

# Morphophylogenetic evidence reveals four new fungal species within Tetraplosphaeriaceae (Pleosporales, Ascomycota) from tropical and subtropical forest in China

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## Abstract

Tetraplosphaeriaceae (Pleosporales, Ascomycota) is a family with many saprobes recorded from various hosts, especially bamboo and grasses. During a taxonomic investigation of microfungi in tropical and subtropical forest regions of Guizhou, Hainan and Yunnan provinces, China, several plant samples were collected and examined for fungi. Four newly discovered species are described based on morphology and evolutionary relationships with their allies inferred from phylogenetic analyses derived from a combined dataset of LSU, ITS, SSU, and *tub2* DNA sequence data. Detailed illustrations, descriptions and taxonomic notes are provided for each species. The four new species of Tetraplosphaeriaceae reported herein are *Polyplosphaeria guizhouensis*, *Polyplosphaeria hainanensis*, *Pseudotetraploa yunnanensis*, and *Tetraploa hainanensis*. A checklist of Tetraplosphaeriaceae species with available details on their ecology is also provided.

**Key words:** Anamorphic fungi, checklist, Dothideomycetes, ribosomal genes, species diversity, taxonomy



Academic editor: C. S. Bhunjun  
Received: 22 September 2023  
Accepted: 9 November 2023  
Published: 6 December 2023

**Citation:** Tang X, Jeewon R, Lu Y-Z, Alrefaei AF, Jayawardena RS, Xu R-J, Ma J, Chen X-M, Kang J-C (2023) Morphophylogenetic evidence reveals four new fungal species within Tetraplosphaeriaceae (Pleosporales, Ascomycota) from tropical and subtropical forest in China. MycoKeys 100: 171–204. <https://doi.org/10.3897/mycokeys.100.113141>

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## Introduction

The Southwestern part of China is characterised by a tropical to subtropical climate and several provinces are well known for their high diversity of plants as well as fungi (Feng and Yang 2018; Hyde et al. 2020b; Bao et al. 2021; Yang et al. 2023). Yunnan province, for example, is considered a hotspot for species diversity. Over the last few decades, there has been a number of studies that have reported novel fungal species from this region (Jeewon et al. 2003; Luo et al. 2017, 2018; Huang et al. 2018; Su et al. 2018; Yang et al. 2019; Hyde et al. 2020b;

Bao et al. 2021; Mortimer et al. 2021). So far more than 6000 fungal species described alone from Yunnan province (Feng and Yang 2018). Guizhou, as a prominent example of China's karst landform (also referred to as a 'karst province'), is also characterised by a geomorphological diversity that can be directly related to species diversity. It boasts a distinctive geographical environment and a special climate that fosters the growth of numerous rare, endangered, and indigenous plant, animal, and fungal species. Over the past few decades, extensive research has focused on fungi, encompassing both macro and microfungi, leading to the identification and documentation of roughly over 2,500 fungal species in Guizhou province (Zhou et al. 2018, 2020a, 2020b, 2022; Dissanayake et al. 2020; Chen et al. 2021; Yang et al. 2023). Hainan Province, the largest island in the Indo-Burma biodiversity hotspot, contains extensive and well-preserved tropical forests (Huang et al. 2023). Recent studies have indicated the presence of diverse fungal species in Hainan, with roughly over 1000 fungal species. Most of these fungi are macrofungi (Zhang et al. 1994; Li et al. 2010; Hapuarachchi et al. 2018; Huang et al. 2023). With our current fungal biodiversity estimates and given that mycologists anticipate many more species remain to be discovered especially in explored habitats, this research study has been undertaken to investigate microfungi in this region, and potentially discover new fungal species.

Tetraplosphaeriaceae was introduced by Tanaka et al. (2009) to accommodate the massarina-like species that produced tetraploa-like anamorphs in culture with *Tetraplosphaeria* as its type genus. Tetraplosphaeriaceae is known to be widely distributed on various hosts, with most species reported from bamboo or grasses (Poaceae) (Tanaka et al. 2009; Ariyawansa et al. 2015; Li et al. 2016), while *Tetraploa* species occur on diverse hosts (Hyde et al. 2013). Tetraplosphaeriaceae was first described to accommodate five genera: *Polyplosphaeria* Kaz. Tanaka & K. Hiray, *Pseudotetraploa* Kaz. Tanaka & K. Hiray, *Quadricrura* Kaz. Tanaka & K. Hiray, *Tetraplosphaeria* Kaz. Tanaka & K. Hiray, and *Triplosphaeria* Kaz. Tanaka & K. Hiray (Tanaka et al. 2009). Hyde et al. (2013) treated the type genus, *Tetraplosphaeria* as a synonym of *Tetraploa* according to nomenclatural priority. Ariyawansa et al. (2015) accepted *Shrungabeeja* in Tetraplosphaeriaceae based on morphological and molecular evidence from *S. longiappendiculata*. Later, *Ernakulamia* was accommodated in Tetraplosphaeriaceae based on morphology and phylogenetic analyses of combined ITS, LSU and *tub2* sequence data (Delgado et al. 2017; Hyde et al. 2020a). Pem et al. (2019) transferred *Byssolophis* from the genera incertae sedis to Tetraplosphaeriaceae based on its massarina-like morphology and phylogenetic analyses based on combined LSU, SSU, *tef1-a*, and *rpb2* sequence data. Hongsanan et al. (2020) provided a taxonomic update on families of Dothideomycetes and eight genera were accepted in Tetraplosphaeriaceae. Recently, Li et al. (2021) discovered a freshwater fungus that had a close phylogenetic affinity with *Ernakulamia* and *Shrungabeeja* in Tetraplosphaeriaceae and accommodated it in a new genus *Aquatisphaeria* based on morphology and phylogeny. To date, Tetraplosphaeriaceae consists of nine genera (Hongsanan et al. 2020; Li et al. 2021; Wijayawardene et al. 2022).

Most members of Tetraplosphaeriaceae contain anamorphic species (Wijayawardene et al. 2022). However, *Pseudotetraploa*, *Tetraploa*, and *Triplosphaeria* exhibit both teleomorphs and anamorphs (Wijayawardene et al. 2022), while *Byssolophis* is only known in its teleomorphic morph (Tanaka et al. 2009; Ariyawansa et al. 2015; Pem et al. 2019; Hongsanan et al. 2020; Li et al. 2021;

Jayawardena et al. 2023). Tetraplosphaeriaceae is characterized by massari-na-like teleomorph morphs but can be distinguished from other families by its immersed to superficial, glabrous or brown hyphae at sides of ascomata with flattened bases and cylindrical to clavate, short pedicellate 8-spored asci which are narrowly fusiform to broadly cylindrical, septate, hyaline to pale brown ascospores, usually with a complete sheath or appendage-like sheath (Tanaka et al. 2009; Hyde et al. 2013). The anamorphs are tetraploa-like hyphomycetes having micronematous to macronematous, erect, unbranched, septate, with presence or absence of conidiophores, monoblastic, terminal conidiogenous cells sometimes indistinguishable from creeping hyphae, solitary, cylindrical to obpyriform, comprising 3–8 columns or internal hyphal structure conidia, mostly verrucose at the conidial base and with 2–8-setose appendages (Tanaka et al. 2009; Hyde et al. 2013; Hongsanan et al. 2020).

In this study, the aim is to characterize anamorphic fungal species collected from the southern part of China. The objectives are to 1) to describe novel species collected from Guizhou, Hainan, and Yunnan provinces in China, based on morphological examination of fresh specimens; 2) to document morphological differences and similarities with extant species; 3) to establish four new species within the family Tetraplosphaeriaceae with support from results generated from phylogenetic analyses of LSU, ITS, SSU, and *tub2* DNA sequence data; 4) to provide a worldwide checklist of Tetraplosphaeriaceae species with available details on their ecology.

This study will undoubtedly increase our understanding of fungal diversity in China.

## Materials and methods

### Sample collection, isolation and morphological studies

Fresh samples of unidentified decaying wood and decaying bamboo were collected in Guizhou (Xingyi city, Xianheping National Forest Park), Hainan (Wuzhishan city, Wuzhishan National Nature Reserve), and Yunnan (Puer city, Ailao mountains) provinces respectively. During the collection period, the environmental conditions at the different regions were as follows: Guizhou-average temperature of 26 °C, subtropical climate, humid environment during autumn; Hainan-average temperature of 29 °C, tropical climate, humid environment during autumn; Yunnan-average temperature of 22 °C, subtropical climate, humid environment during spring. The samples were placed in Ziplock bags, labelled with a marker pen, and observed using the stereomicroscope (Motic SMZ-171). The procedure for specimen collection, observation and isolation follows that of Senanayake et al. (2020) and Tang et al. (2022). The morphological measurements were performed by the Tarosoft (R) Image Frame Work tool (IFW 0.97 version), and photoplates were created using the Adobe Photoshop 2019 program (Adobe Systems, USA).

After morphological examination, the specimens were deposited at the herbaria of Kunming Institute of Botany, Chinese Academy of Sciences (**HKAS**), Kunming, China, and the Guizhou Academy of Agriculture Sciences (**GZAAS**), Guiyang, China, respectively. The ex-type cultures were deposited at the Guizhou Culture Collection (**GZCC**) in China and the Kunming Institute of Botany Culture Collection (**KUNCC**). Faces of Fungi and Index Fungorum numbers are provided as in Jayasiri

et al. (2015) and Index Fungorum (2023). Species recognition and justifications for new species establishment were done based on the guide-lines provided by Jeewon and Hyde (2016), Chethana et al. (2021) and Pem et al. (2021).

### DNA extraction, PCR amplification and sequencing

Fresh mycelium was scraped from the living culture and transferred to 1.5 mL microcentrifuge tubes and kept in a refrigerator at -20 °C. Total genomic DNA was extracted using the DNA extraction kits (Sangon Biotech (Shanghai) Co. Ltd., China). DNA template amplifications were performed by Polymerase Chain Reaction (PCR) using primer pairs, ITS5/ITS4 for ITS (White et al. 1990), NS1/NS4 for SSU (White et al. 1990), LR0R/LR5 for LSU (Vilgalys and Hester 1990, Cubeta et al. 1991), and BT1/BT2b for *tub2* (Glass and Donaldson 1995). For other details pertaining to DNA extraction, PCR amplifications, sequencing, and phylogenetic analyses, see Tang et al. (2022). The polymerase chain reaction was carried out in a volume of 50 µL, and the reagents that were used were as follows: DNA template (2 µL), forward primers (2 µL), reverse primers (2 µL), 2 × Taq PCR Master Mix (25 µL) and 19 µL of ddH<sub>2</sub>O (double-distilled water). PCR profiles are as follows: 35 cycles, and the annealing temperatures for each gene are 52 °C for 1 minute and extension at 72 °C for 90 seconds in LSU, ITS and SSU; and 55 °C for 50 s and elongation at 72 °C for 1 minute for *tub2*. Verification of PCR products was done on 1% agarose gels before being sent to China's Sangon Biotech (Shanghai) Co., Ltd. for sequencing.

### Phylogenetic analyses

The forward and reverse primers of the newly generated sequence were assembled by the Contig Ex-press v3.0.0 application, and the most similar taxa were found by BLASTn (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>) in NCBI. A combination of different DNA sequence data (LSU, ITS, SSU, and *tub2*), which are close hits and similar to other Tetraplosphaeriaceae species in GenBank (Table 1), were downloaded to be further analysed along with our new taxa. Each sequence data was aligned by the online version of MAFFT v. 7 (<https://mafft.cbrc.jp/alignment/server/index.html>) through the “auto” option (Katoh et al. 2017). Multiple genes were assembled by SequenceMatrix (Vaidya et al. 2011). The aligned sequence was trimmed by trimAl v 1.2 with the ‘gappyout’ option (Capella-Gutiérrez et al. 2009). The phylogenetic analyses in this study were based on the maximum likelihood (ML), and Bayesian inference (BI) by using a combined sequence dataset of LSU, ITS, SSU, and *tub2*.

Analyses under different criteria such as maximum likelihood (ML) and Bayesian inference (BI) were processed in the CIPRES web portal (Miller et al. 2010) by using the “RAxML-HPC v.8 on XSEDE” tool, and the tool “MrBayes on XSEDE”, respectively (Huelsenbeck and Ronquist 2001; Swofford 2002; Stamatakis et al. 2008; Ronquist et al. 2012).

For BI, MrModeltest v2 was used for the selection of the best-fit model for each gene region. The Markov Chain Monte Carlo (MCMC) algorithm was launched with four chains running concurrently from a random tree topology. The burn-in factor was set at 25%, and the sampling interval for trees was set to every 1000<sup>th</sup> generation. The Posterior Probabilities (PP) for the remaining

**Table 1.** Taxa used in this study and their GenBank accession numbers for LSU, ITS, SSU and *tub2* sequence data.

| Taxa name                          | Strain Numbers       | GenBank Accession Numbers |                 |                 |                 |
|------------------------------------|----------------------|---------------------------|-----------------|-----------------|-----------------|
|                                    |                      | LSU                       | SSU             | ITS             | <i>tub2</i>     |
| <i>Amniculicola immersa</i>        | CBS 123083T          | NG_056964                 | NG_062796       | –               | –               |
| <i>A. parva</i>                    | CBS 123092T          | NG_056970                 | NG_016504       | –               | –               |
| <i>Aquatisphaeria thailandica</i>  | MFLUCC 21–0025T      | MW890763                  | MW890967        | MW890969        | –               |
| <i>Aq. Thailandica</i>             | DLUCC B151           | MW890764                  | MW890968        | –               | –               |
| <i>Byssolophis sphaerioides</i>    | IFRDCC 2053          | GU301805                  | GU296140        | –               | –               |
| <i>Ernakulamia cochinchensis</i>   | MFLUCC 18–1237       | MN913716                  | MT864326        | MT627670        | –               |
| <i>E. krabiensis</i>               | MFLUCC 18–0237T      | MK347990                  | MK347880        | MK347773        | –               |
| <i>E. tanakae</i>                  | NFCCI 4615T          | MN937211                  | –               | MN937229        | MN938312        |
| <i>E. xishuangbannaensis</i>       | KUMCC 17–0187T       | MH260314                  | MH260354        | MH275080        | –               |
| <i>Polyplosphaeria fusca</i>       | KT 2124              | AB524607                  | AB524466        | AB524791        | AB524853        |
| <i>Po. Fusca</i>                   | KT 1616T             | AB524604                  | AB524463        | AB524789        | AB524851        |
| <b><i>Po. guizhouensis</i></b>     | <b>GZCC 23–0598T</b> | <b>OR438888</b>           | <b>–</b>        | <b>OR427327</b> | <b>OR449118</b> |
| <b><i>Po. Hainanensis</i></b>      | <b>GZCC 23–0599T</b> | <b>OR438889</b>           | <b>OR438285</b> | <b>OR427323</b> | <b>OR449115</b> |
| <b><i>Po. Hainanensis</i></b>      | <b>GZCC 23–0600</b>  | <b>OR438890</b>           | <b>–</b>        | <b>OR427324</b> | <b>–</b>        |
| <i>Po. Thailandica</i>             | MFLUCC 15–0840T      | KU248767                  | –               | KU248766        | –               |
| <i>Po. nabanheensis</i>            | KUMCC 16–0151T       | MH260312                  | MH260352        | MH275078        | MH412745        |
| <i>Po. pandanicola</i>             | MFLUCC 17–2266T      | MH260313                  | MH260353        | MH275079        | –               |
| <i>Pseudotetraploa bambusicola</i> | CGMCC 3.20939T       | ON332933                  | ON332923        | ON332915        | –               |
| <i>Ps. bambusicola</i>             | UESTCC 22.0005       | ON332934                  | ON332924        | ON332916        | –               |
| <i>Ps. curviappendiculata</i>      | JCM 12852T           | AB524608                  | AB524467        | AB524792        | AB524854        |
| <i>Ps. Javanica</i>                | JCM 12854            | AB524611                  | AB524470        | AB524795        | AB524857        |
| <i>Ps. Longissima</i>              | JCM 12853T           | AB524612                  | AB524471        | AB524796        | AB524858        |
| <i>Ps. rajmachiensis</i>           | NFCCI 4618T          | MN937204                  | –               | MN937222        | –               |
| <b><i>Ps. Yunnanensis</i></b>      | <b>KUNCC 10464T</b>  | <b>OR438891</b>           | <b>–</b>        | <b>OR449073</b> | <b>–</b>        |
| <i>Quadricrura bicornis</i>        | CBS 125427T          | AB524613                  | AB524472        | AB524797        | AB524859        |
| <i>Q. meridionalis</i>             | CBS 125684T          | AB524614                  | AB524473        | AB524798        | AB524860        |
| <i>Q. septentrionalis</i>          | CBS 125429           | AB524615                  | AB524474        | AB524799        | AB524861        |
| <i>Shrungabeeja aquatica</i>       | MFLUCC 18–0664T      | MT627663                  | –               | MT627722        | –               |
| <i>S. longiappendiculata</i>       | BCC 76463T           | KT376472                  | KT376471        | KT376474        | –               |
| <i>S. longiappendiculata</i>       | BCC 76464            | KT376473                  | –               | KT376475        | –               |
| <i>S. fluviatilis</i>              | GZCC 20–0505T        | –                         | –               | –               | –               |
| <i>S. fluviatilis</i>              | GZCC 19–0511         | MW133853                  | MW134631        | –               | –               |
| <i>S. vadirajensis</i>             | MFLUCC 17–2362       | MN913685                  | –               | MT627681        | –               |
| <i>Tetraploa aquatica</i>          | MFLU 19–0996         | MT530453                  | MT530454        | MT530449        | –               |
| <i>T. aquatica</i>                 | MFLUCC 19–0995T      | MT530452                  | –               | MT530448        | –               |
| <i>T. aristata</i>                 | CBS 996.70           | AB524627                  | AB524486        | AB524805        | AB524867        |
| <i>T. bambusae</i>                 | KUMCC 21–0844T       | ON077067                  | ON077073        | ON077078        | ON075065        |
| <i>T. dwibahubeeja</i>             | NFCCI 4621T          | MN937207                  | –               | MN937225        | MN938308        |
| <i>T. dwibahubeeja</i>             | NFCCI 4623           | MN937208                  | –               | MN937226        | MN938309        |
| <i>T. endophytica</i>              | CBS 147114T          | MW659165                  | –               | KT270279        | –               |
| <b><i>T. hainanensis</i></b>       | <b>GZCC 23–0601T</b> | <b>OR438892</b>           | <b>OR438286</b> | <b>OR427325</b> | <b>OR449116</b> |
| <b><i>T. hainanensis</i></b>       | <b>GZCC 23–0602</b>  | <b>OR438893</b>           | <b>–</b>        | <b>OR427326</b> | <b>OR449117</b> |
| <i>T. juncicola</i>                | CBS 149046           | ON603800                  | –               | ON603780        | –               |
| <i>T. nagasakiensis</i>            | KUMCC 18–0109        | MK079891                  | MK079888        | MK079890        | –               |
| <i>T. nagasakiensis</i>            | KT 1682T             | AB524630                  | AB524489        | AB524806        | AB524868        |

| Taxa name                   | Strain Numbers  | GenBank Accession Numbers |          |          |          |
|-----------------------------|-----------------|---------------------------|----------|----------|----------|
|                             |                 | LSU                       | SSU      | ITS      | tub2     |
| <i>T. pseudoaristata</i>    | NFCCI 4624T     | MN937214                  | –        | MN937232 | MN938315 |
| <i>T. pseudoaristata</i>    | NFCCI 4625      | MN937212                  | –        | MN937230 | MN938313 |
| <i>T. puzheheensis</i>      | MFLUCC 20–0151T | MT627655                  | –        | MT627744 | –        |
| <i>T. sasicola</i>          | KT 563T         | AB524631                  | AB524490 | AB524807 | AB524869 |
| <i>T. thailandica</i>       | MFLUCC 21–0030T | MZ412530                  | MZ413274 | MZ412518 | –        |
| <i>T. thrayabahubeeja</i>   | NFCCI 4627T     | MN937217                  | –        | MN937235 | MN938318 |
| <i>T. thrayabahubeeja</i>   | NFCCI 4628      | MN937215                  | –        | MN937233 | MN938316 |
| <i>T. yunnanensis</i>       | MFLUCC 19–0319T | MN913735                  | MT864341 | MT627743 | –        |
| <i>T. yakushimensis</i>     | KT 1906T        | AB524632                  | AB524491 | AB524808 | AB524870 |
| <i>T. cylindrica</i>        | KUMCC 20–0205T  | MT893204                  | MT893203 | MT893205 | MT899417 |
| <i>T. cylindrica</i>        | ZHKUCC 22–0087  | ON555688                  | ON555690 | ON555689 | ON564477 |
| <i>T. dashaoensis</i>       | KUMCC 21–0010T  | OL473555                  | OL473556 | OL473549 | OL505601 |
| <i>T. obpyriformis</i>      | KUMCC 21–0011T  | OL473554                  | OL473557 | OL473558 | OL505600 |
| <i>Tetraploa</i> sp.1       | KT 1684         | AB524628                  | AB524487 | –        | –        |
| <i>Tetraploa</i> sp.2       | KT 2578         | AB524629                  | AB524488 | –        | –        |
| <i>T. tetraploa</i>         | CY112           | –                         | –        | HQ607964 | –        |
| <i>Triplosphaeria acuta</i> | KT 1170T        | AB524633                  | AB524492 | AB524809 | AB524871 |
| <i>Tr. Cylindrica</i>       | NBRC 106247     | AB524636                  | AB524495 | AB524811 | AB524873 |
| <i>Tr. cylindrica</i>       | KT 1800         | AB524635                  | AB524494 | AB524810 | AB524872 |
| <i>Tr. maxima</i>           | KT 870T         | AB524637                  | AB524496 | AB524812 | AB524874 |
| <i>Tr. yezoensis</i>        | KT 1715T        | AB524638                  | AB524497 | AB524813 | AB524875 |
| <i>Tr. yezoensis</i>        | KT 1732         | AB524639                  | AB524498 | AB524814 | AB524876 |
| <i>Triplosphaeria</i> sp.   | HHUF 27481      | AB524640                  | AB524499 | AB524815 | AB524877 |
| <i>Triplosphaeria</i> sp.   | KT 2546         | AB524641                  | AB524500 | AB524816 | AB524878 |

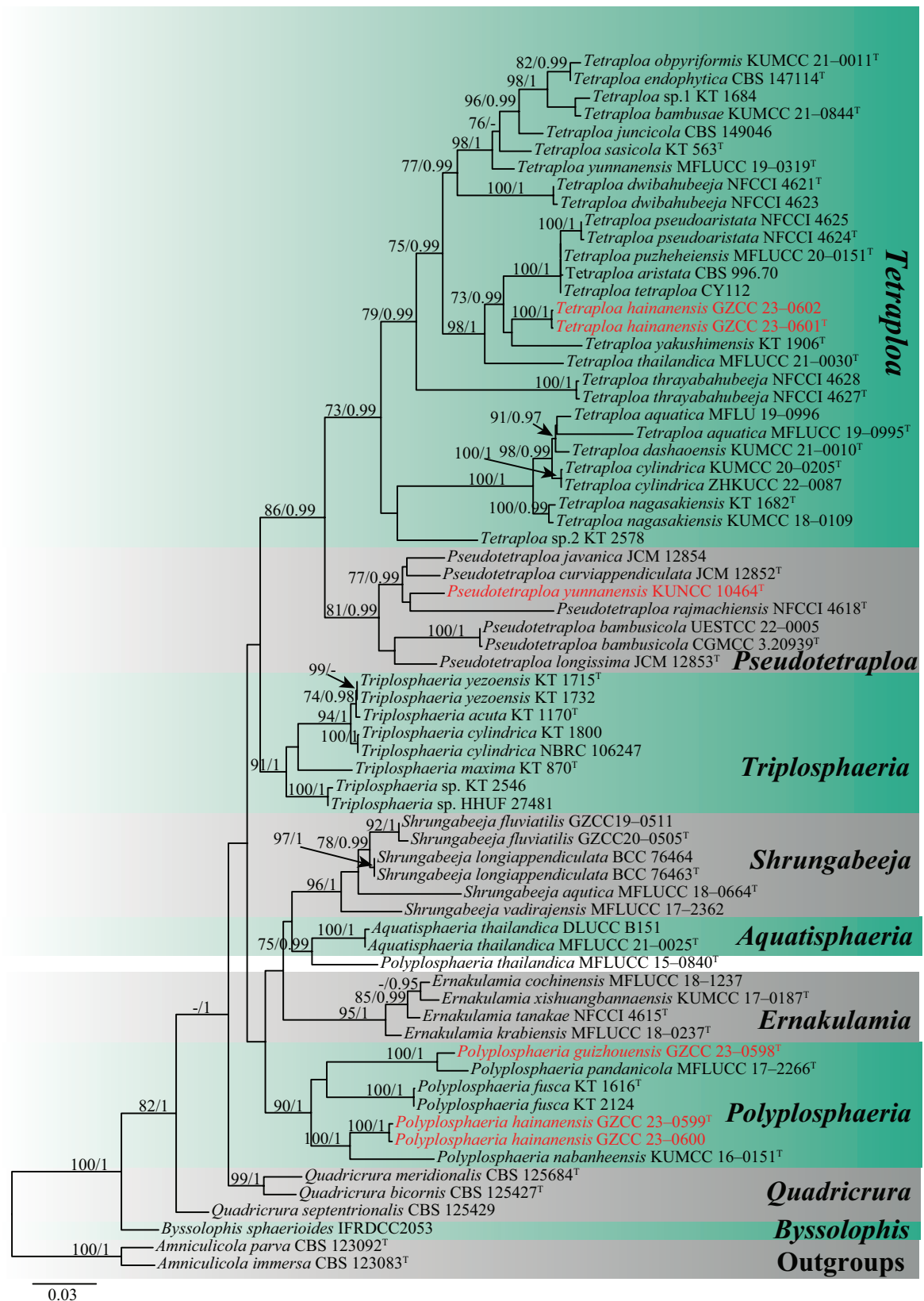
Notes: Ex-type strains are indicated by “T” at the end of the strain number, and newly generated sequences are in bold. Abbreviations: **BCC**: Biotec Culture Collection, Bangkok, Thailand; **CBS**: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; **CGMCC**: China General Microbiological Culture Collection Centre, Beijing, China; **DLUCC**: Dali University Culture Collection, Yunnan, China; **GZCC**: Guizhou Culture Collection, Guizhou, China; **HHUF**: Herbaria of Hirotsaki University; **IFRDCC**: Culture Collection, International Fungal Research and Development Centre, Chinese Academy of Forestry, Kunming, China; **JCM**: the Japan Collection of Microorganisms, Japan; **KUNCC**: Kunming Institute of Botany Culture Collection; **KT**: Kazuaki Tanaka; **MFLUCC**: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand; **MFLU**: Mae Fah Luang University Herbarium Collection; **NBRC**: Nite Biological Resource Center, Department of Biotechnology, National Institute of Technology and Evaluation, Japan; **NFCCI**: National Fungal Culture Collection of India NFCCI-A National Facility; **UESTCC**: University of Electronic Science and Technology Culture Collection, Chengdu, China; **ZHKUCC**: Zhongkai University of Agriculture and Engineering Culture Collection, Guangzhou, China. **A.** = *Amniculicola*. **Aq.** = *Aquatishphaeria*. **E.** = *Ernakulamia*. **Po.** = *Polyplosphaeria*. **Ps.** = *Pseudotetraploa*. **Q.** = *Quadricrura*. **S.** = *Shrungabeeja*. **T.** = *Tetraploa*. **Tr.** = *Triplosphaeria*.

trees were computed. Adobe Illustrator and FigTree were used to view trees. Bootstrap support and Bayesian posterior probabilities above 70 and 0.9 were considered as high support respectively.

## Results

### Phylogenetic analyses

For the phylogenetic analyses, a combined DNA sequence data of 68 taxa on LSU, ITS, SSU, and *tub2* was used and analysed under the ML and PP criteria. The data matrix comprised 2995 total characters, including gaps (LSU: 1–848 bp, ITS: 849–1372 bp, SSU: 1373–2363 bp, *tub2*: 2364–2995 bp). Phylogenetic reconstructions with broadly comparable topologies were recovered from the combined dataset of ML and PP analyses. The top-scoring



**Figure 1.** Phylogenetic construction of Tetraplospora using RAXML-based maximum likelihood analysis of a combined LSU, ITS, SSU, and *tub2* DNA sequence dataset. Bootstrap support values for maximum likelihood (ML) equal to or greater than 70% and Bayesian posterior probabilities (PP) equal to or greater than 0.95 PP are shown above the nodes. The tree is rooted with *Amniculicola immersa* (CBS 123083) and *A. parva* (CBS 123092). Newly generated strains are in red, and the type strains are indicated using "T" in superscript.

RAxML tree is shown in Fig. 1, with a final ML optimization likelihood value of -17569.286960 (ln). In the RAxML analysis, the GTRGAMMA+I-Invar model was used and the results showed 969 unique alignment patterns and 25.50% of indeterminate characters. Base frequency estimates were as follows: A = 0.243260, C = 0.247998, G = 0.277213, T = 0.231530; substitution rates were as follows: AC = 3.027135, AG = 4.828263, AT = 2.159193, CG = 1.385950, CT = 10.517436, GT = 1.000000; gamma distribution shape parameter alpha = 0.166037; and tree-length has been as follows: 1.837225. The best-fit models for the BPP analysis were GTR+I+G for LSU, ITS, and *tub2* gene regions; HKY+I+G for the SSU gene region. With a final average standard deviation of split frequencies of 0.009909, Bayesian posterior probabilities from MCMC were analysed. The new taxa analysed herein all belong to the Tetraplosphaeriaceae clade based on the results of the combined LSU, ITS, SSU, and *tub2* sequence data analysis.

## Taxonomy

### **Tetraplosphaeriaceae Kaz. Tanaka & K. Hiray, Studies in Mycology 64: 177 (2009)**

MycoBank No: 515253

Facesoffungi Number: FoF06665

**Type genus.** *Tetraploa* Berk. & Broome, Ann. Mag. Nat. Hist. 5: 459, t. 11:6 (1850).

**Description.** **Teleomorph** see Tanaka et al. (2009). **Anamorph** Conidiophores absent. Conidiogenous cells monoblastic. Conidia composed of 3–8 columns or internal hyphal structure, brown, mostly verrucose at the base, with more than 3–8 setose appendages (Tanaka et al. 2009).

**Notes.** Tetraplosphaeriaceae was described by Tanaka et al. (2009) to accommodate the species which has massarina-like teleomorphic morph and tetraploa-like anamorphs based on a combined SSU and LSU DNA sequence data and established five genera. To date, the members of Tetraplosphaeriaceae are mainly distributed on Poaceae and unidentified decayed wood as saprobes and pathogens from aquatic and terrestrial habitats (Tanaka et al. 2009; Hyde et al. 2013; Hongsanan et al. 2020; Yu et al. 2022; Li et al. 2021). It now contains nine genera and 69 species (Tanaka et al. 2009; Pem et al. 2019; Hongsanan et al. 2020; Li et al. 2021; Liao et al. 2022).

### **Polyplosphaeria Kaz. Tanaka & K. Hirayama, Studies in Mycology 64: 192 (2009)**

MycoBank No: 515256

Facesoffungi Number: FoF06668

**Type species.** *Polyplosphaeria fusca* Kaz. Tanaka & K. Hirayama, Studies in Mycology 64: 193 (2009).

**Description.** **Teleomorph** see Tanaka et al. (2009). **Anamorph** Conidiophores absent. Conidiogenous cells monoblastic. Conidia globose to subglobose, with thin peel-like outer wall of conidia, composed of numerous internal hyphae at the inside, brown, almost smooth, verrucose at the base. Appendages with 3 to 8 setose appendages, brown, straight (Tanaka et al. 2009).

**Notes.** Tanaka et al. (2009) established *Polyplosphaeria* and typified with *Po. fusca* based on a combined SSU and LSU DNA sequence data. All the members of *Polyplosphaeria* were reported as saprobes from various plant hosts, such as *Pleio-blastus chino*, *Phyllostachys bambusoides* and Pandanaceae (Tanaka et al. 2009; Li et al. 2016; Tibpromma et al. 2018). *Polyplosphaeria* is distributed in Japan, China and Thailand in terrestrial habitats (Tanaka et al. 2009; Li et al. 2016; Tibpromma et al. 2018). Dong et al. (2020) transferred *Po. xishuangbannaensis* into *Ernakula-mia* based on phylogenetic analyses and differences in morphology. In this study, two new *Polyplosphaeria* species are introduced from unidentified decaying wood from China. The genus contains six species viz. *Polyplosphaeria guizhouensis*, *Po. hainanensis*, *Po. fusca*, *Po. nabanheensis*, *Po. pandanicola* and *Po. thailandica* (Tanaka et al. 2009; Li et al. 2016; Tibpromma et al. 2018; This study; Table 2).

***Polyplosphaeria guizhouensis* X. Tang, Jayaward., R. Jeewon & J.C. Kang, sp. nov.**

MycoBank No: 900950

Facesoffungi Number: FoF14571

Fig. 2

**Etymology.** The specific epithet '*guizhouensis*' refers to the place where the fungus was collected, Guizhou Province, China.

**Holotype.** GZAAS 23–0600.

**Description.** *Saprobic* on unidentified decaying wood in the forest. **Teleomorph** not observed. **Anamorph** Hyphomycetous. **Colonies** effuse, gregarious on host substrate, brown to dark brown. **Mycelium** semi-immersed or immersed, pale brown, branched, septate. **Conidiophores** absent. **Conidiogenous cells** forming directly on creeping hyphae, integrated, monoblastic, determinate. **Conidia** 34–61 × 41–63 µm ( $\bar{x}$  = 51 × 51 µm, n = 20), globose to subglobose to turbinate, solitary, olivaceous-green to brown, verrucose and darker at base, with setose appendages on surface. **Appendages** with two forms, solitary, cylindrical, unbranched, septate, smooth, brown at base and paler towards to apex, long appendages 51–152 × 3–5 µm ( $\bar{x}$  = 89 × 4.0 µm, n = 20), wide at the base, 2–6-septate, arising from apical part of conidia; short appendages 13–38 × 2.5–6 µm ( $\bar{x}$  = 25 × 4 µm, n = 20), wide at the base, 0–3-septate, arising randomly from conidial apex.

**Culture characteristics.** Conidia germinated on PDA and incubate at room temperature (25 °C). Colonies circular, cottony, flat, slightly grey with an undulate margin, forming three concentric zonation, margin regular, brownish grey. The reverse side is greenish grey in the centre, with a dark brown margin and pigment.

**Material examined.** CHINA, Guizhou Province, Xingyi City, Xianheping National Forest Park, on unidentified decaying wood, 25 September 2021, Xia Tang, xhp08 (GZAAS 23–0600, holotype), ex-type culture GZCC 23–0598.

**Notes.** The phylogenetic results (Fig. 1) showed that *Polyplosphaeria guizhouensis* is sister to *Po. pandanicola* within *Polyplosphaeria* with high support (ML = 100, BPP = 1). The comparison of pairwise nucleotides showed that *Polyplosphaeria guizhouensis* is different from *Po. pandanicola* in 2/801 bp (0.2%) in LSU and 11/460 (2.5%) in ITS. Thus, we describe *Polyplosphaeria guizhouensis* herein as a novel species in *Polyplosphaeria* following recommendations proposed by Jeewon and Hyde (2016) and Chethana et al. (2021).



**Figure 2.** *Polyposphaeria guizhouensis* (GZAAS 23–0600, holotype) **a** colonies on decaying wood **b, c** colonies on natural substrates **d–n** conidia bearing appendages **o** germinating conidium **p** colony on PDA (front at right, reverse at left). Scale bars: 50 µm (**d–o**).

**Table 2.** Tetraplosphaeriaceae species and their country, life cycle, habitat, host and reference.

| Species name                               | Country                                                           | Life cycle      | Habitat                 | Host                                                                                                                                                                                                                                                                                                                                                                                                         | Reference                                                                                                                                                                                                                                                                   |
|--------------------------------------------|-------------------------------------------------------------------|-----------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Aquatisphaeria thailandica</i>          | Thailand                                                          | saprobic        | freshwater              | decaying wood                                                                                                                                                                                                                                                                                                                                                                                                | Li et al. (2021)                                                                                                                                                                                                                                                            |
| <i>Byssolophis byssiseda</i>               | France                                                            | saprobic        | terrestrial             | branch of <i>Carpinus</i> , decaying wood                                                                                                                                                                                                                                                                                                                                                                    | Zhang et al. (2012)                                                                                                                                                                                                                                                         |
| <i>B. sphaerioides</i>                     | Finland, UK                                                       | saprobic        | terrestrial             | decaying stemp of <i>Rubus</i> , decaying wood birch                                                                                                                                                                                                                                                                                                                                                         | Berkeley and Broome (1854); Karsten (1870)                                                                                                                                                                                                                                  |
| <i>Ernakulamia cochinchensis</i>           | Argentina, Cuba, India, Japan, Malaysia, Mexico, Panama, Thailand | saprobic        | freshwater, terrestrial | <i>Astrocaryum standleyanum</i> , <i>Benthamidia japonica</i> , dead leaves, dead spathes of <i>Cocos nucifera</i> , decomposing leaves of <i>Satakentia liukivensis</i> , <i>Freycinetia multi</i> , palm tree, <i>Ilex</i> sp., <i>Ocotea leucoxylon</i> , <i>Pandanus tectorius</i> , <i>P. monticola</i> , submerged wood, <i>Syagrus romanzoffiana</i> , <i>Stewartia monadelpha</i> , <i>Vitex</i> sp. | Ellis (1976); Holubová-Jechová and Mercado (1986); Holubová-Jechová (1989); Mercado et al. (1997, 2005); Taylor and Hyde (2003); Delgado and Mena (2004); Capdet and Romero (2010); Whitton et al. (2012); Delgado et al. (2017); Dong et al. (2020); Farr and Rossm (2023) |
| <i>E. krabiensis</i>                       | Thailand                                                          | saprobic        | terrestrial             | <i>Acacia</i> sp.                                                                                                                                                                                                                                                                                                                                                                                            | Jayasiri et al. (2019)                                                                                                                                                                                                                                                      |
| <i>E. tanakae</i>                          | India                                                             | saprobic        | terrestrial             | dead spathes of <i>Cocos nucifera</i>                                                                                                                                                                                                                                                                                                                                                                        | Hyde et al. (2020a)                                                                                                                                                                                                                                                         |
| <i>E. xishuangbannaensis</i>               | China                                                             | saprobic        | terrestrial             | dead leaves of <i>Pandanus</i> sp.                                                                                                                                                                                                                                                                                                                                                                           | Tibpromma et al. (2018); Dong et al. (2020)                                                                                                                                                                                                                                 |
| <b><i>Polyplosphaeria guizhouensis</i></b> | <b>China</b>                                                      | <b>saprobic</b> | <b>terrestrial</b>      | <b>unidentified decaying wood</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>This study</b>                                                                                                                                                                                                                                                           |
| <b><i>Po. Hainanensis</i></b>              | <b>China</b>                                                      | <b>saprobic</b> | <b>terrestrial</b>      | <b>unidentified decaying wood</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>This study</b>                                                                                                                                                                                                                                                           |
| <i>Po. Fusca</i>                           | Japan                                                             | saprobic        | terrestrial             | culms of <i>Chimonobambusa marmorea</i> , culms of <i>Phyllostachys bambusoides</i> , culms of <i>Pleioblastus chino</i> , culms of <i>Sasa kurilensis</i>                                                                                                                                                                                                                                                   | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <i>Po. thailandica</i>                     | Thailand                                                          | saprobic        | terrestrial             | decaying bamboo                                                                                                                                                                                                                                                                                                                                                                                              | Li et al. (2016)                                                                                                                                                                                                                                                            |
| <i>Po. nabanheensis</i>                    | China                                                             | saprobic        | terrestrial             | decaying leaves of <i>Pandanus</i> sp.                                                                                                                                                                                                                                                                                                                                                                       | Tibpromma et al. (2018)                                                                                                                                                                                                                                                     |
| <i>Po. pandanicola</i>                     | China                                                             | saprobic        | terrestrial             | decaying leaves of <i>Pandanus</i> sp.                                                                                                                                                                                                                                                                                                                                                                       | Tibpromma et al. (2018)                                                                                                                                                                                                                                                     |
| <i>Pseudotetraploa bambusicola</i>         | China                                                             | saprobic        | terrestrial             | dead branches of Bamboo                                                                                                                                                                                                                                                                                                                                                                                      | Yu et al. (2022)                                                                                                                                                                                                                                                            |
| <i>Ps. curviappendiculata</i>              | Japan                                                             | saprobic        | terrestrial             | culms of <i>Sasa kurilensis</i>                                                                                                                                                                                                                                                                                                                                                                              | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <b><i>Ps. yunnanensis</i></b>              | <b>China</b>                                                      | <b>saprobic</b> | <b>freshwater</b>       | <b>bamboo</b>                                                                                                                                                                                                                                                                                                                                                                                                | <b>This study</b>                                                                                                                                                                                                                                                           |
| <i>Ps. Javanica</i>                        | Indonesia, Japan                                                  | saprobic        | terrestrial             | culms of decaying <i>Bambusa glaucescens</i> , culms of <i>Phyllostachys bambusoides</i> , culms of <i>Pleioblastus chino</i> , culms of <i>Sasa</i> sp., dead bark of broad-leaved tree, dead stems of an unidentified herbaceous plant                                                                                                                                                                     | Hatakeyama et al. (2005); Tanaka et al. (2009); Rifai et al. (2014)                                                                                                                                                                                                         |
| <i>Ps. longissima</i>                      | Japan                                                             | saprobic        | terrestrial             | culms of <i>Pleioblastus chino</i>                                                                                                                                                                                                                                                                                                                                                                           | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <i>Ps. rajmachiensis</i>                   | India                                                             | saprobic        | terrestrial             | decaying bamboo culms, <i>Dendrocalamus stocksii</i> (Poaceae)                                                                                                                                                                                                                                                                                                                                               | Hyde et al. (2020a)                                                                                                                                                                                                                                                         |
| <i>Quadricrura bicornis</i>                | Japan                                                             | saprobic        | terrestrial             | culms of <i>Sasa kurilensis</i> , leaf litter of a conifer                                                                                                                                                                                                                                                                                                                                                   | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <i>Q. meridionalis</i>                     | Japan                                                             | saprobic        | terrestrial             | bamboo                                                                                                                                                                                                                                                                                                                                                                                                       | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <i>Q. septentrionalis</i>                  | Japan                                                             | saprobic        | terrestrial             | culms of <i>Sasa kurilensis</i>                                                                                                                                                                                                                                                                                                                                                                              | Tanaka et al. (2009)                                                                                                                                                                                                                                                        |
| <i>Shrungabeeja aquatica</i>               | Thailand                                                          | saprobic        | freshwater              | submerged wood                                                                                                                                                                                                                                                                                                                                                                                               | Dong et al. (2020)                                                                                                                                                                                                                                                          |

| Species name                    | Country                                                                                                                                                                                                                                                                                                                                    | Life cycle                   | Habitat     | Host                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reference                                                                               |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| <i>S. longiappendiculata</i>    | Thailand                                                                                                                                                                                                                                                                                                                                   | saprobic                     | terrestrial | dead culm of <i>Bambusa</i> sp. (Poaceae)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Ariyawansa et al. (2015)                                                                |
| <i>S. vadirajensis</i>          | Brazil, China, India                                                                                                                                                                                                                                                                                                                       | saprobic                     | terrestrial | dead branches of unidentified plant                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Rao and Reddy (1981); Zhang et al. (2009)                                               |
| <i>S. begoniae</i>              | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | dead branches of <i>Begonia semperflorans</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Zhang et al. (2009)                                                                     |
| <i>S. melicopes</i>             | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | dead branches of <i>Melicope triphylla</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Zhang et al. (2009)                                                                     |
| <i>S. piepenbringiana</i>       | Panama                                                                                                                                                                                                                                                                                                                                     | saprobic                     | terrestrial | dead Poaceae                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Kirschner et al. (2017)                                                                 |
| <i>S. fluviatilis</i>           | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | freshwater  | submerged decaying twig                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Yang et al. (2023)                                                                      |
| <i>Tetraploa abortiva</i>       | Argentina                                                                                                                                                                                                                                                                                                                                  | saprobic                     | freshwater  | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Arambarri et al. (1987)                                                                 |
| <i>T. aquatica</i>              | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | freshwater  | submerged decaying wood                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Li et al. (2020)                                                                        |
| <i>T. aristata</i>              | Africa, Barbados, Bolivia, China, Cuba, Denmark, Eire, Europe, Fiji, Germany, Ghana, Hong Kong (China), India, Italy, Japan, Jamaica, Malaysia, Nepal, New Caledonia, Pakistan, Papua New Guinea (New Britain), Philippines, Puerto Rico, Sierra Leone, Thailand, The Dominican Republic, The Netherlands, Uganda, Venezuela, USA(Alabama) | pathogenic (human), saprobic | terrestrial | <i>Alpinia formosa</i> , <i>Ammophila arenaria</i> , <i>Anadelphia leptocoma</i> , <i>Andropogon</i> , <i>Angelica sylvestris</i> , <i>Avena pralensis</i> , <i>Axonopus</i> , <i>Bambusa</i> , <i>Carex paniculata</i> , <i>Cladium mariscus</i> , <i>Cladium selloana</i> , <i>Cocos</i> , <i>Cortaderia</i> , <i>Cymbopogon afronardus</i> , <i>Cyperus longus</i> , <i>Dactylis</i> , <i>Deschampsia</i> , <i>Erianthus</i> , <i>Euchlaena</i> , <i>Festuca</i> , <i>Gynerium argenteum</i> , <i>Gynerium</i> , <i>Heracleum sphondylium</i> , <i>Heteropogon</i> , <i>Hevea brasiliensis</i> , <i>Juncus</i> , <i>Musa</i> , <i>Phalaris arundinacea</i> , <i>Phaseolus</i> , <i>Phoenix</i> , <i>Phormium</i> , <i>Phragmites communis</i> , <i>Poa pratensis</i> , <i>Pteridium aquilinum</i> , <i>Saccharum officinarum</i> , <i>Sorghum</i> , straw, <i>Triticum</i> , unnamed host, wheat stubble, <i>Zea</i> | Ellis (1949, 1971); Markham et al. (1990); Tanaka et al. (2009); Senwanna et al. (2021) |
| <i>T. bambusae</i>              | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | dead twigs of bamboo                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Phookamsak et al. (2022)                                                                |
| <i>T. biformis</i>              | Japan                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | dead bark of broad-leaved tree                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Matsushima and Matsushima (1996)                                                        |
| <i>T. circinata</i>             | India                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | decaying bamboo twig                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Pratibha and Bhat (2008)                                                                |
| <i>T. conata</i> F              | India                                                                                                                                                                                                                                                                                                                                      | N/A                          | N/A         | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Saxena and Sarkar (1986); Gupta (2002)                                                  |
| <i>T. cylindrica</i>            | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | decaying stems of <i>Saccharum arundinaceum</i> (Poaceae)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Liao et al. (2022)                                                                      |
| <i>T. dashaoensis</i>           | China                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | dead stem of <i>Saccharum arundinaceum</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Jayawardena et al. (2023)                                                               |
| <i>T. divergens</i>             | USA (Mississippi)                                                                                                                                                                                                                                                                                                                          | saprobic                     | terrestrial | leaves of <i>Panicum agrostidiforme</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Tracy and Earle (1895)                                                                  |
| <i>T. dwibahubeeja</i>          | India                                                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | decaying spathes of <i>Cocos nucifera</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Hyde et al. (2020a)                                                                     |
| <i>T. ellisii</i>               | Argentina, USA (New Jersey), Zimbabwe                                                                                                                                                                                                                                                                                                      | saprobic                     | terrestrial | <i>Chloris</i> , <i>Dactylis</i> , <i>Hevea brasiliensis</i> , stalks of <i>Zea mays</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Cooke and Ellis (1879); Ellis (1971); Senwanna et al. (2021)                            |
| <i>T. endophytica</i>           | Germany                                                                                                                                                                                                                                                                                                                                    | endophytic                   | terrestrial | roots of <i>Microthlaspi perfoliatum</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Crous et al. (2021)                                                                     |
| <i>T. hainanensis</i>           | China                                                                                                                                                                                                                                                                                                                                      | Saprobic                     | terrestrial | unidentified decaying wood                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | This study                                                                              |
| <i>T. indica</i> <sup>F</sup>   | India                                                                                                                                                                                                                                                                                                                                      | N/A                          | N/A         | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Saxena and Khare (1991)                                                                 |
| <i>T. josettae</i> <sup>F</sup> | France                                                                                                                                                                                                                                                                                                                                     | N/A                          | N/A         | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Núñez Otaño et al. (2022)                                                               |
| <i>T. juncicola</i>             | The Netherlands                                                                                                                                                                                                                                                                                                                            | saprobic                     | terrestrial | dead culm of <i>Juncus inflexus</i> (Juncaceae)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Crous et al. (2022)                                                                     |

| Species name                       | Country         | Life cycle | Habitat                    | Host                                                                                         | Reference                                    |
|------------------------------------|-----------------|------------|----------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------|
| <i>T. muscicola</i>                | Spain           | N/A        | N/A                        | fronds of <i>Aneura multifida</i> ,<br><i>Lophozia quinquedentata</i>                        | González Fragoso (1916)                      |
| <i>T. nagasakiensis</i>            | Japan, China    | saprobic   | terrestrial                | culms of bamboo                                                                              | Hyde et al. (2013, 2019)                     |
| <i>T. obpyriformis</i>             | China           | saprobic   | terrestrial                | dead grass under <i>Saccharum arundinaceum</i> (Gramineae)                                   | Unpublished                                  |
| <i>T. opaca</i>                    | China           | saprobic   | terrestrial                | dead culms of bamboo,<br>decaying branches of<br>unidentified tree                           | Zhao et al. (2009)                           |
| <i>T. pseudoaristata</i>           | India           | saprobic   | terrestrial                | decaying spathes of <i>Cocos nucifera</i> (Arecaceae)                                        | Hyde et al. (2020a)                          |
| <i>T. puzheheensis</i>             | China           | saprobic   | freshwater                 | submerged wood                                                                               | Dong et al. (2020)                           |
| <i>T. sasicola</i>                 | China, Japan    | saprobic   | terrestrial                | culms of <i>Sasa senanensis</i> , dead<br>leaves of <i>Pennisetum purpureum</i><br>(Poaceae) | Tanaka et al. (2009); Hyde<br>et al. (2020a) |
| <i>T. scabra</i>                   | USA             | N/A        | terrestrial                | <i>Scirpus</i> sp.                                                                           | Harkness (1885)                              |
| <i>T. scheueri</i>                 | UK              | saprobic   | freshwater,<br>terrestrial | leaves of <i>Carex acutiformis</i> ,<br>rotten leaves                                        | Scheuer (1991); Hyde et<br>al. (2013)        |
| <i>T. setifera</i>                 | Hungary         | saprobic   | terrestrial                | rotten wood                                                                                  | Révay (1993)                                 |
| <i>T. siwalika</i> <sup>F</sup>    | N/A             | N/A        | N/A                        | N/A                                                                                          | Saxena et al. (1987)                         |
| <i>T. taugourdeau</i> <sup>F</sup> | India           | N/A        | N/A                        | N/A                                                                                          | Saxena and Sarkar (1986)                     |
| <i>T. thailandica</i>              | Thailand        | saprobic   | freshwater                 | Submerged decaying wood                                                                      | Bao et al. (2021)                            |
| <i>T. thrayabahubeeja</i>          | India           | saprobic   | terrestrial                | decaying spathes of <i>Cocos nucifera</i> (Arecaceae)                                        | Hyde et al. (2020a)                          |
| <i>T. yakushimensis</i>            | Japan           | saprobic   | terrestrial                | culms of <i>Arundo donax</i>                                                                 | Tanaka et al. (2009); Hyde<br>et al. (2013)  |
| <i>T. yunnanensis</i>              | China, Thailand | saprobic   | freshwater                 | submerged wood                                                                               | Dong et al. (2020)                           |
| <i>Tetraploa</i> sp. 1             | Japan           | saprobic   | terrestrial                | culms of bamboo                                                                              | Tanaka et al. (2009)                         |
| <i>Tetraploa</i> sp. 2             | Japan           | saprobic   | terrestrial                | culms of Gramineae                                                                           | Tanaka et al. (2009)                         |
| <i>Triplosphaeria cylindrica</i>   | Japan           | saprobic   | terrestrial                | culms of <i>Sasa kurilensis</i>                                                              | Tanaka et al. (2009)                         |
| <i>Tr. maxima</i>                  | Japan           | saprobic   | terrestrial                | culms of <i>Sasa kurilensis</i>                                                              | Tanaka et al. (2009)                         |
| <i>Tr. yezoensis</i>               | Japan           | saprobic   | terrestrial                | culms of <i>Sasa palmata</i>                                                                 | Tanaka et al. (2009)                         |
| <i>Tr. acuta</i>                   | Japan           | saprobic   | freshwater                 | submerged culms of bamboo                                                                    | Tanaka et al. (2009)                         |
| <i>Triplosphaeria</i> sp.          | Japan           | saprobic   | terrestrial                | culms of <i>Sasa kurilensis</i>                                                              | Tanaka et al. (2009)                         |

Fossil fungi were indicated "F"; N/A: Not available or cannot find; Newly species indicate in bold.

***Polyplosphaeria hainanensis* X. Tang, Jayaward., R. Jeewon & J.C. Kang, sp. nov.**

MycoBank No: 900951

Facesoffungi Number: FoF14665

Figs 3, 4

**Etymology.** The specific epithet '*hainanensis*' refers to the place where the fungus was collected, Hainan Province, China.

**Holotype.** GZAAS 23–0601

**Description.** **Saprobic** on unidentified decaying wood in the forest. **Teleomorph** not observed. **Anamorph** Hyphomycetous. **Colonies** effuse, gregarious on host substrate, brown to blackish brown. **Mycelium** semi-immersed or immersed, dark brown, branched, septate. **Conidiophores** absent. **Conidiogenous**



**Figure 3.** *Polyposphaeria hainanensis* (GZAAS 23-0601, holotype) **a** colonies on decay wood **b** colonies on natural substrates **c–m** conidia bearing appendages **n** germinating conidium **o** colony on PDA (from front) **p** colony on PDA (from reverse). Scale bars: 50 µm (**c–n**).



**Figure 4.** *Polyposphaeria hainanensis* (GZAAS 23-0602, paratype) **a** colonies on decay wood **b, c** colonies on natural substrates **d–o** conidia bearing appendages **p** colony on PDA (from front) **q** colony on PDA (from reverse). Scale bars: 100  $\mu$ m (**d–i, k–m**); 50  $\mu$ m (**j, n, o**).

**cells** indistinguishable from creeping hyphae, integrated, monoblastic, determinate. **Conidia** 49–134.5 × 52–90.5 µm ( $\bar{x}$  = 86 × 71 µm, n = 20), globose, subglobose, obconical, broadly ellipsoidal to broadly pyriform, variable in shape, sometimes with thin peel on the outer wall of conidia, internally filled with a mass of hyaline, solitary, brown to dark brown, smooth. **Appendages** 36–58 × 3–5.5 µm ( $\bar{x}$  = 44.5 × 4 µm, n = 20), cylindrical, solitary, straight or flexuous, unbranched and almost hyaline at the apex, 0–4-septate, smooth, round at apex, pervasive.

**Culture characteristics.** Conidia germinated from both ends on PDA and incubated at room temperature (25 °C). Colonies circular, cottony, flat, olivaceous with a slightly grey entire margin. The reverse side is an olive drab, which gradually extends outwards to form a deep colour ring in the centre with a pale grey margin and no pigment.

**Material examined.** CHINA, Hainan Province, Wuzhishan City, Wuzhishan National Nature Reserve, on unidentified decaying wood, 25 September 2021, Zili Li, WZS27 (GZAAS 23–0601, holotype), ex-type culture GZCC 23–0599; WZS31 (GZAAS 23–0602, paratype), culture GZCC 23–0600.

**Notes.** Based on the phylogenetic analysis (Fig. 1), two of our *Polyposphaeria* collections share similar morphology and clustered together with high support (ML = 100, and BPP = 1). The base pair differences between the two strains (GZCC 23–0599 and GZCC 23–0600) were: LSU = 0.2% (2/834), ITS = 0.1% (1/840), respectively, therefore, we considered them as the same species according to the guidelines for species delineation proposed by Jeewon and Hyde (2016). The phylogenetic result (Fig.1) showed that *Polyposphaeria hainanensis* is sister to *Po. nabanheensis* within *Polyposphaeria*. Based on the comparison of the morphological characters with other species in *Polyposphaeria*, our collection can be distinct in having obconical, broadly ellipsoidal to broadly pyriform, variable conidial shape (without verrucose at the base) and pervasive appendages. The comparison of pairwise nucleotides showed that *Polyposphaeria hainanensis* is different from *Po. nabanheensis* in 24/826 bp (3%) in LSU, 20/758 (2.6%) in SSU, 17/472 (3.6%) in ITS and 16/344 (5%) in *tub2*. Thus, we describe *Polyposphaeria hainanensis* herein as a novel species in *Polyposphaeria* according to the guidelines of Jeewon and Hyde (2016) and Chethana et al. (2021).

***Pseudotetraploa* Kaz. Tanaka & K. Hirayama, Studies in Mycology 64: 193 (2009)**

MycoBank No: 515257

Facesoffungi Number: FoF06669

**Type species.** *Pseudotetraploa curviappendiculata* (Sat. Hatak., Kaz. Tanaka & Y. Harada) Kaz. Tanaka & K. Hirayama, Studies in Mycology 64: 195 (2009).

**Description.** **Teleomorph morph** not observed. **Anamorph Mycelium** superficial. **Conidiophores** absent. **Conidiogenous cells** monoblastic, indistinguishable from creeping hyphae. **Conidia** composed of 4 to 8 columns, obpyriform to long obpyriform, brown to dark brown, almost smooth, verrucose at the base, pseudoseptate, with setose appendages at the apical part. **Appendages** mostly 4, rarely 6 to 8, curved or straight (Tanaka et al. 2009).

**Notes.** Tanaka et al. (2009) established *Pseudotetraploa* (Ps.) with three species, which were previously described in *Tetraploa* and typified by *Ps. curviappendiculata* based on a combined SSU and LSU DNA sequence data. *Pseudotetraploa* species

are reported as saprobes on bamboo, dead bark of the broad-leaved tree, and unidentified herbaceous plants in Japan, China, and India (Hatakeyama et al. 2005; Tanaka et al. 2009; Hyde et al. 2020a; Yu et al. 2022). *Pseudotetraploa* is only known in its anamorphic state and dwells in terrestrial habitats and contains six species viz. *Ps. bambusicola*, *Ps. curviappendiculata*, *Ps. javanica*, *Ps. longissima*, *Ps. Rajmachiensis*, and *Ps. yunnanensis* (Hatakeyama et al. 2005; Tanaka et al. 2009; Hyde et al. 2020a; Yu et al. 2022; This study; Table 2). In this study, a new *Pseudotetraploa* species isolated from bamboo is introduced.

***Pseudotetraploa yunnanensis* X. Tang, Jayaward., R. Jeewon & J.C. Kang, sp. nov.**

MycoBank No: 900963

Facesoffungi Number: FoF14666

Fig. 5

**Etymology.** The specific epithet '*yunnanensis*' refers to the place where the fungus was collected, Yunnan Province, China.

**Holotype.** HKAS 129442.

**Description.** *Saprobic* on bamboo. *Teleomorph* not observed. *Anamorph* Hyphomycetous. **Colonies** effuse, gregarious on host substrate, brown to dark brown. **Mycelium** superficial, hyaline to pale brown. **Conidiophores** absent. **Conidiogenous cells** micronematous, mononematous, monoblastic, integrated, usually undistinguishable from superficial hyphae. **Conidia** 67–120 × 16.5–35 µm ( $\bar{x}$  = 95 × 24 µm, n = 20), solitary, septate, brown to dark brown, ovoid to obclavate or narrowly obpyriform, consisting of 3–6 columns of cells, rounded at the base 19–36 µm wide ( $\bar{x}$  = 26 µm, n = 20), slightly constricted at septa, rarely branched and make V-shaped conidia; setose appendages at the apical part 15–87 × 3.5–7 µm ( $\bar{x}$  = 37 × 5 µm, n = 20), appendages 3–6 in number, 1–8-septate, brown at the base and almost hyaline at the apex, smooth, unbranched, shorter appendage is straight and longer appendage is curved.

**Culture characteristics.** Conidia germinated from both ends on PDA and incubated at room temperature (25 °C). Colonies circular, cottony, flat, slightly grey with an entire margin, containing a circular white mycelium in the centre. The reverse side is a pale brown in the centre that gradually extends outwards while the colour changes to pale grey, with a brown margin and no pigment.

**Material examined.** CHINA, Yunnan Province, Puer City, Ailao mountains, on bamboo, May 23, 2022, Rong-Ju Xu, ALS 29 (HKAS 129442, holotype), ex-type culture KUNCC 10464.

**Notes.** *Pseudotetraploa yunnanensis* is similar to *Ps. curviappendiculata* and *Ps. longissima*. However, *Pseudotetraploa yunnanensis* differs from *Ps. curviappendiculata* in having branched and V-shaped conidia, consisting of 3–6 columns of cells with 3–6 apical appendages, larger conidia [67–120 µm vs. 52–67(–75) µm] in length and [16–35 µm vs. 15–22 µm] in width, while *Ps. curviappendiculata* consists of 4–5 columns of cells with 4 apical appendages; *Pseudotetraploa yunnanensis* differs from *Ps. longissima* in having smaller conidia [67–120 µm vs. (98–)110–148(–155) µm] in length and [16–35 µm vs. 18–25 µm] in width, without verrucose at the base. The phylogenetic analysis showed that *Pseudotetraploa yunnanensis* is sister to *Ps. rajmachiensis* and *Ps. javanica*. The comparison of



**Figure 5.** *Pseudotetraploa yunnanensis* (HKAS 129442, holotype) **a, b** colonies on natural substrates **c–n** conidia. Scale bars: 20 µm (**c**); 50 µm (**d–n**).

pairwise nucleotides showed that *Pseudotetraploa yunnanensis* is different from *Ps. rajmachiensis* in 27/1021 bp (2.6%) in LSU and 30/560 (6%) in ITS; *Pseudotetraploa yunnanensis* is different from *Ps. javanica* in 11/1020 bp (1.1%) in LSU and 17/538 (3.2%) in ITS. Thus, we describe *Pseudotetraploa yunnanensis* herein as a novel species in *Pseudotetraploa* according to the guidelines Jeewon and Hyde (2016) and Chethana et al. (2021).

***Tetraploa* Berk. & Broome, Ann. Mag. Nat. Hist. 5: 459, t. 11:6 (1850)**

MycoBank No: 10199

Facesoffungi Number: FoF06666

= *Tetraplosphaeria* Kaz. Tanaka & K. Hiray., in Tanaka et al., Stud. Mycol. 64: 177 (2009).

**Type species.** *Tetraploa aristata* Berk. & Broome, Ann. Mag. Nat. Hist. 5: 459 (1850).

**Description.** **Teleomorph** see Tanaka et al. (2009). **Anamorph *Tetraploa* sensu stricto** ***Conidiophores*** absent. ***Conidiogenous cells*** monoblastic. ***Conidia*** composed of 4 columns, short-cylindrical, brown, verrucose at the base, euseptate, with 4 setose appendages at the apex (Tanaka et al. 2009).

**Notes.** Tanaka et al. (2009) established *Tetraplosphaeria* to accommodate pleosporalean species that have massarina/lophiostoma-like teleomorph and anamorphs belonging to *Tetraploa* sensu stricto based on a combined SSU and LSU DNA sequence data. Later, Hyde et al. (2013) treated *Tetraploa* as a synonym of *Tetraplosphaeria*, which has been applied previously to anamorphic species and used *Tetraploa* instead of *Tetraplosphaeria*. Species of *Tetraploa* are mainly reported as saprobes, distributed in freshwater and terrestrial habitats, and only *T. aristata* has been reported as a pathogen on various plants and human pathogen that cause cysts (Markham et al. 1990; Tanaka et al. 2009; Hyde et al. 2013; Liao et al. 2022). *Tetraploa* has been recovered from more than 80 plants, such as bamboo culms, submerged wood, palms, and *Poaceae*, on the leaves of *Acer* and liverworts (Ellis 1949; Ando 1992; Hyde et al. 2013; Liao et al. 2022). Saxena et al. (2021) mentioned that *Frasnacritetrus* is probably a fossil of *Tetraploa*. Nuñez Otaño et al. (2022) considered *Frasnacritetrus* as a synonym of *Tetraploa* and transferred five *Frasnacritetrus* fossil species into *Tetraploa* viz. *Tetraploa conata*, *T. indica*, *T. josettae*, *T. siwalika* and *T. taugourdeauui* based on the observation that the spores of both fossil and contemporary species exhibit identical morphological characteristics. To date, there are 35 species accepted in *Tetraploa* (Wijayawardene et al. 2022; Jayawardena et al. 2023; this study; Table 2). In this study, a new *Tetraploa* species is introduced.

***Tetraploa hainanensis* X. Tang, Jayaward., R. Jeewon & J.C. Kang, sp. nov.**

MycoBank No: 900952

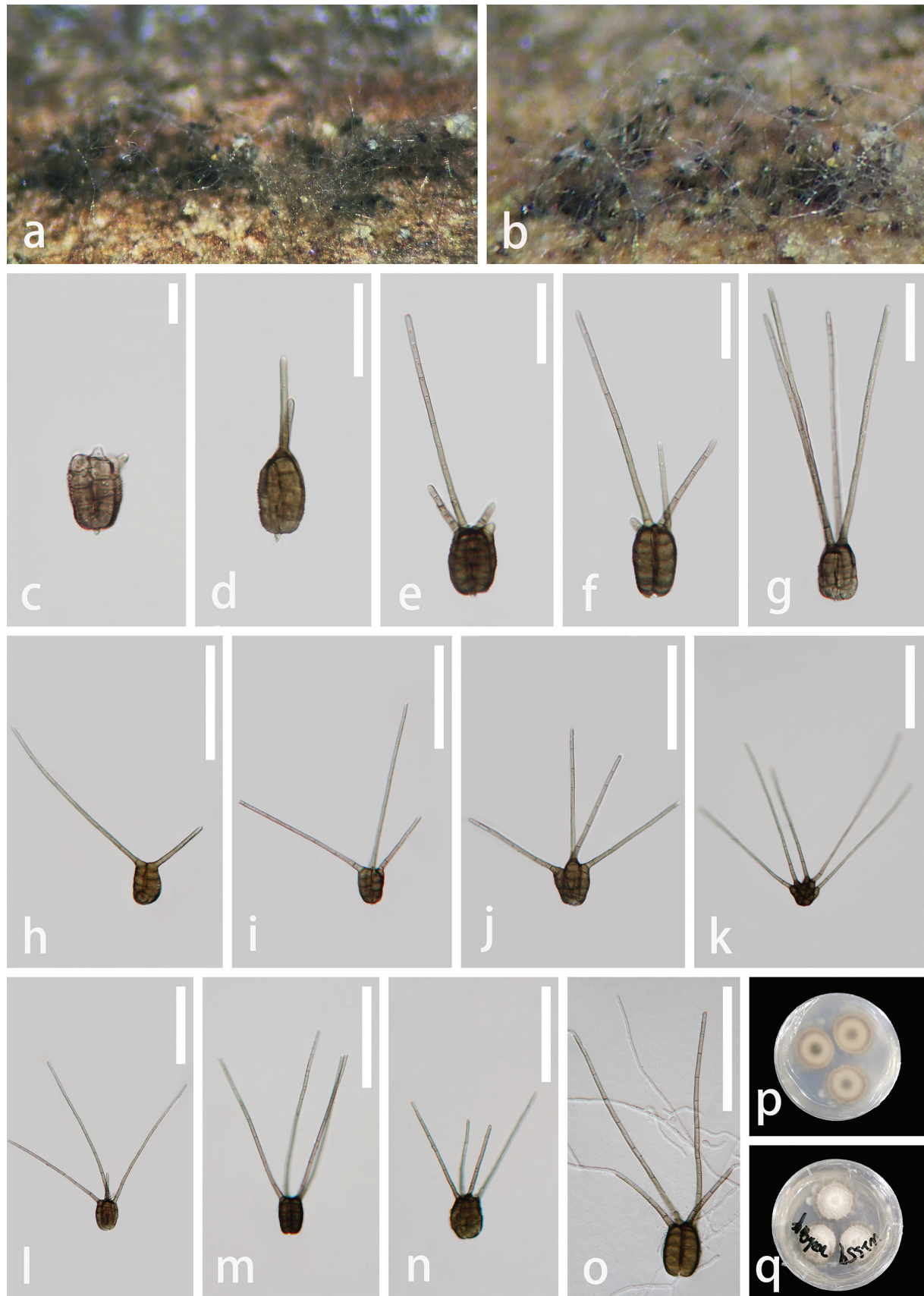
Facesoffungi Number: FoF14667

Figs 6, 7

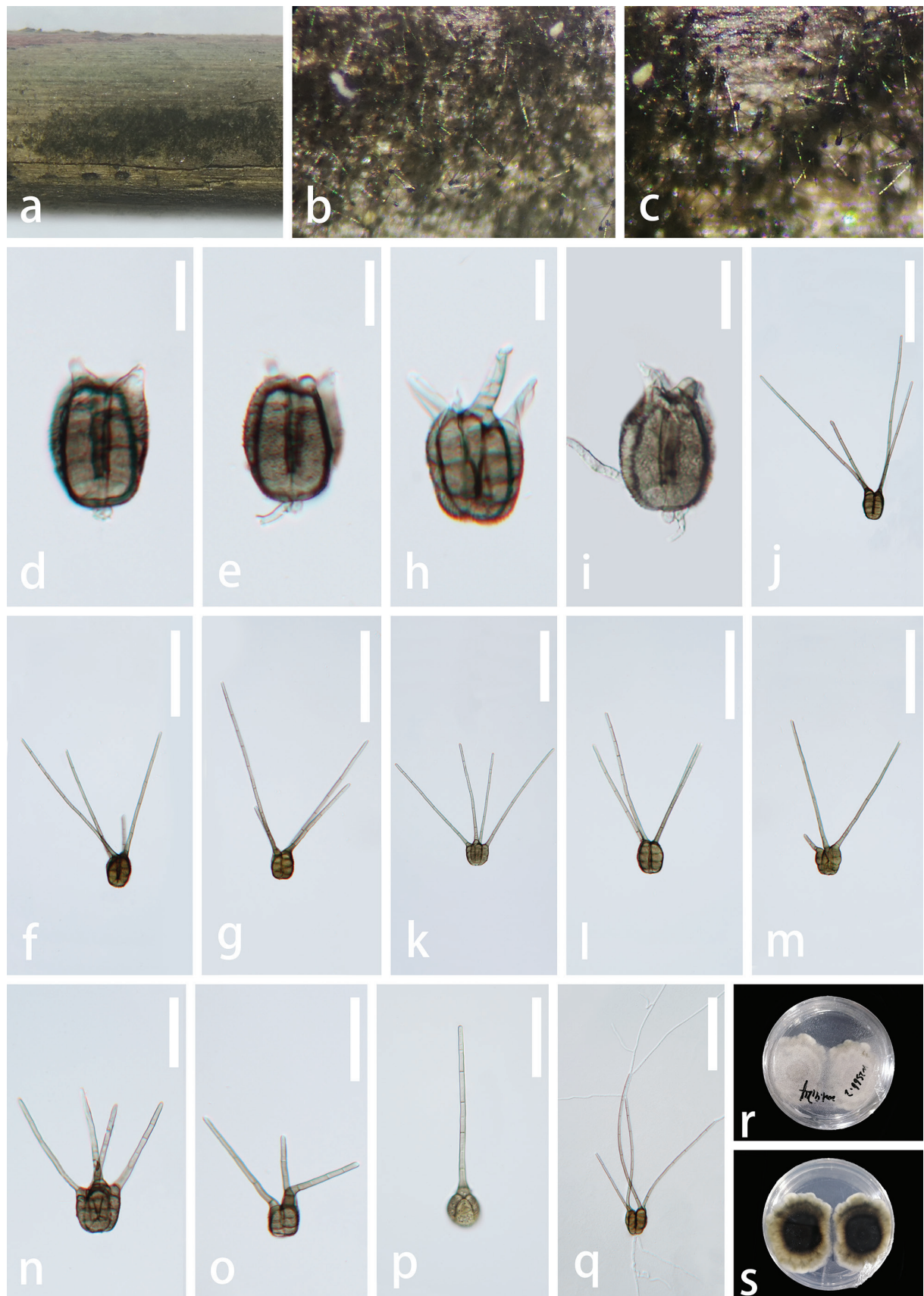
**Etymology.** The specific epithet '*hainanensis*' refers to the place where the fungus was collected, Hainan Province, China.

**Holotype.** GZAAS 23–0603.

**Description.** **Saprobic** on unidentified decaying wood in forest. **Teleomorph** Not observed. **Anamorph** Hyphomycetous. **Colonies** effuse, gregarious on host substrate, brown to dark brown. **Mycelium** semi-immersed or immersed, pale brown, branched, septate. **Conidiophores** absent. **Conidiogenous cells** integrated, monoblastic, determinate. **Conidia** 30–46 × 18–36 µm ( $\bar{x}$  = 38 × 27 µm,  $n$  = 20), cylindrical with obtuse ends, pale brown to brown, verrucose, composed of four columns of cells, sometimes five columns of cells, 4–5-septate in each



**Figure 6.** *Tetraploa hainanensis* (GZAAS 23–0603, holotype) **a, b** colonies on natural substrates **c–n** conidia bearing 1–5 appendages **o** germinating conidium **p** colony on PDA (from reverse) **q** colony on PDA (from front). Scale bars 20 µm (**c**); 50 µm (**d–g**); 100 µm (**h–o**).



**Figure 7.** *Tetraploa hainanensis* (GZAAS 23-0604, paratype) **a** colonies on decay wood **b, c** colonies on natural substrates **d–p** conidia bearing 1–4 appendages **q** germinating conidium **r** colony on PDA (from front) **s** colony on PDA (from reverse). Scale bars: 20 µm (**d–g**); 100 µm (**h–l, o, q**); 50 µm (**m, n, p**).

column, smooth, mostly with four apical appendages, some with one or two or five appendages. **Appendages**  $52\text{--}209 \times 3\text{--}6 \mu\text{m}$  ( $\bar{x} = 140 \times 4 \mu\text{m}$ ,  $n = 20$ ) cylindrical, solitary, unbranched, guttulate, septate, wide at the base, divergent, pale brown to brown, 5–16-septate, straight or slightly flexuous, smooth-walled.

**Culture characteristics.** Conidia germinated from both ends on PDA and incubated at room temperature (25 °C). Colonies circular, cottony, flat, slightly grey with an entire margin, contain a circular white mycelium in the centre. The reverse side is a pale brown in the centre that gradually extends outwards while the colour changes to pale grey, with a brown margin and no pigment.

**Material examined.** CHINA, Hainan Province, Wuzhishan City, Wuzhishan National Nature Reserve, on unidentified decaying wood, 25 September 2021, Zili Li, WZS59 (GZAAS 23–0603, holotype), ex-type culture GZCC 23–0601; WZS66.2 (GZAAS 23–0604, paratype), culture GZCC 23–0602.

**Notes.** *Tetraploa hainanensis* is morphologically similar to *T. pseudoaristata*. However, *Tetraploa hainanensis* can be distinguished from *T. pseudoaristata* in having larger conidia ( $30.5\text{--}46 \times 18\text{--}36 \mu\text{m}$  vs.  $22\text{--}31 \times 15\text{--}20 \mu\text{m}$ ) with four columns of cells, sometimes five columns of cells, and longer appendages ( $52\text{--}209 \times 3\text{--}6 \mu\text{m}$  vs.  $23\text{--}107 \times 2\text{--}5 \mu\text{m}$ ), commonly four in number, sometimes five. Based on the phylogenetic analysis, two of our *Tetraploa* collections which share similar morphology clustered together with high support (ML = 100, and BPP = 1 (Fig. 1)). The base pair differences between the two strains were: LSU = 0.1% (1/806), ITS = 0% (0/516), and *tub2* = 0% (1/633), respectively. Therefore, we considered them as the same species according to the guidelines for species delineation proposed by Jeewon and Hyde (2016). *Tetraploa hainanensis* forms a distinct lineage but close to *T. yakushimensis* and *T. tetraploa*. However, *Tetraploa hainanensis* differs from *T. yakushimensis* by having four or five columns and appendages, while *T. yakushimensis* has only four columns and appendages; *Tetraploa hainanensis* differs from *T. tetraploa* in having four or five columns and shorter appendages ( $52\text{--}209 \times 3\text{--}6 \mu\text{m}$  vs.  $263\text{--}350 \times 2\text{--}3 \mu\text{m}$ ), while *T. tetraploa* has only four columns and slender appendages. The comparison of pairwise nucleotide showed that *Tetraploa hainanensis* is different from *T. yakushimensis* in 31/620 bp (3%) in LSU, 7/814 (0.98%) in ITS, and 87/450 (19%) in *tub2* and *Tetraploa hainanensis* is different from *T. tetraploa* in 31/620 bp (3%) in LSU, 7/814 (0.98%) in ITS, and 87/450 (19%) in *tub2*. Based on the combination of morphological characters and multigene phylogeny, we describe *Tetraploa hainanensis* herein as a distinct species according to the guidelines of Jeewon and Hyde (2016) and Chethana et al. (2021).

## Discussion

Hyde et al. (2018) reported that more than 95% of fungi collected in northern Thailand could be new to science and there is a dire need to collect more samples from a wide variety of hosts to better understand fungal diversity estimates. In the same way, fungal diversity in Yunnan, Guizhou and Hainan is expected to be rather high. In this study, collections of decayed wood samples and bamboo were done to assess which fungal species are potentially colonising them. Our study reveals four anamorphic fungal species that belong to the family Tetraplosphaeriaceae. In this study, we characterise two new anamorphic species collected from unidentified decayed wood samples that belong to *Polyplosphaeria*. In *Polyplosphaeria* this study brings the number of species to

six. The first new species is described as *Po. guizhouensis* and our multigene phylogeny depict a close relationship to *Po. pandanicola*. The latter was collected from fallen dead and decaying leaves of *Pandanus* sp. in China (Tibpromma et al. 2018) and characterized by micronematous conidiophores; monoblastic, incomplete globose connected to base of conidia conidiogenous cell with guttules, hyaline; globose to subglobose, solitary, verrucose at base conidia with almost hyaline at apex, unbranched setose appendages on surface. However, *Po. guizhouensis* differs in having turbinate conidia which are verrucose and darker at the base. Furthermore, it possesses a longer conidium base and two types of appendages originating from the apical part of the conidia. With regard to DNA sequence data comparison, *Po. guizhouensis* differs from *Po. pandanicola* (MFLUCC 17–2266) in having 11 out of 460 (2.5%) and 2 out of 801 (0.2%) different base pairs (bp) in the ITS alignments and LSU gene respectively. Our second new species, named *Polyplosphaeria hainanensis*, forms a strongly supported subclade with *Po. nabanheensis*. The latter was collected from fallen dead and decaying leaves of *Pandanus* sp. in China (Tibpromma et al. 2018). It is characterised by monoblastic, hyaline conidiogenous cells with guttules; oval to ellipsoid conidia, made up of 2–3 cells, and verrucose at base, rough-walled, with apical setose appendages. However, *Po. hainanensis* differs with regards to having an obconical, broadly ellipsoidal to broadly pyriform, variable shaped conidia (no verrucose at the base) and pervasive appendages. Comparison of available LSU, ITS, SSU and *tub2* sequences also reveal differences in base pairs that support species distinctiveness. For instance, *Po. hainanensis* differs from *Po. nabanheensis* in having 24/826 bp (3% difference) in LSU, 20/758 (2.6% difference) in SSU, 17/472 (3.6% difference) in ITS and 16/344 (5% difference) in *tub2*. Another peculiar finding when we analysed the relationships of *Polyplosphaeria* species, we found that two strains of *Polyplosphaeria thailandica* (MFLU 15–3273) and *Aquatisphaeria thailandica* (MFLUCC 21–0025 and DLUCC B151) clustered together with 75% ML/0.99 BPP support and sister to species of *Shrungabeeja*. However, it's important to note that this relationship lacked significant statistical support, a pattern observed in various previous studies as well (Li et al. 2021; Liao et al. 2022). *Aquatisphaeria thailandica* has been reported as a saprobe on submerged decaying wood in China. It is characterised by macronematous, mononematous, solitary, unbranched conidiophores with 3–4 septa; monoblastic, integrated, terminal, subcylindrical conidiogenous cells; and acrogenous, solitary, subglobose or turbinate, muriform, dictyoseptate conidia with 3–4 (mostly 4) cylindrical, upward appendages with 1–2-septa. At the same time, *Po. thailandica* is recognised as a saprobe found in decaying bamboo in Thailand. It is characterised by monoblastic conidiogenous cells; acrogenous, solitary, globose, obovoid, pyriform, ellipsoidal, obconical, muriform, verrucose conidia with 2–5-septate appendages, occasionally, two conidia are associated together at the basal cell (Li et al. 2016; Li et al. 2020). Based on the phylogenetic analyses, it seems that *Po. thailandica* is a member of *Aquatisphaeria*. There is not much taxonomic data available for *Aquatisphaeria*, hence we recommend that further collections of this genus are required to elucidate its relationships to *Po. thailandica*. Alternatively, there might be a need to relook into the taxonomy of *Po. thailandica* and verify whether the DNA sequences submitted are reliable.

The third anamorphic species was collected from bamboo in Yunnan, China and subsequently assigned to *Pseudotetraploa*. To date, five species have been

reported, and this study extends the known species count to six. The new species is described as *Ps. yunnanensis* and our multigene phylogeny depict a close relationship to *Ps. rajmachiensis*. The latter was collected from decaying bamboo culms in India (Hyde et al. 2020a) and characterised by the absence of conidiophores; micronematous, mononematous, monoblastic conidiogenous cells; ovoid to obclavate or obpyriform conidia, minutely verrucose at the base; unbranched, septate, setose appendages at the apical part, consisting of two appendages with one straight and one curved. However, *Ps. yunnanensis* differs in having larger conidia that rarely separate, consisting of 3–6 columns of cells, forming a V-shape conidia, 3–6 apical appendages. In terms of DNA sequence data comparison, *Ps. yunnanensis* differs from *Ps. rajmachiensis* (NFCCI 4618) in LSU by 27/1021 bp (2.6% difference) and in ITS by 30/560 bp (6% difference).

The last anamorphic species was collected from unidentified decaying wood in Hainan, China, and was assigned to *Tetraploa*. With the addition of this species, the genus now comprises a total of 35 species. The new species is described as *T. hainanensis*, and the multigene phylogeny depicts a close relationship to *T. yakushimensis*. The latter was collected on culms of *Arundo donax* in Japan (Tanaka et al. 2009) and characterised by the absence of conidiophores; monoblastic conidiogenous cells; solitary, short cylindrical, brown, verrucose conidia, composed of 4 columns with 4 apical setose appendages. However, *T. hainanensis* differs in having four or five culms and appendages. In terms of DNA sequence data comparison, *T. hainanensis* differs from *T. yakushimensis* (KT 1906) in 31/620 bp (3% difference) in LSU, 7/814 (0.98% difference) in ITS, and 87/450 (19% difference) in *tub2*.

Tetraplosphaeriaceae is a well-known family in terrestrial habitats with mostly saprobes being reported so far, and previous and recent studies have shown that Tetraplosphaeriaceae is widely associated with many plants in different countries. In this work, we describe four new Tetraplosphaeriaceae species based on phylogenetic and morphological comparisons with allied taxa, update the phylogeny of the Tetraplosphaeriaceae family and also provide a checklist of species with other details (Table 2). To date, there are 69 species in Tetraplosphaeriaceae, of which 23 species (including this study) are from China. This study enriches the diversity of fungi in China of Tetraplosphaeriaceae species.

## Acknowledgements

The authors are grateful to Shaun Pennycook for his suggestions on naming the new fungus. In addition, the authors also would like to thank Mae Fah Luang University for its support in the tuition fee scholarship. This work was supported by the Distinguished Scientist Fellowship Program (DSFP) at King Saud University, Riyadh, Saudi Arabia.

## Additional information

### Conflict of interest

The authors have declared that no competing interests exist.

### Ethical statement

No ethical statement was reported.

## Funding

This work was funded by grants from the National Natural Science Foundation of China (NSFC Grants Nos. 32170019 & 31460011) and the Open Fund Program of Engineering Research Centre of Southwest Bio-Pharmaceutical Resources, Ministry of Education, Guizhou University No. GZUKEY20160702. The authors are grateful to the Thailand Research Fund grant “Impact of climate change on fungal diversity and biogeography in the Greater Mekong Sub-region” (RDG6130001).

## Author contributions

Xia Tang conducted the experiments, analysed the data, and wrote the first draft of the manuscript. Rajesh Jeewon, Yong-Zhong Lu, Ruvishika S. Jayawardena and Ji-Chuan Kang planned the experiments. Xia Tang, Jian Ma and Rong-Ju Xu analysed the data. Xia Tang and Xue-Mei Chen conducted the experiments. Rajesh Jeewon, Yong-Zhong Lu, Ruvishika S. Jayawardena, Abdulwahed Fahad Alrefaei and Ji-Chuan Kang corrected and revised the manuscript. Yong-Zhong Lu and Ji-Chuan Kang funded the experiments. All authors revised and agreed to the published version of the manuscript.

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## Data availability

All of the data that support the findings of this study are available in the main text. DNA sequences generated have been submitted to Genbank.

## References

- Ando K (1992) A study of terrestrial aquatic hyphomycetes. *Nippon Kingakkai Kaiho* 33: 415–425. [In Japanese]
- Arambarri A, Cabello M, Mengascini A (1987) New hyphomycetes from Santiago River. II. (Buenos Aires Province, Argentina). *Mycotaxon* 30: 263–267.
- Ariyawansa HA, Hyde KD, Jayasiri SC, Buyck B, Chethana KWT, Dai DQ, Dai YC, Daranagama DA, Jayawardena RS, Lücking R, Ghobad-Nejhad M, Niskanen T, Thambugala KM, Voigt K, Zhao RL, Li GJ, Doilom M, Boonmee S, Yang ZL, Cai Q, Cui YY, Bahkali AH, Chen J, Cui BK, Chen JJ, Dayarathne MC, Dissanayake AJ, Ekanayaka AH, Hashimoto A, Hongsanan S, Jones EBG, Larsson E, Li WJ, Li QR, Liu JK, Luo ZL, Maharachchikumbura SSN, Mapook A, McKenzie EHC, Norphanphoun C, Konta S, Pang KL, Perera RH, Phookamsak R, Phukhamsakda C, Pinruan U, Randrianjohany E, Singtripop C, Tanaka K, Tian CM, Tibpromma S, Abdel-Wahab MA, Wanasinghe DN, Wijayawardene NN, Zhang JF, Zhang H, Abdel-Aziz FA, Wedin M, Westberg M, Ammirati JF, Bulgakov TS, Lima DX, Callaghan TM, Callac P, Chang CH, Coca LF, Dal-Forno M, Dollhofer V, Fliegerová K, Greiner K, Griffith GW, Ho HM, Hofstetter V, Jeewon R, Kang JC, Wen TC, Kirk PM, Kytövuori I, Lawrey JD,

- Xing J, Li H, Liu ZY, Liu XZ, Liimatainen K, Lumbsch HT, Matsumura M, Moncada B, Nuankaew S, Parnmen S, de Azevedo Santiago ALCM, Sommai S, Song Y, de Souza CAF, de Souza-Motta CM, Su HY, Suetrong S, Wang Y, Wei SF, Wen TC, Yuan HS, Zhou LW, Réblová M, Fournier J, Camporesi E, Luangsa-ard JJ, Tasanathai K, Khonsanit A, Thanakitpipattana D, Somrithipol S, Diederich P, Millanes AM, Common RS, Stadler M, Yan JY, Li X, Lee HW, Nguyen TTT, Lee HB, Battistin E, Marsico O, Vizzini A, Vila J, Ercole E, Eberhardt U, Simonini G, Wen HA, Chen XH, Miettinen O, Spirin V, Hernawati (2015) Fungal diversity notes 111–252 – Taxonomic and phylogenetic contributions to fungal taxa. *Fungal Diversity* 75(1): 27–274. <https://doi.org/10.1007/s13225-015-0346-5>
- Bao DF, Hyde KD, McKenzie EHC, Jeewon R, Su HY, Nalumpang S, Luo ZL (2021) Biodiversity of lignicolous freshwater hyphomycetes from China and Thailand and description of sixteen species. *Journal of Fungi* (Basel, Switzerland) 7(8): 669. <https://doi.org/10.3390/jof7080669>
- Berkeley MJ, Broome CE (1854) XLIII. – Notices of British Fungi. *Annals & Magazine of Natural History* 13(78): 458–469. <https://doi.org/10.1080/03745485709495104>
- Capdet M, Romero AI (2010) Fungi from palms in Argentina. 1. *Mycotaxon* 112(1): 339–355. <https://doi.org/10.5248/112.339>
- Capella-Gutiérrez S, Silla-Martínez JM, Gabaldón T (2009) trimAl: A tool for automated alignment trimming in large-scale phylogenetic analyses. *Bioinformatics* (Oxford, England) 25(15): 1972–1973. <https://doi.org/10.1093/bioinformatics/btp348>
- Chen WH, Han YF, Liang JD, Liang ZQ (2021) Taxonomic and phylogenetic characterizations reveal four new species of *Simplicillium* (Cordycipitaceae, Hypocreales) from Guizhou, China. *Scientific Reports* 11(1): 15300. <https://doi.org/10.1038/s41598-021-94893-z>
- Chethana KWT, Manawasinghe IS, Hurdeal VG, Bhunjun CS, Appadoo MA, Gentekaki E, Raspé O, Promputtha I, Hyde KD (2021) What are fungal species and how to delineate them? *Fungal Diversity* 109(1): 1–25. <https://doi.org/10.1007/s13225-021-00483-9>
- Cooke MC, Ellis JB (1879) New Jersey fungi. *Grevillea* 8(45): 11–16. <https://doi.org/10.1086/326617>
- Crous PW, Cowan DA, Maggs-Köling G, Yilmaz N, Thangavel R, Wingfield MJ, Noordeloos ME, Dima B, Brandrud TE, Jansen GM, Morozova OV, Vila J, Shivas RG, Tan YP, Bishop-Hurley S, Lacey E, Marney TS, Larsson E, Le Floch G, Lombard L, Nodet P, Hubka V, Alvarado P, Berraf-Tebbal A, Reyes JD, Delgado G, Eichmeier A, Jordal JB, Kachalkin AV, Kubátová A, Maciá-Vicente JG, Malysheva EF, Papp V, Rajeshkumar KC, Sharma A, Spetik M, Szabóová D, Tomashevskaya MA, Abad JA, Abad ZG, Alexandrova AV, Anand G, Arenas F, Ashtekar N, Balashov S, Bañares Á, Baroncelli R, Bera I, Biketova AY, Blomquist CL, Boekhout T, Boertmann D, Bulyonkova TM, Burgess TI, Carnegie AJ, Cobo-Díaz JF, Corriol G, Cunningham JH, da Cruz MO, Damm U, Davoodian N, de A Santiago ALCM, Dearnaley J, de Freitas LWS, Dhileepan K, Dimitrov R, Di Piazza S, Fatima S, Fuljer F, Galera H, Ghosh A, Giraldo A, Glushakova AM, Gorczak M, Gouliamova DE, Gramaje D, Groenewald M, Gansch CK, Gutiérrez A, Holdom D, Houbraken J, Ismailov AB, Istel Ł, Iturriaga T, Jeppson M, Jurjević Ž, Kalinina LB, Kapitonov VI, Kautmanová I, Khalid AN, Kiran M, Kiss L, Kovács Á, Kurose D, Kušan I, Lad S, Læssøe T, Lee HB, Luangsa-ard JJ, Lynch M, Mahamedi AE, Malysheva VF, Mateos A, Matočec N, Mešić A, Miller AN, Mongkolsamrit S, Moreno G, Morte A, Mostowfizadeh-Ghalemfarsa R, Naseer A, Navarro-Ródenas A, Nguyen TTT, Noisripoom W, Ntandu JE, Nuytinck J, Ostrý V, Pankratov TA, Pawłowska J, Pecenka J, Pham THG, Polhorský A, Pošta A, Raudabaugh DB, Reschke K, Rodríguez A, Romero M, Rooney-Latham S, Roux J, Sandoval-Denis M, Smith MTh, Steinrücken TV, Svetasheva TY, Tkáčec Z, van der Linde EJ, Vegte Mvd, Vauras J, Verbeken A, Visagie CM, Vitelli JS, Volobuev SV, Weill A, Wrzosek M,

- Zmitrovich IV, Zvyagina EA, Groenewald JZ (2021) Fungal Planet description sheets: 1182–1283. *Persoonia* 46: 313. <https://doi.org/10.3767/persoonia.2021.46.11>
- Crous PW, Boers J, Holdom D, Osieck ER, Steinrücken TV, Tan YP, Vitelli JS, Shivas RG, Barrett M, Boxshall A-G, Broadbridge J, Larsson E, Lebel T, Pinruan U, Sommai S, Alvarado P, Bonito G, Decock CA, De la Peña-Lastra S, Delgado G, Houbraken J, Maciá-Vicente JG, Raja HA, Rigueiro-Rodríguez A, Rodríguez A, Wingfield MJ, Adams SJ, Akulov A, Al-Hidmi T, Antonín V, Arauzo S, Arenas F, Armada F, Aylward J, Bellanger J-M, Berraf-Tebbal A, Bidaud A, Boccardo F, Cabero J, Calleda F, Corriol G, Crane JL, Dearnaley JDW, Dima B, Dovana F, Eichmeier A, Esteve-Raventós F, Fine M, Ganzert L, García D, Torres-García D, Gené J, Gutiérrez A, Iglesias P, Istel L, Jangsantear P, Jansen GM, Jeppson M, Karun NC, Karich A, Khamsuntorn P, Kokkonen K, Kolarik M, Kubátová A, Labuda R, Lagashetti AC, Lifshitz N, Linde C, Loizides M, Luangsa-ard JJ, Lueangjaroenkit P, Mahadevakumar S, Mahamedi AE, Malloch DW, Marinowicz S, Mateos A, Moreau P-A, Miller AN, Molia A, Morte A, Navarro-Ródenas A, Nebesářová J, Nigrone E, Nuthan BR, Oberlies NH, Pepori AL, Rämä T, Rapley D, Reschke K, Robicheau BM, Roets F, Roux J, Saavedra M, Sakolrak B, Santini A, Ševčíková H, Singh PN, Singh SK, Somrithipol S, Spletik M, Sridhar KR, Starink-Willemse M, Taylor VA, van Iperen AL, Vauras J, Walker AK, Wingfield BD, Yarden O, Cooke AW, Manners AG, Pegg KG, Groenewald JZ (2022) Fungal Planet description sheets: 1383–1435. *Persoonia* 48(1): 261–371. <https://doi.org/10.3767/persoonia.2022.48.08>
- Cubeta MA, Echandi E, Abernethy T, Vilgalys R (1991) Characterization of anastomosis groups of binucleate *Rhizoctonia* species using restriction analysis of an amplified ribosomal RNA gene. *Phytopathology* 81(11): 1395–1400. <https://doi.org/10.1094/Phyto-81-1395>
- Delgado G, Koukol O, Cáceres O, Piepenbring M (2017) The phylogenetic placement of *Ernakulamia cochinchensis* within Pleosporales (Dothideomycetes, Ascomycota). *Cryptogamie. Mycologie* 38(4): 435–452. <https://doi.org/10.7872/crym/v38.iss4.2017.435>
- Delgado-Rodríguez G, Mena-Portales J (2004) Hifomicetos (hongos anamórficos) de la reserva ecológica “Alturas de Banao” (Cuba). *Boletín de la Sociedad Micológica de Madrid* 28: 115–124.
- Dissanayake AJ, Chen YY, Liu JK (2020) Unravelling *Diaporthe* species associated with woody hosts from karst formations (Guizhou) in China. *Journal of Fungi* (Basel, Switzerland) 6(4): 251. <https://doi.org/10.3390/jof6040251>
- Dong W, Wang B, Hyde KD, McKenzie EHC, Raja HA, Tanaka K, Abdel-Wahab MA, Abdel-Aziz FA, Doilom M, Phookamsak R, Hongsan S, Wanasinghe DN, Yu XD, Wang GN, Yang H, Yang J, Thambugala KM, Tian Q, Luo ZL, Yang JB, Miller AN, Fournier J, Boonmee S, Hu DM, Nalumpang S, Zhang H (2020) Freshwater Dothideomycetes. *Fungal Diversity* 105(1): 319–575. <https://doi.org/10.1007/s13225-020-00463-5>
- Ellis MB (1949) *Tetraploa*. *Transactions of the British Mycological Society* 32(3–4): 246–251. [https://doi.org/10.1016/S0007-1536\(49\)80013-1](https://doi.org/10.1016/S0007-1536(49)80013-1)
- Ellis MB (1971) Dematiaceous hyphomycetes. *Dematiaceous hyphomycetes*.
- Ellis RP (1976) A procedure for standardizing comparative leaf anatomy in the Poaceae. I. The leaf-blade as viewed in transverse section. *Bothalia* 12(1): 65–109. <https://doi.org/10.4102/abc.v12i1.1382>
- Farr DF, Rossman AY (2023) Fungal Databases, US National Fungus Collections, ARS, USDA. 2020. <https://nt.ars-grin.gov/fungaldatabases/> [Accession date: 9August, 2023]
- Feng B, Yang Z (2018) Studies on diversity of higher fungi in Yunnan, southwestern China: A review. *Plant Diversity* 40(4): 165–171. <https://doi.org/10.1016/j.pld.2018.07.001>
- Glass NL, Donaldson GC (1995) Development of primer sets designed for use with the PCR to amplify conserved genes from filamentous ascomycetes. *Applied*

- and Environmental Microbiology 61(4): 1323–1330. <https://doi.org/10.1128/aem.61.4.1323-1330.1995>
- González Fragoso R (1916) Hongos sobre muscineas. Boletín de la Real Sociedad Española de Historia Natural 16: 367–370.
- Gupta A (2002) Algal/fungal spores from Early Tertiary sediments of Sirmaur District, Himachal Pradesh, India. Tertiary Research 21(1/4): 128–154.
- Hapuarachchi KK, Karunarathna SC, Raspé O, De Silva KHWL, Thawthong A, Wu XL, Kakumyan P, Hyde KD, Wen TC (2018) High diversity of *Ganoderma* and *Amauroderma* (Ganodermataceae, Polyporales) in Hainan Island, China. Mycosphere: Journal of Fungal Biology 9(5): 931–982. <https://doi.org/10.5943/mycosphere/9/5/1>
- Harkness HW (1885) Fungi of the Pacific Coast. Bulletin of the California Academy of Sciences 1(3): 159–176.
- Hatakeyama S, Tanaka K, Harada Y (2005) Bambusicolous fungi in Japan (5): Three species of *Tetraploa*. Mycoscience 46(3): 196–200. <https://doi.org/10.1007/S10267-005-0233-0>
- Holubová-Jechová V, Mercado-Sierra A (1986) Studies on Hyphomycetes from Cuba IV. Dematiaceous Hyphomycetes from the Province PinardelRio. Česká Mykologie 40: 142–164.
- Holubová-Jechová V (1989) Hyphomycetes from Loma de la Coca and some localities of La Habana and Matanzas provinces, Cuba. Acta Botánica Cubana 76: 1–15.
- Hongsanan S, Hyde KD, Phookamsak R, Wanasinghe DN, McKenzie EHC, Sarma VV, Boonmee S, Lücking R, Bhat DJ, Liu NG, Tennakoon DS, Pem D, Karunarathna A, Jiang SH, Jones EBG, Phillips AJL, Manawasinghe IS, Tibpromma S, Jayasiri SC, Sandamali DS, Jayawardena RS, Wijayawardene NN, Ekanayaka AH, Jeewon R, Lu YZ, Dissanayake AJ, Zeng XY, Luo ZL, Tian Q, Phukhamsakda C, Thambugala KM, Dai DQ, Chethana KWT, Samarakoon MC, Ertz D, Bao DF, Doilom M, Liu JK (2020) Refined families of Dothideomycetes: Dothideomycetidae and Pleosporomycetidae. Mycosphere: Journal of Fungal Biology 11(1): 1553–2107. <https://doi.org/10.5943/mycosphere/11/1/13>
- Huang SK, Maharachchikumbura SSN, Jeewon R, Bhat JD, Phookamsak R, Hyde KD, Al-Sadi AM, Kang JC (2018) *Lecanicillium subprimulinum* (Cordycipitaceae, Hypocreales), a novel species from Baoshan, Yunnan. Phytotaxa 348(2): 99–108. <https://doi.org/10.11646/phytotaxa.348.2.4>
- Huang T, Su LJ, Zeng NK, Lee SM, Lee SS, Thi BK, Zhang WH, Ma J, Huang HY, Jiang S, Tang LP (2023) Notes on *Amanita* section Validae in Hainan Island, China. Frontiers in Microbiology 13: 1087756. <https://doi.org/10.3389/fmicb.2022.1087756>
- Huelsenbeck JP, Ronquist F (2001) MRBAYES: Bayesian inference of phylogenetic trees. Bioinformatics (Oxford, England) 17(8): 754–589. <https://doi.org/10.1093/bioinformatics/17.8.754>
- Hyde KD, Jones G, Liu JK, Ariyawansa H, Boehm E, Boonmee S, Braun U, Chomnunti P, Crous PW, Dai DQ, Diederich P, Dissanayake A, Doilom M, Doveri F, Hongsanan S, Jayawardena R, Lawrey JD, Li YM, Liu YX, Lücking R, Monkai J, Muggia L, Nelsen MP, Pang KL, Phookamsak R, Senanayake IC, Shearer CA, Suetrong S, Tanaka K, Thambugala KM, Wijayawardene NN, Wikee S, Wu HX, Zhang Y, Aguirre-Hudson B, Alias SA, Aptroot A, Bahkali AH, Bezerra JL, Bhat DJ, Camporesi E, Chukeatirote E, Gueidan C, Hawksworth DL, Hirayama K, Hoog SD, Kang JC, Knudsen K, Li WJ, Li XH, Liu ZY, Mapook A, McKenzie EHC, Miller AN, Mortimer PE, Phillips AJL, Raja HA, Scheuer C, Schumm F, Taylor JE, Tian Q, Tibpromma S, Wanasinghe DN, Wang Y, Xu JC, Yacharoen S, Yan JY, Zhang M (2013) Families of Dothideomycetes. Fungal Diversity 63(1): 1–313. <https://doi.org/10.1007/s13225-013-0263-4>

- Hyde KD, Norphanphoun C, Chen J, Dissanayake AJ, Doilom M, Hongsanan S, Jayawardena RS, Jeewon R, Perera RH, Thongbai B, Wanasinghe DN, Wisitrassameewong K, Tibpromma S, Stadler M (2018) Thailand's amazing diversity: Up to 96% of fungi in northern Thailand may be novel. *Fungal Diversity* 93(1): 215–239. <https://doi.org/10.1007/s13225-018-0415-7>
- Hyde KD, Tennakoon DS, Jeewon R, Bhat DJ, Maharachchikumbura SS, Rossi W, Leonardi M, Lee HB, Mun HY, Houbraken J, Nguyen TTT, Jeon SJ, Frisvad JC, Wanasinghe DN, Lücking R, Aptroot A, Cáceres MES, Karunarathna SC, Hongsanan S, Phookamsak R, de Silva NI, Thambugala KM, Jayawardena RS, Senanayake IC, Boonmee S, Chen J, Luo ZL, Phukhamsakda C, Pereira OL, Abreu VP, Rosado AWC, Bart B, Randrianjohany E, Hofstetter V, Gibertoni TB, da Silva Soares AM, Plautz Jr HL, Sotão HMP, Xavier WKS, Bezerra JDP, de Oliveira TGL, de Souza-Motta CM, Magalhães OMC, Bundhun D, Harishchandra D, Manawasinghe IS, Dong W, Zhang SN, Bao DF, Samarakoon MC, Pem D, Karunarathna A, Lin CG, Yang J, Perera RH, Kumar V, Huang SK, Dayarathne MC, Ekanayaka AH, Jayasiri SC, Xiao YP, Konta S, Niskanen T, Liimatainen K, Dai YC, Ji XH, Tian XM, Mešić A, Singh SK, Phuthacharoen K, Cai L, Sorvongxay T, Thiyagaraja V, Norphanphoun C, Chaiwan N, Lu YZ, Jiang HB, Zhang JF, Abeywickrama PD, Aluthmuhandiram JVS, Brahmanage RS, Zeng M, Chethana T, Wei DP, Réblová M, Fournier J, Nekvindová J, Barbosa RDN, dos Santos JEF, de Oliveira NT, Li GJ, Ertz D, Shang QJ, Phillips AJL, Kuo CH, Camporesi E, Bulgakov TS, Lumyong S, Jones EBG, Chomnunti P, Gentekaki E, Bungartz F, Zeng XY, Fryar S, Tkáčec Z, Liang J, Li GS, Wen TC, Singh PN, Gafforov Y, Promputtha I, Yasanthika E, Goonasekara ID, Zhao RL, Zhao Q, Kirk PM, Liu JK, Yan JY, Mortimer PE, Xu JC, Doilom M (2019) Fungal diversity notes 1036–1150: Taxonomic and phylogenetic contributions on genera and species of fungal taxa. *Fungal Diversity* 96(1): 1–242. <https://doi.org/10.1007/s13225-019-00429-2>
- Hyde KD, Dong Y, Phookamsak R, Jeewon R, Bhat DJ, Jones EBG, Liu NG, Abeywickrama PD, Mapook A, Wei D, Perera RH, Manawasinghe IS, Pem D, Bundhun D, Karunarathna A, Ekanayaka AH, Bao DF, Li J, Samarakoon MC, Chaiwan N, Lin CG, Phuthacharoen K, Zhang SN, Senanayake IC, Goonasekara ID, Thambugala KM, Phukhamsakda C, Tennakoon DS, Jiang HB, Yang J, Zeng M, Huanraluek N, Liu JK, Wijesinghe SN, Tian Q, Tibpromma S, Brahmanage RS, Boonmee S, Huang SK, Thiyagaraja V, Lu YZ, Jayawardena RS, Dong W, Yang EF, Singh SK, Singh SM, Rana S, Lad SS, Anand G, Devadatha B, Niranjana M, Sarma VV, Liimatainen K, Aguirre-Hudson B, Niskanen T, Overall A, Alvarenga RLM, Gibertoni TB, Pfliegler WP, Horváth E, Imre A, Alves AL, da Silva Santos AC, Tiago PV, Bulgakov TS, Wanasinghe DN, Bahkali AH, Doilom M, Elgorban AM, Maharachchikumbura SSN, Rajeshkumar KC, Haelewaters D, Mortimer PE, Zhao Q, Lumyong S, Xu JC, Sheng J (2020a) Fungal diversity notes 1151–1276: Taxonomic and phylogenetic contributions on genera and species of fungal taxa. *Fungal Diversity* 100(1): 5–277. <https://doi.org/10.1007/s13225-020-00439-5>
- Hyde KD, Norphanphoun C, Maharachchikumbura SSN, Bhat DJ, Jones EBG, Bundhun D, Chen YJ, Bao DF, Boonmee S, Calabon MS, Chaiwan N, Chethana KWT, Dai DQ, Dayarathne MC, Devadatha B, Dissanayake AJ, Dissanayake LS, Doilom M, Dong W, Fan XL, Goonasekara ID, Hongsanan S, Huang SK, Jayawardena RS, Jeewon R, Karunarathna A, Konta S, Kumar V, Lin CG, Liu JK, Liu NG, Luangsa-ard J, Lumyong S, Luo ZL, Marasinghe DS, McKenzie EHC, Niego AGT, Niranjana M, Perera RH, Phukhamsakda C, Rathnayaka AR, Samarakoon MC, Samarakoon SMBC, Sarma VV, Senanayake IC, Shang QJ, Stadler M, Tibpromma S, Wanasinghe DN, Wei DP, Wijaya-wardene NN, Xiao YP, Yang J, Zeng XY, Zhang SN, Xiang MM (2020b) Refined families of Sordariomycetes. *Mycosphere: Journal of Fungal Biology* 11(1): 306–1060. <https://doi.org/10.5943/mycosphere/11/1/7>

- Index Fungorum (2023) The Index Fungorum database. <http://www.indexfungorum.org> [Accessed June 24, 2023]
- Jayasiri SC, Hyde KD, Ariyawansa HA, Bhat J, Buyck B, Cai L, Dai YC, Abd-Elsalam KA, Ertz D, Hidayat I, Jeewon R, Jones EBG, Bahkali AH, Karunarathna SC, Liu JK, Luangsa-ard JJ, Lumbsch HT, Maharachchikumbura SSN, McKenzie EHC, Moncalvo JM, Ghobad-Nejhad M, Nilsson H, Pang KL, Pereira OL, Phillips AJL, Raspé O, Rollins AW, Romero AI, Etayo J, Selçuk F, Stephenson SL, Suetrong S, Taylor JE, Tsui CKM, Vizzini A, Abdel-Wahab MA, Wen TC, Boonmee S, Dai DQ, Daranagama DA, Dissanayake AJ, Ekanayaka AH, Fryar SC, Hongsanan S, Jayawardena RS, Li WJ, Perera RH, Phookamsak R, de Silva NI, Thambugala KM, Tian Q, Wijayawardene NN, Zhao RL, Zhao Q, Kang JC, Promputtha I (2015) The Faces of Fungi database: Fungal names linked with morphology, phylogeny and human impacts. *Fungal Diversity* 74(1): 3–18. <https://doi.org/10.1007/s13225-015-0351-8>
- Jayasiri SC, Hyde KD, Jones EBG, McKenzie EHC, Jeewon R, Phillips AJL, Bhat DJ, Wanasinghe DN, Liu JK, Lu YZ, Kang JC, Xu JC, Karunarathna SC (2019) Diversity, morphology and molecular phylogeny of Dothideomycetes on decaying wild seed pods and fruits. *Mycosphere* 10(1): 1–186. <https://doi.org/10.5943/mycosphere/10/1/1>
- Jayawardena RS, Hyde KD, Wang S, Sun YR, Suwannarach N, Sysouphanthong P, Abdel-Wahab MA, Abdel-Aziz FA, Abeywickrama PD, Abreu VP, Armand A, Aptroot A, Bao DF, Begerow D, Bellanger JM, Bezerra JDP, Bundhun D, Calabon MS, Cao T, Cantillo T, Carvalho JLVR, Chaiwan N, Chen CC, Courtecuisse R, Cui BK, Damm U, Denchev CM, Denchev TT, Deng CY, Devadatha B, de Silva NI, Santos LA, Dubey NK, Dumez S, Fernandez HS, Firmino AL, Gafforov Y, Gajanayake AJ, Gomdola D, Gunaseelan S, He SC, Htet ZH, Kaliyaperumal M, Kemler M, Kezo K, Kularathnage ND, Leonardi M, Li JP, Liao CF, Liu S, Loizides M, Luangharn T, Ma J, Madrid H, Mahadevakumar S, Maharachchikumbura SSN, Manamgoda DS, Martín MP, Mekala N, Moreau P-A, Mu YH, Pahoua P, Pem D, Pereira OL, Phonrob W, Phukhamsakda C, Raza M, Ren GC, Rinaldi AC, Rossi W, Samarakoon BC, Samarakoon MC, Sarma VV, Senanayake IC, Singh A, Souza MF, Souza-Motta CM, Spielmann AA, Su WX, Tang X, Tian XG, Thambugala KM, Thongklang N, Tennakoon DS, Wannathes N, Wei DP, Welti S, Wijesinghe SN, Yang HD, Yang YH, Yuan HS, Zhang H, Zhang JY, Balasuriya A, Bhunjun CS, Bulgakov TS, Cai L, Camporesi E, Chomnunti P, Deepika YS, Doilom M, Duan WJ, Han SL, Huanraluek N, Gareth Jones EB, Lakshmidhevi N, Li Y, Lumyong S, Luo ZL, Khuna S, Kumla J, Manawasinghe IS, Mapook A, Punyaboon W, Tibpromma S, Lu YZ, Yan JY, Wang Y (2023) Fungal diversity notes 1512–1610: Taxonomic and phylogenetic contributions on genera and species of fungal taxa. *Fungal Diversity* 117(1): 1–272. <https://doi.org/10.1007/s13225-022-00513-0>
- Jeewon R, Hyde KD (2016) Establishing species boundaries and new taxa among fungi: Recommendations to resolve taxonomic ambiguities. *Mycosphere* 7(11): 1669–1677. <https://doi.org/10.5943/mycosphere/7/11/4>
- Jeewon R, Cai L, Zhang K, Hyde KD (2003) *Dyrithiopsis lakefuxianensis* gen et sp. nov. from Fuxian Lake, Yunnan, China and notes on the taxonomic confusion surrounding *Dyrithium*. *Mycologia* 95(5): 911–920. <https://doi.org/10.1080/15572536.2004.11833050>
- Karsten PA (1870) *Symbolae ad mycologiam Fennicam*. I. Notiser ur Sällskapet pro Fauna et Flora Fennica Förhandlingar. 11: 211–268.
- Katoh K, Rozewicki J, Yamada KD (2017) MAFFT online service: Multiple sequence alignment, interactive sequence choice and visualization. *Briefings in Bioinformatics* 20(4): 1160–1166. <https://doi.org/10.1093/bib/bbx108>
- Kirschner R, Villarreal RV, Hofmann TA (2017) A new species of *Shrungabeeja* (Tetraplospheariaceae) and new records of saprobic dematiaceous hyphomycetes on Poaceae from the high mountains of Panama. *Sydowia* 69: 153–160.

- Li WL, Bao DF, Bhat DJ, Su HY (2020) *Tetraploa aquatica* (Tetraplosphaeriaceae), a new freshwater fungal species from Yunnan Province, China. *Phytotaxa* 459(2): 181–189. <https://doi.org/10.11646/phytotaxa.459.2.8>
- Li HJ, He SH, Cui BK (2010) *Polypores* from Bawangling Nature Reserve, Hainan Province. *Junwu Xuebao* 29(6): 828–833.
- Li GJ, Hyde KD, Zhao RL, Hongsanan S, Abdel-Aziz FA, Abdel-Wahab MA, Alvarado P, Alves-Silva G, Ammirati JF, Ariyawansa HA, Baghela A, Bahkali AH, Beug M, Bhat DJ, Bojantchev D, Boonpratuang T, Bulgakov TS, Camporesi E, Boro MC, Ceska O, Chakraborty D, Chen JJ, Chethana KWT, Chomnunti P, Consiglio G, Cui BK, Dai DQ, Dai YC, Daranagama DA, Das K, Dayarathne MC, De Crop E, De Oliveira RJV, de Souza CAF, de Souza JI, Dentinger BTM, Dissanayake AJ, Doilom M, Drechsler-Santos ER, Ghobad-Nejhad M, Gilmore SP, Góes-Neto A, Gorczak M, Haitjema CH, Hapuarachchi KK, Hashimoto A, He MQ, Henske JK, Hirayama K, Iribarren MJ, Jayasiri SC, Jayawardena RS, Jeon SJ, Jerônimo GH, Jesus AL, Jones EBG, Kang JC, Karunarathna SC, Kirk PM, Konta S, Kuhnert E, Langer E, Lee HS, Lee HB, Li WJ, Li XH, Liimatainen K, Lima DX, Lin CG, Liu JK, Liu XZ, Liu ZY, Luangsa-ard JJ, Lücking R, Lumbsch HT, Lumyong S, Leaño EM, Marano AV, Matsumura M, McKenzie EHC, Mongkolsamrit S, Mortimer PE, Nguyen TTT, Niskanen T, Norphanphoun C, O'Malley MA, Parmen S, Pawłowska J, Perera RH, Phookamsak R, Phukhamsakda C, Pires-Zottarelli CLA, Raspé O, Reck MA, Rocha SCO, de Santiago ALCMA, Senanayake IC, Setti L, Shang QJ, Singh SK, Sir EB, Solomon KV, Song J, Srikitikulchai P, Stadler M, Suetrong S, Takahashi H, Takahashi T, Tanaka K, Tang LP, Thambugala KM, Thanakitpipattana D, Theodorou MK, Thongbai B, Thummarukcharoen T, Tian Q, Tibpromma S, Verbeken A, Vizzini A, Vlasák J, Voigt K, Wanasinghe DN, Wang Y, Weerakoon G, Wen HA, Wen TC, Wijayawardene NN, Wongkanoun S, Wrzosek M, Xiao YP, Xu JC, Yan JY, Yang J, Da Yang S, Hu Y, Zhang JF, Zhao J, Zhou LW, Peršoh D, Phillips AJL, Maharachchikumbura SSN (2016) Fungal diversity notes 253–366: Taxonomic and phylogenetic contributions to fungal taxa. *Fungal Diversity* 78(1): 1–237. <https://doi.org/10.1007/s13225-016-0366-9>
- Li WL, Bao DF, Liu NG, Hyde KD, Liu JK (2021) *Aquatisphaeria thailandica* gen. et sp. nov. (Tetraplosphaeriaceae, Pleosporales) from freshwater habitat in Thailand. *Phytotaxa* 513(2): 118–128. <https://doi.org/10.11646/phytotaxa.513.2.3>
- Liao CF, Dong W, Chethana KT, Pem D, Phookamsak R, Suwannarach N, Doilom M (2022) Morphological and phylogenetic evidence reveal *Tetraploa cylindrica* sp. nov. (Tetraplosphaeriaceae, Pleosporales) from *Saccharum arundinaceum* (Poaceae) in Yunnan Province, China. *Phytotaxa* 554(2): 189–200. <https://doi.org/10.11646/phytotaxa.554.2.7>
- Luo ZL, Bhat DJ, Jeewon R, Boonmee S, Bao DF, Zhao YC, Hong-Mei Chai HM, Su HY, Su XJ, Hyde KD (2017) Molecular phylogeny and morphological characterization of asexual fungi (Tubeufiaceae) from freshwater habitats in Yunnan, China. *Cryptogamie. Mycologie* 38(1): 27–53. <https://doi.org/10.7872/crym/v38.iss1.2017.27>
- Luo ZL, Hyde KD, Bhat DJ, Jeewon R, Maharachchikumbura SS, Bao DF, Li WL, Su XJ, Yang XY, Su HY (2018) Morphological and molecular taxonomy of novel species Pleurotheciaceae from freshwater habitats in Yunnan, China. *Mycological Progress* 17(5): 511–530. <https://doi.org/10.1007/s11557-018-1377-6>
- Markham WD, Key RD, Padhye AA, Ajello L (1990) Phaeohyphomycotic cyst caused by *Tetraploa aristata*. *Medical Mycology* 28(2): 147–150. <https://doi.org/10.1080/02681219080000191>
- Matsushima K, Matsushima T (1996) *Fragmenta Mycologica II*. *Matsushima Mycological Memoirs* 9: 31–40.

- Mercado-Sierra A, González-Fraginals G, Mena-Portales J, Rodríguez-Morejón K (1997) Las Palmas y su relación como sustratos de Hongos Microscópicos (Hifomicetes) en Cuba. *Boletín de la Sociedad Micológica de Madrid* 22: 33–44.
- Miller MA, Pfeiffer W, Schwartz T (2010) Creating the CIPRES Science Gateway for inference of large phylogenetic trees. 2010 Gateway Computing Environments Workshop (GCE). Institute of Electrical and Electronics Engineers, New Orleans, LA, 1–8. <https://doi.org/10.1109/GCE.2010.5676129>
- Mortimer PE, Jeewon R, Xu JC, Lumyong S, Wanasinghe DN (2021) Morpho-phylo taxonomy of novel dothideomycetous fungi associated with dead woody twigs in Yunnan Province, China. *Frontiers in Microbiology* 12: 654683. <https://doi.org/10.3389/fmicb.2021.654683>
- Núñez Otaño NB, Bianchinotti MV, Romero IC, Perez Pincheira E, Saxena RK, Saparrat MCN (2022) Fossil *Tetraploa* redefinition and potential contribution of dark pigments for the preservation of its spores in the fossil record. *Mycosphere* 13(1): 188–206. <https://doi.org/10.5943/mycosphere/si/1f/6>
- Pem D, Jeewon R, Bhat DJ, Doilom M, Boonmee S, Hongsan S, Promputtha I, Xu JC, Hyde KD (2019) Mycosphere Notes 275–324: A morphotaxonomic revision and typification of obscure Dothideomycetes genera (incertae sedis). *Mycosphere* 10(1): 1115–1246. <https://doi.org/10.5943/mycosphere/10/1/22>
- Pem D, Jeewon R, Chethana KWT, Hongsan S, Doilom M, Suwannarach N, Hyde KD (2021) Species concepts of Dothideomycetes: Classification, phylogenetic inconsistencies and taxonomic standardization. *Fungal Diversity* 109(1): 283–319. <https://doi.org/10.1007/s13225-021-00485-7>
- Phookamsak R, Jiang HB, Suwannarach N, Lumyong S, Xu JC, Xu S, Liao CF, Chomnunti P (2022) Bambusicolous fungi in pleosporales: Introducing four novel taxa and a new habitat record for *Anastomitrabeculia didymospora*. *Journal of Fungi* (Basel, Switzerland) 8(6, no. 630): 1–35. <https://doi.org/10.3390/jof8060630>
- Pratibha J, Bhat DJ (2008) New and unusual fungi from Mahabaleshwar, India. *Mycotaxon* 105: 423–431.
- Rao VG, Reddy KA (1981) Two new Hyphomycetes. *Iranian Journal of Botany* 4(1): 108–114.
- Révay A (1993) Some new or interesting hyphomycetes from Hungary. *Nova Hedwigia* 56: 473–482.
- Rifai MA, Zainuddin H, Cholil A (2014) The Javanese species of *Tetraploa*. *Reinwardtia* 10(4): 419–423.
- Ronquist F, Teslenko M, Van Der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian Phylogenetic Inference and model choice across a large model space. *Systematic Biology* 61(3): 539–542. <https://doi.org/10.1093/sysbio/sys029>
- Saxena RK, Khare S (1991) Fungal remains from the Neyveli formation of Tiruchirappalli District, Tamil Nadu, India. *Geophytology* 21(1): 37–43.
- Saxena RK, Sarkar S (1986) Morphological study of *Frasnacritetrus taugourdeau* emend. From tertiary sediments of himachal pradesh, India. *Review of Palaeobotany and Palynology* 46(3–4): 209–225. [https://doi.org/10.1016/0034-6667\(86\)90015-1](https://doi.org/10.1016/0034-6667(86)90015-1)
- Saxena RK, Singh HP, Rao MR (1987) Palynology of the Tatrot – Pinjor sequence exposed between Masol and Kiratpur in Ambala District, Haryana. *Geophytology* 17: 270–284.
- Saxena RK, Wijayawardene NN, Dai DQ, Hyde KD, Kirk PM (2021) Diversity in fossil fungal spores. *Mycosphere* 12(1): 670–874. <https://doi.org/10.5943/mycosphere/12/1/8>
- Scheuer C (1991) *Massarina tetraploa* sp. nov., the teleomorph of *Tetraploa aristata*. *Mycological Research* 95(1): 126–128. [https://doi.org/10.1016/S0953-7562\(09\)81370-1](https://doi.org/10.1016/S0953-7562(09)81370-1)

- Senanayake IC, Rathnayaka AR, Marasinghe DS, Calabon MS, Gentekaki E, Lee HB, Hurdeal VG, Pem D, Dissanayake LS, Wijesinghe SN, Bundhun D, Nguyen TT, Goonasekara ID, Abeywickrama PD, Bhunjun CS, Jayawardena RS, Wanasinghe DN, Jeewon R, Bhat DJ, Xiang MM (2020) Morphological approaches in studying fungi: Collection, examination, isolation, sporulation and preservation. *Mycosphere* 11(1): 2678–2754. <https://doi.org/10.5943/mycosphere/11/1/20>
- Senwanna C, Mapook A, Samarakoon MC, Karunarathna A, Wang Y, Tang AMC, Haituk S, Suwannarach N, Hyde KD, Cheewangkoon R (2021) Ascomycetes on Para rubber (*Hevea brasiliensis*). *Mycosphere* 12(1): 1334–1512. <https://doi.org/10.5943/mycosphere/12/1/18>
- Sierra AM, Guarro J, Heredia G (2005) The hyphomycete genus *Piricauda*, with the description of a new species. *Mycological Research* 109(6): 723–728. <https://doi.org/10.1017/S0953756205002522>
- Stamatakis A, Hoover P, Rougemont J (2008) A rapid bootstrap algorithm for the RAxML Web servers. *Systematic Biology* 57(5): 758–771. <https://doi.org/10.1080/10635150802429642>
- Su XJ, Luo ZL, Jeewon R, Bhat DJ, Bao DF, Li WL, Hao YE, Su HY, Hyde KD (2018) Morphology and multigene phylogeny reveal new genus and species of Torulaceae from freshwater habitats in northwestern Yunnan, China. *Mycological Progress* 17(5): 531–545. <https://doi.org/10.1007/s11557-018-1388-3>
- Swofford DL (2002) PAUP\*: Phylogenetic analysis using parsimony (and other methods), version 4.0 b10. MA: Sinauer Associates, Sunderland, UK.
- Tanaka K, Hirayama K, Yonezawa H, Hatakeyama S, Harada Y, Sano T, Shirouzu T, Hosoia T (2009) Molecular taxonomy of bambusicolous fungi: Tetraplosphaeriaceae, a new pleosporalean family with tetraploa-like anamorphs. *Studies in Mycology* 64: 175–209. <https://doi.org/10.3114/sim.2009.64.10>
- Tang X, Jayawardena RS, Stephenson SL, Kang JC (2022) A new species *Pseudoplagiostoma dipterocarpicola* (Pseudoplagiostomataceae, Diaporthales) found in northern Thailand on members of the Dipterocarpaceae. *Phytotaxa* 543(4): 233–243. <https://doi.org/10.11646/phytotaxa.543.4.3>
- Taylor JE, Hyde KD (2003) Microfungi of tropical and temperate palms. *Fungal Diversity Research Series* 12:1–459.
- Tibpromma S, Hyde KD, McKenzie EHC, Bhat DJ, Phillips AJL, Wanasinghe DN, Samarakoon MC, Jayawardena RS, Dissanayake AJ, Tennakoon DS, Doilom M, Phookamsak R, Tang AMC, Xu J, Mortimer PE, Promputtha I, Maharachchikumbura SSN, Khan S, Karunarathna SC (2018) Fungal diversity notes 840–928: Micro-fungi associated with Pandanaceae. *Fungal Diversity* 93(1): 1–160. <https://doi.org/10.1007/s13225-018-0408-6>
- Tracy SM, Earle FS (1895) New species of parasitic fungi. *Bulletin of the Torrey Botanical Club* 22(4): 174–208. <https://doi.org/10.2307/2477854>
- Vaidya G, Lohman DJ, Meier R (2011) SequenceMatrix: Concatenation software for the fast assembly of multi-gene datasets with character set and codon information. *Cladistics* 27(2): 171–180. <https://doi.org/10.1111/j.1096-0031.2010.00329.x>
- Vilgalys R, Hester M (1990) Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. *Journal of Bacteriology* 172(8): 4238–4246. <https://doi.org/10.1128/jb.172.8.4238-4246.1990>
- White TJ, Bruns T, Lee SJWT, Taylor J (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. *PCR protocols: a guide to methods and applications* 18: 315–322. <https://doi.org/10.1016/B978-0-12-372180-8.50042-1>

- Whitton SR, McKenzie EH, Hyde KD (2012) Anamorphic fungi associated with Pandanaceae. Fungal Diversity Research Series 21: 125–353. [https://doi.org/10.1007/978-94-007-4447-9\\_4](https://doi.org/10.1007/978-94-007-4447-9_4)
- Wijayawardene NN, Hyde KD, Dai DQ, Sánchez-García M, Goto BT, Saxena RK, Erdoğan M, Selçuk F, Rajeshkumar KC, Aptroot A, Błaszczowski J, Boonyuen N, da Silva GA, de Souza FA, Dong W, Ertz D, Haelewaters D, Jones EBG, Karunarathna SC, Kirk PM, Kukwa M, Kumla J, Leontyev DV, Lumbsch HT, Maharachchikumbura SSN, Marguno F, Martínez-Rodríguez P, Mešić A, Monteiro JS, Oehl F, Pawłowska J, Pem D, Pfliegler WP, Phillips AJL, Pošta A, He MQ, Li JX, Raza M, Sruthi OP, Suetrong S, Suwannarach N, Tedersoo L, Thiyagaraja V, Tibpromma S, Tkáčec Z, Tokarev YS, Wanasinghe DN, Wijesundara DSA, Wimalaseana SDMK, Madrid H, Zhang GQ, Gao Y, Sánchez-Castro I, Tang LZ, Stadler M, Yurkov A, Thines M (2022) Outline of Fungi and fungus-like taxa – 2021. Mycosphere 13(1): 53–453. <https://doi.org/10.5943/mycosphere/13/1/2>
- Yang CL, Xu XL, Jeewon R, Boonmee S, Liu YG, Hyde KD (2019) *Acremonium arthrinii* sp. nov., a mycopathogenic fungus on *Arthrinium yunnanum*. Phytotaxa 420(4): 283–299. <https://doi.org/10.11646/phytotaxa.420.4.4>
- Yang J, Liu LL, Jones EG, Hyde KD, Liu ZY, Bao DF, Liu NG, Li WL, Sheng HW, Yu XD, Liu JK (2023) Freshwater fungi from karst landscapes in China and Thailand. Fungal Diversity 119(1): 1–212. <https://doi.org/10.1007/s13225-023-00514-7>
- Yu XD, Zhang SN, Liu JK (2022) Morpho-phylogenetic evidence reveals novel pleosporalean taxa from Sichuan Province, China. Journal of Fungi (Basel, Switzerland) 8(7): 720. <https://doi.org/10.3390/jof8070720>
- Zhang WM, Bi ZS, Li TH, Zheng GY (1994) Taxonomic studies on the genus *Entoloma* from Hainan Province of China (II). Acta Mycologica Sinica 13(4): 260–263.
- Zhang K, Ma LG, Zhang XG (2009) New species and records of *Shrungabeeja* from southern China. Mycologia 101(4): 573–578. <https://doi.org/10.3852/09-006>
- Zhang Y, Crous PW, Schoch CL, Hyde KD (2012) Pleosporales. Fungal Diversity 53(1): 1–221. <https://doi.org/10.1007/s13225-011-0117-x>
- Zhao GZ, Liu XZ, Xie XM, Cao AX (2009) Saprobic dematiaceous hyphomycetes from Shennongjia region, China. Nova Hedwigia 88(1–2): 217–227. <https://doi.org/10.1127/0029-5035/2009/0088-0217>
- Zhou YM, Zhi JR, Ye M, Zhang ZY, Yue WB, Zou X (2018) *Lecanicillium cauligalbarum* sp. nov. (Cordycipitaceae, Hypocreales), a novel fungus isolated from a stemborer in the Yao Ren National Forest Mountain Park, Guizhou. MycoKeys 59(43): 59–74. <https://doi.org/10.3897/mycokeys.43.30203>
- Zhou YM, Zou X, Zhi JR, Xie JQ, Jiang T (2020a) Fast recognition of *Lecanicillium* spp., and its virulence against *Frankliniella occidentalis*. Frontiers in Microbiology 11: 561381. <https://doi.org/10.3389/fmicb.2020.561381>
- Zhou YM, Xie W, Ye JQ, Zhang T, Li DY, Zhi JR, Zou X (2020b) New potential strains for controlling *Spodoptera frugiperda* in China: *Cordyceps cateniannulata* and *Metarhizium rileyi*. BioControl 65(6): 663–672. <https://doi.org/10.1007/s10526-020-10035-w>
- Zhou YM, Zhi JR, Qu JJ, Zou X (2022) Estimated divergence times of *Lecanicillium* in the Family Cordycipitaceae provide insights into the attribution of *Lecanicillium*. Frontiers in Microbiology 13: 859886. <https://doi.org/10.3389/fmicb.2022.859886>