



Fusarium and allied genera from China: species diversity and distribution

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Abstract The genus *Fusarium* includes numerous important plant and human pathogens, as well as many industrially and commercially important species. During our investigation of fungal diversity in China, a total of 356 fusarioid isolates were obtained and identified from diverse diseased and healthy plants, or different environmental habitats, i.e., air, carbonatite, compost, faeces, soil and water, representing hitherto one of the most intensive sampling and identification efforts of fusarioid taxa in China. Combining morphology, multi-locus phylogeny and ecological preference, these isolates were identified as 72 species of *Fusarium* and allied genera, i.e., *Bisifusarium* (1), *Fusarium* (60), and *Neocosmospora* (11). A seven-locus dataset, comprising the 5.8S nuclear ribosomal RNA gene with the two flanking internal transcribed spacer (ITS) regions, the intergenic spacer region of the rDNA (IGS), partial translation elongation factor 1- α (*tef1*), partial calmodulin (*cam*), partial RNA polymerase largest subunit (*rpb1*), partial RNA polymerase second largest subunit (*rpb2*) gene regions, and partial β -tubulin (*tub2*), were sequenced and employed in phylogenetic analyses. A genus-level phylogenetic tree was constructed using combined *tef1*, *rpb1*, and *rpb2* sequences, which confirmed the presence of four fusarioid genera among the isolates studied. Further phylogenetic analyses of two allied genera (*Bisifusarium* and *Neocosmospora*) and nine species complexes of *Fusarium* were separately conducted employing different multi-locus datasets, to determine relationships among closely related species. Twelve novel species were identified and described in this paper. The *F. babinda* species complex is herein renamed as the *F. falsibabinda* species complex, including descriptions of new species. Sixteen species were reported as new records from China.

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INTRODUCTION

Fusarium and allied genera comprise a large number of destructive pathogens and mycotoxigenic fungi, threatening plant, animal, and human health, as well as food security (O'Donnell et al. 2013). Fusarioid species cause many notable plant diseases, such as *Fusarium* head blight or scab of cereals by members of the *F. graminearum* species complex (O'Donnell et al. 2000a, Cuomo et al. 2007), sudden death syndrome of soybeans (Aoki et al. 2005) and root rot of many diverse hosts (Coleman et al. 2009, Sandoval-Denis et al. 2018a) by members of *Neocosmospora* (Lombard et al. 2015, Sandoval-Denis et al. 2019), ear rot of maize by members of the *F. fujikuroi* species complex (Desjardins et al. 2002), and vascular wilts of many economically important crops by members of the *F. oxysporum* species complex (O'Donnell et al. 1998b, Skovgaard et al. 2001,

Van der Does et al. 2008, Lombard et al. 2019a, Maryani et al. 2019a). Species within this complex are also well-known for their ability to produce a range of secondary metabolites, including some notorious mycotoxins produced by *Fusarium* spp. in cereals (Marasas et al. 1984, O'Donnell et al. 2018).

Since the establishment of *Fusarium* (Link 1809), the taxonomic framework of this genus has undergone several significant changes. Link (1809) determined the primary morphological character of *Fusarium* to be the distinctive canoe- or banana-shaped conidia. Wollenweber & Reinking (1935) surveyed the morphology of macro- and microconidia, and the presence of chlamydospores, sclerotia and sporodochia, and suggested that *Fusarium* should be divided into 16 morphological sections, including 65 species and 77 varieties and forms. In the next several decades, this system has largely influenced subsequent taxonomic studies. Despite the impact of this system, other several controversial viewpoints persisted. Snyder & Hansen (1940, 1941, 1945, 1954) reduced the number of species to nine with a number of formae speciales, and highlighted the importance of morphological observations based on cultures derived from single-spore isolates. Gordon (1944, 1952, 1954a, b, 1956a, b, 1959, 1960) developed a pragmatic approach that combined sexual morph morphology, incorporating some thoughts from Wollenweber & Reinking (1935) and Snyder & Hansen (1940, 1941, 1945, 1954), which accepted 26 species in the genus. Booth (1971) introduced the morphology of the conidio-

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genous cells as a species-level diagnostic character. Nelson et al. (1983) provided a detailed morphological identification manual for *Fusarium*. Nevertheless, the species identification in *Fusarium*, based on morphology was still confusing, because of the variable phenotypes in culture, intricate or too vague descriptions of species among different studies, and the historically complicated subspecies level ranks (Leslie & Summerell 2006, Lombard et al. 2019a, b, Wang et al. 2019).

During the last three decades, phylogenetic inference played an increasingly important role in *Fusarium* taxonomy (Lombard et al. 2019a, b). Many morphological sections in the system of Wollenweber & Reinking (1935), e.g., sections *Discolor* and *Elegans*, proved to be polyphyletic based on *rpb1-rpb2* analyses (O'Donnell et al. 2013). Debates about the generic boundary of *Fusarium* also led to disagreement among taxonomists. Gräfenhan et al. (2011) and Schroers et al. (2011) introduced several genera in the basal *Fusarium* clade in the *Nectriaceae*, and indicated that several monophyletic clusters in the terminal *Fusarium* clade corresponded to other genera, including *Neocosmospora*. However, Geiser et al. (2013) insisted on a broader definition of *Fusarium*, to avoid the introduction of additional genera. By means of a 10-locus phylogenetic analysis, Lombard et al. (2015) delineated several genera in the terminal *Fusarium* clade, e.g., *Bisifusarium* (*F. dimerum* species complex), *Rectifusarium* (*F. ventricosum* species complex), and also resurrected some older generic names, e.g., *Albonectria* (*F. decemcellulare* species complex), and *Neocosmospora* (*F. solani* species complex). Based on the combined ITS-LSU-*rpb1-rpb2-tef1* dataset, Crous et al. (2021) re-examined the fusarioid taxa in *Nectriaceae* and showed that the Wollenweber concept of *Fusarium* presently encompasses 20 distinct genera, including four new genera (*Luteonectria*, *Nothofusarium*, *Scolecofusarium*, and *Setofusarium*). Following the end of dual nomenclature, the genus *Fusarium* as currently circumscribed accommodates members that belong to the *Gibberella* clade (O'Donnell et al. 2013, Lombard et al. 2015), including 18 species complexes (Laurence et al. 2011, Aoki et al. 2014, O'Donnell et al. 2013, Zhou et al. 2016, Sandoval-Denis et al. 2018a, Lombard et al. 2019a, Crous et al. 2021). Numerous cryptic species have recently been uncovered based on multi-locus phylogeny, morphology, and ecological characteristics (Gordon & Martyn 1997, O'Donnell et al. 2000a, b, 2008, 2009a, b, Laurence et al. 2014, Lombard et al. 2019a, b, Sandoval-Denis et al. 2018a, b, 2019, Maryani et al. 2019a, b, Wang et al. 2019, Xia et al. 2019, Yilmaz et al. 2021).

Previous investigations on *Fusarium* in China were summarised by Yu (1955), in which 77 species, varieties and formae speciales of pathogenic *Fusarium* spp. from 55 plant hosts were listed. A wider sampling region included 103 species, varieties and formae speciales of *Fusarium* and *Gibberella* (sexual morph of *Fusarium* s.str.) obtained from at least 111 plant species, faeces, and soil (Tai 1979). Identifications in both studies employed the morphology-based taxonomic system of Wollenweber & Reinking (1935). According to the currently used taxonomic system, only 31 of the 77 names in Yu (1955), and 36 of the 103 names in Tai (1979) remain in *Fusarium*. Considering the importance of *Fusarium* and allied species, it is necessary to clarify the species diversity and distribution of *Fusarium* in China in a modern taxonomic framework.

In our continuous survey of phytopathogenic fungi from China, 356 fusarioid strains have been isolated from diverse plant materials and various environmental samples including air, carbonatite, compost, faeces, water, and soil. In this study through a combination of morphology, multi-locus phylogeny and ecological characteristics, we advanced our knowledge on the species diversity of fusarioid taxa from China, as well as their host range and distribution.

MATERIALS AND METHODS

Sample collection

Samples were collected from 15 provinces (Fujian, Guangdong, Guizhou, Hainan, Hebei, Hubei, Hunan, Jiangsu, Jiangxi, Qinghai, Shandong, Shanxi, Sichuan, Yunnan, and Zhejiang), three autonomous regions (Guangxi Zhuang, Neimenggu, and Tibet) and two municipalities (Beijing and Chongqing) in China, and isolated from agricultural products imported into China from 13 other countries (Argentina, Australia, Brazil, Canada, Italy, Japan, Netherlands, Philippines, Poland, Saudi Arabia, Spain, Ukraine, and USA). Diseased and healthy plant tissues were collected and placed in paper bags. Air samples were collected using the Koch sedimentation method (Zhang et al. 2017). Water samples were collected as 10 mL samples and kept in sterile 15 mL centrifuge tubes (Zhang et al. 2017). Compost, faeces, pollen, and soil samples were collected (10–100 g per sample) after removing the surface layer (Zhang et al. 2017). Carbonatite samples were collected as five pieces in different orientations at each sample site (Zhang et al. 2017).

Fungal isolation

Fungi were isolated from plant tissues using single spore isolation as outlined in Zhang et al. (2013). Fungal endophytes were isolated using a tissue isolation method. Briefly, plant tissue pieces (4–5 mm²) were taken from the margin of leaf or stem spots as well as healthy sections, consecutively immersed in 70 % ethanol for 1 min, 5 % NaClO for 3 min, 70 % ethanol for 1 min, and rinsed in sterile distilled water for 30 s. Tissue pieces were blotted dry in sterile paper towels and incubated on 1/4 strength potato dextrose agar (PDA; Crous et al. 2019) containing ampicillin and streptomycin (50 mg/L each) (Liu et al. 2015). Isolates were retrieved from compost, pollen, soil, and water using the plate dilution method. One gram of compost, faeces, pollen, soil, or water was suspended in 9 mL sterile water. The suspension was shaken on the Vortex vibration meter for 10 min. The extract was diluted to a series of concentrations, i.e., 10⁻² to 10⁻⁵. For each concentration, 200 µL suspensions were spread onto the 1/4 strength potato dextrose agar (PDA) with three replicates. Carbonatite samples were treated following the protocol of Zhang et al. (2017).

All plates were incubated at room temperature and examined every 2 d for fungal hyphae. Individual colonies were picked up with a sterilised needle and transferred onto fresh PDA plates. All the cultures were then purified using an optimized protocol of single spore isolation (Zhang et al. 2013).

All isolates examined in this study were deposited in Lei Cai's personal culture collection (LC), housed at the Institute of Microbiology, Chinese Academy of Sciences, Beijing, China. Information of isolates including geographic distribution and host/habitat are listed in Table 1. Type specimens of new species were deposited in the Mycological Fungarium of the Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS), and living ex-type cultures in the China General Microbiological Culture Collection Centre (CGMCC).

Morphological observation

Examined isolates were incubated on synthetic nutrient poor agar plates (SNA; Nirenberg 1976) for 7 d at 25 °C. Agar pieces of approximately 5 × 5 mm were cut from the edge of colonies and transferred onto media for morphological characterisation. Culture characteristics, including colony morphology, pigmentation and odour, were observed after 7 d incubation in the dark on PDA, oatmeal agar (OA; Crous et al. 2019), and SNA. Colours were rated according to the colour charts of Kornerup & Wanscher (1978). Sporodochia were induced by incubating

Table 1 Details of examined isolates included in the phylogenetic analyses. Newly generated GenBank accessions are in **bold**.

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	ter1	rbp1	rbp2	tub2	IGS
<i>Albonectria</i>										
<i>A. rigidiuscula</i>	LC13606 = F503	Japan	unidentified plant	MW016388	MW566255	MW580428	MW024420	MW474374	MW533715	–
<i>Bisfusarium</i>										
<i>B. aseptatum</i>	CGMCC 3.20816 = LC1075 T	China, Guangdong Province, Guangzhou city	Orchidaceae sp.	MW016389	MW566256	MW580429	MW024421	MW474375	MW533716	–
	LC13607	China, Guangdong Province, Guangzhou city	Orchidaceae sp.	MW016390	MW566257	MW580430	MW024422	MW474376	MW533717	–
	LC13608	China, Guangdong Province, Guangzhou city	Orchidaceae sp.	MW016391	MW566258	MW580431	MW024423	MW474377	MW533718	–
<i>Fusarium</i>										
<i>F. concolor</i> species complex										
<i>F. anguloides</i>	LC13612 = M0563	China, Guangdong Province, Shenzhen city	<i>Cordyline stricta</i>	MW016395	MW566262	MW580435	MW024426	MW474381	MW533721	–
	LC13613 = M0568	China, Guangdong Province, Shenzhen city	<i>Alocasia odora</i>	MW016396	MW566263	MW580436	MW024427	MW474382	MW533722	–
	LC7007	China, Jiangxi Province	bamboo	MW016397	MW566264	MW580437	MW024428	MW474383	–	–
	LC7151	China, Jiangxi Province	bamboo	MW016398	MW566265	MW580438	MW024429	MW474384	MW533723	–
	LC7178	China, Jiangxi Province	bamboo	MW016399	MW566266	MW580439	MW024430	MW474385	MW533724	–
	LC7189	China, Guangdong Province, Guangzhou city	bamboo	MW016400	MW566267	MW580440	MW024431	MW474386	MW533725	–
	LC7190	China, Guangdong Province, Guangzhou city	bamboo	MW016401	MW566268	MW580441	MW024432	MW474387	–	–
	LC7240	China, Jiangxi Province, Ganzhou city	bamboo	MW016402	MW566269	MW580442	MW024433	MW474388	MW533726	–
<i>F. bambusarum</i>	CGMCC 3.20820 = LC7180 T	China, Jiangxi Province	bamboo	MW016403	MW566270	MW580443	MW024434	MW474389	–	–
	LC7187	China, Guangdong Province, Guangzhou city	bamboo	MW016404	MW566271	MW580444	MW024435	MW474390	–	–
<i>F. falsibabinda</i> species complex										
<i>F. falsibabinda</i>	CGMCC 3.20823 = LC13610 = F015 T	Japan	<i>Podocarpus macrophyllus</i>	MW016393	MW566260	MW580433	MW024424	MW474379	MW533719	–
	LC13611 = F058	Japan	<i>Camellia sasanqua</i>	MW016394	MW566261	MW580434	MW024425	MW474380	MW533720	–
<i>F. fujikuroi</i> species complex										
<i>F. annulatum</i>	LC1105	China	<i>Lithocarpus glabra</i>	MW016472	MW566339	MW580512	MW024500	MW474458	MW533791	–
	LC11490 = G2	China, Beijing	<i>Vitis</i> sp.	MW016473	MW566340	MW580513	MW024501	MW474459	MW533792	–
	LC11527 = G358	China, Hebei Province	<i>Vitis</i> sp.	MW016474	MW566341	MW580514	MW024502	MW474460	MW533793	–
	LC11584 = G373	China, Hebei Province	<i>Vitis</i> sp.	MW016475	MW566342	MW580515	MW024503	MW474461	MW533794	–
	LC11650 = HM259-L09	China, Hainan Province	<i>Oryza</i> sp.	MW016476	MW566343	MW580516	MW024504	MW474462	MW533795	–
	LC11670 = HM259-S07	China, Hainan Province	<i>Oryza</i> sp.	MW016477	MW566344	MW580517	MW024505	MW474463	MW533796	–
	LC11672 = HM259-S12	China, Hainan Province	<i>Oryza</i> sp.	MW016478	MW566345	MW580518	MW024506	MW474464	MW533797	–
	LC13658 = CF4	China, Neimenggu Province	unidentified mushroom	MW016479	MW566346	MW580519	MW024507	MW474465	MW533798	–
	LC13659 = F007	USA	<i>Glycine max</i>	MW016480	MW566347	MW580520	MW024508	MW474466	MW533799	–
	LC13660 = F023	Philippines	<i>Musa</i> sp.	MW016481	MW566348	MW580521	MW024509	MW474467	MW533800	–
	LC13661 = F028	Italy	<i>Malus domestica</i>	MW016482	MW566349	MW580522	MW024510	MW474468	MW533801	–
	LC13662 = F059	Spain	<i>Chamaerops humilis</i>	MW016483	MW566350	MW580523	MW024511	MW474469	MW533802	–
	LC13663 = F100	Ukraine	<i>Zea mays</i>	MW016484	MW566351	MW580524	MW024512	MW474470	MW533803	–
	LC13664 = F102	USA	<i>Sorghum bicolor</i>	MW016485	MW566352	MW580525	MW024513	MW474471	MW533804	–
	LC13665 = F405	Spain	<i>Olea europaea</i>	MW016486	MW566353	MW580526	MW024514	MW474472	MW533805	–
	LC13666 = GDBYL08-E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016487	MW566354	MW580527	MW024515	MW474473	MW533806	–
	LC13667 = GDBYL10-E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016488	MW566355	MW580528	MW024516	MW474474	MW533807	–
	LC13668 = GDGZSJL01E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016489	MW566356	MW580529	MW024517	MW474475	MW533808	–
	LC13669 = GXBSMAS2-E3	China, Guangxi Zhuang Autonomous Region, Baise city	<i>Musa nana</i>	MW016490	MW566357	MW580530	MW024518	MW474476	MW533809	–
	LC13670 = GXCZMQS1-E2	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	MW016491	MW566358	MW580531	MW024519	MW474477	MW533810	–
	LC13671 = GXLBL15-3	China, Guangxi Zhuang Autonomous Region, Laibin city	<i>Musa nana</i>	MW016492	MW566359	MW580532	MW024520	MW474478	MW533811	–
	LC13673 = HBF3-2	China, Hebei Province	<i>Oryza</i> sp.	MW016494	MW566361	MW580534	MW024522	MW474480	MW533813	–
	LC13674 = JXF3-22	China, Jiangxi Province	<i>Oryza</i> sp.	MW016495	MW566362	MW580535	MW024523	MW474481	MW533814	–

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	ter1	rp1	rp2	tub2	IGS
<i>F. annulatum</i> (cont.)	LC13675 = JXN1-21	China, Jiangxi Province	<i>Oryza</i> sp.	MW016496	MW566363	MW580536	MW024524	MW474482	MW533815	–
	LC2825	China, Beijing	unidentified grass	MW016497	MW566364	MW580537	MW024525	MW474483	MW533816	–
	LC5984	China	submerged wood	MW016498	MW566365	MW580538	MW024526	MW474484	MW533817	–
	LC6002	China	submerged wood	MW016499	MW566366	MW580539	MW024527	MW474485	MW533818	–
	LC7208	China, Guangdong Province, Guangzhou city	bamboo	MW016500	MW566367	MW580540	MW024528	MW474486	MW533819	–
	LC7924	China, Shandong Province	<i>Capsicum</i> sp.	MW016501	MW566368	MW580541	MW024529	MW474487	MW533820	–
	LC13615	China, Guizhou Province, Zunyi city	water	MW016406	MW566273	MW580446	MW024437	MW474392	MW533728	–
	LC13616	China, Guizhou Province, Zunyi city	water	MW016407	MW566274	MW580447	MW024438	MW474393	MW533729	–
	CGMCC 3.20819 = LC7502 T	China, Guizhou Province, Zunyi city	water	MW016408	MW566275	MW580448	MW024439	MW474394	MW533730	–
	LC1003	China, Guangdong Province, Guangzhou city	<i>Reineckia carnea</i>	MW016409	MW566276	MW580449	MW024440	MW474395	MW533731	–
<i>F. aquaticum</i>	LC11489 = G1	China, Beijing	<i>Vitis</i> sp.	MW016410	MW566277	MW580450	MW024441	MW474396	MW533732	–
	LC11491 = G5	China, Beijing	<i>Vitis</i> sp.	MW016411	MW566278	MW580451	MW024442	MW474397	MW533733	–
	LC11507 = G36	China, Beijing	<i>Vitis</i> sp.	MW016412	MW566279	MW580452	MW024443	MW474398	MW533734	–
	LC13617 = CQ1128	China, Jiangsu Province, Changshu city	unknown plant	MW016413	MW566280	MW580453	MW024444	MW474399	MW533735	–
	LC13618 = F409	Japan	<i>Podocarpus macrophyllus</i>	MW016414	MW566281	MW580454	MW024445	MW474400	MW533736	–
	LC13619 = FJWYS10-3	China, Fujian Province, Wuyi Mountain	<i>Musa nana</i>	MW016415	MW566282	MW580455	MW024446	MZ399207	MW533737	–
	LC13620 = FJWYS3-1	China, Fujian Province, Wuyi Mountain	<i>Musa nana</i>	MW016416	MW566283	MW580456	MW024447	MW474402	MW533738	–
	LC13621 = GXLB9-1-1	China, Guangxi Zhuang Autonomous Region, Laibin city	<i>Musa nana</i>	MW016417	MW566284	MW580457	MW024448	MW474403	MW533739	–
	LC13623 = LJM1471	China, Hainan Province, Haikou city	<i>Maianthemum</i> sp.	MW016419	MW566286	MW580459	MW024450	MW474405	MW533741	–
	LC13624 = M0514	China, Fujian Province, Fuzhou city, Wuyi Mountain	<i>Lablab</i> sp.	MW016420	MW566287	MW580460	MW024451	MW474406	MW533742	–
<i>F. elaeagni</i>	LC13647 = M0155	China, Fujian Province, Fuzhou city	<i>Lablab</i> sp.	MW016457	MW566324	MW580497	MW024485	MW474443	MW533776	–
	LC13648 = M0155.2	China, Fujian Province, Fuzhou city	<i>Lablab</i> sp.	MW016458	MW566325	MW580498	MW024486	MW474444	MW533777	–
	LC13649 = M0155.3	China, Fujian Province, Fuzhou city	<i>Lablab</i> sp.	MW016459	MW566326	MW580499	MW024487	MW474445	MW533778	–
	LC4326	China, Jiangxi Province	<i>Aglaonema modestum</i>	MW016421	MW566288	MW580461	MW024452	MW474407	MW533743	–
	LC4359	China, Jiangxi Province	<i>Hedera nepalensis</i>	MW016422	MW566289	MW580462	MW024453	MW474408	MW533744	–
	LC7032	China, Hainan Province	<i>Musa nana</i>	MW016423	MW566290	MW580463	MW024454	MW474409	MW533745	–
	CGMCC 3.20822 = LC13627 = CQ1053 T	China, Jiangsu Province, Suzhou city	<i>Elaeagnus pungens</i>	MW016426	MW566293	MW580466	MW024457	MW474412	MW533748	–
	LC13628 = CQ1053.2	China, Jiangsu Province, Suzhou city	<i>Elaeagnus pungens</i>	MW016427	MW566294	MW580467	MW024458	MW474413	MW533749	–
	LC13629 = CQ1053.3	China, Jiangsu Province, Suzhou city	<i>Elaeagnus pungens</i>	MW016428	MW566295	MW580468	MW024459	MW474414	MW533750	–
	LC13633 = F013	USA	<i>Glycine max</i>	MW016432	MW566299	MW580472	MW024460	MW474418	MW533751	–
<i>F. fujikuroi</i>	LC13634 = F032	Japan	<i>Acer palmatum</i>	MW016433	MW566300	MW580473	MW024461	MW474419	MW533752	–
	LC13635 = F063	USA	<i>Sorghum bicolor</i>	MW016434	MW566301	MW580474	MW024462	MW474420	MW533753	–
	LC13636 = F402	Japan	<i>Rhododendron simsii</i>	MW016435	MW566302	MW580475	MW024463	MW474421	MW533754	–
	LC13637 = FJWYS2-1	China, Fujian Province, Wuyi mountain	<i>Musa nana</i>	MW016436	MW566303	MW580476	MW024464	MW474422	MW533755	–
	LC13638 = GDQY3-1	China, Guangdong Province, Qingyuan city	<i>Musa nana</i>	MW016437	MW566304	MW580477	MW024465	MW474423	MW533756	–
	LC13639 = GXBSNXS01-E1	China, Guangxi Zhuang Autonomous Region, Baise city	<i>Musa nana</i>	MW016438	MW566305	MW580478	MW024466	MW474424	MW533757	–
	LC13640 = GXLZBDL06-E2	China, Guangxi Zhuang Autonomous Region, Liuzhou city	<i>Musa nana</i>	MW016439	MW566306	MW580479	MW024467	MW474425	MW533758	–
	LC13641 = HBF4-8	China, Hebei Province	<i>Oryza</i> sp.	MW016440	MW566307	MW580480	MW024468	MW474426	MW533759	–
	LC13642 = LJM1535	China, Hainan Province, Wanning city	<i>Panicum</i> sp.	MW016441	MW566308	MW580481	MW024469	MW474427	MW533760	–
	LC13643 = LJM1536	China, Hainan Province, Wanning city	<i>Panicum</i> sp.	MW016442	MW566309	MW580482	MW024470	MW474428	MW533761	–
	LC5916	China, Jiangxi Province, Nanchang city	submerged wood	MW016443	MW566310	MW580483	MW024471	MW474429	MW533762	–
	LC5927	China, Jiangxi Province, Nanchang city	submerged wood	MW016444	MW566311	MW580484	MW024472	MW474430	MW533763	–
	LC5945	China, Jiangxi Province, Nanchang city	submerged wood	MW016445	MW566312	MW580485	MW024473	MW474431	MW533764	–
	LC5955	China, Jiangxi Province, Nanchang city	submerged wood	MW016446	MW566313	MW580486	MW024474	MW474432	MW533765	–
	LC5979	China, Jiangxi Province, Nanchang city	submerged wood	MW016447	MW566314	MW580487	MW024475	MW474433	MW533766	–
	LC6014	China, Jiangxi Province, Nanchang city	submerged wood	MW016448	MW566315	MW580488	MW024476	MW474434	MW533767	–
	LC6015	China, Jiangxi Province, Nanchang city	submerged wood	MW016449	MW566316	MW580489	MW024477	MW474435	MW533768	–

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	ter1	rp1	rp2	tub2	IGS
<i>F. fujikuroi</i> (cont.)	LC0624	China, Jiangxi Province, Nanchang city	submerged wood	MW016450	MW566317	MW580490	MW024478	MW474436	MW533769	—
	LC6973	China, Jiangxi Province	<i>Citrus reticulata</i>	MW016451	MW566318	MW580491	MW024479	MW474437	MW533770	—
	LC7147	China, Jiangxi Province	bamboo	MW016452	MW566319	MW024480	MW024481	MW474438	MW533771	—
	LC7864	China, Guangxi Zhuang Autonomous Region	<i>Poaceae</i> sp.	MW016453	MW566320	MW580493	MW024481	MW474439	MW533772	—
	CGMCC 3.20824 = LC13644 = GXHCSWL14-E1 T	China, Guangxi Zhuang Autonomous Region, Hechi city	<i>Musa nana</i>	MW016454	MW566321	MW580494	MW024482	MW474440	MW533773	—
<i>F. hechitense</i>	LC13645 = GXHCSWL14-E12	China, Guangxi Zhuang Autonomous Region, Hechi city,	<i>Musa nana</i>	MW016455	MW566322	MW580495	MW024483	MW474441	MW533774	—
	LC13646 = GXHCSWL14-E13	China, Guangxi Zhuang Autonomous Region, Hechi city	<i>Musa nana</i>	MW016456	MW566323	MW580496	MW024484	MW474442	MW533775	—
	LC13650 = GXCZMQF02-1	China, Guangxi Zhuang Autonomous Region, Hechi city	<i>Musa nana</i>	MW016461	MW566328	MW580501	MW024489	MW474447	MW533780	—
	LC13651 = GXCZMQF02-2	Chongzuo city	<i>Musa nana</i>	MW016462	MW566329	MW580502	MW024490	MW474448	MW533781	—
	LC13652 = MH0493	Chongzuo city	<i>Musa nana</i>	MW016463	MW566330	MW580503	MW024491	MW474449	MW533782	—
<i>F. madaense</i>	LC13614 = HBN5-22	China, Guangxi Zhuang Autonomous Region	<i>Arenga caudata</i>	MW016405	MW566272	MW580445	MW024436	MW474391	MW533727	—
	LC13689 = LGS129	China, Hebei Province	<i>Oryza</i> sp.	MW016516	MW566383	MW580556	MW024544	MW474502	MW533835	—
	LC13689 = LGS129	China, Hainan Province	<i>Paspalum vaginatum</i>	MZ379241	MZ399201	MZ399211	MZ399204	MZ399208	MZ399214	—
	LC13689 = LGS129.3	China, Hainan Province	<i>Paspalum vaginatum</i>	MZ379242	MZ399202	MZ399212	MZ399205	MZ399209	MZ399215	—
	CGMCC 3.20825 = LC13656 = GXGLPL15E2 T	China, Guangxi Zhuang Autonomous Region, Gullin city	<i>Musa nana</i>	MW016470	MW566337	MW580510	MW024498	MW474456	MW533789	—
<i>F. proliferatum</i>	F026	China, Zhejiang Province, Ningbo city	<i>Musa</i> sp.	MZ379243	MZ399203	MZ399213	MZ399206	MZ399210	MZ399216	—
	LC13676 = F428	China, Taiwan Province	<i>Syzgium samarangense</i>	MW016502	MW566369	MW580542	MW024530	MW474488	MW533821	—
	LC13677 = F429	China, Taiwan Province	<i>Syzgium samarangense</i>	MW016503	MW566370	MW580543	MW024531	MW474489	MW533822	—
	LC1058	China, Guangdong Province, Guangzhou city	<i>Arundina graminifolia</i>	MW016504	MW566371	MW580544	MW024532	MW474490	MW533823	—
	LC13625 = F162	Philippines	<i>Musa</i> sp.	MW016424	MW566291	MW580464	MW024455	MW474410	MW533746	—
<i>F. sacchari</i>	LC13626 = GDGZTHL40-E4	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016425	MW566292	MW580465	MW024456	MW474411	MW533747	—
	LC13657 = GXBSGGS01-E2	China, Guangxi Zhuang Autonomous Region, Baise city	<i>Musa nana</i>	MW016471	MW566338	MW580511	MW024499	MW474457	MW533790	—
	LC13678 = GDGZ2-2	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016505	MW566372	MW580545	MW024533	MW474491	MW533824	—
	LC13679 = GXQZPSL01-E1	China, Guangxi Zhuang Autonomous Region, Qinzhou city	<i>Musa nana</i>	MW016506	MW566373	MW580546	MW024534	MW474492	MW533825	—
	LC13680 = GXQZPSL01-E2	China, Guangxi Zhuang Autonomous Region, Qinzhou city	<i>Musa nana</i>	MW016507	MW566374	MW580547	MW024535	MW474493	MW533826	—
<i>F. subglutinans</i>	LC13681 = LJM1180	China, Beijing	<i>Poa annua</i>	MW016508	MW566375	MW580548	MW024536	MW474494	MW533827	—
	LC13682 = F055	USA	<i>Glycine max</i>	MW016509	MW566376	MW580549	MW024537	MW474495	MW533828	—
	LC13683 = F057	USA	<i>Zea mays</i>	MW016510	MW566377	MW580550	MW024538	MW474496	MW533829	—
	LC13684 = F154	Canada	<i>Glycine max</i>	MW016511	MW566378	MW580551	MW024539	MW474497	MW533830	—
	LC13685 = F154-2	Canada	<i>Glycine max</i>	MW016512	MW566379	MW580552	MW024540	MW474498	MW533831	—
<i>F. temperatum</i>	LC13686 = F154-3	Canada	<i>Glycine max</i>	MW016513	MW566380	MW580553	MW024541	MW474499	MW533832	—
	LC5848	China, Guizhou Province	unidentified lichen	MW016460	MW566327	MW580544	MW024488	MW474446	MW533779	—
	LC13687 = F103	USA	<i>Sorghum bicolor</i>	MW016514	MW566381	MW580554	MW024542	MW474500	MW533833	—
	LC13688 = F411	USA	<i>Glycine max</i>	MW016515	MW566382	MW580555	MW024543	MW474501	MW533834	—
	LC13653 = F410	Brazil	<i>Glycine max</i>	MW016464	MW566331	MW580504	MW024492	MW474450	MW533783	—
<i>F. verticilloides</i>	LC13654 = F412	USA	<i>Glycine max</i>	MW016465	MW566332	MW580505	MW024493	MW474451	MW533784	—
	LC13655 = GDGZP4-1-1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016466	MW566333	MW580506	MW024494	MW474452	MW533785	—
	LC2810	China, Sichuan Province, Zhanjiangjie	bamboo	MW016467	MW566334	MW580507	MW024495	MW474453	MW533786	—
	LC2818	China, Beijing	<i>Physospegia virginiana</i>	MW016468	MW566335	MW580508	MW024496	MW474454	MW533787	—
	LC5896	China, Jiangxi Province, Nanchang city	submerged wood	MW016469	MW566336	MW580509	MW024497	MW474455	MW533788	—
<i>F. incarnatum-equiseti</i> species complex										
<i>F. arcuatissporum</i>	LC11639 = HA5-S04	China, Hainan Province	<i>Oryza</i> sp.	MK280840	MK289658	MK289586	MK289798	MK289736	MW533836	—

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. arcuatissporum</i> (cont.)	OGMCC 3.19493 = LC12147 = LF1502 T	China, Hubei Province	<i>Brassica campestris</i>	MK280802	MK289697	MK289584	MK289799	MK289739	MW533837	–
	LC13690 = LGS034	China, Beijing	soil	MW016517	MW574182	MW594360	MW024545	MW474503	MW533838	–
	LC13691 = LGS119	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016518	MW574183	MW594361	MW024546	MW474504	MW533839	–
	LC13692 = LJM0900	China, Beijing	<i>Poa annua</i>	MW016519	MW574184	MW594362	MW024547	MW474505	MW533840	–
	LC13693 = LJM0939	China, Beijing	unidentified grass	MW016520	MW574185	MW594363	MW024548	MW474506	MW533841	–
	LC13694 = LJM1441	China, Hainan Province	<i>Pericum</i> sp.	MW016521	MW574186	MW594364	MW024549	MW474507	MW533842	–
	LC6026	China, Jiangxi Province, Sanya city	<i>Nelumbo nucifera</i> bloom	MK280792	MK289667	MW289585	MK289800	MK289770	MW533843	–
	LC13695 = MH0430	China, Guangxi Zhuang Autonomous Region	<i>Castanopsis boissii</i>	MW016522	MW574187	MW594365	MW024550	MW474508	MW533844	–
	LC13696 = MH0439	China, Guangxi Zhuang Autonomous Region	<i>Castanopsis boissii</i>	MW016523	MW574188	MW594366	MW024551	MW474509	MW533845	–
	LC13697 = MH0446	China, Guangxi Zhuang Autonomous Region	<i>Smilax corbularia</i>	MW016524	MW574189	MW594367	MW024552	MW474510	MW533846	–
<i>F. citri</i>	LC13698 = YNTBL08E1	China, Yunnan Province, Xishuangbanna	<i>Musa nana</i>	MW016525	MW574190	MW594368	MW024553	MW474511	MW533847	–
	LC4879	China, Beijing	<i>Amrygdalus triloba</i>	MK280820	MK289665	MW289586	MK289827	MK289768	MW533848	–
	CGMCC 3.19467 = LC6896 T	China, Hunan Province	<i>Citrus reticulata</i>	MK280803	MK289668	MK289587	MK289828	MK289771	–	–
	LC7922	China, Shandong Province	<i>Capsicum</i> sp.	MK280817	MK289687	MK289634	MK289829	MK289788	–	–
	LC7937	China, Shandong Province	<i>Capsicum</i> sp.	MK280797	MK289693	MK289640	MK289830	MK289794	–	–
	LC13699 = LGS085	China, Beijing	soil	MW016526	MW574191	MW594369	MW024554	MW474512	–	–
	LC13700 = LJM1181	China, Beijing	<i>Poa annua</i>	MW016527	MW574192	MW594370	MW024555	MW474513	MW533850	–
	CGMCC 3.19495 = LC12160 = GXGL9-3 T	China, Guangxi Zhuang Autonomous Region	<i>Musa nana</i>	MK280837	MK289652	MK289594	MK289831	MK289747	MW533851	–
	CGMCC 3.19478 = LC11638 = HA5-S03 T	China, Hainan Province	<i>Oryza</i> sp.	MK280836	MK289657	MK289581	MK289833	MK289735	MW533852	–
	LC12161 = GXGZ-9-1	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	MK280793	MK289648	MK289595	MK289832	MK289748	MW533853	–
<i>F. humuli</i>	LC13701 = YNTBL31E2	China, Yunnan Province, Xishuangbanna	<i>Musa nana</i>	MW016528	MW574193	MW594371	MW024556	MW474514	MW533854	–
	CQ1027	China, Jiangsu Province	<i>Ligustrum lucidum</i>	MK280843	MK289709	MK289567	MK289838	MK289721	MW533855	–
	CQ1032	China, Jiangsu Province	<i>Cedrela</i> sp.	MK280844	MK289710	MK289568	MK289839	MK289722	MW533856	–
	CGMCC 3.19374 = CQ1039T	China, Jiangsu Province	<i>Humulus scandens</i>	MK280845	MK289712	MK289570	MK289840	MK289724	MW533857	–
	CQ1048	China, Jiangsu Province	<i>Viburnum</i> sp.	MK280850	MK289713	MK289571	MK289841	MK289725	MW533858	–
	CQ1133	China, Jiangsu Province	<i>Liquidambar formosana</i>	MK280848	MK289714	MK289572	MK289842	MK289726	MW533859	–
	CQ969	China, Jiangsu Province	<i>Vinca major</i>	MK280847	MK289717	MK289575	MK289843	MK289729	MW533860	–
	CQ970	China, Jiangsu Province	<i>Rosa sempervirens</i>	MK280851	MK289718	MK289576	MK289844	MK289730	MW533861	–
	CQ975	China, Jiangsu Province	<i>Rosa sempervirens</i>	MK280849	MK289719	MK289577	MK289845	MK289731	MW533862	–
	LC12158 = GDBYL14-E1	China, Guangdong Province, Guangzhou city	<i>Paederia foetida</i>	MK280846	MK289720	MK289578	MK289846	MK289732	MW533863	–
<i>F. incarnatum</i> <i>F. ipomoeae</i>	LC12159 = GDGLHL14-E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MK280823	MK289645	MK289592	MK289834	MK289745	MW533864	–
	LC13702 = LJM1412	China, Hainan Province, Haikou city	<i>Musa nana</i>	MK280827	MK289646	MK289593	MK289835	MK289746	MW533865	–
	LC13703 = MH0134	China, Guangxi Zhuang Autonomous Region	<i>Megathyrus</i> sp.	MW016529	MW574194	MW594372	MW024557	MW474515	MW533866	–
	LC13704 = MH0240	China, Guangxi Zhuang Autonomous Region	<i>Coriaria nepalensis</i>	MW016530	MW574195	MW594373	MW024558	MW474516	MW533867	–
	LC4490	China, Jiangxi Province	<i>Chimonanthus praecox</i>	MW016531	MW574196	MW594374	MW024559	MW474517	MW533868	–
	LC7003	China, Hainan Province	<i>Osmanthus</i> sp.	MK280826	MK289654	MK289580	MK289836	MK289767	MW533869	–
	LC13705 = LGS051	China, Hainan Province	<i>Musa paradisica</i>	MK280833	MK289674	MK289596	MK289837	MK289777	MW533870	–
	CQ1099	China, Beijing	soil	MW016532	MW574197	MW594375	MW024560	MW474518	MW533871	–
	CQ1132	China, Jiangsu Province	<i>Rhododendron pulchrum</i>	MK280853	MK289715	MK289573	MK289861	MK289727	MW533872	–
	LC0166	China, Jiangsu Province	<i>Vinca major</i>	MK280854	MK289716	MK289574	MK289862	MK289728	MW533873	–
<i>F. guilinese</i>	LC0455	China, Beijing	<i>Solanum lycopersicum</i>	MK280780	MK289659	MK289579	MK289848	MK289733	–	–
	LC12162 = GXLZCJL05-E2	China, Beijing	<i>Hosta</i> sp.	MK280819	MK289660	MK289580	MK289849	MK289734	MW533874	–
	LC12163 = M0027	China, Guangxi Zhuang Autonomous Region, Liuzhou city	<i>Musa nana</i>	MK280795	MK289655	MK289596	MK289847	MK289749	MW533875	–
	LC12164 = M0028	China, Fujian Province, Fuzhou city	<i>Hibiscus syriacus</i>	MK280790	MK289700	MK289597	MK289857	MK289750	MW533876	–
	CGMCC 3.19496 = LC12165 = M011 T	China, Fujian Province, Fuzhou city	<i>Hibiscus syriacus</i>	MK280822	MK289701	MK289598	MK289858	MK289751	MW533877	–
	CGMCC 3.19496 = LC12165 = M011 T	China, Fujian Province	<i>Ipomoea aquatica</i>	MK280832	MK289704	MK289599	MK289859	MK289752	MW533878	–

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. ipomoeae</i> (cont.)	LC12166 = M0138	China, Fujian Province, Fuzhou city	<i>Lagenaria siceraria</i>	MK280791	MK289706	MK289600	MK289860	MK289753	—	—
	LC13706 = JXN4-3	China, Jiangxi Province	<i>Oryza</i> sp.	MW016533	MW574198	MW594376	MW024561	MW474519	—	—
	LC13707 = LGS036	China, Beijing	soil	MW016534	MW574199	MW594377	MW024562	MW474520	MW533879	—
	LC13708 = LGS052	China, Beijing	soil	MW016535	MW574200	MW594378	MW024563	MW474521	—	—
	LC13709 = LGS071	China, Beijing	soil	MW016536	MW574201	MW594379	MW024564	MW474522	MW533880	—
	LC13710 = LJM0958	China, Beijing	<i>Agrostis matsumurae</i>	MW016537	MW574202	MW594380	MW024565	MW474523	MW533881	—
	LC5912	China, Jiangxi Province	submerged wood	MK280821	MK289666	MK289616	MK289850	MK289769	MW533882	—
	LC6926	China, Hubei Province	<i>Oryza sativa</i>	MK280799	MK289670	MK289619	MK289851	MK289773	—	—
	LC7150	China, Jiangxi Province	bamboo	MK280818	MK289678	MK289627	MK289852	MK289781	MW533883	—
	LC7923	China, Shandong Province	<i>Capsicum</i> sp.	MK280800	MK289688	MK289635	MK289853	MK289789	MW533884	—
	LC7925	China, Shandong Province	<i>Capsicum</i> sp.	MK280796	MK289689	MK289636	MK289854	MK289790	—	—
	LC7936	China, Shandong Province	<i>Capsicum</i> sp.	MK280785	MK289692	MK289639	MK289855	MK289793	—	—
	LC7940	China, Shandong Province	<i>Capsicum</i> sp.	MK280798	MK289695	MK289642	MK289856	MK289796	MW533885	—
<i>F. irregulare</i>	LC12145	China, Guangdong Province	bamboo	MK280830	MK289681	MK289582	MK289864	MK289737	—	—
	LC12146	China, Guangdong Province	bamboo	MK280831	MK289682	MK289583	MK289865	MK289738	—	—
	LC13711 = LJM1544	China, Hainan Province, Wanning city	<i>Digitaria</i> sp.	MW016538	MW574203	MW594381	MW024566	MW474524	MW533886	—
<i>F. lacertarum</i>	LC13712 = LJM1545	China, Hainan Province, Wanning city	<i>Digitaria</i> sp.	MW016539	MW574204	MW594382	MW024567	MW474525	MW533887	—
	LC13713 = MH0410	China, Guangxi Zhuang Autonomous Region	<i>Vigna unguiculata</i>	MW016540	MW574205	MW594383	MW024568	MW474526	MW533888	—
	CGMCC 3.19489 = LC7188 T	China, Guangdong Province	bamboo	MK280829	MK289680	MK289629	MK289863	MK289783	—	—
<i>F. luffae</i>	LC7927	China, Shandong Province	<i>Capsicum</i> sp.	MK280838	MK289690	MK289637	MK289866	MK289791	—	—
	LC7931	China, Shandong Province	<i>Capsicum</i> sp.	MK280801	MK289691	MK289638	MK289867	MK289792	—	—
	LC7942	China, Shandong Province	<i>Capsicum</i> sp.	MK280834	MK289696	MK289643	MK289868	MK289797	—	—
<i>F. nanum</i>	CQ1038	China, Jiangsu Province	<i>Humulus scandens</i>	MK280852	MK289711	MK289569	MK289870	MK289723	MW533889	—
	CGMCC 3.19497 = LC12167 T	China, Fujian Province	<i>Luffa aegyptiaca</i>	MK280807	MK289698	MK289601	MK289869	MK289754	—	—
	LC13714 = JXN4-19	China, Jiangxi Province	<i>Oryza</i> sp.	MW016541	MW574206	MW594384	MW024569	MW474527	—	—
<i>F. penambucanum</i>	CGMCC 3.19498 = LC12168 = GXGL14-2 T	China, Guangxi Zhuang Autonomous Region	<i>Musa nana</i>	MK280794	MK289651	MK289602	MK289871	MK289755	—	—
	LC1384	Saudi Arabia	<i>Solanum lycopersicum</i>	MK280842	MK289661	MK289611	MK289872	MK289764	MW533890	—
	LC1385	Saudi Arabia	<i>Solanum lycopersicum</i>	MK280781	MK289662	MK289612	MK289873	MK289765	MW533891	—
	LC1516	Saudi Arabia	<i>Solanum lycopersicum</i>	MK280782	MK289663	MK289613	MK289874	MK289766	MW533892	—
	LC12148 = GDBYL12-E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MK280778	MK289644	MK289587	MK289801	MK289740	MW533893	—
	LC12149 = GDGP2-3	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MK280783	MK289647	MK289588	MK289802	MK289741	MW533894	—
	LC12151 = GXCZMQF01-3	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	MK280825	MK289649	MK289589	MK289803	MK289742	MW533895	—
	LC12152 = GXCZMQF01-4	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	MK280824	MK289650	MK289590	MK289804	MK289743	MW533896	—
	LC13715 = LJM1300	China, Hainan Province, Haikou city	<i>Heteropogon</i> sp.	MW016542	MW574207	MW594385	MW024570	MW474528	MW533897	—
	LC13716 = LJM1312	China, Hainan Province	<i>Gerbera jamesonii</i>	MW016543	MW574208	MW594386	MW024571	MW474529	MW533898	—
	LC13717 = LJM1438	China, Hainan Province, Sanya city	<i>Cyperus</i> sp.	MW016544	MW574209	MW594387	MW024572	MW474530	MW533899	—
	LC13718 = LJM1523	China, Hainan Province, Haikou city	<i>Chamaedorea</i> sp.	MW016545	MW574210	MW594388	MW024573	MW474531	MW533900	—
	LC13719 = LJM1529	China, Hainan Province, Sanya city	<i>Panicum</i> sp.	MW016546	MW574211	MW594389	MW024574	MW474532	MW533901	—
<i>F. sulawesienae</i>	LC7014	China, Hainan Province	<i>Musa paradisica</i>	MK280786	MK289675	MK289625	MK289812	MK289778	—	—
	LC7019	China, Hainan Province	<i>Musa paradisica</i>	MK280816	MK289676	MK289625	MK289813	MK289779	—	—
	LC7040	China, Hainan Province	<i>Musa paradisica</i>	MK280787	MK289677	MK289626	MK289814	MK289780	MW533902	—
	LC7157	China, Jiangxi Province, Nanchang city	bamboo	MK280804	MK289679	MK289628	MK289815	MK289782	—	—
	LC7842	China, Hainan Province	<i>Zea</i> sp.	MK280813	MK289684	MK289631	MK289817	MK289785	MW533903	—
	LC7920	China, Shandong Province	<i>Capsicum</i> sp.	MK280805	MK289686	MK289633	MK289819	MK289787	—	—
	LC12170 = GXNN-6	China, Guangxi Zhuang Autonomous Region, Nanning city	<i>Musa nana</i>	MK280841	MK289656	MK289604	MK289807	MK289757	MW533908	—
	LC12173 = M0010	China, Fujian Province, Fuzhou city	<i>Luffa aegyptiaca</i>	MK280788	MK289699	MK289605	MK289821	MK289758	—	—
	LC12174 = M0079	China, Fujian Province, Fuzhou city	<i>Ipomoea batatas</i>	MK280815	MK289702	MK289606	MK289822	MK289759	—	—
	LC12175 = M0110	China, Fujian Province, Fuzhou city	<i>Ipomoea aquatica</i>	MK280808	MK289703	MK289607	MK289823	MK289760	MW533909	—

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. sulawesiense</i> (cont.)	LC121176 = M0117	China, Fujian Province, Fuzhou city	<i>Luffa aegyptiaca</i>	MK280839	MK289705	MK289608	MK289824	MK289761	–	–
	LC121177 = M0204	China, Fujian Province, Fuzhou city	<i>Colocasia esculenta</i>	MK280809	MK289707	MK289609	MK289825	MK289762	–	–
	LC121178 = M0751	China, Fujian Province, Fuzhou city	<i>Synonium auritum</i>	MK280789	MK289708	MK289610	MK289826	MK289763	–	–
	LC13720 = JXN4-20	China, Jiangxi Province	<i>Oryza</i> sp.	MW016547	MW574212	MW594390	MW024575	MW474533	–	–
	LC13721 = MH0409	China, Guangxi Zhuang Autonomous Region	<i>Alocasia odora</i>	MW016548	MW574213	MW594391	MW024576	MW474534	MW533904	–
	LC13722 = MH0423	China, Guangxi Zhuang Autonomous Region	<i>Acalypha insulana</i>	MW016549	MW574214	MW594392	MW024577	MW474535	MW533905	–
	LC13723 = MH0447	China, Guangxi Zhuang Autonomous Region	<i>Smilax corbularia</i>	MW016550	MW574215	MW594393	MW024578	MW474536	MW533906	–
	LC6897	China, Hunan Province	<i>Citrus reticulata</i>	MK280810	MK289669	MK289618	MK289808	MK289772	–	–
	LC6928	China, Hubei Province	<i>Oryza sativa</i>	MK280835	MK289671	MK289620	MK289809	MK289774	–	–
	LC6936	China, Hubei Province	<i>Oryza sativa</i>	MK280835	MK289673	MK289671	MK289809	MK289774	–	–
	LC6990	China, Hainan Province	<i>Musa paradisica</i>	MK280814	MK289673	MK289622	MK289811	MK289776	–	–
	LC7210	China, Jiangxi Province, Nanchang city	bamboo	MK280804	MK289679	MK289628	MK289815	MK289782	–	–
<i>F. tanahbumbuense</i>	LC7919	China, Shandong Province	<i>Capsicum</i> sp.	MK280811	MK289685	MK289632	MK289818	MK289786	–	–
	LC7939	China, Shandong Province	<i>Capsicum</i> sp.	MK280806	MK289694	MK289641	MK289820	MK289795	–	–
	LC13724 = HBF4-12	China, Hebei Province	<i>Oryza</i> sp.	MW016551	MW574216	MW594394	MW024579	MW474537	–	–
	LC13725 = HBN4-19	China, Hebei Province	<i>Oryza</i> sp.	MW016552	MW574217	MW594395	MW024580	MW474538	–	–
	LC13726 = LJM1369	China, Hainan Province, Wanning city	<i>Digitaria</i> sp.	MW016553	MW574218	MW594396	MW024581	MW474539	MW533910	–
	LC13727 = F092	China, Yunnan Province	<i>Coffea</i> sp.	MW016554	–	MW594307	MW024582	MW474540	MW533911	–
<i>F. lateritium</i> species complex	LC13728 = CQ1109	China, Jiangsu Province, Changshu city	<i>Forsythia</i> sp.	MW016555	–	MW594308	MW024583	MW474541	MW533912	–
	LC13729 = CQ993	China, Jiangsu Province, Suzhou city	<i>Hedera nepalensis</i> var. <i>sinensis</i>	MW016556	–	MW594309	MW024584	MW474542	MW533913	–
<i>Fusarium</i> sp.	LC13730 = F004	Japan	<i>Acer palmatum</i>	MW016557	–	MW594310	MW024585	MW474543	MW533914	–
	LC13731 = M0759	China, Guangdong Province, Shenzhen city	<i>Schima noronhai</i>	MW016558	–	MW594311	MW024586	MW474544	MW533915	–
	LC13732 = F085	China, Yunnan Province	<i>Coffea</i> sp.	MW016559	–	MW594312	MW024587	MW474545	MW533916	–
	LC13733 = F088	China, Yunnan Province	<i>Coffea</i> sp.	MW016560	–	MW594313	MW024588	MW474546	MW533917	–
<i>F. nisikadai</i> species complex	LC11660 = HM259-R03	China, Hainan Province	<i>Oryza</i> sp.	MW016699	–	MW620160	MW024727	MW474685	MW534045	–
	LC13823 = GDGP2-2	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016700	–	MW620161	MW024728	MW474686	MW534046	–
	LC13824 = GXQZPSRDE4	China, Guangxi Zhuang Autonomous Region, Qinzhou city	<i>Musa nana</i>	MW016701	–	MW620162	MW024729	MW474687	–	–
	LC7503	China, Guizhou Province, Zunyi city	water	MW016565	–	MW594318	MW024593	MW474551	MW533922	–
<i>F. miscanthi</i>	CGMCC 3.20826 = LC2800 T	China, Beijing	unidentified grass	MW016561	–	MW594314	MW024589	MW474547	MW533918	–
	LC2819	China, Beijing	unidentified grass	MW016562	–	MW594315	MW024590	MW474548	MW533919	–
	LC2823	China, Beijing	<i>Pennisetum alopecuroides</i>	MW016563	–	MW594316	MW024591	MW474549	MW533920	–
	LC2824	China, Beijing	unidentified grass	MW016564	–	MW594317	MW024592	MW474550	MW533921	–
<i>F. oxysporum</i> species complex										
<i>F. cugenangense</i>	LC13734 = F001	Japan	<i>Acer palmatum</i>	MW016566	–	MW594319	MW024594	MW474552	MW533923	MW024379
	LC13735 = F080	Brazil	<i>Hordeum vulgare</i>	MW016567	–	MW594320	MW024595	MW474553	MW533924	MW024380
	LC13736 = F422	China, Zhejiang Province, Ningbo city	<i>Solanum tuberosum</i>	MW016568	–	MW594321	MW024596	MW474554	MW533925	MW024381
	LC4496	China, Jiangxi Province	<i>Smilax</i> sp.	MW016571	–	MW594324	MW024599	MW474557	MW533928	MW024384
<i>F. curvatum</i>	LC13739 = F155	Netherlands	<i>Tulipa gesneriana</i>	MW016572	–	MW594325	MW024600	MW474558	MW533929	MW024385
	LC13740 = GXHCFoc1	China, Guangxi Zhuang Autonomous Region, Hechi city	<i>Musa nana</i>	MW016573	–	MW594326	MW024601	MW474559	MW533930	MW024386
<i>F. duoseptatum</i>	LC13741 = GXQZPSRDE3	China, Guangxi Zhuang Autonomous Region, Qinzhou city	<i>Musa nana</i>	MW016574	–	MW594327	MW024602	MW474560	MW533931	MW024387
	LC13742 = M0765	China, Guangdong Province, Shenzhen city	<i>Caryota mitis</i>	MW016575	–	MW594328	MW024603	MW474561	MW533932	MW024388
	GDGP11-2-2	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	OL744448	–	OL771389	OL771373	OL771381	OL771397	OL780783
	GDZJLZ11-2-1	China, Guangdong Province, Zhanjiang city	<i>Musa nana</i>	OL744449	–	OL771390	OL771374	OL771382	OL771398	OL780784

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. grosnichellii</i> (cont.)	GXCZMQS03E1	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	OL744450	–	OL771391	OL771375	OL771383	OL771399	OL780785
	GXCZMQS03E2	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	OL744451	–	OL771392	OL771376	OL771384	OL771400	OL780786
	JXF4-32	China, Jiangxi Province	<i>Oryza</i> sp.	OL744452	–	OL771393	OL771377	OL771385	OL771401	OL780787
	JXF4-6	China, Jiangxi Province	<i>Oryza</i> sp.	OL744453	–	OL771394	OL771378	OL771386	OL771402	OL780788
	JXN4-10	China, Jiangxi Province	<i>Oryza</i> sp.	OL744454	–	OL771395	OL771379	OL771387	OL771403	OL780789
<i>F. nirenbergiae</i>	M0676	China, Guangdong Province, Shenzhen	<i>Chamaerops humilis</i>	OL744455	–	OL771396	OL771380	OL771388	OL771404	OL780790
	LC13752 = F014	Italy	<i>Hydrangea macrophylla</i>	MW016585	–	MW594338	MW024613	MW474571	MW533942	MW024398
	LC13753 = F051	USA	<i>Glycine max</i>	MW016586	–	MW594339	MW024614	MW474572	MW533943	MW024399
	LC13754 = F077	Italy	<i>Olea europaea</i>	MW016587	–	MW594340	MW024615	MW474573	MW533944	MW024400
	LC13755 = F153	Canada	<i>Glycine max</i>	MW016588	–	MW594341	MW024616	MW474574	MW533945	MW024401
	LC13756 = F161	Netherlands	<i>Hippocrepis rutilum</i>	MW016589	–	MW594342	MW024617	MW474575	MW533946	MW024402
	LC13757 = F418	USA	<i>Allium sativum</i>	MW016590	–	MW594343	MW024618	MW474576	MW533947	MW024403
	LC13758 = GDZJLZ16-1	China, Guangdong Province, Zhanjiang city	<i>Musa nana</i>	MW016591	–	MW594344	MW024619	MW474577	MW533948	MW024404
	LC13760 = M0579	China, Guangdong Province	<i>Caryota mitis</i>	MW016593	–	MW594346	MW024621	MW474579	MW533950	MW024406
	LC2804	China, Beijing	<i>Setaria viridis</i>	MW016594	–	MW594347	MW024622	MW474580	MW533951	MW024407
	LC13761 = Foc4-6	China, Guangxi Zhuang Autonomous Region	<i>Musa</i> sp.	MW016595	–	MW594348	MW024623	MW474581	MW533952	MW024408
	LC13762 = Foc4-7	China, Guangxi Zhuang Autonomous Region	<i>Musa</i> sp.	MW016596	–	MW594349	MW024624	MW474582	–	MW024409
	LC13763 = Foc4-8	China, Guangxi Zhuang Autonomous Region	<i>Musa</i> sp.	MW016597	–	MW594350	MW024625	MW474583	–	MW024410
	LC13764 = GXLZCJL02-E5	China, Guangxi Zhuang Autonomous Region, Liuzhou city	<i>Musa nana</i>	MW016598	–	MW594351	MW024626	MW474584	MW533953	MW024411
	LC13765 = GXNNS2	China, Guangxi Zhuang Autonomous Region, Nanning city	<i>Musa</i> sp.	MW016599	–	MW594352	MW024627	MW474585	MW533954	MW024412
<i>F. oxysporum</i> <i>Fusarium</i> sp.	LC13766 = F065	China, Zhejiang Province, Ningbo city	<i>Malus spectabilis</i>	MW016600	–	MW594353	MW024628	MW474586	MW533955	MW024413
	LC13737 = JHBS1	China, Zhejiang Province, Ningbo city	<i>Zingiber officinale</i>	MW016599	–	MW594322	MW024597	MW474555	MW533926	MW024382
	LC13743 = F163	Brazil	<i>Glycine max</i>	MW016576	–	MW594329	MW024604	MW474562	MW533933	MW024389
	LC13744 = F416	Brazil	<i>Glycine max</i>	MW016577	–	MW594330	MW024605	MW474563	MW533934	MW024390
	LC13745 = F151	Australia	<i>Hordeum vulgare</i>	MW016578	–	MW594331	MW024606	MW474564	MW533935	MW024391
	LC13746 = F151-2	Australia	<i>Hordeum vulgare</i>	MW016579	–	MW594332	MW024607	MW474565	MW533936	MW024392
	LC13747 = F151-3	Australia	<i>Hordeum vulgare</i>	MW016580	–	MW594333	MW024608	MW474566	MW533937	MW024393
	LC13748 = F050	Netherlands	<i>Tulipa gesneriana</i>	MW016581	–	MW594334	MW024609	MW474567	MW533938	MW024394
	LC13749 = F156	Netherlands	<i>Muscari botryoides</i>	MW016582	–	MW594335	MW024610	MW474568	MW533939	MW024395
	LC13750 = GDZJLZ16-2	China, Guangdong Province, Zhanjiang city	<i>Musa nana</i>	MW016583	–	MW594336	MW024611	MW474569	MW533940	MW024396
	LC13751 = GXCZ4-1	China, Guangxi Zhuang Autonomous Region, Chongzuo city	<i>Musa nana</i>	MW016584	–	MW594337	MW024612	MW474570	MW533941	MW024397
	LC13767 = LJM1259	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016601	–	MW594354	MW024629	MW474587	MW533956	MW024414
	LC13768 = LJM1259-2	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016602	–	MW594355	MW024630	MW474588	MW533957	MW024415
	LC13769 = LJM1259-3	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016603	–	MW594356	MW024631	MW474589	MW533958	MW024416
<i>F. sambucinum</i> species complex	LC13776 = FJWY2-3	China, Fujian Province, Fuzhou city	<i>Musa nana</i>	MW016630	–	MW620091	MW024658	MW474616	MW533978	–
	LC2797	China, Beijing	unidentified grass	MW016608	–	MW620089	MW024636	MW474594	MW533963	–
	LC2809	China, Beijing	unidentified grass	MW016609	–	MW620070	MW024637	MW474595	MW533964	–
	LC13773 = CQ974	China, Jiangsu Province, Suzhou city	<i>Paederia foetida</i>	MW016607	–	MW620088	MW024635	MW474593	MW533962	–
	LC13774 = GXGLYSL08-1	China, Guangxi Zhuang Autonomous Region, Gulin city	<i>Musa nana</i>	MW016610	–	MW620071	MW024638	MW474596	MW533965	–
	LC13785 = F408	China, Zhejiang Province, Ningbo city	<i>Podocarpus macrophyllus</i>	MW016629	–	MW620090	MW024657	MW474615	MW533977	–
	LC13787 = GDBYL11-E1	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016631	–	MW620092	MW024659	MW474617	MW533979	–
	LC13788 = GXGLPLL07E2	China, Guangxi Zhuang Autonomous Region, Gulin city	<i>Musa nana</i>	MW016632	–	MW620093	MW024660	MW474618	MW533980	–
	LC13789 = JXN5	China, Jiangxi Province	<i>Oryza</i> sp.	MW016633	–	MW620094	MW024661	MW474619	MW533981	–
	LC13790 = JXN5	China, Jiangxi Province	<i>Oryza</i> sp.	MW016633	–	MW620094	MW024661	MW474619	MW533981	–

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. asiaticum</i> (cont.)	LC5153	China, Jiangxi Province, Ganzhou city	<i>Prunus persica</i>	MW016635	–	MW620096	MW024663	MW474621	MW533982	–
	LC5308	China, Guizhou Province	air	MW016636	–	MW620097	MW024664	MW474622	MW533983	–
	LC7143	China, Jiangxi Province, Nanchang city	bamboo	MW016637	–	MW620098	MW024665	MW474623	MW533984	–
	LC7494	China, Guizhou Province, Zunyi city	carbonatite	MW016638	–	MW620099	MW024666	MW474624	MW533985	–
	LC7495	China, Guizhou Province, Zunyi city	carbonatite	MW016639	–	MW620100	MW024667	MW474625	MW533986	–
	LC7500	China, Guizhou Province, Zunyi city	carbonatite	MW016640	–	MW620101	MW024668	MW474626	MW533987	–
	LC7501	China, Guizhou Province, Zunyi city	soil	MW016641	–	MW620102	MW024669	MW474627	MW533988	–
	LC13775 = F056	USA	<i>Zea mays</i>	MW016611	–	MW620072	MW024639	MW474597	MW533966	–
	LC13776 = F110	Italy	<i>Penisetum orientale</i>	MW016612	–	MW620073	MW024640	MW474598	–	–
	LC0725	China, Zhejiang Province, Quzhou city	<i>Chamaedaphne calyculata</i>	MW016613	–	MW620074	MW024641	MW474599	MW533967	–
<i>F. kyushuense</i>	LC1114	China	<i>Lithocarpus glabra</i>	MW016614	–	MW620075	MW024642	MW474600	MW533968	–
	LC13777 = F179	Philippines	unidentified plant	MW016615	–	MW620076	MW024643	MW474601	MW533969	–
	LC13778 = GXLZ6-1	China, Guangxi Zhuang Autonomous Region, Liuzhou city	<i>Musa nana</i>	MW016616	–	MW620077	MW024644	MW474602	MW533970	–
	LC5936	China, Jiangxi Province, Nanchang city	submerged wood	MW016617	–	MW620078	MW024645	MW474603	MW533971	–
<i>F. longipes</i> <i>F. meridionale</i>	LC7000	China, Hainan Province	<i>Musa paradisiaca</i>	MW016618	–	MW620079	MW024646	MW474604	MW533972	–
	LC13779 = LGS185	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016619	–	MW620080	MW024647	MW474605	–	–
	LC13780 = F087	China, Yunnan Province	<i>Coffea</i> sp.	MW016620	–	MW620081	MW024648	MW474606	–	–
	LC7067	China, Yunnan Province	<i>Musa basjoo</i>	MW016621	–	MW620082	MW024649	MW474607	MW533973	–
<i>F. nepalense</i>	LC7496	China, Guizhou Province, Zunyi city	carbonatite	MW016622	–	MW620083	MW024650	MW474608	MW533974	–
	LC13781 = GDBYL14-E3	China, Guangdong Province, Guangzhou city	<i>Musa nana</i>	MW016623	–	MW620084	MW024651	MW474609	MW533975	–
	LC13782 = GXGLPL14-1	China, Guangxi Zhuang Autonomous Region, Guilin city	<i>Musa nana</i>	MW016624	–	MW620085	MW024652	MW474610	–	–
	LC6678	China, Yunnan Province, Xishuangbanna	<i>Camellia sinensis</i>	MW016625	–	MW620086	MW024653	MW474611	MW533976	–
<i>F. poae</i>	LC13783 = F150	Canada	<i>Hordeum vulgare</i>	MW016626	–	MW620087	MW024654	MW474612	–	–
	LC6917	China, Hubei Province	<i>Oryza sativa</i>	MW016627	–	MW620088	MW024655	MW474613	–	–
	LC13784 = F157	USA	<i>Medicago sativa</i>	MW016628	–	MW620089	MW024656	MW474614	–	–
	LC13790 = LJM1343	China, Hainan Province, Wanning city	<i>Rhynchospora</i> sp.	MW016634	–	MW620095	MW024662	MW474620	–	–
<i>F. ussuriianum</i>	LC7573	China, Tibet Autonomous Region	<i>Poaceae</i> sp.	MW016642	–	MW620103	MW024670	MW474628	–	–
	LC7574	China, Tibet Autonomous Region	<i>Poaceae</i> sp.	MW016643	–	MW620104	MW024671	MW474629	MW533989	–
<i>F. trinctum</i> species complex	LC13791 = F034	Argentina	<i>Glycine max</i>	MW016644	–	MW620105	MW024672	MW474630	MW533990	–
	LC13794 = F111	Italy	<i>Feijoa sellowiana</i>	MW016647	–	MW620108	MW024675	MW474633	MW533993	–
	LC13795 = GM18	China, Qinghai Province	<i>Hylotelephium erythrostictum</i>	MW016648	–	MW620109	MW024676	MW474634	MW533994	–
	LC13796 = GM80	China, Qinghai Province	<i>Hylotelephium erythrostictum</i>	MW016649	–	MW620110	MW024677	MW474635	MW533995	–
<i>F. transvaalense</i> <i>F. ussuriianum</i>	LC13797 = LF1633	China, Hubei Province, Xiangyang city	<i>Brassica</i> sp.	MW016650	–	MW620111	MW024678	MW474636	MW533996	–
	LC13798 = LF1636	China, Hubei Province, Xiangyang city	<i>Brassica</i> sp.	MW016651	–	MW620112	MW024679	MW474637	MW533997	–
	LC13799 = LGS021	China, Beijing	soil	MW016652	–	MW620113	MW024680	MW474638	MW533998	–
	LC5227	China, Neimenggu Province, Huhehaote city	<i>Prunus</i> sp.	MW016654	–	MW620115	MW024682	MW474640	MW534000	–
<i>F. alpinum</i>	LC2853	China, Yunnan Province	unidentified plant	MW016684	–	MW620145	MW024712	MW474670	MW534030	–
	LC2854	China, Yunnan Province	unidentified plant	MW016685	–	MW620146	MW024713	MW474671	MW534031	–
	LC6034	China, Tibet Autonomous Region	<i>Fabaceae</i> sp.	MW016686	–	MW620147	MW024714	MW474672	MW534032	–
	LC6037	China, Tibet Autonomous Region	<i>Fabaceae</i> sp.	MW016687	–	MW620148	MW024715	MW474673	MW534033	–
<i>F. avenaceum</i>	LC6043	China, Tibet Autonomous Region	<i>Fabaceae</i> sp.	MW016688	–	MW620149	MW024716	MW474674	MW534034	–
	CGMCC 3.20818 = LC6045 T	China, Tibet Autonomous Region	<i>Fabaceae</i> sp.	MW016689	–	MW620150	MW024717	MW474675	MW534035	–
	LC13801 = F010	Italy	<i>Hydrangea macrophylla</i>	MW016655	–	MW620116	MW024683	MW474641	MW534001	–
	LC13802 = F038	Australia	<i>Trifolium repens</i>	MW016656	–	MW620117	MW024684	MW474642	MW534002	–
<i>F. avenaceum</i>	LC13803 = F039	Australia	<i>Trifolium repens</i>	MW016657	–	MW620118	MW024685	MW474643	MW534003	–
	LC13804 = F071	USA	<i>Acer saccharum</i>	MW016658	–	MW620119	MW024686	MW474644	MW534004	–
	LC13805 = F403	USA	<i>Acer truncatum</i>	MW016659	–	MW620120	MW024687	MW474645	MW534005	–
	LC13806 = F404	USA	<i>Acer truncatum</i>	MW016660	–	MW620121	MW024688	MW474646	MW534006	–
<i>F. avenaceum</i>	LC13808 = GM149	China, Qinghai Province	<i>Halenia sibirica</i>	MW016662	–	MW620123	MW024690	MW474648	MW534008	–

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>F. avenaceum</i> (cont.)	LC13809 = GM30	China, Qinghai Province	<i>Bidens bipinnata</i>	MW016663	—	MW620124	MW024691	MW474649	MW534009	—
	LC13811 = GM71	China, Qinghai Province	<i>Halenia sibirica</i>	MW016665	—	MW620126	MW024693	MW474651	MW534011	—
	LC6044	China, Tibet Autonomous Region	<i>Fabaceae</i> sp.	MW016667	—	MW620128	MW024695	MW474653	MW534013	—
	LC6321	China, Guizhou Province	<i>Camellia sinensis</i>	MW016668	—	MW620129	MW024696	MW474654	MW534014	—
	LC6328	China, Guizhou Province	<i>Camellia sinensis</i>	MW016669	—	MW620131	MW024698	MW474655	MW534015	—
	LC6376	China, Guizhou Province	<i>Camellia sinensis</i>	MW016670	—	MW620132	MW024699	MW474656	MW534016	—
	LC6387	China, Guizhou Province	<i>Camellia sinensis</i>	MW016671	—	MW620133	MW024700	MW474657	MW534017	—
	LC6388	China, Guizhou Province	<i>Camellia sinensis</i>	MW016672	—	MW620134	MW024701	MW474658	MW534018	—
	LC6389	China, Guizhou Province	<i>Camellia sinensis</i>	MW016673	—	MW620135	MW024702	MW474659	MW534019	—
	LC7584	China, Tibet Autonomous Region	<i>Poaceae</i> sp.	MW016674	—	MW620137	MW024704	MW474660	MW534020	—
<i>F. chongqingense</i>	LC13813	China, Chongqing	<i>Bothrocaryum controversum</i>	MW016675	—	MW620136	MW024703	MW474661	MW534021	—
	LC13814	China, Chongqing	<i>Bothrocaryum controversum</i>	MW016676	—	MW620137	MW024704	MW474662	MW534022	—
<i>F. iranicum</i>	CGMCC 3.20821 = LC4957 T	China, Chongqing	<i>Bothrocaryum controversum</i>	MW016677	—	MW620138	MW024705	MW474663	MW534023	—
	LC1112	China	<i>Lithocarpus glabra</i>	MW016678	—	MW620139	MW024706	MW474664	MW534024	—
<i>F. paenoniae</i>	LC13807 = GM123	China, Qinghai Province	<i>Plantago</i> sp.	MW016661	—	MW620122	MW024689	MW474647	MW534007	—
	LC13810 = GM65	China, Qinghai Province	<i>Gentiana scabra</i>	MW016664	—	MW620125	MW024692	MW474650	MW534010	—
	LC13812 = GM85	China, Qinghai Province	<i>Gentiana scabra</i>	MW016666	—	MW620127	MW024694	MW474652	MW534012	—
	LC13815 = GM56	China, Qinghai Province	<i>Elymus dahuricus</i>	MW016679	—	MW620140	MW024707	MW474665	MW534025	—
	LC13816 = YZG10-2	China, Qinghai Province	<i>Populus</i> sp.	MW016680	—	MW620141	MW024708	MW474666	MW534026	—
	CGMCC 3.20817 = LC13817 = YZG12-2 T	China, Qinghai Province	<i>Paeonia lactiflora</i>	MW016681	—	MW620142	MW024709	MW474667	MW534027	—
	LC5166	China, Qinghai Province	<i>Crateagus monogyna</i>	MW016682	—	MW620143	MW024710	MW474668	MW534028	—
	LC7358	China, Tibet Autonomous Region	<i>Poaceae</i> sp.	MW016683	—	MW620144	MW024711	MW474669	MW534029	—
	LC0453	China, Beijing	<i>Hosta</i> sp.	MW016690	—	MW620151	MW024718	MW474676	MW534036	—
	LC0459	China, Beijing	<i>Zamia pumila</i>	MW016691	—	MW620152	MW024719	MW474677	MW534037	—
<i>F. tricinatum</i>	LC13818 = F005	Japan	<i>Acer palmatum</i>	MW016692	—	MW620153	MW024720	MW474678	MW534038	—
	LC13819 = F020	Poland	<i>Clematis</i> sp.	MW016693	—	MW620154	MW024721	MW474679	MW534039	—
	LC13820 = F033	Japan	<i>Acer palmatum</i>	MW016694	—	MW620155	MW024722	MW474680	MW534040	—
	LC13821 = F400	Japan	<i>Chaenomeles japonica</i>	MW016695	—	MW620156	MW024723	MW474681	MW534041	—
	LC13822 = PH53	China, Zhejiang Province, Ningbo city	unidentified plant	MW016696	—	MW620157	MW024724	MW474682	MW534042	—
	LC5032	China, Jiangxi Province, Ganzhou city	<i>Litsea</i> sp.	MW016697	—	MW620158	MW024725	MW474683	MW534043	—
	LC5034	China, Jiangxi Province, Ganzhou city	<i>Litsea</i> sp.	MW016698	—	MW620159	MW024726	MW474684	MW534044	—
Neocosmospora	LC2116	China, Jiangxi Province, Ganzhou city	submerged wood	MW016702	—	MW620163	MW024730	MW474688	—	—
	LC13825 = F009	Japan	<i>Acer palmatum</i>	MW016703	—	MW620164	MW024731	MW474689	MW534047	—
	LC11569 = G649	China	<i>Vitis</i> sp.	MW016704	—	MW620165	MW024732	MW474690	MW534048	—
	LC11572 = G694	China	<i>Vitis</i> sp.	MW016705	—	MW620166	MW024733	MW474691	MW534049	—
	LC13826 = LGS175	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016706	—	MW620167	MW024734	MW474692	—	—
	LC13827 = LG5230	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016707	—	MW620168	MW024735	MW474693	—	—
	LC13828 = LJM1271	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016708	—	MW620169	MW024736	MW474694	MW534050	—
	LC13829 = LJM1289	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016709	—	MW620170	MW024737	MW474695	—	—
	LC13830 = LJM1295	China, Hainan Province	<i>Paspalum vaginatum</i>	MW016710	—	MW620171	MW024738	MW474696	—	—
	CGMCC 3.20827 = LC1113 T	China	<i>Lithocarpus glabra</i>	MW016711	—	MW620172	MW024739	MW474697	—	—
<i>N. lithocarp</i>	LC13831	China	<i>Lithocarpus glabra</i>	MW016712	—	MW620173	MW024740	MW474698	MW534051	—
<i>N. longissima</i>	LC13832	China	<i>Lithocarpus glabra</i>	MW016713	—	MW620174	MW024741	MW474699	MW534052	—
	LC13833 = F301	China	<i>Lithocarpus glabra</i>	MW016714	—	MW620175	MW024742	MW474700	MW534053	—
<i>N. metavorans</i>	LC13834 = F303	Japan	<i>Armeniacae mume</i>	MW016715	—	MW620176	MW024743	MW474701	MW534054	—
	LC5930	China, Jiangxi Province, Nanchang city	submerged wood	MW016716	—	MW620177	MW024744	MW474702	MW534055	—
<i>N. oblonga</i>	LC5933	China, Jiangxi Province, Nanchang city	submerged wood	MW016717	—	MW620178	MW024745	MW474703	MW534056	—
	LC7499	China, Guizhou Province, Zunyi city	carbonatite	MW016718	—	MW620179	MW024746	MW474704	MW534057	—
<i>N. paraeumartii</i>	LC13835 = F066	Japan	<i>Acer</i> sp.	MW016719	—	MW620180	MW024747	MW474705	MW534058	—
	LC13836 = M0478	China, Fujian Province, Fuzhou city	<i>Castanopsis fargesii</i>	MW016720	—	MW620181	MW024748	MW474706	MW534059	—

Table 1 (cont.)

Species	Isolate	Country/Location	Host/Habitat	ITS	cam	tef1	rpb1	rpb2	tub2	IGS
<i>N. petriophila</i>	LC1120	China	<i>Lithocarpus glabra</i>	MW016721	-	MW620182	MW024749	MW474707	-	-
	LC13837 = F073	USA	<i>Acer platanoides</i>	MW016722	-	MW620183	MW024750	MW474708	-	-
	LC13838 = LJM1257	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016723	-	MW620184	MW024751	MW474709	MW534061	-
	LC13839 = LJM1263	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016724	-	MW620185	MW024752	MW474710	MW534062	-
<i>N. pseudensisformis</i>	LC13840 = LJM1273	China, Guangxi Zhuang Autonomous Region	<i>Passiflora edulis</i>	MW016725	-	MW620186	MW024753	MW474711	MW534063	-
	LC5482	China, Guizhou Province	faeces	MW016726	-	MW620187	MW024756	MW474712	MW534066	-
	LC13841 = 6S1	China, Shandong Province, Weifang city	<i>Capsicum annuum</i>	MW016727	-	MW620188	MW024757	MW474713	MW534067	-
	LC13842 = F002	Japan	<i>Acer palmatum</i>	MW016728	-	MW620189	MW024758	MW474714	MW534068	-
<i>N. solani</i>	LC13843 = F016	Italy	<i>Syringa vulgaris</i>	MW016729	-	MW620190	MW024759	MW474715	MW534069	-
	LC13844 = HBN6-5	China, Hebei Province	<i>Oryza sp.</i>	MW016730	-	MW620191	MW024760	MW474716	-	-
	LC13845 = J3R1	China, Shandong Province, Weifang city	<i>Zingiber officinale</i>	MW016731	-	MW620192	MW024761	MW474717	MW534070	-
	LC13846 = J3R2	China, Shandong Province, Weifang city	<i>Zingiber officinale</i>	MW016732	-	MW620193	MW024762	MW474718	MW534071	-
<i>N. silvicola</i>	LC13847 = LGS032	China, Beijing	soil	MW016733	-	MW620194	MW024763	MW474719	MW534072	-
	LC13848 = LGS033	China, Beijing	soil	MW016734	-	MW620195	MW024764	MW474720	-	-
	LC13849 = LGS054	China, Beijing	soil	MW016735	-	MW620196	MW024765	MW474721	MW534073	-
	LC3717	China, Guangxi Zhuang Autonomous Region, Nanning city	soil	MW016736	-	MW620197	MW024766	MW474722	MW534074	-
<i>N. stercicola</i>	LC3785	China, Shanxi Province, Baode city	soil	MW016737	-	MW620198	MW024767	MW474723	MW534075	-
	LC3932	China, Shanxi Province, Baode city	compost	MW016738	-	MW620199	MW024768	MW474724	MW534076	-
	LC5548	China, Guizhou Province	soil	MW016739	-	MW620200	MW024769	MW474725	-	-
	LC5387	China, Guizhou Province	soil	MW016740	-	MW620201	MW024770	MW474726	MW534077	-

Note: T = Ex-type specimen of new species; A. = *Albonectria*, B. = *Bisfusarium*, F. = *Fusarium*, N. = *Neocosmospora*.

under a 12/12 h near-ultraviolet light/dark cycle, on SNA and water agar amended with sterilised pieces of carnation leaves (CLA; Snyder & Hansen 1947, Fisher et al. 1982) at 25 °C, respectively. Micromorphological characteristics were examined and photo-documented with water as mounting medium under a Nikon 80i microscope with Differential Interference Contrast (DIC) optics, and a Nikon SMZ1500 dissecting microscope. For each species, respectively 30 conidiophores, conidiogenous cells and chlamydospores, 50 micro- and macroconidia were mounted and randomly measured to calculate the mean size and standard deviation (SD).

DNA extraction and amplification

Genomic DNA was extracted from fungal mycelia grown on PDA, using a modified CTAB protocol as described in Guo et al. (2000). Seven loci, including the 5.8S nuclear ribosomal RNA gene with the two flanking internal transcribed spacer (ITS) regions, intergenic spacer region of the rDNA (IGS), partial translation elongation factor (*tef1*), partial calmodulin (*cam*), partial RNA polymerase largest subunit (*rpb1*), partial RNA polymerase second largest subunit (*rpb2*) gene regions, and partial β-tubulin (*tub2*), were amplified and sequenced, respectively. The primer pairs and PCR amplification procedures following protocols described by O'Donnell et al. (1998a, b, 2008, 2009a, b, 2010), Crous et al. (2009, 2021), and Lombard et al. (2015), are listed in Table 2. PCR amplifications were performed in a reaction mixture consisting of 12.5 μL 2 × Taq PCR Master Mix (Vazyme Biotech Co., Ltd, Nanjing, China), 1 μL each of 10 μM primers, 1 μL of the undiluted genomic DNA, adjusted to a final volume of 25 μL with distilled deionized water. The PCR products were visualised on 1 % agarose electrophoresis gel. Sequencing was done bi-directionally, conducted by the Tianyi Huiyuan Company (Beijing, China). Consensus sequences were obtained using SeqMan of the Lasergene software package v. 14.1 (DNASTar, Madison, Wisconsin, USA).

Phylogenetic analyses

Sequences of the 425 fusarioid strains studied in this study (356 from China, 69 intercepted from 13 other countries) are listed in Table 1. For each locus, sequences were aligned using MAFFT v. 7 (Kato et al. 2017), and the alignments were manually adjusted where necessary. The best-fit nucleotide substitution models under the Akaike Information Criterion (AIC) were selected using jModelTest v. 2.1.7 (Posada 2008, Darriba et al. 2012). Alignments derived from this study were deposited in TreeBASE (submission ID 29103), taxonomic novelties in MycoBank, and new sequences in NCBI's GenBank database (www.ncbi.nlm.nih.gov; accession numbers shown in Table 1). Phylogenetic analyses of both individual and combined datasets were performed using Bayesian inference (BI) and Maximum-likelihood (ML) methods. The BI analyses were conducted using MrBayes v. 3.2.1 (Huelsenbeck & Ronquist 2001) following the protocol of Wang et al. (2019), with optimisation of each locus treated as partitions in combined analyses, based on the Markov Chain Monte Carlo (MCMC) approach (Ronquist et al. 2012). All characters were equally weighted, and gaps were treated as missing data. Stationarity of analysis was determined by examining the standard deviation of split frequencies (< 0.01) and -ln likelihood plots in AWTY (Nylander et al. 2008). The ML analyses were conducted using PhyML v. 3.0 (Guindon et al. 2010), with 1 000 bootstrap replicates. The general time reversible model was applied with an invariable gamma-distributed rate variation (GTR+I+G).

Table 2 Primers information of PCR amplification of the seven loci.

Locus	Primer	Sequence of Primer (5'-3')	Annealing temperature (°C)	References
ITS	ITS5	GGAAGTAAAAGTCGTAACAAGG	55	White et al. (1990)
	ITS4	TCCTCCGCTTATTGATATGC		
IGS	iNL11	AGGCTTCGGCTTAGCGTCTTAG	55	O'Donnell et al. (2009a)
	iCNS1	TTTCGCAGTGAGGTCGGCAG		
<i>tef1</i>	EF1	ATGGGTAAGGARGACAAGAC	55	O'Donnell et al. (1998b)
	EF2	GGARGTACCAGTSATCATG		
<i>cam</i>	CL1	GARTWCAAGGAGGCCTTCTC	55	O'Donnell et al. (2000a)
	CL2A	TTTTTGTCATCATGAGTTGGAC		
<i>rpb1</i>	RPB1-Fa	CAYAARGARTCYATGATGGGWC	58 (5 cycles)→57 (5)→56 (35)	O'Donnell et al. (2010)
	RPB1-G2R	GTCATYTGDDGTDGCDGGYTCDCC		
<i>rpb2</i>	RPB2-5f2	GGGGWGAYCAGAAGAAGGC	57	Reeb et al. (2004) Liu et al. (1999)
	RPB2-11ar	GCRTGGATCTTRTCRTCSACC		
<i>tub2</i>	T1	AACATGCGTGAGATTGTAAGT	54	O'Donnell & Cigelnik (1997)
	T2	TAGTGACCCTTGGCCAGTTG		

RESULTS

Phylogenetic analyses

Analyses of the generic level phylogeny of fusarioid fungi were conducted by using a combined *tef1*, *rpb1*, and *rpb2* dataset that included 643 bp for *tef1*, 1583 bp of *rpb1*, and 1311 bp for *rpb2*. For the BI and ML analyses, a GTR+I+G model was selected for the combined *tef1-rpb1-rpb2* dataset. The combined *tef1*, *rpb1*, and *rpb2* phylogeny (Fig. 1) revealed that the Chinese isolates clustered into nine species complexes in *Fusarium*, and two allied genera (*Bisifusarium* and *Neocosmospora*). Isolate LC13606 from *Podocarpus macrophyllus* imported from Japan was closest to *Albonectria rigidiuscula* CBS 122570 (Fig. 1).

Phylogenetic analyses of different *Fusarium* species complexes and allied genera were conducted using different multi-locus datasets following O'Donnell et al. (2009b), Jacobs-Venter et al. (2018), Sandoval-Denis et al. (2018a, b, 2019), Lombard et al. (2019a, b), Xia et al. (2019), Crous et al. (2021), and Yilmaz et al. (2021). Briefly, phylogenetic analyses of the *F. concolor*, *F. falsibabinda*, and *F. nisikadoi* species complexes were performed by using the *tef1-rpb1-rpb2* dataset, and rooted with *F. humuli* CQ1039 (Fig. 2), and single gene trees were performed respectively (Supplementary Fig. S1). Phylogenetic analyses of the *F. fujikuroi* species complex was performed by using the *tef1-cam-rpb1-rpb2-tub2* dataset and rooted with *F. nirenbergiae* CBS 744.97 (Fig. 3), and single gene trees were performed respectively (Supplementary Fig. S2). A *tef1-cam-rpb2* dataset was constructed for phylogenetic analyses of the *F. incarnatum-equiseti* species complex and rooted with *F. concolor* NRRL 13994 (Fig. 4). Phylogeny of the *F. lateritium* species complex was performed using the *tef1-rpb1-rpb2-tub2*

dataset, and rooted with *F. sublunatum* NRRL 13384 (Fig. 5). Phylogenetic analyses of the *F. oxysporum* species complex was performed by using the *tef1-cam-rpb1-rpb2-tub2* dataset and rooted with *F. globosum* NRRL 26131 (Fig. 6). Phylogenetic analyses of the *F. sambucinum* species complex was performed using *tef1-rpb1-rpb* dataset and rooted with *F. lactis* CBS 411.97 (Fig. 7). Phylogenetic analyses of the *F. tricinatum* species complex was performed by using a combined ITS-*tef1-rpb1-rpb2* dataset and rooted with *F. concolor* NRRL 13994 (Fig. 8), and single gene trees were performed respectively (Supplementary Fig. S3). Phylogenetic analyses of the genus *Bisifusarium* were performed by using the ITS-*tef1-cam-rpb2-tub2* dataset and rooted by *Rectifusarium robinianum* CBS 430.91 (Fig. 9), and single gene trees were performed respectively (Supplementary Fig. S4). Phylogenetic analyses of *Neocosmospora* were performed using ITS-*tef1-rpb2* dataset, and rooted by *Geejayessia cicatricum* CBS 125552 and *G. atrofusca* NRRL 22316 (Fig. 10), and single gene trees were performed respectively (Supplementary Fig. S5). Composition of the multi-locus datasets, outgroup taxa and character numbers and the best model of each locus were listed in Table 3.

Taxonomy

In total 425 strains were isolated. Of these, 356 isolated from China and were identified to 72 species, including 61 known and 11 novel species (Table 1). Sixty-nine isolates from diverse plants imported from 13 countries were identified as 26 species including one new species, namely *F. falsibabinda*. New species in *Fusarium* are treated alphabetically based on their respective species complexes.

text continues on p. 25

Table 3 Number of characters/model for BI analysis of each locus in phylogenetic analyses of different *Fusarium* species complexes and two other genera.

Genus/Species complex	ITS	<i>tef1</i>	<i>cam</i>	<i>rpb1</i>	<i>rpb2</i>	<i>tub2</i>	Outgroup taxon
<i>Bisifusarium</i>	480/SYM+I+G	660/GTR+G	565/SYM+G	–	1455/SYM+G	528/HKY+I+G	<i>F. concolor</i>
<i>Fusarium concolor</i>	–	627/GTR+G	–	1585/SYM+G	1601/GTR+G	–	<i>F. humuli</i>
<i>F. falsibabinda</i>	–	627/GTR+G	–	1585/SYM+G	1601/GTR+G	–	<i>F. humuli</i>
<i>F. fujikuroi</i>	–	666/GTR+I+G	673/SYM+I	1549/SYM+G	1455/SYM+I+G	573/SYM+G	<i>F. nirenbergiae</i>
<i>F. incarnatum-equiseti</i>	–	592/GTR+I+G	547/SYM+G	–	816/GTR+I+G	–	<i>F. concolor</i>
<i>F. lateritium</i>	–	645/HKY+G	–	1586/SYM+G	1716/GTR+I+G	555/HKY+G	<i>F. sublunatum</i>
<i>F. nisikadoi</i>	–	627/GTR+G	–	1585/SYM+G	1601/GTR+G	–	<i>F. humuli</i>
<i>F. oxysporum</i>	–	544/HKY+G	552/K80	1455/SYM+G	1704/GTR+G	505/SYM+G	<i>F. udum</i>
<i>F. sambucinum</i>	–	621/GTR+G	–	1492/SYM+G	1293/SYM+I	–	<i>F. lactis</i>
<i>F. tricinatum</i>	491/SYM+I	613/GTR+G	–	1575/SYM+G	1270/SYM+G	–	<i>F. concolor</i>
<i>Neocosmospora</i>	333/GTR+I+G	606/GTR+G	–	–	1202/SYM+I+G	–	<i>Geejayessia atrofusca</i> and <i>G. cicatricum</i>



Fig. 1 Fifty percent majority rule consensus tree from a Bayesian analysis based on a three-locus combined dataset (*tef1*, *rbp1*, and *rbp2*) showing the phylogenetic relationships of *Fusarium* and allied genera. The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Fusicolla violacea* (CBS 634.76 T). Ex-type cultures are indicated with 'T', epi-type with 'ET', neotype with 'NT'.

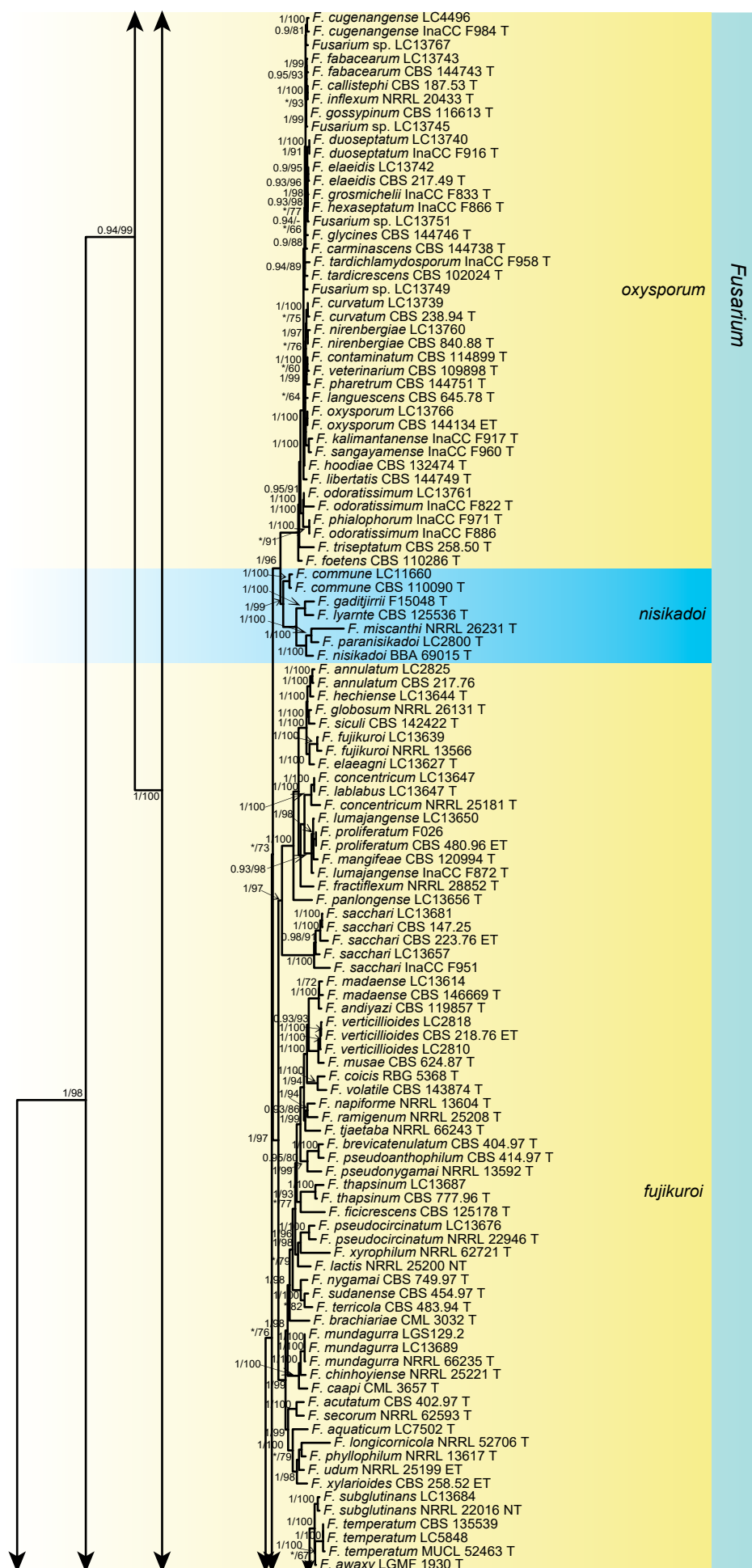


Fig. 1 (cont.)

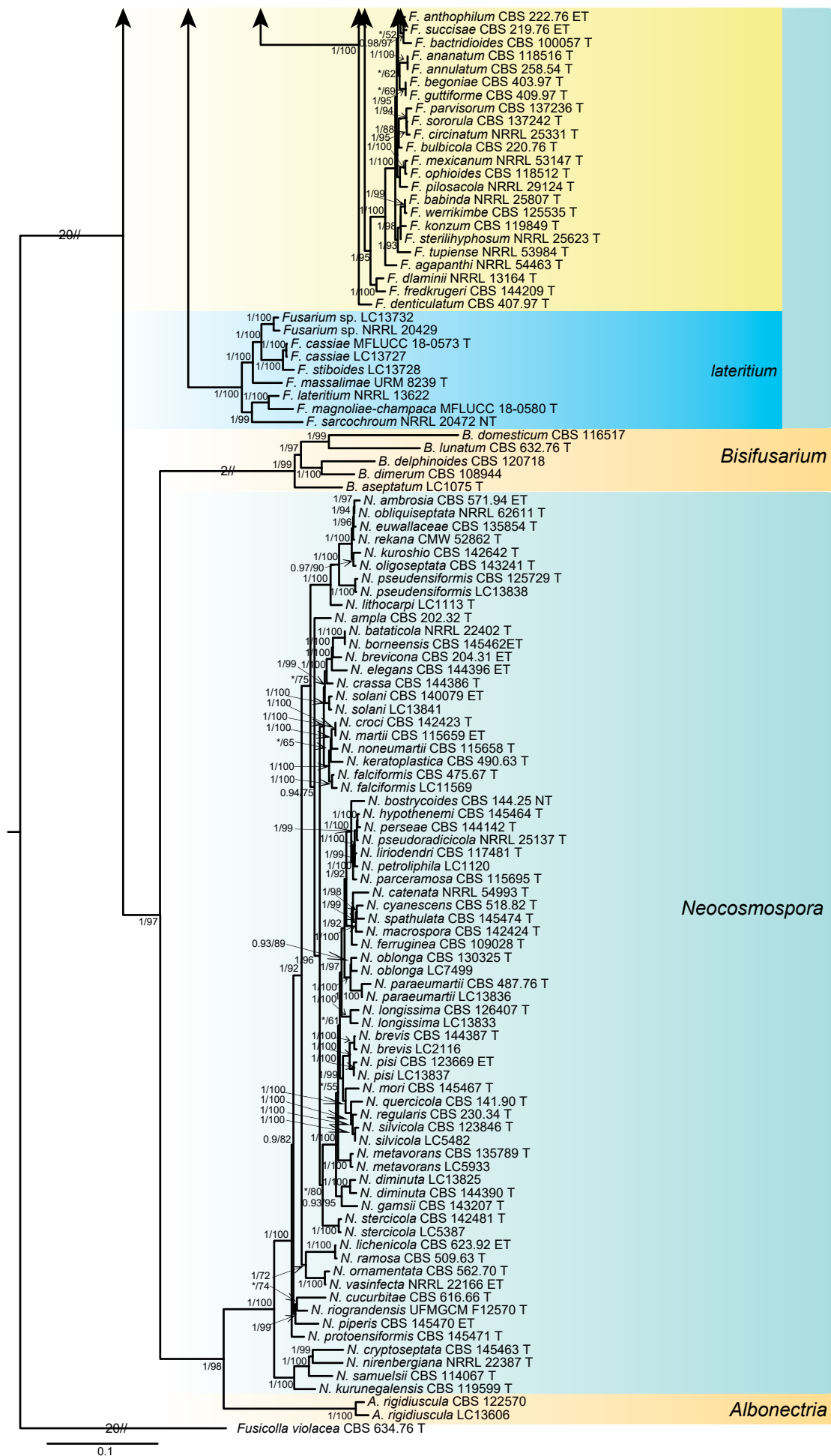


Fig. 1 (cont.)

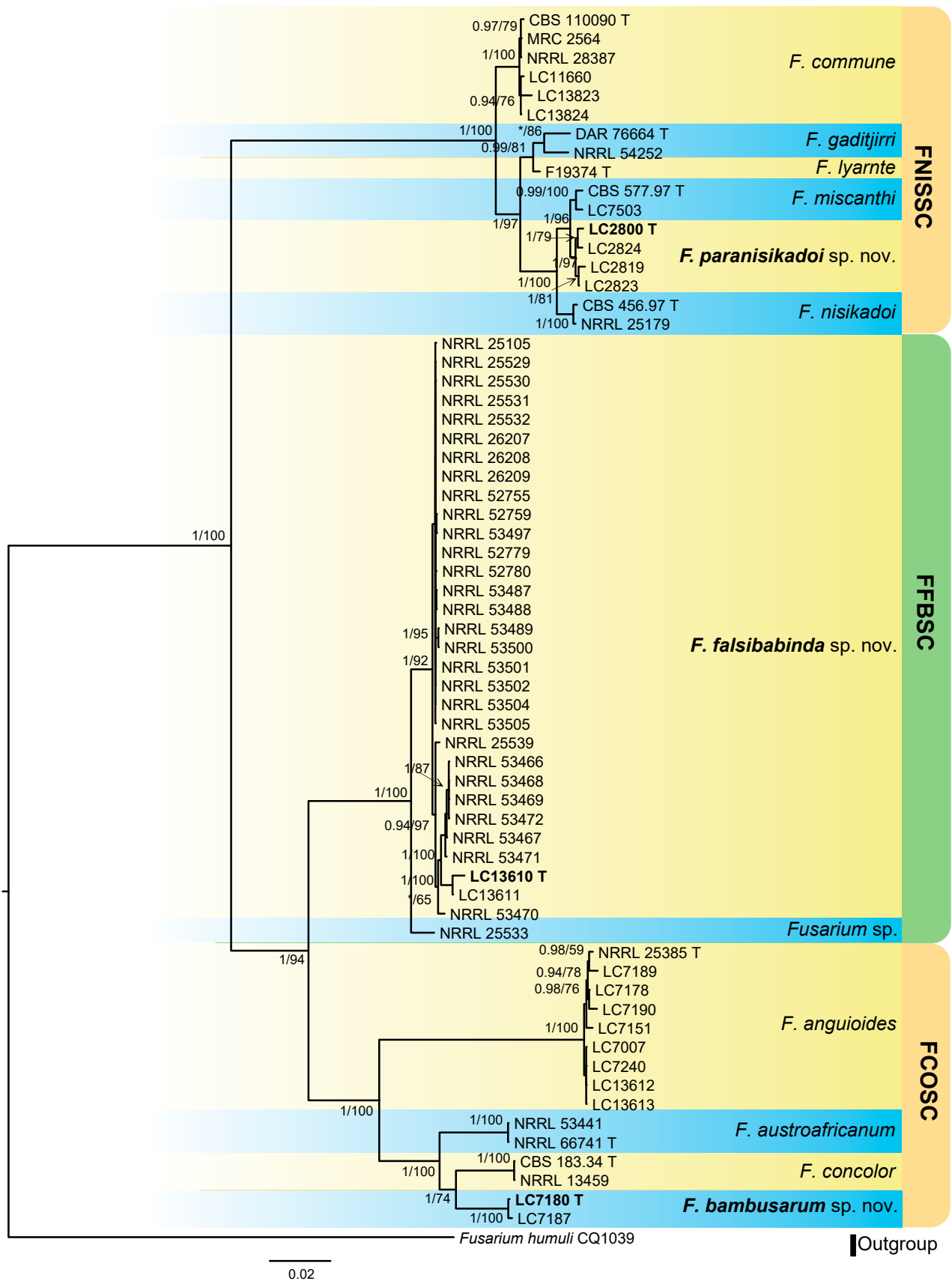


Fig. 2 Fifty percent majority rule consensus tree from a Bayesian analysis based on a three-locus combined dataset (*tef1*, *rpb1*, and *rpb2*) showing the phylogenetic relationships of five species complexes within the *Fusarium*, namely *F. concolor* (FCOSC), *F. falsibabinda* (FFBSC), and *F. nisikadoi* (FNISSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Fusarium humuli* (CQ1039). New species are indicated in **bold**, ex-type cultures in **bold** with 'T'.

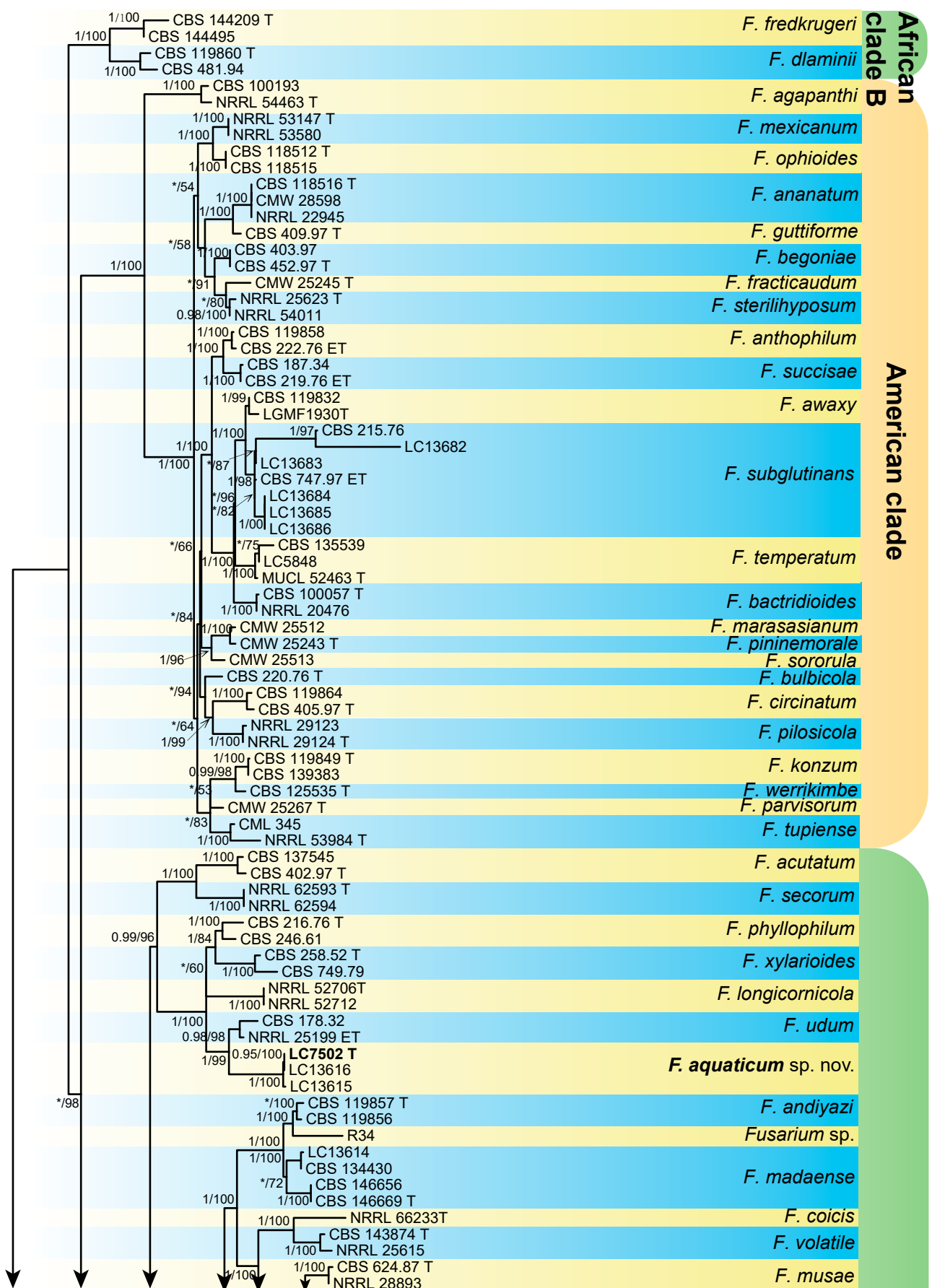


Fig. 3 Fifty percent majority rule consensus tree from a Bayesian analysis based on a five-locus combined dataset (*tef1*, *cam*, *rpb1*, *rpb2*, and *tub2*) showing the phylogenetic relationships of species within the *Fusarium fujikuroi* species complex (FFSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. nirenbergiae* (CBS 744.97). New species are indicated in **bold**, ex-type cultures with 'T', epi-type with 'ET', neotype with 'NT'.

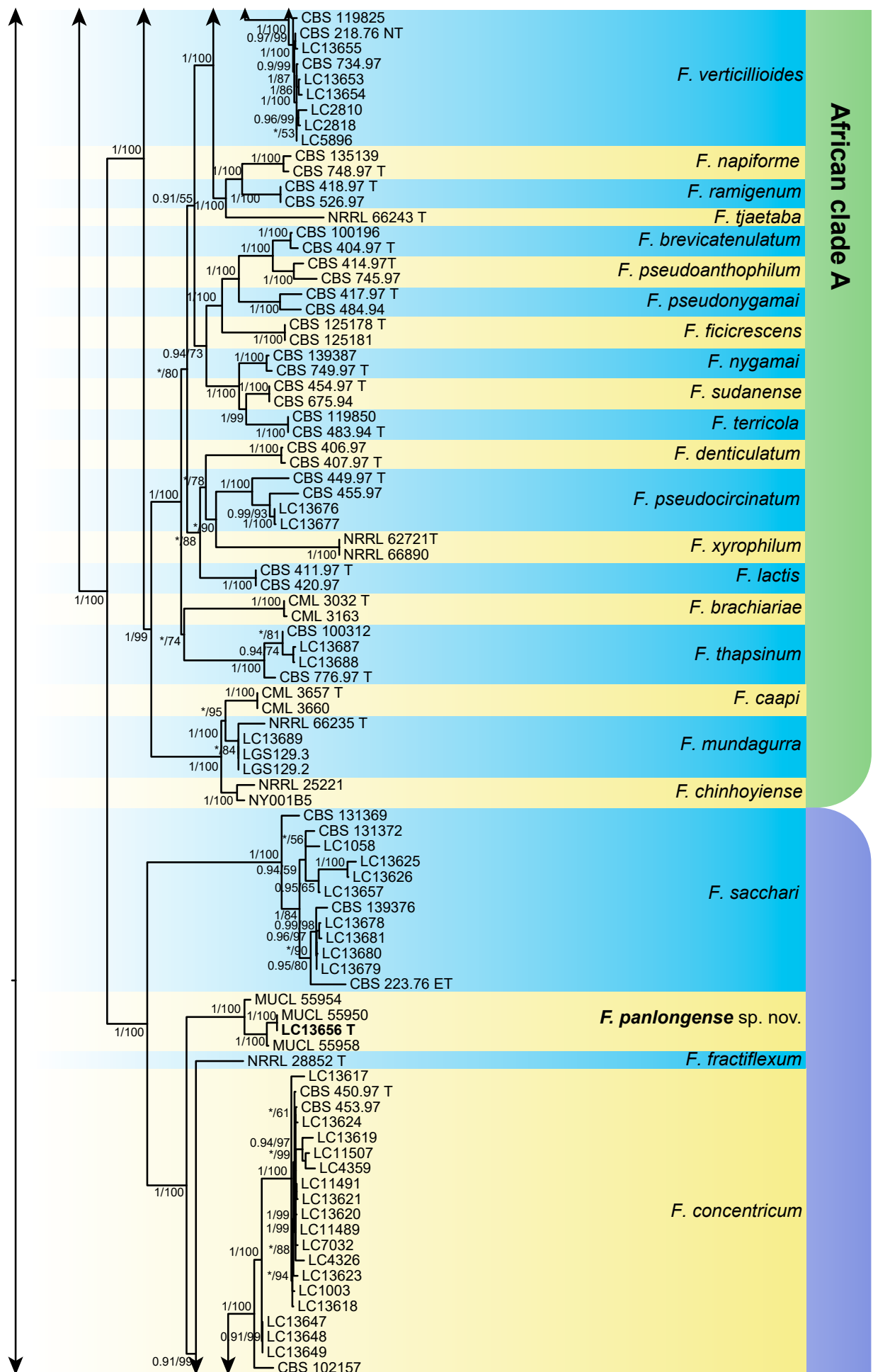


Fig. 3 (cont.)

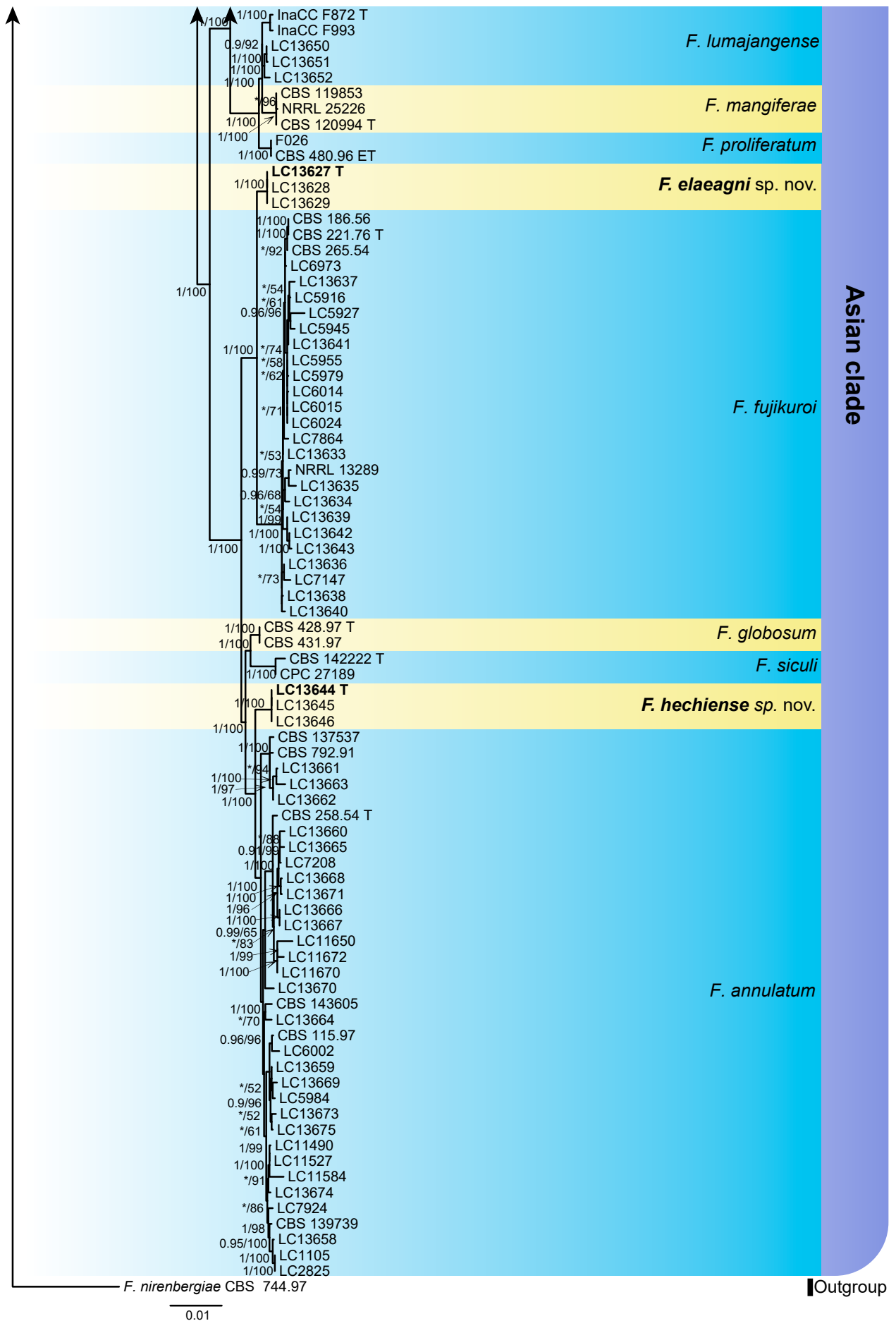


Fig. 3 (cont.)

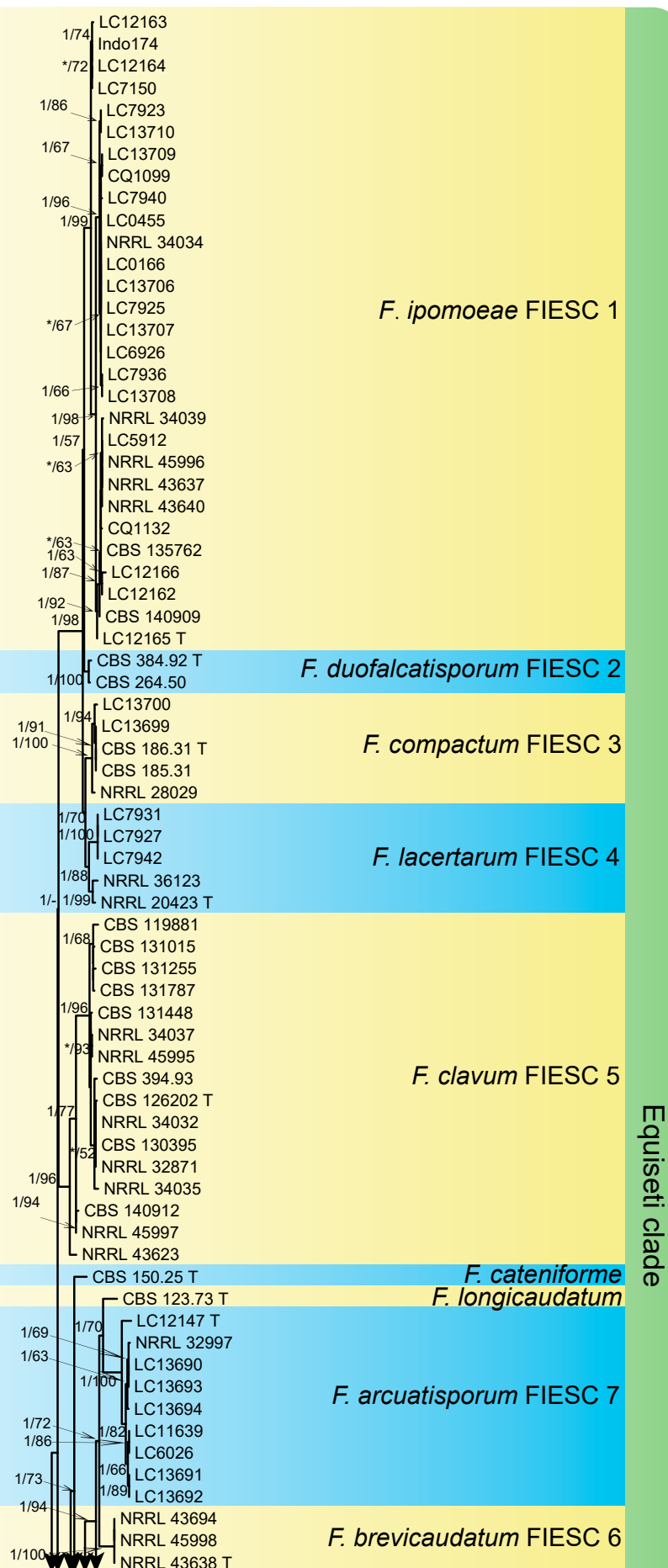


Fig. 4 Fifty percent majority rule consensus tree from a Bayesian analysis based on a three-locus combined dataset (*tef1*, *cam*, and *rpb2*) showing the phylogenetic relationships of species within the *Fusarium incarnatum-equiseti* species complex (FIESC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. concolor* (NRRL 13994 T). Ex-type cultures are indicated with 'T', neotype with 'NT'.

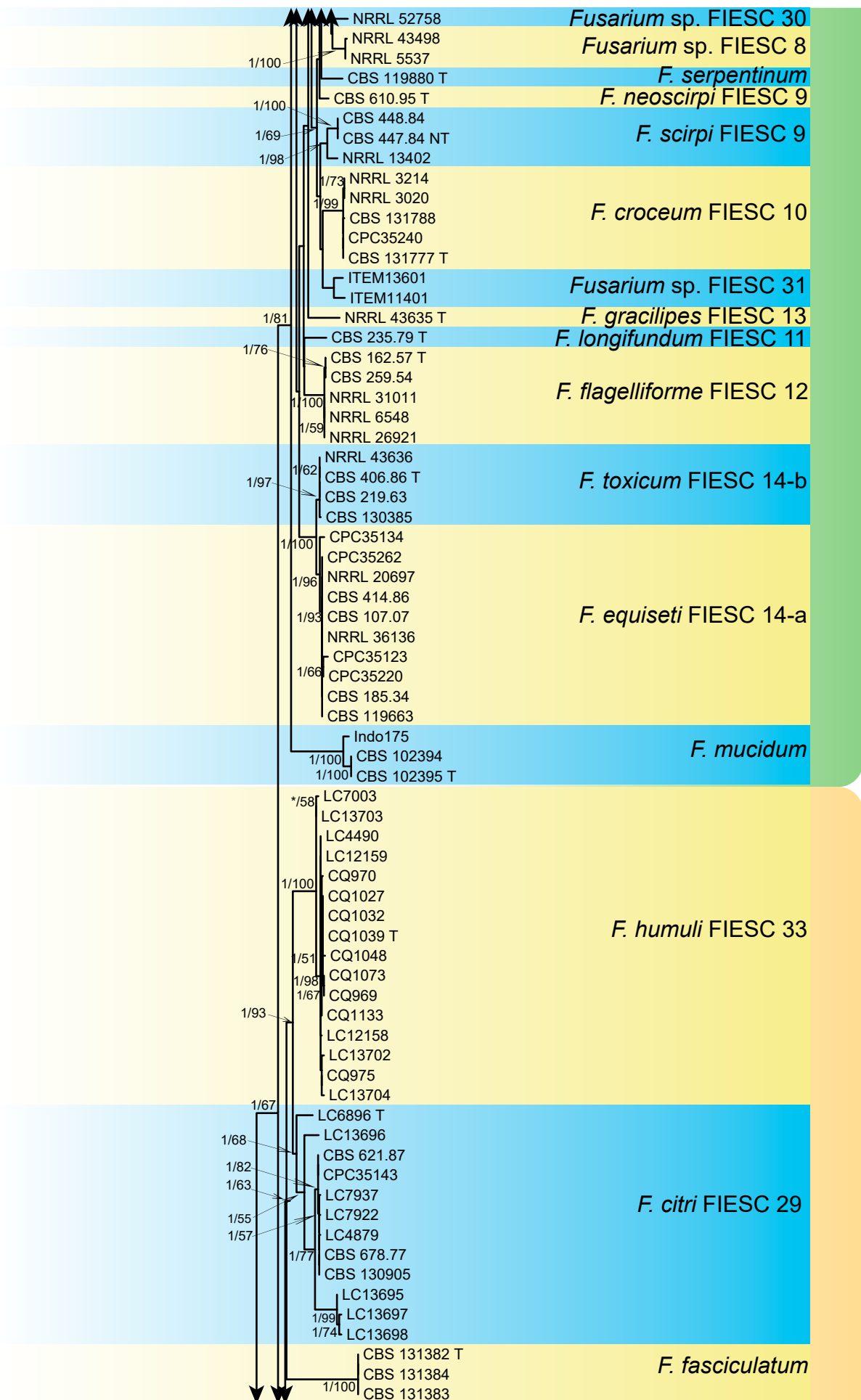


Fig. 4 (cont.)

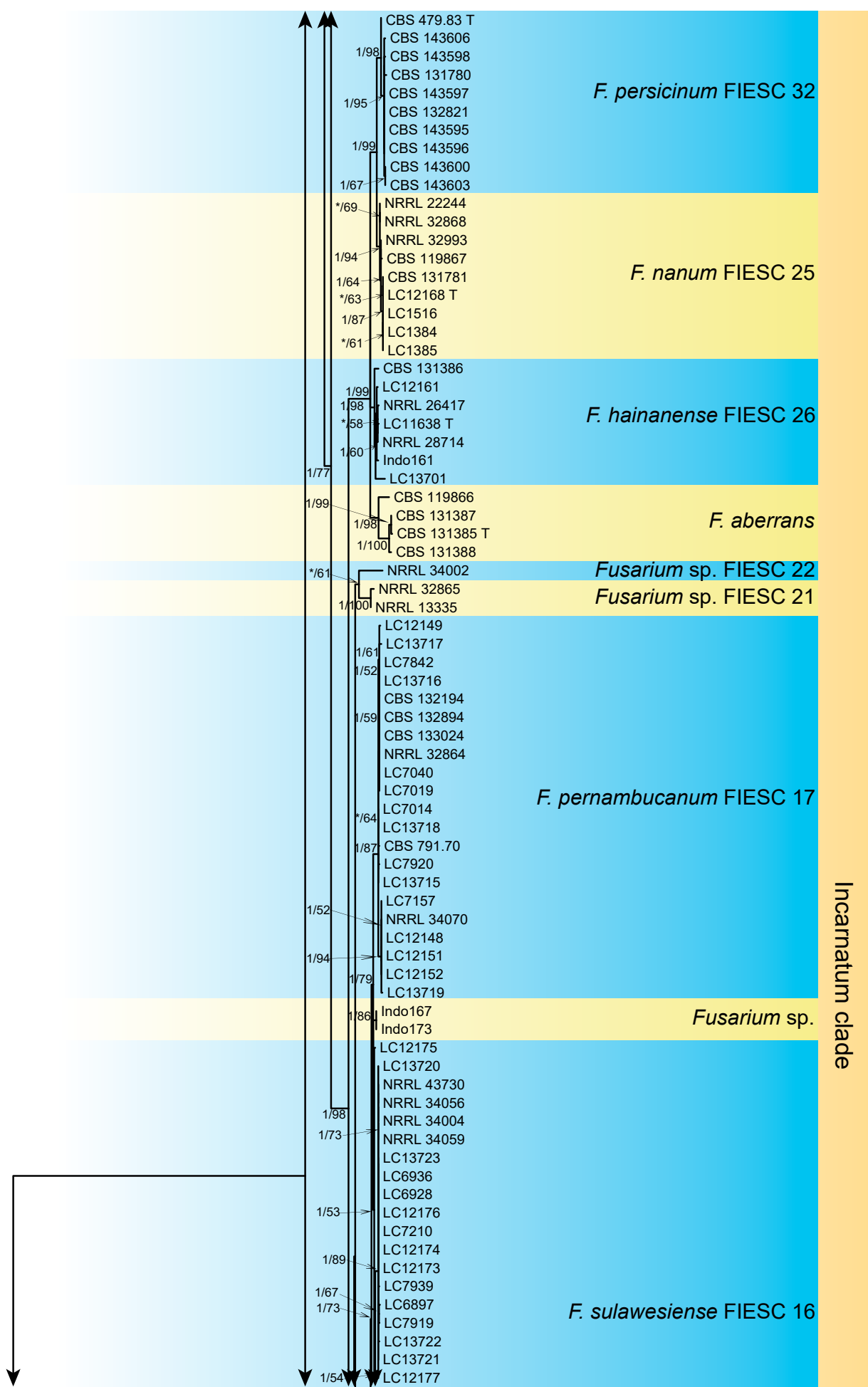


Fig. 4 (cont.)

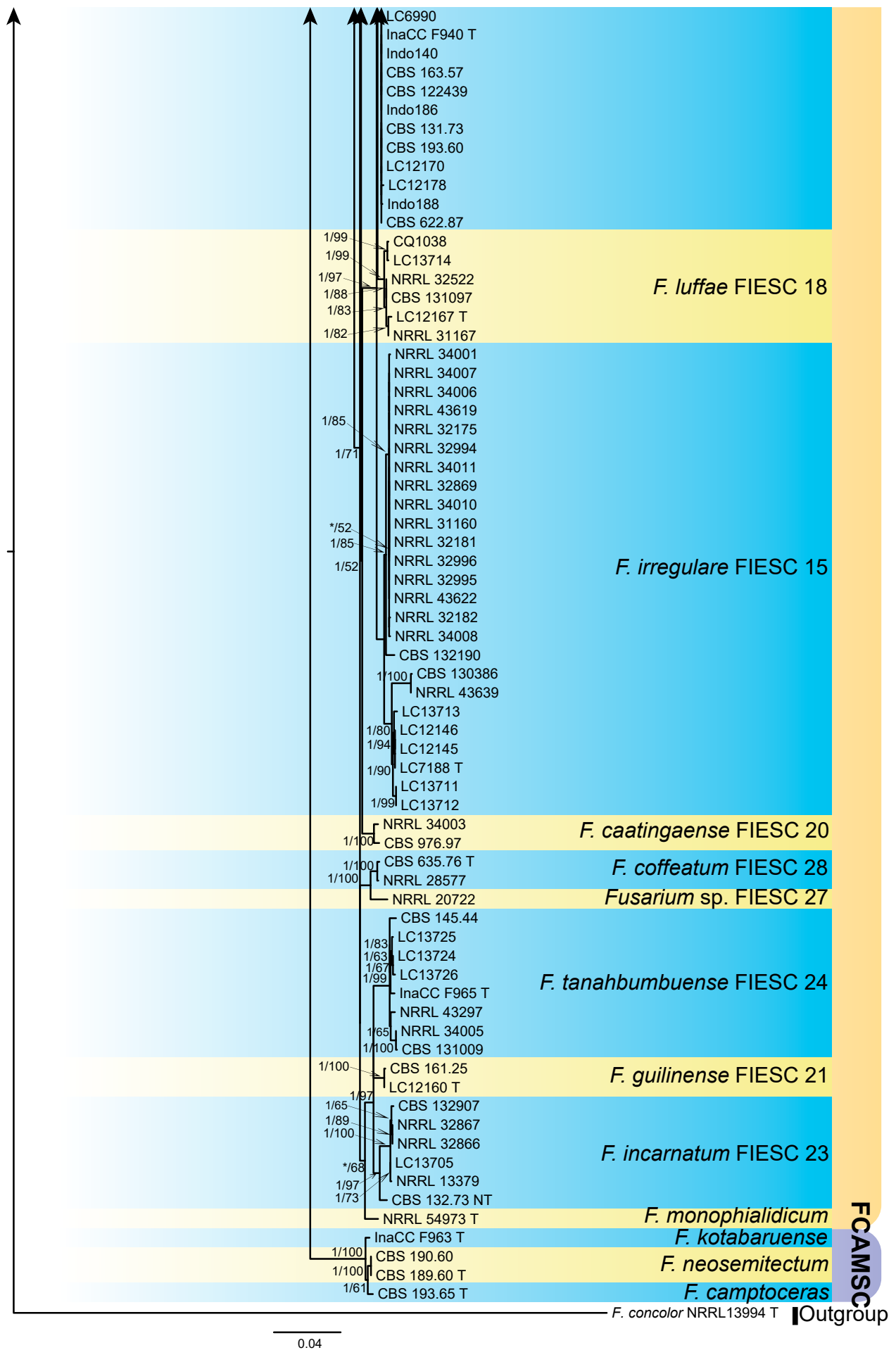


Fig. 4 (cont.)

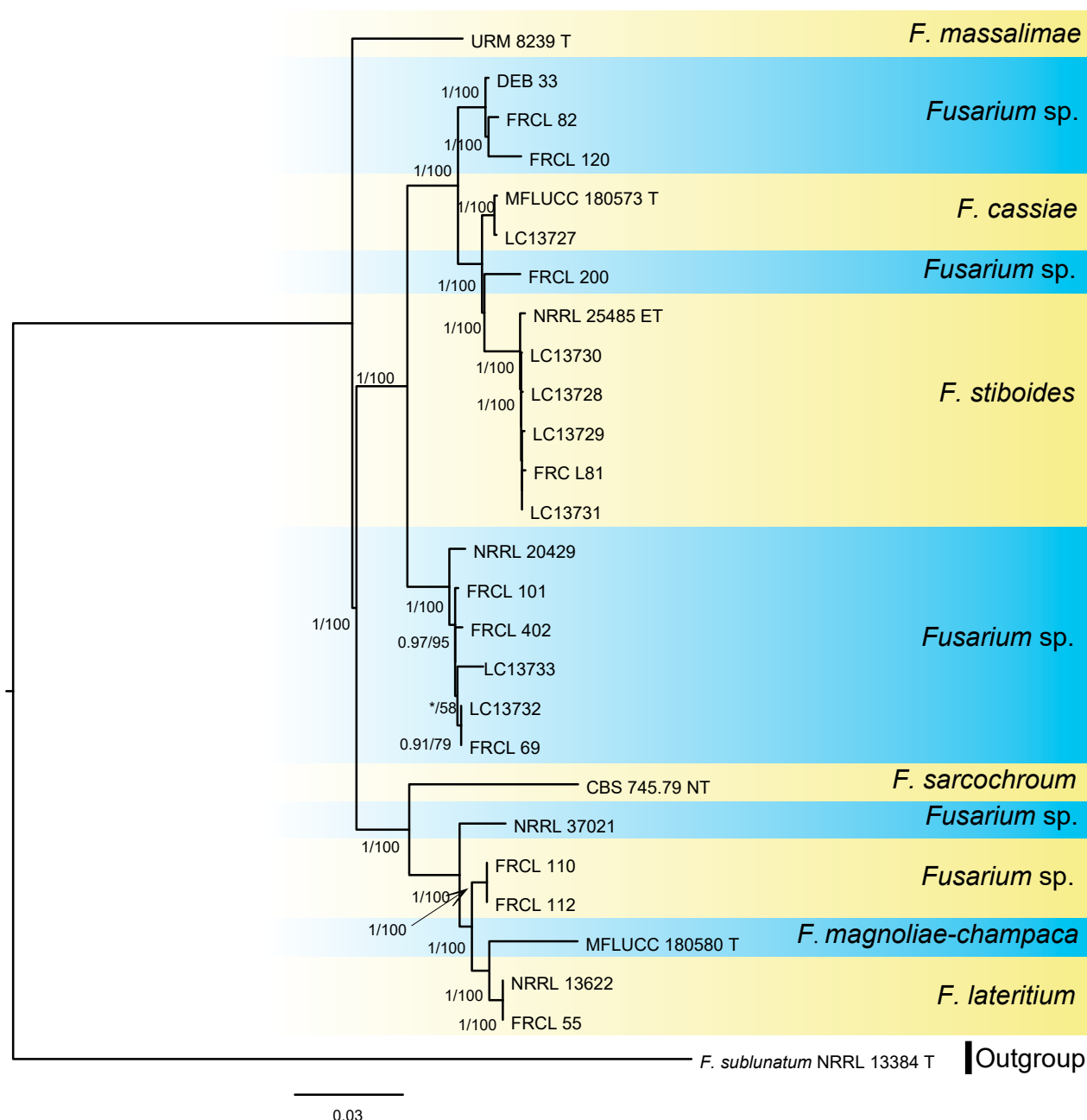


Fig. 5 Fifty percent majority rule consensus tree from a Bayesian analysis based on a four-locus combined dataset (*tef1*, *rpb1*, *rpb2*, and *tub2*) showing the phylogenetic relationships of species within the *Fusarium lateritium* species complex (FLSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. sublunatum* (NRRL 13384 T). Ex-type culture are indicated with 'T', epitype with 'ET', and neotype with 'NT'.

FUSARIUM

Fusarium concolor species complex

Fusarium bambusarum M.M. Wang & L. Cai, *sp. nov.* — Myco-Bank MB 842152; Fig. 11

Etymology. Named after the host of the type specimen, bamboo.

Typus. CHINA, Jiangxi Province, from bamboo, July 2016, J.E. Huang (HMAS 351575, holotype designated here, dried culture on SNA with carnation leaves, culture ex-type CGMCC 3.20820 = LC7180).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin erose to entire, surface and reverse white. Colonies on OA grown in the dark reaching 5.9–6.1 cm diam after 7 d at 25 °C, raise, aerial mycelia dense, colony margin entire, surface and reverse white. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant,

colony margin erose, surface and reverse white. Pigment and odour absent. *Sporodochia* orange grey (5B2), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, consisting of a short, smooth- and thin-walled stipe, 4–7 × 3–5 µm, bearing an apical pair or whorls of 3 monophialides; *sporodochial phialides* subulate to subcylindrical, 12–15 × 3–5 µm, smooth- and thin-walled, sometimes showing a reduced and flared collarete. *Sporodochial macroconidia* falcate, slender, slightly curved with almost parallel sides tapering slightly towards both ends, with a papillate to hooked, curved apical cell and a foot-like basal cell, 3–6-septate, hyaline, smooth- and thin-walled; 3-septate conidia: (39.4–)41.2–50(–51.3) × 3.4–5.6 µm (av. ± sd. 45.7 ± 2.4 × 4.3 ± 0.6 µm); 4-septate conidia: (50.3–)51–59.6(–59.7) × 3.1–5.9 µm (av. ± sd. 56 ± 2.7 × 4.4 ± 0.8 µm); 5–6-septate conidia: (62.9–)63.3–85.2(–85.7) × 3.6–6.2 µm (av. ± sd. 73.2 ± 5.5 × 4.9 ± 0.7 µm). *Conidiophores* borne on aerial mycelia

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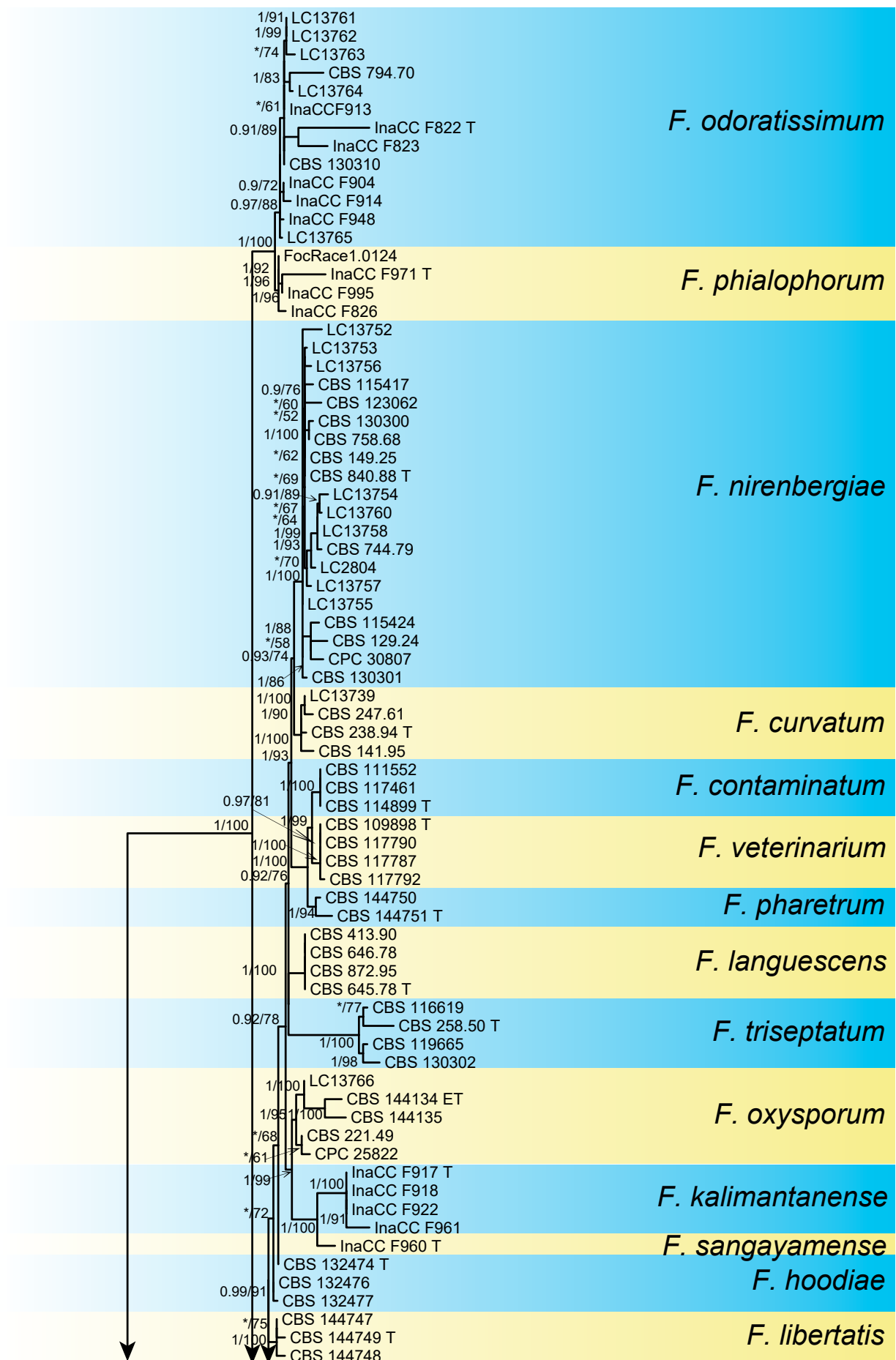


Fig. 6 Fifty percent majority rule consensus tree from a Bayesian analysis based on a five-locus combined dataset (*tef1*, *cam*, *rpb1*, *rpb2*, and *tub2*) showing the phylogenetic relationships of species within the *Fusarium oxysporum* species complex (FOSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. globosum* (NRRL 26131). Ex-type cultures are indicated with 'T', epitype with 'ET'.

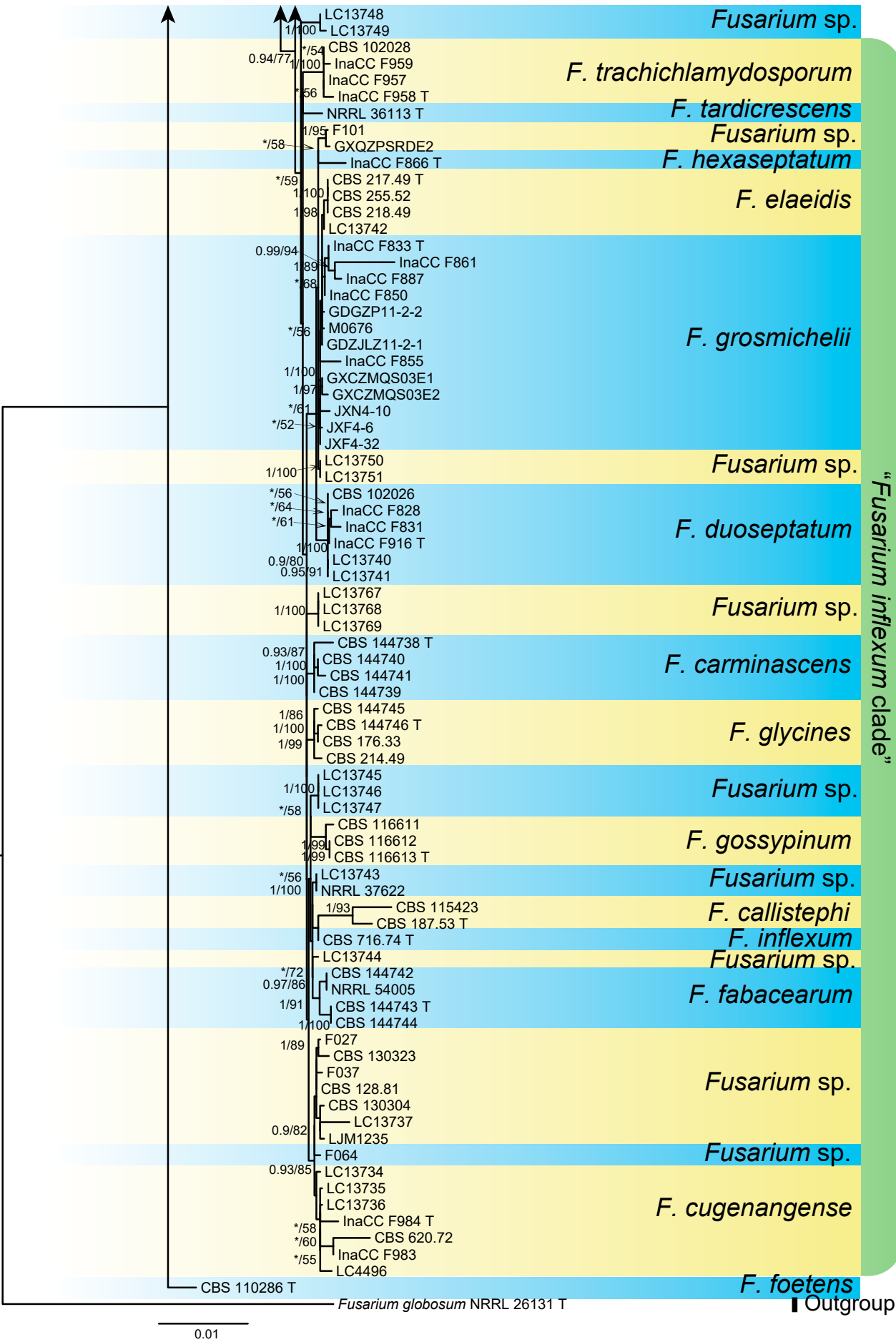


Fig. 6 (cont.)

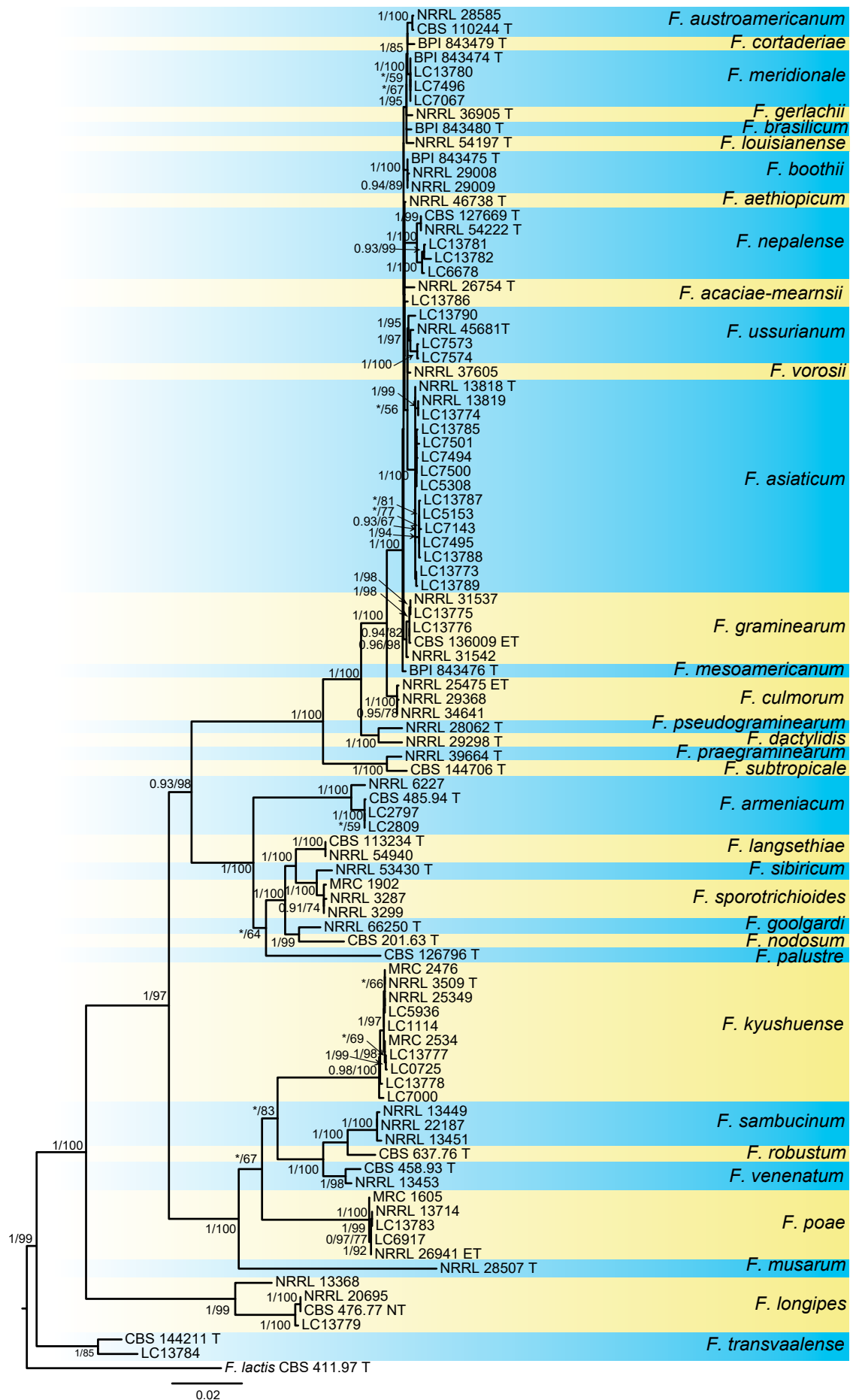


Fig. 7 Fifty percent majority rule consensus tree from a Bayesian analysis based on a three-locus combined dataset (*tef1*, *rpb1*, and *rpb2*) showing the phylogenetic relationships of species within the *Fusarium sambucinum* species complex (FSAMSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. lactis* (CBS 411.97 T). Ex-type cultures are indicated with 'T', epitype with 'ET'.

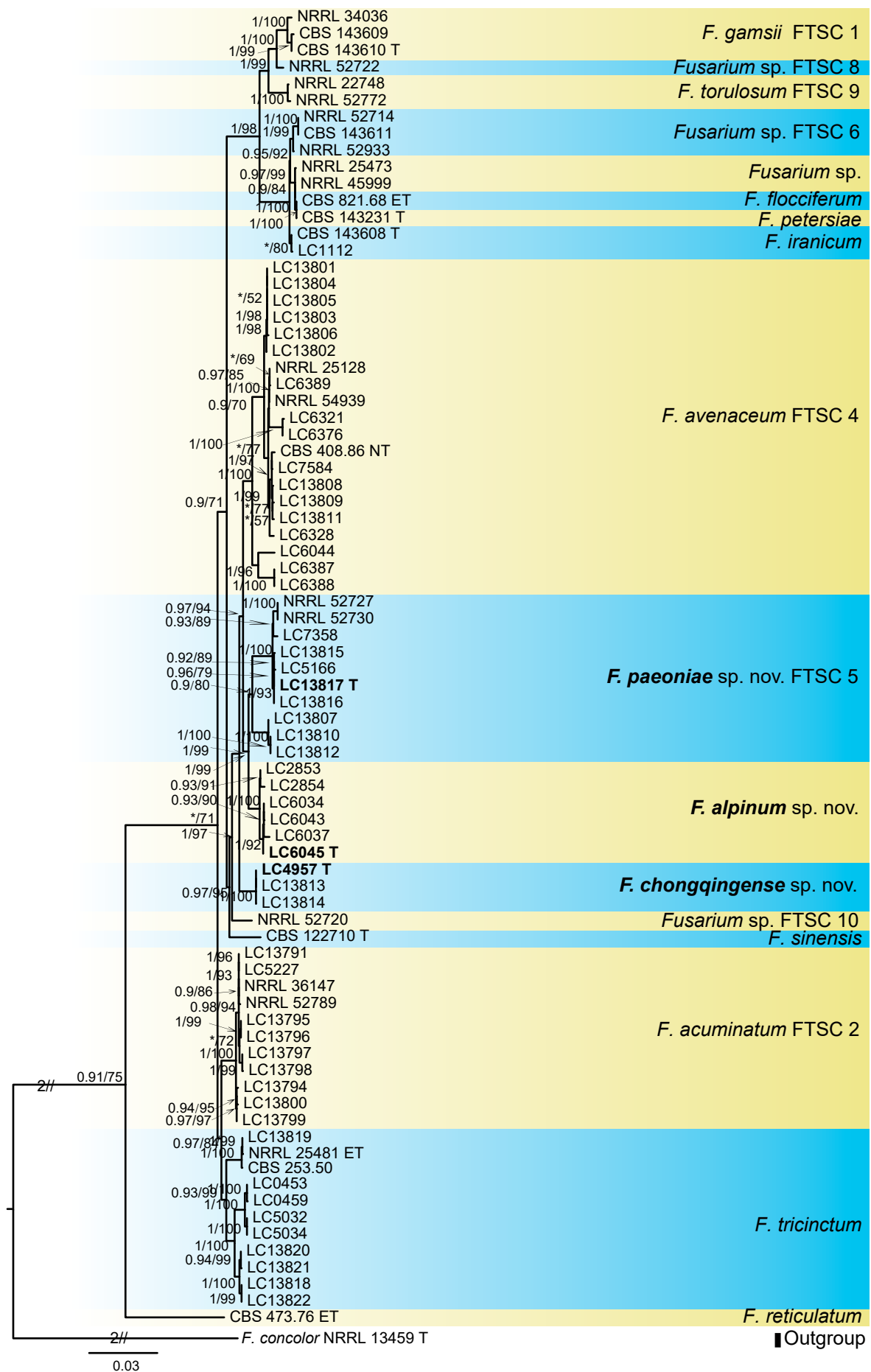


Fig. 8 Fifty percent majority rule consensus tree from a Bayesian analysis based on a four-locus combined dataset (ITS, *tef1*, *rpb1*, and *rpb2*) showing the phylogenetic relationships of species within the *Fusarium tricinctum* species complex (FTSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. concolor* (NRRL 13994 T). New species are indicated in **bold**, ex-type cultures are indicated with 'T', epitype with 'ET', neotype with 'NT'.

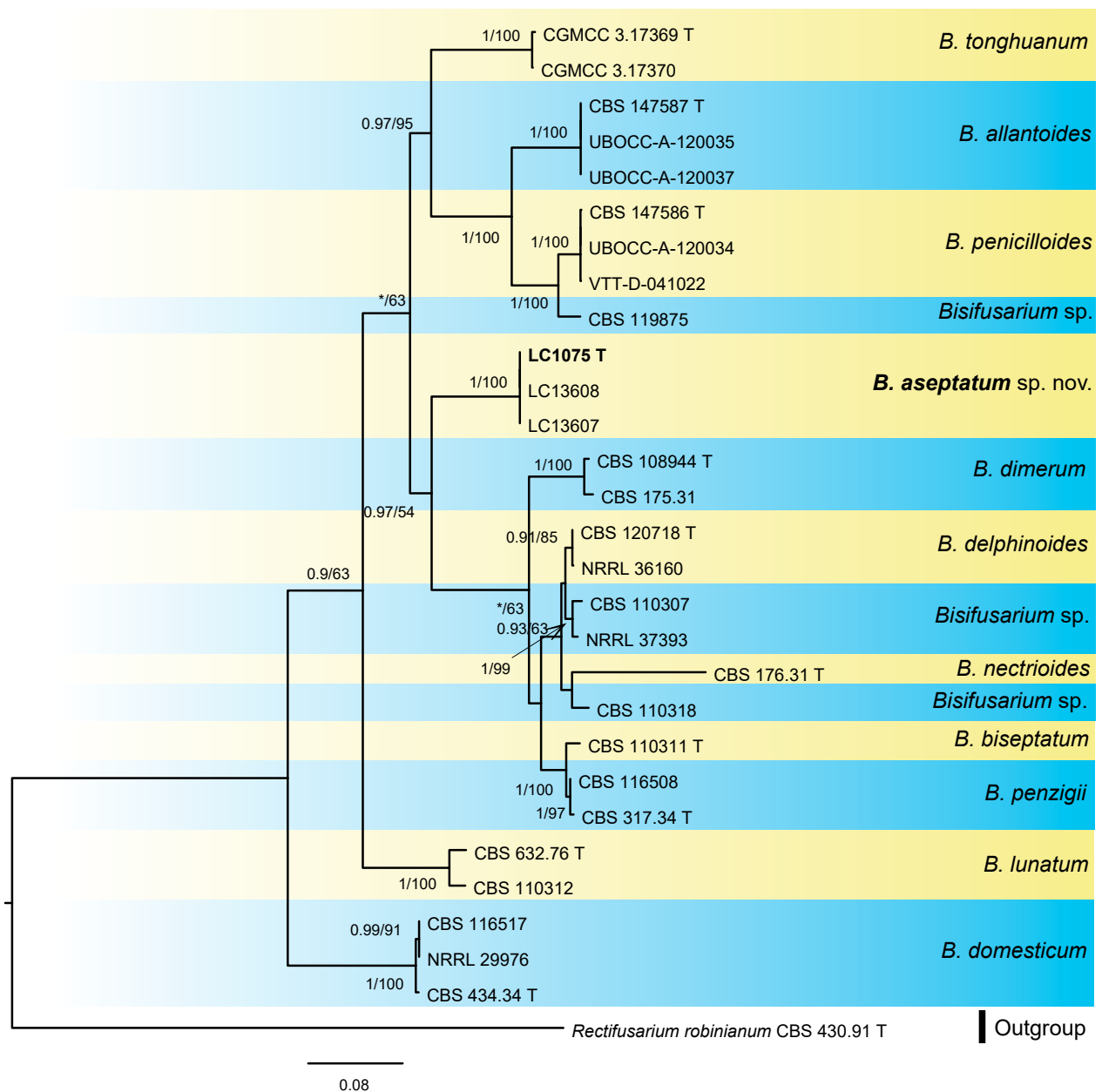


Fig. 9 Fifty percent majority rule consensus tree from a Bayesian analysis based on a five-locus combined dataset (ITS, *tef1*, *cam*, *rpb2*, and *tub2*) showing the phylogenetic relationships of species within the *Bisifusarium*. The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Rectifusarium robinianum* (CBS 430.91 T). New species are indicated in **bold**, ex-type cultures with 'T'.

30–110 µm tall, unbranched or sparingly branched, bearing terminal or intercalary monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 23–30 × 3–4 µm; *aerial microconidia* forming small false heads on the tips of the monophialides, hyaline, oval, smooth- and thin-walled, aseptate, (5–)5.5–11(–12) × 1.6–3.5 µm (av. ± sd. 7.9 ± 1.4 × 2.8 ± 0.4 µm). *Chlamydospores* terminal, almost globose, rough, thick-walled, hyaline, aseptate, 6.3–12.8 µm diam (av. ± sd. 10.4 ± 2.1).

Additional material examined. CHINA, Guangdong Province, Guangzhou city, from bamboo, July 2016, L. Cai, LC7187.

Notes — The two isolates were resolved as a strongly supported genealogically exclusive lineage in the combined *tef1*, *rpb1*, and *rpb2* phylogeny (Fig. 2). Phylogenetically, *F. bambusarum* is closely related to *F. austroafricanum* and *F. concolor*, but differs by 152 bp and 136 bp in the three loci dataset, respectively. Morphologically, this species is distinguished based on the number of septa in sporodochial macroconidia (3–6-septate

in *F. bambusarum* vs 0–11-septate in *F. austroafricanum*) and in the type of aerial phialides (monophialides in *F. bambusarum* vs polyphialides in *F. concolor*) (Marasas et al. 1986).

Fusarium falsibabinda species complex

Fusarium falsibabinda M.M. Wang & L. Cai, sp. nov. — MycoBank MB 842153; Fig. 12

Etymology. Named after species of this newly introduced clade, *F. babinda*.

Typus. JAPAN, intercepted and isolated at Ningbo Customs, from *Podocarpus macrophyllus* imported to China, Oct. 2012, W.J. Duan (HMAS 351576, holotype designated here, dried culture on SNA with carnation leaves, culture ex-type CGMCC 3.20823 = LC13610 = F015).

Colonies on PDA grown in the dark reaching 3.7–4.2 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin erose, surface white; reverse pale yellow in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.9–

text continues on p. 33

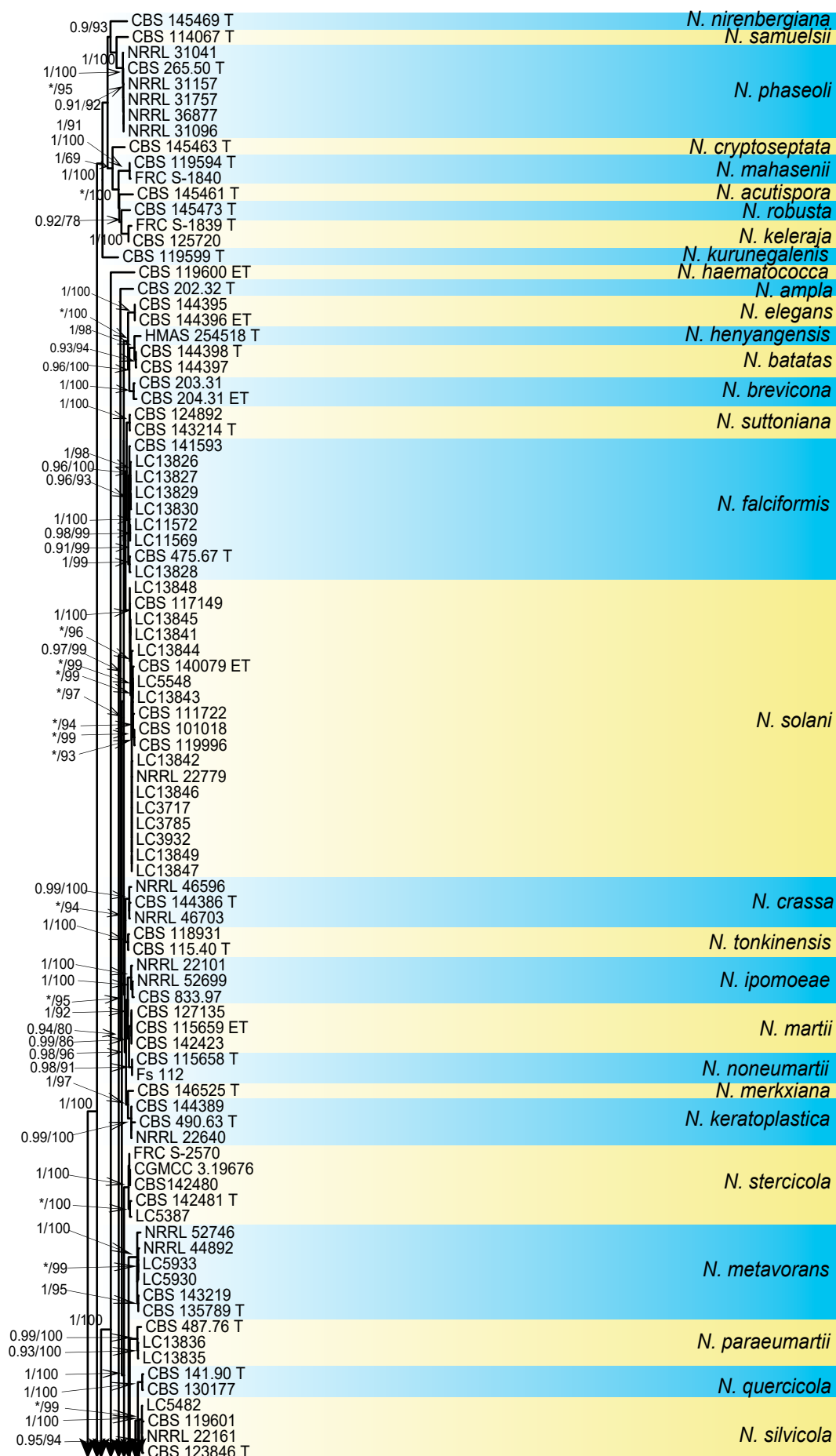


Fig. 10 Fifty percent majority rule consensus tree from a Bayesian analysis based on a three-locus combined dataset (ITS, *tef1*, and *rpb2*) showing the phylogenetic relationships of species within the genus *Neocosmospora*. The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Geejayessia cicatricum* (CBS 125552) and *G. atrofusca* (NRRL 22316). Ex-type cultures are indicated with 'T', epitype with 'ET'.

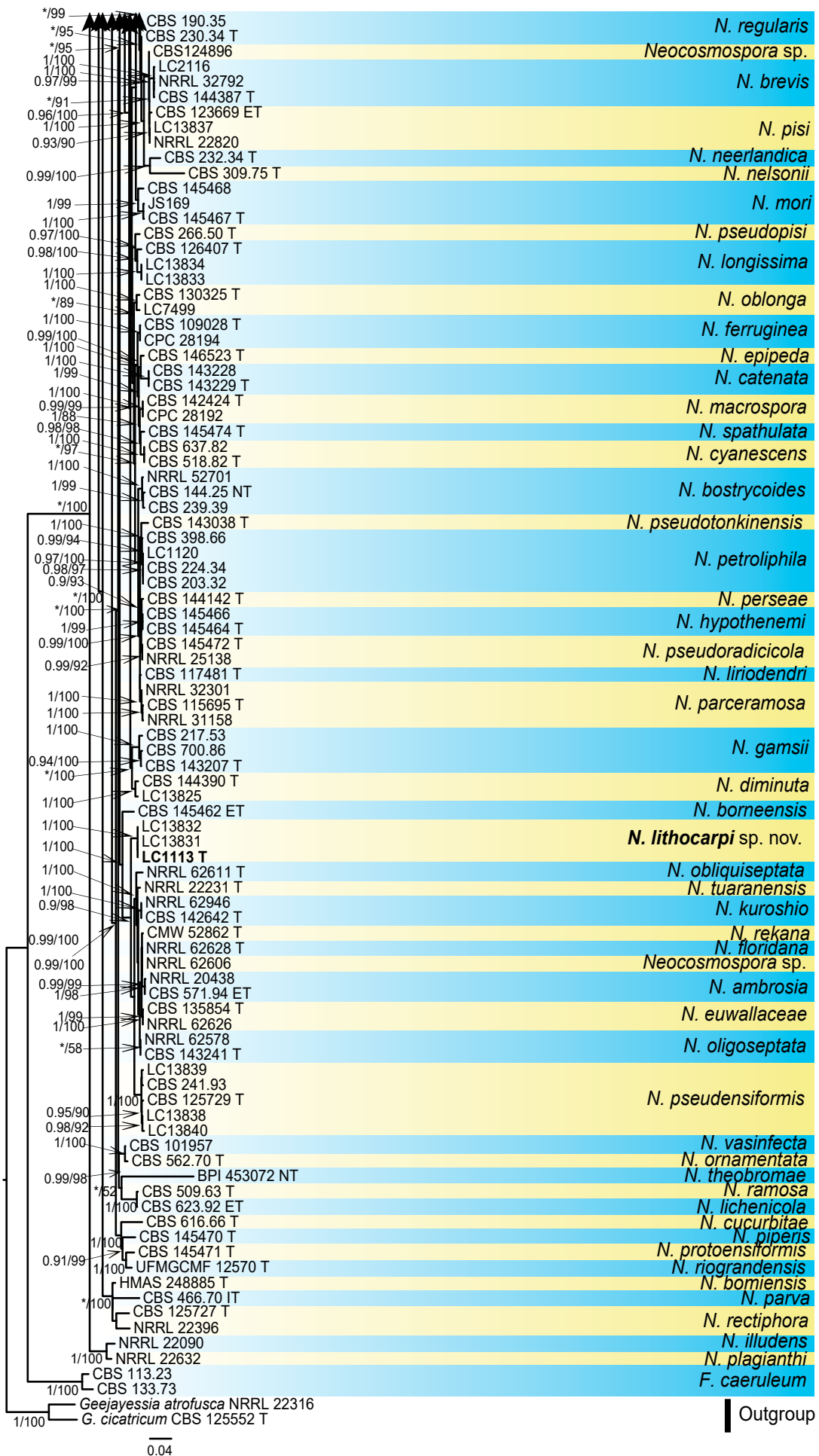


Fig. 10 (cont.)

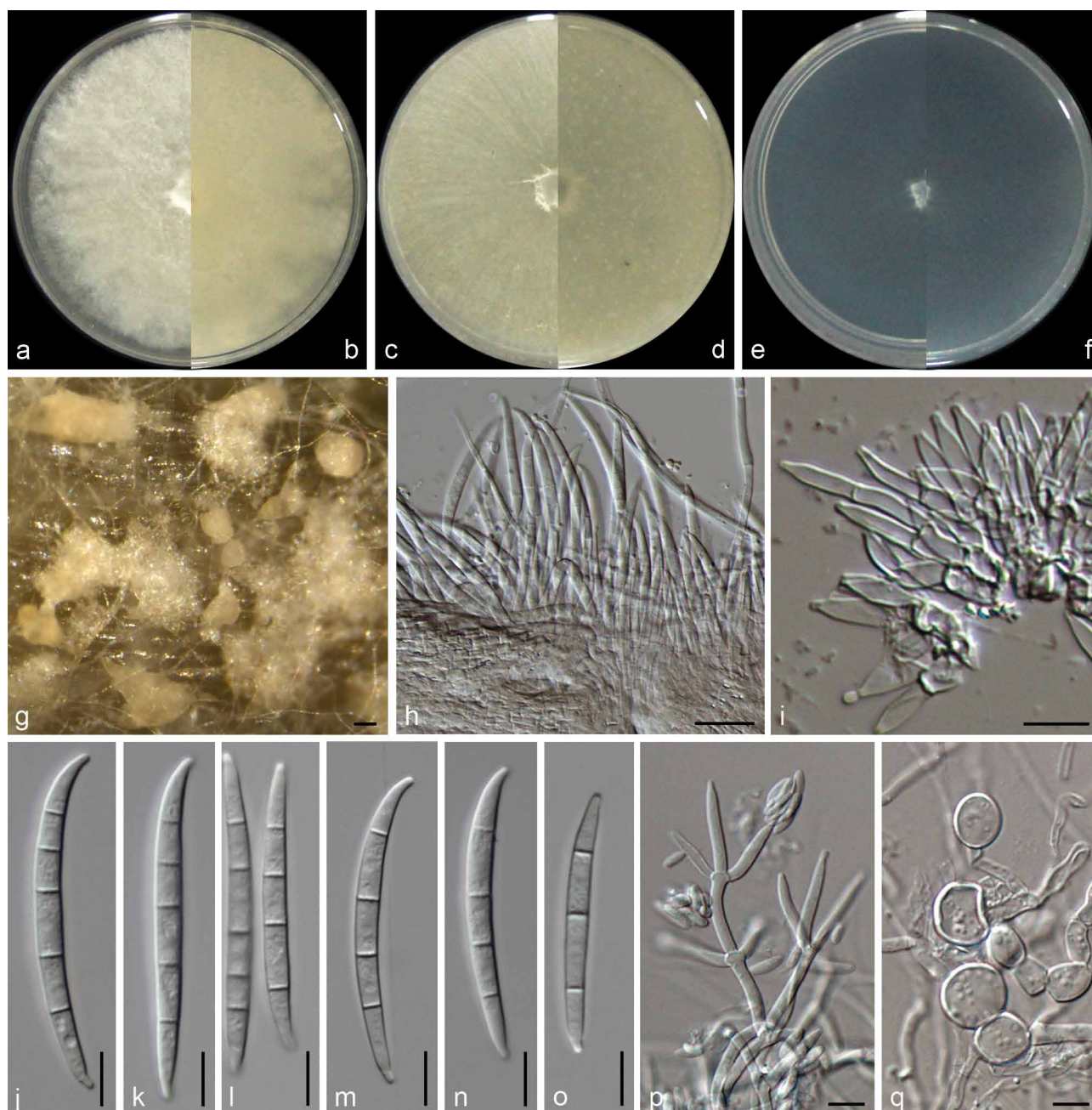


Fig. 11 *Fusarium bambusarum* (ex-type culture LC7180). a, b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA; e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochia on carnation leaves; h–i. conidiophores and phialides on sporodochia; j–o. sporodochial conidia (macroconidia); p. conidiophores and phialides on aerial mycelium; q. chlamydospores. — Scale bars: g = 50 µm; h = 20 µm; i–q = 10 µm.

6.1 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface and reverse white. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, surface and reverse white. Pigment and odour absent. *Sporodochia* golden yellow (5B7), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, consisting of a smooth- and thin-walled stipe, 14–17 × 5–6 µm, bearing apical pairs or whorls of 3 monophialides; *sporodochial phialides* subulate to subcylindrical, 15–21 × 3–5 µm, smooth- and thin-walled, sometimes showing a reduced and flared collarette. *Sporodochial macroconidia* falcate, slender, slightly curved with almost parallel sides tapering slightly towards both ends, with a papillate to hooked apical cell and a barely notched to distinctly notched basal cell, 3–5-septate, hyaline, smooth- and thin-walled; 3-septate conidia: (39.4–) 41.2–47(–49.3) × 3.4–4.5 µm (av. ± sd. 44.6 ± 2.4 × 3.9 ± 0.6 µm);

4-septate conidia: (42.3–) 44–49.6(–51.7) × 3.6–4.5 µm (av. ± sd. 47 ± 1.7 × 4.1 ± 0.4 µm); 5-septate conidia: (50.9–) 51.3–53.2(–53.5) × 3.7–4.5 µm (av. ± sd. 52.2 ± 0.8 × 4.2 ± 0.3 µm). *Conidiophores* borne on aerial mycelia 30–50 µm tall, unbranched, polyphialides or monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 30–40 × 3–5 µm; *aerial microconidia* forming small false heads on tips of mono- and polyphialides, hyaline, oval or obovoid with a truncate base, smooth- and thin-walled, aseptate, (6–) 6.5–11(–12) × 2.6–3.5 µm (av. ± sd. 7.9 ± 1.4 × 3.1 ± 0.4 µm). *Chlamydospores* intercalary, almost globose, slight rough, thick-walled, hyaline, aseptate, 4.3–5.1 µm diam (av. ± sd. 4.7 ± 0.3).

Additional material examined. JAPAN, intercepted and isolated at Ningbo Customs, from *Camellia sasanqua* imported to China, Mar. 2014, W.J. Duan, LC13611 (= F058).

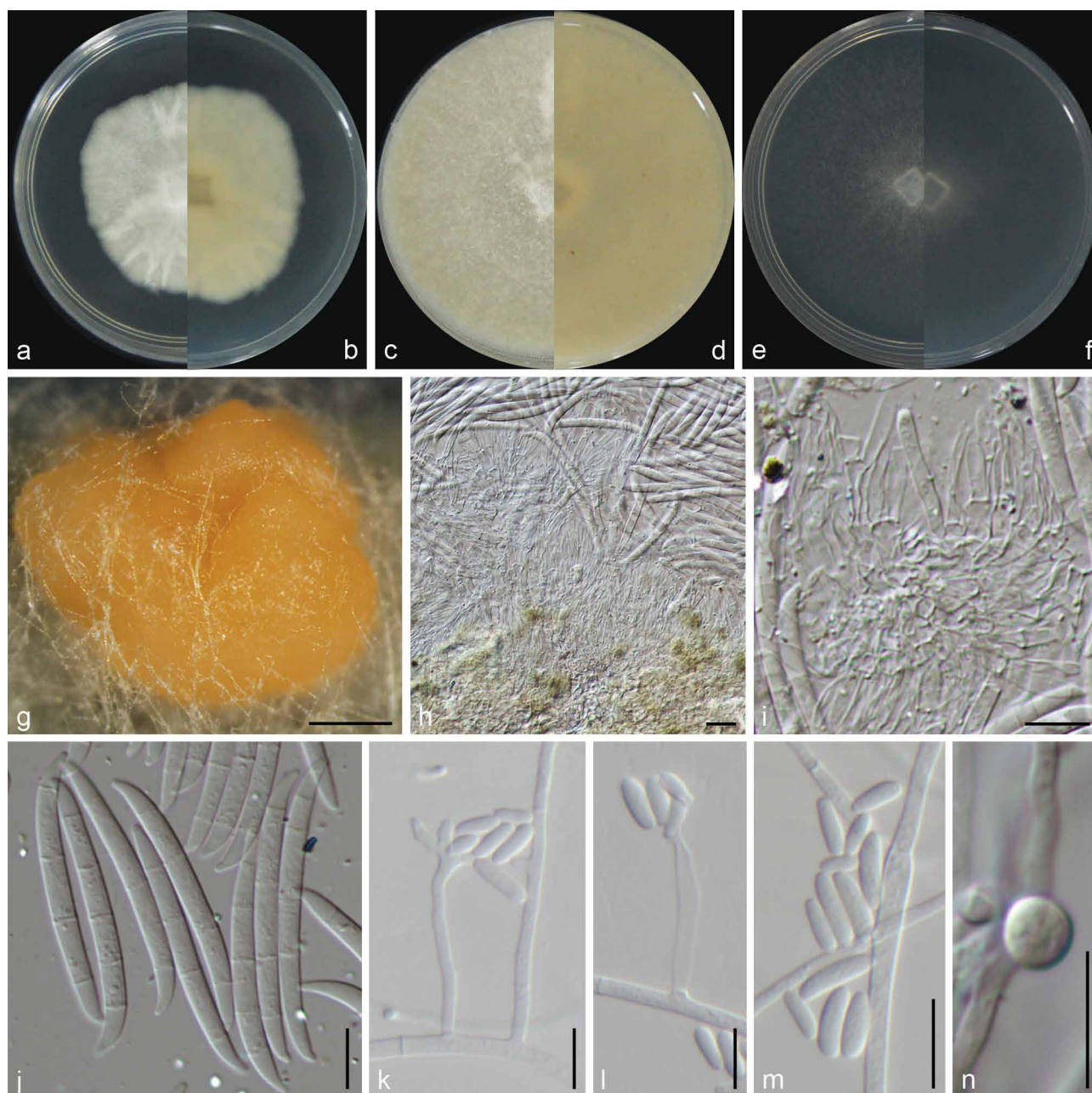


Fig. 12 *Fusarium falsibabinda* (ex-type culture LC13610). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochium on carnation leaves; h–i. conidiophores and phialides on sporodochia; j. sporodochial conidia (macroconidia); k–l. phialides on aerial mycelium; m. aerial conidia (microconidia); n. chlamydospores. — Scale bars: g = 50 µm; h = 20 µm; i–n = 10 µm.

Notes — Several strains isolated from soil in China (NRRL 25539, NRRL 53467, and NRRL 53470), and *Camellia sasanqua* and *Podocarpus macrophyllus* from Japan (LC13610 and LC13611), clustered as a distinct clade near the *F. concolor* complex (Fig. 2). This clade was recognised as *F. babinda* by Jacobs-Venter et al. (2018) and Sandoval-Denis et al. (2018a), with NRRL 25539 (= CBS 396.96) as the representative isolate. However, based on the ex-type isolate of *F. babinda* (BBA 69872 = F11217 = NRRL 25807) designated in Summerell et al. (1995), Crous et al. (2021) confirmed that *F. babinda* clustered in the *F. fujikuroi* complex, distant from the clade encompassing NRRL 25539. In this paper, we introduce a new species, *F. falsibabinda*, to represent this previously incorrectly named clade (Fig. 2). Based on morphology, *F. falsibabinda* is distinct from *F. babinda* in the sporodochia colour (golden yellow in *F. falsibabinda* vs pale orange in *F. babinda*), macroconidial size (39.4–53.5 × 3.4–4.5 µm in *F. falsibabinda* vs 32–72 ×

4–6 µm in *F. babinda*), type of conidiophores (polyphialides or monophialides in *F. falsibabinda* vs monophialides in *F. babinda*), and shape and septation of microconidia (oval or obovoid with a truncate base, aseptate in *F. falsibabinda* vs fusiform, 0–1-septate in *F. babinda*) (Summerell et al. 1995, Leslie & Summerell 2006). Phylogenetically, *F. falsibabinda* is closest to an undescribed *Fusarium* species (represented by NRRL 25533), with both taxa residing in the *F. falsibabinda* species complex (Fig. 2).

Fusarium fujikuroi species complex

Fusarium aquaticum M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842154; Fig. 13

Etymology. Refers to its habitat, water, from which the holotype was isolated.

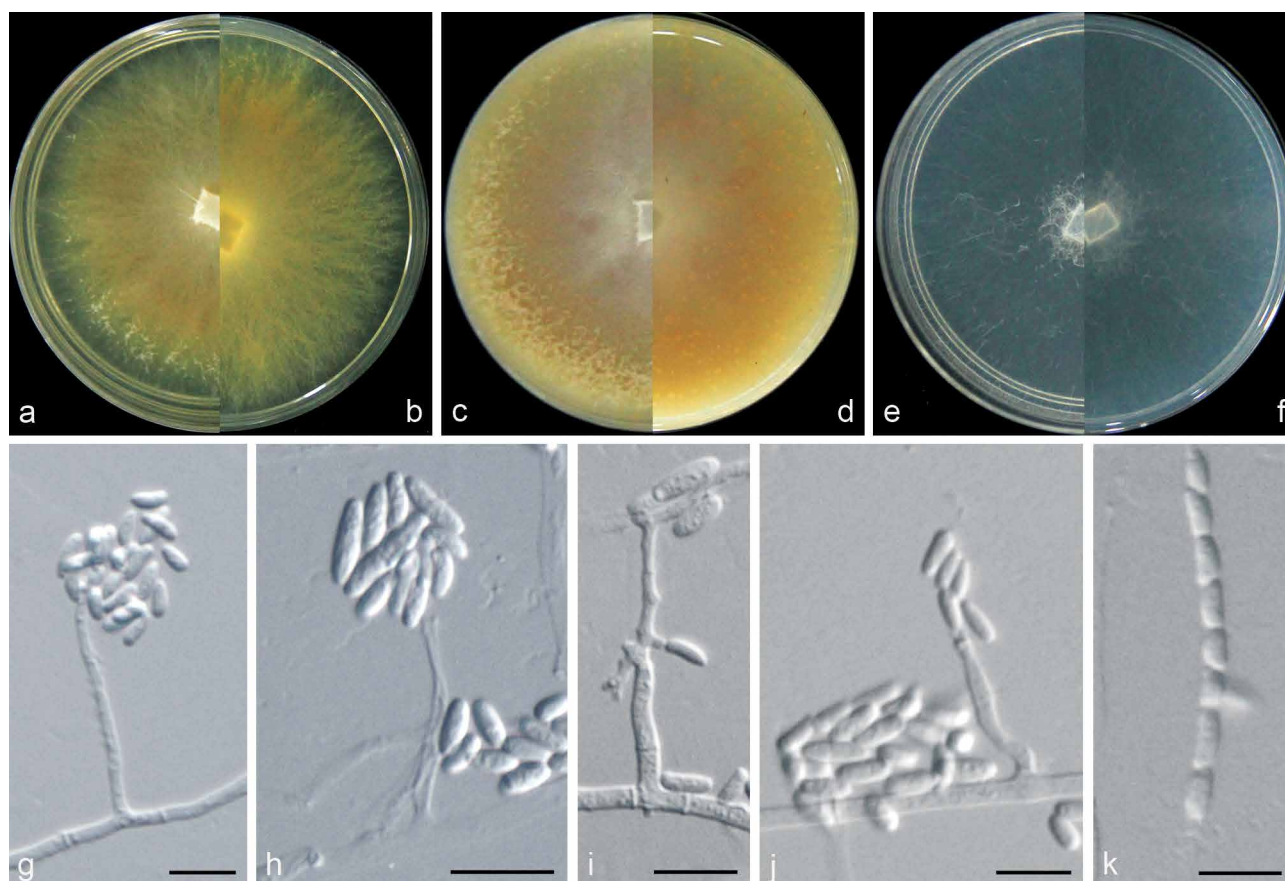


Fig. 13 *Fusarium aquaticum* (ex-type culture LC7502). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g–j. conidiophores and phialides on aerial mycelium; k. aerial conidia. — Scale bars: g–k = 10 μ m.

Typus. CHINA, Guizhou Province, Zunyi city, from water, May 2015, L. Cai, Z.F. Zhang, X. Zhou & J.R. Jiang (HMAS 351577, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20819 = LC7502).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin filamentous to erose, filiform, surface pastel yellow (2A4) in the centre, white at the margin; reverse pastel yellow (2A4). Colonies on OA grown in the dark reaching 5.8–6.2 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin entire, surface and reverse pastel yellow (3A4). Colonies on SNA grown in the dark reaching 5.4–5.7 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* not observed. *Conidiophores* borne on aerial mycelia 30–50 μ m tall, unbranched or rarely branched, bearing terminal or intercalary mono- or polyphialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 2–23 $\times$ 2.5–3 μ m, periclinal thickening inconspicuous or absent; *aerial microconidia* single, forming short chains or small false heads on tips of mono- and polyphialides, hyaline, ovoid, ellipsoid to reniform, smooth- and thin-walled, aseptate, (4–)4.1–11.9(–12.7) $\times$ 1.6–3.7 μ m (av. $\pm$ sd. 6.9 $\pm$ 2 $\times$ 2.6 $\pm$ 0.5 μ m). *Chlamydospores* not observed.

Additional material examined. CHINA, Guizhou Province, Zunyi city, from water, May 2015, L. Cai, Z.F. Zhang, X. Zhou & J.R. Jiang, LC13615; *ibid.*, LC13616.

Notes — *Fusarium aquaticum* is phylogenetically closely related to *F. udum* (Fig. 3), but differs by 68 bp in the five loci dataset. Morphologically, *F. aquaticum* is distinct from *F. udum* in the type of aerial phialides (polyphialides or monophialides in

F. aquaticum vs monophialides in *F. udum*), shape and septation of aerial microconidia (ovoid, ellipsoid to reniform, aseptate in *F. aquaticum* vs fusoid to reniform or ovoid 0–1-septate in *F. udum*) (Leslie & Summerell 2006).

Fusarium elaeagni M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842155; Fig. 14

Etymology. Named after the host genus of the type specimen, *Elaeagnus*.

Typus. CHINA, Jiangsu Province, Suzhou city, from *Elaeagnus pungens*, Nov. 2017, Q. Chen (HMAS 351578, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20822 = LC13627 = CQ1053).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin erose, surface and reverse white. Colonies on OA grown in the dark, reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface and reverse white. Colonies on SNA grown in the dark reaching 5.5–5.8 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, surface and reverse white. Pigment and odour absent. *Sporodochia* greyish orange (2C3), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed; *sporodochial phialides* subulate to subcylindrical, 13–17 $\times$ 3–4 μ m, smooth- and thin-walled. *Sporodochial macroconidia* slender, falcate, slightly curved with almost parallel sides tapering slightly towards both ends, with a papillate to hooked, curved apical cell and a blunt to foot-like basal cell, 3–4-septate, hyaline, smooth- and thin-walled, (21–)23.5–35.8(–37) $\times$ 2.5–3.7 μ m (av. $\pm$ sd. 30.7 $\pm$ 4.1 $\times$ 3.1 $\pm$ 0.9 μ m). *Conidiophores* borne on aerial mycelia 20–40 μ m tall,

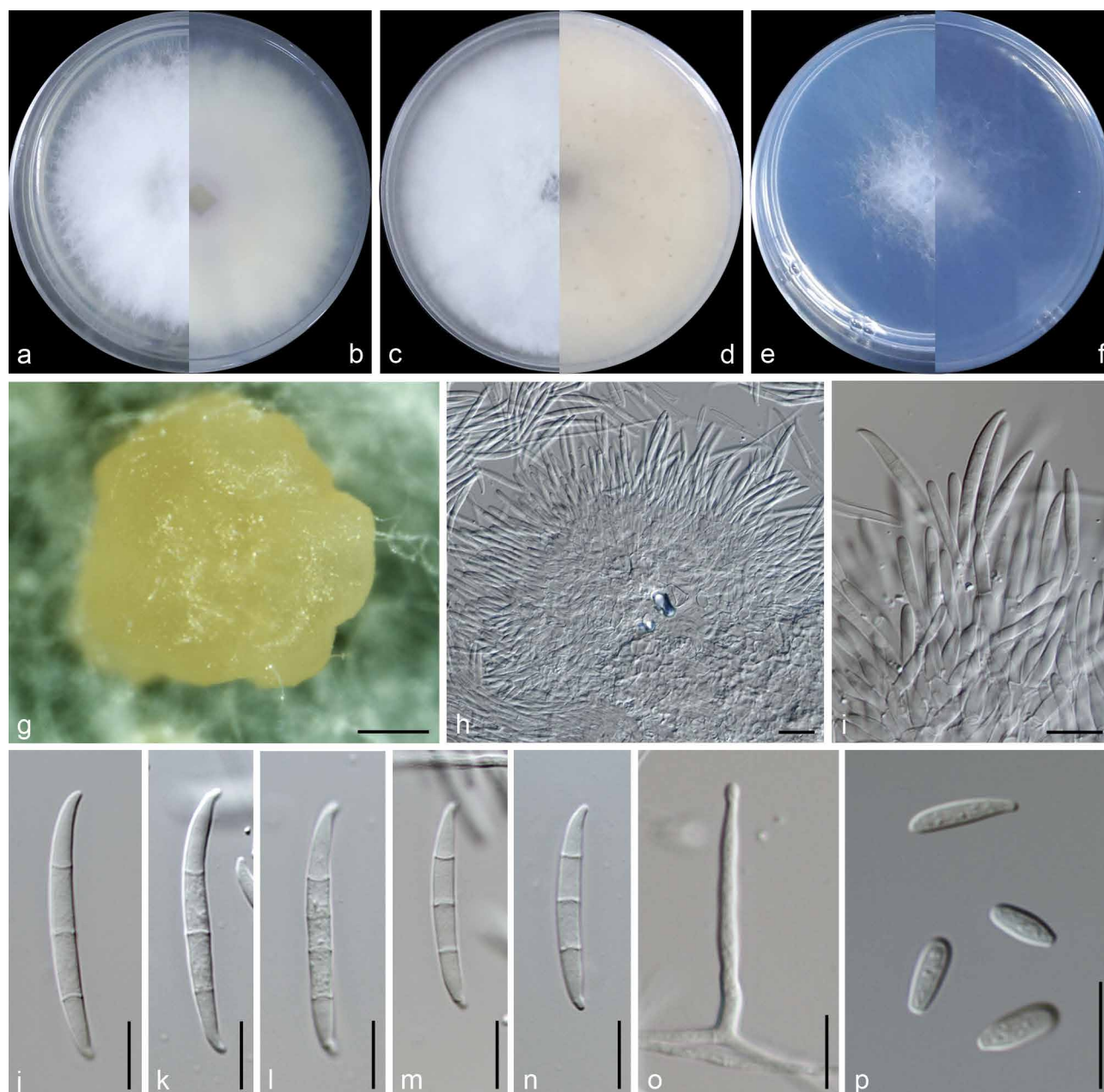


Fig. 14 *Fusarium elaeagni* (ex-type culture LC13627). a–b. Colony on PDA; a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochium on carnation leaves; h–i. conidiophores and phialides on sporodochia; j–n. sporodochial conidia (macroconidia); o. conidiophores and phialides on aerial mycelium; p. aerial conidia. — Scale bars: g = 50 µm; h = 20 µm; i–q = 10 µm.

often reduced to single mono- or polyphialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, $20\text{--}29 \times 2\text{--}3 \mu\text{m}$; *aerial microconidia* forming small false heads on tips of mono- and polyphialides, hyaline, ellipsoid to falcate, rarely club-shaped, smooth- and thin-walled, 0–1-septate; aseptate conidia: $(5\text{--})6\text{--}9\text{--}(11) \times 1.7\text{--}4.2 \mu\text{m}$ (av. $\pm$ sd. $6.9 \pm 1.1 \times 2.4 \pm 0.5 \mu\text{m}$); 1-septate conidia: $(8\text{--})9\text{--}17.5\text{--}(20) \times 2.1\text{--}4.2 \mu\text{m}$ (av. $\pm$ sd. $13.5 \pm 2.8 \times 2.8 \pm 0.5 \mu\text{m}$). *Chlamydospores* not observed.

Additional material examined. CHINA, Jiangsu Province, Suzhou city, from *Elaeagnus pungens*, Nov. 2017, Q. Chen, LC13628 (= CQ1053.2); *ibid.*, LC13629 (= CQ1053.3).

Notes — This species is phylogenetically closely related to *F. fujikuroi*, but differs by 112 bp in the five loci dataset (Fig. 3). Morphologically, *F. elaeagni* is distinguished in sporodochial colour (greyish orange in *F. elaeagni* vs orange in *F. fujikuroi*), macroconidial septa (3–4-septate in *F. elaeagni* vs 3–5-septate in *F. fujikuroi*), microconidial shape (ellipsoidal to falcate, rarely

club-shaped in *F. elaeagni* vs ovoid or club-shaped in *F. fujikuroi*), and the type of aerial phialides (mono- or polyphialides in *F. elaeagni* vs polyphialides commonly in *F. fujikuroi*) (Nirenberg 1976, Leslie & Summerell 2006).

Fusarium hechiense M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842156; Fig. 15

Etymology. Named after the location of the type specimen, Hechi city.

Typus. CHINA, Guangxi Zhuang Autonomous Region, Hechi city, Sanwang country, from *Musa nana*, June 2017, M.M. Wang (HMAS 351579, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20824 = LC13644 = GXHCSWL14-E1).

Colonies on PDA grown in the dark reaching 5.3–5.6 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin erose, surface white; reverse yellowish white (4A2) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense,

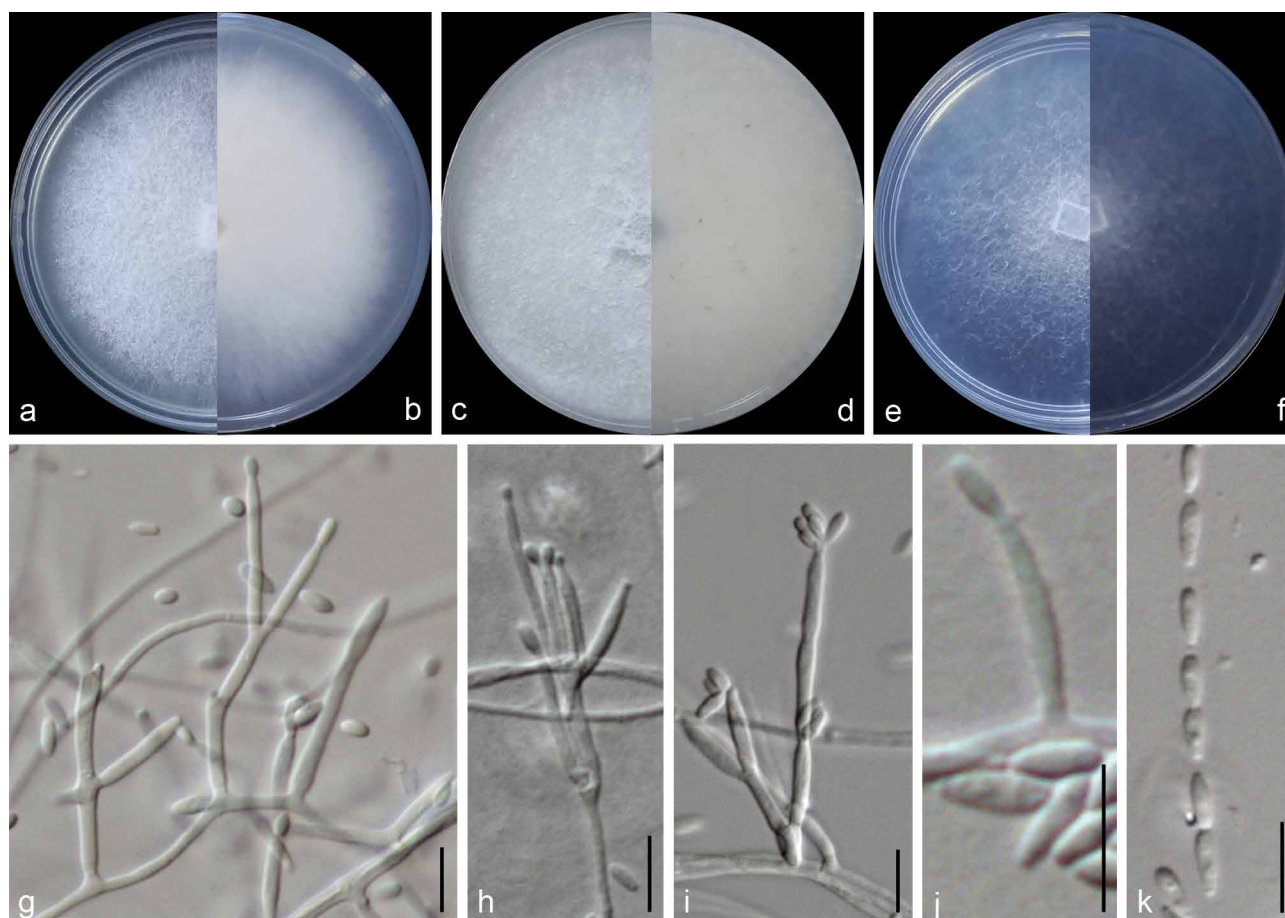


Fig. 15 *Fusarium hechiense* (ex-type culture LC13644). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g–j. conidiophores and phialides on aerial mycelium; k. aerial conidia. — Scale bars: g–k = 10 µm.

colony margin entire, surface and reverse white. Colonies on SNA grown in the dark reaching 5.5–5.8 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* not observed. *Conidiophores* borne on aerial mycelia 15–90 µm tall, unbranched or sparingly branched, bearing terminal or intercalary monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 15–21 × 2–4 µm, periclinal thickening inconspicuous or absent; *aerial microconidia* forming small false heads or chains on tips of monophialides, hyaline, subglobose, oval, reniform or obovoid with a truncate base, ellipsoidal, smooth- and thin-walled, 0–1-septate, (5–)5.2–10 × 1.8–3.5 µm (av. ± sd. 6.9 ± 1.2 × 2.6 ± 0.4 µm). *Chlamydospores* not observed.

Additional material examined. CHINA, Guangxi Zhuang Autonomous Region, Hechi city, Sanwang country, from *Musa nana*, June 2017, M.M. Wang, LC13645 (= GXHCSWL14-E12; *ibid.*, LC13646 (= GXHCSWL14-E13).

Notes — *Fusarium hechiense* is phylogenetically closely related to *F. annulatum* (Fig. 3), but differs by 143 bp in the five loci dataset. Morphologically, the two species are distinguished in the number of microconidial septa (0–1-septate in *F. hechiense* vs aseptate in *F. annulatum*) (Leslie & Summerell 2006).

Fusarium panlongense M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842157; Fig. 16

Etymology. Name refers to the location of the type specimen, Panlong country.

Typus. CHINA, Guangxi Zhuang Autonomous Region, Guilin city, Panlong country, from *Musa nana*, June 2017, M.M. Wang (HMAS 351580, holotype

designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20825 = LC13656 = GXGLPLL15E2).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin filamentous, erose to filiform, surface white; reverse grey (3B1) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.0–5.5 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface white; reverse orange grey (6B2) to brownish grey (6C2) in the centre, white at the margin. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* brownish orange (5C4), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed; *sporodochial phialides* subulate to subcylindrical, 9–17 × 3–4 µm, smooth- and thin-walled. *Sporodochial macroconidia* slender, falcate, slightly curved with almost parallel sides tapering slightly towards both ends, with a papillate to hooked, curved apical cell and a blunt to foot-like basal cell, (3–)4–5-septate, hyaline, smooth- and thin-walled; 3-septate conidia: (35–)37.4–49.7(–50.1) × 2.7–4.4 µm (av. ± sd. 41.7 ± 3.7 × 3.6 ± 0.5 µm); 4-septate conidia: (39.3–)40.3–53(–53.9) × 2.5–5.9 µm (av. ± sd. 48.4 ± 3.7 × 4 ± 0.6 µm); 5-septate conidia: (42.9–)46.1–57.5(–59.4) × 2.6–5.1 µm (av. ± sd. 51.4 ± 3.9 × 4 ± 0.6 µm). *Conidiophores* borne on aerial mycelia often reduced to single monophialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 10–50 × 2–4 µm, periclinal thickening inconspicuous or absent; *aerial microconidia* forming small false heads on tips of monophialides, hyaline, ovoid, reniform, ellipsoid, smooth- and thin-walled, 0–1-septate; aseptate conidia: (4.3–)4.8–7.6(–8) ×

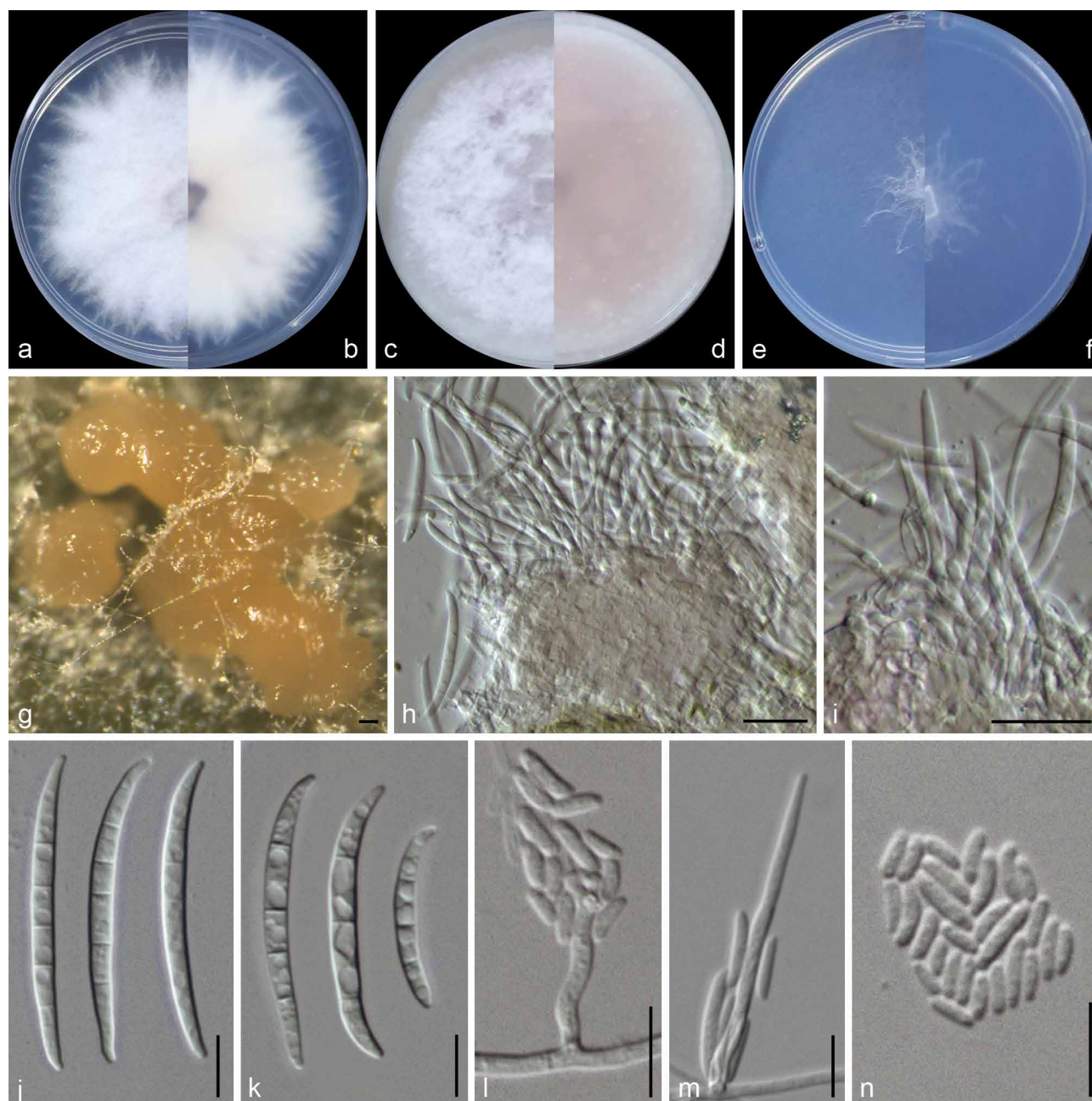


Fig. 16 *Fusarium panlongense* (ex-type culture LC13656). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochia on carnation leaves; h–i. conidiophores and phialides on sporodochia; j–k. sporodochial conidia (macroconidia); l–m. phialides on aerial mycelium; n. aerial conidia (microconidia). — Scale bars: g = 50 µm; h–i = 20 µm; j–n = 10 µm.

1.5–2.7 µm (av. ± sd. $6.0 \pm 0.7 \times 2.1 \pm 0.3$ µm); 1-septate conidia: (7.3–)8.2–14(–16.5) × 2–3.4 µm (av. ± sd. $10.7 \pm 2 \times 2.7 \pm 0.3$ µm). *Chlamydospores* not observed.

Notes — Phylogenetically, *F. panlongense* is well separated from known species in the FFSC, and clustered basally to several species in the Asian clade of the FFSC (Fig. 3). To date all known isolates of this species were isolated from *Musa* spp. in China (isolates MUCL 55954, MUCL 55958, and MUCL 55950 from Hainan Province), suggesting a possible preference in host and geography. Species in the FFSC are common in *Musa* spp. hosts, e.g., *F. concentricum*, *F. lumajangense*, *F. musae*, *F. sacchari*, and *F. verticillioides* were recovered from *Musa* spp. from Costa Rica, Guatemala, Honduras, Indonesia, Mexico (Yilmaz et al. 2021). *Fusarium panlongense* was distinguished from *F. concentricum* in the width of macroconidia, type of aerial phialides and shape of aerial microconidia (macroconidia width 2.7–5.9 µm, monopialides, microconidia oval, reniform,

ellipsoidal in *F. panlongense* vs macroconidia width 3.5–4 µm mono- and polyphialides, microconidia obovoid or ovoid to allantoid in *F. concentricum*) (Nirenberg & O'Donnell 1998), from *F. lumajangense* in the size of microconidia (4.3–14 × 1.5–3.4 µm in *F. panlongense* vs 6–23 × 2–5 µm in *F. lumajangense*) (Maryani et al. 2019b), from *F. musae* in the presence of sporodochia and macroconidia (absent in *F. musae*) and shape and size of aerial microconidia (ovoid, reniform, ellipsoid, 4.3–14 × 1.5–3.4 µm in *F. panlongense* vs claviform or ellipsoid, often truncated, 5–17 × 1.5–4 µm in *F. musae*) (Van Hove et al. 2011), from *F. sacchari* in the septation of conidia (macroconidia 3–5-septate, microconidia 0–1-septate in *F. panlongense* vs macroconidia usually 3-septate, microconidia 0–2-septate in *F. sacchari*) (Leslie & Summerell 2006), and from *F. verticillioides* in the shape and septation of microconidia (oval, reniform, ellipsoidal, 0–1-septate in *F. panlongense* vs ovoid to club-shaped with a flattened base, usually aseptate in *F. sacchari*) (Leslie & Summerell 2006).

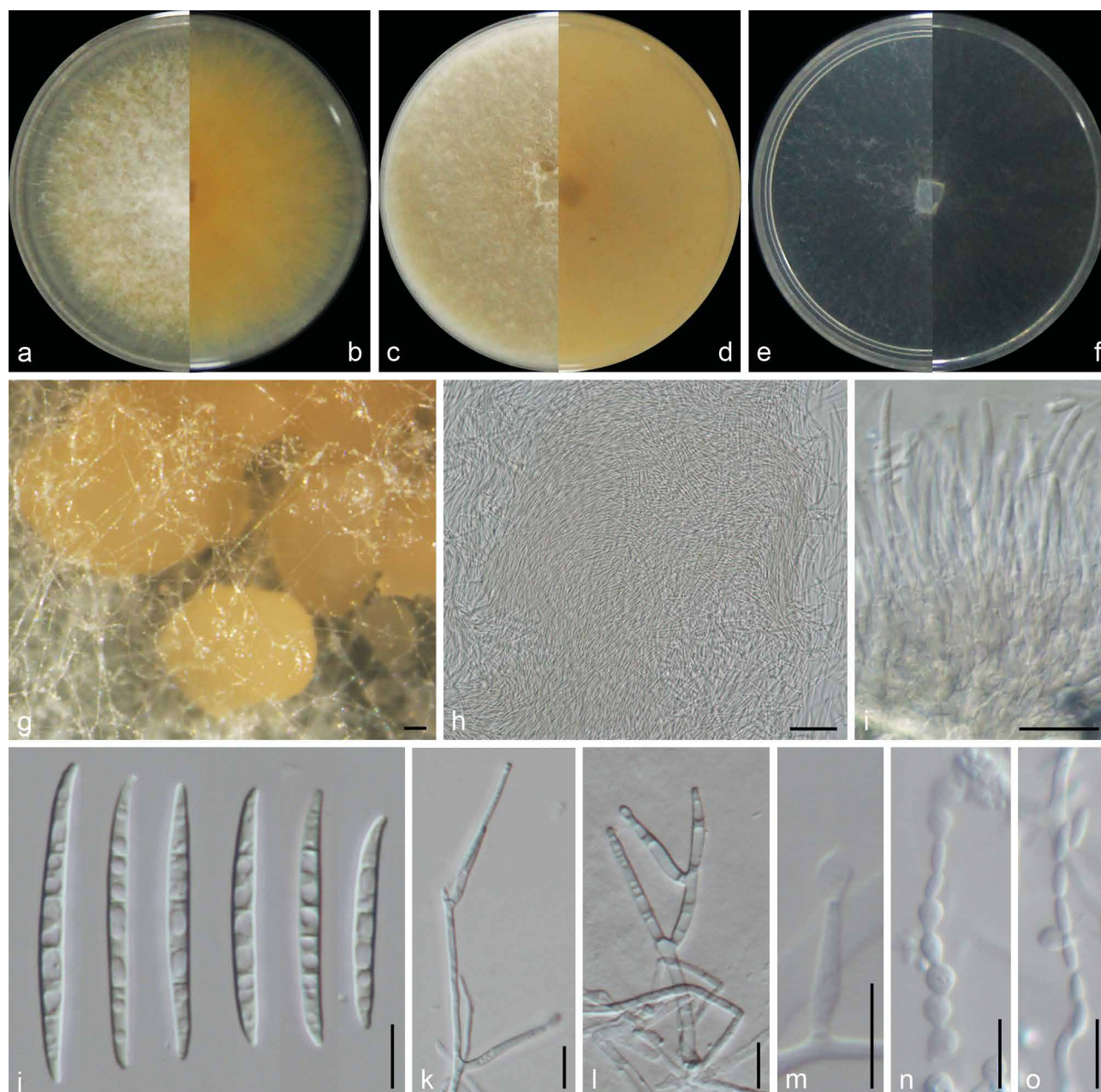


Fig. 17 *Fusarium paranisikadoi* (ex-type culture LC2800). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g–h. sporodochia on carnation leaves; i. conidiophores and phialides on sporodochia; j. aerial conidia (macroconidia); k–m. phialides on aerial mycelium (microconidia); n. aerial conidia (napiform microconidia); o. aerial conidia (ovoid microconidia). — Scale bars: g–h = 50 µm; i = 20 µm; j–o = 10 µm.

Fusarium nisikadoi species complex

Fusarium paranisikadoi M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842158; Fig. 17

Etymology. Named after its morphological similarity to *Fusarium nisikadoi*.

Typus. CHINA, Beijing, Beijing Botanical Garden, from unidentified grass, July 2010, *W. Sun* (HMAS 351581, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20826 = LC2800).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin erose, surface greyish orange (5B3) in the centre, white at the margin; reverse greyish orange (5B4) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.9–6.2 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin entire, surface orange grey (5B2) in the centre, white at the margin; reverse greyish orange (5B4) in the centre, white

at the margin. Colonies on SNA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* greyish orange (5B3), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, consisting of a short, smooth- and thin-walled stipe, 11–17 × 2–5 µm, bearing an apical pair or whorls of three monophialides; *sporodochial phialides* subulate to subcylindrical, 9.2–14.6 × 2.4–3.8 µm, smooth- and thin-walled, sometimes showing a reduced and flared collarette. *Sporodochial macroconidia* falcate, slightly curved with almost parallel sides tapering slightly towards both ends, with a blunt to papillate, slightly curved apical cell and a blunt to distinctly notched basal cell, 3–4-septate, hyaline, smooth- and thin-walled; 3-septate conidia: (36.7–)39.4–50.3(–51.6) × 2.3–4.1 µm (av. ± sd. 45.7 ± 3.5 × 3.1 ± 0.4 µm); 4-septate conidia: (42.8–)43.1–56.3(–57.6) × 2.5–5.2 µm (av. ± sd.

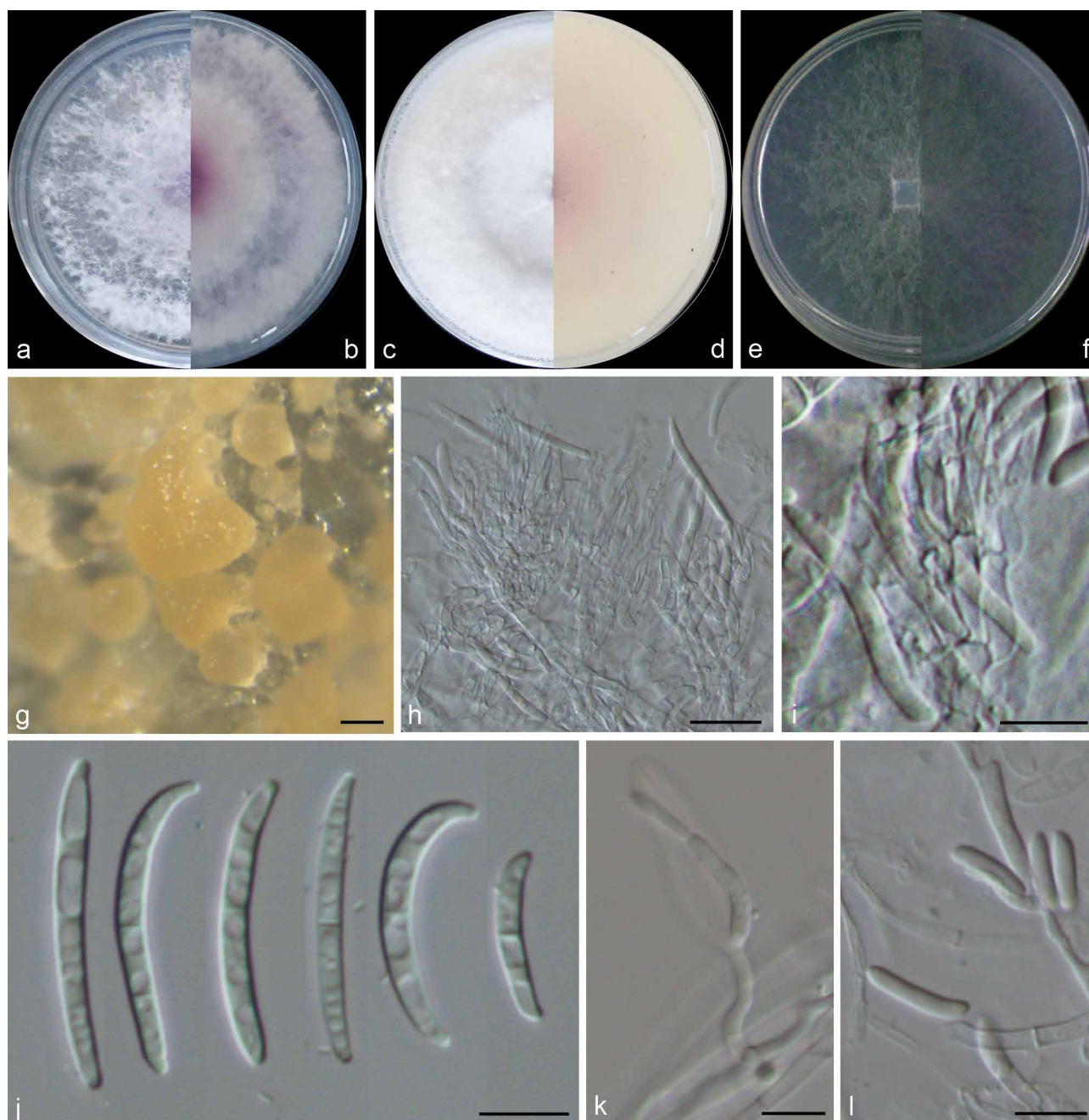


Fig. 18 *Fusarium alpinum* (ex-type culture LC6045). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochia on carnation leaves; h–i. conidiophores and phialides on sporodochia; j. sporodochial conidia (macroconidia); k. phialides on aerial mycelium; l. aerial conidia (microconidia). — Scale bars: g = 50 µm; h = 20 µm; i–l = 10 µm.

$50.2 \pm 3.5 \times 3.8 \pm 0.6$ µm). *Conidiophores* borne on aerial mycelia, 15–80 µm tall, unbranched or sparingly branched, bearing terminal or intercalary monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 15–25 × 2–4 µm, periclinal thickening inconspicuous or absent; *aerial microconidia* forming chains on the tips of the monophialides, hyaline, oval, pyriform to napiform, smooth- and thin-walled, aseptate; ovoid conidia: (3.5–)4.5–7.2(–7.7) × 1.5–3.2 µm (av. ± sd. $5.8 \pm 0.9 \times 2.2 \pm 0.4$ µm); pyriform to napiform conidia: (4.7–)5.2–8(–8.1) × 3.4–6.3 µm (av. ± sd. $6.4 \pm 0.8 \times 4.5 \pm 0.6$ µm). *Chlamydo-*spores not observed.

Additional material examined. CHINA, Beijing, Beijing Botanical Garden, from unidentified grass, July 2010, *Dimuthu*, LC2819; *ibid.*, LC2824; Beijing, Beijing Botanical Garden, from *Pennisetum alopecuroides*, July 2010, *W. Sun*, LC2823.

Notes — *Fusarium paranisikadoi* is phylogenetically closest to *F. miscanthi* and *F. nisikadoi* (Fig. 2), but differs from the latter by 45 bp and 71 bp in the combined *tef1*, *rpb1*, and *rpb2* data-set, respectively. Morphologically, *F. paranisikadoi* differs from *F. miscanthi* in shape, septation, and size of their sporodochial macroconidia (slender, with a slightly foot-shaped basal cell and a curved and gradually tapering apical cell, 3–5-septate, 40–65(–75) × 2.5–4.5 µm in *F. miscanthi* vs falcate, slightly curved with almost parallel sides tapering slightly towards both ends, with a blunt to papillate, slightly curved apical cell and a blunt to distinctly notched basal cell, 3–4-septate, 36.7–57.6 × 2.3–5.2 µm in *F. paranisikadoi*) (Gams et al. 1999), and from *F. nisikadoi* in the size of their sporodochial macroconidia (56–92 × 3.5–4 µm in *F. nisikadoi* vs 36.7–57.6 × 2.3–5.2 µm in *F. paranisikadoi*) (Nirenberg & Aoki 1997).

***Fusarium tricinctum* species complex**

Fusarium alpinum M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842159; Fig. 18

Etymology. Named after the special geographical reference of this species, 'alp'.

Typus. CHINA, Tibet Autonomous Region, from species of *Fabaceae*, June 2015, L. Cai (HMAS 351582, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20818 = LC6045).

Colonies on PDA grown in the dark reaching 5.9–6.2 cm diam after 7 d at 25 °C, raised, punctiform, aerial mycelia dense, colony margin undulate, surface purplish grey (14C2) in the centre, white at the margin; reverse reddish lilac (14C5) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface white; reverse dull red (9B3) in the centre, white at the margin. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* greyish yellow (4B4), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, consisting of a short, smooth- and thin-walled stipe, 9–11 × 3–4 µm, bearing apical whorls of 3 or more monophialides or rarely as single lateral monophialides; *sporodochial phialides* subulate to subcylindrical, 9.3–19.7 × 2–4 µm (av. ± sd. 13.9 ± 2.2 × 3.3 ± 0.4 µm), smooth- and thin-walled, sometimes showing a reduced and flared collarete. *Sporodochial macroconidia* falcate, curved slightly to dorsiventrally with almost parallel sides tapering slightly towards both ends, with a blunt to hooked, curved apical cell and a blunt to distinctly notched basal cell, 1- or 3-septate, hyaline, smooth- and thin-walled; 1-septate conidia: (15.6–)15.7–34.9(–35) × 2.4–4.6 µm (av. ± sd. 26.1 ± 6.3 × 3.3 ± 0.5 µm); 3-septate conidia: (29.2–)30.5–46.3(–48.2) × 2.7–5.1 µm (av. ± sd. 37.8 ± 4.8 × 3.7 ± 0.6 µm). *Conidiophores* borne on aerial mycelia 20–70 µm tall, unbranched or sparingly branched, bearing terminal or intercalary monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, 16–23 × 2–3 µm, periclinal thickening inconspicuous or absent; *aerial microconidia* forming single on the tips of the monophialides, hyaline, ellipsoidal to falcate, smooth- and thin-walled, 0–1-septate; aseptate conidia: (6.8–)7.8–12.6(–12.8) × 2.2–4.7 µm (av. ± sd. 10.3 ± 1.2 × 3.9 ± 0.4 µm); 1-septate conidia: (12.7–)13.3–19.1(–20.8) × 3.1–5.5 µm (av. ± sd. 16.6 ± 1.8 × 4.4 ± 0.5 µm). *Chlamydospores* not observed.

Additional material examined. CHINA, Yunnan Province, from unidentified plant, Sept. 2011, F. Liu, LC2853; *ibid.*, LC2854; Tibet Autonomous Region, from species of *Fabaceae*, June 2015, L. Cai, LC6034; *ibid.*, LC6037; *ibid.*, LC6043.

Notes — *Fusarium alpinum* was collected from high altitude areas of Yunnan province and the Tibet Autonomous Region in this study. Phylogenetically, *F. alpinum* is closely related to *F. paeoniae* (Fig. 8), but differs by 44 bp in the three loci dataset. Morphologically, the two species are distinguished in the number of conidial septa (0–1(–3)-septate microconidia, 3–5-septate macroconidia in *F. paeoniae* vs 0–1-septate microconidia, 1- or 3-septate macroconidia in *F. alpinum*).

Fusarium chongqingense M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842160; Fig. 19

Etymology. Named after the location of the type specimen, Chongqing.

Typus. CHINA, Chongqing, Jinpo Mountain, from *Bothrocaryum controversum*, Oct. 2012, L. Cai (HMAS 351583, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20821 = LC4957).

Colonies on PDA grown in the dark reaching 4.6–5.1 cm diam after 7 d at 25 °C, umbonate, aerial mycelia dense, colony margin erose, surface pale yellow (4A3) to dull red (8B3) in the centre, white at the margin; reverse brownish red (10C6) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin entire, surface white to greyish yellow (4C3) in the centre, white at the margin; reverse brownish orange (5C4) in the centre, white at the margin. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* greyish orange (5B3), formed on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, bearing apical pairs or whorls of three monophialides or single terminal monophialides; *sporodochial phialides* subulate to subcylindrical, 8–11 × 2–4 µm, smooth- and thin-walled, sometimes showing a reduced and flared collarete. *Sporodochial macroconidia* falcate, curved slightly with almost parallel sides tapering slightly towards both ends, with a blunt apical cell and a blunt basal cell, 1- or 3-septate, hyaline, smooth- and thin-walled; 1-septate conidia: (5.8–)8.7–18.8(–19) × 1.5–4.4 µm (av. ± sd. 13.9 ± 3 × 3.1 ± 0.4 µm); 3-septate conidia: (21–)21.8–31.6(–31.8) × 2.6–5 µm (av. ± sd. 25.7 ± 2.5 × 4 ± 0.4 µm). *Conidiophores* borne on aerial mycelia not observed. *Chlamydospores* not observed.

Additional material examined. CHINA, Chongqing, Jinpo Mountain, from *Bothrocaryum controversum*, Oct. 2012, L. Cai, LC13813; *ibid.*, LC13814.

Notes — *Fusarium chongqingense* is phylogenetically closely related to *F. avenaceum*, *F. paeoniae*, and *F. alpinum* (Fig. 8). However, *F. chongqingense* differs by 67 bp from *F. paeoniae*, and 59 bp from *F. alpinum* in the three loci dataset, respectively. Morphologically, *F. chongqingense* is distinct based on the type of apical and basal cells of its macroconidia (blunt apical and basal cell in *F. chongqingense* vs long and tapering to a point to somewhat bent apical cell, and poorly to well-developed foot-shaped basal cell in *F. avenaceum*, blunt to papillate, curved apical cell and a blunt to foot-like basal cell in *F. paeoniae*; and blunt to hooked, curved apical cell and a blunt to distinctly notched basal cell in *F. alpinum*) (Wollenweber & Reinking 1935, Leslie & Summerell 2006).

Fusarium paeoniae M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842161; Fig. 20

Etymology. Named after the host genus of the type specimen, *Paeonia*.

Typus. CHINA, Qinghai Province, from *Paeonia lactiflora*, Aug. 2019, M.M. Wang (HMAS 351584, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20817 = LC13817 = YZG12-2).

Colonies on PDA grown in the dark reaching 5.3–5.5 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface greyish yellow (3B4) to bluish red (12A3) in the centre, white at the margin; reverse greyish ruby (12E4) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5–5.3 cm diam after 7 d at 25 °C, raised, aerial mycelia dense, colony margin entire, surface greyish yellow (3B4) in the centre, white at the margin; reverse golden brown (5D7) to greyish yellow (3B4) in the centre, white at the margin. Colonies on SNA grown in the dark reaching 4.8–5.3 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* pale orange (5A3) to brownish orange (5C4), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed, consisting of a short, smooth- and thin-walled stipe, 8–10 × 6–8 µm, bearing apical pairs or whorls of three monophialides, or as single lateral

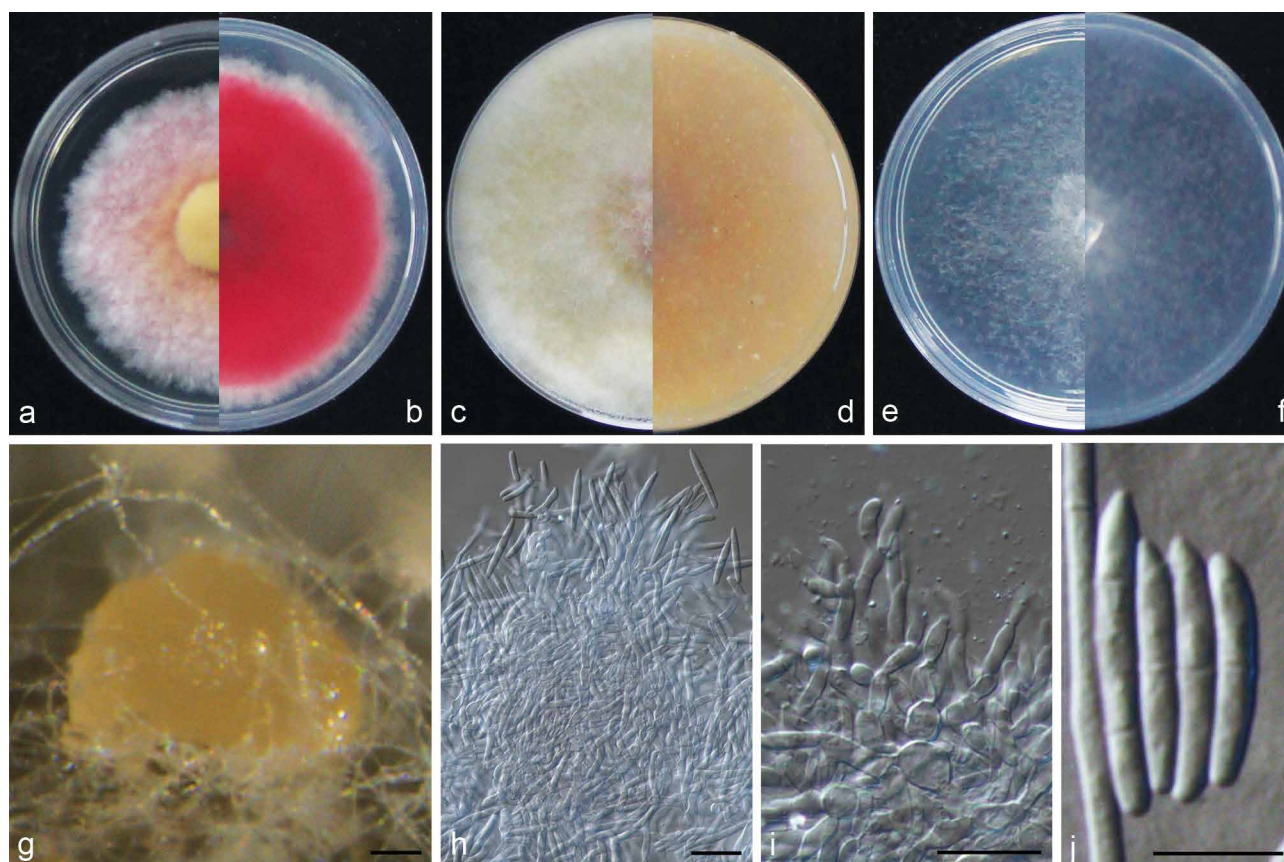


Fig. 19 *Fusarium chongqingense* (ex-type culture LC4957). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochium on carnation leaves; h–i. conidiophores and phialides on sporodochia; j. sporodochial conidia (macroconidia). — Scale bars: g = 50 µm; h–i = 20 µm; j = 10 µm.

monophialides; *sporodochial phialides* subulate to subcylindrical, $6.9\text{--}13.3 \times 2.2\text{--}4.5$ µm (av. $\pm$ sd. $9.6 \pm 1.7 \times 3.6 \pm 0.5$ µm), smooth- and thin-walled, sometimes showing a reduced and flared collarette. *Sporodochial macroconidia* falcate, slightly curved, with a blunt to papillate, curved apical cell and a blunt to foot-like basal cell, 3–5-septate, hyaline, smooth- and thin-walled; 3-septate conidia: $(27.6\text{--})28.4\text{--}39\text{--}(39.4) \times 3.8\text{--}5.8$ µm (av. $\pm$ sd. $32.1 \pm 3.3 \times 4.5 \pm 0.5$ µm); 4-septate conidia: $(30.3\text{--})32.1\text{--}41.7\text{--}(43) \times 3.6\text{--}7.1$ µm (av. $\pm$ sd. $37.9 \pm 2.7 \times 5 \pm 0.8$ µm); 5-septate conidia: $(39.5\text{--})39.8\text{--}50.2\text{--}(52.2) \times 3.2\text{--}5.8$ µm (av. $\pm$ sd. $45.2 \pm 2.8 \times 4.7 \pm 0.7$ µm). *Conidiophores* borne on aerial mycelia often reduced to single phialides, mono- or polyphialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, $5\text{--}20 \times 3\text{--}5$ µm, periclinal thickening inconspicuous or absent; *aerial microconidia* forming small false heads on the tips of the mono- and polyphialides, hyaline, ellipsoid to falcate, smooth- and thin-walled, 0–1(–3)-septate; aseptate conidia: $(6\text{--})7\text{--}10\text{--}(11) \times 2.2\text{--}3.6$ µm (av. $\pm$ sd. $8.6 \pm 0.9 \times 2.9 \pm 0.4$ µm); 1-septate conidia: $(12.7\text{--})13\text{--}15.8\text{--}(16.2) \times 3.5\text{--}4.7$ µm (av. $\pm$ sd. $14.2 \pm 0.8 \times 4.1 \pm 0.3$ µm); 3-septate conidia: $(20.2\text{--})21.3\text{--}25.2\text{--}(25.4) \times 3.6\text{--}5.7$ µm (av. $\pm$ sd. $23.4 \pm 1.5 \times 4.8 \pm 0.6$ µm). *Chlamydospores* not observed.

Additional material examined. CHINA, Qinghai Province, from *Crataegus monogyna*, Sept. 2013, Q. Chen, LC5166; Qinghai Province, from *Elymus dahuricus*, Aug. 2019, M. Gao, LC13815 (= GM56); *ibid.*, from *Plantago* sp., LC13807 (= GM123); *ibid.*, from *Gentiana scabra*, LC13810 (= GM65); *ibid.*, LC13812 (= GM85); Qinghai Province, from *Populus* sp., Aug. 2019, M.M. Wang, LC13816 (= YZG10-2); Tibet Autonomous Region, from species of *Poaceae*, June 2015, F. Liu, LC7358.

Notes — Phylogenetically *F. paeoniae* is closely related to *F. alpinum* (Fig. 8), but differs by 44 bp in the three loci dataset. Morphologically, the two species differ in the number

of conidial septa (0–1(–3)-septate microconidia, 3–5-septate macroconidia in *F. paeoniae* vs 0–1-septate microconidia, 1- or 3-septate macroconidia in *F. alpinum*).

Bisifusarium L. Lombard et al., Stud. Mycol. 80: 223. 2015

Bisifusarium aseptatum M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842162; Fig. 21

Etymology. Refers to the aseptate sporodochial conidia.

Typus. CHINA, Guangdong Province, Guangzhou city, from species of *Orchidaceae*, Mar. 2011, Y.Y. Su (HMAS 351585, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20816 = LC1075).

Colonies on PDA grown in the dark reaching 1.7–2.1 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin erose, surface and reverse white. Colonies on OA grown in the dark reaching 0.9–1.1 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin entire, surface and reverse white. Colonies on SNA grown in the dark reaching 1.2–1.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin filamentous, white; reverse white. Pigment and odour absent. *Sporodochia* white to yellowish white (4A3), formed on carnation leaves. *Conidiophores* in sporodochia forming a smooth- and thin-walled stipe, bearing apical whorls of mostly 3 monophialides; *sporodochial phialides* subulate to subcylindrical, $8\text{--}10 \times 3\text{--}4$ µm, smooth- and thin-walled. *Sporodochial macroconidia* oval, reniform, aseptate, hyaline, smooth- and thin-walled; $(4.4\text{--})4.5\text{--}7\text{--}(7.1) \times 2.6\text{--}4.1$ µm (av. $\pm$ sd. $5.7 \pm 0.7 \times 3.3 \pm 0.3$ µm). *Conidiophores* borne on aerial mycelia, 50–80 µm tall, unbranched, bearing terminal monophialides, sometimes reduced to single phialides; *aerial phialides* subulate to subcylindrical,

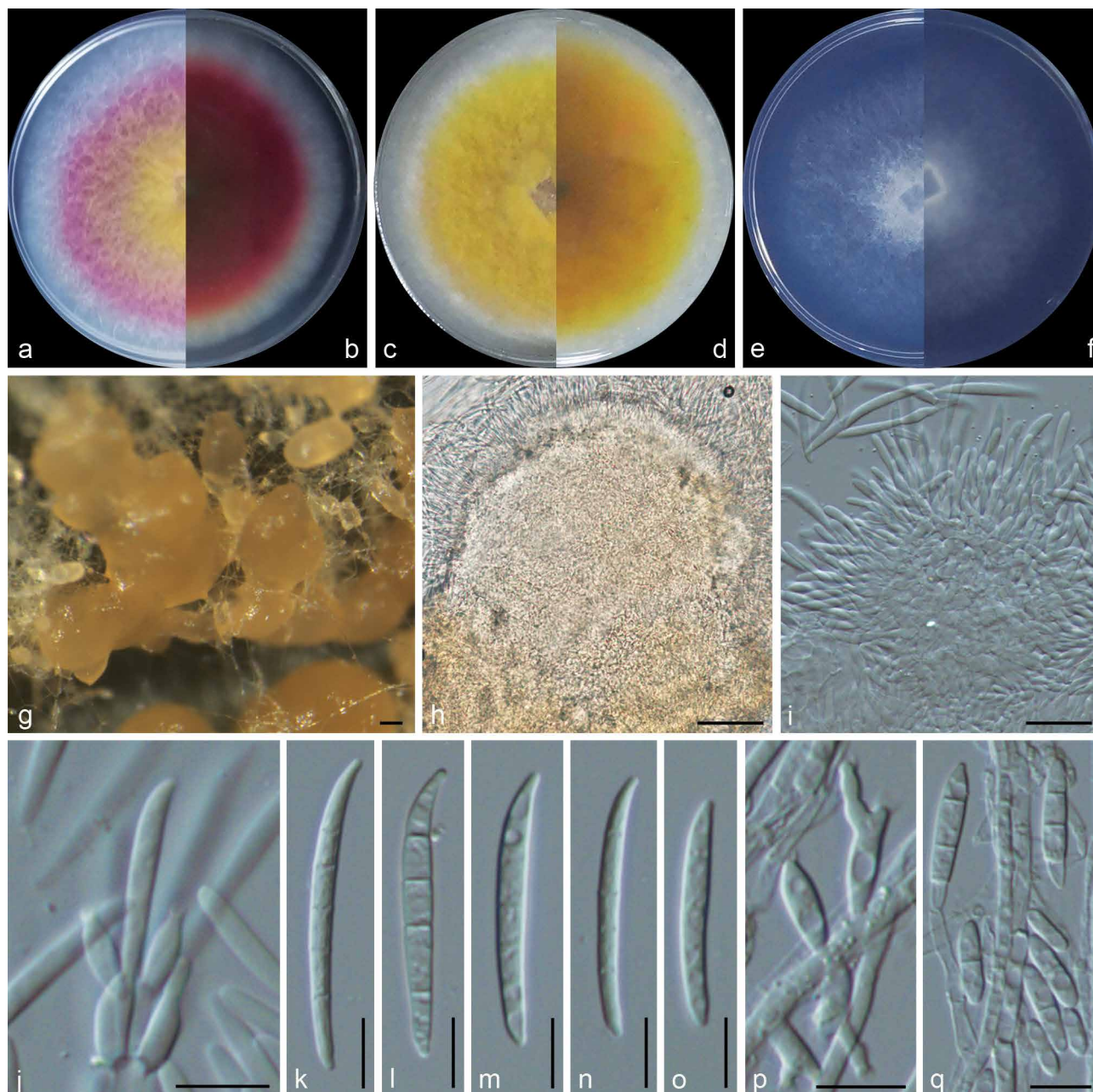


Fig. 20 *Fusarium paeoniae* (ex-type culture LC13817). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g–h. sporodochia on carnation leaves; i–j. conidiophores and phialides on sporodochia; k–o. sporodochial conidia (macroconidia); p. phialides on aerial mycelium; q. aerial conidia (microconidia). — Scale bars: g–h = 50 µm; i–j = 20 µm; k–q = 10 µm.

smooth- and thin-walled, $30\text{--}35 \times 3\text{--}5$ µm, periclinal thickening inconspicuous or absent; *aerial microconidia* single or forming small false heads on the tips of the monophialides, hyaline, ovoid, reniform, or obovoid with a truncate base, smooth- and thin-walled, aseptate, $(5.2\text{--})5.7\text{--}8.8(\text{--}9.7) \times 2.1\text{--}3.8$ µm (av. $\pm$ sd. $7 \pm 0.9 \times 2.7 \pm 0.3$ µm). *Chlamydospores* not observed.

Additional material examined. CHINA, Guangdong Province, Guangzhou city, from species of *Orchidaceae*, Mar. 2011, Y.Y. Su, LC13607; *ibid.*, LC13608.

Notes — The genus *Bisifusarium* was established to accommodate several fusarioid species previously included in the *F. dimerum* species complex, with *B. dimerum* as type species (Lombard et al. 2015). Prior to this study eight species were known from the genus (Lombard et al. 2015, Sun et al. 2017). *Bisifusarium aseptatum* is distinct from other *Bisifusarium* species in producing unicellular sporodochial conidia (Lombard et al. 2015).

Neocosmospora E.F. Sm., U.S.D.A. Div. Veg. Pathol. Bull. 17: 45. 1899

Neocosmospora lithocarpi M.M. Wang & L. Cai, *sp. nov.* — MycoBank MB 842163; Fig. 22

Etymology. Named after the host genus *Lithocarpus*, from which the holotype was isolated.

Typus. CHINA, from *Lithocarpus glabra*, May 2011, W. Sun (HMAS 351586, holotype designated here, dried culture on SNA with carnation leaves; culture ex-type CGMCC 3.20827 = LC1113).

Colonies on PDA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin filamentous to erose, filiform, surface white to greyish yellow (4B3) in the centre, white at the margin; reverse greyish orange (5B3) in the centre, white at the margin. Colonies on OA grown in the dark reaching 5.7–5.9 cm diam after 7 d at 25 °C, flat, aerial mycelia dense, colony margin entire, surface white to yellowish

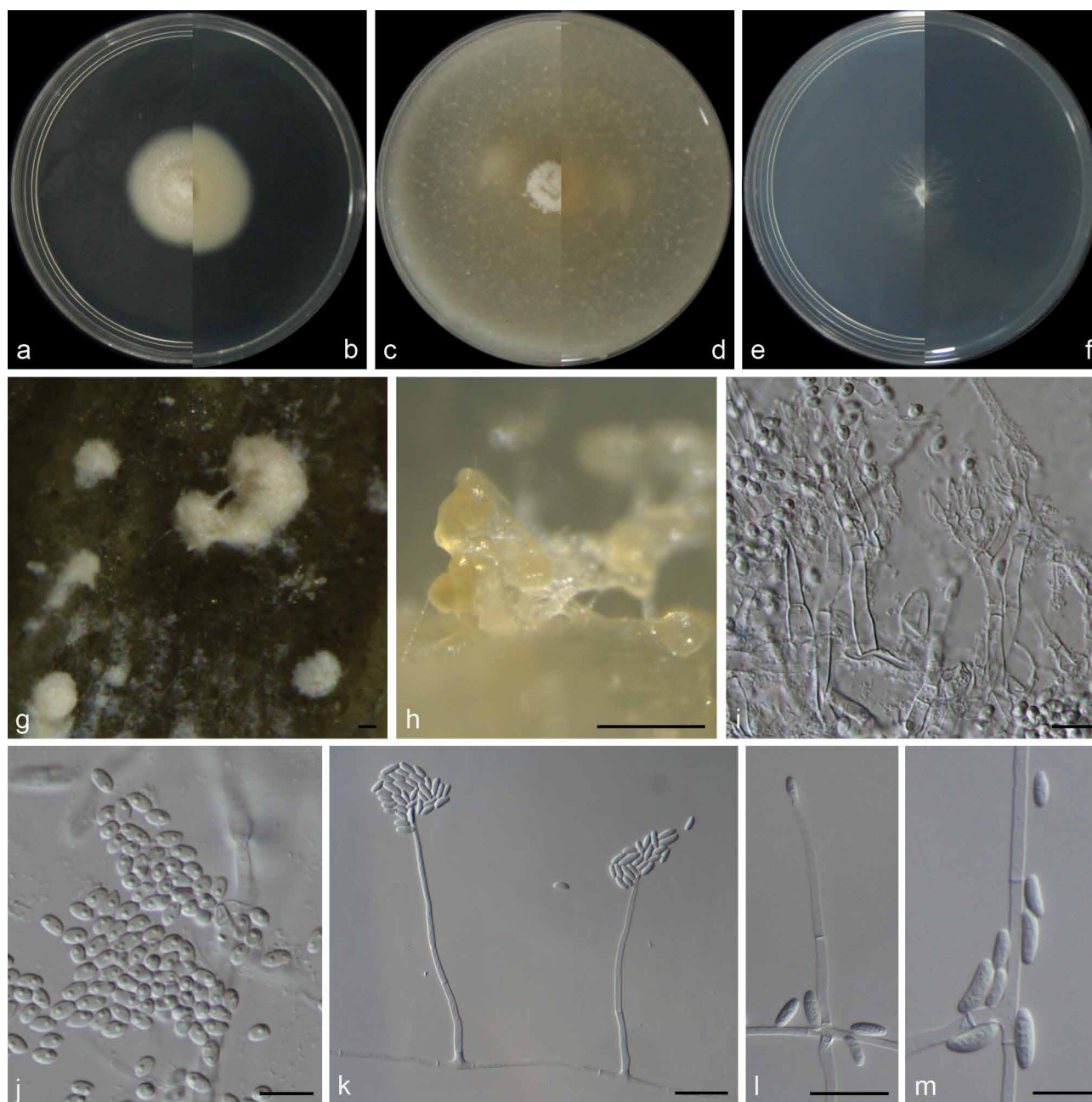


Fig. 21 *Bisifusarium aseptatum* (ex-type culture LC1075). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g–h. sporodochia on carnation leaves; i. conidiophores and phialides on sporodochia; j. sporodochial conidia (macroconidia); k–l. phialides on aerial mycelium; m. aerial conidia (microconidia). — Scale bars: g–h = 50 µm; i–j, m = 10 µm; k–l = 20 µm.

grey (4B2) in the centre, white at the margin; reverse yellowish grey (4B2) in the centre, white at the margin. Colonies on SNA grown in the dark reaching 5.2–5.5 cm diam after 7 d at 25 °C, flat, aerial mycelia scant, colony margin erose, white; reverse white. Pigment and odour absent. *Sporodochia* opaline green (25C6), formed abundantly on carnation leaves. *Conidiophores* in sporodochia verticillately branched and densely packed; *sporodochial phialides* subulate to subcylindrical, $9.9\text{--}23.3 \times 2.8\text{--}6.3$ µm (av. $\pm$ sd. $14.4 \pm 2.7 \times 4.0 \pm 0.8$ µm), smooth- and thin-walled, showing a reduced and flared collarette. *Sporodochial macroconidia* falcate, with a blunt apical and basal cell, 5-septate, hyaline, smooth- and thin-walled, $32.1\text{--}57.8 \times 3.9\text{--}8.1$ µm (av. $\pm$ sd. $49.6 \pm 4.8 \times 5.3 \pm 0.9$ µm). *Conidiophores* borne on aerial mycelia, 20–60 µm tall, unbranched or sparingly branched, bearing terminal or intercalary monophialides, often reduced to single phialides; *aerial phialides* subulate to subcylindrical, smooth- and thin-walled, $20\text{--}45 \times 2\text{--}3$ µm; *aerial microconidia* forming small false heads on the tips of

the monophialides, hyaline, ellipsoid to falcate, smooth- and thin-walled, 0–1-septate; aseptate conidia: $(7\text{--})8.8\text{--}11.1\text{--}(12) \times 3.5\text{--}3.9$ µm (av. $\pm$ sd. $9.9 \pm 1 \times 3.7 \pm 0.2$ µm); 1-septate conidia: $(12\text{--})12.5\text{--}23.8\text{--}(24) \times 3.6\text{--}7$ µm (av. $\pm$ sd. $16.3 \pm 2.8 \times 5 \pm 0.7$ µm). *Chlamydospores* abundant, terminal, ellipsoid, rough, thick-walled, hyaline, aseptate, $6.1\text{--}8.7 \times 5.3\text{--}7.3$ µm (av. $\pm$ sd. $6.8 \pm 0.9 \times 5.8 \pm 0.7$ µm).

Additional material examined. CHINA, from *Lithocarpus glabra*, May 2011, W. Sun, LC13831; *ibid.*, LC13832.

Notes — *Neocosmospora lithocarpi* is phylogenetically closely related to *N. ambrosia*, *N. euwallaceae*, *N. kuroshio*, *N. oligoseptata*, and *N. pseudensiformis* (Fig. 10). Morphologically, this species is distinguished in the shape, septum number and length of its sporodochial macroconidia (falcate, 5-septate in *N. lithocarpi*, vs irregularly clavate and swollen conidia present, 3- or 5-septate in *N. ambrosia*, *N. euwallaceae*, *N. kuroshio*, *N. oligoseptata*; 5-septate, $32.1\text{--}57.8$ µm in *N. lithocarpi*,

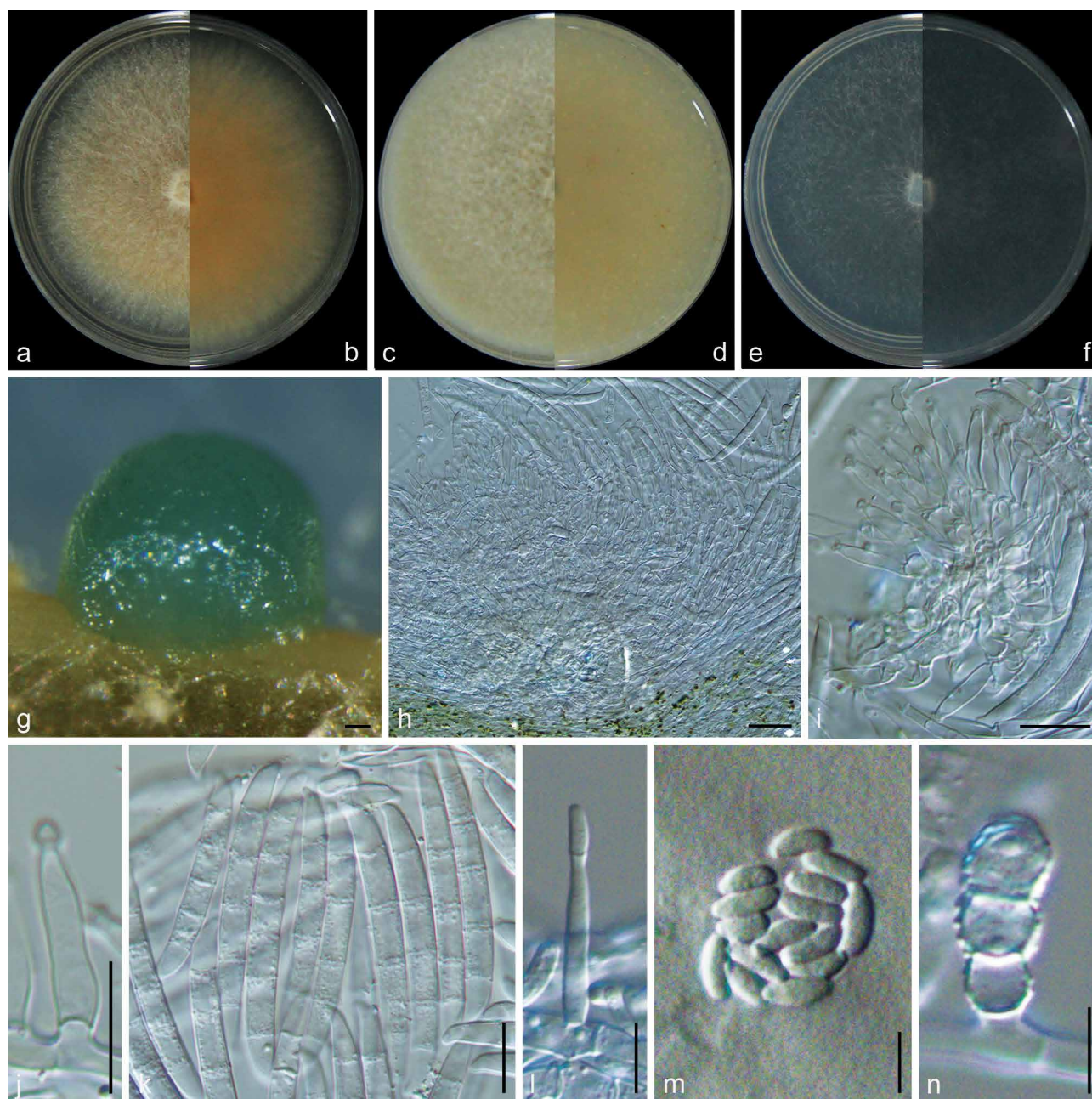


Fig. 22 *Neocosmospora lithocarpi* (ex-type culture LC1113). a–b. Colony on PDA: a. surface of colony on PDA after 7 d at 25 °C; b. reverse of colony on PDA; c–d. colony on OA: c. surface of colony on OA after 7 d at 25 °C; d. reverse of colony on OA; e–f. colony on SNA: e. surface of colony on SNA after 7 d at 25 °C; f. reverse of colony on SNA; g. sporodochium on carnation leaves; h–i. conidiophores and phialides on sporodochia; j. phialide on sporodochia; k. sporodochial conidia (macroconidia); l. phialides on aerial mycelium; m. aerial conidia (microconidia); n. chlamydospores. — Scale bars: g = 50 µm; h = 20 µm; i–n = 10 µm.

vs 2–8-septate, 49–63 µm in *N. pseudensiformis* (Nalim et al. 2011, Aoki et al. 2018, Na et al. 2018, Sandoval-Denis et al. 2019).

DISCUSSION

In this study, 259 species belonging to four well-supported genera, including 12 new species were analysed using a combined *tef1-rpb1-rpb2* multi-locus phylogeny (Fig. 1). Within *Fusarium*, 196 species are categorised in nine species complexes, one of these complexes here renamed as the *F. falsibabinda* complex (previously incorrectly recognised as the *F. babinda* species complex) (Fig. 1, 2). One and four distinct clades in the FLSC (Fig. 5) and FOSC (Fig. 6), respectively, were not described, awaiting more data for species delimitation. Seven loci were employed in this study, i.e., ITS, IGS, *tef1*, *cam*, *rpb1*, *rpb2* and *tub2* (Table 1). Among these seven loci, ITS failed to resolve any species in *Fusarium*, but recognized *B. aseptatum*, *B. penzigii*

and *B. tonghuanum* from other known species in *Bisifusarium*. The IGS locus was amplified for the FOSC members, but its phylogenetic topology showed significant conflict with other loci. The *rpb2* locus appeared to be most effective in species recognition in several *Fusarium* complexes, e.g., the FFSC (Supplementary Fig. S2d), the FTSC (Supplementary Fig. S3d), and *Neocosmospora* (Supplementary Fig. S5c), followed by *tef1* (effective in the FOSC). The *rpb1* locus showed the best species recognition in the FNISSC (Supplementary Fig. S1b). Employing morphological characters, multi-locus phylogenies and ecological preferences, 356 fusarioid isolates from China were identified to 72 species belonging to three genera (1 species with 3 isolates in *Bisifusarium*, 60 species with 321 isolates in *Fusarium* and 11 species with 32 isolates in *Neocosmospora*). Most of the previous studies on *Fusarium* in China focused on species associated with agricultural and cash crops, e.g., maize, rice, wheat, pepper, and tobacco (Yu 1955, Tai 1979, Wang et al. 2013a, b, Zhang et al. 2014a, b), and insects (Bai

Table 4 Species of fusarioid genera occurring in China, with information of their habitats, hosts and references.

Current name	Name of taxon	Host genera/habitats	Recorded reference/ database
<i>A. rigiduscula</i>	<i>F. decemcellulare</i> , <i>F. rigidiusculum</i>	Coccids; <i>Dianthus</i> , <i>Garuga</i> , <i>Idiocerus</i> , <i>Passiflora</i> , <i>Salix</i> , <i>Oxytropis</i>	Bai & Chen (1991); https://nmcdc.cn/fungarium/fungi/chinadirectories this study
<i>B. aseptatum</i>	<i>B. aseptatum</i>	Orchidaceae	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>B. delphinooides</i>	<i>F. delphinooides</i>	Human	Yu (1955), Tai (1979); https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>B. dimerum</i>	<i>F. dimerum</i>	Soil; <i>Citrus</i> , <i>Musa</i>	Yu (1955)
<i>C. cavisperma</i>	<i>F. cavispermum</i>	<i>Pinus</i>	this study
<i>F. acaciae-neamsii</i>	<i>F. acaciae-neamsii</i>	<i>Paederia</i>	Yu (1955), Tai (1979), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. acuminatum</i>	<i>F. acuminatum</i> , <i>F. caudatum</i> , <i>F. scirpi</i> var. <i>acuminatum</i>	Soil; <i>Acer</i> , <i>Brassica</i> , <i>Capsicum</i> , <i>Crotalaria</i> , <i>Cucumis</i> , <i>Eleocharis</i> , <i>Feijoa</i> , <i>Fritillaria</i> , <i>Glycine</i> , <i>Gossypium</i> , <i>Hordeum</i> , <i>Hylotelephium</i> , <i>Ipomoea</i> , <i>Prunus</i> , <i>Solanum</i> , <i>Triticum</i>	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. acutatum</i>	<i>F. acutatum</i>	<i>Triticum</i>	this study
<i>F. alpinum</i>	<i>F. alpinum</i>	<i>Fabaceae</i>	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. ananatum</i>	<i>F. ananatum</i>	<i>Ananas</i>	Yu (1955), this study
<i>F. anguloides</i>	<i>F. anguloides</i>	<i>Alocasia</i> , <i>Cordylone</i> , <i>Gossypium</i> , <i>Ipomoea</i> , <i>Pisum</i> , <i>Solanum</i> , <i>Vicia</i>	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. annulatum</i>	<i>F. annulatum</i>	Submerged wood; human; bamboo, <i>Capsicum</i> , <i>Chamaerops</i> , <i>Glycine</i> , <i>Lithocarpus</i> , <i>Malus</i> , <i>Musa</i> , <i>Olea</i> , <i>Oryza</i> , <i>Sorghum</i> , <i>Vitis</i> , <i>Zea</i> ; unidentified mushroom	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. annuum</i>	<i>F. annuum</i>	<i>Capsicum</i>	Yu (1955); https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. anthophilum</i>	<i>F. anthophilum</i> , <i>F. moniliforme</i> var. <i>anthophilum</i>	Soil; <i>Gossypium</i> , <i>Oryza</i> , <i>Vicia</i>	Tai (1979); https://nmcdc.cn/fungarium/fungi/chinadirectories this study
<i>F. aquatiliun</i>	<i>F. aquatiliun</i>	Water	Wang et al. (2019), this study
<i>F. arcuatissporum</i>	<i>F. arcuatissporum</i>	Soil; <i>Brassica</i> , <i>Nelumbo</i> , <i>Oryza</i> , <i>Panicum</i> , <i>Paspalum</i> , <i>Poa</i>	this study
<i>F. armeniacum</i>	<i>F. armeniacum</i>	Unidentified grass	Yu (1955); https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. arthrosporioides</i>	<i>F. arthrosporioides</i>	Soil; <i>Oryza</i> , <i>Vicia</i>	this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. asiaticum</i>	<i>F. asiaticum</i>	<i>Musa</i> , <i>Triticum</i>	Yu (1955), Tai (1979), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. avenaceum</i>	<i>F. avenaceum</i> , <i>F. avenaceum</i> var. <i>fabae</i> , <i>F. avenaceum</i> var. <i>herbarum</i> , <i>F. avenaceum</i> f. <i>fabae</i> , <i>F. avenaceum</i> f. <i>fabalis</i> , <i>F. avenaceum</i> f. <i>fabarum</i>	Air, faeces, soil; <i>Allium</i> , <i>Atractylodes</i> , <i>Avena</i> , <i>Bidens</i> , <i>Brassica</i> , <i>Camellia</i> , <i>Chrysanthemum</i> , <i>Cicer</i> , <i>Citrus</i> , <i>Codonopsis</i> , <i>Coix</i> , <i>Cucumis</i> , <i>Cucurbita</i> , <i>Daucus</i> , <i>Dianthus</i> , <i>Dolichus</i> , <i>Equisetum</i> , <i>Fritillaria</i> , <i>Gentiana</i> , <i>Glycine</i> , <i>Gossypium</i> , <i>Halenia</i> , <i>Hordeum</i> , <i>Juglans</i> , <i>Lathyrus</i> , <i>Lycopersicum</i> , <i>Malus</i> , <i>Oryza</i> , <i>Panax</i> , <i>Papaver</i> , <i>Paspalum</i> , <i>Pisum</i> , <i>Pisum</i> , <i>Plantago</i> , <i>Prunus</i> , <i>Rosa</i> , <i>Salvia</i> , <i>Setaria</i> , <i>Solanum</i> , <i>Sorghum</i> , <i>Triticum</i> , <i>Triticum</i> , <i>Vicia</i> , <i>Vitis</i> , <i>Zea</i>	Yu (1955), Tai (1979), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. bacridioides</i>	<i>F. bacridioides</i>	<i>Cucumis</i> , <i>Nardissus</i> , <i>Pinus</i>	Yu (1955)
<i>F. bambusacearum</i>	<i>F. bambusacearum</i>	Bamboo	this study
<i>F. bambusicola</i>	<i>F. bambusicola</i>	<i>Sinocalamus</i>	Tai (1979)
<i>F. brachygybosum</i>	<i>F. brachygybosum</i>	<i>Zea</i>	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. caeruleum</i>	<i>F. caeruleum</i> , <i>F. solani</i> var. <i>caeruleum</i> , <i>F. solani</i> var. <i>coeruleum</i>	Soil; <i>Abies</i> , <i>Aconitum</i> , <i>Actinidia</i> , <i>Aloe</i> , <i>Amorphophaga</i> , <i>Arachis</i> , <i>Artocarpus</i> , <i>Astragalus</i> , <i>Atractylis</i> , <i>Atractylodes</i> , <i>Brassica</i> , <i>Camellia</i> , <i>Canna</i> , <i>Capsicum</i> , <i>Castanea</i> , <i>Chrysomphalus</i> , <i>Citrus</i> , <i>Cucumis</i> , <i>Cuminum</i> , <i>Cymbidium</i> , <i>Dendrobium</i> , <i>Dianthus</i> , <i>Dioscorea</i> , <i>Ditylenchus</i> , <i>Eleocharis</i> , <i>Ephedra</i> , <i>Epiphyllum</i> , <i>Eria</i> , <i>Fragaria</i> , <i>Fritillaria</i> , <i>Glycine</i> , <i>Gossypium</i> , <i>Haloxylon</i> , <i>Hearites</i> , <i>Heleocharis</i> , <i>Helianthus</i> , <i>Heliothis</i> , <i>Helwingia</i> , <i>Heterodera</i> , <i>Hevea</i> , <i>Ipomoea</i> , <i>Jatropha</i> , <i>Juglans</i> , <i>Lablab</i> , <i>Lentinus</i> , <i>Ligusticum</i> , <i>Lilium</i> , <i>Lotus</i> , <i>Luffa</i> , <i>Lycium</i> , <i>Malus</i> , <i>Mangifera</i> , <i>Medicago</i> , <i>Momordica</i> , <i>Morus</i> , <i>Musa</i> , <i>Nicotiana</i> , <i>Nopalxochia</i> , <i>Onobrychis</i> , <i>Oryza</i> , <i>Paeonia</i> , <i>Panax</i> , <i>Paphiopedilum</i> , <i>Passiflora</i> , <i>Persica</i> , <i>Phaius</i> , <i>Phalaenopsis</i> , <i>Phaseolus</i> , <i>Phyllostachys</i> , <i>Pinus</i> , <i>Pisum</i> , <i>Pittosporum</i> , <i>Punica</i> , <i>Rabdosia</i> , <i>Ricinus</i> , <i>Robinia</i> , <i>Salvia</i> , <i>Schisandra</i> , <i>Simmondsia</i> , <i>Solanum</i> , <i>Triticum</i> , <i>Vicia</i> , <i>Vigna</i> , <i>Zanthoxylum</i> , <i>Zea</i> ; coccids, human	Yu (1955), Tai (1979), Bai & Chen (1991), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories

Table 4 (cont.)

Current name	Name of taxon	Host genera/habitats	Recorded reference/ database
<i>F. camptoceras</i>	<i>F. camptoceras</i>	Soil; Cinnamomum, Clerodentron, Hordeum, Malus, Momordica, Musa, Phaseolus, Triticum, Vigna, Zea	this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. cassiae</i>	<i>F. cassiae</i>	Coffea	this study
<i>F. chlamydosporum</i>	<i>F. chlamydosporum</i> , <i>F. fusarioides</i>	Aspidiotus, Auricularia, Glycine, Hordeum, Jacaranda, Juglans, Musa, Parlataria, Triticum, Zea	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. chongqingense</i>	<i>F. chongqingense</i>	Bothriocaryum	this study
<i>F. citri</i>	<i>F. citri</i>	Amygdalus, Capsicum, Castanopsis, Citrus, Musa, Smilax	Wang et al. (2019), this study
<i>F. commune</i>	<i>F. commune</i>	Eleocharis, Musa, Oryza, Vigna	this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. compactum</i>	<i>F. compactum</i> , <i>F. scirpi</i> var. <i>compactum</i>	Soil; Poa, Setaria	this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. concentricum</i>	<i>F. concentricum</i>	Aglaonema, Hedera, Lablab, Maianthemum, Musa, Reineckia, Vitis	this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. concolor</i>	<i>F. concolor</i> , <i>F. polyphialidicum</i>	Soil; Anacardium, Carica, Citrus, Ehretia, Gossypium, Hemerocallis, Hordeum, Lycium, Lygodium, Malva, Rhynchosites, Setaria, Triticum, Vicia, Zea	Yu (1955), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. cugenangense</i>	<i>F. cugenangense</i>	Poa, Smilax, Solanum, Zingiber	this study
<i>F. culmorum</i>	<i>F. culmorum</i>	Asparagus, Avena, Beta, Camellia, Cucumis, Cucurbita, Daucus, Dianthus, Diaphorina, Glycine, Helianthus, Hordeum, Ipomoea, Linum, Lycopersicum, Oryza, Pinus, Secale, Setaria, Solanum, Sorghum, Triticum, Vicia, Zea	Yu (1955), Tai (1979); https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. diversisporum</i>	<i>F. diversisporum</i>	Setaria, Zea	Yu (1955)
<i>F. duoseptatum</i>	<i>F. duoseptatum</i>	Musa	this study
<i>F. elaeagni</i>	<i>F. elaeagni</i>	Elaeagnus	this study
<i>F. elaeidis</i>	<i>F. elaeidis</i>	Caryota	this study
<i>F. equiseti</i>	<i>F. equiseti</i>	Faeces, soil; aphids, cicadas, coccids; Aphis, Atractylodes, Beta, Calotropis, Capsicum, Castanea, Citrus, Coix, Cucumis, Cucurbita, Cyamopsis, Cymbidium, Dendrobium, Dendrolimus, Eleocharis, Glycine, Gossypium, Helianthus, Henoseplachia, Hordeum, Icerya, Laccifer, Medicago, Momordica, Nicotiana, Oryza, Phaseolus, Pteris, Populus, Prunus, Pseudostellaria, Raphanus, Rhynchosites, Rosa, Schisandra, Setaria, Simmondsia, Solanum, Spinacia, Triticum, Vicia, Vigna, Zea	Yu (1955), Tai (1979), Bai & Chen (1991), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. flocciferum</i>	<i>F. flocciferum</i>	Soil	https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. fujikuroi</i>	<i>F. fujikuroi</i> , <i>F. subglutinans</i> , <i>F. moniliforme</i> , <i>F. moniliforme</i> f. <i>subglutinans</i> , <i>F. moniliforme</i> var. <i>hangzhouense</i> , <i>F. moniliforme</i> var. <i>intermedium</i> , <i>F. moniliforme</i> var. <i>minus</i> , <i>F. moniliforme</i> var. <i>subglutinans</i>	Faeces, patty, slug moths, soil, submerged wood; human, aphids, arachids, cicadas, coccids; Aleurocanthus, Allium, Amygdalus, Anoplophora, Areca, Asparagus, Avena, Bamboo, Bombyx, Brassica, Camellia, Capsicum, Cedus, Celosia, Ceroplastes, Chilo, Chlorops, Citrullus, Citrus, Cnaphalocrocis, Cocos, Coffea, Coix, Cucumis, Cucurbita, Cymbidium, Dianthus, Dolichos, Elaeis, Eleocharis, Ephedra, Erigeron, Ficus, Gladiolus, Glycine, Gossypium, Helianthus, Hibiscus, Hordeum, Hyphantria, Icerya, Inazuma, Ipomoea, Jasminum, Jatropha, Juglans, Laccifer, Lilium, Lycium, Lycopersicon, Lycopersicum, Lygodium, Malus, Mangifera, Melia, Musa, Myrtina, Nephrolepis, Niliaparvata, Oryza, Ostrinia, Paeonia, Panax, Panicum, Papilio, Parlataria, Parnara, Paulownia, Phaseolus, Phragmites, Pteris, Pinus, Pleurotus, Populus, Proceras, Pseudosclerotia, Raphanus, Rhododendron, Rhynchosites, Ricinus, Rosa, Saccharum, Sansevieria, Saperda, Scirpophaga, Sesamia, Setaria, Simmondsia, Solanum, Sorghum, Spinacia, Taliantha, Taxus, Triticum, Tulipa, Urtica, Vicia, Vigna, Zanthoxylum, Zea	Yu (1955), Tai (1979), Bai & Chen (1991), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories
<i>F. graminearum</i>	<i>F. graminearum</i> , <i>F. zeae</i>	Air, faeces, soil; coccids, psyllids; Agropyron, Allium, Astragalus, Avena, Brassica, Capsicum, Carthamus, Castanea, Coix, Coriaria, Cucumis, Dactylis, Eleocharis, Glycine, Gossypium, Helianthus, Hordeum, Linum, Lolium, Lotus, Lycopersicum, Malus, Medicago, Melilotus, Melissitus, Onobrychis, Oryza, Phalaenopsis, Phaseolus, Pisum, S Populus, Roegneria, ecale, Setaria, Solanum, Sorghum, Spiraea, Triticum, Vicia, Vigna, Zea	Yu (1955), Tai (1979), Bai & Chen (1991), this study; https://nmcdc.cn/fungarium/fungi/chinadirectories

Table 4 (cont.)

Current name	Name of taxon	Host genera /habitats	Recorded reference / database	
F. oxysporum (cont.)	f. apii, F. oxysporum f. betae, F. oxysporum f. callistephi, F. oxysporum f. ciceris, F. oxysporum f. conglutinans, F. oxysporum f. cubense, F. oxysporum f. cucumerinum, F. oxysporum f. cyclaminis, F. oxysporum f. dianthi, F. oxysporum f. gladioli, F. oxysporum f. lini, F. oxysporum f. lupini, F. oxysporum f. lycopersici, F. oxysporum f. medicaginis, F. oxysporum f. melonis, F. oxysporum f. niveum, F. oxysporum f. perniciosum, F. oxysporum f. phaseoli, F. oxysporum f. pisi, F. oxysporum f. spinaciae, F. oxysporum f. tracheiphilum, F. oxysporum f. tuberosi, F. oxysporum f. vasinfectum, F. oxysporum f.sp. batatas, F. oxysporum f.sp. benincasae, F. oxysporum f.sp. betae, F. oxysporum f.sp. conglutinans, F. oxysporum f.sp. cubense, F. oxysporum f.sp. cucumerinum, F. oxysporum f.sp. cumini, F. oxysporum f.sp. dioscoreae, F. oxysporum f.sp. fabae, F. oxysporum f.sp. glycines, F. oxysporum f.sp. lagenariae, F. oxysporum f.sp. lini, F. oxysporum f.sp. lycopersici, F. oxysporum f.sp. magnoliae, F. oxysporum f.sp. melonis, F. oxysporum f.sp. momordicae, F. oxysporum f.sp. mormodicae, F. oxysporum f.sp. narcissi, F. oxysporum f.sp. nelumbicola, F. oxysporum f.sp. niveum, F. oxysporum f.sp. phaseoli, F. oxysporum f.sp. pisi, F. oxysporum f.sp. vasinfectum, F. oxysporum f. fabae, F. oxysporum var. aurantiacum, F. oxysporum var. cubense, F. oxysporum var. gladioli, F. oxysporum var. orthoceras, F. vasinfectum, F. vasinfectum var. sesami	Phascolus, Phaseolus, Pinus, Piper, Pisum, Secchium, Sesamum, Setaria, Solanum, Spinacia, Tamarix, Trifolium, Triticum, Vanilla, Vicia, Vitruillus, Zea		
	F. paeoniae	F. paeoniae	Crataegus, Elymus, Paeonia, Populus	this study
	F. panlongense	F. panlongense	Musa	this study
	F. paransikadoi	F. paransikadoi	Unidentified grass	this study
	F. pernambucanum	F. pernambucanum	Bamboo, Capsicum, Chamaedorea, Cyperus, Gerbera, Heteropogon, Musa, Panicum, Zea	this study
	F. poae	F. poae	Soli; Avena, Cucumis, Dianthus, Oryza, Setaria, Triticum, Zea	Yu (1955), this study; https://hmmdc.cn/fungarium/fungi/chinadirectories
	F. proliferatum	F. proliferatum	Human; Celastrus, Citrullus, Cucumis, Dendrobium, Eleocharis, Glycyrrhiza, Juglans, Musa, Oryza, Oxytropis, Solanum, Vitis	Yu (1955), this study; https://hmmdc.cn/fungarium/fungi/chinadirectories
	F. pseudocircinatum	F. pseudocircinatum	Syzygium	this study
	F. pseudograminearum	F. pseudograminearum	Triticum	https://hmmdc.cn/fungarium/fungi/chinadirectories
	F. redolens	F. oxysporum var. redolens, F. redolens	Soil; arachnids, cicadas, coccids, scarabs, white flies; Acaeia, Alaugium, Aleurocanthus, Allium, Ananas, Anthurium, Arachis, Astragalus, Atractylodes, Auricularia, Avicennia, Bambusoideae, Bauhinia, Benincasa, Brassica, Brevicoryne, Bupleurum, Callistephus, Camellia, Cannabiss, Capsicum, Castanea, Catharanthus, Citrullus, Citrus, Coronilla, Cucumis, Cuminum, Cyamopsis, Cymbidium, Dendrobium, Dianthus, Dimocarpus, Ditylenchus, Dracaena, Elacis, Eleocharis, Ephedra, Excoecaria, Fragaria, Fritillaria, Gerbera, Ginkgo, Gladiolus, Glycine, Glycyrrhiza, Gossypium, Gymnospermae, Gynotemma, Haloxylon, Helianthus, Hevea, Hordeum, Jacaranda, Juglans, Juniporus, Lablab, Laccifer, Lagenaria, Larix, Lcerya, Lentinus, Ligusticum, Lilium, Linum, Llgusticum, Luffa, Lycium, Lycoperdon, Lycopersicon, Magnolia, Medicago, Melilotus, Momordica, Murraya, Musa, Myrica, Nelumbo, Nicotiana, Nopalxochia, Onobrychis, Oryza, Oxytropis, Paeonia, Panax, Parlatoria, Pennisetum, Phalaenopsis, Phaseolus, Pinus, Piper, Pisum, Pocockia, Populus, Rabdosia, Raphanus, Rheum, Rhodiola, Rhynchites, Robinia, Saccharum, Saperda, Schisandra, Simmondsia, Solanum, Sorghum, Spinacia, Spiraea, Stevia, Taxus, Trifolium, Triticum, Unaspis, Ustilago, Vernicia, Vicia, Vigna, Vitis, Zea, Zingiber	Yu (1955), Tai (1979), Bai & Chen (1991); https://hmmdc.cn/fungarium/fungi/chinadirectories
F. reticulatum	F. pallidroseum, F. semitectum var. majus	Beta, Cucumis, Cucurbita	Yu (1955)	
F. sacchari	F. sacchari	Arundina, Musa, Poa	this study	

Table 4 (cont.)

Current name	Name of taxon	Host genera/habitats	Recorded reference / database
<i>F. sambucinum</i>	<i>F. pulicaris</i> , <i>F. roseum</i> , <i>F. sambucinum</i>	Soil; bamboo, Ceroplastes, Citrug, Citrus, Dendrobium, Panax, Ricinus, Saccharum, Solanum, Triticum, Zanthoxylum, Zea	Yu (1955), Tai (1979); https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. sarcochroum</i>	<i>F. sarcochroum</i>	Populus	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. scirpi</i>	<i>F. scirpi</i>	Soil; Avena, Citrus, Gladiolus, Gossypium, Hordeum, Panax, Pinus, Setaria	Yu (1955), Tai (1979); https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. sinense</i>	<i>F. sinense</i>	Triticum	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. sporotrichioides</i>	<i>F. solani</i> var. <i>martii</i> forma 3, <i>F. sporotrichioides</i> , <i>F. sporotrichiella</i> var. <i>sporotrichioides</i> , <i>F. sporotrichioides</i> var. <i>chlamydosporum</i>	Soil; Arachis, Gossypium, Helianthus, Juglans, Phaseolus, Pisum, Pseudaonidia, Solanum, Zea	Yu (1955); https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. stilboides</i>	<i>F. stilboides</i>	Clausena, Coffea	this study; https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. subglutinans</i>	<i>F. subglutinans</i>	Chilo, Dianthus, Ephedra, Erigeron, Raphanus, Zea	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. sulawense</i>	<i>F. sulawense</i>	Acalypha, Alocasia, bamboo, Capsicum, Citrus, Colocasia, Ipomoea, Luffa, Musa, Oryza, Smilax, Syngonium	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. tanahbumbuense</i>	<i>F. tanahbumbuense</i>	Digitaria, Oryza	Wang et al. (2019), this study
<i>F. temperatum</i>	<i>F. temperatum</i>	Unidentified lichen	this study
<i>F. thapsinum</i>	<i>F. thapsinum</i>	Human	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. trinctum</i>	<i>F. trinctum</i>	Dendrobium, Glycine, Hordeum, Hosta, Litsea, Pisum, Setaria, Solanum, Sophora, Triticum, Vicia, Zamilia, Zea	Yu (1955), this study; https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. udum</i>	<i>F. udum</i> , <i>F. udum</i> f.sp. <i>crotalariae</i>	Soil, wood; Amygdalus, Asarum, Citrullus, Coriulus, Gossypium, Salix, Schisandra, Solanum	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. ussuriarum</i>	<i>F. ussuriarum</i>	Air, carbonatite, soil; bamboo, Musa, Oryza, Podocarpus, Prunus, Rhynchospora	this study; https://nmdc.cn/fungarium/fungi/chinadirectories
<i>F. verticillioides</i>	<i>F. verticillioides</i>	Soil, submerged wood; Anoplophora, bamboo, Brassica, Citrullus, Cucumis, Glycine, human, Hyphantria, Musa, Phaseolus, Physosfegia, Saperda, Solanum, Vigna, Zea	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>N. brevis</i>	<i>N. brevis</i>	Submerged wood	this study
<i>N. falciformis</i>	<i>N. falciformis</i>	Paspalum, Passiflora, Vitis	this study
<i>N. lithocarpus</i>	<i>N. lithocarpus</i>	Lithocarpus	this study
<i>N. metavorans</i>	<i>N. metavorans</i>	Submerged wood	this study
<i>N. oblonga</i>	<i>N. oblonga</i>	Carbonatite	this study
<i>N. paraeumartii</i>	<i>N. paraeumartii</i>	Castanopsis	this study
<i>N. petriophila</i>	<i>N. petriophila</i>	Lithocarpus	this study
<i>N. phaseoli</i>	<i>N. phaseoli</i>	Brassica, Vigna	https://nmdc.cn/fungarium/fungi/chinadirectories
<i>N. pseudensiformis</i>	<i>N. pseudensiformis</i>	Passiflora	this study
<i>N. silvicola</i>	<i>N. silvicola</i>	Faeces	this study
<i>N. solani</i>	<i>F. eumartii</i> , <i>F. javanicum</i> , <i>F. javanicum</i> var. <i>radicicola</i> , <i>F. martii</i> , <i>F. solani</i> f. <i>batatus</i> , <i>F. solani</i> f.sp. <i>aleuritidis</i> , <i>F. solani</i> f.sp. <i>fabae</i> , <i>F. solani</i> f.sp. <i>illii</i> , <i>F. solani</i> f.sp. <i>pisii</i> , <i>F. solani</i> var. <i>eumartii</i> , <i>F. solani</i> var. <i>javanicum</i> , <i>F. solani</i> var. <i>martii</i> , <i>F. solani</i> var. <i>solani</i>	Compost, faeces, soil; coccids; Allium, Amomum, Amygdalus, Benincasa, Callistephus, Capsicum, Chrysanthemum, Citrullus, Citrus, Colocasia, Cucumis, Dimocarpus, Dioscorea, Glycine, Gossypium, Ipomoea, Lilium, Lycopersicum, Musa, Oryza, Panax, Phaseolus, Pinus, Pisum, Polygonatum, Polygonatum, Rehmannia, Robinia, Santalum, Solanum, Vernicia, Vicia, Zingiber	Yu (1955), Tai (1979), this study; https://nmdc.cn/fungarium/fungi/chinadirectories
<i>N. stercicola</i>	<i>N. stercicola</i>	Soil	this study
<i>R. ventricosum</i>	<i>F. ventricosum</i>	Soil; sawfly pupae; Camellia, Icerya	Bai & Chen (1991); https://nmdc.cn/fungarium/fungi/chinadirectories
<i>S. ciliatum</i>	<i>F. ciliatum</i>	Populus	Yu (1955)

Note: A. = Albionectria, B. = Bisulfurarium, C. = Cosmospora, F. = Fusarium, N. = Neocosmospora, R. = Rectifusarium, S. = Scolecifusarium.

& Chen 1991), with more than 250 species, subspecies, varieties, and formae specialis hitherto reported. Based on the current taxonomy, these records correlate to 87 species, as summarised in Table 4. Our results present a significant step towards understanding the species diversity and distribution of *Fusarium* in China (Table 1), which increased the number of species to 114 (11 new species and 16 new records from China (23.7 % increase)).

In this study, 321 isolates from China were characterised belonging to eight species complexes in *Fusarium*. The *F. fujikuroi* complex (FFSC) presented the widest geographic distribution (30 locations) and the second highest number of hosts/habitats (28 types; 20 plant genera). Members in this complex were well-known for their worldwide distribution, with wide host ranges, diverse habitats, and pathogenicity to many cereals and economically relevant plants (O'Donnell et al. 1998a, 2000b, Leslie & Summerell 2006). Hitherto about 73 species were accepted in this complex, and 17 of them (15 from China, two from the USA), including four novel species and four newly recorded species in China, were reported in this study. The *F. incarnatum-equiseti* complex (FIESC) presented the second widest geographic distribution (21 locations) and the highest number of hosts/habitats (50 types; 44 plant genera). This complex is well-known as pathogens of plants and animals, endophytes, and saprobes of various host substrates (Leslie & Summerell 2006, O'Donnell et al. 2009b, Villani et al. 2016). Currently about 38 species have been introduced in the FIESC (O'Donnell et al. 2009b, Wang et al. 2019, Xia et al. 2019). In this study, 15 species in the complex were reported from environmental habitats and 44 plant genera (29 families) in China (Table 1), suggesting a very wide host range of this complex. The *F. tricinctum* species complex (FTSC) is an important group in *Fusarium* which encompasses mycotoxin producing species (Leslie & Summerell 2006). Members of this complex are well-known as cereal grain inhabitants (Kulik 2008), smut and mushroom endophytes (Torbaty et al. 2019), and saprobes in soil and other environmental habitats (Leslie & Summerell 2006). Previously four species in this complex were recorded from China, i.e., *F. acuminatum*, *F. avenaceum*, *F. flocciferum*, and *F. tricinctum* from cereals, pumpkin, and winter squash (Yu 1955, Tai 1979, Zhuang 2005, Zhang et al. 2015, Chang et al. 2018, Li et al. 2019). In this study, seven species were identified, including three new species and one species newly recorded from China (*F. iranicum*).

This study also investigated 66 strains isolated and intercepted at Ningbo Customs from various economically important plants of 12 countries over six years (2012–2017), e.g., cereals, ornamental plants, and fruits (Table 1). These strains were identified as 26 species, including 25 known and one new species (Table 1). Six known species were hereto undetected in China, and two of them, *F. curvatum* and *N. pisi*, were previously reported as pathogens of *Brassicaceae* and *Rubiaceae* plants and *Pisum sativum*, respectively (Lombard et al. 2019a, Sandoval-Denis et al. 2019). Interception of these species implies potential threats to biosafety and ecosystem stability of China in international trade.

The taxonomic framework of *Fusarium* and allied genera has undergone several significant changes since establishment. Despite controversial opinions that exist on the generic boundaries of *Fusarium* and allied genera, we favour separating *Fusarium* s.lat. into multiple genera including *Albonectria*, *Bisifusarium*, *Fusarium*, *Neocosmospora*, and *Rectifusarium* as proposed by Gräfenhan et al. (2011), Nalim et al. (2011), Schroers et al. (2011), Lombard et al. (2015), and Crous et al. (2021). Approximately 1800 *Fusarium* and allied species epithets are recorded in the Index Fungorum and MycoBank databases

(accessed December 2021). However, presently less than 400 species are accepted and have been studied using multi-locus DNA data from type specimens (Aoki et al. 2014, O'Donnell et al. 2009a, b, Sandoval-Denis et al. 2018a, b, Lombard et al. 2019a, b, Wang et al. 2019, Xia et al. 2019, Crous et al. 2021, Yilmaz et al. 2021). The taxonomic status of many names remains unresolved because of the lack of type specimens and derived sequences, e.g., *F. caeruleum*. It is noteworthy that there is still an incredibly high number of undescribed *Fusarium* species, e.g., 256 phylogenetic clades recorded in *Fusarium*-ID database (<http://isolate.fusariumdb.org/blast.php>) vs hitherto only about 31 species introduced in the FOSC (Lombard et al. 2019a). Considering the huge number of fusarioid strains/specimens from diverse fungaria around the world, there are undoubtedly many as yet resolved new species. Significant effort is thus required to fully discern the complexity of such a diverse and important fungal group. It is hoped that with the epitypification and neotypification of old names, and description of cryptic species, the classification system of this fungal group would be more stable and less artificial and serve the needs of the users and community impacted by this fungal group in future.

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Supplementary material

Fig. S1 Fifty percent majority rule consensus trees from Bayesian analyses inferred from the *tef1* (a), *rpb1* (b), and *rpb2* (c), showing the phylogenetic relationships of five species complexes within the *Fusarium*, namely *F. concolor* (FCOSC), *F. falsibabinda* (FFBSC), and *F. nisikadoi* (FNISSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Fusarium humuli* (CQ1039). Ex-type cultures are indicated with 'T'.

Fig. S2 Fifty percent majority rule consensus trees from Bayesian analyses inferred from the *tef1* (a), *cam* (b), *rpb1* (c), *rpb2* (d), and *tub2* (e), showing the phylogenetic relationships of species within the *Fusarium fujikuroi* species complex (FFSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). All the trees were rooted to *F. nirenbergiae* (CBS 744.97). Ex-type cultures are indicated with 'T', epi-type with 'ET', neotype with 'NT'.

Fig. S3 Fifty percent majority rule consensus trees from Bayesian analyses inferred from the ITS (a), *tef1* (b), *rpb1* (c), and *rpb2* (d) showing the phylogenetic relationships of species within the *Fusarium tricinatum* species complex (FTSC). The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *F. concolor* (NRRL 13994 T). Ex-type cultures are indicated with 'T', neotype with 'NT'.

Fig. S4 Fifty percent majority rule consensus trees from Bayesian analyses inferred from the ITS (a), *tef1* (b), *rpb2* (c), *cam* (d), and *tub2* (e), showing the phylogenetic relationships of species within the *Bisifusarium*. The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). All the trees were rooted to *Rectifusarium robinianum* (CBS 430.91 T). Ex-type cultures are indicated with 'T'.

Fig. S5 Fifty percent majority rule consensus trees from Bayesian analyses inferred from the ITS (a), *tef1* (b), and *rpb2* (c), showing the phylogenetic relationships of species within the genus *Neocosmospora*. The Bayesian posterior probabilities (PP > 0.9) and PhyML Bootstrap support values (BS > 50) are displayed at the nodes (PP/ML). The tree was rooted to *Geejayessia cicatricum* (CBS 125552) and *G. atrofusca* (NRRL 22316). Ex-type cultures are indicated with 'T', neo-type with 'NT'.