Poaceae*) inhabiting *Dothideomycetes*. *Mycosphere, 8,* 697–796.

Thangavelu, R., & Mustaffa, M. M. (2010). First report on the occurrence of a virulent strain of *Fusarium wilt* pathogen (race-1) infecting cavendish (AAA) group of bananas in India. *Plant Disease, 94,* 1379.

Thangavelu, R., Mostert, D., Gopi, M., Devi, P. G., Padmanaban, B., Molina, A. B., . . . Viljoen, A. (2019). First detection of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (TR4) on Cavendish banana in India. *European Journal of Plant Pathology, 154,* 777–786.

Thaung, M. M. (2008a). A list of hypomycetes (and agonomycetes) in Burma. *Australasian Mycologist, 27,* 149–172.

Thaung, M. M. (2008b). Biodiversity survey of coelomycetes in Burma. *Australasian Mycologist, 27,* 74–110.

Thaung, M. M. (2008c). Pathologic and taxonomic analysis of leaf spot and tar spot diseases in a tropical dry to wet monsoon ecosystem of lowland Burma. *Australasian Plant Pathology, 37,* 180–197.

Thompson, A., & Johnston, A. (1953). A host list of plant diseases in Malaya. *Mycological Papers, 52,* 1–38.

Thompson, J. D., Gibson, T. J., & Higgins, D. G. (2002). Multiple sequence alignment using ClustalW and ClustalX. *Current Protocols in Bioinformatics, 100,* 2–3.

Thongkantha, S., Jeewon, R., Vijaykrishna, D., Lumyong, S., McKenzie, E. H. C., & Hyde, K. D. (2009). Molecular phylogeny of *Magnaporthaceae* (*Sordariomycetes*) with a new species, *Ophioceras chiangdaoense*, from *Dracaena loureiroi* in Thailand. *Fungal Diversity, 34*, 157–173.

Thongkantha, S., Lumyong, S., McKenzie, E. H. C., & Hyde, K. D. (2008). Fungal saprobes and pathogens occurring on tissues of *Dracaena lourieri* and *Pandanus spp.* in Thailand. *Fungal Diversity, 30*, 149–169.

Tian, Q., Doilom, M., Luo, Z. L., Chomnunti, P., Bhat, J. D., Xu, J. C., . . . Hyde, K. D. (2016). Introducing *Melanoctona tectonae* gen. et sp. nov and *Minimelanolocus yunnanensis* sp. nov (*Herpotrichiellaceae, Chaetothyriales*). *Cryptogamie Mycologie, 37*, 477–492.

Tian, W., Chen, Y., & Maharachchikumbura, S. S. (2022). *Neodigitodesmium*, a novel genus of family *Dictyosporiaceae* from Sichuan Province, China. *Phytotaxa, 559*, 176–184.

Tian, X., Karunarathna, S. C., Mapook, A., Promputtha, I., Xu, J., Bao, D., . . . Tibpromma, S. (2021). One new species and two new host records of *Apiospora* from bamboo and maize in northern Thailand with thirteen new combinations. *Life, 11*, 1071.

Tian, X., Karunarathna, S. C., Xu, R., Lu, Y., Suwannarach, N., Mapook, A., . . . Tibpromma, S. (2022). Three new species, two new records, and four new collections of *Tubeufiaceae* from Thailand and China. *Journal of Fungi, 8*, 206.

Tianyu, Z. (2009). *Flora Fungorum Sincorum, Vol. 31, 26 genera of dematiaceous dictyosporous hyphomycetes excluding Alternaria.* Science Press Beijing.

Tokumasu, S., Tubaki, K., & Manoch, L. (1990). A preliminary list of hyphomycetes isolated from pine leaf litter of Thailand. *Reports of Tottori Mycological Institute, 28*, 185–190.

Tongsri, V., Sangngern, S., Palakachain, A., Sangchote, S., Rangjaroen, C., Chaijuckam, P., . . . Songkumarn, P. (2017). Identification of *Corynespora torulosa* Sydow. Cros., isolate SJ1, the causal agent of leaf spot disease on banana cv. Kluay Khai and infection of the pathogen. *King Mongkut's Agricultural Journal, 35*, 84–94.

Torre, A. C. D., & Tangonan, N. G. (2008). Efficacy of *Jatropha* extracts against *Cordana musae* causing leafspot of Cardava banana. *USM R&D Journal, 16*, 89–97.

Torres-Garcia, D., García, D., Cano-Lira, J. F., & Gené, J. (2022). Two novel genera, *Neostemphylium* and *Scleromyces* (*Pleosporaceae*), from freshwater sediments and their global biogeography. *Journal of Fungi, 8*, 868.

Traverso, J. B. (1911). *Sylloge fungorum 20 (Index iconum fungorum M–Z).* Patavii.

Treseder, K. K., & Lennon, J. T. (2015). Fungal traits that drive ecosystem dynamics on land. *Microbiology and Molecular Biology Reviews, 79*, 243–262.

Trotter, A. (1926). *Sylloge fungorum omnium hucusque cognitorum. Digessit PA Saccardo; Vol. XXIV Sectio I, Supplementum Universale Pars X, Phycomycetae, Laboulbeniomycetae, Pyrenomycetae* [Synopsis of all fungi known until now. Vol. XXIV Section I, Universal Supplement Part X, *Phycomycetae, Laboulbeniomycetae, Pyrenomycetae*]. Patavii.

Trujillo, E. E., & Goto, S. (1963). The occurrence of Sigatoka disease of bananas in the Hawaiian Islands. *Plant Disease Reporter, 47*, 362–363.

Tsai, J. N., Ann, P. J., Cheng, H. F., Hsu, Z. H., & Huang, H. C. (2015). First report of *Corynespora cassiicola* causing leaf spot of papaya in Taiwan. *Plant Disease, 99*, 1649–1649.

Tsigbey, F. K. (1996). *Isolation, identification and pathogenicity of fungal pathogen(s) causing Black Sigatoka disease of local plantain and banana in Ghana* (doctoral dissertation). University of Ghana.

Tubaki, K. (1958). Studies on the Japanese hyphomycetes (IV). *Botanical Magazine, 71*, 131–137.

Tulloch, M. (1972). *The genus Myrothecium Tode ex Fr.* Commonwealth Mycological Institute.

Turner, G. J. (1971). Fungi and plant disease in Sarawak. *Phytopathological Papers, 13*, 1–55.

Tushemereirwe, W. K., & Ploetz, R. C. (1993). First report of *Fusarium wilt* on east African highland cultivars of banana. *Plant Disease, 77*, 1063.

Udayanga, D., Manamgoda, D. S., Liu, X., Chukeatirote, E., & Hyde, K. D. (2013). What are the common anthracnose pathogens of tropical fruits? *Fungal Diversity, 61*, 165–179.

Urtiaga, R. (1986). *Indice de enfermedades en plantas de Venezuela y Cuba* [Index of plant diseases in Venezuela]. Impresos en Impresos Nuevo Siglo SRL.

Urtiaga, R. (2004). *Host index of plant diseases and disorders from Venezuela*. Addendum.

Urtiaga, R., & Braun, U. (2013). New species and new records of cercosporoid hyphomycetes from Cuba and Venezuela (Part 2). *Mycosphere, 4*, 174–214.

Uysal, A., & Kurt, S. (2020). First report of *Colletotrichum siamense* causing anthracnose on banana fruits in Turkey. *Journal of Plant Pathology, 102*, 967.

Uzor, P. F., Ebrahim, W., Osadebe, P. O., Nwodo, J. N., Okoye, F. B., Müller, W. E., . . . Proksch, P. (2015). Metabolites from *Combretum dolichopetalum* and its associated endophytic fungus *Nigrospora oryzae*: Evidence for a metabolic partnership. *Fitoterapia, 105*, 147–150.

Valenzuela-Lopez, N., Cano-Lira, J. F., Guarro, J., Sutton, D. A., Crous, P. W., & Stchigel, A. M. (2018). Coelomycetous *Dothideomycetes* with emphasis on the families *Cucurbitariaceae* and *Didymellaceae*. *Studies in Mycology, 90*, 1–69.

Van Der AA, H. A. (1973). Studies in *Phyllosticta* I. *Studies in Mycology*, *5*, 1–110.

Van Hove, F., Waalwijk, C., Logrieco, A., Munaut, F., & Moretti, A. (2011). *Gibberella musae* (*Fusarium musae*) sp. nov., a recently discovered species from banana is sister to *F. verticillioides*. *Mycologia, 103*, 570–585.

Van Westerhoven, A., Mehrabi, R., Talebi, R., Steentjes, M., Corcolon, B., Chong, P., . . . Seidl, M. F. (2023). A chromosome-level genome assembly of *Zasmidium syzygii* isolated from banana leaves. *BioRxiv, 8,* Article jkad262.

Vanev, S. G., & Van-Der AA, H. A. (1998). An annotated list of the published names in *Asteromella*. *Persoonia, 17*, 47–67.

Vanky, K. (1985). Carpathian *Ustilaginales*. *Symbolae Botanicae Upsalienses, 24*, 1–309.

Vanky, K. (1994). *European smut fungi*. Gustav Fischer Verlag, Stuttgart.

Vanky, K. (2013). *Illustrated genera of smut fungi.* APS Press.

Vanky, K., & McKenzie, E. H. C. (2002). *Fungi of New Zealand.* Fungal Diversity Press.

Vanky, K., Gonczol, J., & Toth, S. (1982). Review of the *Ustilaginales* of Hungary. *Acta Botanica Hungarica, 28*, 255–277.

Vardhana, R. (2017). Plant's diseases of district Ghaziabad and adjacent areas. *Plant Archives, 17*, 727–732.

Vasyliūnaitė, R. (2022). Endophytic fungi in leaves of banana plant *Musa* spp.: diversity and species composition. *Mycological Progress, 21*, 25–39.

Vawdrey, L. (2008). *The cause, distribution and economic importance of fruit speckle of banana in north Queensland.* Horticulture Australia Ltd, Sydney.

Verkley, G. J. M., Dukik, K., Renfurm, R., Göker, M., & Stielow, J. B. (2014). Novel genera and species of coniothyrium-like fungi in *Montagnulaceae* (*Ascomycota*). *Persoonia: Molecular Phylogeny and Evolution of Fungi, 32*, 25–51.

Videira, S. I. R., Groenewald, J. Z., Braun, U., Shin, H. D., & Crous, P. W. (2016). All that glitters are not *Ramularia*. *Studies in Mycology, 83*, 49–163.

Videira, S. I. R., Groenewald, J. Z., Nakashima, C., Braun, U., Barreto, R. W., de Wit, P. J. G. M., . . . Crous, P. W. (2017). *Mycosphaerellaceae* - Chaos or clarity? *Studies in Mycology, 87*, 257–421.

Vieira, W. A. S., Lima, W. G., Nascimento, E. S., Michereff, S. J., Camara, M. P. S., & Doyle, V. P. (2017). The impact of phenotypic and molecular data on the inference of *Colletotrichum* diversity associated with *Musa*. *Mycologia, 109*, 912–934.

Vieira, W. A. S., Michereff, S. J., de Morais Jr, M. A., Hyde, K. D., & Camara, M. P. S. (2014). Endophytic species of *Colletotrichum* associated with mango in northeastern Brazil. *Fungal Diversity, 67*, 181–202.

Vilgalys, R., & Hester, M. (1990). Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. *Journal of Bacteriology, 172*, 4238–4246.

Voglmayr, H., & Jaklitsch, W. M. (2017). *Corynespora, Exosporium*, and *Helminthosporium* revisited: New species and generic reclassification. *Studies in Mycology, 87*, 43–76.

Von Arx, J. A., & Mueller, E. (1954). Die Gattungen der amerosporen *Pyrenomyceten* [The genera of amerospore Pyrenomycetes. Contributions to the cryptogamic flora of Switzerland], *Beiträge zur Kryptogamenflora der Schweiz, 11*, 1–434.

Voora, V., Larrea, C., & Bermudez, S. (2020). *Global market report: Bananas* (Report No. 12). International Institute for Sustainable Development.

Vu, D., Groenewald, M., De Vries, M., Gehrmann, T., Stielow, B., Eberhardt, U., . . . Boekhout, T. (2019). Large-scale generation and analysis of filamentous fungal DNA barcodes boosts coverage for kingdom fungi and reveals thresholds for fungal species and higher taxon delimitation. *Studies in Mycology, 92*, 135–154.

Waliullah, S., Fonsah, E. G., & Ali, M. E. (2022). First report of stem-end rot caused by *Lasiodiplodia brasiliensis* on banana in the United States. *Plant Disease, 106*, 2996.

Wallbridge, A. (1981). Fungi associated with crown-rot disease of boxed bananas from the Windward Islands during a two-year survey. *Transactions of the British Mycological Society, 77*, 567–577.

Wallbridge, A., & Pinegar, J. A. (1975). Fungi associated with crown-rot disease of bananas from St Lucia in the Windward Islands. *Transactions of the British Mycological Society, 64*, 247–254.

Wanasinghe, D. N., Bezerra, J. D., Xu, J., & Mortimer, P. E. (2023). *Honghemyces pterolobii* gen. et sp. nov. *(Bezerromycetaceae, Tubeufiales*), a new ascomycetous fungus from *Pterolobium macropterum* in Honghe, China. *Sydowia, 75*, Article 13.

Wanasinghe, D. N., Jeewon, R., Jones, E. G., & Boonmee, S. (2018). Novel palmicolous taxa within *Pleosporales*: Multigene phylogeny and taxonomic circumscription. *Mycological Progress, 17*, 571–590.

Wanasinghe, D. N., Jones, E. B. G., Camporesi, E., Mortimer, P. E., & Hyde, K. D. (2016). Taxonomy and phylogeny of *Laburnicola* gen. nov. and *Paramassariosphaeria* gen. nov. (*Didymosphaeriaceae, Massarineae, Pleosporales*). *Fungal Biology, 120*, 1354–1373.

Wanasinghe, D. N., Nimalrathna, T. S., Xian, L. Q., Faraj, T. K., Xu, J., & Mortimer, P. E. (2024). Taxonomic novelties and global biogeography of *Montagnula* (*Ascomycota, Didymosphaeriaceae*). *MycoKeys*, *101*, 191.

Wanasinghe, D. N., Phukhamsakda, C., Hyde, K. D., Jeewon, R., Lee, H. B., Jones, E. B., . . . Karunarathna, S. C. (2018). Fungal diversity notes 709–839: Taxonomic and phylogenetic contributions to fungal taxa with an emphasis on fungi n *Rosaceae*. *Fungal Diversity*, *89*, 1–236.

Wang, A., Xu, Y., Gao, Y., Huang, Q., Luo, X., An, H., . . . Dong, J. (2015). Chemical and bioactive diversities of the genera *Stachybotrys* and *Memnoniella* secondary metabolites. *Phytochemistry Reviews, 14*, 623–655.

Wang, B., Zhang, Y., Liu, J., Sheng, O., Liu, F., Qiu, D., . . . Cheng, C. (2022). A new leaf blight disease caused by *Alternaria jacinthicola* on banana in China. *Horticulturae, 8*, Article 12.

Wang, G. N., Yu, X. D., Dong, W. B., Bhat, D. J., Boonmee, S., Zhang, D., . . . Zhang, H. (2019). Freshwater hyphomycetes in *Eurotiomycetes*: A new species of *Minimelanolocus* and a new collection of *Thysanorea papuana* (*Herpotrichiellaceae*). *Mycological Progress, 18*, 511–522.

Wang, H., Kong, J., Wu, Y., & Zhang, T. (2009). Notes on soil dematiaceous hyphomycetes from the Qaidam basin, Qinghai province, China I. *Mycosystema, 28*, 20–24.

Wang, M. M., Chen, Q., Diao, Y. Z., Duan, W. J., & Cai, L. (2019). *Fusarium incarnatum-equiseti* complex from China. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 43*, 70–89.

Wang, M., Liu, F., Crous, P. W., & Cai, L. (2017). Phylogenetic reassessment of *Nigrospora*: Ubiquitous endophytes, plant, and human pathogens. *Persoonia-Molecular Phylogeny and Evolution of Fungi, 39*, 118–142.

Wang, Q. H., Fan, K., Li, D. W., Han, C. M., Qu, Y. Y., Qi, Y. K., . . . Wu, X. Q. (2020). Identification, virulence, and fungicide sensitivity of *Colletotrichum gloeosporioides*, responsible for walnut anthracnose disease in China. *Plant Disease, 104*, 1358–1368.

Wang, S. Y., McKenzie, E. H., Phillips, A. J., Li, Y., & Wang, Y. (2022). Taxonomy and multigene phylogeny of *Diaporthales* in Guizhou Province, China. *Journal of Fungi, 8*, 1301.

Wang, Y. C. (1964). Ustilaginales *in China.* Science Publisher.

Wang, Y., Song, X., Xie, S., Geng, Y., Xu, C., Yin, X., . . . Guo, Y. (2024). Diversity of *Lasiodiplodia* species associated with canker and dieback in fruit trees in the Henan and Shandong Provinces of China. *Plant Disease, 108*, 563–575.

Wang, Y., Hyde, K. D., McKenzie, E. H., Jiang, Y. L., Li, D. W., & Zhao, D. G. (2015). Overview of *Stachybotrys*, *Memnoniella*, and current species status. *Fungal Diversity, 71*, 17–83.

Warburg, O. (1899). *Monsunia; Beiträge zur Kenntniss der Vegetation des Süd- und Ostasiatischen Monsungebietes* [Monsunia; Contributions to the knowledge of the vegetation of the South and East Asian monsoon regions]. Verlag von Wilhelm Engelmann.

Watanabe, K., Motohashi, K., & Ono, Y. (2010). Description of *Pestalotiopsis pallidotheae*, a new species from Japan. *Mycoscience, 51*, 182–188.

Weatherhead, E., Davis, E. L., & Koide, R. T. (2022). Many foliar endophytic fungi of *Quercus gambelii* are capable of psychrotolerant saprotrophic growth. *PloS One, 17*, Article e0275845.

Weaver, M. A., Hoagland, R. E., Boyette, C. D., & Brown, S. P. (2021). Taxonomic evaluation of a bioherbicidal isolate of *Albifimbria verrucaria*, formerly *Myrothecium verrucaria*. *Journal of Fungi, 7*, Article 694.

Wei, P. P., Ji, J. C., Ma, X. J., Li, Z. H., Ai, H. L., Lei, X. X., . . . Liu, J. K. (2022). Three new pyrrole alkaloids from the endophytic fungus *Albifimbria viridis*. *Natural Products and Bioprospecting*, *12*, 1–5.

Weir, B. S., Johnston, P. R., & Damm, U. (2012). The *Colletotrichum gloeosporioides* species complex. *Studies in Mycology, 73*, 115–180.

White, T. J., Bruns, T., Lee, S. J. W. T., & Taylor, J. L. (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In *PCR protocols: A guide to methods and applications*, *18*, 315–322.

Whiteside, J. O. (1966). A revised list of plant diseases in Rhodesia. *Kirkia, 5*, 87–196.

Whitton, S. R., McKenzie, E. H. C., & Hyde, K. D. (2001). Microfungi on the *Pandanaceae*: *Stachybotrys*, with three new species. *New Zealand Journal of Botany, 39*, 489–499.

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag, New York.

Wiehe, P. O. (1948). The plant diseases and fungi recorded from Mauritius. *Mycological Papers, 24*, 1–39.

Wiehe, P. O. (1953). The plant diseases of Nyasaland. *Mycological Papers, 53*, 1–39.

Wijayawardene, N. N., Hyde, K. D., Al-Ani, L. K. T., Tedersoo, L., Haelewaters, D., Rajeshkumar, K. C., . . . Saxena, R. K. (2020). Outline of fungi and fungi-like taxa. *Mycosphere, 11*, 1060–1456.

Wijayawardene, N. N., Hyde, K. D., Bhat, D. J., Camporesi, E., Schumacher, R. K., Chethana, K. T., . . . Wang, Y. (2014). *Camarosporium*-like species are polyphyletic in *Pleosporales*: Introducing *Paracamarosporium* and *Pseudocamarosporium* gen. nov. in *Montagnulaceae*. *Cryptogamie Mycologie, 35*, 177–198.

Wijayawardene, N. N., Hyde, K. D., Dai, D. Q., Sánchez-García, M., Goto, B. T., & Magurno, F. (2022). Outline of fungi and fungus-like taxa–2021. *Mycosphere, 13*, 53–453.

Wijayawardene, N. N., Hyde, K. D., Wanasinghe, D. N., Papizadeh, M., Goonasekara, I. D., Camporesi, E., . . . Wang, Y. (2016). Taxonomy and phylogeny of dematiaceous coelomycetes. *Fungal Diversity, 77*, 1–316.

Wikee, S., Lombard, L., Crous, P. W., Nakashima, C., Motohashi, K., Chukeatirote, E., . . . Hyde, K. D. (2013). *Phyllosticta capitalensis*, a widespread endophyte of plants. *Fungal Diversity, 60*, 91–105.

Wikee, S., Lombard, L., Nakashima, C., Motohashi, K., Chukeatirote, E., Cheewangkoon, R., . . . Crous, P. W. (2013). A phylogenetic re-evaluation of *Phyllosticta* (*Botryosphaeriales*). *Studies in Mycology, 76*, 1–29.

Wikee, S., Udayanga, D., Crous, P. W., Chukeatirote, E., McKenzie, E. H. C., Bahkali, A. H., . . . Hyde, K. D. (2011). *Phyllosticta* – An overview of current status of species recognition. *Fungal Diversity, 51*, 43–61.

Williams, T. H., & Liu, P. S. W. (1976). A host list of plant diseases in Sabah, Malaysia. *Phytopathological Papers, 19*, 1–67.

Winter, G. (1886). Fungi exotici III. *Hedwigia, 21*, 92–104.

Wollenweber, H. W. (1930). *Fusaria autographice delineate* [Fusaria depicted accurately]. Cornell University.

Wong, M. H., Crous, P. W., Henderson, J., Groenewald, J. Z., & Drenth, A. (2012). *Phyllosticta* species associated with freckle disease of banana. *Fungal Diversity, 56*, 173–187.

Wong, M. H., Henderson, J., & Drenth, A. (2013). Identification and differentiation of *Phyllosticta* species causing freckle disease of banana using high-resolution melting (HRM) analysis. *Plant Pathology, 62*, 1285–1293.

Wong, M. K. M., & Hyde, K. D. (2001). Diversity of fungi on six species of *Gramineae* and one species of *Cyperaceae* in Hong Kong. *Mycological Research, 105*, 1485–1491.

Woudenberg, J. H. C., Groenewald, J. Z., Binder, M., & Crous, P. W. (2013). *Alternaria* redefined. *Studies in Mycology, 75*, 171–212.

Wu, S. P., Liu, Y. X., Yuan, J. E., Wang, Y., & Liu, Z. Y. (2014). *Phyllosticta* species from banana (*Musa* sp.) in Chongqing and Guizhou Provinces, China. *Phytotaxa, 188*, 135–144.

Wu, Y. M., & Zhang, T. Y. (2009). Two new species of *Stachybotrys* from soil. *Mycotaxon, 109*, 461–464.

Wu, N. A., Dissanayake, A. J., Manawasinghe, I. S., Rathnayaka, A. R., Liu, J. K., Phillips, A. J., . . . Hyde, K. D. (2021). https://botryosphaeriales. org/, an online platform for up-to-date classification and account of taxa of *Botryosphaeriales*. *Database, 2021*, Article baab061.

Wulandari, N. F., Bhat, D. J., & To-anun, C. (2013). A modern account of the genus *Phyllosticta*. *Plant Pathology & Quarantine, 3*, 145–159.

Wulandari, N. F., Hyde, K. D., Duong, L. M., De Gruyter, J., Meffert, J. P., Groenewald, J. Z., . . . To-anun, C. (2009). *Phyllosticta citriasiana* sp. nov., the cause of citrus tan spot of *Citrus maxima* in Asia. *Fungal Diversity, 34*, 23–39.

Wulandari, N. F., To-anun, C., Cai, L., Abd-Elsalam, K. A., & Hyde, K. D. (2010). *Guignardia/Phyllosticta* species on banana. *Cryptogamie Mycologie, 31,* 403–418.

Xia, J. W., Ma, L. G., Castañeda-Ruíz, R. F., & Zhang, X. G. (2014). A new species of *Sporidesmiopsis* and three new records of other dematiaceous hyphomycetes from southern China. *Nova Hedwigia, 98,* 103–111.

Xia, J. W., Sandoval-Denis, M., Crous, P. W., Zhang, X. G., & Lombard, L. (2019). Numbers to names – Restyling the *Fusarium incarnatum-equiseti* species complex. *Persoonia, 43,* 186–221.

Xia, X., Lie, T. K., Qian, X., Zheng, Z., Huang, Y., & Shen, Y. (2011). Species diversity, distribution, and genetic structure of endophytic and epiphytic *Trichoderma* associated with banana roots. *Microbial Ecology, 61,* 619–625.

Xie, L., Wu, Y., Duan, X., Li, T., & Jiang, Y. (2022). Proteomic and physiological analysis provides an elucidation of *Fusarium proliferatum* infection causing crown rot on banana fruit. *Microbiological Research, 256,* Article 126952.

Xu, Z. H., Kuang, W. G., Qiu, L., Zhang, X. G., & Ma, J. (2020). *Corynespora sinensis* sp. nov. from Jiangxi, China. *Mycotaxon, 135,* 803–809.

Yang, J., Liu, L. L., Jones, E. G., Hyde, K. D., Liu, Z. Y., Bao, D. F., . . . Liu, J. K. (2023). Freshwater fungi from karst landscapes in China and Thailand. *Fungal Diversity, 119,* 1–212.

Yang, Q., Du, Z., & Tian, C. M. (2018). Phylogeny and morphology reveal two new species of *Diaporthe* from traditional Chinese medicine in northeast China. *Phytotaxa, 336,* 159–170.

Yang, Q., Fan, X. L., & Tian, C. M. (2017). *Diaporthe* species occurring on *Senna bicapsularis* in southern China, with descriptions of two species. *Phytotaxa, 302,* 145–155.

Yang, Q., Fan, X. L., Guarnaccia, V., & Tian, C. M. (2018). High diversity of *Diaporthe* species associated with dieback diseases in China, with twelve new species described. *MycoKeys, 39*, 97–149.

Yang, Q., Jiang, N., & Tian, C. M. (2020). Three new *Diaporthe* species from Shaanxi Province, China. *MycoKeys*, *67*, 1–18.

Yang, X., Jin, H., Xu, L., Cui, H., Xin, A., Liu, H., . . . Qin, B. (2020). Diversity and functions of endophytic fungi associated with roots and leaves of *Stipa purpurea* in an Alpine Steppe at Tibet plateau. *Journal of Microbiology and Biotechnology*, *30*, 1027–1036.

Yasanthika, W. A. E., Wanasinghe, D. N., Karunarathna, S. C., Bhat, D. J., Samarakoon, S. M. B. C., Ren, G. C., . . . Hyde, K. D. (2020). Two new *Sordariomycetes* records from forest soils in Thailand. *Asian Journal of Mycology*, *3*, 456–471.

Yen, J. M. (1972). Etude sur les champignons parasites du Sud-Est asiatique XXIII. Les Uredinees des Philippines [Study on Parasitic Fungi of Southeast Asia XVIII. Leaf spot diseases of bananas caused by two new fungi in formosa III], *Bulletin de la Société Mycologique de France*, *88*, 221–225.

Yen, J. M. (1974). Etude sur les champignons parasites du Sud-Est asiatique XXIII. Les *Uredinees* des Philippines [Study on parasitic fungi of southeast Asia XXIII. The rust fungi of the Philippines], *Bulletin de la Société Mycologique de France*, *90*, 195–200.

Yuan, X. L., Cao, M., Shen, G. M., Zhang, H. B., Du, Y. M., Zhang, Z. F., . . . Zhang, P. (2020). Characterization of nuclear and mitochondrial genomes of two tobacco endophytic fungi, *Leptosphaerulina chartarum* and *Curvularia trifolii*, and their contributions to phylogenetic implications in the *Pleosporales*. *International Journal of Molecular Sciences, 21*, 2461.

Zakaria, L. (2021). Diversity of *Colletotrichum* species associated with anthracnose disease in tropical fruit crops - A Review. *Agriculture*, *11*, 297.

Zakaria, L., & Aziz, W. N. W. (2018). Molecular identification of endophytic fungi from banana leaves (*Musa* spp.). *Tropical Life Sciences Research, 29*, 201–211.

Zakaria, L., & Jamil, M. I. (2016). Molecular characterisation of endophytic fungi from roots of wild banana (*Musa acuminata*). *Tropical Life Sciences Research, 27*, 153–162.

Zakaria, L., & Rahman, N. H. A. (2011). Endophytic *Fusarium* spp. from wild banana (*Musa acuminata*) roots. *African Journal of Microbiology Research, 5*, 3600–3602.

Zakaria, L., Sahak, S., Zakaria, M., & Salleh, B. (2009). Characterisation of *Colletotrichum* species associated with anthracnose of banana. *Tropical Life Sciences Research, 20*, 119–125.

Zambettakis, C. (1971). Recherches sur les *Ustilaginales* d'Afrique [Research on the *Ustilaginales* of Africa], *Bulletin de la Société Mycologique de France, 86*, 305–692.

Zare, R., Gams, W., Starink-Willemse, M., & Summerbell, R. C. (2007). *Gibellulopsis*, a suitable genus for *Verticillium nigrescens*, and *Musicillium*, a new genus for *V. theobromae*. *Nova Hedwigia, 85*, 463–490.

Zeng, L., Zhao, Z., Xi, Z., Li, M., Xi, P., & Jiang, Z. (2013). The *Fusarium* species isolated from banana and their phylogenetic relationships. *Mycosystema, 32*, 617–632.

Zhang, H., Yang, M. H., Zhuo, F. F., Gao, N., Cheng, X. B., Wang, X. B., . . . Kong, L. Y. (2019). Seven new cytotoxic phenylspirodrimane derivatives from the endophytic fungus *Stachybotrys chartarum*. *RSC Advances, 9*, 3520–3531.

Zhang, J. F., Liu, J. K., Khongphinitbunjong, J., & Liu, Z. Y. (2018). A new species and new record of *Lophiotrema* (*Lophiotremataceae, Dothideomycetes*) from karst landforms in southwest China. *Phytotaxa, 379*, 169–179.

Zhang, L., Fasoyin, O. E., Molnár, I., & Xu, Y. (2020). Secondary metabolites from hypocrealean entomopathogenic fungi: Novel bioactive compounds. *Natural Product Reports, 37*, 1181–1206.

Zhang, L., Yin, Y. Q., Zhao, L. L., Xie, Y. Q., Han, J., & Zhang, Y. (2023). Two new species of *Colletotrichum* (*Glomerellaceae*, *Glomerellales*) causing walnut anthracnose in Beijing. *MycoKeys, 99*, 131.

Zhang, M., Xia, Y. M., & Xia, Y. M. (2020). Effects of foliar application of potassium phosphite on gray mold and leaf spot in *Panax notoginseng*. *Frontiers in Plant Science, 11*, 1448.

Zhang, N., Luo, J., Rossman, A. Y., Aoki, T., Chuma, I., Crous, P. W., . . . Lebrun, M. H. (2016). Generic names in *Magnaporthales*. *IMA Fungus, 7*, 155–159.

Zhang, W., Groenewald, J. Z., Lombard, L., Schumacher, R. K., Phillips, A. J. L., & Crous, P. W. (2021). Evaluating species in *Botryosphaeriales*. *Persoonia – Molecular Phylogeny and Evolution of Fungi, 46*, 63–115.

Zhang, X. G., & Wu, Y. M. (2003). A new species of *Pithomyces*. *Mycotaxon, 85*, 131–133.

Zhang, Z. (2003). *Flora Fungorum Sinicorum, Cladosporium, Fusicladium, Pyricularia* [Flora of Chinese fungi, *Cladosporium, Fusicladium, Pyricularia*]. Science Press, Beijing.

Zhang, Z. (2006). *Flora Fungorum Sinicorum, Botrytis, Ramularia* [Flora of Chinese fungi, *Botrytis, Ramularia*]. Science Press, Beijing.

Zhang, Z., Liu, X., Zhang, X., & Meng, Z. (2022). Morphological and phylogenetic analyses reveal two new species and a new record of *Phyllosticta* (*Botryosphaeriales*, *Phyllostictaceae*) from Hainan, China. *MycoKeys, 91*, 1.

Zhao, G. H., Li, D. W., Jiang, J. H., & Peng, J. (2010). First report of *Stachybotrys chartarum* causing leaf blight of *Tillandsia tenuifolia* in China. *Plant Disease, 94*, 1166.

Zhao, G. Z., Cao, A. X., Zhang, T. Y., & Liu, X. Z. (2011). *Acrodictys* (Hyphomycetes) and related genera from China. *Mycological Progress, 10*, 67–83.

Zhao, H., Qi, Y., & Zhang, X. (2023). First report of *Bipolaris oryzae* causing leaf spot on banana in China. *Journal of Plant Pathology, 105*, 1717–1718.

Zhao, Y. Z., Zhang, Z. F., Cai, L., Peng, W. J., & Liu, F. (2018). Four new filamentous fungal species from newly-collected and hive-stored bee pollen. *Mycosphere, 9*, 1089–1116.

Zhao, Y., Deng, C., & Chen, X. (1990). *Arthrinium phaeospermum* causing dermatomycosis: A new record for China. *Acta Mycologica Sinica, 9*, 232–235.

Zhaxybayeva, O., & Gogarten, J. P. (2002). Bootstrap, Bayesian probability, and maximum likelihood mapping: Exploring new tools for comparative genome analyses. *BMC Genomics, 3*, 1–4.

Zheng, H., Zhang, Z., Liu, D. Z., & Yu, Z. F. (2019). *Memnoniella sinensis* sp. nov., a new species from China and a key to species of the genus. *International Journal of Systematic and Evolutionary Microbiology, 69*, 3155–3163.

Zhimo, V. Y., Dilip, D., Sten, J., Ravat, V. K., Bhutia, D. D., Panja, B., . . . Saha, J. (2017). Antagonistic yeasts for biocontrol of the banana postharvest anthracnose pathogen *Colletotrichum musae*. *Journal of Phytopathology, 165*, 35–43.

Zhou, D., & Hyde, K. D. (2001). Host-specificity, host-exclusivity, and host-recurrence in saprobic fungi. *Mycological Research, 105*, 1449–1457.

Zhou, N., Chen, Q., Carroll, G., Zhang, N., Shivas, R. G., & Cai, L. (2015). Polyphasic characterization of four new plant pathogenic *Phyllosticta* species from China, Japan, and the United States. *Fungal Biology, 119*, 433–446.

Zhou, Y., Huang, J. S., Yang, L. Y., Wang, G. F., & Li, J. Q. (2017). First report of banana anthracnose caused by *Colletotrichum scovillei* in China. *Plant Disease, 101*, 381–382.

Zhuang, W. Y. (2001). *Higher Fungi of Tropical China*. Mycotaxon Ltd., Ithaca.

Zhuang, W. Y. (2005). *Fungi of northwestern China*. Mycotaxon Ltd., Ithaca.

Zundel, G. L. (1953). *The Ustilaginales of the world*. Pennsylvania State College School of Agriculture.

APPENDICES

APPENDIX A

THE GLOBAL CHECKLIST OF FUNGI ASSOCIATED WITH *Musa*

Notes

1. The documentation includes known hosts (solely the genus name or coupled with the species epithet) and the geographical locality of fungi recorded on *Musa*.
2. The nomenclature of Index Fungorum (2024) was followed for all the records.
3. Taxonomic classification updates (Phylum, Class, Order, and Family) were implemented.
4. Fungal names are arranged in descending order in the taxonomic hierarchy.
5. The necessary data are included in front of the **Species Fungorum current name** section as separate columns.
6. The reachable bibliographic information is in-text cited in front of each record.
7. Fungal species for which molecular data are available in GenBank are indicated with an asterisk (*) mark.

Species Fungorum current name	Phylum	Class	Order	Family	Host	Country	References
Atichia sp.	*Ascomycota*	*Ascomycota* families *incertae sedis*	*Ascomycota* families *incertae sedis*	*Seuratiaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Virgariella oblonga Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Mexico	Heredia-Abarcaet al. (1997)
Acumispora biseptata Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Australia	Matsushima (1989)
Arthrobotryum sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Beejadwaya bispora (Matsush.) Subram.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Japan	Dugan et al. (2004), Kobayashi (2007) and Matsushima (1975)
Beejadwaya bispora (Matsush.) Subram.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Australia	Matsushima (1989)
Bispora betulina (Corda) S. Hughes *	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Japan	Kobayashi and Kubono (1986)
Ceratosporium gracile Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Cuba, Micronesia	Delgado-Rodriguez et al. (2003) and Matsushima (1981)
Ceratosporium palmiforme Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)

Chlamydomyces sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Chlamydomyces sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Japan	Kobayashi (2007)
Haplobasidion musae M. B. Ellis *	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Fiji, Malaysia, Malay Peninsula	Ellis (1957), Firman (1972) and Johnston (1960)
Haplobasidion musae M. B. Ellis *	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Fiji, Malaysia, Samoa, Tonga	Dingley et al. (1981), Ellis (1971b) and McKenzie (1996)
Hymenula musae Pat.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Ecuador	Socie´te´ mycologique de France and Socie´te´ botanique de France (1892)
Imicles aquatica (Cabello, Mengasc. & Aramb.) Shoemaker & Hambl.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Lateriramulosa uniinflata Matsush. *	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Australia	Matsushima (1989)
Leptothyrium musae Cif. & Gonz. Frag.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Dominican Republic	Ciferri (1929, 1961)
Leuliisinea bambusicola Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Australia	Matsushima (1989)

Neta quadriguttata (Matsush.) de Hoog	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Japan	Kobayashi (2007)
Parapyricularia musae M. B. Ellis & Peregrine	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Brunei Darussalam, Malaysia	Ellis (1972), Liu (1977) and Peregrine and Ahmad (1982)
Parapyricularia musae M. B. Ellis & Peregrine	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Brunei Darussalam, Malaysia	Ellis (1976)
Pellionella musae Sawada	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa cavendishii*	China	Sawada (1959)
Phaeostalagmus tenuissimus (Corda) W. Gams & Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Bangladesh, Caribbean, China, China, Egypt, Fiji, India, India, Jamaica, Jamaica, Jamaica, Libya, Nigeria, Panama, South Africa, Trinidad and Tobago, United States, Venezuela, Zimbabwe	Chen (2017), Dennis (1970), Dingley et al. (1981), El-Buni and Rattan (1981), Gorter (1977), Kranz (1962), Meredith (1969), Pantou et al. (2005), Piepenbring (2006), Tai (1979), Whiteside (1966) and Zare et al. (2007)
Phaeostalagmus tenuissimus (Corda) W. Gams & Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa cavendishii*	Greece, South Africa	Crous et al. (2000) and Holevas et al. (2000)
Phaeostalagmus tenuissimus (Corda) W. Gams	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa acuminata*	Iran, Thailand	Lumyong et al. (2003) and Zare et al. (2007)

& Hol. -Jech.							
Phaeostalagmus tenuissimus (Corda) W. Gams & Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Brazil, Iran, Kenya, Taiwan region in China, Tanzania, Zambia	Matsushima (1980), Nattrass (1961), Riley (1956, 1960) and Zare et al. (2007)
Phaeostalagmus tenuissimus (Corda) W. Gams & Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Ghana, India, Venezuela, West Indies	Hughes (1952), Sarbhoy et al. (1971), Urtiaga (2004) and Wallbridge (1981)
Piricaudilium lobatum Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Mexico	Heredia-Abarca et al. (1997)
Piricaudilium lobatum Hol. -Jech.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951)
Pseudoramularia ruwenzoriensis Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Uganda	Matsushima (1983)
Radaisiella elegans Bainier	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	France	Index of Fungi (1981)
Rhinotrichum sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Sierra Leone	Deighton (1936)
Rhinotrichum sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Sierra Leone	Deighton (1936)

Rhinotrichum sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa cavendishii*	Sierra Leone	Deighton (1936)
Stauronema sacchari Syd., P. Syd. & E. J. Butler	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* sp.	India	Mathur (1979) and Nag Raj (1993)
Strossmayeria atriseda (Saut.) Iturr.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Brazil	Photita et al. (2002)
Tricellula taiwanensis Matsush.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa sapientum*	Taiwan region in China	Matsushima (1987)
Trichopeltulum sp.	*Ascomycota*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Ascomycota* genera *incertae sedis*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Diplodia musae Died.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa sapientum*	India, Thailand	Giatgong (1980), Mathur (1979) and Sydow et al. (1916)
Diplodia paradisiaca (Mont.) Wollenw.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* × *paradisiaca*	Dominican Republic, Guyana	Ciferri (1929) and Photita et al. (2002)
Diplodia radula Berk. & Broome	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* sp.	Sri Lanka	Linnean Society of London (1875)
Diplodia sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa acuminata*	Venezuela, Thailand	Lumyong et al. (2003) and Urtiaga (2004)
Lasiodiplodia brasiliensis M. S. B. Netto, M. W. Marques & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* sp.	Brazil, United States	Santos et al. (2023) and Waliullah et al. (2022)

Lasiodiplodia citricola Abdollahz., Javadi & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Lasiodiplodia egyptiaca A. M. Ismail, L. Lombard & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Lasiodiplodia iraniensis Abdollahz., Zare & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* sp.	Brazil	Silva et al. (2023)
Lasiodiplodia mahajangana Begoude, Jol. Roux & Slippers *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* sp.	Australia	Burgess et al. (2019) and Tan et al. (2019)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* × *paradisiaca*	Brazil, Cuba, India, Panama, Thailand, United States, West Indies	Alfieri Jr (1984), Arnold (1986), Mathur (1979), McGuire Jr and Crandall (1967), Mendes et al. (1998), Salaemae et al. (2022), Urtiaga (1986), Urtiaga (2004) and Wallbridge (1981)

Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa acuminata*	Australia, China, Cote d'Ivoire, Ethiopia, Hong Kong, Malay Peninsula, Mexico, Somalia, Sri Lanka	Adikaram and Yakandawala (2020), Burgess et al. (2006), Castellani and Ciferri (1937, 1950), Goos et al. (1961), Lu et al. (2000), Resplandy et al. (1954), Simmonds (1966), and Zhuang (2001)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa acuminata* × *Musa balbisiana*	Thailand	This study
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa acuminata* var. *microcarpa*	Malay Peninsula	Goos et al. (1961)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa balbisiana*	Honduras, Malaysia, Panama	Goos et al. (1961)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa gracilis*	Malay Peninsula	Goos et al. (1961)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa reflexa*	Malaysia	Goos et al. (1961)

Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum*	Brunei Darussalam, China, Fiji, Ghana, India, Jamaica, Japan, Malay Peninsula, Taiwan region in China, Thailand, United States	Alfieri Jr (1984), Dade (1940), Firman (1972), Giatgong (1980), Hughes (1953), Johnston (1953), Kobayashi (2007), Larter and Martyn (1943), Mathur (1979), Matsushima (1980), Peregrine and Ahmad (1982) and Thompson and Zhuang (2001)
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	China, Fiji, Ghana, Guinea, Honduras, India, Japan, Malaysia, Nigeria, Panama, Papua New Guinea, Samoa, South Africa, United States	Dingley et al. (1981), Gorter (1977), Hughes (1953), Kobayashi (2007), Kolombia et al. (2023), Kranz (1965), Mathur (1979), Piepenbring (2006), Richardson (1990), Sangeetha et al. (2012), Shaw (1984), Tai (1979) and Zakaria and Aziz (2018)

Lasiodiplodia theobromae (Pat.) Griffon & Maubl. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa textilis*	Honduras	Goos (1961)
Leptodothiorella sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	Myanmar	Thaung (2008)
Macrophoma ensetes Sacc. & Scalia	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa ensete*	Portugal	Saccardo and Saccardo (1906)
Macrophoma sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum*	Malawi	Peregrine and Siddiqi (1972)
Macrophoma sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	Malawi	Corbett (1964)
Macrophomina phaseolina (Tassi) Goid. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa acuminata*	Iran, Venezuela	Amani (2011) and Urtiaga (2004)
Macrophomina phaseolina (Tassi) Goid. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* × *paradisiaca*	India, Sri Lanka	Sarkar et al. (2013) and Small (1928)
Macrophomina phaseolina (Tassi) Goid. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* × *paradisiaca* var. *sapientum*	Southern Africa	Doidge (1950)
Macrophomina phaseolina (Tassi) Goid. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum*	India	Mathur (1979)
Macrophomina phaseolina (Tassi) Goid. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	India, Papua New Guinea, Puerto Rico, Virgin Islands, Zimbabwe	Sarkar et al. (2013), Shaw (1984), Stevenson (1975) and Whiteside (1966)

Neodeightonia subglobosa C. Booth *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Neofusicoccum parvum (Pennycook & Samuels) Crous, Slippers & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa* sp.	Australia	Liddle et al. (2019)
Neofusicoccum parvum (Pennycook & Samuels) Crous, Slippers & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Neofusicoccum ribis (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa acuminata*	Australia	Simmonds (1966)
Neofusicoccum ribis (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A. J. L. Phillips *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa sapientum*	Taiwan region in China	Photita et al. (2002)
Neoscytalidium dimidiatum (Penz.) Crous & Slippers *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriaceae*	*Musa acuminata*	Jamaica, United States	Meredith (1963) and Raabe et al. (1981)

Neoscytalidium dimidiatum (Penz.) Crous & Slippers *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	United States	Meredith (1969)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* × *paradisiaca*	India, Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa humilis*	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum*	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum* var. *cinerea*	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum* var. *lacatan*	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa sapientum* var. *compressa*	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	Philippines	Teodoro (1937)
Sphaeropsis musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa textilis*	Philippines	Teodoro (1937)
Spiropes dorycarpus (Mont.) M. B. Ellis	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Botryosphaeriacea e*	*Musa* sp.	Brazil	Mendes et al. (1998)
Guignardia musicola Wulandari, L. Cai & K. D. Hyde *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca*	Thailand	Wulandari et al. (2010)
Guignardia musicola Wulandari, L. Cai & K. D. Hyde *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	Thailand	Wulandari et al. (2010) and Zhou et al. (2015)
Guignardia sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Thailand	Giatgong (1980)

Guignardia stevensii Wulandari & K. D. Hyde *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	United States	Wulandari et al. (2010)
Guignardia sydowiana Trotter *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Congo	Wulandari et al. (2010)
Phyllosticta capitalensis Henn. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	China, Indonesia, South Africa, Thailand, United States	Glienke et al. (2011), Meyer et al. (2006), Miles et al. (2013), Okane et al. (2003), Sun et al. (2016), Wikee et al. (2013) and Wulandari et al. (2009)
Phyllosticta capitalensis Henn. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca*	Thailand	Glienke et al. (2011), Guarnaccia et al. (2017), Wikee et al. (2013) and Wulandari et al. (2009)
Phyllosticta capitalensis Henn. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Indonesia, Thailand, United States	Glienke et al. (2011), Wikee et al. (2013) and Wulandari et al. (2009)
Phyllosticta cavendishii M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Australia, China, East Timor, Malaysia, Tonga	Hyde et al. (2014), McMaster et al. (2020) and Wong et al. (2012)
Phyllosticta cocoicola (Bat.) Sivan. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	Malaysia	Rashmi et al. (2019)

Phyllosticta gastonis Roum. *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Dominican Republic, Haiti	Ciferri (1929) and Revue mycologique (1886)
Phyllosticta maculata M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa × paradisiaca*	Indonesia, United States	Goos and Gowing (1992) and Photita et al. (2002)
Phyllosticta maculata M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	Australia, Indonesia, Sri Lanka, United States	Adikaram and Yakandawala (2020), Raabe et al. (1991), Shivas (1989), Wong et al. (2012), Wulandari et al. (2010) and Wulandari et al. (2013)
Phyllosticta maculata M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa cavendishii*	Taiwan region in China	Index of Fungi (1981) and Yen (1972)
Phyllosticta maculata M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Malaysia, Thailand	Giatgong (1980) and Williams and Liu (1976)

Phyllosticta maculata M. H. Wong & Crous *	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Australia, Bangladesh, Bhutan, Brunei Darussalam, China, Christmas Island Territory of, Congo, Cook Islands, Fiji, Hong Kong, India, Indonesia, Malaysia, Micronesia, Myanmar, Nepal, New Caledonia, New Guinea, New Zealand, Niue, Pakistan, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Taiwan region in China, Tanzania, Thailand, Tonga, United States, Vanuatu, Vietnam	Dingley et al. (1981), Ebbels and Allen (1979), Hyde and Alcorn (1993), Hyde et al. (2014), McKenzie (1996), Meredith (1969), Photita et al. (2002), Raabe et al. (1991), Shaw (1984), Sivanesan (1984), Stevens (1925), Thaung (2008), Wong et al. (2012) and Wulandari et al. (2010, 2013)
Phyllosticta musae F. Stevens & P. A. Young	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca*	Cambodia, United States	Litzenberger et al. (1962)

Phyllosticta musae F. Stevens & P. A. Young	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	United States	Raabeet al. (1981)
Phyllosticta musae F. Stevens & P. A. Young	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	United States	Goos and Gowing (1992), Meredith (1969), Photita et al. (2002), Raabe et al. (1981) and Stevens (1925)
Phyllosticta musaechinensis S. P. Wu, Zuo Y. Liu & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	China	Wu et al. (2014) and Zhang et al. (2022)
Phyllosticta musae-sapientium Gonz. Frag. & Cif.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Brazil, Dominican Republic	Batista and Vital (1952) and Ciferri (1929, 1961)
Phyllosticta musae-sapientium Gonz. Frag. & Cif.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa× paradisiaca*	Dominican Republic, India, Thailand, United States	Ali and Saikia (1997), Ciferri (1929), Kamal (2010), Mathur (1979), Sarkar et al. (2013) and Wong et al. (2012)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	China, United States, Sri Lanka	Adikaram and Yakandawala (2020), Raabe et al. (1981) and Zhuang (2001)

Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa basjoo*	China	Tai (1979)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Brunei Darussalam, India, Japan, Mexico, New Caledonia, Philippines, Taiwan region in China, Thailand, Sri Lanka	Adikaram and Yakandawala (2020), Alvarez (1976), Giatgong (1980), Huguenin (1966), Kobayashi (2007), Mathur (1979), Peregrine and Ahmad (1982) and Reinking (1918, 1919)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum* var. *paradisiaca*	Dominican Republic	Ciferri (1961)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Australia, Brunei Darussalam, China, India, Malaysia, Myanmar, Nepal, New Caledonia, Sri Lanka, Thailand	Huguenin (1966), Mathur (1979), Thaung (2008), Wong et al. (2012), Wong et al. (2013) and Wulandari et al. (2010)
Phyllosticta musarum (Cooke) Aa*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa textilis*	Philippines	Reinking (1918, 1919)
Phyllosticta rhizophorae Norph. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca*	Thailand	Norphanphoun et al. (2020)
Phyllosticta sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	Cuba, Thailand	Giatgong (1980) and Urtiaga

							(2004)
Phyllosticta sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca*	Cambodia, Cuba	Arnold (1986), Litzenberger et al. (1962) and Urtiaga (2004)
Phyllosticta sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* × *paradisiaca* var. *sapientum*	Cuba	Urtiaga (1986)
Phyllosticta sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Malaysia, Thailand	Giatgong (1980) and Liu (1977)
Phyllosticta sp.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	Australia, Thailand	Hyde and Alcorn (1993) and Li et al. (2020)
Phyllostictina musarum (Cooke) Petr.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa acuminata*	United States	Raabe et al. (1981)
Phyllostictina musarum (Cooke) Petr.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa sapientum*	Fiji, Malaysia, Philippines	Firman (1972), Johnston (1960), Sydow and Petrak (1931), Teodoro (1937), Turner (1971), Van Der (1973) and Williams and Liu (1976)
Phyllostictina musarum (Cooke) Petr.	*Ascomycota*	*Dothideomycetes*	*Botryosphaeriales*	*Phyllostictaceae*	*Musa* sp.	United States	Meredith (1969)
Capnodium musae Viégas	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Capnodiaceae*	*Musa* sp.	Brazil	Hanlin (1992) and Mendes et al. (1998)
Capnodium sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Capnodiaceae*	*Musa* × *paradisiaca* var. *sapientum*	Cuba	Urtiaga (1986)

Capnodium sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Capnodiaceae*	*Musa acuminata*	Cuba	Urtiaga (2004)
Cladosporium austrohemisphaericum Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Australia	Bensch et al. (2015)
Cladosporium cladosporioides (Fresen.) G. A. de Vries*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa acuminata*	Hong Kong, Thailand	Lu et al. (2000), Lumyong et al. (2003) and Zhuang (2001)
Cladosporium cladosporioides (Fresen.) G. A. de Vries*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa sapientum*	Thailand	Giatgong (1980)
Cladosporium cladosporioides (Fresen.) G. A. de Vries*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	India, Samoa, Trinidad and Tobago	Baker and Dale (1951), Dennis (1970), Dingley et al. (1981), Dugan et al. (2008) and Schubert et al. (2007, 2009)
Cladosporium exasperatum Bensch, Summerell, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Cladosporium fumago Link*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Poland	Mulenko and Majewski (2008)
Cladosporium herbarum (Pers.) Link*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa acuminata*	China, Somalia	Castellani and Ciferri (1937) and Zhang (2003)

Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa acuminata*	Egypt, Thailand	Bensch et al. (2015) and Lumyong et al. (2003)
Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa paradisiaca*	Ghana	Hughes (1952)
Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa sapientum*	Brunei Darussalam, Ghana, Malaysia	Hughes (1952), Liu (1976), Williams and Peregrine and Ahmad (1982)
Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa schweinfurthii*	Ghana, Sierra Leone	Martyn (1945) and Hughes (1952)
Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	China, France, Jamaica, Malaysia, Papua New Guinea, Ghana, Guinea, Honduras, Hong Kong, Samoa, Sierra Leone, South Africa, Solomon Islands, Sudan, Uganda, Zimbabwe	Crous et al. (2000), Dugan et al. (2004), Ellis (1971b), Gorter (1977), Ho et al. (1999), Kranz (1965), Lu et al. (2000), Martyn (1945), Shaw (1984), Tarr (1963), Whiteside (1966), Zhang (2003) and Zhuang (2001)
Cladosporium limoniforme Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Cladosporium oxysporum Berk. & M. A. Curtis*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* × *paradisiaca*	Brazil, Cuba	Delgado-Rodriguez and Mena-Portales

							(2004) and Mendes et al. (1998)
Cladosporium oxysporum Berk. & M. A. Curtis*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* × *paradisiaca* var. *sapientum*	Venezuela	Urtiaga (1986)
Cladosporium oxysporum Berk. & M. A. Curtis*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa acuminata*	China, Thailand, Venezuela	Lumyong et al. (2003), Urtiaga (2004), Zhuang (2001) and Zhang (2003)
Cladosporium oxysporum Berk. & M. A. Curtis*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Cook Islands	Dingley et al. (1981)
Cladosporium pannosum Cooke	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	United States	Bensch et al. (2012) and Dugan et al. (2004)
Cladosporium perangustum Bensch, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	India, Pacific Islands	Benschet al. (2010, 2012)
Cladosporium sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Australia, China	Cao et al. (2002) and Hyde and Alcorn (1993)
Cladosporium sphaerospermum Penz. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Guinea, Hong Kong	Kranz (1965), Lu et al. (2000) and Zhuang (2001)
Cladosporium sphaerospermum Penz. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)

Cladosporium tenuissimum Cooke*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Cote d'Ivoire, India, Indonesia, Mozambique, Pacific Islands	Bensch et al. (2010, 2012) and Nam et al. (2015)
Cladosporium xylophilum Bensch, Shabunin, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Cladosporiaceae*	*Musa* sp.	Mexico	Bensch et al. (2012)
Uwebraunia communis (Crous & Mansilla) Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Dissoconiaceae*	*Musa* sp.	Trinidad and Tobago	Arzanlou et al. (2008)
Uwebraunia musae (Arzanlou & Crous) Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Dissoconiaceae*	*Musa acuminata*	India, Indonesia	Stukenbrock et al. (2012) and Videira et al. (2016, 2017)
Uwebraunia musae (Arzanlou & Crous) Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Dissoconiaceae*	*Musa* sp.	China, India	Arzanlou et al. (2008), Chen (2017), Crous et al. (2021) and Li et al. (2012)
Ramichloridium schulzeri var. *schulzeri* (Sacc.) de Hoog*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Dissoconiaceae*	*Musa* sp.	Cuba	Mercado-Sierra et al. (1998)
Hormisciomyces sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Euantennariaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Amycosphaerella keniensis (Crous & T. A. Cout.) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia	Videira et al. (2017)
Asperisporium musicola Matsush.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Japan	Matsushima (1975)
Cercospora apii Fresen. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Cercospora apii Fresen. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca* var. *sapientum*	Cuba, India	Crous et al. (2020, 2021)

Cercospora apii Fresen. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Cuba, Bangladesh, India, Panama	Arzanlou et al. (2008), Calpouzos (1955), Crous et al. (2021), Kirschner and Piepenbring (2014) and Piepenbring (2006)
Cercospora malloti Ellis & Everh. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Thailand	Nguanhom et al. (2015)
Cercospora musigena Nguanhom, Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Thailand	Nguanhom et al. (2015)
Cercospora sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Cambodia	Litzenberger et al. (1962)
Cercospora sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Thailand	Nguanhom et al. (2015)
Cercospora sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Bangladesh, Dominica, Jamaica, Thailand	Album et al. (2016), Groenewald et al. (2013), Guatimosim et al. (2016) and Nguanhom et al. (2015)
Cercospora sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa textilis*	Cambodia	Litzenberger et al. (1962)
Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	China	Tai (1979)
Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa basjoo*	China	Tai (1979)

Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa cavendishii*	Taiwan region in China	Chupp (1954) and Pollack (1987),
Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa liukiuensis*	Japan	Kobayashi (2007)
Cercospora musicola Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Japan, Taiwan region in China	Hsieh and Goh (1990) and Kobayashi (2007)
Cladocillium musae Chun-Hao Chen & R. Kirschner*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa itinerans*	China	Chen et al. (2020) and Crous et al. (2020, 2021)
Mycosphaerella colombiensis Crous & M. J. Wingf. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Mozambique	Arzanlou et al. (2008)
Mycosphaerella formosana T. Y. Lin & J. M. Yen*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	China	Crous et al. (2021), Photita et al. (2002) and Tai (1979)
Mycosphaerella henriquesiana G. Winter*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Africa	Crous et al. (2020)
Mycosphaerella lateralis Crous & M. J. Wingf. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Mauritius	Arzanlou et al. (2008)
Mycosphaerella liukiuensis Sawada*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa formosana*	Taiwan region in China	Crous et al. (2021) and Sawada (1959),
Mycosphaerella liukiuensis Sawada	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa liukiuensis*	Taiwan region in China	Sawada (1959)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Australia, Thailand	Kaewjan et al. (2012) and Simmonds (1966)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Simmonds (1966)

Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa cavendishii*	Philippines	Teodoro (1937)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Cambodia, Philippines, Puerto Rico, Virgin Islands	Litzenberger et al. (1962), Stevenson (1975) and Teodoro (1937)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Argentina, Malaysia, Philippines	Crous et al. (2021), Reinking (1918, 1919), Surridge (2002), Teodoro (1937) and Williams and Liu (1976)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum* var. *rubra*	Myanmar	Thaung (2008)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Brazil, Cameroon, Cook Islands, Malawi, Martinique, Myanmar, Panama, South Africa, Tanzania, Tonga, United States	Arzanlou et al. (2008), Crous et al. (2021), Dingley et al. (1981), Kimunye et al. (2020), Meredith (1969), Piepenbring (2006), Surridge (2002) and Thaung (2008)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa textilis*	Philippines	Reinking (1918, 1919)
Mycosphaerella musae (Speg.) Syd. & P. Syd. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa uranoscopos*	Philippines	Teodoro (1937)
Mycosphaerella sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)

Mycosphaerella sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Fiji	Firman (1972)
Mycosphaerella sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Africa, Fiji	Crous et al. (2021) and Dingley et al. (1981)
Pallidocercospora thailandica (Crous, Himaman & M. J. Wingf.) Phook., Wulandari & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Brazil, Cameroon	Quaedvlieg et al. (2014)
Pantospora guazumae Cif. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia	Crous et al. (2021)
Paramycosphaerella marksii (Carnegie & Keane) Quaedvl. & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	South Africa	Guatimosim et al. (2016b), Quaedvlieg et al. (2014) and Videira et al. (2017)
Paramycosphaerella sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	South Africa	Videira et al. (2017)
Parapallidocercospora thailandica (Crous, Himaman & M. J. Wingf.) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Brazil, Cameroon, Martinique, Mozambique, West Indies	Arzanlou et al. (2008) and Crous et al. (2021)
Passalora loranthi (Petr.) U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Cameroon	Arzanlouet al. (2008)
Pseudocercospora assamensis Arzanlou & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	India	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2013), Crous et al. (2021), Guatimosim et al. (2016) and

							Silva et al. (2016)
Pseudocercospora eumusae Crous & Mour. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Sri Lanka, Thailand	Adikaram and Yakandawala (2020) and Kaewjan et al. (2012)
Pseudocercospora eumusae Crous & Mour. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	India, Malaysia, Mauritius, Nigeria, Reunion, Sri Lanka, Thailand, Vietnam	Braun et al. (2014), Crous et al. (2021) and Rieux et al. (2019)
Pseudocercospora fengshanensis (T. Y. Lin & J. M. Yen) J.M. Yen & S.K. Sun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	China, Taiwan region in China	Crous et al. (2021) and Liu and Guo (1998)
Pseudocercospora fengshanensis (T. Y. Lin & J. M. Yen) J. M. Yen & S. K. Sun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	China, Taiwan region in China	Braun et al. (2014), Hsieh and Goh (1990), Lin and Yen (1970), Liu and Guo (1998) and Tai (1979)
Pseudocercospora fijiensis (M. Morelet) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	China, Mexico, Sri Lanka, Thailand, Trinidad and Tobago, United States	Adikaram and Yakandawala (2020), Crous et al. (2020, 2021), Fortune et al. (2004), Kaewjan et al. (2012), Manzo-Sanchez et al. (2019), Raabe et al. (1991), Tai

							(1979) and Zhuang (2001)
Pseudocercospora fijiensis (M. Morelet) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa cavendishii*	China	Hsieh and Goh (1990) and Lin and Yen (1971)
Pseudocercospora fijiensis (M. Morelet) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Brunei Darussalam	Braun and Sivapalan (1999)
Pseudocercospora fijiensis (M. Morelet) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Bahamas, Bolivia, Brazil, Cameroon, Colombia, Costa Rica, Cote d'Ivoire, Fiji, Honduras, Japan, Martinique, Mexico, Nicaragua, Niue, Panama, Papua New Guinea, Philippines, Puerto Rico, Reunion, Samoa, Somalia, Taiwan region in China, Tanzania, Tonga, Uganda, United States, Zanzibar	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2021), Delgado (2011), Fullerton and Casonato (2019), Hyde and Alcorn (1993), Irish et al. (2006), Kirschner and Kimunye et al. (2020), Liang et al. (2016), Ioos et al. (2011), Mckenzie (1996), Meredith (1969), Morelet (1969), Mulder and Stover (1976), Nakashima et al. (2016), Photita et al. (2002), Piepenbring

							(2006), Piepenbring (2014), Ploetz (2004), Ramos et al. (2018), Rieux et al. (2019), Romero and Sutton (1998), Shaw (1984), Silva et (2016), Sivanesan (1984), Surridge et al. (2003) and Tejerina et al. (1997)
Pseudocercospora indonesiana Arzanlou & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Indonesia	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2021), Guatimosim et al. (2016) and Osorio et al. (2015)
Pseudocercospora longispora Arzanlou & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Indonesia, Malaysia	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2021), Liang et al.

							(2016) and Osorio et al. (2015)
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Brazil, Cambodia, China, Costa Rica, Cuba, El Salvador, Guatemala, Haiti, India, Mexico, Nicaragua, Panama, Puerto Rico, South Africa, Thailand, United States, Venezuela, Virgin Islands	Alfieri Jr (1984), Arnold (1986), Benjamin and Slot (1969), Braun et al. (2014), Crandall (1967), Crous and Braun (2003), Crous et al. (2020, 2021), Delgado (2011), Kamal (2010), Litzenberger et al. (1962), Liu and Guo (1998), McGuire Jr and Batista et al. (1963), Mendes et al. (1998), Phengsintham et al. (2013), Stevenson (1975), Stevenson and Wellman (1944) and Urtiaga (2004)
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca* var. *sapientum*	China, Cuba, Venezuela	Liu and Guo (1998), Tai (1979) and Urtiaga (1986),
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa liukiuensis*	China, Taiwan region in China	Liu and Guo (1998), Sawada (1959) and Tai (1979)

Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Barbados, Brazil, Brunei Darussalam, China, Indonesia, Jamaica, Kenya, Laos, Malawi, Malaysia, Mexico, Mozambique, New Caledonia, Taiwan region in China, Tanzania, Thailand, United States	Alfieri Jr (1984), Alvarez (1976), Braun and Sivapalan (1999), Crous and Braun (1996), Giatgong (1980), Hsieh and Goh (1990), Huguenin (1966), Larter and Martyn (1943), Mendes et al. (1998), Nattrass (1961), Norse (1974), Peregrine and Siddiqi (1972), Phengsintham et al. (2010), Photita et al. (2002), Pollack (1987), Riley (1960), Thompson and Johnston (1953), Turner (1971) and Zhuang (2001)

Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Angola, Australia, Belize, Bolivia, Brazil, Brunei Darussalam, Cambodia, Cameroon, China, Colombia, Congo Republic of the, Costa Rica, Cote d'Ivoire, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Fiji, French Polynesia, Ghana, Grenada, Guadeloupe, Guatemala, Guinea, Guyana, Haiti, Honduras, Hong Kong, India, Indonesia, Jamaica, Japan, Kenya, Kiribati, Laos, Madagascar, Malaysia, Malawi, Martinique, Mauritius, Mexico, Montserrat, Mozambique, New Caledonia, Nicaragua, Niue, Norfolk Island, Panama, Papua New Guinea, Peru, Philippines, Puerto Rico, Saint Lucia, Saint Vincent, Samoa, Sierra Leone, Solomon	Arzanlou et al. (2008), Alvarez (1976), Baker and Dale (1951), Benjamin and Slot (1969), Crous et al. (2021), Corbett (1964), Dennis (1970), Delgado (2011), Doidge (1950), Gorter (1977), Gomes et al. (2013), Gonzalez and Pons (2000), Huguenin (1966), Kranz (1963), Kobayashi (2007), Larter and Martyn (1943), Liang et al. (2016), Lu et al. (2000), McKenzie (1996), Mendes et al. (1998), Nattrass (1961), Norse (1974), Osorio et al. (2015), Ozkilinc et al. (2018), Piepenbring (2006), Pollack (1987), Shaw (1984), Surridge et al. (2003), Thompson and Johnston (1953),

						Islands, Somalia, South Africa, Sri Lanka, Suriname, Taiwan region in China, Thailand, Tonga, Trinidad and Tobago, Uganda, United States, Venezuela, Vietnam, West Indies, Zambia, Zimbabwe, Zanzibar	Trujillo and Goto (1963), Turner (1971), Whiteside (1966) and Zhuang (2001)

Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa textilis*	Brunei Darussalam, China, Mexico	Alvarez (1976), Braun and Sivapalan (1999), Liu and Guo (1998), Peregrine and Ahmad (1982) and Tai (1979)
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Australia, China, Cote d'Ivoire, Cuba, India, Nepal, South Africa, Sri Lanka, Thailand, United States, Venezuela	Alfieri Jr et al. (1984), Crous et al. (2000), Dahal et al. (1992), Giatgong (1980), Kaewjan et al. (2012), Meeboon et al. (2008), Pande (2008), Raabe et al. (1991), Resplandy et al. (1954), Simmonds (1966), Surridge et al. (2003), Urtiaga (2004), Urtiaga and Braun (2013) and Zhuang (2001)
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Simmonds (1966)
Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa basjoo*	China	Guo (1999), Liu and Guo (1998), Roux et al. (1997), Tai (1979) and Zhuang (2001)

Pseudocercospora musae (Zimm.) Deighton*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa cavendishii*	Brazil, Japan, Puerto Rico, Taiwan region in China, Virgin Islands	Goh (1990), Hsieh and Mendes et al. (1998), Kobayashi (2007), Liu and Guo (1998) and Stevenson (1975)
Pseudocercospora musae-sapientium (A. K. Kar & M. Mandal) U. Braun & Mouch. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	India	Braun et al. (2014), Crous et al. (2021) and Kamal (2010)
Pseudocercospora musae-sapientium (A. K. Kar & M. Mandal) U. Braun & Mouch. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	India	Crous and Braun (2003), Kamal (2010) and Kar and Mandal (1975)
Pseudocercospora musicola U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Taiwan region in China	Braun et al. (2014) and Crous et al. (2021)
Pseudocercospora musicola U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa balbisiana* var. *liukiuensis*	Taiwan region in China	Braun et al. (2014)
Pseudocercospora pseudomusae Crous & Carlier*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Indonesia	Crous et al. (2021)
Pseudocercospora sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Rhachisphaerella mozambica (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Mozambique	Videira et al. (2017)

Rhachisphaerella mozambica (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Mozambique	Arzanlou et al. (2008), Crous et al. (2021) and Videira et al. (2017)
Septoria eumusae Carlier, M. F. Zapater, Lapeyre, D. R. Jones & Mour. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Iran	Amani and Avagyan (2014)
Septoria sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum* var. *arakanensis*	Myanmar	Thaung (2008)
Septoria sp.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Sphaerella musae Speg.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Argentina, Dominican Republic	Ciferri (1929) and Museo Nacional de Buenos Aires (1909),
Sphaerella musae Speg.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa coccinea*	Philippines	Photita et al. (2002)
Sphaerella musae Speg.	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa uranoscopos*	Philippines	Teodoro (1937)
Sphaerulina musicola J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Taiwan region in China	Index of Fungi (1981)
Sphaerulina pulii J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Venezuela	Urtiaga (1986)
Sphaerulina pulii J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Taiwan region in China	Index of Fungi (1981)
Zasmidium australe (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia	Crous et al. (2020)

Zasmidium biverticillatum (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Zasmidium biverticillatum (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Kirschner and Piepenbring (2014) and Shivas et al. (2011)
Zasmidium biverticillatum (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa formosana*	Taiwan region in China	Kirschner and Piepenbring (2014)
Zasmidium biverticillatum (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Suriname	Arzanlou et al. (2006), Crous et al. (2021) and Videira et al. (2017)
Zasmidium biverticillatum (Arzanlou & Crous) Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Panama, Taiwan region in China	Kirschner and Piepenbring (2014) and Shivas et al. (2011)
Zasmidium citri (Whiteside) Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Tonga, United States	Arzanlou et al. (2008) and Quaedvlieg et al. (2014)
Zasmidium citrigriseum (F. E. Fisher) U. Braun & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	United States	Huang et al. (2015) and Videira et al. (2017)
Zasmidium ducassei (R. G. Shivas, Grice & A. J. Young) Y. Marín & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Australia	Kirschner and Piepenbring (2014)

Zasmidium ducassei (R. G. Shivas, Grice & A. J. Young) Y. Marín & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata-balbisiana*	Australia	Crous et al. (2021), Marin-Felix et al. (2019) and Shivas et al. (2011)
Zasmidium ducassei (R. G. Shivas, Grice & A. J. Young) Y. Marín & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa balbisiana*	Taiwan region in China	Kirschner and Piepenbring (2014)
Zasmidium ducassei (R. G. Shivas, Grice & A. J. Young) Y. Marín & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Taiwan region in China	Kirschner and Piepenbring (2014), Marin-Felix et al. (2019) and Shivas et al. (2011)
Zasmidium musae (Arzanlou & Crous) Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Arzanlou et al. (2007)
Zasmidium musae (Arzanlou & Crous) Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Gabon, Martinique, Netherlands, Saint Lucia, Tonga, West Indies	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2021) and Videira et al. (2017)
Zasmidium musae-banksii Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Crous et al. (2021) and Videira et al. (2017)
Zasmidium musicola (Arzanlou & Crous) Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	India	Braun et al. (2014), Crous et al. (2021) and Videira et al. (2017)

Zasmidium musigenum Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa acuminata*	Australia	Crous et al. (2021) and Simmonds (1966)
Zasmidium musigenum Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Simmonds (1966)
Zasmidium musigenum Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Zasmidium musigenum Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa sapientum*	Bolivia, Cameroon, Fiji, Ghana, Guinea, Indonesia, Jamaica, Malaysia, Papua New Guinea, Sierra Leone, Suriname, Uganda	Crous et al. (2021), Dade (1940), De Hoog (1977), Ellis (1976), Firman (1972), Larter and Martyn (1943), Turner (1971), Videira et al. (2017) and Williams and Liu (1976)
Zasmidium musigenum Videira & Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Australia, Bolivia, Cameroon, Cook Islands, Fiji, Ghana, Guinea, Haiti, Indonesia, Jamaica, Panama, Papua New Guinea, Samoa, Sierra Leone, Tonga, Trinidad and Tobago, Uganda, Zimbabwe	Benjamin and Ellis (1976), Dingley et al. (1981), Kirschner and Piepenbring (2014), Kranz (1963), McKenzie (1996), Petrak (1950), Shaw (1984), Shivas et al. (2011), Slot (1969) and Whiteside (1966)

Zasmidium queenslandicum (Arzanlou & Crous) Crous & U. Braun*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa banksii*	Australia	Arzanlou et al. (2008), Braun et al. (2014), Crous et al. (2021) and Videira et al. (2017)
Zasmidium syzygii Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Philippines	van Westerhoven et al. (2023)
Zasmidium thailandicum Crous*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Musa* sp.	Thailand	Marin-Felix et al. (2019)
Tripospermum myrti (Lind) S. Hughes*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Neodevriesiaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Chaetothyrina musarum (Speg.) Theiss. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Phaeothecoidiellaceae*	*Musa x paradisiaca*	Argentina, Brazil, Mexico, Paraguay, Uruguay	Farr (1973), McGuire et al. (1967) and Photita et al. (2002)
Chaetothyrina musarum (Speg.) Theiss. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Phaeothecoidiellaceae*	*Musa acuminata*	United States	Raabe et al. (1981)
Chaetothyrina musarum (Speg.) Theiss. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Phaeothecoidiellaceae*	*Musa acuminata-balbisiana*	Thailand	Singtripop et al. (2016)
Chaetothyrina musarum (Speg.) Theiss. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Phaeothecoidiellaceae*	*Musa sapientum*	Brazil	Batista (1959), Hanlin (1992), Mendes et al. (1998) and Singtripopet al. (2016)
Chaetothyrina musarum (Speg.) Theiss. *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Phaeothecoidiellaceae*	*Musa* sp.	Brazil, China, Thailand, United States	Chen (2017), Mendes et al. (1998), Meredith (1969) and Singtripop et al. (2016)

Schizothyrium inaequale (G.Y. Sun & Liu Gao) Crous & Batzer*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa basjoo*	China	Gao et al. (2014)
Schizothyrium jamaicense (E. W. Mason) Rossman	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986) and Urtiaga (1986)
Schizothyrium jamaicense (E. W. Mason) Rossman	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa sapientum*	Jamaica	Martyn (1945)
Schizothyrium jamaicense (E. W. Mason) Rossman	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa* sp.	Fiji	Dingley et al. (1981)
Schizothyrium musae (G.Y. Sun & Liu Gao) Crous & Batzer*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa basjoo*	China	Gao et al. (2014)
Schizothyrium sunii Crous & Batzer *	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Schizothyriaceae*	*Musa basjoo*	China	Gao et al. (2014)
Acrodontium crateriforme (J. F. H. Beyma) de Hoog*	*Ascomycota*	*Dothideomycetes*	*Capnodiales*	*Teratosphaeriaceae*	*Musa* sp.	China	Chen (2017)
Asteromella paradisiaca Petr.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Philippines	Vanev and Van Der (1998)
Asteromella paradisiaca Petr.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa textilis*	Philippines	Teodoro (1937) and Vanev and Van Der (1998)
Asteromella sp.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa sapientum* var. *rubra*	Myanmar	Thaung (2008)
Coniosporium musicola Speg.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* × *paradisiaca* var. *sapientum*	Cuba	Urtiaga (1986)

Coniosporium musicola Speg.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa acuminata*	Cuba	Urtiaga (2004)
Coniosporium musicola Speg.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa sapientum*	Argentina	Farr (1973) and Museo Nacional de Buenos Aires (1911)
Dilophia punctata G. Winter	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* sp.	Africa	Winter (1886)
Dothidella musae Höhn.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Samoa	Kaiserl (1907)
Dothidella musae Höhn.	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* sp.	Fiji, Samoa	Dingley et al. (1981)
Monodictys trichocladiopsis Goh & K. D. Hyde	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Tetracrium musicola Sherwood	*Ascomycota*	*Dothideomycetes*	*Dothideomycetes* genera *incertae sedis*	*Dothideomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Guadeloupe	Photita et al. (2002)
Aureobasidium sp.	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa acuminata*	China	Cao et al. (2002)
Metasphaeria musae Sawada	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa acuminata*	China	Tai (1979)
Metasphaeria musae Sawada	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa basjoo*	China	Tai (1979)
Metasphaeria taiwanensis J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa sapientum*	Taiwan region in China	Yen (1972)
Metasphaeria cumanella Sacc. & Berl.	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa* sp.	Africa	Photita et al. (2002)

Selenophoma asterina (Berk. & Broome) B. Sutton	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa* sp.	South Africa	Surridge (2002)
Selenophoma juncea (Mont.) Arx *	*Ascomycota*	*Dothideomycetes*	*Dothideales*	*Saccotheciaceae*	*Musa* sp.	South Africa	Surridge (2002)
Arxiella terrestris Papendorf *	*Ascomycota*	*Dothideomycetes*	*Muyocopronales*	*Muyocopronaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Acrocalymma vagum (D. F. Farr) Crous & Trakun. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Acrocalymmaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Pithomyces musae X.G. Zhang & Y. M. Wu *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Astrosphaeriellaceae*	*Musa wilsonii*	China	Tianyu (2009) and Zhang and Wu (2003)
Pithomyces africanus M. B. Ellis *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Astrosphaeriellaceae*	*Musa balbisiana*	China	Tianyu (2009)
Corynespora cassiicola (Berk. & M. A. Curtis) C. T. Wei *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Corynespora cassiicola (Berk. & M. A. Curtis) C. T. Wei *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa × paradisiaca*	Brazil, Cuba, Haiti, India, Jamaica, Japan, Nicaragua, Panama, Puerto Rico, Sierra Leone, South Africa, Virgin Islands	Arnold (1986), Benjamin and Slot (1969), Chupp (1954), Crous et al. (2000), Delgado (2011), Ellis (1957), Kobayashi (2007), Matsushima (1975), McGuire Jr and Crandall (1967), Mendes

							et al. (1998), Sarbhoy et al. (1971), Stevenson (1975) and Urtiaga (1986)
Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa* × *paradisiaca* var. *sapientum*	China, Cuba	Tai (1979) and Urtiaga (1986)
Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa acuminata*	Australia, China, Cote d'Ivoire, Cuba, Ethiopia, Mexico, Somalia, Thailand, United States, United States, Venezuela	Alfieri Jr (1984), Castellani and Ciferri (1937, 1950), Giraldo et al. (2017), Lumyong et al. (2003), Raabe et al. (1981), Resplandy et al. (1954), Shivas (1989), Simmonds (1966), Tai (1979), Urtiaga (2004) and Zhuang (2001)
Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa acuminata* × *Musa balbisiana*	Thailand	Samarakoon et al. (2023) and This study
Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa basjoo*	China	Tai (1979)

Corynespora torulosa (Syd. & P. Syd.) Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa cavendishii*	Bermuda, Brazil, Mexico, Puerto Rico, Sierra Leone, Taiwan region in China, Virgin Islands	Crous et al. (2013), Deighton (1936), Ellis (1957), Mendes et al. (1998) and Stevenson (1975)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa coccinea*	United States	Raabe et al. (1981)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa errans* var. *botoan*	Philippines	Teodoro (1937)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa ornata*	India	Gupta et al. (1983)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum*	Barbados, Bermuda, Brazil, Brunei Darussalam, Jamaica, Mexico, Myanmar, Sierra Leone, Sudan, Taiwan region in China, Thailand, United States	Alfieri Jr (1984), Alvarez (1976), Deighton (1936), Ellis (1957), Giatgong (1980), Larter and Martyn (1943), Matsushima (1980), Norse (1974), Peregrine and Ahmad (1982), Tarr (1963) and Thaung (2008)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum* var. *cinerea*	Philippines	Teodoro (1937)

Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum* var. *compressa*	Philippines	Teodoro (1937)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum* var. *paradisiaca*	Dominican Republic	Ciferri (1961)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa sapientum* var. *rubra*	Myanmar	Thaung (2008)
Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa* sp.	Australia, Brazil, Cook Islands, Cuba, Egypt, Georgia, Guinea, Haiti, India, Jamaica, Japan, Kiribati, Mauritius, Panama, Samoa, Sierra Leone, Somalia, South Africa, Trinidad and Tobago, United States	Baker and Dale (1951), Benjamin and Slot (1969), Crous and Braun (2003), Crous et al. (2013) Dingley et al. (1981), Ellis (1957), Felix (1968), Gorter (1977), Hyde and Alcorn (1993), Kobayashi (2007), Kranz (1965), Mendes et al. (1998), Mercado Sierr (1984), Meredith et al. (1968), Meredith (1969), Orieux and Piepenbring (2006)

Corynespora torulosa (Syd. & P. Syd.) Crous *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Corynesporascaceae*	*Musa textilis*	Brunei Darussalam, Malaysia, Mexico, Papua New Guinea, Philippines	Alvarez (1976), Ellis (1957), Johnston (1960), Peregrine and Ahmad (1982), Shaw (1984), Teodoro (1937), Turner (1971) and Williams and Liu (1976)
Dendryphiella vinosa (Berk. & M. A. Curtis) Reisinger *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Dictyosporiaceae*	*Musa* sp.	Thailand	This study
Dictyocheirospora heptaspora (Garov.) M. J. D'souza, Boonmee & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Dictyosporiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2002, 2003)
Dictyocheirospora musae (Photita) J. Yang, K. D. Hyde & Z. Y. Liu*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Dictyosporiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2002)
Amerodothis musae Sawada	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa cavendishii*	China, Taiwan region in China	Photita et al. (2002) and Sawada (1959)
Ascochyta sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa sapientum*	Malaysia	Johnston (1960)
Chaetosphaeropsis truncata var. *indica* R. N. Rai & B. Lal	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* × *paradisiaca*	India	Rai and Lal (1984)
Didymella musae (P. Joly) Qian Chen & L. Cai*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)
Didymella sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Epicoccum latusicollum Qian	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa acuminata*	China	Liu et al. (2023)

Chen, Crous & L. Cai *							
Epicoccum nigrum Link *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa sapientum*	Malawi	Peregrine and Siddiqi (1972)
Epicoccum nigrum Link *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Malawi, South Africa	Corbett (1964) and Surridge (2002)
Epicoccum sorghinum (Sacc.) Aveskamp, Gruyter & Verkley*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* × *paradisiaca*	Malaysia, West Indies	Wallbridge (1981) and Zakaria and Aziz (2018)
Leptosphaerulina trifolii (Rostr.) Petr. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951)
Microsphaeropsis sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa acuminata* subsp. *banksii*	Australia	Brown et al. (1998)
Phoma glomerata (Corda) Wollenw. & Hochapfel *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	South Africa	Surridge (2002)
Phoma jolyana Piroz. & Morgan-Jones *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	India	Photita et al. (2002)
Phoma jolyi M. Morelet	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	France	Photita et al. (2002)
Phoma musae Sacc.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa acuminata*	United States	Raabe et al. (1981)
Phoma musae Sacc.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa sapientum*	Dominican Republic	Ciferri (1929)
Phoma musae Sacc.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	France, United States	Index of Fungi (1972) and Stevens (1925)
Phoma musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa sapientum*	Barbados	Norse (1974)
Phoma musarum Cooke	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	United States	Cooke and Massee (1883)

Phoma musicola Tassi	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* × *paradisiaca*	Argentina, Cuba, India	Arnold (1986), Mathur (1979) and Saccardo and Sydow (1902)
Phoma musicola Tassi	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Italy	Saccardo and Sydow (1902)
Phoma sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* × *paradisiaca*	Brazil, India	Mathur (1979) and Mendes et al. (1998)
Phoma sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Phoma sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa acuminata* subsp. *banksii*	Australia	Brown et al. (1998)
Phoma sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa sapientum*	Mexico, United States	Alfieri Jr (1984) and Alvarez (1976)
Phoma sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Stagonosporopsis cucurbitacearum (Fr.) Aveskamp *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymellaceae*	*Musa* sp.	Bangladesh	Nguanhom et al. (2015)
Dictyoarthrinium musae Samarakoon, Chomnunti & K. D. Hyde *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2020b) and This study
Dictyoarthrinium sacchari (J. A. Stev.) Damon*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Dictyoarthrinium sacchari (J. A. Stev.) Damon*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Dictyoarthrinium synnematicum Somrith.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	Somrithipol (2007)

Dictyoarthrinium thailandica G. C. Ren & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	This study
Phaeodothis winteri (Niessl) Aptroot*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa sapientum*	Costa Rica	Aptroot (1995)
Pseudopithomyces chartarum (Berk. & M. A. Curtis) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa sapientum*	Africa, Jamaica, Philippines	Ellis (1960), Reinking (1918, 1919) and Teodoro (1937)
Pseudopithomyces chartarum (Berk. & M. A. Curtis) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Pseudopithomyces chartarum (Berk. & M. A. Curtis) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa acuminata* × *Musa balbisiana*	Thailand	This study
Pseudopithomyces chartarum (Berk. & M. A. Curtis) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Pseudopithomyces maydicus (Sacc.) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa sapientum*	China, Taiwan region in China	Matsushima (1980) and Tianyu (2009)
Pseudopithomyces maydicus (Sacc.) Jun F. Li, Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951)
Pseudopithomyces sacchari (Speg.) Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa sapientum*	Trinidad and Tobago,	Ellis (1960)

Pseudopithomyces sacchari (Speg.) Ariyaw. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	South Africa	Surridge (2002)
Spegazzinia deightonii (S. Hughes) Subram. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2020)
Spegazzinia radermacherae Jayasiri, E. B. G. Jones & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	Chethana et al. (2021)
Spegazzinia musae Samarakoon, Phookamsak, Wanas., Chomnunti & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Didymosphaeriaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2020)
Bahusandhika indica (Subram.) Subram. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Lentimurisporaceae*	*Musa* sp.	Thailand	This study
Leptosphaeria musae T. Y. Lin & J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa acuminata*	China	Tai (1979)
Leptosphaeria musae T. Y. Lin & J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa cavendishii*	Taiwan region in China	Crane and Shearer (1991) and Socie´te´ mycologique de France (1972)
Leptosphaeria musarum Sacc. & Berl.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa* × *paradisiaca*	Venezuela	Urtiaga (1986)
Leptosphaeria musarum Sacc. & Berl.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Leptosphaeria musarum Sacc. & Berl.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa* sp.	Africa, Brazil, India	Crane and Shearer (1991), Mendes et al. (1998) and Revue

							mycologique (1889)
Leptosphaeria musigena T. Y. Lin & J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa acuminata*	China	Tai (1979)
Leptosphaeria musigena T. Y. Lin & J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa cavendishii*	Taiwan region in China	Crane and Shearer (1991) and Socie´te´ mycologique de France (1972)
Leptosphaeria sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Leptosphaeria taichungensis J. M. Yen	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Leptosphaeriaceae*	*Musa* sp.	Taiwan region in China	Crane and Shearer (1991) and Socie´te´ mycologique de France (1972)
Lophiotrema hydei J. F. Zhang, J. K. Liu & Z. Y. Liu	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Lophiotremataceae*	*Musa* sp.	Thailand	This study
Helminthosporium cubense Matsush.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* sp.	Dominican Republic	Ciferri (1961)
Helminthosporium gibberosporum Curzi*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Helminthosporium gibberosporum Curzi*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa cavendishii*	Somalia	Ciferri (1961)
Helminthosporium palmicola Pat. & Gaillard	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* sp.	Venezuela	Dennis (1970)
Helminthosporium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* × *paradisiaca*	Haiti, South Africa	Crous et al. (2000)
Helminthosporium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa acuminata*	South Africa, Somalia, United States	Castellani and Ciferri (1937), Crous et al. (2000) and

							Raabe et al. (1981)
Helminthosporium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa sapientum*	Thailand	Giatgong (1980)
Helminthosporium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* sp.	South Africa, United States	Gorter (1977) and Meredith (1969)
Helminthosporium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa textilis*	Malay Peninsula, Philippines	Teodoro (1937) and Thompson and Johnston (1953)
Helminthosporium velutinum Link*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Stagonospora sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa* × *paradisiaca* var. *sapientum*	Cuba	Urtiaga (1986)
Stagonospora sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Massarinaceae*	*Musa acuminata*	Cuba	Urtiaga (2004)
Aposphaeria musarum Speg.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Melanommataceae*	*Musa sapientum*	Argentina	Museo Nacional de Buenos Aires (1911)
Byssosphaeria musae Phook. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Melanommataceae*	*Musa* sp.	Thailand	Liu et al. (2015)
Phragmocephala atra var. *atra* (Berk. & Broome) E. W. Mason & S. Hughes	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Melanommataceae*	*Musa* sp.	Mexico	Mercado-Sierra and Heredia (1994)
Periconia byssoides Pers.*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* × *paradisiaca*	Cuba, Solomon Islands	Delgado-Rodriguez and Mena-Portales (2004) and Matsushima (1971)

Periconia byssoides Pers. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* × *paradisiaca* var. *sapientum*	Venezuela	Urtiaga (1986)
Periconia byssoides Pers. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa acuminata*	Venezuela	Urtiaga (2004)
Periconia digitata (Cooke) Sacc. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Periconia digitata (Cooke) Sacc. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Periconia echinochloae (Bat.) M. B. Ellis*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* sp.	Thailand	This study
Periconia lateralis Ellis & Everh. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Periconia minutissima Corda*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* × *paradisiaca*	Ghana	Hughes (1953)
Periconia pycnospora Fresen.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Periconia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa sapientum*	Indonesia, Malay Peninsula, Malaysia, Nigeria	Ellis (1967), Thompson and Johnston (1953) and Williams and Liu (1976)
Periconia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* sp.	Iran, Malaysia, Nigeria, Papua New Guinea, Samoa, Sierra Leone, Solomon Islands, South Africa	Ellis (1967), Ellis (1971b) and Shaw (1984)
Periconia cortaderiae Thambug. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021)

Periconia delonicis Jayasiri, E. B. G. Jones & K.D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Periconiaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021)
Hendersonia musae Cooke	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* sp.	United States	Cooke and Massee (1883)
Hendersonia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Hendersonia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Leptospora musae Drost	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa sapientum*	United States	Saccardo et al. (1931)
Neosetophoma poaceicola Goonas., Thambug. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa acuminata*	Taiwan region in China	Tennakoon et al. (2020)
Ophiobolus sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Phaeoseptoria musae Punith. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa sapientum*	Colombia, India	Punithalingam (1983)
Phaeoseptoria musae Punith. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* sp.	Tanzania	Ebbels and Allen (1979)
Phaeoseptoria sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Phaeosphaeria musae Sawada *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa cavendishii*	Taiwan region in China	Sawada (1959)
Phaeosphaeria oryzae I. Miyake *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* sp.	Thailand	This study
Phaeosphaeriopsis musae Arzanlou & Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* sp.	Mauritius	Arzanlou and Crous (2006)
Saccharicola sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Phaeosphaeriaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Alternaria alternata (Fr.)	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Bangladesh, India	Bashar et al. (2012) and Rao

Keissl. *							(1969)
Alternaria alternata (Fr.) Keissl. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China, Iran, Thailand	Amani (2011), Lu et al. (2000), Lumyong et al. (2003) and Zhuang (2001)
Alternaria alternata (Fr.) Keissl. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Malawi, Pakistan	Ahmad (1969) and Peregrine and Siddiqi (1972)
Alternaria alternata (Fr.) Keissl. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	India, Malawi, South Africa, United States	Andersen et al. (2001), Parkunan et al. (2013), Surridge (2002) and Wiehe (1953)
Alternaria burnsii Uppal, Patel & Kamat*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Cameroon	Bechem and Afanga (2017)
Alternaria citri Ellis & N. Pierce*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Alternaria dianthicola Neerg. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Brazil	Photita et al. (2002)
Alternaria jacinthicola Dagno & Jijakli*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata* cv. Giant Cavendish	China	Wang et al. (2022)
Alternaria musae Bouriquet & Bataille	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa x paradisiaca*	Cuba	Arnold (1986)
Alternaria musae Bouriquet & Bataille	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Malawi	Peregrine and Siddiqi (1972)
Alternaria musae Bouriquet & Bataille	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Madagascar, Malawi	Corbett (1964) and Index of Fungi (1963)

Alternaria sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Alternaria sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum* var. *arakanensis*	Myanmar	Thaung (2008)
Alternaria sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	China	Chen (2017)
Alternaria tenuissima (Kunze) Wiltshire*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986) and Urtiaga (1986)
Alternaria tenuissima (Kunze) Wiltshire*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Pakistan	Ahmad et al. (1997)
Alternaria tenuissima (Kunze) Wiltshire*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Bipolaris bicolor (Mitra) Shoemaker*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Tanzania	Riley (1960)
Bipolaris cynodontis (Marignoni) Shoemaker*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Argentina, South Africa	Khan et al. (2022), Manamgoda et al. (2011) and Surridge (2002)
Bipolaris gigantea (S. Ito) B. Lane, Stricker, M. E. Sm., S. L. Flory & Harmon*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	Iran	Amani (2011) and Amani and Avagyan (2014)
Bipolaris gigantea (S. Ito) B. Lane, Stricker, M. E. Sm., S. L. Flory & Harmon*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	United States	Meredith (1969)
Bipolaris oryzae (Breda de Haan) Shoemaker*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China	Zhao et al. (2023)

Bipolaris papendorfii (Aa) Alcorn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Malaysia	Khan et al. (2022) and Zakaria and Aziz (2018)
Bipolaris sacchari (E. J. Butler) Shoemaker*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Brazil, West Indies	Silva et al. (2008) and Wallbridge and Pinegar (1975)
Bipolaris sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Malaysia	Zakaria and Aziz (2018)
Bipolaris triticicola Sivan. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	West Indies	Sivanesan (1987)
Cochliobolus geniculatus R. R. Nelson*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Cuba	Delgado-Rodriguez et al. (2002)
Cochliobolus geniculatus R. R. Nelson*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Cochliobolus geniculatus R. R. Nelson*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata* cv. Formosana	China	Qi et al. (2022)
Cochliobolus geniculatus R. R. Nelson*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Brunei Darussalam	Peregrine and Ahmad (1982)
Cochliobolus geniculatus R. R. Nelson	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Fiji	Dingley et al. (1981)
Cochliobolus intermedius R. R. Nelson*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Malaysia	Khan et al. (2022)
Curvularia clavata B. L. Jain*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Bangladesh	Bashar et al. (2012)
Curvularia eragrostidis (Henn.) J. A. Mey. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Brunei Darussalam	Peregrine and Ahmad (1982)

Curvularia fallax Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Solomon Islands	Matsushima (1971)
Curvularia fallax Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa textilis*	Malaysia	Turner (1971)
Curvularia hawaiiensis (Bugnic. ex M. B. Ellis) Manamgoda, L. Cai & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Pakistan, Taiwan region in China	Ahmad et al. (1997) and Matsushima (1980)
Curvularia lunata (Wakker) Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China, Pakistan, Somalia	Castellani and Ciferri (1937), Khan and Javaid (2020) and Zhuang (2001)
Curvularia lunata (Wakker) Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Brunei Darussalam, Taiwan region in China	Matsushima (1980) and Peregrine and Ahmad (1982)
Curvularia lunata (Wakker) Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Australia, Ghana, Guinea, South Africa, Trinidad and Tobago	Castellani and Ciferri (1937), Hughes (1953), Kranz (1963) and Surridge (2002)
Curvularia lunata (Wakker) Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Castellani and Ciferri (1937), Hughes (1953) and Surridge (2002)
Curvularia pallescens Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge and Pinegar (1975)

Curvularia pallescens Boedijn*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Curvularia pseudobrachyspora Y. Marín, Cheew. & Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China	Qi et al. (2022)
Curvularia senegalensis (Speg.) Subram.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China	Zhuang (2001)
Curvularia senegalensis (Speg.) Subram. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa x paradisiaca*	West Indies	Wallbridge and Pinegar (1975)
Curvularia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	United States	Raabe et al. (1981)
Curvularia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Guatemala, Papua New Guinea, United States	Marin et al. (1996), Meredith (1969) and Shaw (1984)
Curvularia sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Curvularia tsudae H. Deng, Y. P. Tan & R. G. Shivas*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Khan et al. (2022) and Manamgoda et al. (2011)
Curvularia umbiliciformis M. Raza, K. D. Hyde & L. Cai*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Thailand	This study
Curvularia verruculosa	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge and Pinegar (1975)

Tandon & Bilgrami*							
Drechslera musae-sapientium (Hansf.) M. B. Ellis	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Brunei Darussalam, Uganda	Index of Fungi (1954), Manamgoda et al. (2014) and Peregrine and Ahmad (1982)
Drechslera musae-sapientium (Hansf.) M. B. Ellis	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum* var. *rubra*	Myanmar	Thaung (2008)
Drechslera musae-sapientium (Hansf.) M. B. Ellis	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Ethiopia, Sudan, Uganda	Ellis (1971b) and Tarr (1963)
Exserohilum prolatum K. J. Leonard & Suggs*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Nigeria	Sivanesan (1984)
Exserohilum rostratum (Drechsler) K. J. Leonard & Suggs*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	China, Thailand	Lin et al. (2011) and Lumyong et al. (2003)
Exserohilum rostratum (Drechsler) K. J. Leonard & Suggs*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	India	Sarkar et al. (2013)
Exserohilum rostratum (Drechsler) K. J. Leonard & Suggs*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa sapientum*	Brunei Darussalam, Taiwan region in China	Matsushima (1980), Peregrine and Ahmad (1982)
Exserohilum rostratum (Drechsler) K. J. Leonard & Suggs*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Macrosporium ensetes Thüm.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa ensete*	Portugal	Saccardo (1886)

Pyrenophora dematioidea (Bubák & Wróbl.) Rossman & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Pyrenophora grahamii Rossman & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Stemphylium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* × *paradisiaca*	Cuba, Japan	Kobayashi (2007), Matsushima (1975) and Urtiaga (1986)
Stemphylium vesicarium (Wallr.) E. G. Simmons*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Stemphylium vesicarium (Wallr.) E. G. Simmons*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporaceae*	*Musa* sp.	Libya	El-Buni and Rattan (1981) and Kranz (1965)
Chaetophoma musae Cooke	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa* sp.	United States	Cooke and Massee (1883)
Pyrenochaeta sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa sapientum var. rubra*	Myanmar	Thaung (2008)
Pyrenochaeta sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Scleroramularia musae G. Y. Sun & Liu Gao*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa basjoo*	China	Gao et al. (2015)
Scolecobasidium humicola G. L. Barron & L. V. Busch*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa* sp.	Papua New Guinea	Shaw (1984)

Scolecobasidium musae G. Y. Sun & Lu Hao*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa basjoo*	China	Crous et al. (2021) and Hao et al. (2013)
Scolecobasidium musicola (Crous) Crous, M. Shen & Y. Zhang ter*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa* sp.	Cameroon, France, India, Malaysia	Crous et al. (2018) and Crous et al. (2021)
Scolecobasidium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Scolecobasidium sp.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Scolecobasidium variabile G.L. Barron & L. V. Busch*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pleosporales* genera *incertae sedis*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Berkleasmium phyllostachydis Matsush.	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pseudoberkleasmiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Pyrenochaetopsis musae Samarakoon & Chomnunti*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Pyrenochaetopsidaceae*	*Musa* sp.	Thailand	This study
Setoarthopyrenia chromolaenae Mapook & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Roussoellaceae*	*Musa* sp.	Thailand	This study
Sporormiella minima (Auersw.) S. I. Ahmed & Cain*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Sporormiaceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951)
Tetraploa aristata Berk. & Broome*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Tetraplosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Tetraploa aristata Berk. & Broome*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Tetraplosphaeriaceae*	*Musa textilis*	Malaysia	Liu (1977)
Tetraploa ellisii Cooke	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Tetraplosphaeriaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)

Torula chromolaenae Jun F. Li, Phook., Mapook & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021)
Torula fici Crous*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa* sp.	China	Samarakoon et al. (2021)
Torula herbarum (Pers.) Link*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa* × *paradisiaca*	Papua New Guinea	Matsushima (1971)
Torula herbarum (Pers.) Link*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa acuminata*	Somalia, Thailand	Castellani and Ciferri (1937) and Lumyong et al. (2003)
Torula herbarum (Pers.) Link*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa sapientum*	Taiwan region in China, Zambia	Matsushima (1980) and Riley (1956)
Torula mackenziei Jun F. Li, Phook. & K. D. Hyde*	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa* sp.	Thailand	This study
Torula mansonii (Castell.) Vuill. *	*Ascomycota*	*Dothideomycetes*	*Pleosporales*	*Torulaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021)
Helicoma sp.	*Ascomycota*	*Dothideomycetes*	*Tubeufiales*	*Tubeufiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Helicomyces macrofilamentosus Matsush. *	*Ascomycota*	*Dothideomycetes*	*Tubeufiales*	*Tubeufiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Helicomyces roseus Link*	*Ascomycota*	*Dothideomycetes*	*Tubeufiales*	*Tubeufiaceae*	*Musa sapientum*	Australia	Matsushima (1989)
Neohelicosporium terrestris Samarakoon & Chomnunti*	*Ascomycota*	*Dothideomycetes*	*Tubeufiales*	*Tubeufiaceae*	*Musa* sp.	Thailand	This study
Napicladium musae Sawada	*Ascomycota*	*Dothideomycetes*	*Venturiales*	*Venturiaceae*	*Musa cavendishii*	Taiwan region in China	Index of Fungi (1954)
Venturia musae Sawada	*Ascomycota*	*Dothideomycetes*	*Venturiales*	*Venturiaceae*	*Musa cavendishii*	Taiwan region in China	Sawada (1959)

Venturia musae Sawada	*Ascomycota*	*Dothideomycetes*	*Venturiales*	*Venturiaceae*	*Musa formosana*	Taiwan region in China	Sawada (1959)
Sarcinella sp.	*Ascomycota*	*Dothideomycetes*	*Zeloasperisporiales Incertae sedis*	*Englerulaceae*	*Musa acuminata*	China	Cao et al. (2002)
Chaetothyrium sp.	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Chaetothyriaceae*	*Musa* sp.	Puerto Rico	Batista & Ciferri (1962)
Phaeosaccardinula tenuis (Earle) Seaver & Chardón	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Chaetothyriaceae*	*Musa* × *paradisiaca*	Puerto Rico, Virgin Islands	Photita et al. (2002), Piatek et al. (2013) and Stevenson (1975)
Limacinula musicola (Bat.) D. R. Reynolds	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Coccodiniaceae*	*Musa* sp.	United Kingdom	Index of Fungi (1957)
Limacinula musicola (Bat.) D. R. Reynolds	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Coccodiniaceae*	*Musa sapientum*	Brazil	Batista and Ciferri (1962)
Cyphellophora musae G. Y. Sun & Liu Gao*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Cyphellophoraceae*	*Musa basjoo*	China	Gao et al. (2015)
Cladophialophora bantiana (Sacc.) de Hoog, Kwon-Chung & McGinnis*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa sapientum*	Australia	Matsushima (1989)
Metulocladosporiella chiangmaiensis Y. Marín, Cheew. & Crous*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	Thailand	Crous et al. (2021) and Marin-Felix et al. (2019)
Metulocladosporiella malaysiana Y. Marín & Crous*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	Malaysia	Crous et al. (2021)
Metulocladosporiella musae (E. W. Mason) Crous, Schroers, J. Z. Groenew., U. Braun & K. Schub.	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	South Africa, Honduras, Jamaica, Mexico, Thailand	Crous et al. (2006, 2021), Surridge et al. (2002, 2003) and This study

*							
Metulocladosporiella musae (E. W. Mason) Crous, Schroers, J. Z. Groenew., U. Braun & K. Schub. *	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa sapientum*	Cameroon	Crous et al. (2006)
Metulocladosporiella musicola Crous, Schroers & J. Z. Groenew. *	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa acuminata*	Africa	Crous et al. (2021)
Metulocladosporiella musicola Crous, Schroers & J. Z. Groenew. *	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* × *paradisiaca*	Uganda	Crous et al. (2006)
Metulocladosporiella musicola Crous, Schroers & J. Z. Groenew. *	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa sapientum*	Kenya, Mozambique, Uganda, Zimbabwe	Crous et al. (2006)
Metulocladosporiella musicola Crous, Schroers & J. Z. Groenew. *	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	China, France, Kenya, Mozambique, South Africa, Uganda, Zimbabwe	Chen (2017) and Crous et al. (2006)
Metulocladosporiella musigena Y. Marín, Cheew. & Crous*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	Thailand	Crous et al. (2021) and Marin-Felix et al. (2019)
Metulocladosporiella samutensis Y. Marín, Luangsa-ard & Crous*	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	Thailand	Crous et al. (2021) and Marin-Felix et al. (2019)

Minimelanolocus sp.	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Veronaea sp.	*Ascomycota*	*Eurotiomycetes*	*Chaetothyriales*	*Herpotrichiellaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Aspergillus appendiculatus Blaser*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus austroafricanus Jurjevic, S. W. Peterson & B. W. Horn*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus caesiellus Saito*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus carneus Blochwitz*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Iran	Amani (2011) and Amani and Avagyan (2014)
Aspergillus clavatus Desm. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa sp.*	Brazil	Mendes et al. (1998)

Aspergillus costiformis H. Z. Kong & Z. T. Qi*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus flavus Link*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Aspergillus flavus Link*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* × *paradisiaca*	Bangladesh, Brazil, India	Bashar et al. (2012), Gupta (2023) and Mendes et al. (1998)
Aspergillus flavus Link*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Aspergillus flavus Link	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Aspergillus flavus Link*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus fumigatus Fresen. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* × *paradisiaca*	India	Gupta (2023)
Aspergillus fumigatus Fresen. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Aspergillus glaucus (L.) Link*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Aspergillus niger Tiegh. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* × *paradisiaca*	Bangladesh, Brazil	Bashar et al. (2012) and

							Mendes et al. (1998)
Aspergillus niger Tiegh. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Aspergillus niger Tiegh. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Aspergillus niger Tiegh. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus ochraceus G. Wilh. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Hong Kong	Lu et al. (2000) and Zhuang (2001)
Aspergillus oryzae (Ahlb.) Cohn*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Spain	Garoé et al. (2013)
Aspergillus penicillioides Speg. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus puulaauensis Jurjevic, S. W. Peterson & B. W. Horn*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)

Aspergillus restrictus G. Sm. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Aspergillus sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa x paradisiaca*	Brazil	Mendes et al. (1998)
Aspergillus sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Aspergillus sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Brazil, United States	Mendes et al. (1998) and Meredith (1969)
Aspergillus sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Aspergillus versicolor (Vuill.) Tirab. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Aspergillus wentii Wehmer*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Citromyces musae Bainier & Sartory	*Ascomycota*	*Eurotiomycetes,*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	France	Socie´te´ mycologique de France (1913)
Penicillium atrobrunneum Cooke	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	United States	Cooke (1878)

Penicillium bialowiezense K. W. Zaleski*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium chlorinum Fresen.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* × *paradisiaca*	Germany	Fresenius (1850)
Penicillium cinnamopurpureum S. Abe*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium citrinum Thom*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium commune Thom*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	England	Smith (1951)
Penicillium corylophilum Dierckx*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Ecuador	Marin et al. (1996)

Penicillium dierckxii Biourge*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium digitatum (Pers.) Sacc. *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Hong Kong, Japan	Kobayashi (2007), Lu et al. (2000) and Zhuang (2001)
Penicillium dodgei Pitt*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Kobayashi (2007), Lu et al. (2000) and Zhuang (2001)
Penicillium italicum Wehmer*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Hong Kong, Japan	Kobayashi (2007), Lu et al. (2000) and Zhuang (2001)
Penicillium marinum Frisvad & Samson*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium melanostipe Houbraken &	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Cuba	Mercado-Sierra et al. (1998)

Samson							
Penicillium meleagrinum var. *viridiflavum* S. Abe*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium musae Weid.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Germany	Traverso (1911)
Penicillium olsoni Bainier & Sartory	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	France	Bainier and Sartory (1912)
Penicillium solitum Westling *	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Somalia, Thailand	Lumyong et al. (2003)
Penicillium sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* × *paradisiaca*	Bangladesh, Venezuela	Bashar et al. (2012) and Urtiaga (1986)
Penicillium sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Penicillium sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Costa Rica, Guatemala, Mexico, United States	Marin et al. (1996), Meredith (1969) and Raabe et al. (1981)

Penicillium steckii K. W. Zaleski*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Penicillium taiwanense (Matsush.) Houbraken & Samson	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1985)
Penicillium purpureogenum Stoll*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa* sp.	Malaysia	Zakaria and Aziz (2018)
Sphaeromyces sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Aspergillaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Paecilomyces musicola Matsush.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Thermoascaceae*	*Musa* × *paradisiaca*	Japan	Matsushima (1975)
Paecilomyces sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Thermoascaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Paecilomyces variotii Bainier*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Thermoascaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Paecilomyces variotii Bainier*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Thermoascaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Paecilomyces sp.	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Thermoascaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)

Talaromyces musae Houbraken, Kraak & M. Meijer*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Trichocomaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Talaromyces musae Houbraken, Kraak & M. Meijer*	*Ascomycota*	*Eurotiomycetes*	*Eurotiales*	*Trichocomaceae*	*Musa* sp.	Germany	Crous et al. (2017)
Treleasia musicola Speg.	*Ascomycota*	*Laboulbeniomycetes*	*Pyxidiophorales*	*Pyxidiophoraceae*	*Musa* sp.	Argentina	Museo Nacional de Buenos Aires (1909)
Physcia sp.	*Ascomycota*	*Lecanoromycetes*	*Caliciales*	*Physciaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Stictis musae Seaver & Waterston	*Ascomycota*	*Lecanoromycetes*	*Ostropales*	*Stictidaceae*	*Musa* sp.	Bermuda	Seaver and Waterston (1941)
Stictis tropicalis Speg.	*Ascomycota*	*Lecanoromycetes*	*Ostropales*	*Stictidaceae*	*Musa* × *paradisiaca*	Argentina	Museo Nacional de Buenos Aires (1909)
Hainesia tellingsii Koord.	*Ascomycota*	*Leotiomycetes*	*Chaetomellales*	*Chaetomellaceae*	*Musa* sp.	Indonesia	Koorders (1907)
Chlorociboria musae Dennis	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Chlorociboriaceae*	*Musa sapientum*	Bolivia	Index of Fungi (1963)
Cryptosporiopsis sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Dermateaceae*	*Musa acuminata*	Hong Kong	Lu et al. (2000) and Zhuang (2001)
Gloeosporium chioneum Syd. & P. Syd.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa* sp.	Congo	Sydow and Sydow (1912)
Gloeosporium orbiculare (Berk.) Berk.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa* sp.	United States	Cash (1952)

Gloeosporium orbiculare (Berk.) Berk.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa acuminata*	United States	Ellis and Everhart (1889)
Gloeosporium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Gloeosporium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Gloeosporium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa* × *paradisiaca*	India	Mathur (1979)
Gloeosporium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa cavendishii*	United States	Stevens (1925)
Gloeosporium musae Berk. & M. A. Curtis ex Ellis	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Drepanopezizaceae*	*Musa acuminata*	China	Cao et al. (2002)
Erysiphe geniculata (W. R. Gerard) U. Braun & S. Takam.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Erysiphaceae*	*Musa cavendishii*	Jordan	Amano (1986)
Oidium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Erysiphaceae*	*Musa indica*	India	Paul and Thakur (2006)
Oospora alquieri Delacr.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Erysiphaceae*	*Musa* sp.	Congo	Socie´te´ mycologique de France and Socie´te´ botanique de France (1885)
Oospora roseoflava Sacc.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Erysiphaceae*	*Musa purpurea*	Italy	Saccardo (1877)
Uncinula sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Erysiphaceae*	*Musa acuminata*	China	Cao et al. (2002)
Hymenoscyphus musicola Dennis	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiaceae*	*Musa* × *paradisiaca*	Bolivia	Farr and Stevenson (1963)
Dactylella atractoides Drechsler	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa basjoo*	Japan	Kobayashi (2007) and Tubaki (1958)

Dactylaria dimorphospora Veenb. -Rijks*	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Dactylaria obtriangularia Matsush. *	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa* × *paradisiaca*	Japan	Kobayashi (2007) and Matsushima (1975)
Dactylaria parvispora (Preuss) de Hoog & Arx*	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa sapientum*	Taiwan region in China	Matsushima (1987)
Dactylaria sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Dactylaria sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Helotiales* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Harpographium sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Hyaloscyphaceae*	*Musa* sp.	South Africa	Surridge (2002)
Haplographium atrobrunneum (Cooke) Sacc.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Hyaloscyphaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Haplographium musae Sawada	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Hyaloscyphaceae*	*Musa cavendishii*	Taiwan region in China	Sawada (1959)
Exochalara guadalcanalensis (Matsush.) W. Gams & Hol. Jech.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Neolauriomycetaceae*	*Musa* sp.	Solomon Islands	Matsushima (1971), Reblova et al. (2011) and Rong and Gams (2000)
Chalara musae Sawada	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Pezizellaceae*	*Musa cavendishii*	Taiwan region in China	Sawada (1959)
Botrytis cinerea Pers.*	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Sclerotiniaceae*	*Musa acuminata*	China	Zhang (2006)
Botrytis cinerea Pers. *	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Sclerotiniaceae*	*Musa cavendishii*	Greece	Holevas et al. (2000)
Botrytis sp.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Sclerotiniaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Sclerotinia sclerotiorum (Lib.)	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Sclerotiniaceae*	*Musa acuminata*	Australia	Simmonds (1966)

de Bary*							
Sclerotinia sclerotiorum (Lib.) de Bary*	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Sclerotiniaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Diplococcium capitatum Piroz.	*Ascomycota*	*Leotiomycetes*	*Helotiales*	*Vibrisseaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Cylindrocolla musicola Speg.	*Ascomycota*	*Leotiomycetes*	*Leotiomycetes* families *incertae sedis*	*Calloriaceae*	*Musa* × *paradisiaca*	Argentina	Farr (1973) and Museo Nacional de Buenos Aires (1910)
Coronellaria musicola (Speg.) Dennis	*Ascomycota*	*Leotiomycetes*	*Leotiomycetes* genera *incertae sedis*	*Leotiomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Argentina	Farr (1973)
Coccomyces annulatus Sherwood	*Ascomycota*	*Leotiomycetes*	*Rhytismatales*	*Rhytismataceae*	*Musa* × *paradisiaca*	Colombia	Sherwood (1980)
Coccomyces clusiae (Lév.) Sacc.	*Ascomycota*	*Leotiomycetes*	*Rhytismatales*	*Rhytismataceae*	*Musa* × *paradisiaca*	Puerto Rico, Virgin Islands	Stevenson (1975)
Coccomyces clusiae (Lév.) Sacc.	*Ascomycota*	*Leotiomycetes*	*Rhytismatales*	*Rhytismataceae*	*Musa* sp.	Central America, Colombia	Dennis (1970) and Photita et al. (2002)
Leptostroma musicola Tassi	*Ascomycota*	*Leotiomycetes*	*Rhytismatales*	*Rhytismataceae*	*Musa* × *paradisiaca*	Italy	Saccardo (1906)
Dactylella rhombica Matsush.	*Ascomycota*	*Orbiliomycetes*	*Orbiliales*	*Orbiliaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Orbilia oxyspora (Sacc. & Marchal) E. Weber & Baral*	*Ascomycota*	*Orbiliomycetes*	*Orbiliales*	*Orbiliaceae*	*Musa* × *paradisiaca*	Japan	Kobayashi (2007) and Matsushima (1975)
Orbilia oxyspora (Sacc. & Marchal) E. Weber & Baral*	*Ascomycota*	*Orbiliomycetes*	*Orbiliales*	*Orbiliaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Orbilia rhopalota (Drechsler) Baral & E. Weber*	*Ascomycota*	*Orbiliomycetes*	*Orbiliales*	*Orbiliaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)

Peziza musicola (Henn.) Sacc. & D. Sacc.	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pezizaceae*	*Musa* × *paradisiaca*	Brazil	Photita et al. (2002)
Purpureodiscus bananincola (Rehm) Van Vooren	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pezizaceae*	*Musa* sp.	Philippines	Pfister (1991) and Teodoro (1937)
Purpureodiscus bananincola (Rehm) Van Vooren	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pezizaceae*	*Musa sapientum*	Philippines	Reinking (1918, 1919) and Teodoro (1937)
Oedocephalum guadalcanalense Matsush.	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pezizales* genera *Incertae sedis*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Scutellinia cubensis (Berk. & M. A. Curtis) Gamundí	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pyronemataceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951)
Scutellinia scutellata (L.) Lambotte*	*Ascomycota*	*Pezizomycetes*	*Pezizales*	*Pyronemataceae*	*Musa* × *paradisiaca*	Puerto Rico, Virgin Islands	Stevenson (1975)
Debaryomyces vindobonensis Lopandic, Rents. & Prillinger*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Debaryomycetaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Meyerozyma guilliermondii (Wick.) Kurtzman & M. Suzuki*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Debaryomycetaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa* sp.	South Africa	Gorter (1977)

Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa cavendishii*	Ghana	Dade (1940)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa* sp.	Papua New Guinea, Zimbabwe	Shaw (1984) and Whiteside (1966)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa* × *paradisiaca*	South Africa	Crous et al. (2000)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa acuminata*	China, South Africa	Crous et al. (2000) and Zhuang (2001)
Geotrichum candidum Link*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa* × *paradisiaca*	Brazil, South Africa, West Indies	Crous et al. (2000), Mendes et al. (1998) and Wallbridge and Pinegar (1975)
Micrococcus sp.	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Dipodascaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Clavispora fructus (Nakase) Kurtzman, Robnett & Basehoar*	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Metschnikowiaceae*	*Musa sapientum*	Japan	Photita et al. (2002)
Candida conglobata (Redaelli) Cif. *	*Ascomycota*	*Saccharomycetes*	*Saccharomycetales*	*Saccharomycetales* genera *incertae sedis*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Apiospora locuta-pollinis (F. Liu & L. Cai) Pintos & P. Alvarado*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Thailand	This study
Apiospora sphaerosperma (Pers.) Pintos & P. Alvarado*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951) and Dennis (1970)
Nigrospora aurantiaca Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Raza et al. (2019) and Wang et al. (2017)

Nigrospora camelliae-sinensis Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Wang et al. (2017)
Nigrospora chinensis Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Wang et al. (2017)
Nigrospora hainanensis Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Raza et al. (2019) and Wang et al. (2017)
Nigrospora lacticolonia Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Raza et al. (2019) and Wang et al. (2017)
Nigrospora musae McLennan & Hoëtte*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa acuminata*	Australia	Hao et al. (2020)
Nigrospora musae McLennan & Hoëtte*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa acuminata* subsp. *banksii*	Australia	Brown et al. (1998)
Nigrospora musae McLennan & Hoëtte*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	Australia, China	Wang et al. (2017)
Nigrospora musae McLennan & Hoëtte*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa sapientum*	Australia	Wang et al. (2017)
Nigrospora musae McLennan & Hoëtte*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Australia	Petrak (1944)
Nigrospora oryzae (Berk. & Broome) Petch*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa acuminata*	Australia, Hong Kong, Somalia, Thailand	Castellani and Ciferri (1937), Hao et al. (2020), Lu et al. (2000), Lumyong et al. (2003) and Zhuang (2001)

Nigrospora oryzae (Berk. & Broome) Petch*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	India, Japan	Kobayashi (2007)
Nigrospora oryzae (Berk. & Broome) Petch*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa sapientum*	Japan	Kobayashi (2007)
Nigrospora oryzae (Berk. & Broome) Petch*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Hong Kong, India, Japan, Malaysia, South Africa	Brown et al. (1998), Gorter (1977) and Kobayashi (2007)
Nigrospora pyriformis Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Wang et al. (2017)
Nigrospora sacchari (Speg.) E. W. Mason*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	South Africa	Surridge (2002)
Nigrospora sp.	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa acuminata*	Guatemala	Tarnowski et al. (2010)
Nigrospora sp.	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Nigrospora sphaerica (Sacc.) E. W. Mason*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Australia, Fiji, Guinea, Japan, Malaysia, South Africa, Thailand	Dingley et al. (1981), Hao et al. (2020), Kobayashi (2007), Kranz (1965), Surridge (2002), This study, and Zakaria and Aziz (2018),
Nigrospora sphaerica (Sacc.) E. W. Mason*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa sapientum*	Brunei Darussalam, Fiji, Malaysia, Taiwan region in China	Firman (1972), Matsushima (1980), Peregrine and Ahmad (1982) and Turner (1971)

Nigrospora sphaerica (Sacc.) E. W. Mason*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa acuminata*	Australia, Somalia, Venezuela	Castellani and Ciferri (1937), Simmonds (1966) and Urtiaga (2004)
Nigrospora sphaerica (Sacc.) E. W. Mason*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China, West Indies	Wallbridge and Pinegar (1975) and Wang et al. (2017)
Nigrospora vesicularis Mei Wang & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* × *paradisiaca*	China	Raza et al. (2019) and Wang et al. (2017)
Nigrospora zimmermanii Crous*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Apiosporaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Beltraniella portoricensis (F. Stevens) Piroz. & S. D. Patil*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Beltraniaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Beltrania rhombica Penz. *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Beltraniaceae*	*Musa* × *paradisiaca*	Solomon Islands	Heredia-Abarca (1994) and Matsushima (1971)
Hansfordia ovalispora S. Hughes	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Hansfordiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Physalospora fallaciosa Sacc.	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Hyponectriaceae*	*Musa* sp.	Germany	Saccardo (1877)
Neopestalotiopsis clavispora (G. F. Atk.) Maharachch., K. D. Hyde & Crous*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa acuminata*	China	Qi et al. (2022)
Neopestalotiopsis clavispora (G. F. Atk.) Maharachch., K. D. Hyde & Crous*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Thailand	This study

Neopestalotiopsis musae Norph. & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Thailand	Hyde et al. (2016) and This study
Pestalotiopsis acaciae (Thüm.) K. Yokoy. & S. Kaneko*	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Japan	Watanabe et al. (2010)
Pestalotiopsis chethallensis Sohi & O. Prakash	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	India	Nag Raj (1993)
Pestalotiopsis disseminata (Thüm.) Steyaert	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sapientum*	Malaysia	Johnston (1960)
Pestalotiopsis eugeniae (Thüm.) S. Kaneko *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Malaysia	Zakaria and Aziz (2018)
Pestalotiopsis guepinii (Desm.) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	South Africa	Surridge (2002)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa x paradisiaca* var. *sapientum*	China, Venezuela	Tai (1979) and Urtiaga (1986)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sapientum*	Argentina, Brazil, China, India, Malaysia, Taiwan region in China	Ge et al. (2009), Guba (1961), Johnston (1960), Mathur (1979), Nag Raj (1993) and Photita et al. (2002)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sp.*	Argentina, India, United States	Guba (1961), Mathur (1979) and Meredith (1969)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa textilis*	China	Ge et al. (2009)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa basjoo*	China	Ge et al. (2009)

Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca*	India	Mathur (1979)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sapientum*	Argentina, China, India	Ge et al. (2009), Mathur (1979) and Nag Raj (1993)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	India	Mathur (1979)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa textilis*	China	Ge et al. (2009)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa acuminata*	United States, Venezuela	Raabe et al. (1981) and Urtiaga (2004)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa basjoo*	China, Somalia	Castellani and Ciferri (1937), Ge et al. (2009) and Tai (1979)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa cavendishii*	Taiwan region in China, Venezuela	Dennis (1970) and Guba (1961)
Pestalotiopsis leprogena (Speg.) Kausar	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa x paradisiaca*	Argentina, Brazil, India, Puerto Rico, Virgin Islands	Guba (1961), Mathur (1979) and Stevenson (1975)
Pestalotiopsis menezesiana (Bres. & Torrend) Bissett *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca*	China	Huang et al. (2007)
Pestalotiopsis menezesiana (Bres. & Torrend) Bissett *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	China	Huang et al. (2007)
Pestalotiopsis microspora (Speg.) Bat. & Peres *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Bangladesh	Bhuiyan et al. (2022)

Pestalotiopsis oxyanthi (Thüm.) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Malaysia	Zakaria and Aziz (2018)
Pestalotiopsis palmarum (Cooke) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa acuminata*	Hong Kong	Lu et al. (2000) and Zhuang (2001)
Pestalotiopsis palmarum (Cooke) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa acuminata subsp. banksii*	Australia	Brown et al. (1998)
Pestalotiopsis palmarum (Cooke) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Hong Kong	Brown et al. (1998)
Pestalotiopsis psidii (Pat.) Venkatakr. *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca*	India	Mathur (1979)
Pestalotiopsis sp.	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Pestalotiopsis sp.	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Pestalotiopsis theae (Sawada) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* sp.	Malaysia	Zakaria and Aziz (2018)
Pestalotiopsis versicolor (Speg.) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge and Pinegar (1975)
Pestalotiopsis versicolor (Speg.) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa* × *paradisiaca* var. *robusta*	India	Mathur (1979)
Pestalotiopsis versicolor (Speg.) Steyaert *	*Ascomycota*	*Sordariomycetes*	*Amphisphaeriales*	*Sporocadaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Catenularia kalakadensis Subram. & Bhat	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriacea e*	*Musa* sp.	India	Bhat (2010)
Chloridium sp.	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriacea e*	*Musa acuminata*	Thailand	Lumyong et al. (2003)

Dictyochaeta sp.	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Gonytrichum macrocladum (Sacc.) S. Hughes *	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Multiguttulispora triseptata (Matsush.) Réblová & Hern. -Restr. *	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriaceae*	*Musa* sp.	Micronesia	Matsushima (1981)
Sporoschisma hemipsilum (Berk. & Broome) Zelski, A. N. Mill. & Shearer *	*Ascomycota*	*Sordariomycetes*	*Chaetosphaeriales*	*Chaetosphaeriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Coniochaeta sp.	*Ascomycota*	*Sordariomycetes*	*Coniochaetales*	*Coniochaetaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Cordana terrestris (Timonin) Hern. -Restr., Gené & Guarro *	*Ascomycota*	*Sordariomycetes*	*Coniochaetales*	*Cordanaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Melanospora zamiae Corda *	*Ascomycota*	*Sordariomycetes*	*Coronophorales*	*Ceratostomataceae*	*Musa* sp.	England	Cannon and Hawksworth (1982)
Melanospora zamiae Corda *	*Ascomycota*	*Sordariomycetes*	*Coronophorales*	*Ceratostomataceae*	*Musa sapientum*	Ghana	Dade (1940)
Microthecium argentinense (Speg.) Höhn.	*Ascomycota*	*Sordariomycetes*	*Coronophorales*	*Ceratostomataceae*	*Musa sapientum*	Argentina	Museo Nacional de Buenos Aires (1909)
Cladotrichum mitratum Penz. & Sacc.	*Ascomycota*	*Sordariomycetes*	*Coronophorales*	*Chaetosphaerellaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1987)

Cladotrichum mitratum Penz. & Sacc.	*Ascomycota*	*Sordariomycetes*	*Coronophorales*	*Chaetosphaerellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Phomopsis musicola (F. Stevens & E. Young) Punith.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* sp.	Australia, Hong Kong, United States	Brown et al. (1998), Goos and Gowing (1992), Meredith (1969), Pearce and Hyde (2006), Photita et al. (2002), Raabe et al. (1981) and Stevens (1925)
Phomopsis musicola (F. Stevens & E. Young) Punith.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* × *paradisiaca*	India	Mathur (1979)
Phomopsis musicola (F. Stevens & E. Young) Punith.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa cavendishii*	Taiwan region in China	Sawada (1959)
Phomopsis musicola (F. Stevens & E. Young) Punith.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa acuminata*	China, Thailand, United States	Chi et al. (2007), Hyde et al. (2014), Lu et al. (2000), Raabe et al. (1981) and Zhuang (2001)
Phomopsis musicola (F. Stevens & E. Young) Punith.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa banksii*	Australia	Pearce and Hyde (2006)
Phomopsis sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* sp.	Hong Kong	Brown et al. (1998)
Phomopsis sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)

Phomopsis sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa acuminata subsp. banksii*	Australia	Brown et al. (1998)
Phomopsis sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa acuminata*	Hong Kong	Lu et al. (2000), Lumyong et al. (2003) and Zhuang (2001)
Pseudophaeocytostroma sacchari (Ellis & Everh.) B. Sutton *	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* sp.	Thailand	This study
Diaporthe melitensis Guarn. & Crous *	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Diaporthe musae Speg.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* × *paradisiaca*	Samoa	Photita et al. (2002)
Diaporthe musae Speg.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa sapientum*	Argentina	Museo Nacional de Buenos Aires (1909)
Diaporthe musigena Crous & R. G. Shivas *	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* sp.	Australia	Crous et al. (2011)
Diaporthe pterocarpicola Udayanga, Xing Z. Liu & K. D. Hyde *	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)

Diaporthe siamensis Udayanga, Xing Z. Liu & K. D. Hyde *	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Diaporthe sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	*Musa* sp.	South Africa	Surridge (2002)
Diaporthe tectonae Doilom, Dissan. & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Diaporthe tectonendophytica Doilom, Dissan. & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Botryodiplodia sp.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthales* families *Incertae sedis*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Botryodiplodia palmarum (Cooke) Petr. & Syd.	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthales* families *Incertae sedis*	*Musa sapientum*	Malaysia	Williams & Liu (1976)

Kapooria musarum (J. N. Kapoor) J. Reid & C. Booth	*Ascomycota*	*Sordariomycetes*	*Diaporthales*	*Diaporthales* genera *incertae sedis*	*Musa sapientum*	India	Kapoor (1968), Photita et al. (2002) and Sarbhoy et al. (1971)
Ellisembia minigelatinosa (Matsush.) W. P. Wu	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* genera *incertae sedis*	*Sordariomycetes* genera *incertae sedis*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Colletotrichum acutatum J. H. Simmonds*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Thailand	Udayanga et al. (2013)
Colletotrichum aotearoa B. S. Weir & P. R. Johnst. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	India	Sharma et al. (2015)
Colletotrichum chrysophilum W. A. S. Vieira, W. G. Lima, M. P. S. Câmara & V. P. Doyle*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Brazil, Mexico	Vieira et al. (2017) and Zakaria et al. (2021)
Colletotrichum citricola F. Huang, L. Cai, K. D. Hyde & Hong Y. Li*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	China	Huang et al. (2022)
Colletotrichum cliviicola Damm & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	China	Huang et al. (2021)
Colletotrichum fructicola Prihast., L. Cai & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	China	Huang et al. (2021)
Colletotrichum gigasporum Rakotonir. & Munaut*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Japan, Mexico	Jayawardena et al. (2016) and Liu et al. (2014)

Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	Australia, Hong Kong, Malaysia, Sri Lanka, Thailand, United States	Adikaram and Yakandawala (2020), Brown et al. (1998), Hyde et al. (2018), Intan et al. (2013), Lu et al. (2000), Raabe et al. (1981), Simmonds (1966) and Zhuang (2001),
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa cavendishii*	Taiwan region in China	Matsushima (1980)
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* x *paradisiaca*	Bangladesh, Brazil, Cambodia, Dominican Republic, United States, West Indies	Bashar et al. (2012), Ciferri (1929), Litzenberger et al. (1962), Mendes et al. (1998) and Wallbridge and Pinegar (1975)
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa sapientum*	Barbados, Dominican Republic, Kenya, Malaysia, Malawi, Taiwan region in China, Barbados, Kenya, Malawi, Malaysia, Taiwan region in China	Abd-Alla et al. (2014), Brown et al. (1998), Ciferri (1929), Matsushima (1980), Nattrass (1961), Norse (1974), Peregrine and Siddiqi (1972), Riera et al. (2019), Sarbhoy and Agarwal (1990), Wiehe

							(1953) and Williams and Liu (1976)
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Australia, Ecuador, Guinea, Hong Kong, India, Malaysia, Malawi, Mexico, Sri Lanka, Trinidad and Tobago	Adikaram and Yakandawala (2020), Baker and Dale (1951), Hyde and Alcorn (1993), Kranz (1965), Surridge (2002), Wiehe (1953) and Zakaria et al. (2021)
Colletotrichum graminicola (Ces.) G. W. Wilson*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Colletotrichum karsti You L. Yang, Zuo Y. Liu, K. D. Hyde & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa banksii*	Australia	Shivas et al. (2016)

Colletotrichum karsti You L. Yang, Zuo Y. Liu, K. D. Hyde & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	China, Colombia, Mexico	Costa et al. (2019), Damm et al. (2012), Douanla-Meli et al. (2018), Guarnaccia et al. (2017), Hou et al. (2016), Huang et al. (2021) and Zakaria et al. (2021)
Colletotrichum liukiuensis Sawada*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa liukiuensis*	Taiwan region in China	Sawada (1959)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	Australia, China, Cote d'Ivoire, Egypt, Hong Kong, Somalia, South Africa, Sri Lanka, Thailand, United States, United States	Abd-Alla et al. (2014), Adikaram and Yakandawala (2020), Alfieri Jr et al. (1984), Castellani and Ciferri (1937), Crous et al. (2000), Du et al. (2005), Hyde et al. (2018), Jayawardena et al. (2016), Lu et al. (2000), Lumyong et al. (2003), Resplandy et al. (1954), Shivas (1989), Shivas et al. (2016), Simmonds (1966), Tai (1979) and

							Zhuang (2001)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata* × *Musa balbisiana*	Thailand	Samarakoon et al. (2023)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata-babilonica*	Japan	Kobayashi (2007)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa basjoo*	China	Tai (1979)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa cavendishii*	Brazil, Ghana, Puerto Rico, Sierra Leone, Southern Africa, Taiwan region in China, Virgin Islands	Dade (1940), Deighton (1936), Doidge (1950), Mendes et al. (1998) Sawada (1959) and Stevenson (1975)

Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* × *paradisiaca*	Brazil, Costa Rica, Cuba, El Salvador, Guatemala, Haiti, India, Italy, Puerto Rico, Somalia, South Africa, United States, Venezuela, Virgin Islands	Alfieri Jr et al. (1984), Arnold (1986), Benjamin and Slot (1969), Castellani and Ciferri (1937), Crous et al. (2000), Faedda et (2011), Gurunath (1966), Mathur (1979), McGuire Jr and Crandall (1967), Mendes et al. (1998), Schena et al. (2014), Stevenson (1975) and Urtiaga (1986)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* × *paradisiaca* var. *sapientum*	China, Greece, Southern Africa	Doidge (1950), Pantidou (1973) and Tai (1979)

Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa sapientum*	Barbados, Brunei Darussalam, China, Fiji, Ghana, Iran, Jamaica, Japan, Kenya, Korea, Malay Peninsula, Malawi, Mexico, Myanmar, Pakistan, Philippines, Somalia, Tanzania, Thailand, United States	Ahmad et al. (1997), Alfieri Jr et al. (1984), Alizadeh et al. (2015), Alvarez (1976), Castellani and Ciferri (1937), Cho and Shin (2004), Dade (1940), Diao et al. (2017), Firman (1972), Giatgong (1980), Kobayashi (2007), Larter and Martyn (1943), Liu et al. (2015), Maneval (1937), Moriwaki et al. (2003), Nattrass (1961), Norse (1974), Peregrine and Ahmad (1982), Peregrine and Siddiqi (1972), Reinking (1919), Riley (1960), Teodoro (1937), Thaung (2008), Thompson and Johnston (1953), Vieira et al. (2014), Weir et al. (2012) and Zhuang (2001)

Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa sapientum* var. *paradisiaca*	Dominican Republic	Ciferri (1961)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Australia, Brazil, China, Cook Islands, Dominican Republic, Fiji, Guinea, Haiti, Hong Kong, India, Indonesia, Japan, Kenya, Libya, Malawi, Malaysia, Mauritius, New Zealand, North America, Pakistan, Papua New Guinea, Samoa, South Africa, Sri Lanka, Thailand, Tonga, United States, Zimbabwe	Abd-Alla et al. (2014), Ahmad et al. (1997), Alizadeh et al. (2015), Benjamin and Slot (1969), Braithwaite et al. (1990), Chethana et al. (2016), Corbett (1964), Costa et al. (2019), Cooke and Chen (2017), De Silva et al. (2017), Diao et al. (2017), Dingley et al. (1981), El-Buni and Rattan (1981), Faedda et al. (2011), Fuentes-Aragon et al. (2018), Gorter (1977), Guarnaccia et al. (2017), Honger et al. (2014), Hyde et al. (2018), Ivic et al. (2013), Jayawardena et al. (2016), Kranz (1963), Kranz (1965), Liu et al.

							(2015), Massee (1874, 1887), Masel et al. (1993), Mathur (1979), Mendes et al. (1998), Meredith (1969), Mo et al. (2018), Orieux and Felix (1968), Paul et al. (2014), Raabe et al. (1981), Sharma and Shenoy (2014), Sharma et al. (2015), Shaw (1984), Shivas et al. (2016), Stevens (1925), Su et al. (2011), Surridge (2002), Vieira et al. (2014), Wang et al. (2020) and Whiteside (1966)
Colletotrichum musae (Berk. & M. A. Curtis) Arx*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa textilis*	Brunei Darussalam	Peregrine and Ahmad (1982)
Colletotrichum musicola Damm*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Mexico	Damm et al. (2019)

Colletotrichum paxtonii Damm, P. F. Cannon & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	West Indies	Damm et al. (2020)
Colletotrichum paxtonii Damm, P. F. Cannon & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Mexico, Saint Lucia	Alizadeh et al. (2015), Braganca et al. (2016), Chethana et al. (2016), Damm et al. (2012), Damm et al. (2020), De Silva et al. (2017), Jayawardena et al. (2016) and Zakaria et al. (2021)
Colletotrichum plurivorum Damm, Alizadeh & Toy. Sato*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	Sri Lanka	Kurera et al. (2023)
Colletotrichum plurivorum Damm, Alizadeh & Toy. Sato*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Japan	Damm et al. (2019)
Colletotrichum scovillei Damm, P. F. Cannon & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	China	Zakaria et al. (2021) and Zhou et al. (2017)
Colletotrichum siamense Prihast., L. Cai & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	Turkey, Thailand	Uysal and Kurt (2020)
Colletotrichum siamense Prihast., L. Cai & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa sapientum*	Thailand	Samarakoon et al. (2023)

Colletotrichum siamense Prihast., L. Cai & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Brazil, China, India, Malaysia, Thailand, Turkey	Huang et al. (2021), Sharma et al. (2015), Su et al. (2011), This study, Udayanga et al. (2019), Uysal and Kurt (2020) and Zakaria and Aziz (2018, 2021)
Colletotrichum sojae Damm & Alizadeh *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa x paradisiaca*	Bangladesh, Brazil	Bashar et al. (2012) and Mendes et al. (1998)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Hong Kong, Mexico, Tonga	Dingley et al. (1981), Lu et al. (2000), Marin et al. (1996) and Zhuang (2001)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa textilis*	Mexico	Alvarez (1976)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa acuminata*	Venezuela	Urtiaga (2004)
Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa banksii*	Australia	Simmonds (1966)

Colletotrichum sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa basjoo*	China	Zhuang (2005)
Colletotrichum theobromicola Delacr. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Brazil	Zakaria et al. (2021)
Colletotrichum tropicale E. I. Rojas, S. A. Rehner & Samuels*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* sp.	Brazil	Zakaria et al. (2021)
Colletotrichum truncatum (Schwein.) Andrus & W. D. Moore*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Glomerella musarum Petch*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Glomerellaceae*	*Musa* × *paradisiaca*	Sri Lanka	Ceylon Department of Agriculture (1917)
Acrostalagmus annulatus (Berk. & M. A. Curtis) Seifert*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Canada	Seifert (1985)
Acrostalagmus luteoalbus (Link) Zare, W. Gams & Schroers*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Brazil	Giraldo and Crous (2019)
Gibellulopsis serrae (Maffei) Giraldo López & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	India	Giraldo and Crous (2019) and This study
Musicillium elettariae Giraldo López & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Thailand	Giraldo and Crous (2019) and This study
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Australia, Iran, United States, Sri Lanka, Venezuela	Adikaram and Yakandawala (2020), Alfieri Jr (1984), Giraldo and Crous (2019), Raabe et al. (1991),

							Shivas (1989), Simmonds (1966) and Urtiaga (2004)
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa cavendishii*	Ghana, Sierra Leone	Dade (1940) and Deighton (1936)
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* × *paradisiaca*	Brazil, Costa Rica, Cuba, El Salvador, Haiti, Mexico, Panama, United States	Alfieri Jr (1984), Arnold (1986), Benjamin and Slot (1969), McGuire Jr and Crandall (1967) and Mendes et al. (1998)
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* × *paradisiaca* var. *sapientum*	Southern Africa	Doidge (1950)
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Iran, Thailand	Giatgong (1980) and Giraldo and Crous (2019)
Musicillium theobromae (Turconi) Zare & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Brazil, China, Cote d'Ivoire, Egypt, Eritrea, Ethiopia, Jamaica, Morocco, Netherlands, Nicaragua, Trinidad and Tobago	Baker and Dale (1951), Castellani and Ciferri (1937), Chen (2017), Delgado (2011), Giraldo and Crous (2019), Mendes et al. (1998) and Resplandy et al. (1954)

Musicillium tropicale Giraldo López & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Bangladesh, Thailand, Zambia	Giraldo and Crous (2019) and This study
Musidium stromaticum (W. Gams & R. H. Stover) Giraldo López & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Colombia, Costa Rica, Honduras, Panama, Philippines, Tanzania, United Kingdom	Giraldo and Crous (2019)
Musidium stromaticum (W. Gams & R. H. Stover) Giraldo López & Crous*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Honduras	Giraldo and Crous (2019) and Zare et al. (2007)
Plectosphaerella cucumerina (Lindf.) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	India	Kanakala and Singh (2013)
Stachylidium bicolor Link*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Stachylidium bicolor Link*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* × *paradisiaca*	Cuba, Ghana	Arnold (1986), Delgado-Rodriguez and Mena-Portales (2004) and Hughes (1952)
Stachylidium bicolor Link*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Ghana, Taiwan region in China	Hughes (1952) and Matsushima (1980)
Stachylidium bicolor Link*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Cuba	Mercado Sierra (1984)
Stachylidium bicolor Link*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa textilis*	Malaysia	Johnston (1960) and Williams and Liu (1976)
Verticillium dahliae Kleb. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Australia	Simmonds (1966)

Verticillium dahliae Kleb. *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Tanzania	Riley (1960)
Verticillium sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Verticillium sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa cavendishii*	Greece	Pantidou (1973)
Verticillium sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa x paradisiaca*	Brazil	Mendes et al. (1998)
Verticillium sp.	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* sp.	Brazil, Canada, Mauritius	Ginns (1986), Mendes et al. (1998), Orieux and Felix (1968) and Wiehe (1948)
Verticillium tenerum Nees*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Verticillium tenerum Nees*	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Verticillium albo-atrum Reinke & Berthold *	*Ascomycota*	*Sordariomycetes*	*Glomerellales*	*Plectosphaerellaceae*	*Musa* × *paradisiaca*	Papua New Guinea	Matsushima (1971)
Acremonium elatum (C. H. Dickinson) W. Gams	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Sierra Leone	Dickinson (1968)
Acremonium longisporum (Preuss) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa sapientum*	Netherlands	Kiyuna et al. (2011)
Acremonium murorum (Corda) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Sierra Leone	Ellis (1971b)
Acremonium murorum (Corda) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Acremonium polychromum (J. F. H. Beyma) W.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge and Pinegar (1975)

Gams*							
Acremonium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Canada, China, Costa Rica, Ecuador, England, Honduras, Papua New Guinea, Philippines, Tanzania	Chen (2017), Gams (1975), Ginns (1986), Marin et al. (1996) and Shaw (1984)
Acremonium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa acuminata*	Iran, Thailand	Amani and Avagyan (2014) and Lumyong et al. (2003)
Bionectria byssicola (Berk. & Broome) Schroers & Samuels*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa acuminata*	Philippines	Alvindia et al. (2011)
Bionectria ochroleuca (Schwein.) Schroers & Samuels*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa acuminata*	Malaysia	Zakaria et al. (2016)
Clonostachys rosea (Link) Schroers, Samuels, Seifert & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)
Clonostachys rosea (Link) Schroers, Samuels, Seifert & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Costa Rica	Marin et al. (1996)
Furcasterigmium furcatum (C. Moreau & Moreau ex W. Gams) Giraldo López &	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	China	Chen (2017)

Crous*							
Gliomastix cerealis (P. Karst.) C. H. Dickinson*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge and Pinegar (1975)
Gliomastix musicola (Speg.) C. H. Dickinson	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	French Guiana	Photita et al. (2002)
Gliomastix roseogrisea (S. B. Saksena) Summerb. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Nicaragua	Delgado (2011)
Gliomastix sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Ecuador	Marin et al. (1996)
Gliomastix sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Hydropisphaera nymaniana (Henn.) Rossman & Samuels	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Indonesia	Warburg (1899)
Hydropisphaera suffulta (Berk. & M. A. Curtis) Rossman & Samuels*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* × *paradisiaca*	Cuba, Puerto Rico, Virgin Islands	Arnold (1986) and Stevenson (1975)
Hydropisphaera suffulta (Berk. & M. A. Curtis) Rossman & Samuels*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	Vietnam	Saccardo et al. (1887)
Hydropisphaera yunnanensis J. Luo & W.Y. Zhuang*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* sp.	China	Luo and Zhuang (2010)
Nectriella musicola (Speg.) Sacc. & Trotter	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa* × *paradisiaca*	Argentina	Linnean Society of London (1869)

Stilbocrea gracilipes (Tul. & C. Tul.) Samuels & Seifert*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Bionectriaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Metacordyceps chlamydosporia (H. C. Evans) G. H. Sung, J. M. Sung, Hywel-Jones & Spatafora*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Clavicipitaceae*	*Musa acuminata*	Spain	Mingot-Ureta et al. (2020)
Metarhizium anisopliae (Metschn.) Sorokin*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Clavicipitaceae*	*Musa* sp.	Brazil	Lopes et al. (2013)
Beauveria bassiana (Bals. -Criv.) Vuill. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Cordycipitaceae*	*Musa* sp.	Brazil, Uganda	Akello et al. (2008) and Lopes et al. (2013)
Cordyceps fumosorosea (Wize) Kepler, B. Shrestha & Spatafora*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Cordycipitaceae*	*Musca domestica*	France	Cantone and Vandenberg (1998)
Gliocladium caespitosum Petch*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	Nicaragua	Delgado (2011)
Gliocladium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	Costa Rica, Mexico	Marin et al. (1996)
Mycogone rufa Petch	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* × *paradisiaca*	Sri Lanka	Ceylon Department of Agriculture (1915)
Trichoderma asperellum Samuels, Lieckf. & Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China	Xia et al. (2011)
Trichoderma atroviride P. Karst. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa acuminata*	Malaysia	Zakaria et al. (2016)

Trichoderma atroviride P. Karst. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China	Xia et al. (2011)
Trichoderma brevicompactum G. F. Kraus, C. P. Kubicek & W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China	Xia et al. (2011)
Trichoderma harzianum Rifai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa acuminata*	Philippines	Alvindia et al. (2011)
Trichoderma harzianum Rifai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* × *paradisiaca*	Cameroon	Bechem and Afanga (2017)
Trichoderma harzianum Rifai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Trichoderma koningii Oudem. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China, Papua New Guinea	Shaw (1984) and Xia et al. (2011)
Trichoderma lixii (Pat.) P. Chaverri*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* × *paradisiaca*	Cameroon	Bechem and Afanga (2017)
Trichoderma lixii (Pat.) P. Chaverri*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China	Xia et al. (2011)
Trichoderma longibrachiatum Rifai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Trichoderma reesei E.G. Simmons*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa Paradisiaca*	India	Savani et al. (2021)
Trichoderma sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Trichoderma sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* × *paradisiaca*	Bangladesh	Bashar et al. (2012)

Trichoderma sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Trichoderma virens (J. H. Mill., Giddens & A. A. Foster) Arx*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* sp.	China	Xia et al. (2011)
Trichoderma viride Pers. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreaceae*	*Musa* × *paradisiaca*	Brazil, West Indies	Mendes et al. (1998) and Wallbridge and Pinegar (1975)
Cephalosporium acremonium Corda*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Cephalosporium crassum Petch*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa* sp.	Philippines	Teodoro (1937)
Cephalosporium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa acuminata*	China	Cao et al. (2002)
Cephalosporium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa* sp.	Brazil	Mendes et al. (1998)
Cephalosporium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa x paradisiaca*	Brazil	Mendes et al. (1998)
Cephalosporium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa sapientum*	Tanzania	Riley (1960)
Harzia palmara (Cooke) D. W. Li & N. P. Schult. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa sapientum*	Ghana	Dade (1940)
Harzia palmara (Cooke) D. W. Li & N. P. Schult. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Hypocreales* genera *incertae sedis*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)

Trichothecium roseum (Pers.) Link*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Myrotheciomycetaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Trichothecium roseum (Pers.) Link*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Myrotheciomycetaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Trichothecium roseum (Pers.) Link*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Myrotheciomycetaceae*	*Musa x paradisiaca*	India	Gurunath Rao (1966)
Bidenticula cannae Deighton*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Sierra Leone	Deighton (1972) and Ellis (1976)
Bisifusarium dimerum (Penz.) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Nicaragua, West Indies	Delgado (2011) and Wallbridge and Pinegar (1975)
Calonectria apoensis Petr.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Philippines	Photita et al. (2002)
Calonectria clavata Alfieri, El-Gholl & E. L. Barnard*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Guadeloupe, Martinique, Saint Lucia	Crous et al. (2006)
Calonectria gracilis Crous, M. J. Wingf. & Alfenas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Malaysia	Zakaria et al. (2016)
Calonectria gracilis Crous, M. J. Wingf. & Alfenas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Cameroon, Martinique, Saint Lucia	Crous (2002) and Crous et al. (2006)
Calonectria multiseptata Crous & M. J. Wingf. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Cameroon	Crous et al. (2005)
Calonectria pteridis Crous, M. J. Wingf. & Alfenas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Cameroon, Costa Rica, Martinique	Crous (2002)

Calonectria spathiphylli El-Gholl, J. Y. Uchida, Alfenas, T. S. Schub., Alfieri & A. R. Chase*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Cameroon, Costa Rica, Dominica, Guadeloupe, Martinique	Crous (2002)
Calostilbe striispora (Ellis & Everh.) Seaver*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Jamaica	Larter and Martyn (1943)
Corallomycetella elegans (Berk. & M. A. Curtis) C. S. Herrera & P. Chaverri*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Congo, Costa Rica	Herrera et al. (2013) and Lombard et al. (2015)
Cylindrocarpon congoense J. A. Mey.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Iran	Gerlach and Ershad (1970)
Cylindrocarpon didymum (Harting) Wollenw. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Dominica	Booth (1966)
Cylindrocarpon musae C. Booth & R. H. Stover*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Asia, Colombia, Costa Rica, Costa Rica, Ecuador, Guadeloupe, Martinique, North America, Panama, Papua New Guinea, Philippines, South America.	Booth and Stover (1974), Brayford (1987), Piepenbring (2006) and Shaw (1984)
Cylindrocarpon sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Somalia, Thailand	Castellani and Ciferri (1937) and Lumyong et al. (2003)
Cylindrocarpon supersimplex	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Japan	Kobayashi (2007) and

Matsush. *							Matsushima (1975)
Cylindrocladium musae Semer, D. J. Mitch., M. E. Mitch., F. N. Martin & Alfenas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Costa Rica	Semer et al. (1987)
Fusarium acuminatum Ellis & Everh. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia	Shivas (1989)
Fusarium acuminatum Ellis & Everh. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa x paradisiaca*	Ecuador, Panama	Altomare et al. (1997)
Fusarium acuminatum Ellis & Everh. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Turkey	Altomare et al. (1997)
Fusarium acuminatum Ellis & Everh. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Panama	Piepenbring (2006)
Fusarium breviconum (Wollenw.) O'Donnell, Geiser, Kasson & T. Aoki*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Honduras	Sandoval-Denis et al. (2019)
Fusarium camptoceras Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, China, Ecuador, Malaysia,	Abd-Murad et al. (2017), Marasas et al. (1998) and Summerell et al. (2011)
Fusarium chlamydosporum Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	India	Sarkar et al. (2013)
Fusarium chlamydosporum Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Honduras	Lombard et al. (2019)

Fusarium chlamydosporum Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Malaysia	Du et al. (2017), Zakaria and Aziz (2018) and Zeng et al. (2013)
Fusarium chlamydosporum Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Fusarium chuoi R. Hill, Gaya, D. T. Vu, Sand. Den. & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa itinerans*	Vietnam	Crous et al. (2021)
Fusarium compactum (Wollenw.) Raillo*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia	Summerell et al. (2011)
Fusarium concentricum Nirenberg & O'Donnell*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Costa Rica, Guatemala	Abd Murad et al. (2017), Herron et al. (2015), Ibrahim et al. (2016), Jacobs et al. (2010), Lima et al. (2012), Nirenberg and O'Donnell (1998), Sandoval-Denis et al. (2018) and Scauflaire et al. (2011)
Fusarium concentricum Nirenberg & O'Donnell*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, China, Malaysia	Abd Murad et al. (2017), Summerell et al. (2011) and Zeng

							et al. (2013)
Fusarium concentricum Nirenberg & O'Donnell*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Fusarium concolor Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Malaysia	Abd Murad et al. (2017)
Fusarium concolor Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Fusarium crassum (Sand. -Den. & Crous) O'Donnell, Geiser, Kasson & T. Aoki*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Guatemala	Sandoval-Denis et al. (2019)
Fusarium cugenangense Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Vietnam	Le Th et al. (2022)
Fusarium cugenangense Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia, Thailand	Maryani et al. (2019)
Fusarium desaboruense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China	Zhuang (2001)

Fusarium desaboruense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)
Fusarium duoseptatum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia, Malaysia	Maryani et al. (2019)
Fusarium duoseptatum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Vietnam	Le Th et al. (2022)
Fusarium duoseptatum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malaysia	Lombard et al. (2019)
Fusarium duoseptatum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia, Malaysia	Maryani et al. (2019)
Fusarium equiseti (Corda) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)
Fusarium equiseti (Corda) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Kenya	Nattrass (1961)
Fusarium equiseti (Corda) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Iran, Libya, Malaysia	Abd Murad et al. (2017), El-Buni and Rattan (1981), Gerlach and Ershad (1970), Papizadeh et al. (2018) and Zakaria and Aziz (2018)

Fusarium ershadii M. Papizadeh, A. van Diepeningen & H. R. Zamanizadeh*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Vietnam	Le Th et al. (2022)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, Guatemala, Egypt, Iran, Somalia, South Africa, United States	Amani (2011), Amani and Avagyan (2014), Castellani and Ciferri (1937), Crous et al. (2000), Maswada (2017), Raabe et al. (1991), Shivas (1989) and Tarnowski et al. (2010)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa cavendishii*	Cuba, Mexico	Arnold (1986) and Hirata et al. (2001)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Brazil, Cuba, India, West Indies	Agarwal (1990), Arnold (1986), Sarbhoy and Mendes et al. (1998) and Wallbridge (1981)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	India, Korea, Malawi, Pakistan	Ahmad et al. (1997), Cho and Shin (2004), Peregrine and Siddiqi (1972) and Sarbhoy and Agarwal (1990)

Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Congo, Costa Rica, Ecuador, Guatemala, Indonesia, Jordan, Malaysia, Philippines, South Africa, Thailand, Turkey	Abd Murad et al. (2017), Gorter (1977), Marin et al. (1996), Maryani et al. (2019), O'Donnell et al. (1998), Salem et al. (2020), Van Hove et al. (2011) and Zeng et al. (2013)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Fusarium fujikuroi Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Fusarium graminearum Schwabe*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)
Fusarium graminearum Schwabe*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Honduras	Schilling et al. (1995)
Fusarium grosmichelii Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia	Maryani et al. (2019)
Fusarium grosmichelii Maryani, L. Lombard, Kema &	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)

Crous*							
Fusarium guilinense M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China	Wang et al. (2019) and Xia et al. (2019)
Fusarium hainanense M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China, Indonesia	Wang et al. (2019) and Xia et al. (2019)
Fusarium hexaseptatum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia	Maryani et al. (2019)
Fusarium humuli M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China	Wang et al. (2019) and Xia et al. (2019)
Fusarium humuli M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	China	Wang et al. (2019)
Fusarium incarnatum Subraman. & Rao*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Sri Lanka	Adikaram and Yakandawala (2020)
Fusarium incarnatum Subraman. & Rao*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Malaysia	Abd Murad et al. (2017)
Fusarium ipomoeae M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China	Wang et al. (2019)
Fusarium ipomoeae M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Xia et al. (2019)

Fusarium kalimantanense Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Brazil, Indonesia	Maryani et al. (2019), Santos et al. (2023)
Fusarium kotabaruense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019), Xia et al. (2019)
Fusarium kurunegalense Samuels, Nalim & Geise*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Fusarium lateritium Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Hong Kong, South Africa	Crous et al. (2000), Lu et al. (2000) and Zhuang (2001)
Fusarium lateritium Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa x paradisiaca*	South Africa	Crous et al. (2000)
Fusarium lateritium Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Hong Kong, South Africa	Brown et al. (1998) and Gorter (1977)
Fusarium longipes Wollenw. & Reinking*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)

Fusarium lumajangense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia	Maryani et al. (2019)
Fusarium lumajangense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)
Fusarium mesoamericanum T. Aoki, Kistler, Geiser & O'Donnell*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, Honduras	Hafez et al. (2020), O'Donnell et al. (2004) and Summerell et al. (2011)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China, Philippines	Nozawa et al. (2023) and Zhuang (2001)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Australia, Cuba, United States	Alfieri Jr et al. (1984), Shivas (1989) and Urtiaga (1986)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malawi, Pakistan, United States	Ahmad et al. (1997), Alfieri Jr et al. (1984) and Peregrine and Siddiqi (1972)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Libya, Pakistan, Trinidad and Tobago, United States.	Ahmad et al. (1997), Baker and Dale (1951), El-Buni and Rattan (1981), Kranz (1962), Kranz (1965) and Meredith

							(1969)
Fusarium mindoanum Petr. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Fusarium mucidum J. W. Xia, L. Lombard, Sand. Den., X. G. Zhang & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia	Xia et al. (2019)
Fusarium musae Van Hove, Waalwijk, Munaut, Logrieco & Ant. Moretti*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa lanceolata*	Tanzania	Photita et al. (2002)
Fusarium musae Van Hove, Waalwijk, Munaut, Logrieco & Ant. Moretti*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Brazil, Canary Islands, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Philippines	Costa et al. (2019), Herron et al. (2015), Pfenning et al. (2019) and Van Hove et al. (2011)
Fusarium musarum Logrieco & Marasas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Australia, Panama	Marasas et al. (1998)
Fusarium musarum Logrieco & Marasas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Panama	Piepenbring (2006)
Fusarium nanum M. M. Wang, Qian Chen & L. Cai*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China	Wang et al. (2019) and Xia et al. (2019)
Fusarium neosemitectum J. W. Xia, L. Lombard, Sand. -	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Congo	Xia et al. (2019)

Den., X. G. Zhang & Crous*							
Fusarium odoratissimum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China, Colombia, Indonesia, Jordan, Lebanon, Pakistan, Philippines	Garcia-Bastidas et al. (2020) and Maryani et al. (2019)
Fusarium odoratissimum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Vietnam	Le Th et al. (2022)
Fusarium odoratissimum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malaysia	Lombard et al. (2019)
Fusarium odoratissimum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, Indonesia	Lombard et al. (2019) and Maryani et al. (2019)
Fusarium orthoceras Appel & Wollenw. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)

Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, China, Cuba, India, Indonesia, Israel, Iran, Jordan, Laos, Lebanon, Mozambique, Nepal, Nigeria, Pakistan, Peru, South Africa, Sri Lanka, Taiwan region in China, Turkey, Uganda, United States, Venezuela, Vietnam	Adikaram and Yakandawala (2020), Alfieri Jr et al. (1984), Castellani and Ciferri (1937), Chittarath et al. (2018), Crous et al. (2000), Dahal et al. (1992), Hung et al. (2018), Irandegani et al. (2023), Maymon et al. (2018), Maryani et al. (2019), Ozarslandan and Akgul (2020), Qi et al. (2008), Raabe et al. (1991), Schroer et al. (2004), Shivas (1989), Su et al. (1986),Thangavelu et al. (2019), Tushemereirwe and Ploetz (1993), Urtiaga (2004) and Zhuang (2001)
Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa basjoo*	China	Tai (1979)

Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Australia, Bangladesh, Brazil, Cameroon, Cuba, Dominican Republic, Haiti, India, Japan, Puerto Rico, South Africa, United States, Virgin Islands, West Indies	Alfieri et al. (1984), Arnold (1986), Bashar et al. (2012), Bechem and Afanga (2017), Benjamin and Slot (1969), Ciferri (1929), Crous et al. (2000), Gurunath (1966), Mendes et al. (1998), Nitani et al. (2018), Sarkar et al. (2013), Shivas (1989), Stevenson (1975) and Wallbridge (1981)
Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca* var. *sapientum*	China, Cuba, Venezuela	Tai (1979) and Urtiaga (1986)

Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Brazil, Dominican Republic, Ghana, India, Jamaica, Kenya, Malaysia, Malay Peninsula, Mexico, Philippines, Sierra Leone, Tanzania, Thailand, Tropical America	Alvarez (1976), Araujo et al. (2017), Ciferri (1929), Dade (1940), Deighton (1936), Giatgong (1980), Larter and Martyn (1943), Nattrass (1961), Padwick (1939), Riley (1960), Saccardo et al. (1931), Stevens (1925), Teodoro (1937), Thompson and Johnston (1953) and Williams and Liu (1976)
Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum* var. *paradisiaca*	Dominican Republic	Ciferri (1961)

Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, Bangladesh, Brazil, Burundi, Cambodia, Canary Islands, China, Congo, Costa Rica, Cuba, Fiji, Honduras, India, Indonesia, Iran, Island of Mayotte, Israel, Jamaica, Jordan, Laos, Lebanon, Malawi, Malaysia, Mauritius, Mozambique, Nepal, Nicaragua, Pakistan, Panama, Papua New GuinePhilippines, Puerto Rico, Rwanda, South Africa, Sri Lanka, Taiwan region in China, Tanzania, Thailand, Trinidad and Tobago, Turkey, Uganda, United States, Venezuela, Vietnam	Baker and Dale (1951), Deltour et al. (2018), Damodaran et al. (2019), Dingley et al. (1981), Garcia et al. (2018), Gerlach and Ershad (1970), Karangwa et al. (2018), Koyyappurath et al. (2016), Maryani et al. (2019), Mendes et al. (1998), Meredith (1969), Mostert (2017), O'Donnell et al. (1998), O'Neill et al. (2016), Orieux and Felix (1968), Padwick (1939), Piepenbring (2006), Ploetz and Shepard (1988), Raabe et al. (1991), Sarkar et (2013), Shaw (1984), Skovgaard et al. (2003), Stevens (1925), Thangavelu and Mustaffa (2010), Wiehe (1948) and Zeng et al. (2013)

Fusarium oxysporum Schltdl. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia, Philippines	Teodoro (1937) and Williams and Liu (1976)
Fusarium pallidoroseum (Cooke) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia, Philippines, South Africa, Spain	Crous et al. (2000) and Maryani et al. (2019)
Fusarium pallidoroseum (Cooke) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	India, South Africa	Crous et al. (2000) and Sarkar et al. (2013)
Fusarium pallidoroseum (Cooke) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, China, Indonesia	Maryani et al. (2019) and Zeng et al. (2013)
Fusarium poae (Peck) Wollenw. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	India	Sarkar et al. (2013)
Fusarium proliferatum (Matsush.) Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Guatemala, Indonesia, Iran, Malaysia, Sri Lanka	Adikaram and Yakandawala (2020), Amani (2011), Amani and Avagyan (2014), Maryani et al. (2019), Tarnowski et al. (2010) and Zakaria et al. (2016),
Fusarium proliferatum (Matsush.) Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca cv.* Awak	China	Huang et al. (2019)
Fusarium proliferatum (Matsush.) Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Indonesia, Malaysia	Abd Murad et al. (2017), Huang et al. (2019), Maryani et al. (2019) and Zeng et al. (2013)

Fusarium pseudocircinatum O'Donnell & Nirenberg*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Guatemala, United States	Tarnowski et al. (2010)
Fusarium purpurascens Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	United States	Maryani et al. (2019)
Fusarium purpurascens Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Honduras, Indonesia	Maryani et al. (2019)
Fusarium sacchari (E. J. Butler) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Guatemala, Italy	Riolo et al. (2020) and Tarnowski et al. (2010)
Fusarium sacchari (E. J. Butler) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Guatemala, Honduras	Nirenberg and O'Donnell (1998) and O'Donnell et al. (1998)
Fusarium sacchari (E. J. Butler) W. Gams*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Malaysia, Puerto Rico	Abd Murad et al. (2017), Garcia et al. (2018) and Zeng et al. (2013)
Fusarium sambucinum Brondeau*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, Honduras, Iran, Panama	Amani (2011), Amani and Avagyan (2014), Shivas (1989), Simmonds (1966) and Stover (1966)
Fusarium sambucinum Brondeau*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	India, Brazil	Gurunath Rao (1966) and Mendes et al. (1998)

Fusarium sambucinum Brondeau*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Fusarium sambucinum Brondeau*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Brazil, Libya, Trinidad and Tobago	Baker and Dale (1951), Dennis (1970), El-Buni and Rattan (1981), Kranz (1962), Kranz (1965) and Mendes et al. (1998)
Fusarium sangayamense Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)
Fusarium scirpi Lambotte & Fautrey*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Cote d'Ivoire	Resplandy et al. (1954)
Fusarium scirpi Lambotte & Fautrey*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Libya	Kranz (1962)
Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, China, Egypt, Iran, Malaysia	Abd-Alla et al. (2014), Amani (2011), Amani and Avagyan (2014), Shivas (1989), Zakaria and Rahman (2011) and Zhuang (2001)
Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa cavendishii*	Ghana	Dade (1940)
Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)

Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Brunei Darussalam, Pakistan	Ahmad et al. (1997) and Peregrine and Ahmad (1982)
Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, Costa Rica, Ecuador, Guatemala, Mexico, Papua New Guinea, South Africa, Sri Lanka, Trinidad and Tobago, United States	Abd-Alla et al. (2014), Dennis (1970), Gorter (1977), Marin et al. (1996), Photita et al. (2002), Shaw (1984) and Summerell et al. (2011)
Fusarium semitectum Berk. & Ravenel*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, Honduras, Malaysia, Panama	Chehri et al. (2014), Shivas (1989) and Stover (1966)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Australia, Brazil, Puerto Rico, West Indies, Virgin Islands	Mendes et al. (1998), Shivas (1989), Stevenson (1975) and Wallbridge (1981)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	India	Sarbhoy and Agarwal (1990)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Malaysia, Papua New Guinea	Abd Murad et al. (2017), Shaw (1984) and Zeng et al. (2013)

Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Fusarium solani (Mart.) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	Seed collection of *Musa* spp. in the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew	Malaysia and Vietnam	Hill et al. (2021)
Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, Guatemala, Indonesia, Somalia, Thailand.	Castellani and Ciferri (1937), Lumyong et al. (2003), Maryani et al. (2019), Simmonds (1966) and Tarnowski et al. (2010)
Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa cavendishii*	Greece	Holevaset al. (2000)
Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Brazil, Nicaragua	Delgado (2011) and Mendes et al. (1998)
Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Fiji, Mexico	Alvarez (1976) and Firman (1972)
Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Fiji, Hong Kong, Indonesia, Papua New Guinea, United States	Chen (2017), Dingley et al. (1981), Lu et al. (2000), Maryani et al. (2019), Meredith (1969), Shaw (1984), Xia et al. (2019) and Zhuang (2001)

Fusarium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Mexico	Alvarez (1976)
Fusarium succisae J. Schröt. ex Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Trinidad and Tobago	Baker and Dale (1951) and Dennis (1970)
Fusarium sulawesiense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019)
Fusarium sulawesiense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	China, Indonesia	Maryani et al. (2019), Wang et al. (2019) and Xia et al. (2019)
Fusarium sulawesiense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	China	Wang et al. (2019)
Fusarium sulawesiense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Bahamas	Xia et al. (2019)
Fusarium tanahbumbuense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Indonesia	Maryani et al. (2019)
Fusarium tanahbumbuense Maryani, Sand. Den., L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Maryani et al. (2019) and Xia et al. (2019)

Fusarium tardichlamydosporum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Australia, Indonesia	Maryani et al. (2019)
Fusarium tardichlamydosporum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa lutea*	Vietnam	Le Th et al. (2022)
Fusarium tardichlamydosporum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Vietnam	Le Th et al. (2022)
Fusarium tardichlamydosporum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malaysia	Lombard et al. (2019)
Fusarium tardichlamydosporum Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Australia, Brazil, Honduras, Malaysia, Tanzania	Maryani et al. (2019)
Fusarium tardicrescens Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Malawi	Maryani et al. (2019)
Fusarium tardicrescens Maryani, L. Lombard, Kema & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Malawi	Maryani et al. (2019)
Fusarium thapsinum Klittich, J. F. Leslie, P. E. Nelson & Marasas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Saudi Arabia, Thailand	Abd-Elsalam (2009) and O'Donnell et al. (1998)

Fusarium tonkinense (Bugnic.) O'Donnell, Geiser & T. Aoki*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Indonesia	Booth (1966)
Fusarium tricinctum (Corda) Sacc. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Brazil	Mendes et al. (1998)
Fusarium stilboides Wollenw. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China	Zeng et al. (2013)
Fusarium subglutinans (Wollenw. & Reinking) P. E. Nelson, Toussoun & Marasas*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa acuminata*	Iran	Amani (2011) and Amani and Avagyan (2014)
Gliocephalotrichum simplex (J. A. Mey.) B. J. Wiley & E. G. Simmons*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	New Zealand	Lombardet al. (2014)
Ilyonectria destructans (Zinssm.) Rossman, L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Malaysia	Booth (1966)
Ilyonectria destructans (Zinssm.) Rossman, L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Ilyonectria radicicola (Gerlach & L. Nilsson) P. Chaverri & Salgado*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Ilyonectria radicicola (Gerlach & L. Nilsson) P. Chaverri &	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)

Salgado*							
Nectria foliicola Berk. & M. A. Curtis	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Cuba	Linnean Society of London (1869)
Nectria foliicola Berk. & M. A. Curtis	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa textilis*	Malaysia	Johnston (1960) and Williams and Liu (1976)
Nectria foliicola Berk. & M. A. Curtis	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* × *paradisiaca*	Cuba	Arnold (1986)
Nectria henningsii Rehm	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Germany	Photita et al. (2002)
Nectria sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Brazil, Ecuador	Hanlin (1992), Marin et al. (1996) and Mendes et al. (1998)
Nectria subfalcata Henn.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	Indonesia	Samuels et al. (1990)
Neocosmospora tonkinensis (Bugnic.) Sand. Den. & Crous	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Vietnam	Sandoval-Denis et al. (2019)
Pseudonectria musae Hochapfel	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa* sp.	China, Germany	Liu and Guo (1998) and Wollenweber (1930)
Sphaerostilbe musarum S. F. Ashby	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Jamaica	Ashby (1913)
Ustilaginoidella musaeperda Essed	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa sapientum*	Tropical America	Photita et al. (2002)
Volutella sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Nectriaceae*	*Musa cavendishii*	Cuba	Arnold (1986)

Blistum musae Seifert	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Ophiocordycipitaceae*	*Musa* sp.	Canada	Ginns (1986) and Seifert (1979)
Sarocladium strictum (W. Gams) Summerb.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Sarocladiaceae*	*Musa* × *paradisiaca*	West Indies	Wallbridge (1981)
Albifimbria verrucaria (Alb. & Schwein.) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	South Africa, Thailand, Venezuela	Dennis (1970), Samarakoon et al. (2022), Surridge (2002) and This study
Brevistachys globosa L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Mexico, Sri Lanka	Lombard et al. (2016)
Brevistachys lateralis L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Australia, Thailand	Crous et al. (2019) and Lombard et al. (2016)
Brevistachys ossiformis L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* × *paradisiaca*	Brazil	Lombard et al. (2016)
Brevistachys ossiformis L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Mexico	Lombard et al. (2016)
Brevistachys subsimplex (Cooke) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Hong Kong, Thailand, Venezuela	Lumyong et al. (2003), Photita et al. (2003) and Urtiaga (2004)
Brevistachys subsimplex (Cooke) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* × *paradisiaca*	Cuba, Japan	Arnold (1986), Kobayashi (2007) and Matsushima (1975)
Brevistachys subsimplex (Cooke) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* × *paradisiaca* var. *sapientum*	Venezuela	Urtiaga (1986)

Brevistachys subsimplex (Cooke) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)
Brevistachys subsimplex (Cooke) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Bermuda, Cuba, Fiji, Mexico, Samoa, Sierra Leone, Sudan, United States	Deighton (1960), Dingley et al. (1981), McKenzie (1996), Mercado-Sierra (1984) and Heredia-Abarca et al. (1997)
Brevistachys variabilis L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa sp.*	Australia	Lombard et al. (2016)
Memnoniella dichroa (Grove) L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Thailand	Photita et al. (2003)
Memnoniella echinata (Rivolta) Galloway*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* × *paradisiaca*	Honduras, Japan	Kobayashi (2007), Matsushima (1975) and McGuire Jr and Crandall (1967),
Memnoniella levispora Subram. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021b)
Myrothecium sp.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Brazil, United States	Junior et al. (2018) and Miller (1991)
Myxospora musae L. Lombard & Crous*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Madagascar	Lombard et al. (2016)
Smaragdiniseta musae Samarakoon & Chomnunti*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2022)

Stachybotrys chartarum (Ehrenb.) S. Hughes*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)
Stachybotrys microsporus (B. L. Mathur & Sankhla) S. C. Jong & E. E. Davis*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2021)
Stachybotrys musae Samarakoon & Chomnunti*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	China	Samarakoon et al. (2021)
Stachybotrys subcylindrosporus C. Y. Jie, Y. L. Jiang, D. W. Li, McKenzie & Yong Wang*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	Thailand	This study
Stachybotrys suthepensis Photita, P. Lumyong, K. D. Hyde & McKenzie*	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Stachybotrys theobromae Hansf. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Stachybotrys globosus P. C. Misra & S. K. Srivast. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* sp.	India	Misra and Srivastava (1982)
Stachybotrys kampalensis Hansf. *	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa* × *paradisiaca*	Japan	Kobayashi (2007) and Matsushima (1975)
Stachybotrys nephrosporus Hansf.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003) and Photita et al. (2003)

Stachybotrys ruwenzoriensis Matsush.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Stachybotrys ruwenzoriensis Matsush.	*Ascomycota*	*Sordariomycetes*	*Hypocreales*	*Stachybotryaceae*	*Musa sapientum*	Uganda	Matsushima (1985)
Clavatisporella musicola K. D. Hyde	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa* sp.	Indonesia, Java	Hyde (1995)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa* sp.	Africa, Cameroon, Ghana, Guinea, Hong Kong, Jamaica, Malaysia, Sierra Leone, Taiwan region in China	Ellis (1971b), Klaubauf et al. (2014), Kranz (1963) and Revue mycologique (1889)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa acuminata*	Thailand, Venezuela	Lumyong et al. (2003) and Urtiaga (2004)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (2004)
Pyriculariopsis parasitica (Sacc. & Berl.) M. B. Ellis*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Magnaporthaceae*	*Musa sapientum*	Australia, Taiwan region in China	Matsushima (1980, 1989)

Neocordana johnstonii (M. B. Ellis) Hern. -Restr. & Crous	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa sapientum*	Australia, Indonesia, Iran, Ireland, Malaysia, Philippines, Tonga	Ellis (1971a), Ellis (1976) and Hernandez-Restrepo et al. (2015)
Neocordana johnstonii (M. B. Ellis) Hern. -Restr. & Crous	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Australia, Tonga	Allen and Dettmann (1990) and Dingley et al. (1981)
Neocordana malayensis Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Malaysia	Crous et al. (2019)
Neocordana musae (Zimm.) Hern. -Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa acuminata*	Australia, Samoa, Somalia, Sri Lanka, United States, Thailand, Venezuela	Adikaram and Yakandawala (2020), Castellani and Ciferri (1937), Dingley et al. (1981), Lumyong et al. (2003), Raabe et al. (1981), Simmonds (1966) and Urtiaga (2004)
Neocordana musae (Zimm.) Hern. -Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa banksii*	Australia	Simmonds (1966)
Neocordana musae (Zimm.) Hern. -Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa cavendishii*	Sierra Leone, Taiwan region in China	Deighton (1936)
Neocordana musae (Zimm.) Hern. -Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa ornata*	India	Gupta et al. (1983)

Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca*	Brazil, Cuba, Costa Rica, El Salvador, Haiti, Mexico, Panama, South Africa	Arnold (1986), Benjamin and Slot (1969), Crous et al. (2000), McGuire Jr and Crandall (1967) and Mendes et al. (1998)
Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca* var. *arakanensis*	Myanmar	Thaung (2008)
Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca* var. *sapientum*	China	Tai (1979)
Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa sapientum* var. *paradisiaca*	Dominican Republic	Ciferri (1961)
Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa schweinfurthii*	Ghana	Dade (1940) and Hughes (1952)

Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Australia, Brazil, China, Cook Islands, Dominican Republic, Fiji, Haiti, Hong Kong, Malaysia, Mauritius, Mexico, Niue, Panama, Papua New Guinea, Puerto Rico, Samoa, South Africa, Thailand, Tonga, United States, Venezuela, Virgin Islands, Zimbabwe	Benjamin and Slot (1969), Chen (2017), Ciferri (1961), Dennis (1970), Dingley et al. (1981), Doidge (1950), Gorter (1977), Hernandez-Restrepo et al. (2015), Hyde and Alcorn (1993), Lu et al. (2000), McKenzie (1996), Mendes et al. (1998), Meredith (1969), Orieux and Felix (1968), Piepenbring (2006), Shaw (1984), Stevenson (1975), Surridge (2002), This study, Whiteside (1966) and Zhuang (2001)
Neocordana musae (Zimm.) Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa textilis*	Brunei Darussalam, Malaysia, Malay PeninsulaPapua New Guinea	Peregrine and Ahmad (1982), Shaw (1984), Thompson and Johnston (1953), Turner (1971) and Williams and Liu (1976)

Neocordana musarum Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	France, Reunion	Crous et al. (2016) and Hernandez-Restrepo et al. (2015)
Neocordana musicola Hern. - Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Mauritius, Mexico	Hernandez-Restrepo et al. (2015)
Neocordana musigena Crous*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Morocco	Crous et al. (2017)
Pyricularia angulata Hashioka*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa acuminata*	Australia	Male et al. (2011)
Pyricularia angulata Hashioka*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa sapientum*	Japan, Korea, Thailand	Bussaban et al. (2005), Cho and Shin (2004) and Index of Fungi (1981)
Pyricularia angulata Hashioka*	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	India	Ganesan et al. (2017)
Pyricularia grisea Cooke ex Sacc. *	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa acuminata*	Australia, China, India, Somalia	Castellani and Ciferri (1937), Simmonds (1966), Sonah et al. (2009) and Zhuang (2001)
Pyricularia grisea Cooke ex Sacc. *	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca*	Brazil, Cuba	Arnold (1986) and Mendes et al. (1998)
Pyricularia grisea Cooke ex Sacc. *	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Pyricularia grisea Cooke ex Sacc. *	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Haiti	Benjamin and Slot (1969)
Pyricularia pyricularioides (Matsush.) de Hoog & Oorschot	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)

Pyricularia rabaulensis Matsush.	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* sp.	Papua New Guinea	Matsushima (1971)
Pyricularia sp.	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Pyricularia buloloensis Matsush.	*Ascomycota*	*Sordariomycetes*	*Magnaporthales*	*Pyriculariaceae*	*Musa* × *paradisiaca*	Papua New Guinea	Matsushima (1971)
Meliola sp.	*Ascomycota*	*Sordariomycetes*	*Meliolales*	*Meliolaceae*	*Musa acuminata*	China	Cao et al. (2002)
Ceratocystis musarum Riedl*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa* sp.	New Zealand	Mbenoun et al. (2014)
Ceratocystis musarum Riedl*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa speciosa*	Austria	Mbenoun et al. (2014)
Ceratocystis paradoxa (Dade) C. Moreau*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa acuminata*	Australia, Cote d'Ivoire, Egypt, Turkey, United States	Demiray et al. (2020), Maswada (2017), Raabe et al. (1981), Resplandy et al. (1954) and Simmonds (1966)
Ceratocystis paradoxa (Dade) C. Moreau*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa* × *paradisiaca*	Brazil, El Salvador, New Zealand, West Indies	Barnes et al. (2003), McGuire Jr and Crandall (1967), Mendes et al. (1998) and Wallbridge (1981)
Ceratocystis paradoxa (Dade) C. Moreau*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa sapientum*	Fiji, Jamaica, Japan, Mexico, Taiwan region in China, Tanzania, Thailand	Alvarez (1976), Firman (1972), Giatgong (1980), Kobayashi (2007), Larter and Martyn (1943) and Riley

							(1960)
Ceratocystis paradoxa (Dade) C. Moreau*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa* sp.	Brazil, Canada, China, Fiji, Haiti, Jamaica, South Africa, Southern Africa, Tanzania, Trinidad and Tobago, United States	Baker and Dale (1951), Benjamin and Slot (1969), Crous et al. (2000), Dingley et al. (1981), Doidge (1950), Gorter (1977), Ginns (1986), Meredith (1969), Nag Raj and Kendrick (1975), Roux and Wingfield (2013) and Tai (1979)
Thielaviopsis musarum (R. S. Mitchell) Riedl*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa sapientum*	Brazil	de Melo et al. (2016)
Thielaviopsis musarum (R. S. Mitchell) Riedl*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa* sp.	New Zealand	De Beer et al. (2014) and Guatimosim et al. (2016)
Thielaviopsis musarum (R. S. Mitchell) Riedl*	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa cavendishii*	Australia	Photita et al. (2002)
Thielaviopsis sp.	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Ceratocystidaceae*	*Musa textilis*	Mexico	Alvarez (1976)
Graphium sp.	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Graphiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)

Triadelphia queenslandica Matsush. *	*Ascomycota*	*Sordariomycetes*	*Microascales*	*Triadelphiaceae*	*Musa sapientum*	Australia	Matsushima (1989)
Sporothrix sp.	*Ascomycota*	*Sordariomycetes*	*Ophiostomatales*	*Ophiostomataceae*	*Musa acuminata*	Guatemala	Tarnowski et al. (2010)
Phyllachora afzeliae Syd. & P. Syd.	*Ascomycota*	*Sordariomycetes*	*Phyllachorales*	*Phyllachoraceae*	*Musa* sp.	Samoa	McKenzie (1996)
Phyllachora musae (Klotzsch) Sacc.	*Ascomycota*	*Sordariomycetes*	*Phyllachorales*	*Phyllachoraceae*	*Musaceae sp.*	India	Garcke (1833)
Phyllachora musicola C. Booth & D. E. Shaw	*Ascomycota*	*Sordariomycetes*	*Phyllachorales*	*Phyllachoraceae*	*Musa sapientum*	Fiji	Firman (1972)
Phyllachora musicola C. Booth & D. E. Shaw	*Ascomycota*	*Sordariomycetes*	*Phyllachorales*	*Phyllachoraceae*	*Musa* sp.	Australia, Fiji, Niue, Papua New Guinea, Samoa, Tonga	Dingley et al. (1981), Hyde and Alcorn (1993), Index of Fungi (1972) and Shaw (1984)
Phaeoisaria sp.	*Ascomycota*	*Sordariomycetes*	*Pleurotheciales*	*Pleurotheciaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Canalisporium caribense (Hol. - Jech. & Mercado) Nawawi & Kuthub. *	*Ascomycota*	*Sordariomycetes*	*Savoryellales*	*Savoryellaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Chaetomium elatum Kunze*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Chaetomium globosum Kunze*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa* × *paradisiaca*	Cameroon	Bechem and Afanga (2017)
Chaetomium globosum Kunze*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Chaetomium sp.	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)

Dichotomopilus erectus (Skolko & J. W. Groves) X. Wei Wang & Samson*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Dichotomopilus funicola (Cooke) X. Wei Wang & Samson*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Chaetomiaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Triangularia microsclerotigena (Madrid, Cano, Gené & Guarro) S. K. Huang & K. D. Hyde*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Lasiosphaeriaceae*	*Musa* sp.	Turkey	Madrid et al. (2011)
Bombardia musae (Maire) C. Moreau	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Lasiosphaeriaceae*	*Musa sapientum*	Mauritania	Trotter (1926)
Podospora austroamericana (Speg.) J. H. Mirza & Cain*	*Ascomycota*	*Sordariomycetes*	*Sordariales*	*Podosporaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Acrodictys oblonga G. Z. Zhao*	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* family *incertae sedis*	*Acrodictyaceae*	*Musa* sp.	China	Zhao et al. (2011)
Junewangia globulosa (Tóth) W. A. Baker & Morgan-Jones *	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* family *incertae sedis*	*Junewangiaceae*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Ellisembia minigelatinosa (Matsush.) W. P. Wu*	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* genera *incertae sedis*	*Sordariomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Solomon Islands	Matsushima (1971)
Ellisembia minigelatinosa (Matsush.) W. P. Wu*	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* genera *incertae sedis*	*Sordariomycetes* genera *incertae sedis*	*Musa sapientum*	Taiwan region in China	Matsushima (1980)

Leptosphaerella sp.	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* genera *incertae sedis*	*Sordariomycetes* genera *incertae sedis*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Leptosphaerella musicola Speg. *	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* genera *incertae sedis*	*Sordariomycetes* genera *incertae sedis*	*Musa* × *paradisiaca*	Argentina	Farr (1973) and Museo Nacional de Buenos Aires (1909)
Catabotrys sp.	*Ascomycota*	*Sordariomycetes*	*Sordariomycetes* order *incertae sedis*	*Catabotrydaceae*	*Musa* sp.	Bermuda, Sri Lanka	von Arx and Mueller (1954)
Myxosporium sp.	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Diatrypaceae*	*Musa acuminata*	China	Cao et al. (2002)
Peroneutypa scoparia (Schwein.) Carmarán & A. I. Romero*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Diatrypaceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Hyponectria sp.	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Hyponectriaceae*	*Musa* sp.	Hong Kong	Jeewon et al. (2003)
Nodulisporium sp.	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Hypoxylaceae*	*Musa acuminata*	China	Nuangmek et al. (2008)
Daldinia eschscholtzii (Ehrenb.) Rehm*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Hypoxylaceae*	*Musa* sp.	Thailand	Samarakoon et al. (2019)
Microdochium colombiense Hern. -Restr. & Crous*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Microdochiaceae*	*Musa sapientum*	Colombia	Hernandez-Restrepo et al. (2016), Liang et al. (2019) and Rana et al. (2017)
Microdochium musae Crous*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Microdochiaceae*	*Musa* sp.	China, Costa Rica, Malaysia, Mauritius, Mexico	Crous et al. (2018), Laboratoire de cryptogamie (1971) and Tai (1979)

Microdochium stoveri (C. Booth) Samuels & I. C. Hallett*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Microdochiaceae*	*Musa* sp.	Fiji, Honduras	Booth (1964), Dingley et al. (1981), Photita et al. (2002) and Rana et al. (2017)
Anthostomella clypeoides Rehm	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa acuminata*	Thailand	Lumyong et al. (2003)
Anthostomella moelleriana G. Winter	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa* sp.	Virgin Islands	Photita et al. (2002)
Astrocystis formosa (Penz. & Sacc.) L. E. Petrini	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa textilis*	Malaysia	Johnston (1960)
Dematophora bunodes (Berk. & Broome) C. Lamb., Wittstein & M. Stadler*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa sapientum*	Brazil	Hanlin (1992)
Rosellinia sp.	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa cavendishii*	Brazil	Hanlin (1992) and Mendes et al. (1998)
Zygosporium minus S. Hughes*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa* sp.	Kiribati	Dingley et al. (1981)
Zygosporium oscheoides Mont.*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa sapientum*	Ghana, Taiwan region in China, Tanzania	Hughes (1952), Matsushima (1980) and Riley (1960)
Zygosporium oscheoides Mont.*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa* × *paradisiaca*	Ghana, Japan, Papua New Guinea	Hughes (1952), Kobayashi (2007) and Matsushima (1971, 1975)
Zygosporium oscheoides Mont.*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa* sp.	Philippines	van Westerhoven et al. (2023)
Zygosporium oscheoides Mont.*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariaceae*	*Musa acuminata*	Thailand, United States	Lumyong et al. (2003) and

							Raabe et al. (1981)
Gyrothrix hughesii Piroz.	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariales* genera *incertae sedis*	*Musa* × *paradisiaca*	Sierra Leone	Pirozynski (1962)
Pseudosubramaniomyces fusisaprophyticus (Matsush.) Crous*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariales* genera *incertae sedis*	*Musa* × *paradisiaca*	Papua New Guinea	Index of Fungi (1981)
Stromatoneurospora phoenix (Kunze) S. C. Jong & E. E. Davis*	*Ascomycota*	*Sordariomycetes*	*Xylariales*	*Xylariales* genera *incertae sedis*	*Musa acuminata*	Malaysia	Zakaria et al. (2016)
Agaricus musicola Berk. & M. A. Curtis	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricaceae*	*Musa cavendishii*	Taiwan region in China	Photita et al. (2002)
Coprinus musicola (Berk.) Sacc.	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricaceae*	*Musa* sp.	French Polynesia	Photita et al. (2002)
Calyptella musae (Jungh.) W. B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* sp.	Cuba	Photita et al. (2002)
Calyptella musae (Jungh.) W. B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* × *paradisiaca*	Indonesia	Photita et al. (2002)
Calyptella musae (Jungh.) W. B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa ensete*	Germany, Netherlands	Batista and Ciferri (1962)
Cellypha musicola (Berk. & M. A. Curtis) W.B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* sp.	Cuba	Batista and Ciferri (1962)
Collybia semiusta (Berk. & M. A. Curtis) Dennis	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa textilis*	Papua New Guinea, Malaysia	Shaw (1984) and Williams and Liu (1976)
Collybia semiusta (Berk. & M. A. Curtis) Dennis	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* sp.	Fiji, Samoa, United States	Dingley et al. (1981), McKenzie (1996) and

							Meredith (1969)
Collybia semiusta (Berk. & M. A. Curtis) Dennis	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa sapientum*	Malaysia	Williams and Liu (1976)
Collybia semiusta (Berk. & M. A. Curtis) Dennis	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa acuminata*	Cote d'Ivoire, Cuba, United States	Arnold (1986), Raabe et al. (1991) and Resplandy et al. (1954)
Glabrocyphella bananae (Cooke) W. B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* sp.	United States	Cooke (1878) and Photita et al. (2002)
Glabrocyphella bananae (Cooke) W. B. Cooke	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa sapientum*	United States	Batista and Ciferri (1962)
Marasmius sp.	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* × *paradisiaca*	United States	Alfieri Jr (1984)
Marasmius sp.	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa sapientum*	United States	Alfieri Jr (1984)
Marasmius sp.	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Agaricales* genera *incertae sedis*	*Musa* sp.	Papua New Guinea, Samoa	McKenzie (1996) and Shaw (1984)
Mycena citricolor (Berk. & M. A. Curtis) Sacc. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Mycenaceae*	*Musa* × *paradisiaca*	Puerto Rico	Stevenson (1975)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa textilis*	Malaysia, Malay Peninsula	Thompson and Johnston (1953) and Turner (1971)

Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa* sp.	Fiji, Haiti, Trinidad and Tobago	Baker and Dale (1951), Benjamin and Slot (1969) and Dingley et al. (1981)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa* × *paradisiaca*	Cuba, Ghana, Sierra Leone	Arnold (1986), Dade (1940) and Deighton (1936)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa sapientum*	Fiji, Ghana, Jamaica, Malay Peninsula, Sierra Leone, Tanzania	Dade (1940), Deighton (1936), Firman (1972), Larter and Martyn (1943), Riley (1960) and Thompson and Johnston (1953)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa sinensis*	Guinea	Kranz (1963)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa cavendishii*	Sierra Leone	Deighton (1936)
Collybiopsis stenophylla (Mont.) R. H. Petersen	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa acuminata*	Australia	Simmonds (1966)
Marasmiellus epochnous (Berk. & M. A. Curtis) Singer	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa acuminata*	China	Tai (1979)
Marasmiellus inoderma (Berk.) Singer ex Furneaux*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa* × *paradisiaca*	Cuba	Urtiaga (1986)
Marasmiellus inoderma (Berk.) Singer ex Furneaux*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa sapientum*	Malaysia	Williams and Liu (1976)

Marasmiellus inoderma (Berk.) Singer ex Furneaux*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Marasmiellus inoderma (Berk.) Singer ex Furneaux*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa* sp.	Haiti, Samoa	Benjamin and Slot (1969) and McKenzie (1996)
Marasmiellus scandens (Massee) Dennis & D. A. Reid*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa sapientum*	Malaysia	Turner (1971)
Nothopanus eugrammus (Mont.) Singer*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Omphalotaceae*	*Musa* × *paradisiaca*	Venezuela	Urtiaga (1986)
Armillaria sp.	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa acuminata*	Kenya	Perez Sierra et al. (2003)
Armillaria mellea (Vahl) P. Kumm. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa textilis*	Mexico	Alvarez (1976)
Armillaria mellea (Vahl) P. Kumm. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa acuminata*	Australia	Simmonds (1966)
Armillaria mellea (Vahl) P. Kumm. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa sapientum*	Kenya, Malawi, Tanzania	Nattrass (1961) and Riley (1960)
Armillaria mellea (Vahl) P. Kumm. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa* sp.	Papua New Guinea, Southern Africa, Zimbabwe	Crous et al. (2000), Doidge (1950), Gorter (1977), Peregrine and Siddiqi (1972), Shaw (1984) and Whiteside (1966)
Desarmillaria tabescens (Scop.) R. A. Koch & Aime*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa acuminata*	United States	Alfieri Jr et al. (1984)

Desarmillaria tabescens (Scop.) R. A. Koch & Aime*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa* sp.	Mauritius	Orieux and Felix (1968)
Desarmillaria tabescens (Scop.) R. A. Koch & Aime*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa sapientum*	United States	Alfieri Jr et al. (1984)
Desarmillaria tabescens (Scop.) R. A. Koch & Aime*	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Physalacriaceae*	*Musa* × *paradisiaca*	United States	Alfieri Jr et al. (1984) and Orieux and Felix (1968)
Volvaria esculenta Massee	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Pluteaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Volvaria esculenta Massee	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Pluteaceae*	*Musa* sp.	Philippines	Teodoro (1937)
Schizophyllum commune Fr. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Schizophyllaceae*	*Musa sapientum*	Philippines	Reinking (1919) and Teodoro (1937)
Schizophyllum commune Fr. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Schizophyllaceae*	*Musa* sp.	Brazil	Assunção, et al. (2010)
Agrocybe musicola Natarajan & Purush. *	*Basidiomycota*	*Agaricomycetes*	*Agaricales*	*Strophariaceae*	*Musa* sp.	India	Photita et al. (2002)
Mycocalia reticulata (Petch) J. T. Palmer*	*Basidiomycota*	*Agaricomycetes*	*Agaricales* genera *incertae sedis*	*Mycocalia*	*Musa* sp.	Panama	Piepenbring (2006)
Agroathelia rolfsii (Sacc.) Redhead & Mullineux*	*Basidiomycota*	*Agaricomycetes*	*Amylocorticiales*	*Amylocorticiaceae*	*Musa* × *paradisiaca*	Cuba, Panama	McGuire Jr and Crandall (1967) and Urtiaga (1986)
Agroathelia rolfsii (Sacc.) Redhead & Mullineux*	*Basidiomycota*	*Agaricomycetes*	*Amylocorticiales*	*Amylocorticiaceae*	*Musa sapientum*	Malaysia, Taiwan region in China	Johnston (1960) and Sawada (1959)
Agroathelia rolfsii (Sacc.) Redhead & Mullineux*	*Basidiomycota*	*Agaricomycetes*	*Amylocorticiales*	*Amylocorticiaceae*	*Musa* sp.	India, Japan, Trinidad and Tobago	Baker and Dale (1951), Kobayashi (2007) and

							Thangavelu and Mustaffa (2010)
Agroathelia rolfsii (Sacc.) Redhead & Mullineux*	*Basidiomycota*	*Agaricomycetes*	*Amylocorticiales*	*Amylocorticiaceae*	*Musa acuminata*	Australia, India	Simmonds (1966) and Thangavelu and Mustaffa (2010)
Athelia rolfsii (Curzi) C. C. Tu & Kimbr. *	*Basidiomycota*	*Agaricomycetes*	*Atheliales*	*Atheliaceae*	*Musa* × *paradisiaca*	Philippines	Acabal et al. (2019)
Athelia rolfsii (Curzi) C. C. Tu & Kimbr. *	*Basidiomycota*	*Agaricomycetes*	*Atheliales*	*Atheliaceae*	*Musa* sp.	Panama, Philippines	Acabal Jr et al. (2019) and Piepenbring (2006)
Ceratobasidium sp.	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa* sp.	United States	Charlton et al. (2008)
Ceratobasidium sp.	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa sapientum*	Malaysia	Liu (1977)
Rhizoctonia grisea (J. A. Stev.) Matz*	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa* × *paradisiaca*	Puerto Rico, Virgin Islands	Stevenson (1975)
Rhizoctonia solani J. G. Kühn*	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa* × *paradisiaca*	United States	Alfieri Jr (1984)
Rhizoctonia solani J. G. Kühn*	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa sapientum*	Taiwan region in China	Gao et al. (2015)
Rhizoctonia solani J. G. Kühn*	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa textilis*	Malaysia, Mexico	Alvarez (1976) and Williams and Liu (1976)
Rhizoctonia sp.	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa x paradisiaca*	Bangladesh, Cuba	Arnold (1986) and Bashar et al. (2012)
Rhizoctonia sp.	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa sapientum*	Mexico	Alvarez (1976)
Rhizoctonia sp.	*Basidiomycota*	*Agaricomycetes*	*Cantharellales*	*Ceratobasidiaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Rhizoctonia sp.	*Basidiomycota*	*Agaricomycetes*	*Corticiales*	*Ceratobasidiaceae*	*Musa acuminata*	Somalia	Castellani and Ciferri (1937)

Thanatephorus microsclerotium (Matz) Boidin, Mugnier & Canales	*Basidiomycota*	*Agaricomycetes*	*Incertae sedis*	*Ceratobasidiaceae*	*Musa* × *paradisiaca*	Puerto Rico, Virgin Islands	Stevenson (1975)
Lyomyces sambuci (Pers.) P. Karst. *	*Basidiomycota*	*Agaricomycetes*	*Incertae sedis*	*Corticiaceae*	*Musa* × *paradisiaca*	United States	Gilbertson et al. (2002)
Dictyophora phalloidea Desv. *	*Basidiomycota*	*Agaricomycetes*	*Phallales*	*Phallaceae*	*Musa cavendishii*	Taiwan region in China	Photita et al. (2002)
Sporotrichum musarum Torrend	*Basidiomycota*	*Agaricomycetes*	*Polyporales*	*Phanerochaetaceae*	*Musa sapientum*	Brazil	Photita et al. (2002)
Fomes sp.	*Basidiomycota*	*Agaricomycetes*	*Polyporales*	*Polyporaceae*	*Musa acuminata*	Australia	Simmonds (1966)
Poria ravenalae (Berk. & Broome) Sacc. *	*Basidiomycota*	*Agaricomycetes*	*Polyporales*	*Polyporaceae*	*Musa textilis*	Malay Peninsula	Thompson and Johnston (1953)
Trametes tenuis (Berk.) Justo	*Basidiomycota*	*Agaricomycetes*	*Polyporales*	*Polyporaceae*	*Musa sapientum*	Philippines	Reinking (1919) and Teodoro (1937)
Peniophora crassitunicata Boidin, Lanq. & Gilles*	*Basidiomycota*	*Agaricomycetes*	*Russulales*	*Peniophoraceae*	*Musa* sp.	Brazil	Junior et al. (2018)
Pseudobensingtonia musae (M. Takash., S. O. Suh & Nakase) F. Y. Bai, Q. M. Wang, M. Groenew. & Boekhout*	*Basidiomycota*	*Agaricostilbomycetes*	*Agaricostilbales*	*Agaricostilbaceae*	*Musa* × *paradisiaca*	Thailand	Takashima et al. (1995)
Corticium centrifugum (Weinm.) Fr.	*Basidiomycota*	*Bartheletiomycetes*	*Corticiales*	*Corticiaceae*	*Musa* sp.	China	Tai (1979)
Pyrrhoderma noxium (Corner) L. W. Zhou & Y. C. Dai*	*Basidiomycota*	*Bartheletiomycetes*	*Hymenochaetales*	*Hymenochaetaceae*	*Musa acuminata-balbisiana*	Australia	Stewart et al. (2020)

Rigidoporus microporus (Sw.) Overeem*	*Basidiomycota*	*Bartheletiomycetes*	*Polyporales*	*Meripilaceae*	*Musa* × *paradisiaca*	United States	Gilbertson et al. (2002)
Rigidiporus vinctus (Berk.)	*Basidiomycota*	*Bartheletiomycetes*	*Polyporales*	*Meripilaceae*	*Musa Paradisiaca*	India	Savani et al. (2021)
Rigidiporus vinctus (Berk.)	*Basidiomycota*	*Bartheletiomycetes*	*Polyporales*	*Meripilaceae*	*Musa acuminata*	Australia	Simmonds (1966)
Puccinia heliconiae (Dietel) Arthur	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniaceae*	*Musa textilis*	Brazil	Hennen et al. (1982), Hennen et al. (2005) and Mendes et al. (1998)
Uromyces musae Henn. *	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniaceae*	*Musa* sp.	Fiji, Samoa	Dingley et al. (1981)
Uromyces musae Henn. *	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniaceae*	*Musa sapientum*	Fiji, Philippines	Firman (1972) and Teodoro (1937)
Uredo musae Cummins*	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniales* genera *incertae sedis*	*Musa sapientum*	Malaysia, Pacific Islands	Mouchacca and Horak (1998) and Turner (1971)
Uredo musae Cummins*	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniales* genera *incertae sedis*	*Musa* × *paradisiaca*	Indonesia	Boedijn (1959)
Uredo musae Cummins*	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniales* genera *incertae sedis*	*Musa acuminata* subsp. *banksii*	Samoa	Dingley et al. (1981)
Uredo musae Cummins*	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniales* genera *incertae sedis*	*Musa* sp.	Fiji, New Guinea, Papua New Guinea, Samoa, Thailand	Cummins (1941), Dingley et al. (1981), Engkhaninun et al. (2005), McKenzie (1996) and Shaw (1984)

Uredo musicola J. M. Yen	*Basidiomycota*	*Pucciniomycetes*	*Pucciniales*	*Pucciniales* genera *incertae sedis*	*Musa* sp.	Philippines	Yen (1974)
Mortierella sp.	*Mortierellomycota*	*Mortierellomycetes*	*Mortierellales*	*Mortierellaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Cunninghamella echinulata var. *echinulata* (Thaxt.) Thaxt. ex-Blakeslee*	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Cunninghamellaceae*	*Musa acuminata*	Honduras, Panama	Stover (1966)
Cunninghamella echinulata var. *echinulata* (Thaxt.) Thaxt. ex-Blakeslee*	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Cunninghamellaceae*	*Musa* sp.	Papua New Guinea	Shaw (1984)
Mucor caespitulosus Speg. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Mucoraceae*	*Musa ensete*	Argentina	Photita et al. (2002)
Mucor hiemalis Wehmer*	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Mucoraceae*	*Musa textilis*	Malaysia	Williams and Liu (1976)
Mucor racemosus Bull. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Mucoraceae*	*Musa textilis*	Philippines	Teodoro (1937)
Mucor sp.	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Mucoraceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)
Rhizoctonia sp.	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa textilis*	Malay Peninsula, Philippines	Teodoro (1937) and Thompson and Johnston (1953)
Rhizopus arrhizus A. Fisch. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa textilis*	Philippines	Teodoro (1937)
Rhizopus arrhizus A. Fisch. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa sapientum*	South Korea	Kwon et al. (2012)
Rhizopus sp.	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa* × *paradisiaca*	Brazil	Mendes et al. (1998)

Rhizopus stolonifer (Ehrenb.) Vuill. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa sapientum*	Japan, Kenya, South Korea, Taiwan region in China	Kobayashi (2007), Kwon et al. (2012) and Nattrass (1961)
Rhizopus stolonifer (Ehrenb.) Vuill. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa* × *paradisiaca* var. *sapientum*	Cuba	Urtiaga (1986)
Rhizopus stolonifer (Ehrenb.) Vuill. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa* × *paradisiaca*	Cuba, South Africa	Crous et al. (2000) and Urtiaga (1986)
Rhizopus stolonifer (Ehrenb.) Vuill. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa acuminata*	Cuba, South Africa	Crous et al. (2000) and Urtiaga (2004)
Rhizopus stolonifer (Ehrenb.) Vuill. *	*Mucoromycota*	*Mucoromycetes*	*Mucorales*	*Rhizopodaceae*	*Musa* sp.	South Africa, United States	Gorter (1977), Sarkar et al. (2013), Shaw (1984), Stevenson (1975) and Whiteside (1966)

APPENDIX B

COLLECTION DETAILS OF CHAPTER 11

Note Based on the Von Loesecke ripening scale (Companhia de Entrepostos e Armazéns Gerais de São Paulo, 2006), the ripening stages of bananas were divided into seven categories:

Stage 1 = entirely green peel

Stage 2 = green peel with traces of yellow

Stage 3 = more green than yellow peel

Stage 4 = more yellow than green peel

Stage 5 = yellow peel with traces of green

Stage 6 = entirely yellow peel

Stage 7 = yellow peel with brown spots

Note Additionally, the maturity of the banana specimens was documented in collaboration with both the commercial seller and the cultivator. The days were counted in weeks since the formation of the banana inflorescence.

Note A summary of collected specimens, disease severity index, maturity, peel colour index, collection sites, season, and the identified fungal taxa are attached in this appendix

Disease symptom	Sample unit (bunch number)	Variety	Disease Severity Category (1/2/3 for Anthracnose, 5/6/7 for Speckles)	Maturity when the symptoms observed (Weeks since inflorescence)	The ripening stages and peel colour (based on the Von Loesecke ripening scale)	Total number of				Collection details				Fungal taxa isolated from the symptoms (identified by culture and spore Morphology/ phylogeny)		
						Disease symptoms selected per fruit	Fruits selected from a bunch	Symptoms observed	Symptoms selected for isolation	Collected date	Season	Sample location	Province	Initial group (separated based on colony characters)	Name of the taxa	Isolates selected from the initial plates
Anthracnose	B2	Namwa banana	Mild (1)	15-16	Entirely yellow (6)	2	2	4	2	15-Sep-18	Rainy season	Nang Lae, Fah Thai local market	Chiang Rai	CGA	*Colletotrichum musae*	SMBC2, SMBC3, SMBC5
Anthracnose	B5	Namwa banana	Severe (3)	15-16	Entirely yellow with brown spots (7)	4	5	20	3	Sep-18	Rainy season	Nang Lae, Fah Thai local market	Chiang Rai	CGA	*C. musae*	SMBC7, SMBC8
Anthracnose	B6	Namwa banana	Moderate (2)	15-16	Entirely yellow with brown spots (7)	3	4	12	4	5-Dec-18	Dry season	Local banana stall at Nan city	Nan	CGA	*C. musae*	SMBC9A, SMBC9B
Anthracnose	B8	Namwa banana	Moderate (2)	15-16	Entirely yellow with brown spots (7)	3	4	12	4	2-Feb-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGA	*C. musae*	SM11, SM12, SM13
Anthracnose	**B52**	**Namwa banana**	**Moderate (2)**	15-16	Entirely yellow with brown spots (7)	**3**	**4**	**12**	**4**	**16-Apr-22**	**Dry season**	**Saraphi, Commercial seller**	**Chiang Mai**	CGA	***C. musae***	**SM33, SM14, SM15**
Anthracnose	B51	Namwa banana	Moderate (2)	15-16	Entirely yellow with brown spots (7)	3	4	12	4	9-Apr-22	Dry season	Local market at Chiang Dao	Chiang Mai	CGA	*C. musae*	SM17, SM18

Anthracnose	B21	Namwa banana	Mild (1)	15-16	Entirely yellow (6)	2	2	4	2	14-May-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGA	*C. musae*	SM19, SM19B
Anthracnose	**B22**	**Namwa banana**	**Mild (1)**	15-16	Entirely yellow (6)	**2**	**2**	**4**	**2**	**15-Oct-21**	**Dry season**	**Nang Lae, Fah Thai local market**	**Chiang Rai**	CGA	***C. musae***	**SM30, SM22, SM24**
Anthracnose	B27	Namwa banana	Severe (3)	15-16	Entirely yellow with brown spots (7)	4	5	20	3	14-May-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGA	*C. musae*	SM26A, SM 26C
Anthracnose	**B30**	**Namwa banana**	**Severe (3)**	**16**	Entirely yellow with brown spots (7)	**4**	**5**	**20**	**3**	**23-Nov-21**	**Rainy season**	**Ban Du municipality market**	**Chiang Rai**	CGA	***C. musae***	**SM31, SM31D**
Anthracnose	B5	Khai bananas	Moderate (2)	15-16	Entirely yellow with brown spots (7)	2	2	4	2	25-Jan-19	Dry season	Ban Du municipality market	Chiang Rai	CGB	*C. siamense*	SMBC16
Anthracnose	B28	Khai bananas	Moderate (2)	15-16	Entirely yellow with brown spots (7)	2	2	4	2	16-May-19	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGB	*C. siamense*	SM46
Anthracnose	**B44**	**Khai bananas**	**Mild (1)**	15-16	Entirely yellow (6)	**2**	**3**	**6**	**2**	**4-Dec-21**	**Dry season**	**Mae Chan municipality market**	**Chiang Rai**	CGB	***C. siamense***	**SM42, SM43**
Anthracnose	B10	Khai bananas	Moderate (2)	15-16	Entirely yellow with brown spots (7)	3	3	9	3	21-Apr-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGB	*C. siamense*	SM48
Anthracnose	B11	Khai bananas	Severe (3)	16	Entirely yellow with brown spots (7)	3	2	6	3	24-Apr-21	Dry season	Mae Chan municipality market	Chiang Rai	CGB	*C. siamense*	SM49

Anthracnose	B18	Khai bananas	Severe (3)	16	Entirely yellow with brown spots (7)	3	3	9	3	28-Apr-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGB	*C. siamense*	SM50, SM51A
Anthracnose	**B19**	**Khai bananas**	**Severe (3)**	**15-16**	Entirely yellow with brown spots (7)	**3**	**2**	**6**	**3**	**22-Jun-21**	**Dry season**	**Nang Lae, Fah Thai local market**	**Chiang Rai**	CGB	***C. siamense***	**SM36, SM37**
Anthracnose	B23	Khai bananas	Severe (3)	15-16	Entirely yellow with brown spots (7)	3	1	3	3	28-May-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CGB	*C. siamense*	SM53, SM54
Anthracnose	B25	Khai bananas	Moderate (2)	15-16	Entirely yellow with brown spots (7)	3	1	3	3	9-Jun-21	Rainy season	Nang Lae, Fah Thai local market	Chiang Rai	CGB	*C. siamense*	SM55, SM60
Anthracnose	**B35**	**Khai bananas**	**Moderate (2)**	**15-16**	Entirely yellow with brown spots (7)	**3**	**2**	**6**	**3**	**19-Jun-22**	**Dry season**	**Ban Du municipality market**	**Chiang Rai**	**CGB**	***C. siamense***	**SM35, SM34A**
Fruit speckles	**B3**	**Namwa banana**	**Mild (5)**	**13**	Entirely **green (1)**	**5**	**2**	**10**	**4**	**4-Dec-18**	**Dry season**	**Local banana stall at Nan city**	**Nan**	**CORGC**	***Corynespora torulosa***	**NAN2018**
Fruit speckles	B7	Namwa banana	Mild (5)	13	Entirely green (1)	5	2	10	4	4-Dec-20	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CORGC	*C. torulosa*	B03, B03B
Fruit speckles	B45	Namwa banana	Mild (5)	13-14	More green than yellow (3)	5	3	15	4	25-Oct-21	Rainy season	Nang Lae, Fah Thai local market	Chiang Rai	CORGC	*C. torulosa*	B04
Fruit speckles	B46	Namwa banana	Mild (5)	13-14	**More yellow than green (4)**	5	3	15	4	30-Oct-21	Rainy season	Ban Du municipality market	Chiang Rai	CORGC	*C. torulosa*	B05

Fruit speckles	B17	Namwa banana	Moderate (6)	13	Entirely green (1)	10	3	30	4	6-Nov-21	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CORGC	*C. torulosa*	B06
Fruit speckles	B55	Namwa banana	Moderate (6)	13-14	More green than yellow (3)	10	3	30	4	14-Nov-21	Dry season	Ban Du municipality market	Chiang Rai	CORGC	*C. torulosa*	B07
Fruit speckles	**B24**	**Namwa banana**	**Severe (7)**	**14-15**	**Yellow peel with traces of green (5)**	**10**	**4**	**40**	**4**	**17-Jan-22**	**Dry season**	**Nang Lae, Fah Thai local market**	**Chiang Rai**	**CORGC**	***C. torulosa***	**B01, B01A**
Fruit speckles	B50	Namwa banana	Moderate (6)	14-15	Entirely yellow (6)	10	3	30	4	23-Dec-21	Dry season	Ban Du municipality market	Chiang Rai	CORGC	*C. torulosa*	B08, B10
Fruit speckles	**B49**	**Namwa banana**	**Moderate (6)**	**14-15**	**More green than yellow (3)**	**10**	**3**	**30**	**4**	**10-May-21**	**Dry season**	**Local market at Chiang Dao**	**Chiang Mai**	**CORGC**	***C. torulosa***	**B02, B02A**
Fruit speckles	B68	Namwa banana	Moderate (6)	14-15	More green than yellow (3)	10	3	30	4	14-Dec-22	Dry season	Nang Lae, Fah Thai local market	Chiang Rai	CORGC	*C. torulosa*	B09

APPENDIX C

CHEMICAL REAGENTS AND MEDIA

1. Potassium hydroxide (KOH) used in the rehydration of dried specimens. 5% aqueous solution

2. Lactoglycerol used for maintaining semipermanent slides

Lactic acid 10 ml

Glycerol 10 ml

Distilled water 10 ml

Mix 10 ml lactic acid, 10 ml glycerol, and add 10 ml distilled water

3. Lactic acid which preserves fungal structures and for getting a true color image of the fungal spore and structures without staining. This is helpful for some of the darker colored organisms.

85% Lactic acid 100 ml

3. Lactophenol-Cotton Blue used to highlight fungal structures for viewing with the compound light microscope. Cotton blue is the most popular stain for observe pseudoparaphyses, septate or ascus walled. This is gives excellent clarity and is also suitable for most fungal groups

Phenol (crystals) 20 g

Lactic acid 16 ml

Glycerol 31 ml

Dissolve phenol in distilled water, add lactic acid, glycerol and 0.05 g of Poirrier's (cotton) blue or acid fuchsin.

4. Melzer's Reagent is a good general mounting medium that clears the material somewhat and allows particularly brilliant resolution with a microscope, and used for identification of ascomycete fungi. Amyloid reaction of asci changed to blue or heavily purple colours.

Chloral hydrate 100 g

Potassium iodide 5 g

Iodine 1.5 g

Distilled water 100 ml

5. Malt Extract Agar (MEA) used for fungal cultivation

Agar 15 g

Peptone 0.78 g

Glycerol 2.35 g

Dextrin 2.75 g

Maltose, Technical 12.75 g

Suspend 33.6 g of malt extract agar in distilled water and mix thoroughly. Heat with frequent agitation and boil for 1 minute to completely dissolve the power and bring volume to 1000 ml. Autoclave at 121^{o}C for 15 minutes

6. Potato dextrose agar (PDA) used for fungal cultivation

Potato starch (from infusion) 4 g

Dextrose 20 g

Agar 15 g

Suspend 39 g of Potato dextrose agar in distilled water and mix thoroughly. Heat with frequent agitation and boil for 1 minute to completely dissolve the power and bring volume to 1000 ml. Autoclave at 121^{o}C for 15 minutes.

APPENDIX D

PUBLICATIONS

Eur J Plant Pathol
https://doi.org/10.1007/s10658-024-02842-z

Taxonomic and phylogenetic assessment of selected fungal pathogens associated with banana fruits in the local markets of northern Thailand

Binu C. Samarakoon · Milan C. Samarakoon · Dhanushka N. Wanasinghe · Ruvishika S. Jayawardena · Kevin D. Hyde · Putarak Chomnunti

Accepted: 5 March 2024
© Koninklijke Nederlandse Planteziektenkundige Vereniging 2024

Abstract Bananas are susceptible to various post-harvest diseases caused by a diverse range of pathogens. The present study focused on the identification and characterization of two prevalent banana fruit diseases, anthracnose and speckle, in three provinces of northern Thailand. Symptomatic banana fruits were collected from local markets. Surface-sterilized, infected banana skin segments were used to isolate the associated fungi on potato dextrose agar. Morphologically distinct isolates of *Colletotrichum* spp. and *Corynespora* sp. were obtained from the anthracnose lesions and speckles, respectively. Fungal identification was based on morphology and phylogenetic analyses of the ITS, LSU, *act*, *cmdA*, *tub*2, *chs*-1, and *gapdh* sequences. *Colletotrichum musae* and *C. siamense* were identified as the causal agents of post-harvest anthracnose in the bananas Kluai Namwa (*Musa acuminata* × *M. balbisiana*; ABB genomic group; Pisang Awak) and Kluai Khai (*M. acuminata*; AA genomic group; Sucrier), respectively. *Corynespora torulosa* was found to cause speckles in Kluai Namwa fruits. Koch's postulates were successfully established by inoculating fresh and unripe banana fruits with the identified strains, and confirmed the pathogenicity. *Colletotrichum musae*, *C. siamense*, and *C. torulosa* were re-isolated from the inoculated fruits and justified with morpho-molecular data. To our knowledge, this is the first confirmed occurrence of *C. torulosa* causing banana fruit speckles in Kluai Namwa in Thailand. In addition, we document the presence of *C. siamense*, causing post-harvest anthracnose in Kluai Khai. This study contributes to a better understanding of post-harvest banana diseases and addresses the current challenges in the commercial banana industry in northern Thailand.

Keywords Anthracnose · *Colletotrichum siamense* · *Corynespora torulosa* · First report · *Musa* · Speckles

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10658-024-02842-z.

B. C. Samarakoon · R. S. Jayawardena · K. D. Hyde · P. Chomnunti (✉)
School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
e-mail: putarak.cho@mfu.ac.th

B. C. Samarakoon · R. S. Jayawardena · K. D. Hyde
Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand

M. C. Samarakoon
Department of Entomology and Plant Pathology, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand

D. N. Wanasinghe
Centre for Mountain Futures (CMF), Kunming Institute of Botany, Chinese Academy of Sciences, Honghe, Yunnan 654400, China

Published online: 02 April 2024

Biodiversity Data Journal 10: e89360
doi: 10.3897/BDJ.10.e89360

open access

Taxonomy & Inventories

Taxonomy and phylogeny of *Smaragdiniseta musae* sp. nov. and *Albifimbria verrucaria* (Hypocreales, Stachybotryaceae) on *Musa* from Thailand

Binu C. Samarakoon[‡,§], Dhanushka N. Wanasinghe[|,¶], Jayarama Bhat[#], Putarak Chomnunti[¤]

‡ Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai, 57100, Thailand
§ School of Science, Mae Fah Luang University, Chiang Rai, 57100, Thailand
| CIFOR-ICRAF China Program, World Agroforestry (ICRAF), Kunming 650201, China
¶ Centre for Mountain Futures (CMF), Kunming Institute of Botany, Chinese Academy of Sciences, Honghe 654400, Yunnan, China
# Department of Botany, Goa University, Goa, India
¤ School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand

Corresponding author: Putarak Chomnunti (putarak.cho@mfu.ac.th)

Academic editor: Ning Jiang

Received: 21 Jun 2022 | Accepted: 22 Jul 2022 | Published: 27 Jul 2022

Citation: Samarakoon BC, Wanasinghe DN, Bhat J, Chomnunti P (2022) Taxonomy and phylogeny of *Smaragdiniseta musae* sp. nov. and *Albifimbria verrucaria* (Hypocreales, Stachybotryaceae) on *Musa* from Thailand. Biodiversity Data Journal 10: e89360. https://doi.org/10.3897/BDJ.10.e89360

Abstract

Background

Smaragdiniseta musae is introduced as a leaf-based novel saprobic species from *Musa*. Multi-gene phylogenetic analyses of internal transcribed spacer (ITS), RNA polymerase II second largest subunit (rpb2) and β-tubulin (tub2) data support the taxonomic placement of the new collection in *Smaragdiniseta* (Hypocreales, Stachybotryaceae). The novel species is characterised by cup-shaped sporodochia covered by numerous peripheral setae and simple hyaline, guttulate conidia produced by the ultimate branches (phialides) of conidiophores.

© Samarakoon B et al. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

life

MDPI

Article

Stachybotrys musae sp. nov., *S. microsporus*, and *Memnoniella levispora* (*Stachybotryaceae*, *Hypocreales*) Found on Bananas in China and Thailand

Binu C. Samarakoon [1,2,3], Dhanushka N. Wanasinghe [1,4,5], Rungtiwa Phookamsak [1,4,5,6], Jayarama Bhat [7], Putarak Chomnunti [2,3], Samantha C. Karunarathna [1,4,5,6,*] and Saisamorn Lumyong [6,8,9,*]

1 CAS Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China; binusamarakoon2@gmail.com (B.C.S.); wanasinghe@mail.kib.ac.cn (D.N.W.); jomjam.rp2@gmail.com (R.P.)
2 Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand; putarak.cho@mfu.ac.th
3 School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
4 World Agroforestry Centre, East and Central Asia, 132 Lanhei Road, Kunming 650201, China
5 Centre for Mountain Futures (CMF), Kunming Institute of Botany, Kunming 650201, China
6 Research Center of Microbial Diversity and Sustainable Utilization, Faculty of Sciences, Chiang Mai University, Chiang Mai 50200, Thailand
7 Formerly, Department of Botany, Goa University, Goa, Res: House No. 128/1-J, Azad Co-Op Housing Society, Curca, P.O. Goa Velha 403108, India; bhatdj@gmail.com
8 Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand
9 Academy of Science, The Royal Society of Thailand, Bangkok 10300, Thailand
* Correspondence: samanthakarunarathna@gmail.com (S.C.K.); scboi009@gmail.com (S.L.)

check for updates

Citation: Samarakoon, B.C.; Wanasinghe, D.N.; Phookamsak, R.; Bhat, J.; Chomnunti, P.; Karunarathna, S.C.; Lumyong, S. *Stachybotrys musae* sp. nov., *S. microsporus*, and *Memnoniella levispora* (*Stachybotryaceae*, *Hypocreales*) Found on Bananas in China and Thailand. *Life* **2021**, *11*, 323. https://doi.org/10.3390/life11040323

Academic Editor: Laura Selbmann

Received: 10 March 2021
Accepted: 1 April 2021
Published: 7 April 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract: A study was conducted to investigate saprobic fungal niches of *Stachybotryaceae* (Hypocreales) associated with leaves of *Musa* (banana) in China and Thailand. Three hyphomycetous taxa were collected during the dry season of 2018 and 2019. After a careful phenotypic characterization (both macro- and microscopically) and a phylogenetic tree reconstruction using a concatenated sequence dataset of internal transcribed spacer (ITS), calmodulin (*cmdA*), RNA polymerase II second largest subunit (*rpb2*), β-tubulin (*tub2*), and the translation elongation factor 1-alpha (*tef1*) gene regions, we report three species of Stachybotryaceae. *Stachybotrys musae* is introduced as a novel taxon from Yunnan, China, while *S. microsporus* is reported from Chiang Rai Province in Thailand on *Musa*. In addition, *Memnoniella levispora* is also reported from China for the first time.

Keywords: new species; fungi on banana; *Musaceae*; saprobes; *Sordariomycetes*

1. Introduction

In the past three decades, there have been several studies on saprobic fungi associated with tropical monocotyledonous hosts [1–10]. In addition, detailed taxonomic studies have been conducted to describe and document the saprobic fungi on *Musa* across South and South East Asia [11–16].

Stachybotryaceae accommodates 39 genera (including *Memnoniella* and *Stachybotrys*) in *Hypocreales* [17,18]. The taxonomic histories of *Memnoniella* and *Stachybotrys* are detailed in Wang et al. [19] and Lombard et al. [20]. An updated phylogeny for *Stachybotryaceae* was provided by Lombard et al. [20] using partial 28S large sub unit (LSU), internal transcribed spacer (ITS), *rpb2*, *cmdA*, *tef1*, and *tub2* sequence data. Previously, Smith [21] and Wang et al. [19] stated that *Memnoniella* and *Stachybotrys* are congeneric. However, Lombard et al. [20] resurrected *Memnoniella* as a distinct genus in *Stachybotryaceae*. Lin et al. [22], Doilom et al. [23], Hyde et al. [17], and Mapook et al. [24] further supported the observations of Lombard et al. [20] and treated *Memnoniella* and *Stachybotrys* as two distinct genera. Hyde et al. [17] documented nine species of *Memnoniella* with DNA sequence data. Index



Studies in Fungi 6(1): 92–115 (2021) www.studiesinfungi.org ISSN 2465-4973
Article

Doi 10.5943/sif/6/1/5

New host and geographic records of five pleosporalean hyphomycetes associated with *Musa* spp. (Banana)

Samarakoon BC[2,3], Phookamsak R[4,5,6,7,9], Karunarathna SC[4,5,6,7,9], Jeewon R[8], Chomnunti P[2,3], Xu JC[4,5,6,7*] and Li YJ[1*]

[1]*The State Phosphorus Resource Development and Utilization Engineering Technology Research Centre, Yunnan Phosphate Chemical Group Co. Ltd, Kunming 650201, China*
[2]*Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand.*
[3]*School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand.*
[4]*CAS Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, Yunnan, China.*
[5]*East and Central Asia Regional Office, World Agroforestry Centre (ICRAF), Kunming 650201, Yunnan, China.*
[6]*Centre for Mountain Futures (CMF), Kunming Institute of Botany, Kunming 650201, Yunnan, China.*
[7]*Honghe Center for Mountain Futures, Kunming Institute of Botany, Chinese Academy of Sciences, Honghe County 654400, Yunnan, People's Republic of China*
[8]*Department of Health Sciences, Faculty of Medicine and Health Sciences, University of Mauritius, Reduit, Mauritius*
[9]*Research Center of Microbial Diversity and Sustainable Utilization, Faculty of Sciences, Chiang Mai University, Chiang Mai 50200, Thailand*

Samarakoon BC, Phookamsak R, Karunarathna SC, Jeewon R, Chomnunti P, Xu JC, Li YJ 2021 – New host and geographic records of five pleosporalean hyphomycetes associated with *Musa* spp. (Banana). Studies in Fungi 6(1), 92–115, Doi 10.5943/sif/6/1/5

Abstract

A study was undertaken to collect and identify saprobic fungi associated with *Musa* spp. (banana) from Taiwan, China, and Thailand. Samples were collected during the dry season and their morpho–molecular relationships were investigated. Five brown pleosporalean hyphomycetous taxa in Periconiaceae and Torulaceae viz. *Periconia cortaderiae*, *P. delonicis*, *Torula chromolaenae*, *T. fici*, and *T. masonii* were identified for the first time from *Musa* spp. (Musaceae). Phylogenetic analyses of a combined SSU, LSU, ITS, RPB2 and TEF DNA sequence dataset further justified the taxonomic placements of these five taxa in the above mentioned families. *Periconia delonicis* is reported for the first time on a monocotyledonous host and *T. masonii* is the first geographical record from Taiwan.

Key words – Dothideomycetes – *Periconia* – Pleosporales – taxonomy – *Torula*

Introduction

Studies of fungi on *Musa* spp. have been conducted since the 19th century, especially in tropics and subtropics (Sawada 1959, Ellis 1971, 1976, Matsushima 1971, Ebbels & Allen 1979, Shaw 1984, Sivanesan 1984, Arnold 1986, Aptroot 1995, Heredia–Abarca et al. 1997, Photita et al. 2001a, b, 2002, 2003b, Somrithipol 2007). However, these studies were restricted to some fungal groups (e.g. hyphomycetous and endophytic fungi) and were based mostly on morphological characteristics. Hence, less novel species on *Musa* spp. were consequently introduced based on morphological characteristics coupled with phylogenetic analyses (Gao et al. 2014, Hernández–Restrepo et al. 2015, Liu et al. 2015, Crous et al. 2016, 2017, Samarakoon et al. 2020a, b).

Submitted 9 January 2021, Accepted 3 February 2021, Published 24 February 2021
Corresponding Author: Jian-Chu Xu – email – jxu@mail.kib.ac.cn, Yun-Ju Li – email – 93905507@qq.com

MycoKeys 70: 19–37 (2020)
doi: 10.3897/mycokeys.70.52043
http://mycokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
MycoKeys
Launched to accelerate biodiversity research

Taxonomy and phylogenetic appraisal of *Spegazzinia musae* sp. nov. and *S. deightonii* (Didymosphaeriaceae, Pleosporales) on Musaceae from Thailand

Binu C. Samarakoon[1,2,3,4], Rungtiwa Phookamsak[4,5,6,7,9], Dhanushka N. Wanasinghe[4,5,6,7], Putarak Chomnunti[2,3], Kevin D. Hyde[2,3,4,7], Eric H. C. McKenzie[8], Itthayakorn Promputtha[9,10], Jian-Chu Xu[4,5,6], Yun-Ju Li[1]

1 *The State Phosphorus Resource Development and Utilization Engineering Technology Research Centre, Yunnan Phosphate Chemical Group Co. Ltd, Kunming 650201, China* **2** *School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand* **3** *Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand* **4** *Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, Yunnan, China* **5** *East and Central Asia Regional Office, World Agroforestry Centre (ICRAF), Kunming 650201, Yunnan, China* **6** *Honghe Center for Mountain Futures, Kunming Institute of Botany, Chinese Academy of Sciences, Honghe County, Yunnan, China* **7** *Institute of Plant Health, Zhongkai University of Agriculture and Engineering, Guang Dong Province, China* **8** *Landcare Research Manaaki Whenua, Private Bag 92170, Auckland, New Zealand* **9** *Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand* **10** *Research Center in Bioresources for Agriculture, Industry and Medicine, Chiang Mai University, Chiang Mai 50200, Thailand*

Corresponding author: Jian-Chu Xu (jxu@mail.kib.ac.cn); Yun-Ju Li (93905507@qq.com)

Academic editor: H. Raja | Received 13 March 2020 | Accepted 29 April 2020 | Published 21 July 2020

Citation: Samarakoon BC, Phookamsak R, Wanasinghe DN, Chomnunti P, Hyde KD, McKenzie EHC, Promputtha I, Xu J-C, Li Y-J (2020) Taxonomy and phylogenetic appraisal of *Spegazzinia musae* sp. nov. and *S. deightonii* (Didymosphaeriaceae, Pleosporales) on Musaceae from Thailand. MycoKeys 70: 19–37. https://doi.org/10.3897/mycokeys.70.52043

Abstract

Tropical plants host a range of fungal niches including endophytes, pathogens, epiphytes and saprobes. A study undertaken to discover the saprobic fungal species associated with *Musa* sp. (banana) from northern Thailand found two hyphomycetous taxa of *Spegazzinia* (Didymosphaeriaceae, Pleosporales). These were collected during the dry season and their morpho-molecular taxonomic relationships were investigated. Based on phylogenetic analysis of combined SSU, LSU, ITS and TEF1-α sequence data (77% ML, 0.99 BYPP) and contrasting morphological features to the sister taxon, we introduce *Spegazzinia musae* as a

Copyright *Binu C. Samarakoon et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

MycoKeys 71: 101–118 (2020)
doi: 10.3897/mycokeys.71.55493
http://mycokeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
MycoKeys
Launched to accelerate biodiversity research

Multi-gene phylogenetic evidence suggests *Dictyoarthrinium* belongs in Didymosphaeriaceae (Pleosporales, Dothideomycetes) and *Dictyoarthrinium musae* sp. nov. on *Musa* from Thailand

Binu C. Samarakoon[1,2,3], Dhanushka N. Wanasinghe[4,5,6], Milan C. Samarakoon[1,2], Rungtiwa Phookamsak[1,4,5,6,9], Eric H. C. McKenzie[8], Putarak Chomnunti[2,3], Kevin D. Hyde[2,7], Saisamorn Lumyong[1,9,10], Samantha C. Karunarathna[1,4,5,6,9]

1 *Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand* **2** *Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand* **3** *School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand* **4** *CAS Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, Yunnan, China* **5** *World Agro Forestry Centre, East and Central Asia, 132 Lanhei Road, Kunming 650201, Yunnan, China* **6** *Centre for Mountain Futures (CMF), Kunming Institute of Botany, Kunming 650201, Yunnan, China* **7** *Innovative Institute of Plant Health, Zhongkai University of Agriculture and Engineering, Guangdong Province, People's Republic of China* **8** *Manaaki Whenua-Landcare Research, Private Bag 92170, Auckland, New Zealand* **9** *Research Center of Microbial Diversity and Sustainable Utilization, Faculty of Sciences, Chiang Mai University, Chiang Mai 50200, Thailand* **10** *Academy of Science, The Royal Society of Thailand, Bangkok 10300, Thailand*

Corresponding authors: S. C. Karunarathna (samanthakarunarathna@gmail.com); S. Lumyong (scboi009@gmail.com)

Academic editor: Huzefa Raja | Received 16 June 2020 | Accepted 12 July 2020 | Published 5 August 2020

Citation: Samarakoon BC, Wanasinghe DN, Samarakoon MC, Phookamsak R, McKenzie EHC, Chomnunti P, Hyde KD, Lumyong S, Karunarathna SC (2020) Multi-gene phylogenetic evidence suggests *Dictyoarthrinium* belongs in Didymosphaeriaceae (Pleosporales, Dothideomycetes) and *Dictyoarthrinium musae* sp. nov. on *Musa* from Thailand. MycoKeys 71: 101–118. https://doi.org/10.3897/mycokeys.71.55493

Abstract

Dead leaves of *Musa* sp. (banana) were collected in northern Thailand during an investigation of saprobic fungi. Preliminary morphological observations revealed that three specimens belong to *Dictyoarthrinium*. Phylogenetic analyses of combined SSU, LSU, ITS and *tef*1-α sequence data revealed that *Dictyoarthrinium* forms a clade in Didymosphaeriaceae (Massarineae, Pleosporales, Dothideomycetes) sister to *Spegazzinia*. Based on contrasting morphological features with the extant taxa of *Dictyoarthrinium*, coupled with the multigene analyses, *Dictyoarthrinium musae* sp. nov. is introduced herein. Our study

Copyright *Binu C. Samarakoon et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Asian Journal of Mycology 2(1): 183–197 (2019) ISSN 2651-1339

www.asianjournalofmycology.org **Article**

Doi 10.5943/ajom/2/1/9

The first report of *Daldinia eschscholtzii* as an endophyte from leaves of *Musa* sp. (Musaceae) in Thailand

Samarakoon SMBC[1,2], Samarakoon MC[2,5], Aluthmuhandiram JVS[1,2,6], Wanasinghe DN[3,4] and Chomnunti P[1,2*]

[1] *School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand*
[2] *Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai 57100, Thailand*
[3] *Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Science, Kunming 650201, Yunnan, China*
[4] *World Agro Forestry Centre, East and Central Asia, 132 Lanhei Road, Kunming 650201, Yunnan, China*
[5] *Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand*
[6] *Beijing Key Laboratory of Environment Friendly Management on Fruit Diseases and Pests in North China, Institute of Plant and Environment Protection, Beijing Academy of Agriculture and Forestry Sciences, Beijing 100097, China*

Samarakoon SMBC, Samarakoon MC, Aluthmuhandiram JVS, Wanasinghe DN, Chomnunti P 2019 – The first report of *Daldinia eschscholtzii* as an endophyte from leaves of *Musa* sp. (Musaceae) in Thailand. Asian Journal of Mycology 2(1), 183–197, Doi 10.5943/ajom/2/1/9

Abstract

There has been increasing research interest in the isolation of fungal endophytes from different hosts or tissue types of the same host from many tropical regions. However, there have been few studies conducted on musaceous endophytes in Thailand. In this study, we provide the first report of *Daldinia eschscholtzii* (Hypoxylaceae) as an endophyte isolated from symptomless fresh leaves of *Musa* sp. (Musaceae) in northern Thailand. In addition, this is the first record of *Daldinia* from Musaceae and the second report of *D. eschscholtzii* from monocotyledons. Fungi isolates are illustrated, described and subjected to LSU-ITS-RPB2-BTUB concatenated phylogenies using maximum likelihood and Bayesian analysis with an updated tree of Hypoxylaceae.

Keywords – Banana – Host – Hypoxylaceae – Monocots – Record

Introduction

Fungi exhibit various nutritional modes such as endophytes, saprobes and pathogens in different hosts and habitats (Wang et al. 2005, Hyde et al. 2018, Tibpromma et al. 2018, Jayawardena et al. 2019). Endophytes inhabit living and healthy tissues without causing apparent disease symptoms (Schulz & Boyle 2006). *Musa* sp. (banana) is a tropical monocotyledonous plant in family Musaceae. Several endophytic fungi have been recorded from *Musa* species in Australia (Brown et al. 1998), Brazil (Pereira et al. 1999), Central America (Pocasangre et al. 1999), China (Cao et al. 2002, 2003) and Hong Kong (Brown et al. 1998). *Acremonium* Link (Pocasangre et al. 1999, Cao et al. 2003), *Bipolaris* Shoemaker (Zakaria & Aziz 2018), *Colletotrichum* Corda (Brown et al. 1998, Cao et al. 2003), *Fusarium* Link, *Nigrospora* Zimm. (Brown et al. 1998), *Pestalotiopsis* Steyaert, *Phoma* Fr., *Trichoderma* Pers. and *Verticillium* Nees (Pocasangre et al. 1999, Cao et al. 2003) were the common genera that found as fungal endophytes from *Musa* sp. Cao et al. (2002)

Submitted 16 May 2019, Accepted 25 June 2019, Published 28 June 2019
Corresponding Author: Putarak Chomnunti– e-mail – putarak.cho@mfu.ac.th

Plant Pathology & Quarantine 9(1): 139–151 (2019) ISSN 2229-2217
www.ppqjournal.org **Article**

Doi 10.5943/ppq/9/1/12

The plant pathogenic genus *Neocordana*

Samarakoon SMBC[1,2], Wanasinghe DN[3,5], Jeewon R[4], Tian Q[1,5], Jayawardena RS[1] and Chomnunti P[2*]

[1] Center of Excellence in Fungal Research, Mae Fah Luang University, Chiang Rai, 57100, Thailand
[2] School of Science, Mae Fah Luang University, Chiang Rai, 57100, Thailand
[3] World Agro Forestry Centre, East and Central Asia, 132 Lanhei Road, Kunming 650201, Yunnan, China
[4] Department of Health Sciences, Faculty of Science, University of Mauritius, Reduit, Mauritius
[5] Key Laboratory for Plant Biodiversity and Biogeography of East Asia (KLPB), Kunming Institute of Botany, Chinese Academy of Science, Kunming 650201, Yunnan, China

Samarakoon SMBC, Wanasinghe DN, Jeewon R, Tian Q, Jayawardena RS, Chomnunti P 2019 – The plant pathogenic genus *Neocordana*. Plant Pathology & Quarantine 9(1), 139–151, Doi 10.5943/ppq/9/1/12

Abstract

Neocordana species mainly causes leaf spots on *Musa* spp. (banana and plantain) and on *Canna denudata* (an ornamental plant). Leaf spots on *Musa* spp. reduce the quality of the commodity and result in significant economic loss. Based on molecular and morphological data, the genus accommodates seven species at present with a worldwide distribution. Most of the taxonomic work has been conducted on *Neocordana musae*. In this study, updates on the diversity, distribution, and morpho-molecular taxonomy of *Neocordana* are provided. In addition, important aspects such as pathogenicity, disease control, antagonistic activity and association with other pathogenic fungi are discussed. The phylogenetic relationships of *Neocordana* with other genera in the family Pyriculariaceae based on LSU and ITS DNA sequence data are investigated. Our results support the monophyletic nature of *Neocordana* which is sister to *Barretomyces*. This study provides the first comprehensive account on diversity, taxonomy, and pathogenicity of *Neocordana*.

Keywords – antagonistic – banana – controlling – endophytic – pathogens – Pyriculariaceae

Introduction

Fungi are organisms that play various ecological roles in the environment, including decomposition of organic matter, recycling of nutrients, and exhibit pathogenic and endophytic lifestyles (Tang et al. 2005, Treseder & Lennon 2015, Rampadarath et al. 2018, Wanasinghe et al. 2018b). The asexual genus, *Neocordana* was established by Hernández-Restrepo et al. (2015) and accommodated in the family Pyriculariaceae, order Magnaporthales. *Neocordana musae* (Zimm.) Hern.-Restr. & Crous is the type species (Hernández-Restrepo et al. 2015) and seven plant pathogenic and saprobic taxa (Index Fungorum 2019) are included in the genus from a limited number of hosts (Musaceae and Cannaceae) worldwide (Jones 1999, Hernández-Restrepo et al. 2015, Crous et al. 2016, 2017, 2019) (Table 1). Several studies have reported that fungi can exhibit different lifestyles such as endophytes, saprobes or pathogens (Promputtha et al. 2007, Maharachchikumbura et al. 2011, Jeewon et al. 2013). *Neocordana* is an excellent example for a

Submitted 28 December 2018, Accepted 27 May 2019, Published 6 June 2019
Corresponding Author: Putarak Chomnunti – e-mail – putarak.cho@mfu.ac.th

CURRICULUM VITAE

CURRICULUM VITAE

NAME Binu Chamini Samarakoon Mudiyanselage

EDUCATIONAL BACKGROUND

2016 B.Sc. (Honors) Special Degree in Botany, Biological Science
University of Peradeniya, Sri Lanka.

WORK EXPERIENCE

2017-2024 Graduate research assistant
School of Science, Mae Fah Luang University, Thailand

2022-2024 Graduate teaching assistant
School of Science, Mae Fah Luang University

SCHOLARSHIP

2020-2022 Post-graduate Tuition Scholarship,
Mae Fah Luang University

PUBLICATIONS

Samarakoon, B. C., Wanasinghe, D. N., Samarakoon, M. C., Bundhun, D., Jayawardena, R., Hyde, K. D., . . . Chomnunti, P. (2024). Exploring fungi: A taxonomic and phylogenetic study of leaf-inhabiting *Ascomycota* in *Musa* species from northern Thailand, with a global checklist. *Mycosphere*, *In press.*

Samarakoon, B. C., Samarakoon, M. C., Wanasinghe, D. N., Jayawardena, R. S., Hyde, K. D., & Chomnunti, P. (2024). Taxonomic and phylogenetic assessment of selected fungal pathogens associated with banana fruits in the local markets of northern Thailand. *European Journal of Plant Pathology, 169,* 483–502.

Samarakoon, B. C., Wanasinghe, D., Bhat, J., & Chomnunti, P. (2022). Taxonomy and phylogeny of *Smaragdiniseta musae* sp. nov. and *Albifimbria verrucaria* (*Hypocreales*, *Stachybotryaceae*) on *Musa* from Thailand. *Biodiversity Data Journal*, *10*, Article e89360.

Samarakoon, B. C., Wanasinghe, D. N., Phookamsak, R., Bhat, J., Chomnunti, P., Karunarathna, S. C., . . . Lumyong, S. (2021). *Stachybotrys musae* sp. nov., *S. microsporus*, and *Memnoniella levispora* (*Stachybotryaceae*, *Hypocreales*) found on bananas in China and Thailand. *Life*, *11*, 323.

Samarakoon, B. C., Phookamsak, R., Karunarathna, S. C., Jeewon, R., Chomnunti, P., Xu, J. C., . . . Li, Y. J. (2021). New host and geographic records of five pleosporalean hyphomycetes associated with *Musa* spp. (Banana). *Studies in Fungi*, *6*, 92-115.

Samarakoon, B. C., Wanasinghe, D. N., Samarakoon, M. C., Phookamsak, R., McKenzie, E. H. C., Chomnunti, P., . . . Karunarathna, S. C. (2020). Multi-gene phylogenetic evidence suggests *Dictyoarthrinium* belongs in *Didymosphaeriaceae* (*Pleosporales*, *Dothideomycetes*) and *Dictyoarthrinium musae* sp. nov. on *Musa* from Thailand. *MycoKeys*, *71*, 101–118.

Samarakoon, B. C., Phookamsak, R., Wanasinghe, D. N., Chomnunti, P., Hyde, K. D., McKenzie, E. H. C., . . . Li, Y. J. (2020). Taxonomy and phylogenetic appraisal of *Spegazzinia musae* sp. nov. and *S. deightonii* (*Didymosphaeriaceae*) on *Musaceae* from Thailand. *MycoKeys*, *70*, 19–37.

Samarakoon, B. C., Samarakoon, M. C., Aluthmuhandiram, J. V. S., Wanasinghe, D. N., & Chomnunti, P. (2019). The first report of *Daldinia eschscholtzii* as an endophyte from leaves of *Musa sp.* (*Musaceae*) in Thailand. *Asian Journal of Mycology*, *2*, 183–197.

Samarakoon, B. C., Wanasinghe, D. N., Jeewon, R., Tian, Q., Jayawardena, R. S., & Chomnunti, P. (2019). The plant pathogenic genus *Neocordana*. *Plant Pathology & Quarantine*, *9*, 139–151.