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Novel taxa within Nectriaceae: *Cosmosporella* gen. nov. and *Aquanectria* sp. nov. from freshwater habitats in China

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Abstract – To clarify phylogenetic relationships among *Aquanectria*, *Cosmospora*, *Fusicolla* and other related taxa in Nectriaceae, we examined detailed morphological characters and performed cladistic analyses of a concatenated dataset based on the ITS, LSU and β-*tubulin* DNA sequences of fungal specimens collected from freshwater habitats in China. A new genus, *Cosmosporella*, is described to accommodate *C. olivacea* as its type species. *Cosmospora obscura* is transferred to *Cosmosporella* based on morphological similarities and phylogenetic support. *Aquanectria jacinthicolor*, a freshwater lignicolous taxon, characterized by its orange ascomata and ellipsoid ascospores with broad paraphyses is a newly described freshwater species. This species has affinities with other two known species of *Aquanectria* and can be distinguished based on ascospore morphology. A specimen with sexual morph of *Fusicolla aquaeductuum* is reported for the first time.

Aquatic fungi / morphology / multigene phylogeny / phylogeny / sexual morph / Sordariomycetes

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INTRODUCTION

Nectriaceae Tul. & C. Tul. was established by Tulasne and Tulasne (1865) and previously identified as a part of Hypocreaceae De Not. (Miller, 1949; Bessy, 1950; Luttrell, 1951; Dingley, 1953, 1954, 1956; von Arx & Müller, 1954; Müller & von Arx, 1962; Gäumann, 1964; Rogerson, 1970; Barr, 1990). However, these two families were considered as separate taxonomic groups in Hypocreales (Seaver, 1909a, b, 1910a, b, 1911; Kreisel, 1969; Spatafora & Blackwell, 1993; Rossman *et al.*, 1999; Maharachchikumbura *et al.*, 2015, 2016). Nectriaceae is characterized by brightly pigmented ascomata with fusiform to allantoid ascospores and globose to fusiform phialidic conidia (Rossman *et al.*, 1999, 2000, 2013; Lombard *et al.*, 2015; Maharachchikumbura *et al.* 2015). Most species were recovered as folicolous, entomogenous, endophytic and saprobic taxa on woody plant material from terrestrial and freshwater habitats, while a few are also known as human pathogens (Rossman *et al.*, 1999, 2000, 2013; Chang *et al.*, 2006; Chaverri *et al.*, 2011; de Hoog *et al.*, 2011; Gräfenhan *et al.*, 2011; Schroers *et al.*, 2011; Guarro, 2013; Lombard *et al.*, 2015; Maharachchikumbura *et al.*, 2015, 2016). Nectriaceae is typified by *Nectria* and accommodates 47 genera (Lombard *et al.*, 2015; Maharachchikumbura *et al.*, 2016; Wijayawardene *et al.*, 2018).

Aquanectria was proposed as a new genus with two species (type: *A*. *penicillioides* and *A*. *submerse*) within the Nectriaceae to circumscribe members of *Flagellospora* and *Heliscus* (Lombard *et al.*, 2015). *Cosmospora* initially was established by Rabenhorst (1862) and typified by *C. coccinea* (Rossman *et al.*, 1999). At that time, more than 40 sexual species were accepted in this genus. Gräfenhan *et al.* (2011) redefined *Cosmospora sensu* Rossman and accommodated nectroid taxa with reddish, smooth ascomata and in having acremonium-like or verticillium-like asexual morphs and subsequently most cosmospora-like fungi have been transferred to *Chaetospsina*, *Cosmospora sensu stricto*, *Cylindrocladiella*, *Dialonectria*, *Fusicolla*, *Macroconia*, *Microcera*, *Pseudocosmospora*, *Stylonectria* and *Volutella* with support from DNA based phylogenies (Schoch *et al.*, 2000; Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013; Lombard *et al.*, 2015; Luo & Zhuang, 2010, 2012; Zeng & Zhuang, 2016). However, *Cosmospora flavoviridis*, *C. obscura* and *C. stegonsporii* have been treated as an orphan group given its ambiguous taxonomic affinities to *Cosmospora sensu stricto*, *Dialonectria* and *Pseudocosmospora* (Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013). Most of the members of *Cosmospora sensu stricto* occur on basidiomycetes or xylariaceous hosts; *Dialonectria* grows on *Diatrype* (Diatrypaceae), *Pseudocosmospora* primarily occurs on *Eutypa* and *Eutypella* (Diatrypaceae) (Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013).

Fusicolla belongs to the Nectriaceae and comprises an estimated eight species (Wijayawardene *et al.*, 2017). Some *Fusicolla* species have been considered as synonyms of *Fusarium* (Wolleweber, 1916). Whereafter, Gräfenhan *et al.* (2011) resurrected this genus typified by *F. betae* (Desm.) Bonord. Typical morphs of *Fusicolla* as proposed by Gräfenhan *et al.* (2011) include pale orange ascomata, without any reaction with KOH with 1-septate ascospores and straight or slightly curved, ellipsoid conidia. Seventeen species currently are accepted with *F. aquaneductuum*, known only in its asexual morph (Gerlach & Nirenberg, 1982; Gräfenhan *et al.*, 2011).

We are carrying out a survey of freshwater fungi along a north-south latitudinal gradient in China and Thailand (Hyde *et al.*, 2016; Luo *et al.*, 2017). In this study, we report on a new genus *Cosmosporella*, a collection of *Aquanectria* and a new sexual morph of *Fusicolla* from China. The specimens were examined morphologically to enable identification and ITS regions, partial LSU and β-*tubulin* gene regions were analyzed to determine their phylogenetic affinities with other Nectriaceae species.

MATERIALS AND METHODS

Sample collection, morphological studies and isolation

Submerged dead wood pieces were collected from Yunnan and Xinjiang Province in China and brought to the laboratory in zip lock plastic bags. Incubation of specimens was performed as outlined by Vrijmoed (2000). Fungal fruiting bodies were found growing on decayed wood in a sterile plastic box after 2 weeks and were subsequently isolated based on the method of Chomnunti *et al.* (2014). Morphological characters were examined using an Olympus SZ61 stereoscope and ascomata were sectioned by free-hand with a razor-blade. These sections were examined by a Nikon ECLIPSE Ni compound microscope and images taken with a Canon EOS 600D digital camera. Measurements were made with Tarosoft® Image Frame Work program v. 0.9.7. The specimens are deposited in the Kunming Institute of Botany, Academia Sinica and duplicated in Mae Fah Luang University (MFLU) Herbarium, Chiang Rai, Thailand. Facesoffungi numbers (FoF) were obtained as in Jayasiri *et al.* (2015) and Index Fungorum numbers (IF) as in Index Fungorum (2017) (http://www.indexfungorum.org/names/names.asp.). New species are established based on the recommendations outlined by Jeewon & Hyde (2016).

DNA extraction, PCR amplification and sequencing

Total genomic DNA was extracted directly from mycelium using a *Trelief*™ Plant Genomic DNA Kit following manufacturer's protocol. DNA was amplified by using polymerase chain reaction (PCR) in a 25 μL reaction mixture (Huang *et al.*, 2018). Regions of the internal transcribed spacers (ITS1-5.8S-ITS2), large subunit rRNA (LSU) and β-*tubulin* (*TUB*) and were amplified using primer pair ITS5 and ITS4 (White *et al.*, 1990), LR0R and LR5 (Vilgalys & Hester, 1990) and T1 (O'Donnell & Cigelnik, 1997) and Bt2b (Glass & Donaldson, 1995) respectively. The PCR profiles were as follows: an initial is denaturation at 94°C for 3 min, followed by 35 cycles of denaturation at 94°C for 30 sec, annealing at 56°C (ITS) or 50°C (LSU) or 51°C (*TUB*) for 50 sec and extension at 72°C for 1 min, a final extension at 72°C for 10 min. The PCR products were sent to a commercial sequencing provider Tsingke Company, Beijing, P.R. China and sequenced using primers mentioned above.

Phylogenetic analysis

The quality of our amplified nucleotide sequences were checked and combined by SeqMan version 7.1.0 (44.1) and Finch TV version 1.4.0 (www.geospiza.com), and reference sequences were retrieved from the National Center for Biotechnology Information (NCBI) by nucleotide BLAST and from recent publications of the order Hypocreales (Gräfenhan *et al.*, 2011; Hirooka *et al.*, 2011; Herrera *et al.*, 2013, 2015; Lombard *et al.*, 2015; Zeng & Zhuang, 2015). Sequences were aligned using the default setting of MAFFT v. 7.310 (http://mafft.cbrc.jp/alignment/server/index.html) (Katoh & Standley, 2016), and manually corrected using Bioedit 7.0.9.0 (Hall, 1999).

Phylogenetic analyses of the combined gene regions were performed using maximum-likelihood (ML), Bayesian inference (BI) and maximum parsimony (MP) methods. The data was edited in AliView version: 1.19-beta1k and the evolutionary model was obtained using MrModeltest v. 2.3 (Nylander *et al.*, 2008) under the Akaike Information Criterion (AIC) performed in PAUP v. 4.0b10. The maximum-likelihood (ML) analysis was run or performed using RAxML-HPC v.8 on XSEDE in CIPRES Science Gateway (Stamatakis, 2014; Miller *et al.*, 2010, 2015) with 1000 rapid bootstrap replicates using the GTR+I+G model of nucleotide substitution. Bayesian inference (BI) was implemented by MrBayes v. 3.0b4 (Ronquist & Huelsenbeck, 2003) with GTR+I+G as the best-fit model. Posterior probabilities (PP) were estimated by Markov Chain Monte Carlo sampling (MCMC) in MrBayes v. 3.0b4 (Huelsenbeck & Ronquist, 2001; Zhaxybayeva & Gogarten, 2002; Rannala & Yang, 2008). Four simultaneous Markov chains were run for 15,000,000 generations sampling one tree every 100th generations. The temperature value was lowered to 0.15, burn-in was set to 0.25. Maximum parsimony analyses were also performed using PAUP v. 4.0b10 (Swofford, 2002). Details are outlined as in Jeewon *et al.* (2002, 2003). Phylogenetic trees were viewed with FigTree v1.4.0 (http://tree.bio.ed.ac.uk/software/figtree/) and processed by Adobe Illustrator CS5. Alignment and trees were deposited in TreeBASE (submission ID: 22465). The nucleotide sequence data of new taxa have been deposited in GenBank (Table 1).

Table 1. Strains and GenBank accession numbers of the isolates used in this study. Isolates from this study are in red bold and the type strains are in bold.

Species	*Voucher/Culture*	*GenBank accession number*		
		ITS	*LSU*	*TUB*
Albonectria rigidiuscula	CBS 122570	HQ897815	KM231676	KM232070
Allantonectria miltina	CBS 474.69	KM231835	KM231716	
Allantonectria miltina	CBS 121121	HM484547	HM484572	HM484609
Allantonectria miltina	CBS 125499	KM231836	KM231717	KM232107
Aquanectria jacinthicolor	**KUMCC 17-0146**	**MH051230**	**MH051232**	**MH051234**
Aquanectria jacinthicolor	**KUMCC 18-0017**	**MH051231**	**MH051233**	**MH051235**
Aquanectria penicillioides	CBS 257.54	KM231743	KM231613	KM232000
Aquanectria submerses	**CBS 394.62**	**HQ897796**	**KM231612**	**KM231999**
Atractium crissum	**CBS 180.31**	**KM231790**	**U88110**	**KM232049**
Atractium stilbaster	**CBS 410.67**	**KM231791**	**KM231654**	**KM232050**
Atractium stilbaster	CBS 783.85	KM231792	KM231655	KM232051
Bisifusarium delphinoides	**CBS 120718**	**EU926229**	**KM231660**	**KM232056**
Bisifusarium dimerum	**CBS 108944**	**JQ434586**	**JQ434514**	**EU926400**

Species	*Voucher/Culture*	*GenBank accession number*		
		ITS	*LSU*	*TUB*
Bisifusarium domesticum	CBS 116517	EU926219	JQ434512	JQ434531
Bisifusarium lunatum	**CBS 632.76**	**HQ897819**	**KM231662**	**KM232057**
Bisifusarium nectrioides	**CBS 176.31**	**EU926245**	**KM231659**	**KM232055**
Bisifusarium penzigii	**CBS 317.34**	**KM231795**	**KM231661**	**EU926390**
Calonectria brassicae	CBS 111869	GQ280576	GQ280698	AF232857
Calonectria ilicicola	**CBS 190.50**	**GQ280605**	**GQ280727**	**AY725631**
Calonectria naviculata	**CBS 101121**	**GQ280600**	**GQ280722**	**GQ267211**
Calostilbe striispora	CBS 133491	KM231789	KM231653	KM232048
Campylocarpon fasciculare	**CBS 112613**	**AY677301**	**HM364313**	**AY677221**
Campylocarpon pseudofasciculare	**CBS 112679**	**AY677306**	**HM364314**	**AY677214**
Chaetopsina acutispora	**CBS 667.92**	**KM231771**	**KM231636**	**KM232029**
Chaetopsina chaetopsinae	HMAS 76860	GU075858	DQ119553	
Chaetopsina fulva	**CBS 142.56**	**KM231772**	**KM231637**	**KM232030**
Chaetopsina penicillatae	**CBS 608.92**	**HQ897798**	**KM231638**	**KM232031**
Coccinonectria pachysandricola	CBS 501.63	KM231774	KM231640	KM232033
Coccinonectria pachysandricola	CBS 476.92	KM231775	KM231641	KM232034
Coccinonectria pachysandricola	CBS 128674	JF832658	JF832715	JF832909
Coccinonectria rusci	**CBS 126108**	**KM231773**	**KM231639**	**KM232032**
Corallomycetella elegans	CBS 275.60	KM231828	KM231710	KM232100
Corallomycetella repens	CBS 118.84	KC479755	KM231709	KC479784
Corallomycetella repens	CBS 358.49	KC479756	KM231708	KC479785
Corallonectria jatrophae	**CBS 913.96**	**KC479758**	**KM231611**	**KC479787**
Cosmospora arxii	CBS 748.69	**KM231819**	**KM231694**	**KM232089**
Cosmospora butyri	ATCC 52620	JQ070093	JQ070164	
Cosmospora clavi	CBS 123941	KJ676149	KJ676186	KJ676262
Cosmospora coccinea	**CBS 341.70**	**HQ897827**	**KM231692**	**KM232086**
Cosmospora cymosa	**CBS 762.69**	**HQ897828**	**KM231693**	**KM232087**
Cosmospora fomiticola	PDD 46398	KJ676158	KJ676195	KJ676274
Cosmospora inonoticola	HMAS:271401	KU563625		KU563621
Cosmospora khandalensis	A.R. 4799	KJ676146	KJ676183	KJ676259
Cosmospora lavitskiae	HMAS:252477	KU563624		KU563620
Cosmospora novozelandica	G.J.S. 83-197	KC291732	KC291777	KC291907

Table 1. Strains and GenBank accession numbers of the isolates used in this study (*continued*).

Species	*Voucher/Culture*	*GenBank accession number*		
		ITS	*LSU*	*TUB*
Cosmospora scruposae	G.J.S. 86-320	KJ676163	KJ676200	KJ676279
Cosmospora stilbohypoxyli	A.R. 4783	KJ676144	KJ676181	KJ676257
Cosmospora ustulinae	MAFF 241532	KJ676175	KJ676212	KJ676296
Cosmospora vilior	G.J.S. 90-217	JF832596	JF832681	JF832840
Cosmospora viliuscula	G.J.S 10-114	KJ676155	KJ676192	KJ676270
Cosmospora viridescens	CBS 102433	KJ676148	KJ676185	KJ676261
'*Cosmospora*' cf. *flavoviridis*	BBA 65542	HQ897791		
'*Cosmospora*' *rishbethii*	**CBS 496.67**		**HQ232162**	**AB237493**
'*Cosmospora*' *stegonsporii*	**A.R. 4385**	**KC291718**	**KC291755**	**KC291901**
Cosmosporella obscura	MAFF 241484	KC291719	KC291788	KC291903
Cosmosporella olivacea	**KUMCC 17-0321**	**MH087212**	**MH087214**	**MH087216**
Cosmosporella olivacea	**KUMCC 18-0016**	**MH087213**	**MH087215**	**MH087217**
Curvicladiella cignea	CBS 101411	KM231744	JQ666075	KM232001
Curvicladiella cignea	**CBS 109167**	**AF220973**	**AY793431**	**KM232002**
Curvicladiella cignea	CBS 109168	KM231745	JQ666074	KM232003
Cyanonectria buxi	CBS 130.97	KM231811	KM231679	KM232075
Cyanonectria buxi	**CBS 125551**	**HM626661**	**HM626673**	
Cyanonectria cyanostoma	**CBS 101734**	**FJ474076**	**HM626671**	
Cylindrocarpostylus gregarius	**CBS 101072**	**KM231747**	**JQ666084**	**KM232005**
Cylindrocarpostylus gregarius	CBS 101073	KM231748	JQ666083	KM232006
Cylindrocarpostylus gregarius	CBS 101074	KM231746	KM231614	KM232004
Cylindrocladiella camelliae	**CPC 234**	**AF220952**	**JN099249**	**AY793471**
Cylindrocladiella lageniformis	**CBS 340.92**	**AF220959**	**JN099165**	**AY793481**
Cylindrocladiella parva	**CBS 114524**	**AF220964**	**JN099171**	**AY793486**
Cylindrodendrum album	**CBS 301.83**	**KM231764**	**KM231626**	**KM232021**
Cylindrodendrum album	CBS 110655	KM231765	KM231627	KM232022
Cylindrodendrum hubeiense	CBS 129.97	KM231766	KM231628	KM232023
Dactylonectria alcacerensis	**CBS 129087**	**JF735333**	**KM231629**	**AM419111**
Dactylonectria estremocensis	**CBS 129085**	**JF735320**	**KM231630**	**JF735448**
Dactylonectria macrodidyma	**CBS 112615**	**AY677290**	**HM364315**	**AY677233**
Dactylonectria novozelandica	**CBS 113552**	**JF735334**		**AY677237**

Species	Voucher/Culture	GenBank accession number		
		ITS	LSU	TUB
Dactylonectria torresensis	**CBS 129086**	**JF735362**	**KM231631**	**JF735492**
Dematiocladium celtidis	**CBS 115994**	**AY793430**	**AY793438**	
Dialonectria episphaeria	CBS:125494	HQ897811	KM231697	KM232092
Dialonectria ullevolea	CBS 125493	KM231821	KM231696	KM232091
Fusarium proliferatum	CBS 189.38	KM231816	KM231685	KM232082
Fusarium proliferatum	CBS 263.54	KM231815	KM231684	KM232081
Fusarium sambucinum	CBS 146.95	KM231813	KM231682	KM232078
Fusarium subluratum	**CBS 189.34**	**HQ897830**	**KM231680**	**KM232076**
Fusarium venenatum	**CBS 458.93**	**KM231814**	**KM231683**	**KM232079**
Fusarium verrucosa	CBS 102163	KM231812	KM231681	KM232077
Fusicolla acetilerea	BBA 63789	HQ897790		
Fusicolla aquaeductuum	CBS 837.85	KM231823	KM231699	KM232094
Fusicolla aquaeductuum	**KUMCC 17-0320**	**MH087218**	**MH087220**	**MH087222**
Fusicolla aquaeductuum	**KUMCC 18-0015**	**MH087219**	**MH087221**	**MH087223**
Fusicolla matuoi	CBS 581.78	KM231822	KM231698	KM232093
Fusicolla melogrammae	CBS:141092	KX897140	KY092489	
Fusicolla merismoides	N271A	KP710612		KP710663
Fusicolla violacea	**CBS 634.76**	**KM231824**	**KM231700**	**KM232095**
Geejayessia celtidicola	**CBS 125502**	**HM626657**	**HM626669**	**KM232074**
Geejayessia cicatricum	**CBS 125549**	**KM231810**	**KM231678**	**KM232073**
Geejayessia desmazieri	CBS 125507	HM626651	HM626663	KM232072
Gliocephalotrichum cylindrosporum	**CBS 902.70**	**DQ366705**	**JQ666077**	**DQ377841**
Gliocephalotrichum longibrachium	**CBS 126571**	**DQ278422**	**KM231686**	**DQ377835**
Gliocladiopsis irregularis	**CBS 755.97**	**AF220977**	**JQ666082**	**JQ666133**
Gliocladiopsis pseudotenui	**CBS 116074**	**AF220981**	**JQ666080**	**JQ666140**
Gliocladiopsis sagariensis	**CBS 199.55**	**JQ666063**	**JQ666078**	**JQ666141**
Ilyonectria capensis	**CBS 132815**	**JX231151**	**KM515908**	**JX231103**
Ilyonectria coprosmae	CBS 119606	JF735260	KM515910	JF735373
Macroconia cupularis	H97514	EF121864	EF121870	
Macroconia leptosphaeria	CBS 717.74	KM231827	KM231707	KM232099
Macroconia leptosphaeria	CBS 100001	HQ897810	KM231705	KM232097
Macroconia leptosphaeria	CBS 112770	KM231826	KM231706	KM232098
Macroconia papilionacearum	CBS 125495	HQ897826	KM231704	KM232096

Table 1. Strains and GenBank accession numbers of the isolates used in this study (*continued*).

Species	*Voucher/Culture*	*GenBank accession number*		
		ITS	*LSU*	*TUB*
Mariannaea camptospora	**CBS 209.73**	**AY624202**		AY624245
***Mariannaea** camptospora*	CBS 120801	KM231753	KM231618	KM232010
Mariannaea catenulatae	**CBS 491.92**	**KM231752**	**KM231617**	**KM232009**
Mariannaea humicola	**CBS 740.95**	**KM231755**	**KM231619**	**KM232012**
Mariannaea humicola	CBS 102628	KM231756	KM231620	KM232013
Mariannaea pinicola	**CBS 745.88**	**KM231754**	**AY554242**	**KM232011**
Mariannaea samuelsii	CBS 746.88	KM231757	KM231621	KM232014
Mariannaea samuelsii	**CBS 125515**	**HQ843767**	**HQ843766**	**KM232015**
Microcera aurantiicola	ICMP:11047	EU860062		EU860023
Microcera coccophila	CBS 310.34	HQ897794	KM231703	
Microcera diploa	BBA 62173	HQ897817		
Microcera larvarum	CBS 738.79	KM231825	KM231701	
Microcera rubra	**CBS 638.76**	**HQ897820**	**KM231702**	**EU860019**
Nalanthamala psidii	**CBS 116952**	**AY864836**	**AY864837**	**AY864838**
Nalanthamala vermoesenii	CBS 230.48	AY554212	AY554263	AY554231
Nalanthamala vermoesenii	**CBS 110893**	**AY554214**	**AY554246**	**AY554233**
Nectria balansae	CBS 123351	HM484552	GQ505996	HM484607
Nectria balansae	CBS 125119	HM484857	HM484868	HM484874
Nectria balansae	CBS 129349	JF832653	JF832711	JF832908
Nectria cinnabarina	**CBS 125165**	**HM484548**	**HM484562**	**HM484606**
Nectria mariae	**CBS 125294**	**JF832629**	**JF832684**	**JF832899**
Nectria nigrescens	**CBS 125148**	**HM484707**	**HM484720**	**HM484806**
'*Nectria*' *flavoviridis*	IMI 338173	KC291747	KC291785	KC291902
Neocosmospora ambrosia	CBS 571.94	KM231801	KM231668	KM232063
Neocosmospora haematococca	CBS 101573	KM231798	KM231665	KM232060
Neocosmospora haematococca	**CBS 119600**	**KM231797**	**KM231664**	**KM232059**
Neocosmospora haematococca	CBS 123669	KM231796	KM231663	KM232058
Neocosmospora illudens	CBS 119605	KM231806	KM231673	KM232068
Neocosmospora illudens	CBS 126406	JF832660	JF832762	JF832841
Neocosmospora phaseoli	CBS 102429	KM231808	KM231675	KM232069
Neocosmospora ramosa	**CBS 509.63**	**KM231802**	**KM231669**	**KM232064**

Species	Voucher/Culture	GenBank accession number		
		ITS	LSU	TUB
Neocosmospora rubicola	CBS 320.73	KM231799	KM231666	KM232061
Neocosmospora rubicola	**CBS 101018**	**KM231800**	**KM231667**	**KM232062**
Neocosmospora vasinfecta	CBS 325.54	KM231803	KM231670	KM232065
Neocosmospora vasinfecta	CBS 562.70	KM231805	KM231672	KM232067
Neocosmospora vasinfecta	CBS 517.71	KM231804	KM231671	KM232066
Neonectria candida	CBS 151.29	AY677291	HM042436	DQ789863
Neonectria lugdunensis	CBS 125485	KM231762	KM231625	KM232019
Neonectria neomacrospora	CBS 324.61	JF735312	HM364318	DQ789875
Neonectria neomacrospora	CBS 198.62	AJ009255	HM364316	DQ789866
Neonectria tsugae	**CBS 788.69**	**KM231763**	**HQ232146**	**KM232020**
Paracremonium contagium	**CBS 110348**	**KM231831**	**HQ232118**	**KM232103**
Paracremonium inflatum	**CBS 485.77**	**KM231829**	**HQ232113**	**KM232101**
Paracremonium inflatum	CBS 482.78	KM231830	KM231711	KM232102
Penicillifer bipapillatus	**CBS 420.88**	**KM231740**	**KM231608**	**KM231996**
Penicillifer penicilliferi	**CBS 423.88**	**KM231739**	**KM231607**	**KM231995**
Pseudocosmospora eutypellae	G.J.S. 10-248	KC291722	KC291772	KC291911
Pseudocosmospora rogersonii	G.J.S. 10-296	KC291727	KC291774	KC291917
Pseudonectria buxi	CBS 324.53	KM231778	KM231644	KM232037
Pseudonectria buxi	CBS 114049	KM231779	U17416	KM232038
Pseudonectria foliicola	CBS 122566	KM231777	KM231643	KM232036
Pseudonectria foliicola	**CBS 123190**	**KM231776**	**KM231642**	**KM232035**
Rectifusarium robinianum	CBS 830.85	KM231793	KM231656	KM232052
Rectifusarium robinianum	**CBS 430.91**	**KM231794**	**KM231657**	**KM232053**
Rugonectria neobalansae	CBS 125120	KM231750	HM364322	HM352869
Rugonectria rugulosa	CBS 126565	KM231749	KM231615	KM232007
Rugonectria rugulosa	CBS 129158	JF832661	JF832761	JF832911
Sarcopodium circinatum	CBS 587.92	KM231787	KM231651	KM232046
Sarcopodium circinatum	CBS 100998	KM231786	KM231650	KM232045
Sarcopodium circinosetiferum	CBS 100251	KM231782	KM231646	KM232041
Sarcopodium circinosetiferum	CBS 100252	KM231781	KM231645	KM232040
Sarcopodium flavolanatum	CBS 112283	KM231785	KM231649	KM232044
Sarcopodium flavolanatum	CBS 128370	KM231784	KM231648	KM232043
Sarcopodium macalpinei	CBS 115296	KM231783	KM231647	KM232042
Sarcopodium vanillae	CBS 100582	KM231780	HQ232174	KM232039

Table 1. Strains and GenBank accession numbers of the isolates used in this study (*continued*).

Species	*Voucher/Culture*	*GenBank accession number*		
		ITS	*LSU*	*TUB*
Septofusidium berolinense	CBS 731.70	KM231841	KM231722	KM232112
Septofusidium herbarum	**CBS 265.58**	**KM231842**	**KM231723**	**KM232113**
Stylonectria applanata	CBS 125498	HQ897803	KM231689	KM232083
Stylonectria wegeliniana	CBS 125490	KM231817	KM231690	KM232084
Thelonectria discophora	CBS 125153	HM364294	HM364307	HM352860
Thelonectria olida	**CBS 215.67**	**AY677293**	**HM364317**	**KM232024**
Thelonectria trachosa	**CBS 112467**	**AY677297**	**HM364312**	**AY677258**
Thyronectria lamyi	CBS 417.89	KM231837	KM231718	KM232108
Thyronectria pyrrhochlora	CBS 125131	HM484545	HM484570	HM484598
Thyronectria quercicola	**CBS 128976**	**JF832624**	**JF832743**	**JF832880**
Thyronectria sinopica	CBS 462.83	HM484542	GQ506001	HM484595
Tilachlidium brachiatum	CBS 505.67	KM231839	KM231720	KM232110
Tilachlidium brachiatum	CBS 363.97	KM231838	KM231719	KM232109
Volutella ciliata	CBS 483.61	KM231770	KM231635	KM232028
Volutella consors	CBS 139.79	KM231768	KM231633	KM232026
Volutella minima	CBS 122767	KM231767	KM231632	KM232025
Volutella rosea	CBS 128258	KM231769	KM231634	KM232027
Xenoacremonium falcatus	**CBS 400.85**	**KM231832**	**HQ232025**	**KM232104**
Xenoacremonium recifei	**CBS 137.35**	**KM231833**	**HQ232106**	**KM232105**
Xenoacremonium recifei	CBS 541.89	KM231834	HQ232114	KM232106
Xenocylindrocladium guianense	**CBS 112179**	**AF317348**	**JQ666073**	**AF320197**
Xenocylindrocladium serpens	**CBS 128439**	**AF220982**	**KM231688**	
Xenocylindrocladium subverticillatum	**CBS 113660**	**AF317347**	**KM231687**	**AF320196**
Xenogliocladiopsis cypellocarpa	CBS 133814	KM231760	KM231623	KM232017
Xenogliocladiopsis cypellocarpa	CPC 17153	KM231761	KM231624	KM232018
Xenogliocladiopsis eucalyptorum	**CBS 138758**	**KM231759**	**KM231622**	**KM232016**

Abbreviations: **A.R.**: Amy Y. Rossman personal collection; **ATCC**: American Type Culture Collection, Manassas, Virginia, U.S.A.; **BBA**: Julius Kühn-Institute, Institute for Epidemiology and Pathogen Diagnostics, Berlin & Braunschweig, Germany; **CBS**: Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; **CPC**: Culture collection of Pedro Crous, housed at CBS; JK: J. Kohlmeyer; **G.J.S.**: Gary J. Samuels personal collection; **HMAS**: Chinese Academy of Sciences, Beijing, P.R.C; **ICMP**: International Collection of Microorganisms from Plants; **IMI**: CABI Bioservices, Egham, Surrey, UK; **MAFF**: The Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Japan; **KUMCC**: Kunming Institute of Botany Culture Collection, China; **PDD**: Manaaki Whenua Landcare Research, Auckland, New Zealand.

RESULTS

Phylogenetic analyses

Familial relationships within Nectriaceae

The combined ITS, LSU, and *TUB* sequences dataset comprised 198 taxa of Hypocreales. The tree was rooted with species of *Septofusidium* (Nectriaceae) and *Tilachlidium* (Tilachlidiaceae). The alignment comprised 1874 total characters including gaps (ITS: 575 bp; LSU: 802 bp; *TUB*: 562 bp). ML and BI analyses yielded trees which were topologically congruent in terms of species groupings. RAxML analysis yielded a best scoring tree with a final optimization likelihood value of -48502.656032 (Fig. 1). Our new *Aquanectria jacinthicolor* strains cluster with each other with high support and sister to *A*. *penicillioides* (Fig. 1, 95%/ML, 0.99/PP). Two strains of *Cosmosporella olivacea* also cluster together in a strongly supported (Fig. 1, 100%/ML, 1.00/PP) monophyletic lineage clade with *C*. *obscura* as basal taxa. Phylogeny also depicts a high branch support for *Fusicolla aquaeductuum* collected in this study to *F*. *aquaeductuum* (CBS 837.85) (Fig. 1, 100%/ML, 1.00/PP).

Placement of Cosmosporella

The combined ITS and *TUB* sequences dataset comprised 28 taxa of the Nectriaceae. The tree was rooted with *Fusicolla aquaeductuum* and *F*. *matuoi*. The alignment comprised 1052 total characters including gaps (ITS: 548 bp; *TUB*: 504 bp). ML, BI and MP analyses yielded trees which were topologically congruent in terms of species groupings (results not shown). RAxML analysis yielded a best scoring tree with a final optimization likelihood value of -5082.141104 (Fig. 2). Dataset from the parsimony analyses indicated that 755 characters were constant, 70 variable characters were parsimony-uninformative and 227 characters were parsimony-informative. Phylogenetic relationships of recovered taxa herein indicate that the undefined species, '*Nectria*' *flavoviridis* (IMI 338173) and '*Cosmospora*' cf. *flavoviridis* (BBA 65542), are related to *Cosmosporella olivacea* and *C*. *obscura* in a strongly supported monophyletic lineage (99%/ML, 0.96/PP, 78%/MP, Fig. 2) and distant from other known *Cosmosporella* species.

Taxonomy

Cosmosporella S.K. Huang, R. Jeewon & K.D. Hyde, gen. nov.

Index Fungorum number: IF554371.

Type species: ***Cosmosporella olivacea*** S.K. Huang, R. Jeewon & K.D. Hyde

Etymology: "*sporella*" refers to the morphological similarity to *Cosmospora sensu stricto*.

Sexual morph: *Ascomata* perithecial, solitary to gregarious, superficial, immersed to erumpent, oval, globose to obpyriform, collapsing laterally when dry, orange red, red to pale yellow, KOH-, with a central ostiole, with hyaline periphyses. *Peridium* membranous, composed of orange to hyaline cells of *textura angularis*, with septate paraphyses. *Asci* 8-spored, unitunicate, cylindrical to slightly clavate, apically rounded, with evanescent wall, pedicel combined with paraphyses. *Ascospores* hyaline to pale brown, ellipsoid to oval, 0-1-septate. Asexual morph: *Conidiophores* irregularly branched, with cylindrical phialides. *Conidia* 0-multi-septate, hyaline, falcate.

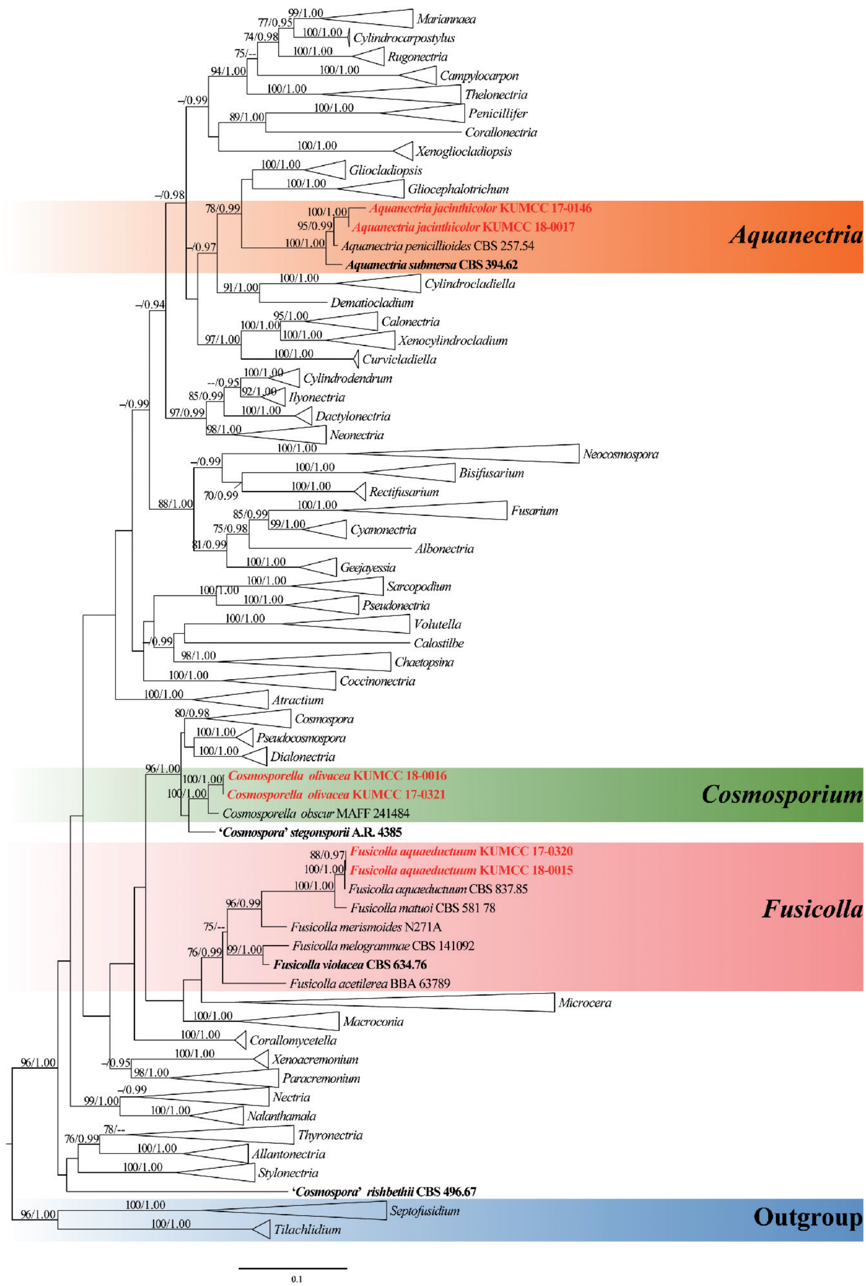

Fig. 1. Maximum likelihood phylogenetic tree generated from analysis of a combined ITS, LSU and *TUB* sequences dataset for 198 taxa of Hypocreales. *Septofusidium* and *Tilachlidium* as outgroup taxa. ML support values greater than 70% (BSML, left) and Bayesian posterior probabilities greater than 0.95 (BYPP, right) are indicated above the nodes. The group of each genus are collapsed and annotated after the clade. The strain numbers are noted after the species names. Ex-type strains are indicated in bold. Isolates from this study are indicated in red.

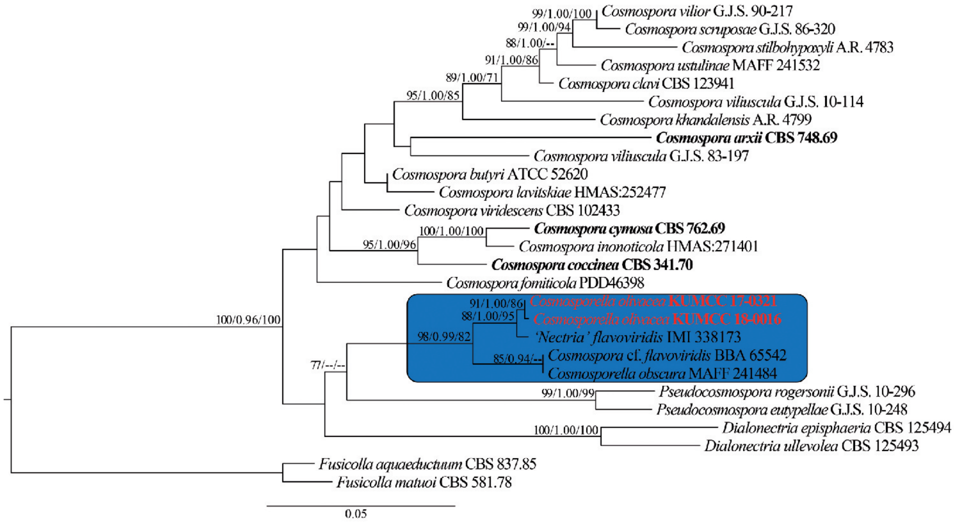

Fig. 2. Maximum likelihood phylogenetic tree generated from analysis of a combined ITS and *TUB* sequences dataset for 28 taxa of Nectriaceae. *Fusicolla aquaeductuum* and *F. matuoi* as outgroup taxa. ML support values greater than 70% (BSML, left), Bayesian posterior probabilities greater than 0.95 (BYPP, middle) and MP bootstrap value higher than 70% (BSMP, right) are indicated above the nodes. The strain numbers are noted after the species names. Ex-type strains are indicated in bold. Isolates from this study are indicated in red.

Cosmosporella olivacea S.K. Huang, R. Jeewon & K.D. Hyde, sp. nov.

Index Fungorum number: IF554373; *Facesoffungi number*: FoF 04381.
Fig. 3

Etymology: The name *olivacea* refers to the diffusion of olive-green pigment into PDA.

Holotype: HKAS 99607.

Saprobic on dead wood. **Sexual morph** *Ascomata* 270-320 × 200-270 µm ($\bar{x}$ = 295 × 220 µm, *n* = 5), perithecial, solitary to gregarious, superficial, unilocular, oval to globose, collapsing laterally when dry, orange red, KOH-, with a central ostiole, with hyaline periphyses. *Peridium* 30-60 µm diam., membranous, composed of orange to hyaline cells of *textura angularis* (Fig. 3e). *Hamathecium* 10-20 µm wide, hyaline, septate paraphyses, severely contracted at septa. *Asci* 80-110 × 6-10 µm ($\bar{x}$ = 90 × 9 µm, *n* = 30), 8-spored, unitunicate, cylindrical, apically truncate, wall evanescent, pedicel combined with paraphyses. *Ascospores* 10-15 × 4-7 µm ($\bar{x}$ = 10 × 5 µm, *n* = 50), bi-seriate, hyaline, ellipsoid to oval, 1-septate, slightly contracted at septum when mature, verrucose, rounded at ends. **Asexual morph**: Undetermined.

Culture characteristics: Ascospores germinating on potato dextrose agar (PDA) within 3 days at 23°C. After 20 days, colony 3 cm diam., circular form, umbonate, filiform margin, with rough surface texture, yellow-green to olive-green pigment from above and the flaxen to brown from reverse.

Material examined: CHINA, Xinjiang Province, Zhaosu, a lake near by the snow mountains; on dead wood, 14 September 2017; J.W. Liu (KUN HKAS99607, **holotype**); ex-type living culture KUMCC 17-0321).

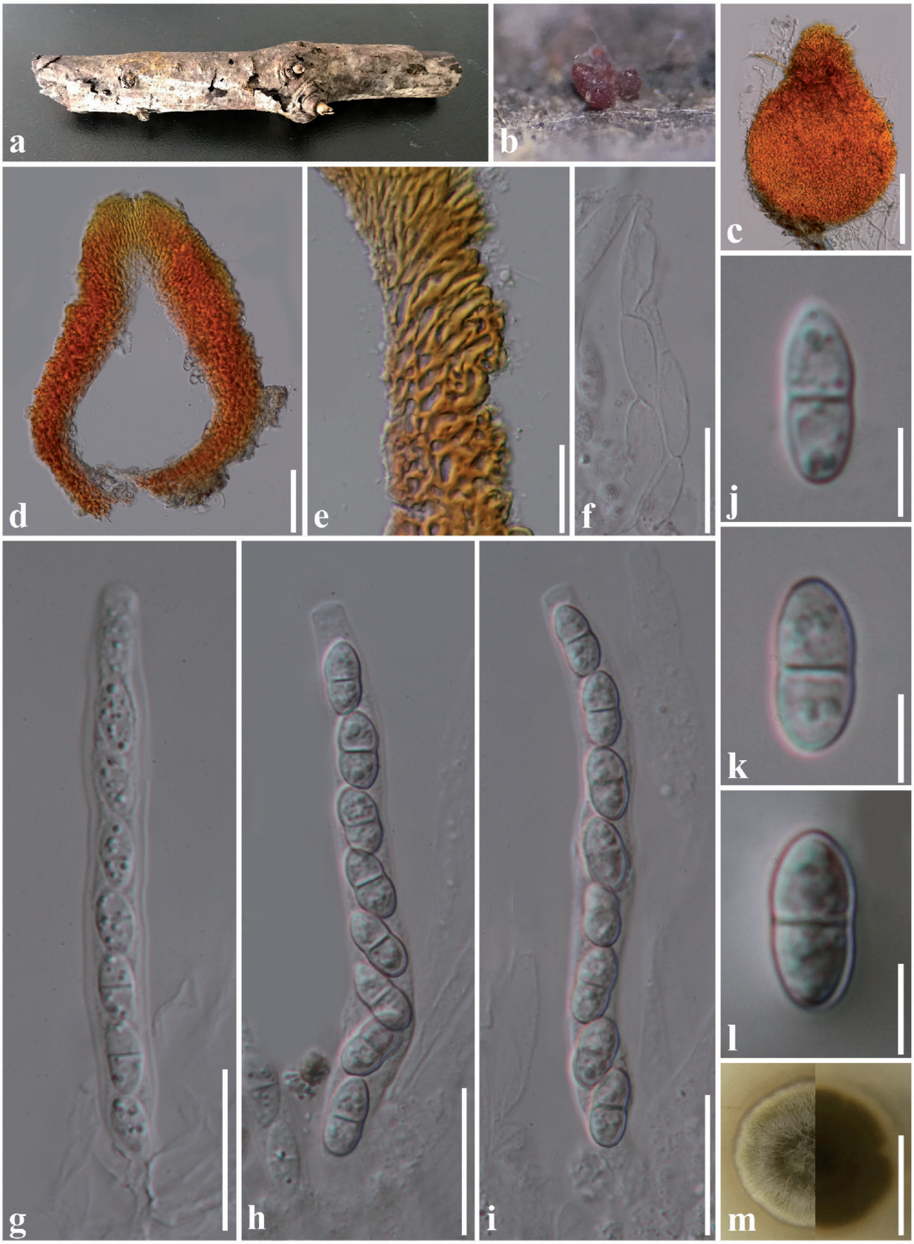

Fig. 3. ***Cosmosporella olivacea* (HKAS99607, holotype). a** Material. **b** Ascomata on host. **c** Squashed ascoma. **d** Appearance of ascoma. **e** Peridium. **f** Paraphyses. **g-i** Asci. **j-l** Ascospores. **m** Culture plate (above, left/reverse, right). Scale bars: m = 2 cm, c = 100 μm, d = 50 μm, e-i = 20 μm, j-l = 5 μm.

Aquanectria jacinthicolor S.K. Huang, R. Jeewon & K.D. Hyde, sp. nov.

Index Fungorum number: IF554374; *Facesoffungi number*: FoF 04380.

Fig. 4

Etymology: The name *jacinthicolor* refers to the diffusion of jacinth pigment into PDA.

Holotype: HKAS 99551.

Saprobic on dead wood. **Sexual morph** *Ascomata* 270-450 × 255-300 µm ($\bar{x}$ = 320 × 285 µm, *n* = 5), perithecial, solitary, superficial, unilocular, oval to globose, collapsing laterally when dry, orange, with a central ostiole, with hyaline periphyses. *Peridium* 65-90 µm diam., membranous, composed of orange to hyaline cells of *textura angularis*. *Hamathecium* 10-20 µm wide, hyaline, with septate paraphyses, severely contracted at septa. *Asci* 90-135 × 7-15 µm ($\bar{x}$ = 115 × 10 µm, *n* = 30), 8-spored, unitunicate, cylindrical, apically rounded with a distinct ring, wall evanescent, pedicel combined with paraphyses. *Ascospores* 15-20 × 3-7 µm ($\bar{x}$ = 18 × 5 µm, *n* = 50), bi-seriate, hyaline, ellipsoid, 0-1-septate, slightly contracted at septum when mature, smooth, rounded at ends. **Asexual morph**: Undetermined.

Culture characteristics: Ascospores germinating on potato dextrose agar (PDA) within 1 week at 23°C. After 30 days, colony 2 cm diam., circular form, umbonate, filiform margin, with rough surface texture, with orange to jacinth-pigment from above and reverse.

Material examined: CHINA, Yunnan Province, Baoshan, a stream along the roadside; on dead wood, 21 December 2016; Huang S.K. (KUN HKAS99551, **holotype**); ex-type living culture KUMCC 17-0146).

Fusicolla aquaeductuum (Radlk. & Rabenh.) Gräfenhan, Seifert & Schroers, *Studies in Mycology* 68: 100 (2011)

Facesoffungi number: FoF 04382. Fig. 5

Holotype: HKAS 99608.

Saprobic on dead wood. **Sexual morph** *Ascomata* 220-230 × 135-140 µm ($\bar{x}$ = 220 × 140 µm, *n* = 5), perithecial, solitary, superficial, unilocular, oval to globose, collapsing laterally when dry, yellow, central ostiole, with hyaline periphyses. *Peridium* 6-10 µm diam., membranous, composed of yellow to hyaline cells of *textura angularis*. *Hamathecium* 1-2 µm wide, hyaline, septate paraphyses, severely contracted at septa. *Asci* 55-70 × 3-6 µm ($\bar{x}$ = 65 × 5 µm, *n* = 30), 8-spored, unitunicate, cylindrical, apically rounded with a distinct ring, wall evanescent, pedicel combined with paraphyses. *Ascospores* 5-10 × 2-4 µm ($\bar{x}$ = 7 × 3 µm, *n* = 50), bi-seriate, hyaline, ellipsoid to oval, 1-septate, slightly contracted at septum when mature, smooth, rounded at ends. **Asexual morph**: *Mycelium* 1-3 µm diam., partly superficial, composed of septate, branched, hyaline hyphae. *Conidiophores* 17-30 × 1.5-4 µm ($\bar{x}$ = 20 × 3 µm, *n* = 20), usually arising from hyaline hyphae, septate, rarely uni-septate, hyaline, tapering towards apex, discrete, solitary or up to 2-3 phialidic conidiogenous cells per node, often with secondarily produced phialides. *Conidiogenous cells* 15-25 × 1-3 µm ($\bar{x}$ = 20 × 1.5 µm, *n* = 30), monophialidic, elongate, fusiform, wide at base, narrowed at apex, with a small collarette, smooth, hyaline. *Conidia* 20-30 × 2-5 µm ($\bar{x}$ = 27 × 3.5 µm, *n* = 30), hyaline, ovoid to ellipsoidal, elongated, straight or slightly curved, 0-1-septate, smooth, developing in basipetal succession, accumulated in a slimy mass at the apex of phialides.

Culture characteristics: Ascospores germinating on potato dextrose agar (PDA) within 3 days at 23°C. After 20 days, colony 3 cm diam., circular form,

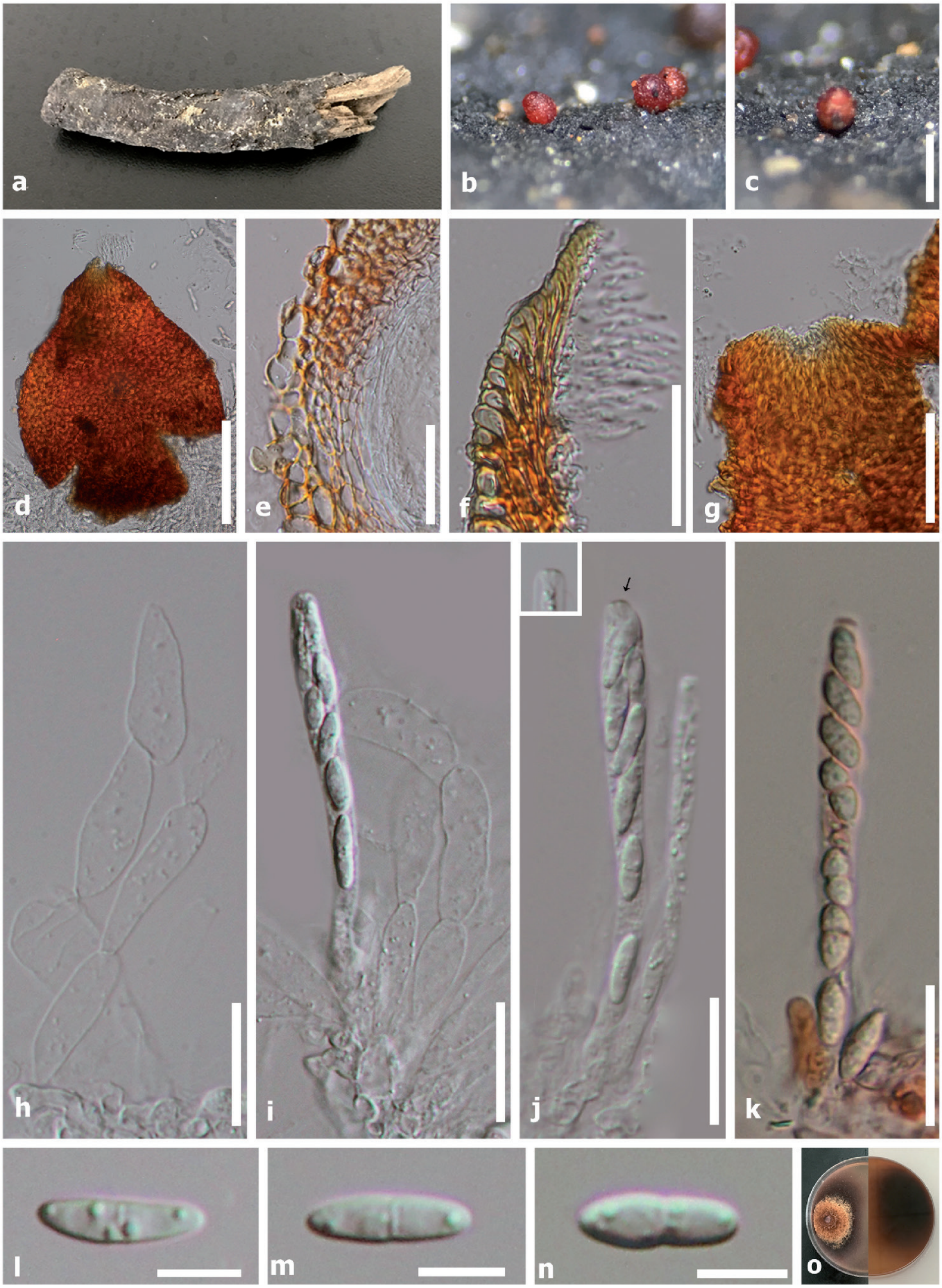

Fig. 4. ***Aquanectria jacinthicolor*** **(HKAS99551, holotype).** **a** Material. **b** Ascomata on host. **c** Appearance of ascoma. **d** Squashed ascoma with overflowing periphyses. **e** Peridium. **f** Peridium near ostiole with periphyses. **g** Ostiole. **h** Paraphyses. **i-k** Asci (arrowed apex ring). **l-n** Ascospores. **o** Culture plate (above, left/reverse, right). Note: Fig. k stained in Congo red reagent. Scale bars: c = 500 µm, d = 100 µm, e. g = 200 µm, f. h-k = 20 µm, l-n = 5 µm.

umbonate, filiform margin, with rough surface texture, pink-pigment from above and the flaxen to brown from reverse.

Material examined: CHINA, Xinjiang Province, Zhaosu, a lake near by the snow mountains; on dead wood, 14 September 2017; Liu J.W. (KUN HKAS99608, **holotype**); ex-type living culture KUMCC 17-0320).

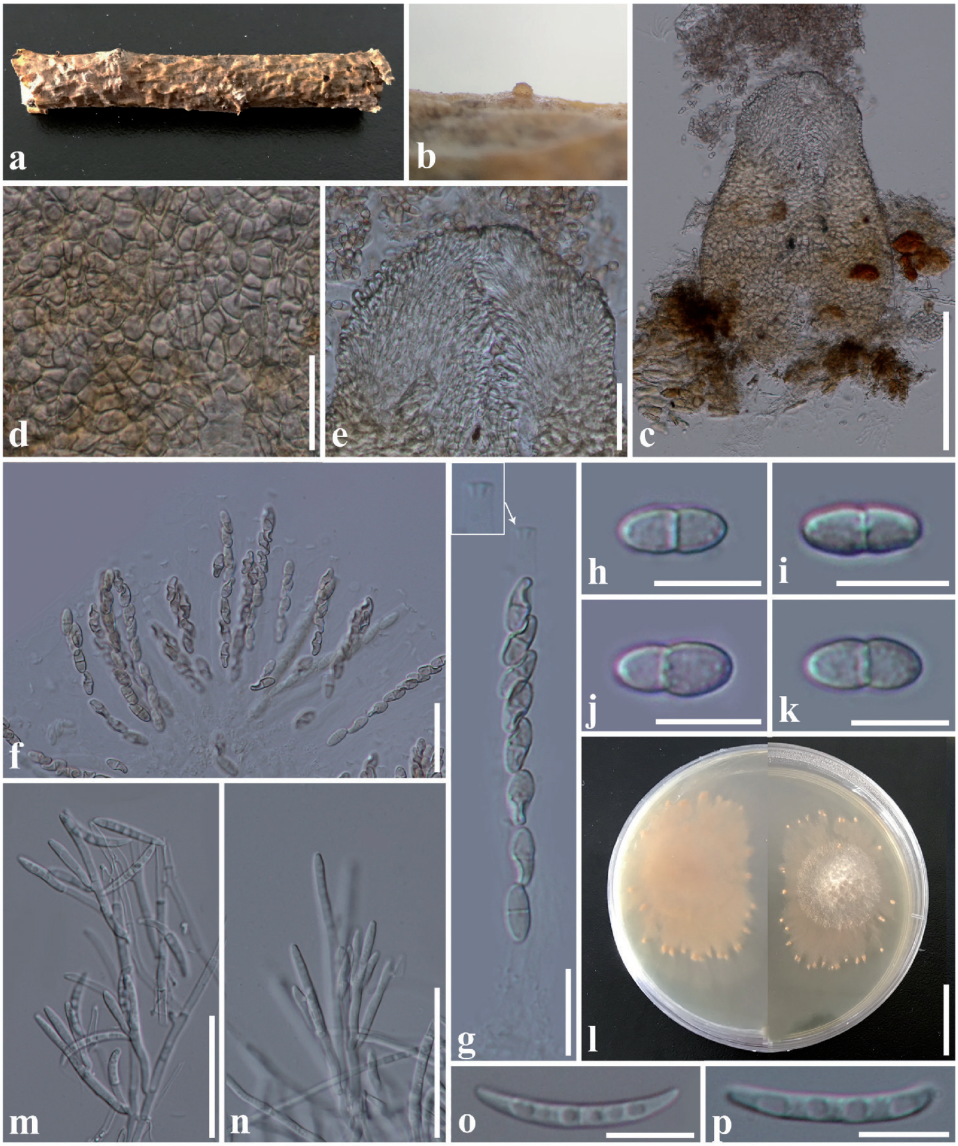

Fig. 5. ***Fusicolla aquaeductuum* (HKAS99608, holotype). a** Material. **b** Ascomata on host. **c** Squashed ascoma. **d** Appearance of ascoma. **e** Squashed ostiole with periphyses. **f-g** Asci. **h-k** Ascospores. **l** Culture plate (reverse, left/ above, right). **m-n** Conidiophore with conidia. **o-p** Conidia. Scale bars: l = 2 cm, c = 100 µm, m-n = 50 µm, d-f = 20 µm, g, o-p = 10 µm, h-k = 5 µm.

DISCUSSION

Species of *Cosmospora* are a taxonomically controversial group of fungi and have been revisited based on examination of type materials and multi-gene sequence analyses (Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013). Taxonomic work on '*Cosmospora*' *stegonsporii* (A.R. 4385) and '*Nectria*' cf. *flavoviridis* (BBA 65542) once considered as orphans, have been reported to be closely related to *Cosmospora* and *Dialonectria* based on multigene sequence analyses (Gräfenhan *et al.*, 2011). However, further multigene analyses including more protein genes reveal that '*Cosmospora*' *flavoviridis* (IMI 338173), '*Cosmospora*' *obscura* (MAFF 241484) and '*Cosmospora*' *stegonsporii* (A.R. 4385) are more closely related to *Cosmospora sensu stricto*, *Dialonectria* and *Pseudocosmospora* (Herrera *et al.*, 2013). The taxonomy of these fungi remains largely unresolved and they have different modes of life. Most of the species in *Cosmospora sensu stricto* occur on basidiomycetes or xylariaceous fungi and common diatrypaceous fungi are hosts for *Dialonectria* and most member of *Pseudocosmospora* species (Rossman *et al.*, 2008; Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013; Luo & Zhuang, 2010, 2012). '*Cosmospora*' *stegonsporii* is known to occur on the fungus *Stegonsporium pyriforme* (Diaporthales) while '*Cosmospora*' *flavoviridis* has been found on stromatic ascomycetes on wood (Rossman *et al.*, 1999, 2008; Gräfenhan *et al.*, 2011; Herrera *et al.*, 2013). '*Cosmospora*' *obscura* and our new collection herein also occur on wood (Rossman *et al.*, 1999). Initially, species of *Nectria flavoviridis* (Fuckel) Wollenw. (synonymy: *Sphaerostilbe flavoviridis*) was introduced with KOH+ perithecia (Wollenweber, 1926; Samuels & Seifert, 1991; Rossman *et al.*, 1999). Recently, Gräfenhan *et al.* (2011) analysed DNA sequence data and reexamined the materials of *Nectria* cf. *flavoviridis* (BBA 65542). This material was accepted as *Cosmospora flavoviridis*, while the morphology was reported with KOH- perithecia (Gräfenhan *et al.*, 2011). In our phylogenetic study, *Nectria* cf. *flavoviridis* BBA 65542 clusters with *Cosmosporella obscura* (Fig. 2, 86%/ML, 0.91/PP, 70%/MP). There are limited descriptions available for *Nectria* cf. *flavoviridis* (Gräfenhan *et al.*, 2011). The morphology *Nectria* cf. *flavoviridis* (BBA 65542) and '*Cosmospora*' *flavoviridis* (IMI 338173) have not been reexamined in this study and therefore we do not accept these species in *Cosmosporella*.

In our multigene phylogeny, we recovered a strongly supported clade (Fig. 1, 100%/ML, 1.00/PP) associated with *Cosmosporella, Cosmospora*, *Dialonectria* and *Pseudocosmospora*. *Dialonectria* and *Pseudocosmospora* are phylogenetically distinct from *Cosmospora* species. Of peculiar interest is the dual placement of *Cosmospora* into two separate lineages. The type strain of '*Cosmospora*' *stegonsporii* is phylogenetically apart from other *Cosmosporella* and constitutes an independent lineage with low support (Fig. 1, 2). Given that *C. obscura* and our new taxon, *C. olivacea* cluster with reasonable support (Fig. 1, 100%/ML, 1.00/PP), we establish a new genus, *Cosmosporella*, typified by *C. olivacea* to accommodate them and avoid taxonomic confusion. '*Cosmospora*' *stegonsporii* is not considered as a member of *Cosmosporella* as supported from our phylogeny. This finding corroborates with our predicted morphological examination given that *Cosmosporella* is characterized by yellow to red, KOH- ascomata with ellipsoid to ovoid ascospores, whereas '*Cosmospora*' *stegonsporii* is characterized by having orange red to red ascomata, turning dark red in KOH+ and possess broadly ellipsoid ascospores (Rossman *et al.*, 1999, 2008). The establishment of our new taxon, *C. olivacea*, is therefore justified and phylogenetic segregation from *C. obscura* is supported as well. Phylogeny of the ITS, LSU and *TUB* genes also reveals a close relationship of *C. olivacea* and *C. obscura* (Fig. 1, 100% BS, 1.00/PP). In addition, *C. olivacea* is also characterized by orange red ascomata with hyaline ascospores that help delineate it from *C. obscura* in having pale yellow ascomata with pale brown ascospores (Rossman *et al.*, 1999; Table 2).

Some contentious strains, such as *Cosmospora magnusiana* (CBS 129430) and *C. meliopsicola* (HMAS 86473) are not the type strains. Molecular data from Gräfenhan *et al.* (2011) and our other phylogenetic analyses (results not shown) depict that they are distantly related to other *Cosmospora* species. Therefore, those two species have not been considered in our phylogenetic sampling in this study. Morphologically, the spinulose to roughened ascospores in *C. magnusiana* and *C. meliopsicola* are different from the smooth ones in our collection (Rossman *et al.*, 1999; Nong & Zhuang, 2005; Luo & Zhuang, 2008; Hirooka *et al.*, 2014). Gräfenhan *et al.* (2011) reported a close phylogenetic relationship of *C. rishbethii* (CBS 496.67) to *Cosmospora* and *Dialonectria* but with low support. Our broader taxon sampling and analytical approaches herein showcase a different phylogenetic scenario as *C. rishbethii* did not cluster with the above taxa. Instead it constitutes an independent lineage but any close ties with these genera are unresolved (Fig. 1).

Species of *Aquanectria* are common from freshwater habitats in America and Europe (Ingold, 1944; Ranzoni, 1956; Hudson, 1961). This is possibly for the first time we found a member of *Aquanectria* in southern China (Table 3), however species of *Nectria* and *Bionectria* may have previously been misidentified (Tsui *et al.*, 2000; Ho *et al.*, 2001; Luo *et al.*, 2004), as their identities were not confirmed with molecular data. In addition to the difference in locality, our new taxon is characterized by globose ascomata with ellipsoid ascospores and is different from *Aquanectria penicillioides*, in having subglobose ascomata with fusiform ascospores (Table 3). The asexual morph of *A. penicillioides* and *A. submersa* are known to form filiform, slightly curved and 0-1-septate conidia (Ingold, 1944; Ranzoni, 1956; Hudson, 1961; Lombard *et al.*, 2015). Those hyphomycetes were previously obtained in pure culture with sterile water (Ingold, 1944; Hudson, 1961), but we were unsuccessful in our attempts to do the same. However, our phylogeny (Fig. 1) reveals a close relationship of our new species, *A. jacinthicolor,* to *A. penicillioides* which supports its placement in the genus. Results also indicate that our *A. jacinthicolor* strains cluster together with high statistical support and are separated from other known *Aquanectria* species (Fig. 1, 95%/ML, 0.99/PP). Following recommendations by Jeewon & Hyde (2016), we also noted a 10 bp (1.8%) difference across the 556 nucleotides of the ITS1-5.8S-ITS2 regions and a 13 bp (2.5%) difference across the 520 bp of *TUB* region compared to *A. penicillioides*.

In this study, we collected a *Fusicolla* species and morphological comparison suggests that it is *F. aquaeductuum*. Phylogenetic data as well clearly indicates that our collection is related to *F. aquaeductuum* with strong support (CBS 837.85) (Fig. 1 (100%/ML, 1.00/PP). Gräfenhan *et al.* (2011) described *Fusicolla aquaeuctuum* in its asexual state bearing conidia which are 18-22 × 1.5 ×2 µm and 1-septate. This is almost similar to ours herein (27 × 3.5 µm, 0-1-septate), but we recovered the sexual morph as well (Fig. 5) and hence we establish its fungal holomorph.

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Table 2 Morphological comparison between *Cosmosporella* species

Species	*Sexual morph (high × diam. µm)*			*Asexual morph*	*Host/Locality*	*Literature*
	Ascomatal	*Asci*	*Ascospores*			
Cosmosporella. obscura	150-300 × 100-230 immersed to sub-immersed, obpyriform, pale yellow, KOH-, with sparse setae.	60-110 × 5-8 cylindrical to slightly clavate, truncate apex	8-12 × 4-8 ellipsoid to ovoid, 1-septate, hyaline to pale brown, verucose	*Fusarium* cf. *merismoides*	On wood/ French, New Zealand	Rossman *et al.* 1999
Cosmosporella. olivacea	270-320 × 200-270 superficial, oval to globose, orange red, KOH-	80-110 × 6-10 cylindrical, truncate apex	10-15 × 4-7 ellipsoid to oval, 1-septate, hyaline, verrucose	Undetermined	On wood/ China	This paper

Table 3 Morphological comparison between *Aquanectria* species

Species	*Sexual morph*		*Asexual morph*	*Host/Locality*	*Literature*
	Ascomatal size (high × diam. µm)	*Ascospores (high × diam. µm)*	*Conidia (high × diam. µm)*		
Aquanectria penicillioides	155-380 × 120-225 µm Reddish-orange	8-17 × 3-7 µm fusiform, 1-septate, paraphyses absent	45-55 × 1.5-2.5 µm hyaline, 1-septate, filiform	Decayed maple leaves/ America	Ranzoni 1956; Ingold 1944
Aquanectria submersa	Undetermined		29-50 × 1.5-2.5 µm hyaline, 0-1-septate, with clove-shaped	Decayed leaves/ Jamaica	Hudson 1961
Aquanectria jacinthicolor	270-450 × 255-300 µm orange	15-20 × 3-7 µm ellipsoid, 0-1-septate, with broad paraphyses	Undetermined	Decayed woody plant/ China	This paper

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