Persoonia 54, 2025: 225–263
https://www.persoonia.org

RESEARCH ARTICLE

ISSN (Online) 1878-9080
https://doi.org/10.3114/persoonia.2025.54.07

Taxonomy and phylogeny of *Cortinarius* sect. *Anomali* in China

M.L. Xie[1,2,3], B. Dima[4], K. Wang[5], C. Phukhamsakda[1], Y. Li[3], L.L. Qi[6], G.J. Li[7], T.Z. Liu[8], P.S. Jia[9], Q. Wang[1], L.R. Song[10], T.Z. Wei[5*], Y. Li[1*]

[1]Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, Changchun 130118, Jilin, China
[2]Life Science College, Northeast Normal University, Changchun 130024, Jilin, China
[3]School of Food Science and Engineering, Yangzhou University, Yangzhou 225127, Jiangsu, China
[4]Department of Plant Anatomy, Institute of Biology, Eötvös Loránd University, Pázmány Péter sétány 1/C, H-1117, Budapest, Hungary
[5]Fungarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, China
[6]Microbiology Research Institute, Guangxi Academy of Agriculture Sciences, Nanning 530007, Guangxi, China
[7]Key Laboratory of Vegetable Germplasm Innovation and Utilization of Hebei, Collaborative Innovation Center of Vegetable, College of Horticulture, Hebei Agricultural University, Baoding 071001, Hebei, China
[8]College of Life Science, Chifeng University, Chifeng 024000, Inner Mmongolia, China
[9]Institute of Plant Protection, Xinjiang Academy of Agricultural Sciences, Urumqi 830091, Xinjiang, China
[10]Gansu Engineering Laboratory of Applied Mycology, Hexi University, Zhangye 734000, Gansu, China

*Corresponding authors: Y. Li, yuli966@126.com; T.Z. Wei, weitiezheng@163.com

Key words:
Agaricales
barcodes
Basidiomycota
Cortinariaceae
ectomycorrhizal fungi
new taxa

Abstract: *Cortinarius* section *Anomali* is a species-rich group that occurs worldwide, particularly in Europe and North America. The overlapping morphological and microscopical characteristics of *Anomali* species pose significant challenges for species identification. Therefore, the focus of this study was to clarify the taxonomy and phylogeny of section *Anomali* in China. A total of 229 specimens of section *Anomali* were collected in China over the past two decades. The present study, based on a combination of extensive morphological investigations and molecular methods, reports 22 *Anomali* species. Eleven of them are recognized as new to science and formally described here as *C. albocyaneoides*, *C. campanianomalus*, *C. microalbocyaneus*, *C. neocaninus*, *C. qilianensis*, *C. robustianomalus*, *C. rufolilacinus*, *C. subalbocyaneus*, *C. subanomalus*, *C. xizangensis*, and *C. vernalianomalus*, respectively. *Cortinarius albocyaneus*, *C. azureovelatus*, *C. caninus*, *C. kranabetteri*, *C. lepidopus*, and *C. perrotensis* are reported in China for the first time. In addition, the occurrence of *C. cinnamomeolilacinus*, *C. epsomiensis*, *C. subclackamasensis*, *C. tabularis*, and *C. tropicus* in China is confirmed. Descriptions, accompanied by illustrations of morphological characters of the Chinese *Anomali* species, and comparisons with closely related taxa are provided. The present study reports *Cortinarius* section *Anomali* in China or Asia, clarifying taxonomy and conducting phylogeny analyses based on nrITS, nrLSU, *rpb1* and *rpb2* sequences. We compare the *Anomali* species from China with those in Europe and North America, enriching the species and sequences of sect. *Anomali*. In addition, the ornamentation of basidiospores was studied using scanning electron microscopy.

Citation: Xie ML, Dima B, Wang K, Phukhamsakda C, Li Y, Qi LL, Li GJ, Liu TZ, Jia PS, Wang Q, Song LR, Wei TZ, Li Y (2025). Taxonomy and phylogeny of *Cortinarius* sect. *Anomali* in China. *Persoonia* **54**: 225–263. doi: 10.3114/persoonia.2025.54.07
Received: 13 October 2023; **Accepted:** 23 April 2025; **Effectively published online:** 16 May 2025
Corresponding editor: J. Nuytinck

INTRODUCTION

Cortinarius is a distinct agaric genus with high species richness and morphological variation (Garnica *et al.* 2016, Ammirati *et al.* 2021). More than 3000 species are estimated worldwide in this genus and are distributed in all continents except Antarctica (Niskanen *et al.* 2018). The genus *Cortinarius* plays a key role in different forest ecosystems by forming an obligate ectomycorrhizal association with various spermatophytes (e.g., Singer 1986, Harrower *et al.* 2015). Molecular methods have been continuously applied in *Cortinarius* studies over the past two decades (Liu *et al.* 1997, Garnica *et al.* 2005, Liimatainen *et al.* 2014, 2020, Soop *et al.* 2019), and previous studies demonstrate the importance of molecular methods in re-evaluating species limits and diversity, as well as discovering undescribed species within this genus (Niskanen *et al.* 2016, Liimatainen *et al.* 2017, Ammirati *et al.* 2021, Bidaud *et al.* 2021, Dima *et al.* 2021).

Cortinarius section *Anomali* is a bihemispherical lineage, especially common in the Northern Hemisphere. The section was classified into various subgenera based on traditional morpho-taxonomy in the past several decades (Moser 1961, Moser 1983, Brandrud *et al.* 1990, 2014, Bidaud *et al.* 1992, Consiglio *et al.* 2005, 2006, Melot 2007, Consiglio 2012, Ballarà *et al.* 2014). However, the phylogenetic studies of *Cortinarius* showed that sect. *Anomali* does not belong

to any classical subgenera, but rather forms a separate monophyletic lineage within the genus (Høiland & Holst-Jensen 2000, Peintner *et al.* 2004, Garnica *et al.* 2005, 2016, Harrower *et al.* 2011, Stensrud *et al.* 2014, Dima *et al.* 2016, Soop *et al.* 2019). Recently, Liimatainen *et al.* (2022b) divided the genus *Cortinarius* into 10 genera based on genomic and multi-genic data. According to this new classification, sect. *Anomali* still belongs to the genus *Cortinarius*. Based on Soop *et al.* (2019) and Liimatainen *et al.* (2022b), sect. *Anomali* might belong to subgen. *Camphorati*. The morphological characteristics of the basidiomata of different sect. *Anomali* species are very similar, which has limited our understanding of the taxonomy and species diversity in this section (Dima *et al.* 2021). However, this limitation has been largely resolved with the application of polyphasic methods. These methods combine molecular phylogenetic analyses with morphological and ecological studies, as well as typifications, which clarified the taxonomy and nomenclature of classical *Cortinarius* names (Ammirati 2014, Dima *et al.* 2016, 2021, Eyssartier *et al.* 2017, Liimatainen & Ainsworth 2018, Liimatainen *et al.* 2022a). Previous molecular studies showed that there are more than 90 phylogenetic species that belong to sect. *Anomali* based on global nrDNA ITS sequence data, and most of them are not properly described (Dima *et al.* 2016).

In China, seven known sect. *Anomali* names, *C. anomalus*, *C. azureus*, *C. caesiifolius*, *C. epsomiensis*, *C. pastoralis*, *C. tabularis*, and *C. xanthocephalus*, have been reported in previous literature (Teng 1963, Tai 1979, Shao & Xiang 1997, Li *et al.* 2015, Xie 2018, Chen & Zhang 2019, Wei & Liu 2019, Wang *et al.* 2021, Shi *et al.* 2022, Wang *et al.* 2022), of which *C. azureus* and *C. pastoralis* were clarified as later synonyms of *C. anomalus* and *C. epsomiensis*, respectively (Dima *et al.* 2016, Liimatainen & Ainsworth 2018). Recently, three new species, *C. cinnamomeolilacinus*, *C. subclackamasensis*, and *C. tropicus*, were reported based on Chinese specimens (Zhang *et al.* 2023). So far, 10 names representing eight species have been reported in China.

Species of *Cortinarius* have a strong obligate symbiosis with plant hosts. The flora of China has strong affinity with the floras of Europe and western North America, as well as with tropical Asia (Wu 1979), and plays an important role in connecting these continents (Li 2008). Therefore, the investigation of *Cortinarius* species diversification in China is very important. In this study, we focus on the *Cortinarius* sect. *Anomali* in China. During the mycological expedition and the research on the morphology and phylogeny of sect. *Anomali* in recent years, we found that although some Chinese *Anomali* species have similar appearances to Euro-American species, they are quite different in microscopic structures and molecular data. Here, we describe 11 new species based on morphological, ecological, and molecular studies. In addition, six species are newly reported in China, and five known species in China are confirmed. The phylogenetic analyses are carried out based on nrITS+nrLSU+*rpb1*+*rpb2* datasets.

MATERIALS AND METHODS

Studied specimens and morphological studies

A total of 229 sect. *Anomali* specimens from China were studied. All the specimens are deposited in the HMJAU, HMAS, CFSZ, and/or HBAU herbaria. The morphological descriptions are based on field notes and photographs of fresh collections. Microscopic characteristics were obtained from the dried specimens, which were observed in 5 % potassium hydroxide solution and/or Melzer's reagent under a Zeiss AX10 light microscope, following Xie *et al.* (2020). Basidiospore measurements were taken from basidiospores on lamella surfaces and those deposited on the stipe apex, veil, or pileus surface. Basidiospore measurements, averages, and Q values (length/width) were calculated based on 30–40 basidiospores per specimen, and measurements in parentheses were exceptional. The ornamentation of basidiospores was studied using a Hitachi, model SU8010, field emission scanning electron microscope in Jilin Agricultural University. All the specimens in this study were examined with molecular data (Table 1).

Molecular studies

Protocols for DNA extraction, PCR, and cycle sequencing were in accordance with those described in Papp & Dima (2018) and Xie *et al.* (2022). The amplification of the nrITS region used primers ITS1-F and ITS4 (White *et al.* 1990, Gardes & Bruns 1993), nrLSU region with primers LR0R and LR5 (Moncalvo *et al.* 2000), *rpb1* region with primers RPB1-Af and RPB1-Cr (Stiller & Hall 1997, Matheny *et al.* 2002) and *rpb2* region with primers bRPB2-6F and bRPB2-7.1R (Matheny & Ammirati 2003; Matheny 2005). The newly generated sequences were submitted to GenBank. To select similar sequences for phylogenetic analyses, BLASTn comparisons against the NCBI (http://blast.ncbi.nlm.nih.gov) and UNITE (http://unite.ut.ee) databases were used. *Cortinarius* sect. *Bolares* was selected as outgroup according to Dima *et al.* (2021).

Sequences of nrITS, nrLSU, *rpb1*, *rpb2* loci were aligned separately with MAFFT v. 7 (http://mafft.cbrc.jp/alignment/server) choosing the E-INS-I method (Katoh & Standley 2013) under default settings. Based on the work of Nagy *et al.* (2012), phylogenetically informative indels in the ITS region were coded as presence/absence data with FastGap v. 1.2 (Borchsenius 2009) following the simple indel coding algorithm (Simmons *et al.* 2001). The final alignments including nucleotide and binary data were concatenated in SeaView v. 5 (Gouy *et al.* 2021) and were analysed in RAxML (Stamatakis 2014) and MrBayes v. 3.2.6 (Ronquist *et al.* 2012). Maximum Likelihood (ML) phylogenetic reconstruction was performed in raxmlGUI v. 2.0 (Edler *et al.* 2021) using rapid bootstrap analysis with 1000 replicates. Six nucleotide partitions (ITS1, 5.8S, ITS2, LSU, *rpb1*, *rpb2*) were set to the GTRGAMMA substitution model in addition to one binary partition (indel characters) that was set to default. In the Bayesian Inference (BI) phylogeny, the alignment was divided into seven partitions (ITS1, 5.8S, ITS2, LSU, *rpb1*, *rpb2* and indels) as well. The GTR + G substitution model was applied to the nucleotide characters, while the two-parameter Markov model was set for the indels. Two independent runs of four Markov Chain Monte Carlo (MCMC) were performed each for 10 M generations, sampling every 1000th generation. The first 30 % of the trees was discarded as burn-in. For the remaining trees, a 50 % majority rule consensus phylogram with posterior probabilities as nodal supports was computed. The best scoring ML tree from Maximum Likelihood analysis

Table 1. Specimens included in the phylogenetic analyses. Newly generated sequences are marked in **bold**.

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
sect. *Anomali*						
Cortinarius adrianae	UCH CO5272	MZ580485	—	—	—	Panama
C. albidipes	NYS-F-000129 (holotype)	MZ580485	—	—	—	USA, New York
	MICH10325 (as *C. caesiellus*, holotype)	MZ580484	—	—	—	USA, Michigan
	614-HRL 614 (as *C. tabularis*)	KJ705108	—	—	—	Canada, Quebec
C. albidoavellaneus	MICH10313 (holotype)	MZ580483	—	—	—	USA, Michigan
C. albocyaneoides	HMJAU 48663	**ON254418**	**OR105104**	—	**OR137743**	China, Inner Mongolia
	HMJAU 48637	**ON254419**	—	—	—	China, Inner Mongolia
	HMJAU 48664 (holotype)	**ON254420**	**OR105105**	—	**OR137744**	China, Inner Mongolia
	HMJAU 48665	**ON254421**	**OR105106**	—	**OR137745**	China, Inner Mongolia
	YM580 (as *Cortinarius* sp.)	AB848433	—	—	—	Japan, Yamanashi
	YM123 (as *Cortinarius* sp.)	AB848430	—	—	—	Japan, Yamanashi
	sirokoke2_e192_TD (as Uncultured fungus)	LC711478	—	—	—	Japan, Hokkaido
	sirokoke1 (as Uncultured fungus)	LC711479	—	—	—	Japan, Hokkaido
	sirokoke2 (as Uncultured fungus)	LC711480	—	—	—	Japan, Hokkaido
	sirokoke (as Uncultured fungus)	LC711481	—	—	—	Japan, Hokkaido
C. albocyaneus	HMJAU 44500	**ON254434**	**OR105121**	**OR137675**	**OR137758**	China, Inner Mongolia
	HMJAU 44504	**ON254435**	**OR105122**	**OR137676**	**OR137759**	China, Jilin
	HMAS 291406	MW555443	**OR105123**	**OR137677**	—	China, Hebei
	HMAS 291444	MW555448	**OR105124**	**OR137678**	**OR137760**	China, Beijing
	HMAS 260342	**ON254436**	**OR105125**	**OR137679**	—	China, Heilongjiang
	CFSZ 21343	**ON254437**	—	—	—	China, Inner Mongolia
	HMAS 268417	**ON254438**	**OR105126**	—	—	China, Sichuan
	HMJAU 48710	**ON254439**	**OR105127**	**OR137680**	**OR137761**	China, Jilin
	HMAS 295967	**ON254440**	**OR105128**	**OR137681**	**OR137762**	China, Hebei
	CFP1177 (epitype)	KX302206	—	—	—	Sweden
	NYS-F-000864 (as *C. copakensis*, holotype)	MZ580482	—	—	—	USA, New York
C. albomalus	H7000816 (holotype)	MZ568645	—	—	—	Canada, Ontario
	MQ19-HRL2777-QFB31043 (as *Cortinarius* sp.)	MN751632	—	—	—	Canada, Québec

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
	iNAT59505932 (as *Cortinarius* sp.)	MW305253	—	—	—	USA, New Jersey
C. anocorium	H7068022 (holotype)	MZ568646	—	—	—	USA, Florida
C. anomalellus	TU105328	UDB018358	—	—	—	Estonia
C. anomalobrunneus	UCH AC653 (holotype)	OP265185	—	—	—	Panama
C. anomalodelicatus	JFA8146 (holotype)	MZ580480	—	—	—	USA, Colorado
	TN11-241	MZ580481	—	—	—	USA, Alaska
C. anomalomontanus	JFA9919 (holotype)	MZ580478	—	—	—	USA, Wyoming
	JFA9973	MZ580479	—	—	—	USA, Wyoming
C. anomalopacifcus	JFA11887	MZ580471	—	—	—	USA, California
	TN12-301	MZ580477	—	—	—	USA, California
	DBB11745 (holotype)	MZ663774	—	—	—	USA, California
C. anomalovelatus	JFA13109 (holotype)	FJ717605	FJ717605	—	—	USA, Washington
	TN12-236	KJ019014	—	—	—	USA, California
	PK4741	FJ039655	FJ039655	—	—	Canada, British Columbia
C. anomalus	NL-5414	MZ663777	—	—	—	USA, Massachusetts
	CFP1154 (neotype)	KX302224	—	—	—	Sweden
	CNV9 (as *Cortinarius* sp.)	MT345186	—	—	—	USA, New Hampshire
C. azureovelatus	HMJAU 48656	**ON254406**	**OR1050892**	**OR137652**	**OR137731**	China, Inner Mongolia
	HMJAU 48657	**ON254407**	**OR1050893**	**OR137653**	**OR137732**	China, Jilin
	HMJAU 48658	**ON254408**	**OR1050894**	**OR137654**	**OR137733**	China, Jilin
	HMJAU 48736	**ON254409**	**OR1050895**	**OR137655**	**OR137734**	China, Jilin
	HMJAU 48737	**ON254410**	**OR1050896**	**OR137656**	**OR137735**	China, Jilin
	HMJAU 48654	**ON254411**	**OR1050897**	**OR137657**	**OR137736**	China, Heilongjiang
	HMJAU 48713	**ON254412**	**OR1050898**	—	**OR137737**	China, Heilongjiang
	HMJAU 48655	**ON254413**	**OR1050899**	**OR137658**	**OR137738**	China, Heilongjiang
	LE312082	MN308203	—	—	—	Russia, Altai Republic
	LE315531	MN308204	—	—	—	Russia, Altai Republic
C. barlowensis	MN	FJ157009	FJ157009	—	—	Canada, British Columbia
	JFA13140 (holotype)	FJ717554	FJ717554	—	—	USA, Washington

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
	TN07-366	KJ019015	—	—	—	USA, Washington
C. brevissimus	NYS-F-000541 (holotype)	MZ580467	—	—	—	USA, New York
	Cort_H2QY2 (as *Cortinarius* sp.)	JX030219	—	—	—	USA, New York
C. caeruleoanomalus	TENN068383	KY744156	—	—	—	USA, North Carolina
	JFA13084 (holotype)	MZ663780	—	—	—	USA, Tennessee
C. caesiifolius	MICH10326 (holotype)	MZ580462	—	—	—	USA, Washington
	JMB10-20-2007-15	FJ717517	FJ717517	—	—	USA, Washington
	TN12-066	MZ580463	—	—	—	USA, California
C. campanianomalus	HMAS 275110	**ON254478**	**OR105164**	—	—	China, Sichuan
	HMAS 254399	**ON254476**	**OR105162**	**OR137711**	—	China, Sichuan
	HMAS 275083	**ON254477**	**OR105163**	—	—	China, Sichuan
	HMAS 254393	**ON254475**	**OR105161**	—	—	China, Sichuan
	HMJAU 48692	**ON254473**	**OR105159**	**OR137709**	**OR137790**	China, Xizang
	HMJAU 48693	**ON254474**	**OR105160**	**OR137710**	**OR137791**	China, Xizang
	HMJAU 48748 (holotype)	**ON254479**	**OR105165**	**OR137712**	**OR137792**	China, Xizang
	wii1A4sp9 (as Uncultured *Cortinarius*)	KC679831	—	—	—	China, Taiwan
C. caninus	HMJAU 44258	**ON254441**	**OR105129**	**OR137682**	**OR137763**	China, Heilongjiang
	HMJAU 44367	**ON254442**	**OR105130**	**OR137683**	—	China, Heilongjiang
	HMJAU 44497	**ON254443**	**OR105131**	**OR137684**	**OR137764**	China, Inner Mongolia
	HMAS 268204	**ON254444**	—	—	—	China, Sichuan
	HMJAU 44279	**ON254445**	**OR105132**	**OR137685**	**OR137765**	China, Heilongjiang
	HMJAU 44371	**ON254446**	**OR105133**	**OR137686**	**OR137766**	China, Heilongjiang
	HMJAU 44372	**ON254447**	**OR105134**	**OR137687**	**OR137767**	China, Heilongjiang
	HMJAU 44373	**ON254448**	**OR105135**	**OR137688**	**OR137768**	China, Heilongjiang
	HMJAU 48714	**ON254449**	**OR105136**	**OR137689**	**OR137769**	China, Inner Mongolia
	JFA7985	MZ580454	—	—	—	Canada, Ontario
	JFA12434	MZ580456	—	—	—	USA, Wyoming
	CFP627 (epitype)	KX302250	—	—	—	Sweden
C. cinnamomeolilacinus	rpr-487	MW363482	—	—	—	China, Yunnan

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
	HKAS 122446 (as *C. caesiifolius*)	ON794298	—	—	—	China, Yunnan
	TCWH 007 (holotype)	OQ913384	—	—	—	China, Yunnan
	Li 161015-10	OQ913385	—	—	—	China, Guizhou
	Li 180825-21	OQ913390	—	—	—	China, Yunnan
	Li 130908-29	OQ913391	—	—	—	China, Yunnan
C. clackamasensis	JFA11616 (holotype)	MZ580452	—	—	—	USA, Oregon
	TN11-451	MZ580453	—	—	—	USA, Washington
	OSC114858 (as *C. barlowensis*)	EU669315	—	—	—	USA, Oregon
C. clintonianus	NYS-F-000786 (holotype)	MZ580450	—	—	—	USA, New York
	MIN896348	MZ663784	—	—	—	USA, Minnesota
	DBB21645	MZ663783	—	—	—	Canada, British Columbia
C. deceptivus	iNAT56430786	MT939445	—	—	—	USA, New York
	NL-5180	MZ663785	—	—	—	USA, New York
	MICH10343 (syntype)	MZ663788	—	—	—	USA, New York
C. durifoliorum	PDD101829 (holotype)	KJ635210	MW263597	—	—	New Zealand
	PDD107700	KT875205	MW263614	MH141033	MH141028	New Zealand
C. epsomiensis	HMJAU 44242	**ON254422**	**OR105107**	**OR137662**	**OR137746**	China, Heilongjiang
	K(M)74963 (holotype)	MK010952	—	—	—	UK
	HMJAU 44505	**ON254423**	**OR105108**	**OR137663**	**OR137747**	China, Inner Mongolia
	HMAS 291356 (as *C. pastoralis*)	MW555545	**OR105109**	**OR137664**	—	China, Hebei
	HMAS 291465 (as *C. pastoralis*)	MW555546	**OR105110**	**OR137665**	—	China, Beijing
	HMAS 291466 (as *C. pastoralis*)	MW555547	—	—	—	China, Beijing
	TN06-165 (as *C. pastoralis*, holotype)	KX302258	—	—	—	Finland
C. ferrusinus	JB8106 13 (holotype)	KY657254	—	—	—	Spain
C. harvardensis	MQ17058-QFB29566	MN751559	—	—	—	Canada, Québec
	NL-5415 (holotype)	MZ663789	—	—	—	USA, Massachusetts
	MQ18-HL1449-QFB30070	MN751560	—	—	—	Canada, Québec
C. huddartensis	DBB12118 (holotype)	MZ663790	—	—	—	USA, California
	src174 (as *Cortinarius* sp.)	DQ974719	—	—	—	USA, California

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
C. jonimitchelliae	HL03-339 (holotype)	KX302253	—	—	—	Sweden
C. kranabetteri	HMJAU 48644	**ON254398**	**OR105086**	**OR137645**	**OR137725**	China, Heilongjiang
	HMJAU 48645	**ON254399**	—	**OR137646**	**OR137726**	China, Heilongjiang
	HMJAU 48646	**ON254400**	**OR105087**	**OR137647**	**OR137727**	China, Heilongjiang
	HMJAU 48647	**ON254401**	**OR105088**	**OR137648**	**OR137728**	China, Inner Mongolia
	HMJAU 48643	**ON254402**	**OR105089**	**OR137649**	**OR137729**	China, Inner Mongolia
	HMAS 277353	**ON254404**	—	—	—	China, Xizang
	HMAS 277354	**ON254403**	**OR1050890**	**OR137650**	—	China, Xizang
	HMJAU 48648	**ON254405**	**OR1050891**	**OR137651**	**OR137730**	China, Inner Mongolia
	TN11-287 (holotype)	MZ580449	—	—	—	USA, Alberta
	S705 (as *Cortinarius* sp.)	UDB0181521	—	—	—	Estonia
	S483 (as *Cortinarius* sp.)	UDB0126937	—	—	—	Estonia
	F16435 (as *Cortinarius* sp.)	FJ039656	FJ039656	—	—	Canada, British Columbia
	F16436 (as *Cortinarius* sp.)	FJ039657	FJ039657	—	—	Canada, British Columbia
C. latiodistributus	DB6139 (holotype)	MZ663791	—	—	—	Sweden
	JFA13487	MZ663793	—	—	—	USA, Washington
	YM187 (as *Cortinarius* sp.)	AB848436	—	—	—	Japan, Yamanashi
C. lebretonii	770	JF907863	—	—	—	Italy
C. lepidopus	HMJAU 48640	**ON254480**	**OR105166**	**OR137713**	**OR137793**	China, Heilongjiang
	HMJAU 48641	**ON254481**	**OR105167**	—	**OR137794**	China, Heilongjiang
	HMJAU 48715	**ON254482**	**OR105168**	**OR137714**	**OR137795**	China, Inner Mongolia
	DB6253	MZ663794	—	—	—	Hungary
	LE315536	MN308207	—	—	—	Russia, Altai Republic
	HMAS 275397	**ON254486**	**OR105172**	—	**OR137798**	China, Xizang
	HMAS 275384	**ON254485**	**OR105171**	**OR137717**	**OR137797**	China, Xizang
	HMAS 271997	**ON254483**	**OR105169**	**OR137715**	**OR137796**	China, Xizang
	HMAS 272035	**ON254484**	**OR105170**	**OR137716**	—	China, Xizang
	AT2005124 (as *C. anomalus*)	UDB002227	—	—	—	Sweden
C. lividomalvaceus	JMT-15102001 (holotype)	KY315416	—	—	—	France

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
	AL10/303	KY315417	—	—	—	Hungary
C. luteoperonatus	JMB2011112610	KY315415	—	—	—	France
C. microalbocyaneus	HMJAU 48649	**ON254461**	**OR105147**	**OR137700**	**OR137779**	China, Jilin
	HMJAU 48706 (holotype)	**ON254462**	**OR105148**	**OR137701**	**OR137780**	China, Jilin
	HMJAU 48652	**ON254463**	**OR105149**	**OR137702**	**OR137781**	China, Jilin
	HMJAU 48704	**ON254464**	**OR105150**	**OR137703**	**OR137782**	China, Jilin
	HMJAU 48705	**ON254465**	**OR105151**	**OR137704**	**OR137783**	China, Jilin
	HMJAU 48724	**ON254466**	**OR105152**	**OR137705**	**OR137784**	China, Jilin
	HMJAU 48726	**ON254467**	**OR105153**	**OR137706**	**OR137785**	China, Jilin
	OUC97234 (as *C. alboviolaceus*)	DQ097877	—	—	—	Canada, British Columbia
	MQ21-HRL1598-QFB32934 (as *Cortinarius* sp.)	MW845268	—	—	—	Canada, Québec
	CNV8 (as *Cortinarius* sp.)	MT345185	—	—	—	USA, New Hampshire
	YM1162 (as Uncultured *Cortinarius*)	LC175062	—	—	—	Japan
	HMJAU 60641 (as *C. anomalus*)	OL891464	—	—	—	China, Jilin
	MQ22-QFB33093-HRL3520 (as *Cortinarius* sp.)	OQ321992	—	—	—	Canada, Québec
C. modestus	MQ17140-QFB29648	MN751561	—	—	—	Canada, Québec
	NYS-F-001966 (holotype)	MZ580446	—	—	—	USA, New York
	TN10-035	MZ580447	—	—	—	Canada, Québec
C. neocaninus	HMJAU 48688	**ON254450**	**OR105137**	**OR137690**	**OR137770**	China, Heilongjiang
	HMJAU 48689	**ON254451**	**OR105138**	**OR137691**	**OR137771**	China, Xinjiang
	HMJAU 44495	**ON254452**	**OR105139**	**OR137692**	**OR137772**	China, Heilongjiang
	HMJAU 48691 (holotype)	**ON254453**	**OR105140**	**OR137693**	**OR137773**	China, Inner Mongolia
	HMAS 274789	**ON254454**	—	**OR137694**	**OR137774**	China, Xinjiang
	HMJAU 48690	**ON254455**	**OR105141**	**OR137695**	**OR137775**	China, Inner Mongolia
	S594 (as *Cortinarius* sp.)	UDB0168416	—	—	—	Estonia
	G4278 (as *Cortinarius* sp.)	UDB0513824	—	—	—	Estonia
	TAAM128969 (as *Cortinarius* sp.)	UDB034762	—	—	—	Estonia
	S703 (as *Cortinarius* sp.)	UDB0180344	—	—	—	Estonia
	S682 (as *Cortinarius* sp.)	UDB0176168	—	—	—	Estonia

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
C. nettieae	JFA9613 (holotype)	MZ580442	—	—	—	USA, Washington
	JFA8747	MZ580443	—	—	—	USA, Oregon
	TN09-176	MZ580445	—	—	—	USA, Oregon
C. ochraceodiscus	DJM2195 (holotype)	MZ663795	—	—	—	USA, Minnesota
	DJM2194	MZ663796	—	—	—	USA, Minnesota
C. parvulosquamolosus	UCH AC371	OP339753	—	—	—	Panama
C. pelerinii	XC2012-21 (holotype)	MH784627	—	—	—	France
C. perrotensis	TENN071126 (holotype)	KX897405	—	—	—	Canada, Québec
	HMJAU 48662	**OR140843**	**OR140846**	**OR161812**	**OR161813**	China, Heilongjiang
C. perrugatus	771	JF907864	—	—	—	Italy
C. perviolaceus	NL-5173	MZ663798	—	—	—	USA, Massachusetts
	FLAS-F32992 (holotype)	MZ580438	—	—	—	USA, Florida
	FLAS-F61753 (as *Cortinarius* sp.)	MH281882	—	—	—	USA, Florida
C. qilianensis	HMJAU 48666	**ON254414**	**OR105100**	**OR137659**	**OR137739**	China, Gansu
	HMJAU 48716	**ON254415**	**OR105101**	**OR137660**	**OR137740**	China, Xinjiang
	HMJAU 44508 (holotype)	**ON254416**	**OR105102**	**OR137661**	**OR137741**	China, Gansu
	HMJAU 44509	**ON254417**	**OR105103**	—	**OR137742**	China, Gansu
C. rarus	DBB04712 (holotype)	MZ663800	—	—	—	USA, California
	JLF8707 (as *Cortinarius* sp.)	MW341328	—	—	—	USA, Oregon
	JLF8771 (as *Cortinarius* sp.)	MW341331	—	—	—	USA, Oregon
C. rattinoides	PDD88283 (holotype)	JX000375	JX000406	—	—	New Zealand
C. robustianomalus	HMAS 254763 (holotype)	**ON254459**	**OR105145**	**OR137698**	**OR137778**	China, Sichuan
	HMAS 254764	**ON254460**	**OR105146**	**OR137699**	—	China, Sichuan
C. rufolilacinus	HMJAU 48739 (holotype)	**ON254456**	**OR105142**	**OR137696**	**OR137776**	China, Xizang
	HMJAU 48745	**ON254457**	**OR105143**	**OR137697**	**OR137777**	China, Xizang
	HMJAU 48746	**ON254458**	**OR105144**	—	—	China, Xizang
	ZJ0003SMJ01 (as *C. caninus*)	KU836522	—	—	—	China
C. sclerophyllarum	HO-A20430A6 (paratype)	AY669637	AY669637	—	—	Australia
C. sericeolazulinus	JFA12053 (holotype)	EF420146	—	—	—	Costa Rica

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
C. subalbocyaneus	HMJAU 44282	**ON254424**	**OR105111**	**OR137666**	**OR137748**	China, Jilin
	HMJAU 48659 (holotype)	**ON254425**	**OR105112**	**OR137667**	**OR137749**	China, Inner Mongolia
	HMJAU 48660	**ON254426**	**OR105113**	—	**OR137750**	China, Jilin
	HMJAU 48661	**ON254427**	**OR105114**	**OR137668**	**OR137751**	China, Jilin
	HMJAU 48728	**ON254428**	**OR105115**	**OR137669**	**OR137752**	China, Jilin
	HMJAU 48729	**ON254429**	**OR105116**	**OR137670**	**OR137753**	China, Jilin
	HMJAU 48730	**ON254430**	**OR105117**	**OR137671**	**OR137754**	China, Jilin
	HMJAU 48731	**ON254431**	**OR105118**	**OR137672**	**OR137755**	China, Jilin
	HMJAU 48732	**ON254432**	**OR105119**	**OR137673**	**OR137756**	China, Jilin
	HMJAU 48733	**ON254433**	**OR105120**	**OR137674**	**OR137757**	China, Jilin
	F18506 (as *C.* aff. *caninus*)	FJ157104	FJ157104	—	—	Canada, British Columbia
	HB29 (as *Cortinarius* sp.)	UDB0706856	—	—	—	Estonia
	228A (as *Cortinarius* sp.)	UDB031695	—	—	—	Canada, British Columbia
	szYM140 (as Uncultured *Cortinarius*)	LC547581	—	—	—	Russia, Amur Oblast
C. subanomalus	HMAS 277626	**ON254488**	**OR105174**	—	—	China, Xizang
	HMJAU 48752 (holotype)	**ON254489**	**OR105175**	—	**OR137800**	China, Yunnan
C. subclackamasensis	HMJAU 48642	**ON254390**	**OR105079**	**OR137639**	**OR137721**	China, Inner Mongolia
	CFSZ 18827	**ON254391**	—	—	—	China, Inner Mongolia
	HMJAU 48757	**ON254392**	**OR105080**	**OR137640**	**OR137722**	China, Zhejiang
	HMJAU 48718	**ON254393**	**OR105081**	**OR137641**	**OR137723**	China, Jilin
	HMAS 291362	**ON254394**	**OR105082**	**OR137642**	**OR137724**	China, Hebei
	HMAS 281433	**ON254395**	**OR105083**	—	—	China, Hebei
	HMAS 291518	**ON254396**	**OR105084**	**OR137643**	—	China, Hebei
	HMAS 249872	**ON254397**	**OR105085**	**OR137644**	—	China, Hebei
	HBAU 15665 (as *C. caninus*)	MW862366	—	—	—	China, Hebei
	HBAU 15437 (as *C. xanthocephalus*)	MW862347	—	—	—	China, Hebei
	110116MFBPC490 (as *Cortinarius* sp.)	MW554249	—	—	—	China
	Li 170818-16 (holotype) (as *Cortinarius* sp.)	OQ913394	—	—	—	China
	Li 170818-01 (as *Cortinarius* sp.)	OQ913397	—	—	—	China

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
C. suecicolor	PDD74698 (holotype)	JX000360	JX000391	—	—	New Zealand
C. tabularis	HMJAU 44248	**ON254468**	**OR105154**	**—**	**OR137786**	China, Heilongjiang
	HMJAU 44249	**ON254469**	**OR105155**	**OR137707**	**OR137787**	China, Heilongjiang
	HMJAU 44269	**ON254470**	**OR105156**	**—**	**OR137788**	China, Heilongjiang
	HMJAU 44484	**ON254471**	**OR105157**	**OR137708**	**OR137789**	China, Heilongjiang
	HMJAU 44506	**ON254472**	**OR105158**	—	—	China, Heilongjiang
	CFP949 (epitype)	KX302275	—	—	—	Sweden
	TN11-219	MZ580437	—	—	—	USA, Alaska
C. tenneovelatus	UCH AC415	OP265183	—	—	—	Panama
C. tetonensis	JFA10350 (holotype)	MZ580436	—	—	—	USA, Wyoming
	JFA10349 (as *C. caninus*)	U56024	—	—	—	USA, Wyoming
	N343 (as *C.* cf. *alpinus*)	HQ445618	**—**	**—**	**—**	Norway, Svalbard
C. tristis s. Garnica	TUB011917	AY669648	AY669648	—	—	Chile
C. tropicus	tcqushi006 (holotype)	OQ913379	—	—	—	China, Yunnan
	Li 150728-56	OQ913380	—	—	—	China, Yunnan
	Li 150728-63	OQ913381	—	—	—	China, Yunnan
C. vernalianomalus	HMJAU 48770 (holotype)	**ON254487**	**OR105173**	**OR137718**	**OR137799**	China, Guangxi
	rxsbn-456 (as *C. rigens*)	MW374218	—	—	—	China, Yunnan
C. violaceobrunneus	UCH AC41	OP265182	—	—	—	Panama
C. xizangensis	HMAS 254260	**ON254490**	—	—	**OR137801**	China, Xizang
	HMAS 274219	**ON254491**	**OR105176**	**OR137719**	**OR137802**	China, Xizang
	HMAS 275210	**ON254495**	**OR105177**	**OR137720**	**OR137805**	China, Xizang
	HMAS 254415	**ON254493**	—	—	—	China, Xizang
	HMAS 275038	**ON254494**	—	—	**OR137804**	China, Xizang
	HMAS 254261	**ON254492**	—	—	**OR137803**	China, Xizang
	HMAS 274227 (holotype)	**ON254496**	—	—	**OR137806**	China, Xizang
	HMAS 274980	**ON254497**	—	—	**OR137807**	China, Xizang
Cortinarius sp1	MHHNU 8228 (as *C. caesiifolius*)	MK250940	—	—	—	China, Hu'nan
	SC20170921-025	OQ920005	—	—	—	China, Guizhou

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
Cortinarius sp2	170805-35	OQ920003	—	—	—	China, Yunnan
Cortinarius sp3	190527-01	OQ920004	—	—	—	China, Xizang
Cortinarius sp4	YM73 (as Uncultured *Cortinarius*)	LC175532	—	—	—	Japan, Hokkaido
Cortinarius sp5	Pj3-mOTU024 (as Uncultured fungus)	LC260432	—	—	—	Japan
Cortinarius sp6	YM873 (as *Cortinarius* sp.)	AB848465	—	—	—	Japan, Yamanashi
Cortinarius sp7	ME12_D2 (as *Cortinarius* sp.)	JX436862	—	—	—	USA, Alaska
	MENJG096 (as Uncultured clone)	JF304376	—	—	—	Norway
	HV_D8_8 (as Uncultured clone)	JX630733	—	—	—	USA, Alaska
Cortinarius sp8	JLP2431 (as Uncultured *Cortinariaceae*)	DQ377379	—	—	—	USA, Oregon
Cortinarius sp9	OUC97199 (as *C. spilomeus*)	DQ093855	—	—	—	Canada, British Columbia
Cortinarius sp10	7_70M6 (as Uncultured clone)	JQ393041	—	—	—	USA, California
Cortinarius sp11	MQ17280-QFB29788 (as *C.* aff. *tabularis*)	MN750926	—	—	—	Canada, Québec
	MQ17300-QFB29808 (as *C.* aff. *tabularis*)	MN750925	—	—	—	Canada, Québec
Cortinarius sp12	UBC-F17161 (as *C. holophaeus*)	GQ159904	GQ159904	—	—	Canada, British Columbia
	UBC-F17157 (as *C. rigens*)	GQ159900	GQ159900	—	—	Canada, British Columbia
Cortinarius sp13	GO-2010-171 (as *Cortinarius* sp.)	KC152091	—	—	—	Mexico, Distrito Federal
Cortinarius sp14	TN10-141 (as *Cortinarius* sp.)	MZ821030	—	—	—	Canada, Québec
Cortinarius sp15	MQ21-HRL2477-QFB32937 (as *Cortinarius* sp.)	MW845269	—	—	—	Canada, Québec
Cortinarius sp16	Russell iNaturalist 8602253 (as *Cortinarius* sp.)	MZ710565	—	—	—	USA, Indiana
Cortinarius sp17	ANT183-QFB28611 (as *Cortinarius* sp.)	MN992356	—	—	—	Canada, Québec
Cortinarius sp18	PERTH06437109 (as *Cortinarius* sp.)	MG553013	—	—	—	Australia
Cortinarius sp19	PDD10596 (as *Cortinarius* sp.)	MH101576	MH108414	MH141032	MH141027	New Zealand
Cortinarius sp20	PDD107512 (as *Cortinarius* sp.)	MG019346	—	—	—	New Zealand
Cortinarius sp21	PERTH06659462 (as *Cortinarius* sp.)	MG553083	—	—	—	Australia
Cortinarius sp22	NVE433 (as *Cortinarius* sp.)	KF937326	—	—	—	Colombia
Cortinarius sp23	NVE219 (as *Cortinarius* sp.)	KF937328	—	—	—	Colombia
sect. *Bolares*						
C. bolaris	CFP1008 (neotype)	KX302233	—	—	—	Sweden
	TUB 0118524	AY669596	AY669596	KJ403795	—	Germany

Table 1. (Continued).

Sections and Species	Voucher	nrITS acc. No	nrLSU acc. No	*rpb1* acc. No	*rpb2* acc. No	Locality
sect. *Spilomei*						
C. spilomeus	TUB 011523	AY669654	AY669654	—	—	Germany
	CFP1137 (neotype)	KX302267	—	—	—	Sweden
Cortinarius sp.	TU105220 (as *C. spilomeus*)	UDB015906	—	—	—	Sweden
	SWUBC741 (as Uncultured clone)	DQ481671	—	—	—	Canada, British Columbia
section incertae sedis						
C. eunomalus	PDD94040 (holotype)	JQ287690	—	—	—	New Zealand

was further edited and visualized with MEGA v. 7 (Kumar *et al.* 2016) and Adobe Illustrator CS4.

RESULTS

Phylogenetic analyses

A total of 293 specimens, including 61 type specimens, were analysed in this study. This resulted in a total of 109 nrITS, 100 nrLSU, 83 *rpb1* and 88 *rpb2* sequences were newly generated from vouchered specimens from China. The concatenated four-loci dataset including binary data from gap coding comprises 3830 characters. Alignments are available in Figshare (doi: 10.6084/m9.figshare.19882870). The clustering of the species in both ML and BI phylogenetic trees from the ML and BI analyses was supported with congruent topologies. Some topological differences in the deeper branches were, however, noticed. The resulting phylogenetic tree based on our analyses is showed in Fig. 1. Support values were showed on the branch when the ML bootstrap proportion (MLBP) ≥ 70 % and Bayesian posterior probabilities (BPP) ≥ 0.90.

The phylogenetic analyses showed three sections and one singleton species. Section *Anomali* received high support in our analyses (MLBP/BPP = 100 %/1), as well as sect. *Spilomei* (100 %/1), and sect. *Bolares* (100 %/1) as outgroup. A total of 66 described species and 23 phylogenetic species of sect. *Anomali* were analysed in this study. Based on the phylogenetic analyses, most species are monophyletic and strongly supported, except that several cases of species limit were not fully resolved. *Cortinarius albocyaneus* and *C. caeruleoanomalus* are paraphyletic. *Cortinarius nettiaea*, *C. tabularis* and *Cortinarius* sp11 are paraphyletic, and got together with *C. anomalopacificus* and *C. brevissimus* with a strong support (100 %/1). *Cortinarius modestus* and the very closely related *C. lepidopus* are paraphyletic.

Section *Anomali* is split into six clades, of which the five small, basal clades consist of mostly Australasian and a few South American species, *C. tristis* s. Garnica, *Cortinarius* sp20, and *Cortinarius* sp21 remain singleton species-level lineages (clade I, clade II, and clade IV), respectively. Three Australasian species *C. durifoliorum*, *C. rattinoides*, and *C. sclerophyllarum* together with Colombian uncultured species *Cortinarius* sp22 and *Cortinarius* sp23 formed clade III with strong support (100 %/1). *Cortinarius suecicolor*, *Cortinarius* sp18, and *Cortinarius* sp19 gathered in clade V with high support (90 %/1). The mostly Northern Hemisphere species clustered into the largest clade VI with high support (98 %/1). In this clade, most subclades can be recognized with moderate to strong support, except several species remain singletons or without enough support. *Cortinarius caesiifolius*, *C. perviolaceus*, *C. rarus*, and *C. tenneovelatus* are singletons. *Cortinarius albomalus*, *C. barlowensis*, *C. luteoperonatus*, *Cortinarius* sp8, and *Cortinarius* sp17 clustered together but with weak support, and so did *C. anocorium* and *C. anomalellus*, as well as *Cortinarius* sp2, *Cortinarius* sp6, and *Cortinarius* sp16.

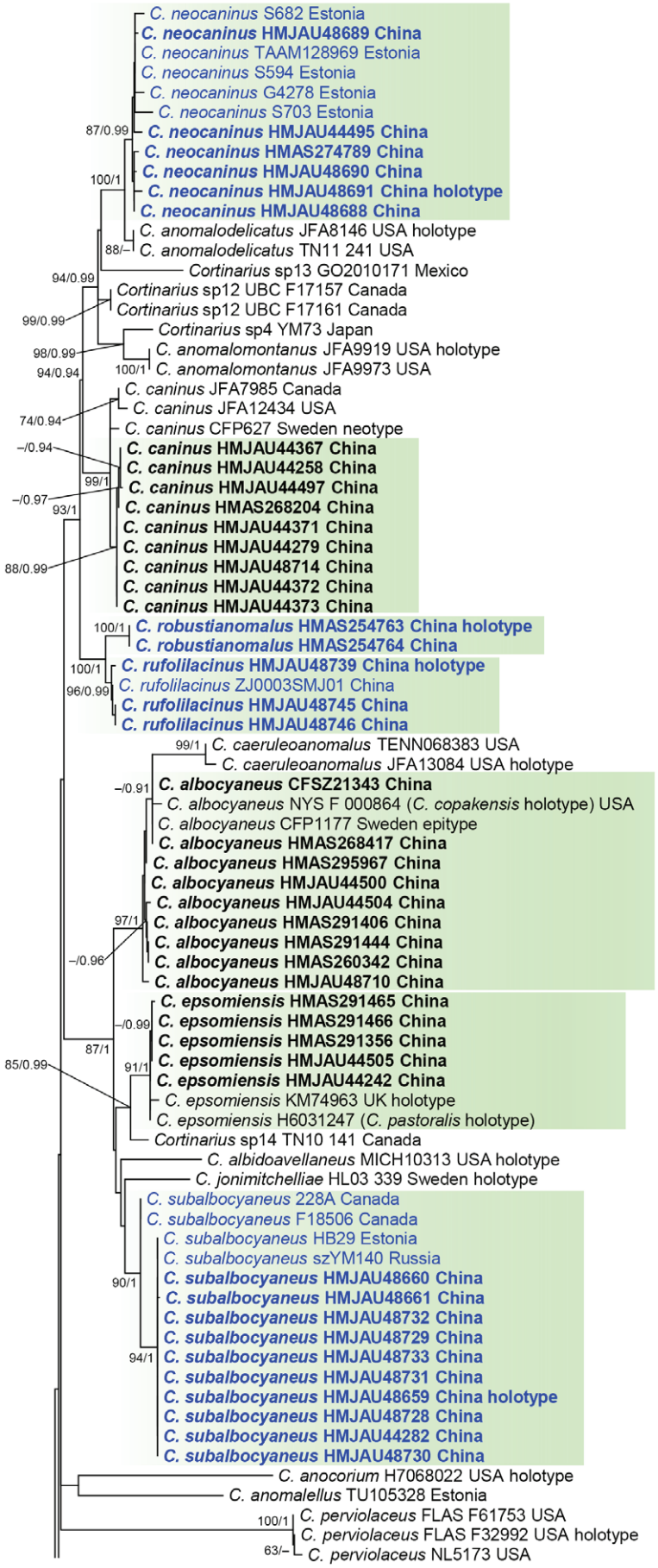

Fig. 1. Maximum Likelihood (ML) phylogenetic tree showing the species-level relationship in sect. *Anomali* based on nrITS+ nrLSU+*rpb1*+*rpb2* sequences analyses in RAxML and MrBayes. Clades containing the described Chinese species are highlighted in the green boxes, while the newly described species are written in blue. Further undescribed species in China are written in green. Sequences generated for this study are in **boldface**. The ML bootstrap proportion (MLBP) ≥ 70 % as well as Bayesian posterior probabilities (BPP) ≥ 0.90 are indicated above branches (MLBP/BPP). Scale bar indicates 0.02 expected changes per site.

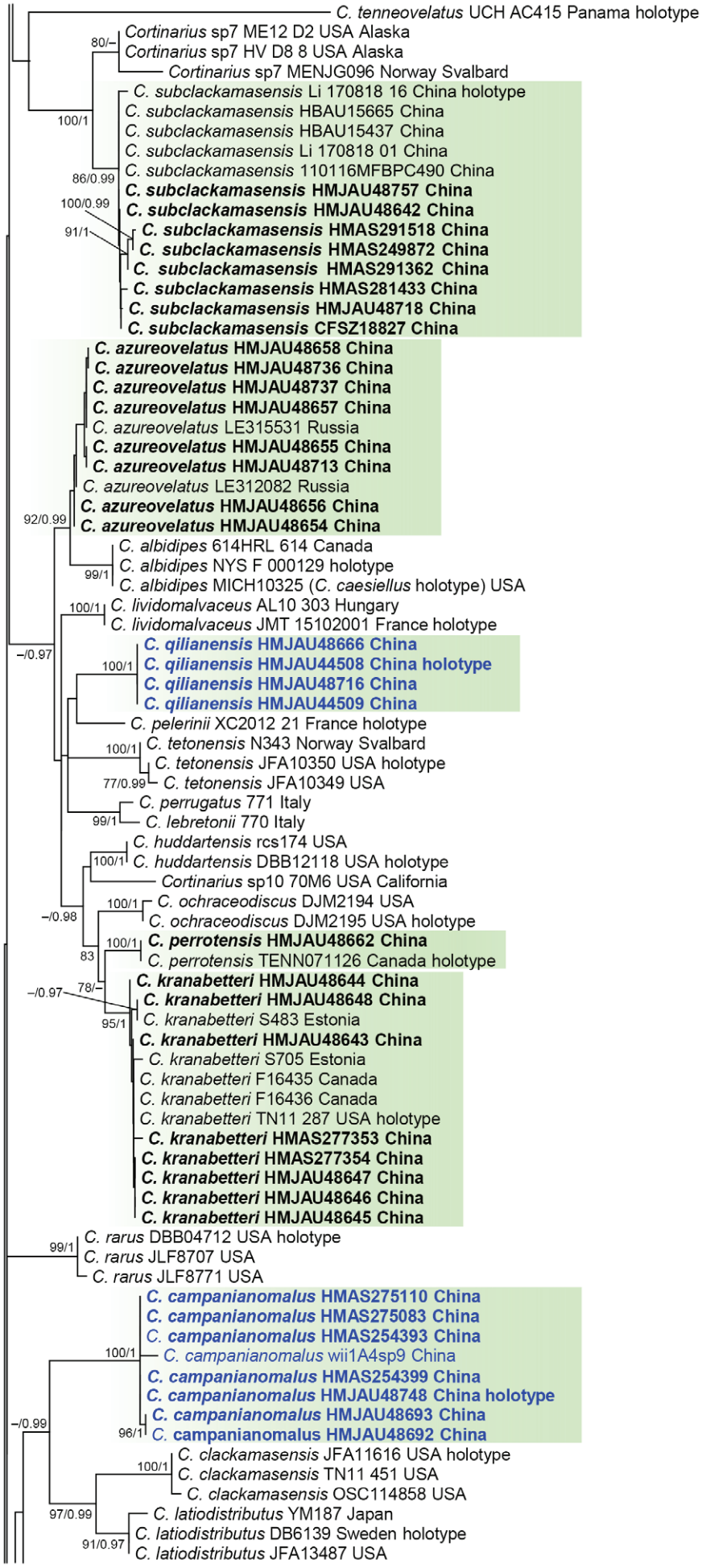

Fig. 1. (Continued).

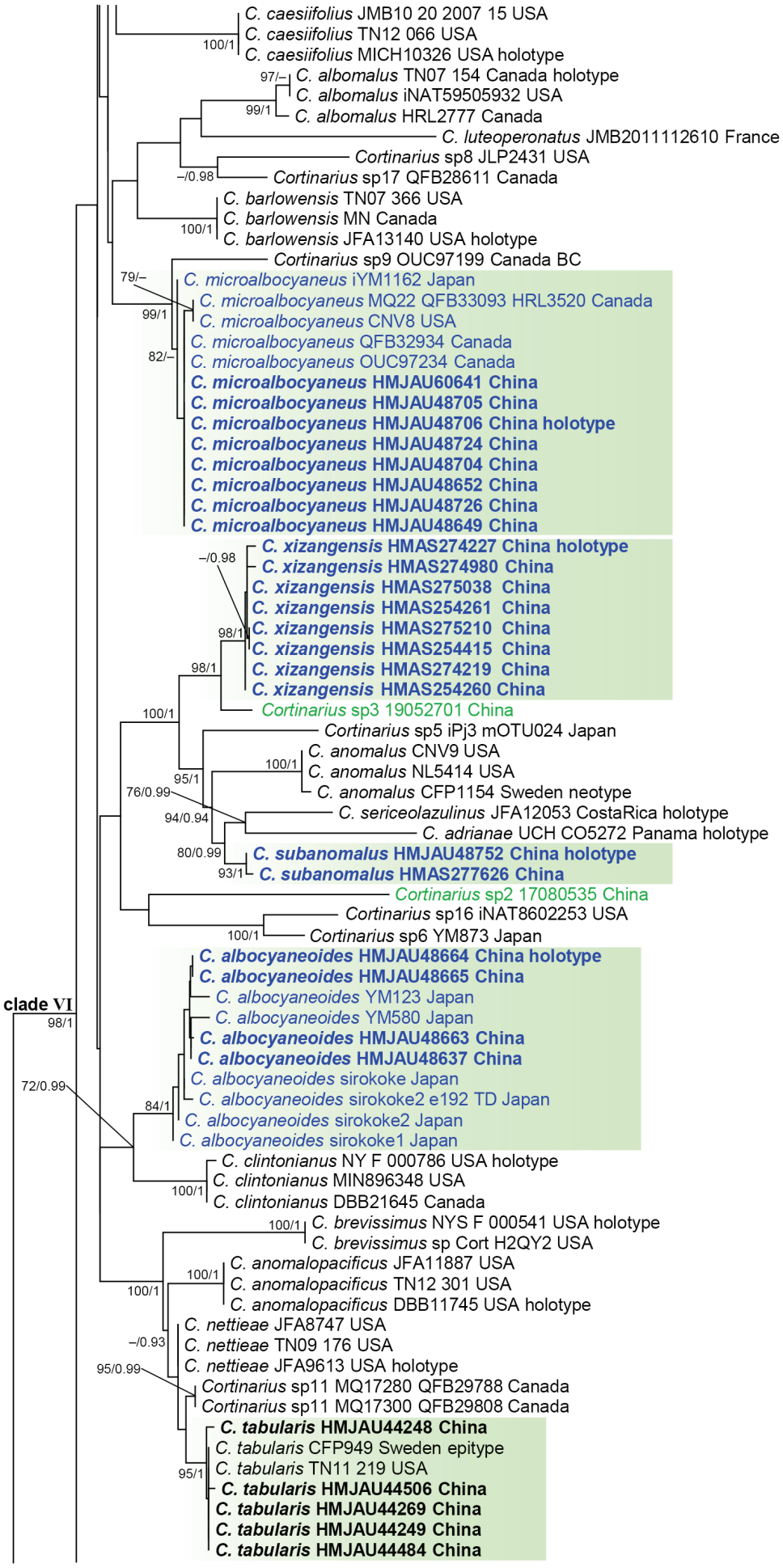

Fig. 1. (Continued).

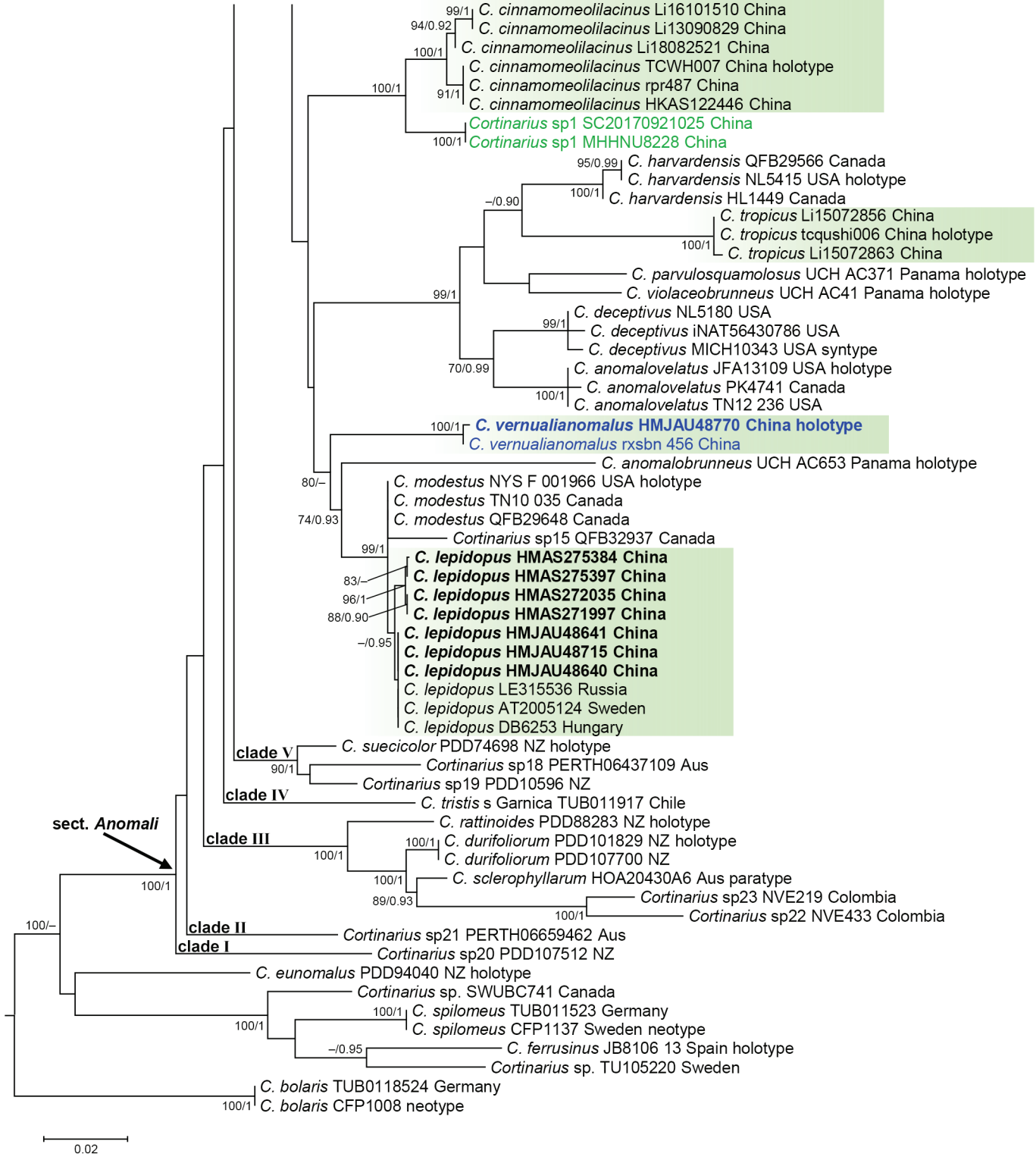

Fig. 1. (Continued).

TAXONOMY

A total of 22 sect. *Anomali* species from China, including eleven new species, six new records, and five known species, were reported based on morphological, ecological, and phylogenetic data. The species are treated in alphabetical order.

Cortinarius* sect. *Anomali Konrad & Maubl., *Icon. Sel. Fung*. **6**: 169. 1930.
Type species: *Cortinarius anomalus* (Fr.) Fr.
Synonym: *Cortinarius* sect. *Azurei* Kühner & Romagn. ex Melot. *Doc. Mycol*. **20**: 97. 1989.
Type species: *Cortinarius azureus* Fr.

Basidiomata small-, medium- to large-sized; *pileus* greyish, yellowish to brownish, some species with olive or bluish to violaceous tinges; *lamellae* often greyish blue, bluish to violaceous when young; *stipe* often whitish at first, then discolouring yellowish, bluish at the apex, base usually enlarged at first, then cylindrical to clavate, basal mycelium white to bluish; *universal veil* white, bluish, yellowish or grey, spares to copious; *context* thin to thick, white at first, with

Fig. 2. Basidiomata. **A.** *Cortinarius albocyaneoides* HMJAU 48664 (holotype). **B.** *C. albocyaneus* HMJAU 44499. **C.** *C. azureovelatus* HMJAU 48736. **D.** *C. campanianomalus* HMJAU 48692. **E.** *C. campanianomalus* HMJAU 48748 (holotype). **F.** *C. caninus* HMJAU 44372. **G.** *C. epsomiensis* HMJAU 44505. **H.** *C. kranabetteri* HMJAU 48644. Photos by M.L. Xie. Scale bars = 20 mm.

bluish tinges at the stipe apex, usually discolouring yellowish, sometimes hollow in the stipe; *basidiospores* globoid to subgloboid or broadly ellipsoid to ellipsoid, mostly moderately verrucose, rarely weakly or coarsely verrucose; *pileipellis* typically duplex; *clamp connections* present; associated with broadleaf trees, conifers, shrubs, and subshrubs.

Cortinarius albocyaneoides M.L. Xie, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843745. Figs 2A, 6A, 7A.

Etymology: The name refers to morphological similarity with *Cortinarius albocyaneus*.

Typus: **China**, Inner Mongolia Autonomous Region, Genhe County, Mangui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 630 m, 24 Aug. 2017, *M.L. Xie* (**holotype** HMJAU 48664).

Pileus 16–64 mm diam., at first convex, later plane to plano-convex, margin persistently incurved, becoming ± wavy, surface somewhat viscid and weakly hygrophanous when moist, somewhat wrinkled, at first with some greyish white universal veil, especially at the margin, smooth when mature, greyish lilac to dull violet grey when young, then slightly greyish ochraceous to greyish brown, with violet tinge. *Lamellae* subadnate at first, then emarginate, moderately crowded, greyish violet when young, later greyish ochraceous to brown, edges somewhat paler, even. *Stipe* 50–95 mm long, 6–10 mm thick, cylindrical to subcylindical, slightly thickened at the base, surface shiny white fibrillose, violet tinged when young, later dull whitish to yellowish. *Universal veil* whitish to greyish white, forming fibrils on pileus surface and sock like sheath on the stipe when young, later becoming yellowish. *Context* fleshy, hygrophanous when moist, soft, becoming hollow, at first greyish violet at the pileus and upper part of stipe, yellowish below, becoming yellowish in age. *Odour* indistinct. *Taste* mild. *Basidiospores* (6.9–)7.3–8.7 × 5.8–6.8 µm, Q = 1.11–1.34, Xav. = 7.6–7.9 × 6.2–6.5 µm, Qav. = 1.20–1.25, subgloboid to broadly ellipsoid, moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae loosely interwoven, hyaline or yellowish to yellowish brown, 2–10.5 µm wide, smooth; hypocutis well developed, hyphae 10–22 µm wide, hyaline or slightly yellowish brown, somewhat cellular, smooth. *Clamp connections* present.

Ecology and distribution: Solitary or gregarious in mixed forests of *Larix gmelinii* and *Betula platyphylla*. Known from Northeast China, as well as from Japan based on molecular data.

Additional specimens examined: **China**, Inner Mongolia Autonomous Region, Genhe County, Mangui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 630 m, 24 Aug. 2017, *M.L. Xie*, HMJAU 48637, HMJAU 48663; Genhe County, Mangui Town, Ningcuishan Park, in mixed forests of *Larix gmelinii* and *Betula platyphylla*, alt. 820 m, 25 Aug. 2017, *M.L. Xie*, HMJAU 48665

Additional nrITS sequences data from public sequence repositories: **Japan**, Yamanashi, Mount Fuji, AB848433, YM580 from root tip, as uncultured *Cortinarius* in GenBank; Morioka, *Pinus densiflora*, AB251830, Pdmt24 as uncultured ectomycorrhizal fungus in GenBank; Hokkaido, *Abies sachalinensis*, LC711478, a317_GR1_ma_td_4_1_sirokoke2_e192_TD from root tip, as uncultured fungus in GenBank, LC711479, a207_GR1_chi7_1_sirokoke1 from root tip, as uncultured fungus in GenBank, LC711480, a302_GR1_chi3_2_sirokoke2 from root tip, as uncultured fungus; LC711481, a102_PC1_chi7_2_sirokoke from root tip, as uncultured fungus in GenBank.

Notes: *Cortinarius albocyaneoides* produces small- to medium-sized basidiomata, a greyish violet to greyish brown pileus, and subgloboid to broadly ellipsoid basidiospores. The Chinese specimens occur in mixed forests of *Larix gmelinii* and *Betula platyphylla*. Moreover, based on the root data from Japan, this species also occurs with *Pinus* and *Abies*. Its appearance is similar to that of *C. albocyaneus* and *C. epsomiensis.* However, the basidiospores of *C. albocyaneus* and *C. epsomiensis* are rather large, on average 8.5–9 × 6–7.5 µm and 8.5–9 × 7–8 µm, respectively (Dima *et al.* 2016). The nrITS sequences of all Chinese specimens are identical and the holotype differs from other known members of sect. *Anomali* by at least 17 substitutions and indel positions. Six nrITS sequences in GenBank that originated from Japan, AB848433 from an ectomycorrhizal root tip in the Fuji Mountains, AB251830 from an uncultured specimen in Morioka and LC711478–LC711481 from ectomycorrhizal root tips of *Abies sachalinensis* in Hokkaido, are clustered with Chinese collections and considered as *C. albocyaneoides*.

Cortinarius albocyaneus Fr., *Monogr. Hymenomyc. Suec. (Upsaliae)* **2**: 62. 1863. Figs 2B, 6B, 7B.

Pileus 37–65 mm diam., sometimes up to 100 mm, at first convex, later plane to plano-convex, margin persistently incurved, surface somewhat viscid and weakly hygrophanous when young or moist, somewhat shiny to distinctly glittery when dry, at first with veil remnants, especially at the margin, smooth when mature, light blue to greyish blue when young, finally slightly greyish ochraceous to greyish brown, rarely entirely light blue even when old. *Lamellae* subadnate at first, then emarginate, moderately crowded, greyish violet when young, later greyish ochraceous to brown, edges paler, uneven. *Stipe* 45–100 mm long, 4–10 mm thick, cylindrical to clavate, slightly thickened at the base, surface shiny white fibrillose, at first pale violet, later becoming bluish tinged at apex, yellowish to brownish downwards, basal mycelium whitish, sometimes with bluish tinges. *Universal veil* sparse, bluish white, forming fibrils on pileus surface and sock like sheath on the stipe, later becoming yellowish. *Context* rather thin, hygrophanous when moist, stipe sometimes hollow, at first bluish white at the pileus and upper part of the stipe, yellowish below, later becoming yellowish. *Odour* somewhat radish. *Taste* mild. *Basidiospores* (6.0–)7.6–8.9 × (4.6–)5.8–7.2 µm, Q = 1.14–1.32, Xav. = 8.1 × 6.7 µm, Qav. = 1.21–1.24, subgloboid to broadly ellipsoid, moderately verrucose, indextrinoid. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae upward loosely entangled, hyaline or yellowish brown, 3–7 µm wide, smooth or weakly encrusted; hypocutis well developed,

hyphae 7–22 µm wide, hyaline or slightly yellowish brown, enlarged, almost isodiametric, somewhat irregular. *Clamp connections* present.

Ecology and distribution: Solitary or gregarious under deciduous forests of *Betula* and/or *Quercus*, also in mixed forests of *Betula* and *Pinaceae* (*Abies*, *Larix* and/or *Pinus*). Known from Beijing, Hebei, Heilongjiang, Inner Mongolia, Jilin, and Sichuan of China. Widespread in Europe, North America and Siberia of Russia as well.

Specimens examined: **China**, Beijing Municipality, Fangshan District, Baihuashan National Nature Reserve, in *Betula albosinensis* forest, alt. 1850–1970 m, 25 Aug. 2020, *K. Wang*, HMAS 291443, HMAS 291444, HMAS 291446, *T.Z. Wei*, HMAS 295967; Hebei Province, Laiyuan County, Baishishan Geopark, in *Betula albosinensis* forest, alt. 1900 m,21 Aug. 2019, *M.L. Xie*, HMJAU 48707, HMJAU 48708, HMJAU 48712; 21 Aug. 2020, *Y.B. Guo*, HMAS 291406; 25 Aug. 2020, *T.T. Fan*, HMAS 291371, HMAS 291374, *X.N. Shan*, HMAS 291360; Heilongjiang Province, Dongning County, alt. 415 m, 5 Sep. 2009, *T.Z. Wei*, HMAS 260342; Inner Mongolia Autonomous Region, Genhe County, Mangui Town, Ningcuishan Park, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 820 m, 25 Aug. 2017, *M.L. Xie*, HMJAU 44483; Arxan County, in *Betula platyphylla* forest, alt. 1200 m, 22 Aug. 2018, *M.L. Xie*, HMJAU 44498, HMJAU 44499, HMJAU 44500; Kalaqin Qi, Ma'anshan National Forest Park, 2 Sep. 2019, *T.Z. Liu & Y.M. Gao*, CFSZ 21464; Ningcheng County, Heilihe National Nature Reserve, Dabagou, 29 Aug. 2019, *T.Z. Liu & Wulantuya*, CFSZ 21343; Jilin Province, Antu County, Changbai Mountain National Nature Reserve, in *Betula platyphylla* forest, alt. 1100 m, 6 Sep. 2018, *M.L. Xie*, HMJAU 44501; 19 Sep. 2020, *M.L. Xie*, HMJAU 48740; in *Quercus mongolica* dominated forest with *Betula platyphylla* and Aceraceae, alt. 770 m, 20 Sep. 2020, *M.L. Xie*, HMJAU 48741; Yanji County, Sandaowan Town, Wupiyegou, in *Quercus mongolica* forest, alt. 580 m, 7 Sep. 2018, *M.L. Xie*, HMJAU 44502, HMJAU 44503, HMJAU 44504; 4 Sep. 2019, *M.L. Xie*, HMJAU 48709, HMJAU 48710, HMJAU 48711; 22 Sep. 2020, *M.L. Xie*, HMJAU 48742; Sichuan Province, Xiaojin County, Siguniang Mountain, alt. 2014 m, 15 Aug. 2013, *W.L. Lu*, HMAS 268389, HMAS 268417, HMAS 268519; in mixed forest with *Abies*, alt. 3468 m, 17 Aug. 2015, *T.Z. Wei & D. Wang*, HMAS 274394, HMAS 274404; Balang Mountain, in mixed forest of *Abies* and *Betula*, alt. 3459 m, 18 Aug. 2015, *T.Z. Wei & D. Wang*, HMAS 274469, HMAS 274474; in mixed forest of *Abies, Betula* and *Pinus*, alt. 3345 m, 19 Aug. 2015, *T.Z. Wei & D. Wang*, HMAS 274507.

Notes: *Cortinarius albocyaneus*, a newly recorded species in China, is a very common species and widely distributed in the temperate zone of Northern Hemisphere. It is characterized by a greyish blue, somewhat viscid, weakly hygrophanous pileus in young or moist conditions. Phylogenetically, *C. albocyaneus* formed a sister relationship with North American *C. caeruleoanomalus* from which it differs by seven substitutions and indel positions. The nrITS sequences between Chinese specimens and epitype specimen of *C. albocyaneus* (KX302206) are identical or have one to two substitutions.

Cortinarius azureovelatus P.D. Orton, *Naturalist, Leeds (Suppl.)*: 147. 1958. Figs 2C, 6C, 7C.

Pileus 50–110 mm diam., hemispherical at first, later convex to plane, somewhat wavy at the margin, surface viscid to somewhat glutinous when moist, somewhat shiny to distinctly glittery when dry, not hygrophanous, innately fibrillose, sometimes wrinkled when mature, at first pale to yellowish, then brownish yellow, paler at the margin. *Lamellae* emarginate at first, then adnate, moderately crowded, violet when young, later greyish brown to rusty brown, edges almost even. *Stipe* 55–120 mm long, 12–23 mm thick, cylindrical to subcylindical, slightly thickened at the base, surface with white fibrillose, later becoming yellowish, bluish tinge at the stipe apex, basal mycelium whitish. *Universal veil* yellowish, forming a sock like sheath on the stipe. *Context* fleshy, thick, strong bluish violet when young, especially at the stipe apex, later white to yellowish, sometimes somewhat hollow in the stipe when mature. *Odour* indistinct or somewhat raphanoid. *Taste* mild. *Basidiospores* 7.4–9.7 × 6.3–7.7 µm, Q = 1.06–1.34, Xav. = 7.9–9.0 × 6.8–7.0 µm, Qav. = 1.15–1.27, subgloboid to broadly ellipsoid, rarely ellipsoid, rather weakly to moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae upward loosely entangled, hyaline or yellowish to yellowish brown, 3–7 µm wide, smooth; hypocutis well developed, hyphae 9–25 µm wide, hyaline or slightly yellowish brown, cylindrical, smooth. *Clamp connections* present.

Ecology and distribution: Solitary or gregarious under *Betula* and/or *Quercus*. Known from Northeast China. Widespread in Europe and Siberia of Russia as well.

Specimens examined: **China**, Heilongjiang Province, Heihe City, Shengshan National Nature Reserve, in *Betula platyphylla* forest, alt. 300 m, 20 Aug. 2017, *G.H. Cheng*, HMJAU 48654, HMJAU 48655, HMJAU 48713; Inner Mongolia Autonomous Region, Arxan County, in *Betula platyphylla* forest, alt. 1200 m, 22 Aug. 2018, *M.L. Xie,* HMJAU 48656; Jilin Province, Antu County, Changbai Mountain National Nature Reserve, in *Quercus mongolica* dominated forest with *Betula platyphylla* and Aceraceae, alt. 770 m, 20 Sep. 2020, *M.L. Xie*, HMJAU 48734, HMJAU 48735, HMJAU 48736, HMJAU 48737; Yanji County, Sandaowan town, Wupiyegou, in *Quercus mongolica* forest, alt. 580 m, 7 Sep. 2018, *M.L. Xie*, HMJAU 48657; Jiaohe County, Haiqing Forest Farm, in broadleaf forest of *Betula platyphylla* and Aceraceae, alt. 360 m, 13 Sep. 2018, *M.L. Xie*, HMJAU 48658.

Notes: *Cortinarius azureovelatus* is a newly recorded species in China. It is characterized by its robust, ochraceous basidiomata, and viscid to somewhat glutinous pileus. Bluish tinges are only present on the lamellae and stipe apex of young specimens. This species usually occurs in broadleaf forests, associated with *Betula* and *Quercus*. The sister species of *C. azureovelatus* is *C. albidipes* from which it differs by six substitutions and indel positions in nrITS region, with a similarity of 99.0 %.

Cortinarius campanianomalus M.L. Xie, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843746. Figs 2D, E, 6D, 7D.

Etymology: From the Latin *campanus*-, bell, referring to the shape of the pileus and associated with sect. *Anomali*.

Typus: **China**, Xizang Autonomous Region, Linzhi City, Sejila Mountain, in *Abies georgei* var. *smithii* forest with *Rhododendron*, alt. 4120 m, 5 Sep. 2020, *M.L. Xie* (**holotype** HMJAU 48748).

Pileus 10–53 mm diam., campanulate when young, then expanded with a broadly umbonate, margin becoming ± wavy, surface somewhat viscid and weakly hygrophanous when moist, wrinkled when mature, at first surface with patches of yellowish universal veil remnants, dull greyish orange to brown. *Lamellae* subadnate to adnexed, subdistant, violet white to greyish violet when young, later greyish orange to brown, edges paler, even. *Stipe* 45–90 mm long, 4–9 mm thick above, cylindrical, surface yellowish fibrillose, bluish tinges at the upper part, basal mycelium whitish. *Universal veil* yellowish, forming fibrils on the pileus and sock like sheath on the stipe. *Context* thin, hygrophanous when moist, stipe hollow, greyish brown with bluish tinges at first, especially at the stipe apex. *Odour* radish. *Taste* mild. *Basidiospores* (8.1–)8.7–9.7(–11.6) × (6.2–)6.6–7.7(–8.7) µm, Q = 1.14–1.48, Xav. = 9.2–9.4 × 7.1–7.2 µm, Qav. = 1.31–1.32, broadly ellipsoid to ellipsoid, rather weakly, finely verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae parallel, hyaline or yellowish to yellowish brown, 4–11 µm wide, smooth to slightly encrusted; hypocutis well developed, hyphae 10–30 µm wide, hyaline to yellowish, somewhat cellular. *Clamp connections* present.

Ecology and distribution: Gregarious in moist moss under coniferous forests. Known from Sichuan, Taiwan and Xizang of China.

Additional specimens examined: **China**, Sichuan Province, Li County, Bipenggou, nearby Zhuomatan, in *Pinus* dominated forest with *Rhododendron*, alt. 3616 m, 23 Aug. 2015, *T.Z. Wei & D. Wang*, HMAS 254393, HMAS 254399, HMAS 275083, HMAS 275110; Xizang Autonomous Region, Linzhi City, Sejila Mountain, in *Abies georgei* var. *smithii* forest with *Rhododendron*, alt. 4250 m, 30 Aug. 2019, *M.L. Xie & J.Z. Li*, HMJAU 48692, HMJAU 48693.

Additional nrITS sequences data from public sequence repositories: **China**, Taiwan Province, Hehuan Mountain, KC679831, wii1A4sp9 from ectomycorrhiza samples of *Abies kawakamii* and *Tsuga chinensis* var. *formosana* mixed forest, as *Cortinarius* sp. in GenBank.

Notes: *Cortinarius campanianomalus* is characterized by its slender basidiomata, campanulate, weakly hygrophanous, ± wrinkled pileus, a yellowish universal veil, ellipsoid basidiospores, and alpine coniferous habitats. Bluish tinges are very slight and only present on the lamellae and stipe apex when young. In the phylogenetic analyses, this species clustered together with *C. latiodistributus* and *C. clackamasensis* with a strong support in BI analysis but not in ML. *Cortinarius latiodistributus* is the most closely related species of *C. campanianomalus* from which it differs by 20 substitutions and indel positions in nrITS region, with a similarity of 96.7 %.

Cortinarius caninus (Fr.) Fr., *Epicr. syst. mycol. (Upsaliae)*: 285. 1838. [1836–1838]. Figs 2F, 6E, 7E.

Pileus 46–87 mm diam., hemispherical when young, then plane to convex, margin incurved, surface not viscid, not hygrophanous, innately fibrillose, greyish brown with bluish at first, then ochrace brown to yellowish brown, paler at the margin, dull. *Lamellae* emarginate, moderately crowded, greyish blue at first, soon greyish orange to brown, edges almost even. *Stipe* 60–100 mm long, 8–13 mm thick above, cylindrical, slightly thickened at the base, surface whitish fibrillose, bluish tinges at the upper part, basal mycelium whitish. *Universal veil* white, soon yellowish, usually forming a thin, incomplete band on the stipe. *Context* thick, firm at first, white, with bluish tinges at the stipe apex, later becoming yellowish, becoming hollow in the stipe. *Odour* indistinct. *Basidiospores* 7.1–9.7 × 5.8–7.7 µm, Q = 1.13–1.55, Xav. = 8.4–8.8 × 6.5–6.8 µm, Qav. = 1.23–1.37, subgloboid, broadly ellipsoid to ellipsoid, moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly to moderately developed, hyphae interwoven, hyaline or yellowish to yellowish brown hyphae, 3–8 µm wide, smooth to slightly encrusted; hypocutis well developed, hyphae 10–20 µm wide, hyaline or slightly yellowish brown. *Clamp connections* present.

Ecology and distribution: Sparse to gregarious in *Larix gmelinii* forests or mixed forests with *Betula platyphylla*, sometimes in broadleaf forests of *Betula* and *Populus*. Known from Heilongjiang, Inner Mongolia, Sichuan, and Xinjiang of China. Widespread in Europe and North America as well under coniferous forests.

Specimens examined: **China**, Heilongjiang Province, Mohe County, Qianshao Forest Farm, in *Larix gmelinii* forest, alt. 510 m, 26 Aug. 2016, *M.L. Xie*, HMJAU 44258; Tahe County, Taergen Forest Farm, in *Larix gmelinii* forest, 21 Aug. 2017, *M.L. Xie, Y. Wang & Z.H. Luo*, HMJAU 44367, HMJAU 44371, HMJAU 44372, HMJAU 44373; Talin Forest Farm, in *Larix gmelinii* forest, alt. 400 m, 28 Aug. 2016, *M.L. Xie*, HMJAU 44279; Inner Mongolia Autonomous Region, Genhe County, Jinhe Town, in *Larix gmelinii* forest, alt. 750 m, 25 Aug. 2018, *M.L. Xie,* HMJAU 44497; Mangui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt 640 m, 10 Sep. 2019, *M.L. Xie,* HMJAU 48714; Sichuan Province, Seertar County, alt. 3092 m, 11 Aug. 2013, *W.L. Lu*, HMAS 268204; Xinjiang Uygur Autonomous Region, Zhaosu County, in broadleaf forest of *Betula* and *Populus*, alt. 2244 m, 31 July 2021, *Y. Wang*, HMJAU 49114, HMJAU 49115.

Notes: *Cortinarius caninus* is a newly recorded species in China. It is characterized by robust basidiomata and an ochraceous brown and dry pileus. In China, it is usually associated with *Larix gmelinii*, as well as some broadleaf trees like *Betula* and *Populus*. The bluish tinges are only present in the pileus, lamellae, and stipe apex when young.

Basidiospores are somewhat narrower than European and North American specimens (Dima *et al.* 2016, 2021). The newly generated Chinese nrITS sequences and the neotype sequence KX302206 have two to five substitutions and indel positions, with a similarity of 99.2–99.7 %, here we recognize the Chinese specimens as *C. caninus*.

Cortinarius cinnamomeolilacinus Q.Y. Zhang *et al.*, *Front. Cell. Infect. Microbiol.* **13**: 10. 2023.

Notes: *Cortinarius cinnamomeolilacinus* is widely distributed in tropical and subtropical China, usually having small basidiomata, the pileus being hemispheric to plano-convex, with a low umbo, pale silvery grey to lilac, the lamellae violet, greyish violet to brown, and the basidiospores subglobose to broadly ellipsoid. It is usually associated with *Fagaceae* or *Pinaceae*. For the detailed description and illustrations of this species, see Zhang *et al.* (2023).

Cortinarius epsomiensis P.D. Orton, *Naturalist, Leeds* (Suppl.): 147. 1958. Figs 2G, 6F, 7F.
Synonym: *Cortinarius pastoralis* Soop *et al.*, *Mycol. Progr*. **15**: 914. 2016.

Pileus 25–70 mm diam., hemispherical when young, later convex to plane, with a broadly umbonate at the centre, margin becoming ± wavy, surface somewhat viscid when moist, not hygrophanous, innately fibrillose, greyish white when young, then yellowish brown to slightly ochraceous brown, with some dark striates radially, yellowing from the centre. *Lamellae* emarginate, moderately crowded, greyish violet when young, then greyish brown, edges paler, uneven. *Stipe* 55–77 mm long, 8–10 mm thick, cylindrical, slightly thickened at the base, surface whitish fibrillose, bluish tinges at the stipe apex, basal mycelium whitish. *Universal veil* sparse, white at first, then yellowish. *Context* fleshy, white, with bluish tinges at the stipe apex, later yellowish brown at base, sometimes hollow in the stipe. *Odour* indistinct to somewhat radish. *Taste* mild. *Basidiospores* 7.3–9.7 × 6.3–7.7 µm, Q = 1.04–1.38, Xav. = 8.4–8.6 × 6.9–7.2 µm, Qav. = 1.18–1.24, subgloboid to broadly ellipsoid, moderately to rather strongly and densely verrucose, indextrinoid. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae loosely interwoven, hyaline to slightly yellowish brown, 3.0–7.7 µm wide, smooth to slightly encrusted; hypocutis well developed, hyphae 8.7–17.4 µm wide, almost hyaline, somewhat cellular, smooth. *Clamp connections* present.

Ecology and distribution: Scattered or gregarious, associated with *Betula* in Northeast China. Widespread in Europe as well, associated with several deciduous trees and with *Helianthemum*.

Specimens examined: **China**, Beijing Municipality, Fangshan District, Baihuashan National Nature Reserve, in *Betula albosinensis* forest, alt. 1954 m, 21 Aug. 2020, *T.Z. Wei*, HMAS 291465, HMAS 291466; Hebei Province, Laiyuan County, Baishishan Geopark, alt. 1931 m, 25 Aug. 2020, *X.N. Shan*, HMAS 291356; Heilongjiang Province, Mohe County, Gulian Forest Farm, in *Betula platyphylla* forest, alt. 550 m, 25 Aug. 2016, *M.L. Xie*, HMJAU 44241, HMJAU 44242; Inner Mongolia Autonomous Region, Hexigten Qi, Huangangliang, in *Betula platyphylla* forest, alt. 1743 m, 3 Sep. 2018, *T.Z. Wei, Z.W. Peng, J.Y. Zhuang & T.Z. Liu*, HMAS 279963; Arxan County, in *Betula platyphylla* forest, alt. 1200 m, 22 Aug. 2018, *M.L. Xie*, HMJAU 44505.

Notes: *Cortinarius epsomiensis* is an ochraceous to brown and slender species. It occurs in broadleaf forests in northern China, especially associated with *Betula*. This species was reported as *C. pastoralis* in China (Xie 2018, Wei & Liu 2019). It is also associated with *Helianthemum*, *Corylus*, and *Tilia* in Europe (Dima *et al.* 2016, Liimatainen & Ainsworth 2018). Phylogenetically, the sister species of *C. epsomiensis* is *Cortinarius* sp14 from which it differs by six substitutions and indel positions in nrITS region, with a similarity of 99.0 %.

Cortinarius kranabetteri Niskanen *et al.*, *Mycol. Progr*. **20**: 1425. 2021. Figs 2H, 6G, 7G.

Pileus 16–54 mm diam., at first hemispherical, later plane to convex, surface viscid when moist, somewhat shiny to distinctly glittery when dry, not hygrophanous, at first yellowish fibrillose, smooth when mature, violet white when young, finally greyish ochreous to greyish brown. *Lamellae* emarginate, moderately crowded, lilac to greyish violet when young, later greyish orange to brown, edges even at first, then slightly serrate. *Stipe* 43–90 mm long, 10–11 mm thick, cylindrical to subcylindical, slightly thickened at the base, 10–25 mm thick, surface shiny white fibrillose, white with bluish tinges when young, then yellowish, basal mycelium whitish. *Universal veil* yellowish, forming fibrils on pileus surface and sock like sheath on the stipe, later sparse. *Context* in pileus fleshy, white, in stipe bluish tinges at apex, becoming white to greyish white at base, soft to hollow. *Odour* radish. *Taste* mild. *Basidiospores* 6.7–9.3 × 5.7–7.2 µm, Q = 1.06–1.40, Xav. = 7.5–7.9 × 6.0–6.4 µm, Qav. = 1.21–1.24, subgloboid to broadly ellipsoid, weakly, finely to moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae interwoven, hyaline or yellow to yellowish brown, hyphae 2.5–8.0 µm wide, smooth; hypocutis well developed, hyphae 10–30 µm wide, hyaline to slightly yellowish brown, cylindrical to enlarged, smooth. *Clamp connections* present.

Ecology and distribution: Known from Heilongjiang, and Inner Mongolia under *Betula platyphylla* or mixed with *Larix gmelinii*, also from Xizang in mixed forests of *Abies*, *Betula*, *Quercus* and *Rosaceae*. Widespread in North America, under conifer or mixed with *Populus*, also known from Estonia in Europe based on the molecular data from soil samples.

Specimens examined: **China**, Heilongjiang Province, Mohe County, Gulian Town, in *Betula platyphylla* forest, alt. 550 m, 25 Aug. 2016, *M.L. Xie*, HMJAU 48644, HMJAU 48645, HMJAU 48646; Inner Mongolia Autonomous Region, Genhe County, Mangui Town, Ningcuishan Park, in mixed forest of *Betula platyphylla* and *Larix gmelinii*, alt. 820 m,1 Sep. 2016, *M.L. Xie*, HMJAU 48647, HMJAU 48648; 25 Aug. 2017, *M.L. Xie*, HMJAU 48643; Xizang Autonomous Region, Mainling County, Lilonggou, in mixed forest of *Abies*, *Betula*, *Quercus*

and Rosaceae, alt. 3219 m, 14 Sep. 2016, *T.Z. Wei, Z.X. Wu, L. Yang, H.D. Zheng & X.C. Wang*, HMAS 277353, HMAS 277354.

Notes: This is the first report of *C. kranabetteri* from China. It produces small- to medium-sized basidiomata. The pileus is often viscid when moist, shiny to distinctly glittery when dry, and the basidiospores are subgloboid to broadly ellipsoid. The sequences of the Chinese specimens formed a strongly supported monophyletic group with the holotype. Phylogenetically, *C. kranabetteri* formed a sister relationship with *C. perrotensis* and differs by six substitutions and indel positions in nrITS region, with a similarity of 99.0 %.

Cortinarius lepidopus Cooke, *Grevillea* **16**(no. 78): 43. 1887. Figs 3A, 6H, 7H.

Pileus 33–72 mm diam., hemispherical when young, later plane to convex with rounded umbo, surface weakly hygrophanous when moist, at first white fibrillose, especially at the margin, sometimes slightly wrinkled, dull yellowish brown with somewhat reddish, margin paler. *Lamellae* adnexed to emarginate, moderately crowded, violet when young, then greyish blue to yellowish brown, edges uneven. *Stipe* 65–78 mm long, cylindrical at above, 12–15 mm thick, clavate at base, 10–21 mm, white fibrillose, bluish tinges at apex, basal mycelium whitish. *Universal veil* white, forming a white sock like sheath on the stipe, then discolouring yellowish, sometimes forming a ring at the middle of the stipe. *Context* in pileus rather thin, white, in stipe bluish tinges, especially at apex. *Odour* indistinct. *Basidiospores* 6.3–8.4(–9.0) × 5.1–6.9 µm, Q = 1.10–1.39, Xav. = 7.2–7.6 × 5.9–6.1 µm, Qav. = 1.18–1.27, subgloboid to broadly ellipsoid, rather weakly to moderately verrucose. Basidia clavate, 4-spored, hyaline to yellowish brown. Lamellar edge fertile. Pileipellis duplex: epicutis thinly developed, hyphae parallel, hyaline to yellowish brown, 4–12 µm wide, smooth; hypocutis well developed, hyphae 15–34 µm wide, hyaline to slightly yellowish brown, smooth. *Clamp connections* present.

Ecology and distribution: Known from Northeast China under *Betula platyphylla*, or mixed with *Larix gmelinii*, and from Xizang under mixed forests dominated by *Abies georgei* var. *smithii*. It also known from Europe and Western Siberia in coniferous forests.

Specimens examined: **China**, Heilongjaing Province, Mohe County, Qianshao Forest Farm, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 540 m, 20 Aug. 2017, *M.L. Xie*, HMJAU 48634, HMJAU 48635, HMJAU 48636; in *Betula platyphylla* forest, alt. 540 m, 25 Aug. 2016, *M.L. Xie*, HMJAU 48641; Gulian Forest Farm, in *Betula platyphylla* forest, alt. 550 m, 25 Aug. 2016, *M.L. Xie*, HMJAU 48640; Inner Mongolia Autonomous Region, Genhe County, ManGui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 630 m, 24 Aug. 2017, *M.L. Xie*, HMJAU 48638, HMJAU 48639; 10 Sep. 2019, *M.L. Xie*, HMJAU 48715; Xizang Autonomous Region, Linzhi City, Lulang Town, Sejila Mountain, in *Abies* dominated forest with *Rhododendron*, alt. 3340 m, 7 Sep. 2014, *T.Z. Wei, J.Y. Zhuang, X.Y. Liu & H. Huang*, HMAS 271923, HMAS 271997, HMAS 272035, HMAS 273324; in *Abies* dominated forest with scattered *Quercus aquifolioides*, *Rhododendron* and *Rosa*, alt. 3451 m, 22 Sep. 2015, *T.Z. Wei & B.B. Li*, HMAS 275384, HMAS 275397; Linzhi City, Sejila Mountain, in *Abies georgei* var. *smithii* dominated forest with *Rhododendron*, Sep. 2014, *S.R. Wang*, HMJAU 48744.

Notes: *Cortinarius lepidopus* is a newly recorded species in China. It is characterized by the greyish brown to reddish brown pileus without bluish tinges and the yellowish universal veil. The Chinese specimens are distributed in two floras, northeast China and the Tibetan Plateau, in which the nrITS sequences from the specimens of northeast China are identical to European sequences, while the nrITS sequences from the specimens of the Tibetan Plateau usually differ from others by three to four substitutions and indel positions. The Tibetan specimens are almost indistinguishable from other specimens in morphology, except that they have three to four substitutions and indel positions, as well as a special plateau ecology, so they were treated as *C. lepidopus*. The taxonomy of this species in China requires further research. Phylogenetically, *C. lepidopus* and *C. modestus* are paraphyletic, but the sequences of *C. lepidopus* consistently differ from those of the latter by at least two nucleotides in the nrITS region, and here we treat them as different species following Dima *et al.* (2021).

Cortinarius microalbocyaneus M.L. Xie, T.Z. Wei, Y. Li & Dima, ***sp. nov.*** MB 843748. Figs 3B, C, 6I, 7I.

Etymology: The name refers to the small-sized basidiomata and similarity to *Cortinarius albocyaneus*.

Typus: **China**, Jilin Province: Yanji County, Sandaowan Town, Wupiyegou, under *Quercus mongolica* with scattered *Pinus koraiensis*, alt. 580 m, 4 Sep. 2019, *M.L. Xie* (**holotype** HMJAU 48706).

Pileus 23–32 mm diam., convex when young, later plane, surface somewhat viscid when moist, innately fibrillose, with patches of pale yellowish universal veil remnants at the margin, sometimes wrinkle, especially at the margin when mature, at first greyish lilac to greyish violet, then greyish orange from centre. *Lamellae* emarginate to adnexed, moderately crowded, pale violet to greyish violet when young, later pale orange to brown, even at first, then with weakly serrate. *Stipe* 40–47 mm long, 6–8 mm thick, subclavate to clavate, somewhat thickened at the base, up to 11–12 mm, whitish, blue tinges at the stipe apex when young, later yellowish, basal mycelium whitish. *Universal veil* yellowish, sparse, sometimes forming fibrils on pileus surface and sock like sheath on the stipe. *Context* in pileus fleshy, hygrophanous when moist, bluish when young, especially at the stipe apex, later white, sometimes hollow in stipe. *Odour* radish. *Taste* mild. *Basidiospores* 6.2–7.7 × 5.4–6.8 µm, Q = 1.06–1.33, Xav. = 6.8–7.2 × 5.8–6.2 µm, Qav. = 1.17–1.20, subgloboid to broadly ellipsoid, rather weakly verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly developed, hyphae somewhat interwoven, hyaline or yellowish to yellowish brown, 2.5–7.5 µm wide, slightly encrusted; hypocutis well developed, hyphae 12–27 µm wide, hyaline to slightly yellowish brown, somewhat cellular, smooth. *Clamp connections* present.

Fig. 3. Basidiomata. **A.** *C. lepidopus* HMJAU 48715. **B.** *C. microalbocyaneus* HMJAU 48649. **C.** *C. microalbocyaneus* HMJAU 48706 (holotype). **D.** *C. neocaninus* HMJAU 44495. **E.** *C. neocaninus* HMJAU 48691 (holotype). **F.** *C. perrotensis* HMJAU 48662. **G.** *C. qilianensis* HMJAU 44508 (holotype). **H.** *C. qilianensis* HMJAU 48666. Photos by: A–F, H. M.L. Xie; G. S.L. Wei. Scale bars = 20 mm.

Ecology and distribution: Known from Northeast China in *Betula platyphylla* forests or *Quercus mongolica* dominated forests. It may be associated with *Pinus* based on the sequences (LC175062) of mycorrhizal root tips, too. Also known from Canada, Japan and USA based on molecular data.

Additional specimens examined: **China**, Jilin Province: Yanji County, Sandaowan Town, Wupiyegou, under *Quercus mongolica*, with scattered *Pinus koraiensis*, alt. 580 m, 7 Sep. 2018, *M.L. Xie*, HMJAU 48649, HMJAU 48650, HMJAU 48651, HMJAU 48652; ibid., 8 Sep. 2018, *M.L.* Xie, HMJAU 48653; ibid., 4 Sep. 2019, *M.L. Xie*, HMJAU 48702, HMJAU 48703, HMJAU 48704, HMJAU 48705; ibid., 23 Sep. 2020, *M.L. Xie*, HMJAU 48721, HMJAU 48722, HMJAU 48723, HMJAU 48724, HMJAU 48725, HMJAU 48726, HMJAU 48727; Antu County, Changbai Mountain National Nature Reserve, under *Betula platyphylla*, alt. 1110 m, 19 Sep. 2020, *M.L. Xie*, HMJAU 48720; Ji'an County, Wunvfeng National Forest Park, unknown date, *Y.L. Tuo*, HMJAU 60641.

Additional nrITS sequences data from public sequence repositories: **Canada**, British Columbia, Interior Cedar Hemlock Forests, DQ097877, OUC97234 as *C. alboviolaceus* in GenBank; Québec, Riviere-a-Pierre, MW845268, MQ21-HRL1598-QFB32934 as *Cortinarius* sp. in GenBank; Riviere-au-Tonnerre, OQ321992, MQ22-QFB33093-HRL3520 as *Cortinarius* sp. in GenBank. **Japan**, Iwate, Mt. Hayachine, LC175062, YM1162 from *Pinus parviflora* root tips, as *Cortinarius* sp. in GenBank. **USA**, New Hampshire, MT345185, CNV8 as *Cortinarius* sp. in GenBank.

Notes: *Cortinarius microalbocyaneus* is characterized by small-sized basidiomata (pileus < 50 mm diam.), greyish blue to yellowish brown pileus, clavate and somewhat hollow stipe, and subgloboid and small-sized basidiospores. *Cortinarius albocyaneus* and *C. epsomiensis* are morphologically similar species but can be distinguished by their ± shiny to distinctly glittery pileus and larger basidiospores of *C. albocyaneus* (8.5–9.0 × 6.0–7.5 µm) and *C. epsomiensis* (8.5–9 × 7–8 µm) (Dima *et al.* 2016, Liimatainen & Ainsworth 2018). *Cortinarius microalbocyaneus* also shares a similar appearance with *C. albocyaneoides* and *C. subalbocyaneus*. But *C. albocyaneoides* and *C. subalbocyaneus* have larger basidiospores and are associated with *Larix* and *Betula*. HMJAU 60641 was labeled as *C. anomalus* by Tuo *et al.* (2022), here we treat it as *C. microalbocyaneus*. Phylogenetically, the sister species of *C. microalbocyaneus* is *Cortinarius* sp9 from which it differs by 16 substitutions and indel positions in nrITS region, with a similarity of 97.3 %. Five GenBank sequences, DQ097877, MW845268 and OL891464 from Canada, LC175062 from Japan, and MT345185 from the USA, were treated as *Cortinarius* sp. in Dima *et al.* (2021), are clustered with the Chinese specimens and considered as *C. microalbocyaneus*.

Cortinarius neocaninus M.L. Xie, T.Z. Wei, Y. Li & Dima, ***sp. nov.*** MB 843749. Figs 3D, E, 6J, 7J.

Etymology: The name refers to the affinity with *Cortinarius caninus.*

Typus: **China**, Inner Mongolia Autonomous Region, Genhe County, Mangui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 630 m, 10 Sep. 2019, *M.L. Xie* (**holotype** HMJAU 48691).

Pileus 15–52 mm diam., hemispherical at first, later plane to convex with a broadly umbonate, surface somewhat viscid when moist, not hygrophanous, with yellowish fibrillose, at first olive brown, then greyish orange to brownish orange, dull. *Lamellae* subadnate at first, then emarginate, moderately crowded, violaceous white when young, later greyish orange to brown, edges paler, somewhat uneven. *Stipe* 60–90 mm long, 3–6 mm thick, cylindrical to subcylindical, somewhat thickened at the base (up to 13 mm), surface white fibrillose, later yellowish, bluish tinges at the apex, basal mycelium whitish. *Universal veil* yellowish. *Context* fleshy, hygrophanous when moist, hollow in stipe, in pileus and in stipe violet tinge at first, especially at the stipe apex, later becoming white. *Odour* weak. *Taste* mild. *Basidiospores* 7.2–10.6 × 5.8–7.7 µm, Q = 1.07–1.59, Xav. = 7.9–8.9 × 6.5–6.8 µm, Qav. = 1.21–1.4, subgloboid, broadly ellipsoid to ellipsoid, moderately and densely verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly developed, hyphae slightly interwoven, hyaline to yellowish brown, 3–13 µm wide, smooth to slightly encrusted; hypocutis well developed, hyphae 8–20 µm wide, hyaline to slightly yellowish brown, somewhat irregular. *Clamp connections* present.

Ecology and distribution: Known from Heilongjiang and Inner Mongolia of China in *Larix gmelinii* forests or mixed *Betula platyphylla*, and known from Sichuan in mixed forests of *Abies* and *Quercus*, Xinjiang in *Abies* or *Picea* forests. Also known from Estonia based on molecular data.

Additional specimens examined: **China**, Heilongjiang Province, Mohe County, Jingou Forest Farm, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 730 m, 26 Aug. 2016, *M.L. Xie*, HMJAU 48688; in *Larix gmelinii* forest, alt. 500 m, 19 Aug. 2017, *M.L. Xie*, HMJAU 44495; Inner Mongolia Autonomous Region, Genhe County, ManGui Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 630 m, 10 Sep. 2019, *M.L. Xie*, HMJAU 48690; Sichuan Province, Xiaojin County, Heshangcun Songrong Protected Area, in mixed forest of *Abies* and *Quercus*, alt. 3578 m, 18 Aug. 2015, *T.Z. Wei & D. Wang*, HMAS 274431; Xinjiang Uygur Autonomous Region, Hami City, Haiziyan Town, in *Abies* forest, alt. 2500 m, 3 Aug. 2019, *M.L. Xie & P.S. Jia*, HMJAU 48689; Ili Kazak Autonomous Prefecture, Qiaoerma, in *Picea* forest with shrubs, alt. 2341 m, 13 Aug. 2015, *T.Z. Wei & K. Wang*, HMAS 274789.

Additional nrITS sequences data from public sequence repositories: **Estonia**, UDB0168416, S594 from soil, as *Cortinarius* sp. in UNITE; UDB0176168, S682 from soil, as *Cortinarius* sp. in UNITE; UDB0180344, S703 from soil, as *Cortinarius* sp. in UNITE; UDB0513824, G4278 from soil, as *Cortinarius* sp. in UNITE; Saare maakond, Leisi vald, UDB034762, TAAM128969 as *Cortinarius* sp. in UNITE.

Notes: *Cortinarius neocaninus* has small-sized basidiomata without bluish tinges except for the lamellae and stipe apex. The pileus is olive brown at first, and then brownish orange, the context is somewhat hollow at the stipe, and the basidiospores are subglobose to ellipsoid. The nrITS sequences of *C. neocaninus* differ from those of the North American *C. anomalodelicatus* by only three to four substitutions and indel positions. The former, however, forms a well-supported monophyletic group in both ML and BI analyses. It is also related to *C. caninus*, which is one of the typically medium- to large-sized and robust species in sect. *Anomali* (Dima *et al.* 2016).

Cortinarius perrotensis A. Paul *et al.*, *Mycol. Progr*. **20**: 1429. 2021. Figs 3F, 6K, 7K.

Pileus 16–32 mm diam., convex when young, later plane, margin inrolled at first; surface innately fibrillose, somewhat viscid when moist, soon drying with shiny; greyish brown, paler at the margin. *Lamellae* emarginate, moderately crowded, violet at first, soon greyish violet to pale brown, edges slightly serrate. *Stipe* 32–69 mm long, 5–8 mm thick above, clavate, thickened at the base (9–15 mm); surface fibrillose, whitish, blue tinge at the apex when young, basal mycelium whitish. *Universal veil* white, soon yellowish, sometimes forming a sock like sheath on the stipe. *Context* fleshy, whitish, at first bluish in the stipe apex. *Odour* indistinct. *Taste* mild. *Basidiospores* 6.8–8.4 × 5.4–6.1 µm, Q = 1.17–1.41, Xav. = 7.6 × 5.8 µm, Qav. = 1.31, subglobose, broadly ellipsoid to ellipsoid, moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely light olivaceous brown to olivaceous brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis of hyaline, light olivaceous brown to olivaceous brown hyphae; hyphae 3–10 µm wide, smooth to weakly encrusted spots; hypocutis well developed, hyphae 8–23 µm wide, hyaline to olivaceous brown, irregular, smooth. *Clamp connections* present.

Ecology and distribution: Gregarious in broadleaf-conifer forests of *Betula* and *Larix*. Known only from Heilongjiang Province in China. It was described from Eastern North America in broadleaf-conifer forests.

Specimen examined: **China**, Heilongjiang Province, Tahe County, Talin Forest Farm, in mixed forest of *L. gmelinii* and *B. platyphylla*, 28 Aug. 2016, *M.L. Xie*, HMJAU 48662.

Notes: *Cortinarius perrotensis* is a new record in China. It is a small-sized species. The pileus is usually greyish brown without a bluish tinge, the violet lamellae soon become pale brown and are slightly serrate at the edge. The basidiospores in Chinese materials, which average 7.6 × 5.8 µm, are slightly narrower than those of North American specimens. In phylogenetic analyses, the Chinese specimens formed a well-supported monophyletic clade with the holotype.

Cortinarius qilianensis M.L. Xie, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843750. Figs 3G, H, 6L, 7L.

Etymology: The name refers to the type location, Qilian Mountain, a famous mountain in China.

Typus: **China**, Gansu Province, Shandan County, Qilianshan National Nature Reserve, Yanzhishan Forest Park, in *Picea* forest, alt. 2800 m, 20 Aug. 2017, *S.L. Wei* (**holotype** HMJAU 44508).

Pileus 15–80 mm diam., convex, later plane with a low umbo, incurved at the margin, surface viscid to somewhat glutinous in fresh condition, somewhat shiny to distinctly glittery when dry, not hygrophanous, orange white to greyish orange, paler at the margin. *Lamellae* emarginate, moderately crowded, purple to greyish violet when young, later brownish with violaceous tinges to brown, at first edges paler, even, then slightly serrate. *Stipe* 35–100 mm long, 9–26 mm thick, cylindrical at the upper part, clavate-bulbous at the base, up to 35 mm, surface with abundant yellowish white fibrillose, whitish with blue tinges at the apex when young, later yellowish, basal mycelium whitish. *Universal veil* yellowish, usually forming a sock like sheath on the stipe. *Context* fleshy, with marbled watery when moist, violet when young, especially at the upper stipe, later white with bluish tinges, somewhat hollow in stipe. *Odour* somewhat aromatic. *Taste* mild. *Basidiospores* 8.6–10.6 × 6.8–8.7 µm, Q = 1.09–1.43, Xav. = 9.0–9.5 × 7.0–7.7 µm, Qav. = 1.20–1.30, broadly ellipsoid to ellipsoid, rather weakly to moderately and densely verrucose, moderately dextrinoid. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae loosely interwoven, hyaline to yellowish brown, 2–7 µm wide, smooth; hypocutis well developed, hyphae interwoven, 6–16 µm wide, hyaline, ± cylindrical, smooth. *Clamp connections* present.

Ecology and distribution: Solitary or scattered in *Abies* and *Picea* forests. Known from Northwest China.

Additional specimens examined: **China**, Gansu Province, Shandan County, Qilianshan National Nature Reserve, Yanzhishan Forest Park, in *Picea* forest, alt. 2800 m, 5 Sep. 2013, *S.L. Wei*, HMJAU 44510; ibid., 20 Aug. 2017, *S.L. Wei*, HMJAU 44509; Minle County, Qilianshan Nature Reserve, Dahekou, in *Picea* forest, alt. 2860 m, 9 Aug. 2018, *M.L. Xie*, HMJAU 48666; Xinjiang Uygur Autonomous Region, Shawan County, Lujiaowan, in *Abies* forest, alt. 2400 m, 8 Aug. 2019, *M.L. Xie & P.S. Jia*, HMJAU 48716.

Notes: *Cortinarius qilianensis* is a phlegmacioid species, usually with robust and medium- to large-sized basidiomata. The pileus is usually viscid to somewhat glutinous in fresh condition, somewhat shiny to distinctly glittery when dry, with an odour that is somewhat aromatic, and the basidiospores are broadly ellipsoid to ellipsoid. *Cortinarius qilianensis* is similar to *C. albocyaneus* and *C. lividomalvacus* due to the shiny to distinctly glittery pileus. However, *C. albocyaneus* (e.g., *Betula* and *Fagus*) and *C. lividomalvacus* (*Quercus*) are associated with broadleaf trees, and the basidiomata of *C. albocyaneus* are slender (Dima *et al.* 2016, Eyssartier *et al.* 2017). The most closely related species of *C. qilianensis* is *C. azureovelatus* from which it differs by 15 substitutions and indel positions in nrITS region, with a similarity of 97.5 %.

Cortinarius robustianomalus T.Z. Wei, M.L. Xie & Y. Li, ***sp. nov.*** MB 843751. Figs 4A, B, 6M, 7M.

Etymology: The name refers to sect. *Anomali* species with robust habit.

Typus: **China**, Sichuan Province, Li County, Miyaluo, Jiabigou, in mixed forest of *Abies*, *Picea* and *Betula*, alt. 2832 m, 10 Aug. 2016, *T.Z. Wei, L.H. Sun, Z.X. Wu & R.C. Zhang* (**holotype** HMAS 254763).

Pileus 80–150 mm diam., convex when young, later plane to convex, sometimes depressed at centre, margin wavy and up-curved in mature basidiomata, surface not viscid, weakly hygrophanous when wet, with greyish fibrillose, somewhat wrinkled, at first olive brown, then brownish orange to brown at the centre, paler at the margin, dull. *Lamellae* emarginate, moderately crowded, greyish violet to violet when young, greyish orange to brown with age, edges even at first, then somewhat uneven. *Stipe* 110–190 mm long, 14–45 mm thick, cylindrical, surface greyish fibrillose, bluish tinges at the apex, basal mycelium whitish. *Universal veil* greyish, forming fibrils on pileus and thin ring on the stipe. *Context* fleshy, somewhat marbled watery when moist, hollow in the stipe, whitish, with violet tinges, especially at the stipe apex. *Odour* radish. *Taste* mild. *Basidiospores* (7.4–)8.0–9.0(–9.5) × 6.5–8.1 µm, Q = 1.07–1.23, Xav. = 8.4–8.5 × 7.2–7.3 µm, Qav. = 1.16–1.17, subgloboid to broadly ellipsoid, weakly to moderately and sharply verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly developed, hyphae somewhat interwoven, yellowish brown, 3–10 µm wide, smooth to slightly encrusted; hypocutis well developed, hyphae 16–38 µm wide, cylindrical to somewhat cellular, hyaline to slightly yellowish brown. *Clamp connections* present.

Ecology and distribution: Gregarious to fascicular in mixed forests of *Abies*, *Picea* and *Betula*. Known from Sichuan of China.

Additional specimens examined: **China**, Sichuan Province, Li County, Miyaluo, Jiabigou, in mixed forest of *Abies*, *Picea* and *Betula*, alt. 2832 m, 10 Aug. 2016, *T.Z. Wei, L.H. Sun, Z.X. Wu & R.C. Zhang*, HMAS 254764.

Notes: *Cortinarius robustianomalus* is a distinctive species that has very robust basidiomata, a dully olive tinged and wavy pileus, a cylindrical stipe, and a greyish universal veil. The context is very thick in the pileus and hollow in the stipe. Bluish tinges are only present in the lamellae and stipe apex. The sister species of *C. robustianomalus* is *C. rufolilacinus* from which it differs by five substitutions and indel positions in nrITS region, with a similarity of 99.2 %. *Cortinarius rufolilacinus* usually has a dull reddish lilac pileus and a violet universal veil, but without olive tinges.

Cortinarius rufolilacinus M.L. Xie, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843752. Figs 4C, D, 6N, 7N.

Etymology: The name refers to the reddish lilac pileus.

Typus: **China**, Xizang Autonomous Region, Linzhi City, Sejila Mountain, in *Abies georgei var. smithii* forest with *Rhododendron*, alt. 4120 m, 5 Sep. 2020, *M.L. Xie* (**holotype** HMJAU 48739).

Pileus 35–64 mm diam., at first convex, later plane to plano-convex, margin sometimes incurved and wavy, surface weakly hygrophanous when moist, innately fibrillose, pale violet universal veil remnants at first, especially at the margin, dull reddish lilac when young, finally brownish orange to slightly brown. *Lamellae* emarginate, moderately crowded, greyish violet when young, later bluish grey to brown, edges even. *Stipe* 80–120 mm long, 8–11 mm thick, cylindrical to subcylindrical, slightly thickened at the base, surface violet fibrillose when young, later becoming greyish brown at the middle part, basal mycelium white to pale bluish. *Universal veil* copious, pale violet at first, flocculose-fibrous, forming fibrils on the pileus and sock like sheath on the stipe, latter yellowish. *Context* fleshy, whitish when young, marbled watery at the pileus when moist, with bluish tinges, especially at the upper part and base of stipe, becoming yellowish at the middle part of stipe, finally yellowish brown. *Odour* radish. *Taste* not recorded. *Basidiospores* 7.7–10.1 × 6.1–7.9 µm, Q = 1.13–1.31, Xav. = 8.4–8.9 × 6.8–7.2 µm, Qav. = 1.22–1.25, subgloboid to broadly ellipsoid, moderately verrucose, moderately to rather strongly dextrinoid. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae interwoven, slightly yellowish brown to brown, 4–14 µm wide, slightly encrusted; hypocutis well developed, hyphae 12–25 µm wide, hyaline to slightly yellowish brown, somewhat cellular, smooth. *Clamp connections* present.

Ecology and distribution: Solitary to gregarious in *Abies georgei* var. *smithii* forests with *Rhododendron*. Known from Tibetan Plateau of China.

Additional specimens examined: **China**, Xizang Autonomous Region, Linzhi City, Sejila Mountain, in *Abies georgei* var. *smithii* forest with *Rhododendron*, 24 Jul. 2013, *S.R. Wang*, HMJAU 48747; ibid., 4 Aug. 2013, HMJAU48745, HMJAU48746.

Additional nrITS sequences data from public sequence repositories: **China**, KU836522, ZJ0003SMJ01 as *C. caninus* in GenBank.

Notes: *Cortinarius rufolilacinus* is characterized by medium-sized basidiomata, a reddish lilac and weakly hygrophanous pileus, and a violet universal veil. The most closely related species of *C. rufolilacinus* is *C. robustianomalus* from which it differs by five substitutions and indel positions. Morphologically, compared with *C. rufolilacinus*, *C. robustianomalus* has an olive tinged pileus, a more robust stipe, a greyish universal veil, and rather round basidiospores.

Cortinarius subalbocyaneus M.L. Xie, T.Z. Wei, Y. Li & Dima, ***sp. nov.*** MB 843753. Figs 4E, 4F, 6O, 7O.

Etymology: The name refers to the affinity to *Cortinarius albocyaneus*.

Fig. 4. Basidiomata. **A.** *C. robustianomalus* HMAS 254763 (holotype). **B.** *C. robustianomalus* HMAS 254764. **C.** *C. rufolilacinus* HMJAU 48739 (holotype). **D.** *C. rufolilacenus* HMJAU 48747. **E.** *C. subalbocyaneus* HMJAU 48659 (holotype). **F.** *C. subalbocyaneus* HMJAU 48729. **G.** *C. subanomalus* HMJAU 48752 (holotype). **H.** *C. subanomalus* HMJAU 48755. Photos by: A, B. T.Z. Wei; C, E, F, H. M.L. Xie; D. S.R. Wang; G. Q. Zhao. Scale bars = 20 mm.

Typus: **China**, Inner Mongolia Autonomous Region, Eerguna County, Moerdaoga Town, in mixed forest of *Betula platyphylla* and *Larix gmelinii*, alt. 750 m, 24 Aug. 2018, *M.L. Xie* (**holotype** HMJAU 48659).

Pileus 23–34 mm diam., convex when young, later plane to convex, surface somewhat viscid when young, somewhat shiny to distinctly glittery when dry, not hygrophanous, with greyish fibrillose, at first violet grey, then slightly brownish orange, paler at the margin. *Lamellae* emarginate, moderately crowded, greyish violet when young, finally greyish orange to brown, edges somewhat uneven. *Stipe* 72–102 mm long, 3–5 mm thick above, cylindrical to subcylindrical, somewhat thickened at the base (up to 9–17 mm), surface with shiny greyish white fibrillose, white when young, blue tinges at the apex, finally dull whitish to yellowish. *Universal veil* greyish, forming fibrils on pileus surface and a sock like sheath on the stipe, later sparse, sometimes discolouring yellowish. *Context* fleshy, marbled watery when young, somewhat hollow in stipe, at first whitish, bluish tinges at the stipe apex. *Odour* somewhat radish. *Taste* mild. *Basidiospores* 7.7–9.7 × 6.2–7.7 µm, Q = 1.04–1.48, Xav. = 7.9–8.6 × 6.7–7.0 µm, Qav. = 1.14–1.29, subgloboid to broadly ellipsoid, rarely ellipsoid, moderately to rather strongly and densely verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly developed, hyphae parallel, yellowish to slightly yellowish brown, 4–8 µm wide, smooth; hypocutis well developed, hyphae 10–19 µm, hyaline, somewhat cellular. *Clamp connections* present.

Ecology and distribution: Solitary or gregarious in *Betula platyphylla* or mixed with *Larix gmelinii*, also associated with *Populus* based on the sequences of ECM root sample. Known from Heilongjiang and Jilin of China, as well as Canada, Estonia and Amur Oblast of Russia based on molecular data.

Additional specimens examined: **China**, Heilongjiang Province, Tahe County, Tafeng Forest Farm, in mixed forest of *Betula platyphylla* and *Larix gmelinii*, alt. 360 m, 28 Aug. 2016, *M.L. Xie*, HMJAU 44282; Jilin Province, Antu County, Changbai Mountain National Nature Reserve, in *Betula platyphylla* forest with scattered *Populus*, alt. 1100 m, 6 Sep. 2018, *M.L. Xie*, HMJAU 48660, HMJAU 48661; under *Betula platyphylla* trees, alt. 1110 m, 19 Sep. 2020, *M.L. Xie*, HMJAU 48728, HMJAU 48729, HMJAU 48730, HMJAU 48731, HMJAU 48732, HMJAU 48733; Xizang Autonomous Region, Linzhi City, Lulang Town, Sejila Mountain, in *Abies* dominated forest with *Rhododendron*, alt. 3326 m, 6 Sep. 2014, *T.Z. Wei, J.Y. Zhang, X.Y. Liu & H. Huang*, HMAS 271932.

Additional nrITS sequences data from public sequence repositories: **Canada**, British Columbia, FJ157104, F18506 as *C.* aff. *caninus* in GenBank; British Columbia, Cariboo, UDB031695, 228A as *Cortinarius* sp. in UNITE. **Estonia**, UDB0706856, HB29 as *Cortinarius* sp. in UNITE. **Russia**, Amur Oblast, Zeya, LC547581, szYM140 from ectomycorrhizal root tip of *Populus* sp., as uncultured *Cortinarius* in GenBank.

Notes: *Cortinarius subalbocyaneus* is a small species. The pileus is violet grey when young, ± viscid when moist, and somewhat shiny to distinctly glittery when dry. The universal veil is greyish. The basidiospores are subgloboid to broadly ellipsoid, rarely ellipsoid. *Cortinarius subalbocyaneus* shows a high degree of morphological convergence with *C. microalbocyaneus*. However, the basidiospores of *C. microalbocyaneus* are rather small, on average 6.8–7.5 × 5.8–6.2 µm, and its habitats are related to *Quercus mongolica*. Phylogenetically, the most closely related species of *C. subalbocyaneus* is *C. jonimitchelliae* from which it differs by at least six substitutions and indel positions in the nrITS region, with a similarity of 98.9 %. The nrITS sequences FJ157104 and UDB031695 from Canada, UDB0706856 from Estonia, and LC547581 from Russia are clustered with Chinese sequences and considered as *C. subalbocyaneus*. This species was treated as *Cortinarius* sp. in Dima *et al.* (2021).

Cortinarius subanomalus M.L. Xie, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843754. Figs 4G, H, 6P, 7P.

Etymology: The name refers to the affinity to *Cortinarius anomalus*.

Typus: **China**, Yunnan Province, Shangri-La County, in *Quercus aquifolioides* forest, alt. 3609 m, 25 Sep. 2012, *Q. Zhao* (**holotype** HMJAU 48752).

Pileus 15–30 mm diam., hemispherical when young, later convex, surface weakly hygrophanous, innately fibrillose, greyish violet at first, then pale orange to greyish orange, dull. *Lamellae* emarginate to adnexed, moderately crowded, dark violet when young, then brown, edges paler and even. *Stipe* 50–80 mm long, 6–10 mm thick, cylindrical to subcylindical, somewhat thickened at the base, surface persistently violaceous tinged fibrillose at the lower part, violet at the apex, basal mycelium violet. *Universal veil* violet at first, then discolouring yellowish. *Context* fleshy, at first whitish with ± violet tinge, greyish violet at the stipe apex, sometimes becoming hollow in stipe. *Odour* radish. *Taste* mild. *Basidiospores* 6.8–8.8(–9.7) × 5.8–7.7 µm, Q = 1.06–1.31, Xav. = 7.9–8.1 × 6.6–6.8 µm, Qav. = 1.16–1.21, subglobose to broadly ellipsoid, moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae parallel, hyaline to yellowish brown, 2–7 µm wide, smooth; hypocutis well developed, hyphae 8–30 µm wide, hyaline, cylindrical to enlarged, smooth. *Clamp connections* present.

Ecology and distribution: Solitary to gregarious in *Quercus aquifolioides* forests, or mixed forests of *Picea* and *Betula*. Known from Yunnan and Xizang of China.

Additional specimens examined: **China**, Xizang Autonomous Region, Linzhi City, Bomi County, in mixed forests *Picea* and *Betula*, alt. 2750 m, 19 Sep. 2016, *T.Z. Wei, Z.X. Wu, L. Yang, H.D. Zheng & X.C. Wang*, HMAS 277626; Linzhi City, Lulang Town, in *Quercus aquifolioides* forest, alt. 3280 m, 4 Sep. 2020, *M.L. Xie*, HMJAU 48755, HMJAU 48769.

Notes: *Cortinarius subanomalus* produces small basidiomata, the pileus ranges greyish violet to greyish orange, the

universal veil is violet, the stipe has persistently violet tinged fibrillose at the lower part, the context is usually hollow in stipe, and the basidiospores are subgloboid to broadly ellipsoid. *Cortinarius subanomalus* is similar to *C. anomalus*, but the latter usually has a whitish universal veil and forms a sock like sheath on the stipe, and the basal mycelium is white (Dima *et al.* 2016, 2021). The most closely related species of *C. subanomalus* is *C. anomalus* from which it differs by 12 substitutions and indel positions in nrITS region, with a similarity of 97.9 %.

Cortinarius subclackamasensis Q.Y. Zhang *et al.*, *Front. Cell. Infect. Microbiol*. **13**: 11. 2023. Figs 5A, B, 6Q, 7Q.

Pileus 50–135 mm diam., hemispherical when young, later plane to convex, margin ± wavy finally, surface weakly hygrophanous when moist, especially at margin, violet grey to dull violet grey when young, finally brownish grey to brownish orange, sometimes reddish brown at the centre, brownish orange with violet at margin. *Lamellae* emarginate, moderately crowded, greyish violet when young, then pale orange to brown, edges paler, weakly serrate. *Stipe* 65–78 mm long, 12–15 mm thick, subcylindrical when young, later cylindrical, surface whitish fibrillose, bluish tinges at the apex. *Universal veil* yellowish, forming fibrils on pileus and sock like sheath on the stipe, later sparse. *Context* in pileus fleshy, soft, sometimes hollow in the stipe, marbled watery when moist, at first violet in pileus and in stipe, later whitish with bluish tinges, especially at the stipe apex, yellowish brown at base. *Odour* radish. *Taste* mild. *Basidiospores* (8.0–)8.6–10.1(–10.8) × 5.1–6.7 µm, Q = 1.42–1.77, Xav. = 9.1–9.5 × 5.8–6.2 µm, Qav. = 1.54–1.61, ellipsoid, moderately and densely verrucose, moderately dextrinoid. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae parallel, yellowish to yellowish brown, 3–10 µm wide, smooth; hypocutis well developed, hyphae 11–29 µm wide, hyaline to slightly yellowish brown. *Clamp connections* present.

Ecology and distribution: Scattered under broadleaf trees of *Betula*, *Populus*, and *Salix* or mixed forests. Known from Beijing, Hebei, Inner Mongolia, Jilin, Qinghai and Sichuan of China.

Specimens examined: **China**, Beijing Municipality, Huairou District, Yanqihu Town, 19 Sep. 2003, *H. Deng & L. Jiao*, HMAS 86629; Mentougou District, Xiaolongmen National Forest Park, in *Populus* forest, alt. 1156–1201 m, 4 Sep. 2020, *K. Wang*, HMAS 291450, HMAS 291452; Hebei Province, Laiyuan County, Prairie Air, in shrubs, alt. 1748 m, 24 Aug. 2020, *X.J. Xie*, HMAS 291480; Pingshan County, Tuoliang National Nature Reserve, in *Betula* forest, 31 July 2020, *G.J. Li*, HBAU 15319; in *Betula* forest, alt. 1450–1684 m, 20 Aug. 2020, *G.J. Li*, HBAU 15471, HBAU 15473, *Y.B. Guo*, HMAS 281435, *X. Zhang*, HMAS 249875, HMAS 291498, HMAS 291503, *T.T. Fan*, HMAS 291375; in mixed forest of *Betula*, *Quercus* and *Pinus*, alt. 1470 m, 20 Aug. 2020, *T.K. Zong*, HMAS 291504; in *Betula* forest, alt. 1542 m, 22 Aug. 2020, *G.J. Li*, HBAU 15552, *X. Zhang*, HMAS 249872; in *Larix* forest, alt. 2031 m, 22 Aug. 2020, *T.T. Fan*, HMAS 281433, *X.J. Xie*, HMAS 291477; in *Larix* forest, alt. 1560–1585 m, 22 Aug. 2020, *Y.B. Guo*, HMAS 281437, HMAS 291524; Yu County, Jinhekou Forest Park, in broadleaf forest, 8 Aug. 2020, *G.J. Li*, HBAU 15437, HBAU 15457; ibid., 27 Aug. 2020, *G.J. Li*, HBAU 15665, HBAU 15672, HBAU 15679; Yu County, Xiao Wutai Mountain National Nature Reserve, under *Populus* and *Acer*, alt. 1356–1468 m, 8 Aug 2020, *Y.B. Guo*, HMAS 291387, *X.M. Jiao*, HMAS 291423, HMAS 291424, *L. Sun*, HMAS 291430, HMAS 291431; under *Populus* and *Acer*, alt. 1319–1482 m, 27 Aug. 2020, *T.T. Fan*, HMAS 281445, HMAS 291381, *Y.B. Guo*, HMAS 291399, HMAS 291400, *X.N. Shan*, HMAS 291362, HMAS 291363, HMAS 291365, *X.J. Xie*, HMAS 281649, HMAS 281650, HMAS 291489, HMAS 291490, HMAS 291491, HMAS 291492, *X. Zhang*, HMAS 291500, HMAS 291502, *T.K. Zong*, HMAS 281652, HMAS 291518, HMAS 291528, HMAS 291529; Inner Mongolia Autonomous Region, Aohan Qi, Daheishan National Nature Reserve, 4 Sep. 2015, *T.Z. Liu, J.N. Zhao & H.L. Meng*, CFSZ 10743; Balinyou Qi, Saihanwula National Nature Reserve, 1 Sep. 2017, *T.Z. Liu & Wulantuya*, CFSZ 18827; Genhe County, Mangui Town, under *Populus* trees, alt. 603 m, 24 Aug. 2017, *M.L. Xie*, HMJAU 48642; Jilin Province, Antu County, Changbai Mountain National Nature Reserve, in broadleaf forest of *Populus* and *Salix*, alt. 770 m, 20 Sep. 2020, *M.L. Xie*, HMJAU 48717, HMJAU 48718, HMJAU 48719; Qinghai Province, Huzhu County, Beishan Forest Farm, alt. 3000 m, 15 Aug. 2004, *L.D. Guo & Y. Zhang*, HMAS 145566; Sichuan Province, Batang County, roadside to Litang County, in mixed forest of *Pinus densata*, *Abies* and Rosaceae, alt. 3711 m, *T.Z. Wei, L.H. Sun, Z.X. Wu & R.C. Zhang*, HMAS 277064; Zhejiang Province, Qingyuan County, Baishanzu National Park, in evergreen broadleaf forest of *Lithocarpus* scattered *Rhododendron* and *Theaceae*, 12 Sep. 2013, *J.L. Chen*, HMJAU 48768; ibid., 5 Sep. 2020, *J.L. Chen*, HMJAU 48749, HMJAU 48750, HMJAU 48757.

Notes: *Cortinarius subclackamasensis* is characterized by ellipsoid basidiospores. It produces medium- to large-sized basidiomata, a violet grey to brownish orange or reddish brown pileus, a yellowish universal veil, and ellipsoid basidiospores, on average 9.1–9.5 × 5.8–6.2 µm. It is a widely distributed species in China, and can be easily distinguished from other species in sect. *Anomali*. Two specimens, HBAU 15665 (MW862366) and HBAU 15437 (MW862347), were reported as *C. caninus* and *C. xanthocephalus* respectively by Shi *et al.* (2022). However, the morphological and phylogenetic investigations concluded that they were *C. subclackamasensis*. Phylogenetically, the sister species of *C. subclackamasensis* is *Cortinarius* sp7 from which it differs by seven substitutions and indel positions in the nrITS region, with a similarity of 98.8 %. In molecular data, the intraspecific genetic variability of *C. subclackamasensis* is 0.8 % in the nrITS region.

Cortinarius tabularis (Fr.) Fr., *Epicr. Syst. Mycol. (Upsaliae)*: 284. 1838. Figs 5C, D, 6R, 7R.

Pileus 23–85 mm diam., hemispherical when young, later plano-convex to plane, sometimes with a broad umbo, surface somewhat viscid when young, non hygrophanous, somewhat shiny to distinctly glittery when dry, slight clay greyish yellow to greyish brown. *Lamellae* emarginate, moderately crowded, slightly greyish blue when young, then greyish brown, edges

Fig. 5. Basidiomata. **A.** *C. subclackamasensis* HMJAU 48642. **B.** *C. subclackamasensis* HMJAU 48718. **C.** *C. tabularis* HMJAU 44269. **D.** *C. tabularis* HMAS 287406. **E.** *C. vernalianomalus* HMJAU 48770 (holotype). **F.** *C. vernalianomalus* HMAS 287405. **G, H.** *C. xizangensis* HMAS 274227 (holotype). Photos by: A–C. M.L. Xie; D. Q.Q. Huang; E. L.L. Qi; F. Q. Yang; G, H. T.Z. Wei. Scale bars = 20 mm.

even. *Stipe* 50–102 mm long, 3–9 mm thick above, cylindrical to somewhat clavate at the base, surface somewhat shiny, white, with bluish tinges at apex, later greyish yellow, basal mycelium whitish. *Universal veil* usually sparse, thin, white to yellowish. *Context* in pileus rather thick, solid, fragile, white at first, bluish in stipe apex, later yellowish. *Odour* radish. *Taste* mild. *Basidiospores* 6.8–8.7(–9.2) × 5.6–6.9 µm, Q = 1.09–1.44, Xav. = 7.4–8.2 × 6.0–6.4 µm, Qav. = 1.21–1.27, broadly ellipsoid, rarely subgloboid, weakly to moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae entangled to interwoven, radially arranged, hyaline to yellowish brown, 3–8 µm wide, smooth to somewhat encrusted; hypocutis well developed, hyphae 12–30 µm wide, hyaline to yellowish, somewhat cellular. *Clamp connections* present.

Ecology and distribution: Known from northeast China in *Betula platyphylla* forests or mixed with *Larix gmelinii*, and from east China under broadleaf. Also widespread in Europe and in North America from northern Quebec and Alaska under broadleaf and mixed forests including *Picea*, *Betula*, *Alnus*, *Salix*, *Quercus*, and *Fagus*.

Specimens examined: **China**, Heilongjiang Province, Mohe County, Gulian Forest Farm, in *Betula platyphylla* forest, alt. 550 m, 25 Aug. 2016, *M.L. Xie, A. Ma & J.J. Hu*, HMJAU 44248, HMJAU 44249; Qianshao Forest Farm, in mixed forest of *Betula platyphylla* and *Larix gmelinii*, alt. 490 m, 26 Aug. 2016, *M.L. Xie, A. Ma & J.J. Hu*, HMJAU 44269; Inner Mongolia Autonomous Region, Genhe County, Mangui Town, Ningcuishan Park, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 820 m, 25 Aug. 2017, *M.L. Xie & Y. Wang*, HMJAU 44484; Jinhe Town, in mixed forest of *Larix gmelinii* and *Betula platyphylla*, alt. 820 m, 25 Aug. 2018, *M.L. Xie*, HMJAU 44506; Zhejiang Province, Xihu District, Hangzhou Botanical Garden, in broadleaf, 7 Apr. 2023, *Q.Q. Huang*, HMAS 287406.

Notes: *Cortinarius tabularis* is a greyish brown species, without bluish tinges except at the lamellae and stipe apex. The whitish stipe is often with sparse universal veil. The basidiospores are broadly ellipsoid. It is reported as a common and widespread species in China (Zang 1996, Wu *et al.* 2011), but our studies show that it is a rare species, and only occurs in Heilongjiang, Inner Mongolia and Zhejiang. The distribution of this species in China requires further confirmation. The most closely related species of *C. tabularis* is *Cortinarius* sp11 from which it differs by seven substitutions and indel positions in the nrITS region, with a similarity of 98.8 %.

Cortinarius tropicus Q.Y. Zhang *et al.*, *Front. Cell. Infect. Microbiol*. **13**: 12. 2023.

Notes: *Cortinarius tropicus* occurs in the subalpine ranges of the tropics and subtropics of China, with small basidiomata, a fibrillose disc on the pileal surface that ranges from violet to dark violet and is nearly glabrous. The basidiospores are subglobose to broadly ellipsoid. It is usually scattered or gregarious on the ground dominated by *Fagaceae*. Detailed descriptions and illustrations of *C. tropicus* can be found in Zhang *et al.* (2023).

Cortinarius vernalianomalus M.L. Xie, L.L. Qi, T.Z. Wei & Y. Li, ***sp. nov.*** MB 843756. Figs 5E, F, 6S, 7S.

Etymology: The name refers to sect. *Anomali* species with spring fruiting pattern.

Typus: **China**, Guangxi Zhuang Autonomous Region, Cangwu County, Wangfu Town, Bahui Village, in *Castanopsis chinensis* forest with scattered *Phyllostachys*, alt. 30 m, 23 Apr. 2021, *L.L. Qi* (**holotype** HMJAU 48770, **isotype** HMAS 285290).

Pileus 10–35 mm diam., hemispherical when young, later plano-convex to plane, surface covered violet squamules, greyish orange with age, dully greyish violet at first, then greyish orange at the centre. *Lamellae*, emarginate, moderately crowded, greyish violet when young, then greyish brown to brown, edges paler and uneven. *Stipe* 30–60 mm long, 3–5 mm thick, cylindrical to subcylindrical, slightly thickened at the base, up to 9 mm, bluish tinged at the apex, surface thin fibrillose, basal mycelium pale violet. *Universal veil* white, very sparse. *Context* thin, greyish violet. *Odour* radish. *Taste* mild. *Basidiospores* 6.3–7.5 × 5.5–6.2 µm, Q = 1.09–1.28, Xav. = 6.9 × 5.8 µm, Qav. = 1.18, subgloboid to broadly ellipsoid, rather weakly to moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis thinly developed, hyphae hyaline to purplish, 5–12 µm wide, smooth; hypocutis well developed, hyphae 10–50 µm wide, hyaline, irregular, somewhat cellular, smooth. *Clamp connections* present.

Ecology and distribution: Gregarious in subtropical evergreen broadleaf forest, associated with *Castanopsis chinensis*. Known from Guangxi and Yunnan of China.

Additional specimen examined: **China**, Guangxi Zhuang Autonomous Region, Xingye County, Beishi Town, Hongfu Village, in *Castanopsis chinensis* forest, alt. 100 m, 23 May 2021, *Q. Yang*, HMAS 298141.

Additional nrITS sequences data from public sequence repositories: **China**, Yunnan Province, MW374218, rxsbn-456 as *C. rigens* in GenBank.

Notes: *Cortinarius vernalianomalus* is characterized by a dully greyish violet and small basidiomata, with a subtropical distribution, a spring fruiting pattern, and occurring in habitats with *Castanopsis chinensis*. The small basidiospores are subgloboid to broadly ellipsoid, on average 6.9 × 5.8 µm. The nrITS sequence of the holotype differs from other known members of sect. *Anomali* by at least 29 substitutions and indel positions. The phylogenetic analyses also support *C. vernalianomalus* as a separate species from other members in sect. *Anomali*. The sequence MW374218 (rxsbn-456, as *C. rigens*) from a specimen in Yunnan Province is considered as the new species because it clusters with our specimens.

Cortinarius xizangensis T.Z. Wei, M.L. Xie & Y. Li, ***sp. nov.*** MB 843755. Figs 5G, H, 6T, 7T.

Etymology: The name refers to the type location, Xizang Autonomous Region, China.

Typus: **China**, Xizang Autonomous Region, Milin County, Nanyigou, under *Abies* and *Pinus*, alt. 3166 m, 20 Sep. 2015, *B.B. Li* & *T.Z. Wei* (**holotype** HMAS 274227).

Pileus 20–55 mm diam., convex when young, later plane to convex with rounded umbo, margin somewhat wavy, surface

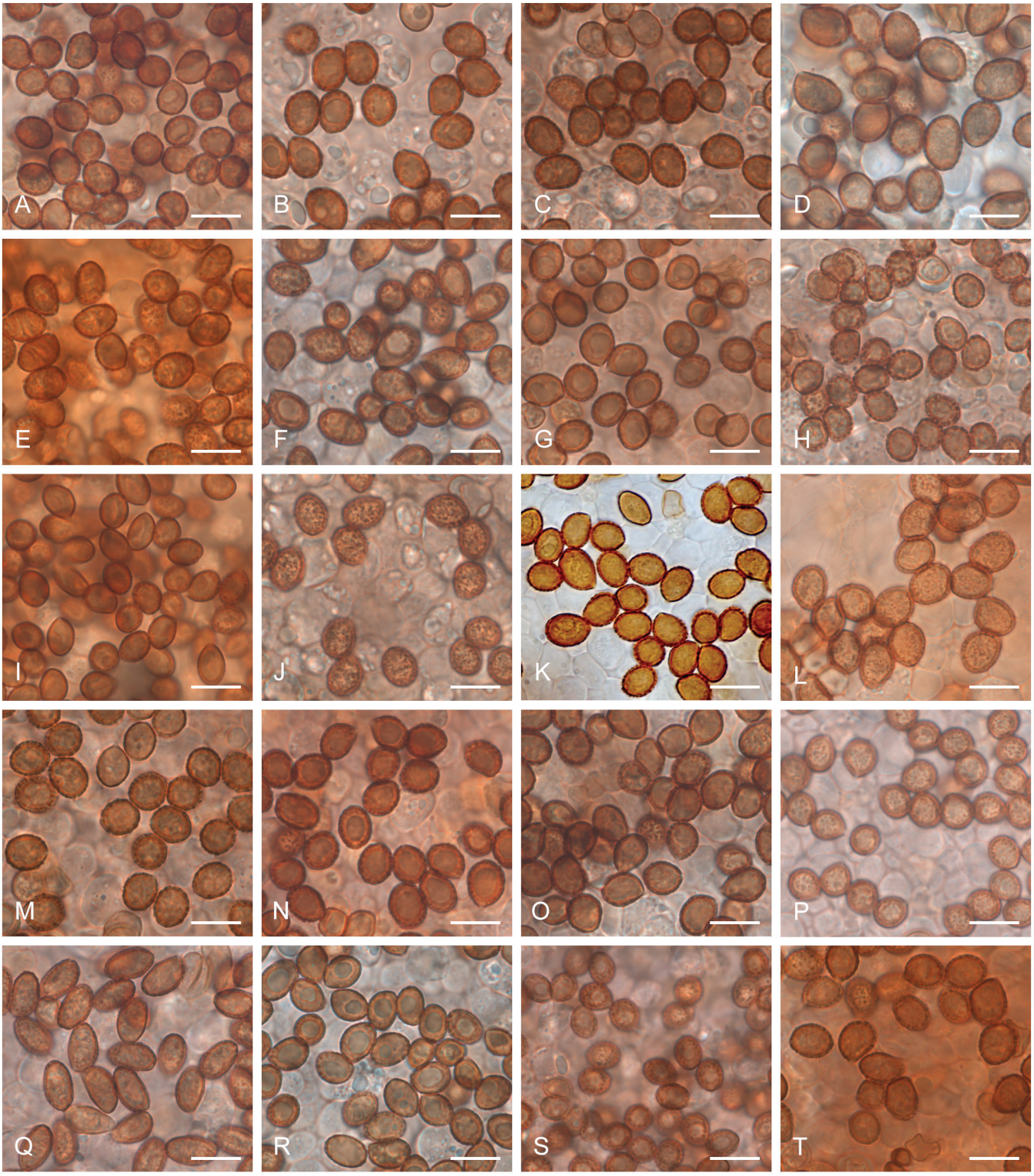

Fig. 6. Transmitted light microscopy imaging of basidiospores. **A.** *Cortinarius albocyaneoides* HMJAU 48664 (holotype). **B.** *C. albocyaneus* HMJAU 44499. **C.** *C. azureovelatus* HMJAU 48736. **D.** *C. campanianomalus* HMJAU 48748 (holotype). **E.** *C. caninus* HMJAU 44372. **F.** *C. epsomiensis* HMJAU 44505. **G.** *C. kranabetteri* HMJAU 48644. **H.** *C. lepidopus* HMJAU 48715. **I.** *C. microalbocyaneus* HMJAU 48706 (holotype). **J.** *C. neocaninus* HMJAU 48691 (holotype). **K.** *C. perrotensis* HMJAU 48662. **L.** *C. qilianensis* HMJAU 44508 (holotype). **M.** *C. robustianomalus* HMAS 254763 (holotype). **N.** *Cortinarius rufolilacinus* HMJAU 48739 (holotype). **O.** *Cortinarius subalbocyaneus* HMJAU 48659 (holotype). **P.** *C. subanomalus* HMJAU 48752 (holotype). **Q.** *C. subclackamasensis* HMJAU 48642. **R.** *C. tabularis* HMJAU 44269. **S.** *C. vernalianomalus* HMJAU 48770 (holotype). **T.** *C. xizangensis* HMAS 274227 (holotype). Photos by M.L. Xie. Scale bars = 10 µm.

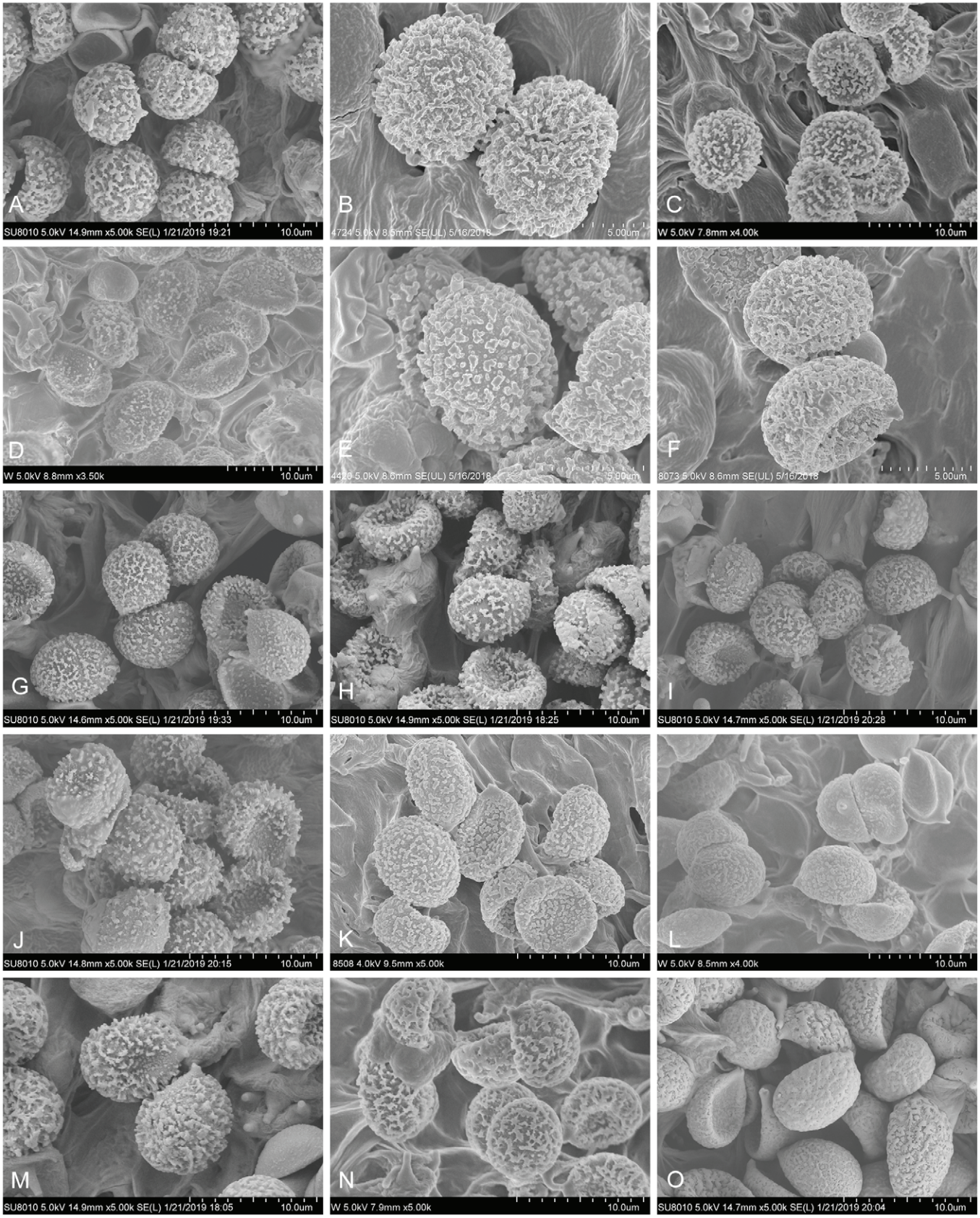

Fig. 7. Scanning electron microscopy imaging of basidiospores. **A.** *Cortinarius albocyaneoides* HMJAU 48664 (holotype). **B.** *C. albocyaneus* HMJAU 44499. **C.** *C. azureovelatus* HMJAU 48736. **D.** *C. campanianomalus* HMJAU 48748 (holotype). **E.** *C. caninus* HMJAU 44372. **F.** *C. epsomiensis* HMJAU 44505. **G.** *C. kranabetteri* HMJAU 48644. **H.** *C. lepidopus* HMJAU 48715. **I.** *C. microalbocyaneus* HMJAU 48706 (holotype). **J.** *C. neocaninus* HMJAU 48691 (holotype). **K.** *C. perrotensis* HMJAU 48662. **L.** *C. qilianensis* HMJAU 44508 (holotype). **M.** *C. robustianomalus* HMAS 254763 (holotype). **N.** *Cortinarius rufolilacinus* HMJAU 48739 (holotype). **O.** *Cortinarius subalbocyaneus* HMJAU 48659 (holotype). **P.** *C. subanomalus* HMJAU 48752 (holotype). **Q.** *C. subclackamasensis* HMJAU 48642. **R.** *C. tabularis* HMJAU 44269. **S.** *C. vernalianomalus* HMJAU 48770 (holotype). **T.** *C. xizangensis* HMAS 274227 (holotype). Photos by M.L. Xie.

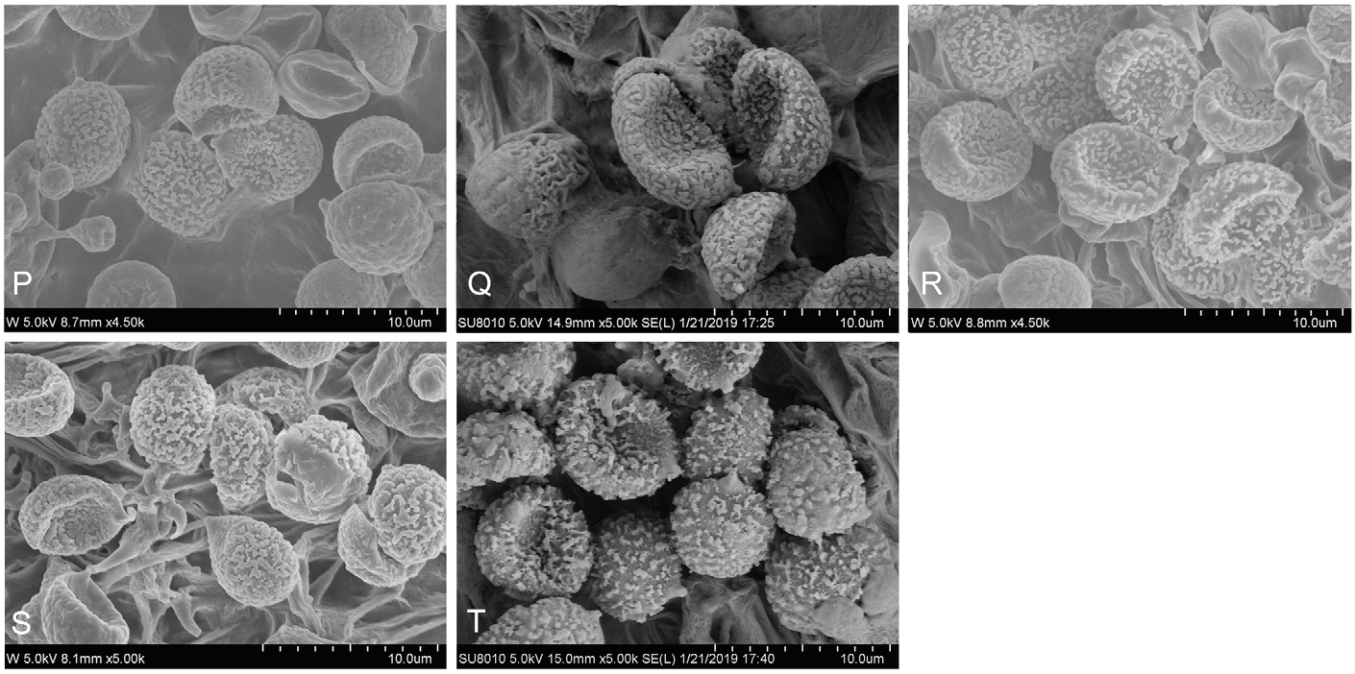

Fig. 7. (Continued).

somewhat viscid and strongly hygrophanous when moist, at first with white fibrillose, especially at the margin, violet brown at margin, orange red at the centre. *Lamellae* emarginate, moderately crowded, greyish violet when young, later greyish orange to brown, edges even. *Stipe* 20–80 mm long, 5–7 mm thick, cylindrical to subcylindrical, slightly thickened at base, up to 12 mm, surface white fibrillose, bluish tinges at the apex. *Universal veil* white, sometimes forming a thin ring on the stipe. *Context* fleshy, bluish tinges, especially at the stipe apex. *Odour* and *Taste* not recorded. *Basidiospores* 7.1–9.0(–9.5) × 5.7–7.3 µm, Q = 1.10–1.38, Xav. = 7.6–8.2 × 6.3–7.0 µm, Qav. = 1.21–1.28, subgloboid to broadly ellipsoid, finely to moderately verrucose. *Basidia* clavate, 4-spored, hyaline to subhyaline, rarely yellowish to yellowish brown. *Lamellar edge* fertile. *Pileipellis* duplex: epicutis well developed, hyphae interwoven, hyaline to yellowish brown, 3.5–10 µm wide, smooth or with encrusted spots; hypocutis well developed, hyphae 15–34 µm wide, hyaline, somewhat cellular. *Clamp connections* present.

Ecology and distribution: Scattered or gregarious in alpine coniferous forests of *Abies* and *Pinus* or mixed *Abies* dominated forests with *Cupressus*, *Quercus, Rhododendron* and *Rosa*. Known from Xizang of China.

Additional specimens examined: **China**, Xizang Autonomous Region, Bomi County, alt. 3246 m, 21 Sep. 2014, *Q.M. Wang & W.L. Lu*, HMAS 272517; Milin County, Nanyigou, in *Abies* dominated forest with *Quercus, Rhododendron* and *Rosa*, alt. 3166 m, 20 Sep. 2015, *T.Z. Wei* & *B.B. Li*, HMAS 254260, HMAS 254261, HMAS 254415, HMAS 274219, HMAS 274980, HMAS 275038; Yadong County, Naiduila, in *Abies* dominated forest with *Cupressus*, *Rosa* and *Rhododendron*, alt. 3956 m, 14 Sep. 2015, *T.Z. Wei* & *B.B. Li*, HMAS 275210.

Notes: *Cortinarius xizangensis* is characterized by a reddish brown and strongly hygrophanous pileus, a whitish universal veil, and subgloboid to broadly ellipsoid basidiospores. The nrITS sequence of the holotype differs from other known members of sect. *Anomali* by at least 32 substitutions and indel positions. Phylogenetically, *C. xizangensis* is close to *C. anomalus* and *C. subanomalus*. However, the pileus of *C. anomalus* is usually weakly hygrophanous and the basidiospores are larger, with dimensions of 8.0–9.0(–9.5) × (5.5–)6.0–7.0 µm (Dima *et al.* 2016). *Cortinarius subanomalus* has a violet veil, subgloboid basidiospores, and occurs in *Quercus aquifolioides* forests.

DISCUSSION

Species diversity

Cortinarius sect. *Anomali* is a species-rich and widely distributed group. However, previous studies showed that there are still many species that have not been properly described and published (Dima *et al.* 2016, 2021, Soop *et al.* 2019). Furthermore, most *Anomali* species were originally described from Europe, North America, and Australasia (Dima *et al.* 2016, 2021, Soop *et al.* 2019). Little has been done in Asia and Africa. In China, there are only 12 names that represent nine species of sect. *Anomali* that have been reported. To clarify the species composition of sect. *Anomali* in China and enrich the species diversity of this section, we examined 229 specimens in this study collected in China over the last two decades. Eleven species are described as new to science, and six species are newly recorded in China, and five known species were confirmed to be in China. In addition, the distributions of *C. caesiifolius* and *C. xanthocephalus* in China were excluded here based on the morphological and phylogenetic analyses.

Although our study presents 22 species in sect. *Anomali*, including several new species and new records for China, the phylogenetic analyses have revealed that there are still some species that are undescribed, challenging our knowledge of the species diversity in the *Anomali*. For example, MHHNU

8228 (MK250940) was recorded as *C. caesiifolius* (Chen & Zhang 2019), but the phylogenetic analyses have revealed that it belongs to the clade called *Cortinarius* sp1, not clustering with the USA species *C. caesiifolius*. Another case is that *Cortinarius anomalus* (synonym: *C. azureus*) has been widely reported in China (e.g., Xie & Wang 1983, Zhuang 2005, Yuan & Sun 2007, Bau *et al.* 2015). However, we have not found any specimens of *C. anomalus* collected in China based on the specimens obtained from field investigations and herbarium specimens. We also checked the sequences in public databases (GenBank and UNITE). The four sequences, MZ145075 (HBAU 15552), MZ145076 (HBAU 15672), MZ145077 (HBAU 15679), and MW862294 (HBAU 15473), from Chinese specimens deposited in the HBAU Herbarium were recorded as *C. anomalus* in GenBank, but the morphological examination showed the basidiospores of these specimens are ellipsoidal, and the molecular data revealed that these specimens are *C. subclackamasensis*. Additionally, the specimen HMJAU60641 labelled as *C. anomalus* by Tuo *et al.* (2022) is here treated as *C. microalbocyaneus* due to its nrITS sequence, OL891464, which is identical to our sequences. We therefore hypothesize that *C. anomalus* may not occur in China. Furthermore, in the view of the study of Dima *et al.* (2021), the phylogenetic analyses revealed that there are still many species of sect. *Anomali* undescribed globally, and the species diversity of this section is still far from being understood. Particularly, there are scanty reports of sect. *Anomali* in Africa and South America, creating an important gap in our knowledge on these continents.

Morphological and microscopical characters

As for many sections of *Cortinarius*, the various and similar morphological and microscopical characteristics between different species in sect. *Anomali* often increase the difficulty of correct identification. The basidiomata size of *Anomali* species appears to be somewhat helpful in separating species from others. For example, *C. microalbocyaneus* and *C. subalbocyaneus* are consistently smaller and slender, which could be distinguished from *C. albocyaneus*. All species of the section have violet to blue tinges at the early stages, and most of them lose this coloration and become greyish to brownish colours when mature. However, few species, e.g. *C. subanomalus*, *C. vernalianomalus* and *C. xizangensis*, have completely and persistently violet to blue basidiomata in the whole development period. Few species have a hygrophanous pileus under wet conditions, e.g. *C. xizangensis* in China, as well as *C. albidoavellaneus* and *C. barlowensis* (Dima *et al.* 2021), show a typically telamonioid feature. Moreover, some species have a viscid to ± glutinous pilei and dry stipe, which shows a phlegmacioid feature, for example *C. azureovelatus* and *C. qilianensis*. The universal veil in many *Anomali* species in Europe and North America is whitish to pale (Dima *et al.* 2016, 2021), however, the veil colour of Chinese species is apparently much more variable, for example *C. rufolilacinus* and *C. subanomalus* are violet buff, and *C. robustianomalus* is more greyish buff.

Few microscopic characteristics are available for the identification of sect. *Anomali*. The shape and size of basidiospores are often one of the useful characteristics for the identification of sect. *Anomali*. The basidiospore shapes of the species are usually subgloboid to broadly ellipsoid (Qav. < 1.30). However, few species produce ellipsoid basidiospores (Qav. > 1.30), especially *C. subclackamasensis* (Qav. > 1.50). Although most species produce basidiospores that are 7–9 × 5.5–7 µm on average (Dima *et al.* 2021), there are some species with larger or smaller basidiospores. For example, *C. barlowensis* has rather large basidiospores, on average 11 × 6.5 µm, whereas *C. anomalopacificus* and *C. vernalianomalus* produce rather small basidiospores that are 6.5 × 5.5 µm and 6.9 × 5.8 µm on average, respectively (Dima *et al.* 2021). The basidiospore ornamentation is difficult to interpret without considerable observation using a 1000 × oil immersion lens. However, the ornamentation can be readily observed under the SEM, e.g. the spore ornamentation of *C. campanianomalus* and *C. kranabetteri* is weakly and finely ornamented, as opposed to those of *C. epsomiensis* and *C. rufolilacinus*, which are moderately ornamented and subreticulate.

Distribution

The distribution of species in sect. *Anomali* from China showed the following distribution patterns. A total of 10 species are shared with Europe and/or North America representing 45.5 % of the known *Anomali* species in China. *Cortinarius albocyaneus*, *C. caninus*, *C. kranabetteri*, *C. subalbocyaneus*, and *C. tabularis* are shared with North America and Europe. *Cortinarius azureovelatus*, *C. epsomiensis*, *C. lepidopus*, and *C. neocaninus* are shared only with Europe. *Cortinarius microalbocyaneus* is shared only with North America. Totally 11 species seem to be endemic to East Asia, representing 50 % of the known sect. *Anomali* species in China. *Cortinarius albocyaneoides*, *C. subclackamasensis*, and *C. qilianensis* are distributed in northern China, of which *C. albocyaneoides* is shared with Japan. *Cortinarius campanianomalus*, *C. subanomalus*, *C. robustianomalus*, *C. rufolilacinus*, and *C. xizangensis* have a limited distribution in the Tibetan Plateau and Hengduan Mountains, except that *C. campanianomalus* also occurs in Taiwan Province. These patterns of distribution show that the East Asian flora plays an important role in linking European and/or North American floras and facilitating the process of species dispersal and diversification. On the other hand, 12 species are distributed in northeast China and 13 species are distributed in southwest China, of which six species are shared by the two regions, accounting for 54.5 % and 59.1 % of the known sect. *Anomali* species in China, respectively. This suggests a high species diversity in these two floristic regions. In addition, *C. cinnamomeolilacinus*, *C. tropicus*, and *C. vernalianomalus* are distributed in tropical China.

Phylogeny

Multi-gene phylogeny in sect. *Anomali*, including almost all known species of this section, was processed in this study based on 286 nrITS, 117 nrLSU, 85 *rpb1*, and 90 *rpb2* sequences. These barcodes represent 100 %, 34.8 %, 23.6 %, and 25.8 % of the sect. *Anomali* species present in this study, respectively. All the known species formed a separate lineage and could be distinguished from each other according to the phylogenetic analyses. More than 20 separate lineages are unnamed, which indicates that there may be

many potential undescribed species. The sect. *Anomali* split into six clades in the phylogenetic tree: the clades I–V consist of the Southern Hemisphere species, mainly Australasian species; the clade VI is the largest lineage formed by the species from the Northern Hemisphere. Except for the three singletons of clades I, II, and IV, the other clades all have high support. However, the relationships among these clades seem to be inextricable. We speculate that it may be caused by insufficient data of multi-gene sequences. Supplementing the multi-gene sequences of species in sect. *Anomali* is significant for clarifying the phylogenetic relationships of this section. Another possibility should not be overlooked; the inability to resolve the phylogenetic relationships of this section may be an inherent problem in the data, resulting from rapid diversification or explosive speciation during its evolutionary process (Gallone *et al.* 2024). This problem cannot be resolved with more species or more and better genes.

ACKNOWLEDGEMENTS

This study was supported by the China Agriculture Research System (No. CARS20), the Overseas Expertise Introduction Project for Discipline Innovation (No. D17014), the National Natural Science Foundation of China (No. 31270072), the Special Funds for the Young Scholars of Taxonomy of the Chinese Academy of Sciences (No. ZSBR-001), The Biodiversity Survey and Assessment Project of the Ministry of Ecology and Environment, China (2019HJ2096001006), the National Key Research and Development Program of China (No. 2019YFC1604703), and the Natural Science Foundation of Guangxi Province (No. 2018JJB130139). The work of B. Dima was supported by the National Research, Development and Innovation Office of Hungary (No. OTKA FK-143061), the János Bolyai Research Scholarship of the Hungarian Academy of Sciences and the ELTE Institutional Excellence Program 2020 (No. TKP2020-IKA-05) financed by the National Research, Development and Innovation Office of Hungary. We would like to express our gratitude to Y. Yang, Y.X. Guo, and Y. Wang (Jilin Agricultural University) for their help during the molecular experiments and field trips. We thank S.R. Wang (Shanxi Agricultural University) and Y.C. Zhao (Yunnan Academy of Agricultural Sciences) for their kindly provided habitat photos, as well as mycophiles Q.Q. Huang and Q. Yang for their kindly provided specimens. We particularly thank Y.J. Yao and L. Cai (Institute of Microbiology, Chinese Academy of Sciences) and T.H. Li (Guangdong Institute of Microbiology) for their kind help during borrowing specimens from HMAS and HMIGD, respectively.

Declaration on conflict of interest The authors declare that there is no conflict of interest.

REFERENCES

Ammirati JF (2014). Nomenclatural novelties. *Index Fungorum* **93**: 1.

Ammirati J, Liimatainen K, Bojantchev D, *et al.* (2021). *Cortinarius* subgenus *Leprocybe*, unexpected diversity and significant differences in species compositions between western and eastern North America. *Persoonia* **46**: 216–239. https://doi.org/10.3767/persoonia.2021.46.08

Ballarà J, Cadiñanos Aguirre JA, Campos JC, *et al.* (2014). *Cortinarius* ibero-insulares-4. *Fungi non Delineati,* Pars LXXI–LXXII. Edizioni Candusso, Alassio (SV).

Bau T, Wang JR, Cui BK, *et al.* (2015). Diversity of macrofungi in Shandong Province, China. *Mycosystema* **32**: 643–670. https://doi.org/10.13346/j.mycosystema.2013.04.014

Bidaud A, Loizides M, Armada F, *et al.* (2021). *Cortinarius* subgenus *Leprocybe* in Europe: expanded Sanger and Next Generation Sequencing unveil unexpected diversity in the Mediterranean. *Persoonia* **46**: 188–215. https://doi.org/10.3767/persoonia.2021.46.07

Bidaud A, Moënne-Loccoz P, Reumaux P (1992). *Atlas des Cortinaires* Pars IV. Fédération mycologique Dauphiné-Savoie, France.

Borchsenius F (2009). *FastGap 1.2*. Department of Bio-sciences, Aarhus University, Denmark. http://www.aubot.dk/FastGap_home.htm.

Brandrud TE, Lindstrom H, Marklund H, *et al.* (1990). *Cortinarius, Flora Photographica* Vol. I. *Cortinarius* HB, Sweden.

Brandrud TE, Lindstrom H, Marklund H, *et al.* (2014). *Cortinarius, Flora Photographica* Vol. V. *Cortinarius* HB, Sweden.

Chen ZH, Zhang P (2019). *Atlas of Macrofungi in Hunan*. Hunan Normal University Press, China.

Consiglio G (2012). *Il Genere Cortinarius in Italia* Parte sesta. Associazione Micologica Bresadola. Fondazione Centro Studi Micologici, Trento, Italy.

Consiglio G, Antonini DA, Antonini M (2005). *Il Genere Cortinarius in Italia* Parte terza. Associazione Micologica Bresadola. Fondazione Centro Studi Micologici, Vicenza, Italy.

Consiglio G, Antonini DA, Antonini M (2006). *Il Genere Cortinarius in Italia* Parte quarta. Associazione Micologica Bresadola. Fondazione Centro Studi Micologici, Vicenza, Italy.

Dima B, Lindström H, Liimatainen K, *et al.* (2016). Typification of Friesian names in *Cortinarius* sections *Anomali*, *Spilomei*, and *Bolares*, and description of two new species from northern Europe. *Mycological Progress* **15**: 903–919. https://doi.org/10.1007/s11557-016-1217-5

Dima B, Liimatainen K, Niskanen T, *et al.* (2021). Type studies and fourteen new North American species of *Cortinarius* section *Anomali* reveal high continental species diversity. *Mycological Progress* **20**: 1399–1439. https://doi.org/10.1007/s11557-021-01738-0

Edler D, Klein J, Antonelli A, *et al.* (2021). raxmlGUI 2.0: A graphical interface and toolkit for phylogenetic analyses using RAxML. *Methods in Ecology and Evolution* **12:** 373–377. https://doi.org/10.1111/2041-210X.13512

Eyssartier G, Trendel J-M, Dima B (2017). *Cortinarius lividomalvaceus sp. nov.* un nouveau cortinaire de la section *Anomali*. *Bulletin Trimestriel de la Société Mycologique de France* **130**: 275–286.

Gallone B, Kuyper TW, Nuytinck J (2024). The genus *Cortinarius* should not (yet) be split. *IMA Fungus* **15**: 24. https://doi.org/10.1186/s43008-024-00159-4

Gardes M, Bruns TD (1993). ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. *Molecular Ecology* **2**: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Garnica S, Schön ME, Abarenkov K, *et al.* (2016). Determining threshold values for barcoding fungi: lessons from, *Cortinarius* (*Basidiomycota*), a highly diverse and widespread ectomycorrhizal genus. *FEMS Microbiology Ecology* **92**: fiw045. https://doi.org/10.1093/femsec/fiw045

Garnica S, Weiß M, Oertel B, *et al.* (2005). A framework for a phylogenetic classification in the genus *Cortinarius* (*Basidiomycota*, *Agaricales*) derived from morphological and molecular data. *Canadian Journal of Botany* **83**: 1457–1477. https://doi.org/10.1139/b05-107

Gouy M, Tannier E, Comte N, *et al.* (2021). Seaview Version 5: A multiplatform software for multiple sequence alignment, molecular phylogenetic analyses, and tree reconciliation. *Methods in Molecular Biology* **2231**: 241–260. https://doi.org/10.1007/978-1-0716-1036-7_15

Harrower E, Ammirati JF, Cappuccino AA, *et al.* (2011). *Cortinarius* species diversity in British Columbia and molecular phylogenetic comparison with European specimen sequences. *Botany* **89**: 799–810. https://doi.org/10.1139/b11-065

Harrower E, Bougher NL, Henkel TW, *et al.* (2015). Long-distance dispersal and speciation of Australasian and American species of *Cortinarius* sect. *Cortinarius*. *Mycologia* **107**: 697–709. https://doi.org/10.3852/14-182

Høiland K, Holst-Jensen A (2000). *Cortinarius* phylogeny and possible taxonomic implications of ITS rDNA sequences. *Mycologia* **92**: 694–710. https://doi.org/10.1080/00275514.2000.12061210

Katoh K, Standley DM (2013). MAFFT multiple sequence alignment software version 7: improvements in performance and usability. *Molecular Biology and Evolution* **30**: 772–780. https://doi.org/10.1093/molbev/mst010

Kumar S, Stecher G, Tamura K (2016). MEGA7: molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution* **33**: 1870–1874. https://doi.org/10.1093/molbev/msw054

Li DZ (2008). Floristics and plant biogeography in China. *Journal of Integrative Plant Biology* **50**: 771–777. https://doi.org/10.1111/j.1744-7909.2008.00711.x

Li Y, Li TH, Yang ZL, *et al.* (2015). *Atlas of Chinese macrofungal resources*. Central China Farmers Publishing House, China.

Liimatainen K, Ainsworth AM (2018). Fifteen *Cortinarius* species associated with *Helianthemum* in Great Britain results of a DNA-based analysis. *Field Mycology* **19**: 119–135. https://doi.org/10.1016/j.fldmyc.2018.10.006

Liimatainen K, Ammirati JF, Niskanen T, *et al.* (2022a). Nomenclatural novelties. *Index Fungorum* **528**: 1–10.

Liimatainen K, Carteret X, Dima B, *et al.* (2017). *Cortinarius* section *Bicolores* and section *Saturnini* (*Basidiomycota*, *Agaricales*), a morphogenetic overview of European and North American species. *Persoonia* **39**: 175–200. https://doi.org/10.3767/persoonia.2017.39.08

Liimatainen K, Kim JT, Pokorny L, *et al.* (2022b). Taming the beast: a revised classification of *Cortinariaceae* based on genomic data. *Fungal Diversity* **112**: 89–170. https://doi.org/10.1007/s13225-022-00499-9

Liimatainen K, Niskanen T, Dima B, *et al.* (2014). The largest type study of *Agaricales* species to date: bringing identification and nomenclature of *Phlegmacium* (*Cortinarius*) into the DNA era. *Persoonia* **33**: 98–140. https://doi.org/10.3767/003158514X684681

Liimatainen K, Niskanen T, Dima B, *et al.* (2020). Mission impossible completed: unlocking the nomenclature of the largest and most complicated subgenus of *Cortinarius*, *Telamonia*. *Fungal Diversity* **104**: 291–331. https://doi.org/10.1007/s13225-020-00459-1

Liu YJ, Rogers SO, Ammirati JF (1997). Phylogenetic relationships in *Dermocybe*, and related *Cortinarius* taxa based on nuclear ribosomal DNA internal transcribed spacers. *Canadian Journal of Botany* **75**: 519–532. https://doi.org/10.1139/b97-058

Matheny PB (2005). Improving phylogenetic inference of mushrooms with RPB1 and RPB2 nucleotide sequences (*Inocybe*; *Agaricales*). *Molecular Phylogenetics and Evolution* **35**: 1–20. https://doi.org/10.1016/j.ympev.2004.11.014

Matheny PB, Ammirati JF (2003). *Inocybe angustispora*, *I. taedophila*, and *Cortinarius aureifolius*: an unusual Inocyboid *Cortinarius*. *Mycotaxon* **88**: 401–407.

Matheny PB, Liu YJ, Ammirati JF, *et al.* (2002). Using RPB1 sequences to improve phylogenetic inference among mushrooms (*Inocybe*, *Agaricales*). *American Journal of Botany* **89**: 688–698. https://doi.org/10.3732/ajb.89.4.688

Melot J (2007). Interprétation et typification de quelques espèces friésiennes critiques ou peu connues du genre *Cortinarius*. *Journal des Journées Européennes du Cortinaire* **9**: 112–124.

Moncalvo JM, Lutzoni FM, Rehner S, *et al.* (2000). Phylogenetic relationships of agaric fungi based on nuclear large subunit ribosomal DNA sequences. *Systematic Biology* **49**: 278–305. https://doi.org/10.1093/sysbio/49.2.278

Moser M (1961). *Die Gattung Phlegmacium. Die Pilze Mitteleuropas, Band IV*. Julius Klinkhardt, Germany.

Moser M (1983). Die Röhrlinge und Blätterpilze. In: *Kleine Kryptogamenflora, Band IIb/2* (Gams H, eds). 5th edn. Fischer Verlag, Germany.

Nagy LG, Kocsubé S, Csanádi Z, *et al.* (2012). Re-mind the gap! Insertion-deletion data reveal neglected phylogenetic potential of the nuclear ribosomal internal transcribed spacer (ITS) of fungi. *PLoS ONE* **7**: e49794. https://doi.org/10.1371/journal.pone.0049794

Niskanen T, Douglas B, Kirk P, *et al.* (2018). New discoveries: species of fungi described in 2017. In: *State of the World's Fungi 2018, Report* (Willis KJ, eds). Royal Botanic Gardens, Kew, UK: 18–23.

Niskanen T, Liimatainen K, Kytövuori I, *et al.* (2016). *Cortinarius* subgenus *Callistei* in North America and Europe — type studies, diversity, and distribution of species. *Mycologia* **108**: 1018–1027. https://doi.org/10.3852/16-033

Papp V, Dima B (2018). New systematic position of *Aurantiporus alborubescens* (*Meruliaceae*, *Basidiomycota*), a threatened old-growth forest polypore. *Mycological Progress* **17**: 319–332. https://doi.org/10.1007/s11557-017-1356-3

Peintner U, Moncalvo JM, Vilgalys R (2004). Towards a better understanding of the infrageneric relationships in *Cortinarius* (*Agaricales*, *Basidiomycota*). *Mycologia* **96**: 1042–1058. https://doi.org/10.1080/15572536.2005.11832904

Ronquist F, Teslenko M, van der Mark P, *et al.* (2012). MrBayes 3.2: Efficient bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* **61**: 539–542. https://doi.org/10.1093/sysbio/sys029

Shao LP, Xiang CT (1997). *Forest Mushrooms of China*. Northeast Forestry University Press, China.

Shi LY, Guo YB, Wei TZ, *et al.* (2022). Species diversity of macrofungi in the northern Taihang Mountains of Hebei Province. *Journal of Hebei Agricultural University* **45**: 56–66. https://doi.org/10.13320/j.cnki.jauh.2022.0078

Simmons MP, Ochoterena H, Carr TG (2001). Incorporation, relative homoplasy, and effect of gap characters in sequence-based phylogenetic analysis. *Systematic Biology* **50**: 454–462.

Singer R (1986). *The Agaricales in modern taxonomy*. 4th edn. Koeltz Scientific Books, Germany.

Soop K, Dima B, Cooper JA, *et al.* (2019). A phylogenetic approach to a global supraspecifc taxonomy of *Cortinarius* (*Agaricales*) with an emphasis on the southern mycota. *Persoonia* **42**: 261–

290. https://doi.org/10.3767/persoonia.2019.42.10

Stamatakis A (2014). RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics* **30**: 1312–1313. https://doi.org/10.1093/bioinformatics/btu033

Stensrud Ø, Orr RJS, Reier-Røberg K, *et al.* (2014). Phylogenetic relationships in *Cortinarius* with focus on North European species. *Karstenia* **54**: 57–71. https://doi.org/10.29203/ka.2014.464

Stiller JW, Hall BD (1997). The origin of red algae: Implications for plastid evolution. *Proceedings of the National Academy of Sciences of the United States of America* **94**: 4520–4525. https://doi.org/10.1073/pnas.94.9.452

Tai FL (1979). *Sylloge fungorum sinicorum*. Science Press, China.

Teng SC (1963). *Fungi of China*. Science Press, China.

Tuo Y, Rong N, Hu JJ, *et al.* (2022). Exploring the relationships between macrofungi diversity and major environmental factors in Wunvfeng National Forest Park in Northeast China. *Journal of Fungi* **8**: 98. https://doi.org/10.3390/jof8020098

Wang K, Liu DM, Li GJ, *et al.* (2021). Taxonomy of *Cortinarius* spp. from Taihang Mountains in Beijing Municipality and Hebei Province on the base of molecular phylogenetic analysis. *Journal of Liaocheng University (Nat. Sci.)* **34**: 72–87. https://doi.org/10.19728/j.issn1672-6634.2021.05.011

Wang R, Herrera M, Xu WJ, *et al.* (2022). Ethnomycological study on wild mushrooms in Pu'er Prefecture, Southwest Yunnan, China. *Journal of Ethnobiology and Ethnomedicine* **18**: 55. https://doi.org/10.1186/s13002-022-00551-7

Wei TZ, Liu TZ (2019). Resources survey of macro-basidiomycetes in southern Greater Khingan Mountains, Chifeng City. *Journal of Liaocheng University (Nat. Sci.)* **32**: 76–89. https://doi.org/10.19728/j.issn1672-6634.2019.06.012

White TJ, Bruns T, Lee S, *et al.* (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: *PCR protocols: a guide to methods and applications* (Innis MA, Gelfand DH, Sninsky JJ, *et al.* eds). Academic Press, USA: 315–322.

Wu CY (1979). The regionalization of Chinese flora. *Acta Botanica Yunnanica* **1**: 1–22.

Wu XL, Dai YC, Li TH, *et al.* (2011). *Fungi of tropical China*. Science Press, China.

Xie ML (2018). *Resources and taxonomy of Cortinarius in Northeast of China*. MA dissertation, Faculty of Agronomy, Jilin Agricultural University, China.

Xie ML, Phukhamsakda C, Wei TZ, *et al.* (2022). Morphological and phylogenetic evidence reveal five new telamonioid species of *Cortinarius* (*Agaricales*) from East Asia. *Journal of Fungi* **8**: 257. https://doi.org/10.3390/jof8030257

Xie ML, Wei TZ, Fu YP, *et al.* (2020). Three new species of *Cortinarius* subgenus *Telamonia* (*Cortinariaceae*, *Agaricales*) from China. *MycoKeys* **69**: 91–109. https://doi.org/10.3897/mycokeys.69.49437

Xie ZX, Wang Y (1983). Study of *Cortinarius* in Northeast of China. *Journal of Shanxi University* **1**: 71–81, 88. https://doi.org/10.13451/j.cnki.shanxi.univ(nat.sci.).1983.01.013

Yuan MS, Sun PQ (2007). *The pictorial book of mushrooms of China*. Sichuan Scientific and Technological Press, China.

Zang M (1996). *Fungi of Hengduan Mountains*. Science Press, China.

Zhang QY, Jin C, Zhou HM, *et al.* (2023). Enlargement of the knowledge of *Cortinarius* section *Anomali* (*Agaricales*, *Basidiomycota*): introducing three new species from China. *Frontiers in Cellular and Infection Microbiology* **13**: 1215579. https://doi.org/10.3389/fcimb.2023.1215579

Zhuang WY (2005). *Fungi of Northwestern China*. Mycotaxon, New York, USA.