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NEW DATA ON *CORTINARIUS FUNGA* (*AGARICALES*, *BASIDIOMYCOTA*) FROM ALTAISKIY NATURE RESERVE AND GORNO-ALTAYSK AREA (SW SIBERIA, RUSSIA)

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Abstract—During an expedition in 2018 to Teletskoye Lake, Altaiskiy Nature Reserve and Gorno-Altaysk area (Altay Republic), 49 *Cortinarius* species were collected and documented, including ITS DNA sequencing of 32 samples. A total of 29 telamonioid species, 3 dermocyboid species, 6 anomaloid species, 6 phlegmacioid species, 3 myxacioid species and 2 species from other groups were found, of which 32 species are new to Altay and 14 species new to Russia. The *Cortinarius* funga of the *Pinus* – *Betula* – *Abies* forests of Altay is apparently very similar to that of boreal North Europe, and indicates a remarkable uniformity of the taiga from Scandinavia to western Siberia, with respect to fungal communities. *Cortinarius privignipallens* coll., *C. subheterocyclus*, *C. nodosiporus* appeared to be rare Eurasian species. A few undescribed species were also recorded, but since belonging to species complexes, they need further studies. Most of *Cortinarius* species (33) were found in *Pinus sylvestris* (*Betula*) mossy delta forests on sand/pebbles, whereas 9 species were found in the *Pinus sibirica* – *Abies sibirica* – *Betula* mixed tall herb slope forests. A few species were also found in the *Alnus viridis* subsp. *fruticosa* – *Salix viminalis* (*Betula*) riparian delta forest (3 taxa). Altogether 13 species were recorded in the calciphilous semi-open, partly grazed *Betula pendula* woodland around Gorno-Altaysk.

Keywords: Altay funga, ITS-barcoding, morphology, new to Russia, taiga

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INTRODUCTION

The *Cortinarius* funga of the boreal taiga of Fennoscandia has been intensively studied for decades (Brandrud et al., 1990–2018; Soop, 1992–2017; Niskanen et al., 2009, 2011, 2012; Jeppesen et al., 2012), but the vast eastern taiga through European Russia and Siberia has been comparatively little studied and documented. Nezdoinog (1983, 1996), in her all-Russian monograph on *Cortinariaceae*, published a number of records from Siberia (18 species from West and 102 species from East Siberia), but with the quite different species concept of that time, it is often difficult to exactly

interpret her species names. This applies especially to critical groups such as subgenus *Telamonina*, where many classical species have been split in more taxa.

Mycologists from different regions of Siberia have collected and published *Cortinarius* species in a number of regional papers (Beglyanova, 1972; Kutafieva, 1984; Astapenko, Kutafieva, 1990; Petrov, 1991; Perova, Gorbunova, 2001; Gorbunova et al., 2016; Malyshcheva et al., 2017), however, most of these data are included in the monograph of Nezdoinog (1996). Rolf Singer collected many former *Cortinariaceae*

specimens in the Altay in 1937 (Singer, 1950), but *Cortinarius* findings has not been published.

The interest for *Cortinarius* in the eastern taiga region is now increasing, and in recent years, mycologists such as T. Bulyonkova, D. Ageev (Novosibirsk) and N. Filippova (Khanty-Mansiysk) have collected and studied a lot of Siberian cortinariid from the Ob river area. So far, a study from *Abies sibirica* – *Picea obovata* – *Pinus* – *Betula* – *Populus* forests near Khanty-Mansiysk has been published, including 69 *Cortinarius* species (Filippova, Bulyonkova, 2017). In Tomsk Region, a study on the mycorrhizal partners of *Pinus sibirica* and *P. sylvestris* has recently been performed, including 50 *Cortinarius* species compiled (Vaishlya et al., 2017). However, little has been published from the Altay region, except a study from alpine belt, *Dryas oxydontha* tundra (Gorbunova, 2003, 2010, 2014), and some data from forests compiled in regional macromycetes studies (Gorbunova, 1997, 2001, 2018, 2019), but no data from the Altaiskiy Nature Reserve.

At the end of August 2018, after the national Russian mycological workshop at Tomsk, a mycological expedition was performed to Novosibirsk, Gorno-Altaysk and to the Altaiskiy Nature Reserve (Teletskoye Lake). The results on *Cortinarius* found the Altay expedition are presented here. Another mycological expedition was arranged to Altay including the Teletskoye Lake area in 2001, and a number of *Cortinarius* samples were collected by Meinhard Moser (Henning Knudsen, Ursula Peintner, pers. comm.). According to list of 2001 Altay collections from the Innsbruck IBF Ferdinandeum herbarium provided by U. Peintner, Moser found 9 *Cortinarius* species in the Teletskoye Lake area. Unfortunately, Moser did not manage publish the Altay results before he passed away autumn 2002 (except for the find of *C. moseri*; Moser, 2002). So, we can state that very little on the diversity, distribution and ecology of *Cortinarius* in Altay forests were published before our study, and vast areas of Siberia are almost to be regarded as “terra incognita” for our cortinariid.

MATERIALS AND METHODS

The following forest types were visited in the Altaiskiy Nature Reserve and Gorno-Altaysk area during our expedition 28 August to 02 September 2018: (i) tall-herb mixed *Pinus sibirica* (*Abies* – *Betula*) forests, (ii) mossy/grassy, herb-rich *Pinus sylvestris* forests on deltas, (iii) calcareous, semi-open *Larix sibirica* steppe forests, (iv) riparian *Alnus viridis* subsp. *fruticosa* and *Salix viminalis* forests on deltas, and (v) calcareous, grazed, semi-open *Betula pendula* woodlands. We devoted approximately one day on each of these forest types; a little less on the *Larix* steppe forest which was poor in fungi, and some more on the *Pinus sylvestris* type, which was the richest. The four first forest types were visited along Teletskoye Lake, whereas the semi-open *Betula* woodlands were studied near Gorno-Altaysk.

Material of all species was collected and deposited in the Mycological herbarium of the Komarov Botanical Institute RAS (St. Petersburg, Russia). Microscope examinations have been performed with standard (Zeiss) equipment, mounting in KOH. So far, 32 samples have been rDNA ITS sequenced. Sequencing methods, including DNA extraction, polymerase chain reaction (PCR) and sequencing procedures follow the methods as described in Brandrud et al. (2018b) and Holec et al. (2018). Most sequences are deposited to the GenBank. However, sequences of undescribed species or partial sequences remain unpublished.

In the annotated list, all species are commented in the following manner: each record contains information on locality, date of collecting, collection number in the Mycological herbarium of the Komarov Botanical Institute (LE), personal field number of Tor Erik Brandrud (TEB), and notes on taxonomy and ecology of species, if it is necessary. Species, new to Altay are marked with one asterisk (*), and those to Russia – with two asterisks (**). Most records were made in the territory of the Altaiskiy Nature Reserve along the Teletskoye Lake. In these cases, only the name of the site is indicated (cordon means forestry station) (Fig. 1):

1) Cordon Bele, near Verkhniy Kamelik River (calcareous, semi-open steppe forest with *Larix sibirica* and (near trail) some *Betula*, *Salix* spp., single *Pinus sibirica*), 51.411226° N, 87.798057° E, 28.08.2018;

2) Cordon Chelyush, near farm (mixed delta forest with *Pinus sylvestris*, *P. sibirica*, *Larix sibirica*, *Betula*, *Alnus viridis* subsp. *fruticosa*), 51.411907° N, 87.796356° E, 28.08.2018;

3) Cordon Kokshi, Kokshi River mouth (delta on coarse sediments of sand and boulders; mossy/grassy *Pinus sylvestris*-dominated forest with *Betula*, and some *Larix sibirica*, *Pinus sibirica*, *Salix* and *Rhododendron dauricum*), 51.576963° N, 87.685533° E, 28.08.2018, 31.08.2018;

4) Cordon Baygazan: a) upper part, ecological trail and Camera trap (*Abies sibirica*, *Larix*, *Pinus sibirica*, *Populus*), 51.76326° N, 87.796356° E; b) lower part, near cordon (tall-herb *Pinus sibirica* forest with *Betula* and some *Populus*, *Salix* and *Pinus sylvestris*), 51.758889° N, 87.432032° E, 29.08.2018;

5) Kamga bay (large bay in north east; including large delta at mouth, and smaller delta to the east along the brook, with *Alnus viridis* subsp. *fruticosa*, *Betula*, *Salix viminalis*): a) cordon Kamga, Malyi Mionok river mouth, Kamga River delta, 51.798796° N, 87.708793° E; b) north side (bear landing), 51.795376° N, 87.702699° E; c) Turochak river mouth, 51.778923° N, 87.695694° E, 30.08.2018;

6) Vicinities of the Yaylu village – 51.767483° N, 87.598526° E, 31.08.2018.

In the Gorno-Altaysk area, material was collected from two sites: a) on the left (south) bank of the Mayma River, near skilift, on slope of Komsomolskaya mountain (51.952599° N, 85.954561° E), 01.09.2018, and b) near of the village Biryula near Mayma River – 51.790722° N, 86.053993° E, 02.09.2018.

RESULTS AND DISCUSSION

General overview. Altogether 42 species of the genus *Cortinarius* were recorded during our 5 days expedition along Teletskoye Lake, whereas 13 species were collected during approx. one-day field work around Gorno-Altaysk. During the entire Altay expedition, we collected 49 *Cortinarius* species. In both regions, the material was dominated by species of the subgenus *Telamonia* sensu Brandrud et al. (1990–2018) and Niskanen et al. (2012). According to recent phylogenetic studies, this morphologically defined *Telamonia* is not a monophyletic group (Garnica et al., 2016), and should be referred to as “telamonioid taxa” verified by rDNA ITS sequencing (30 samples). Only 16 of the 49 species have been reported from Altay before (Petrova, Gorbunova, 2001; Gorbunova, 1997, 2001, 2010, 2018, 2019). Altogether 15 species are here reported for the first time to Russia and to Siberia, and as far as we know, these are also new to Asia. Some of these, such as *C. privignipallens* coll. and *C. subheterocyclus*, seem to be truly rare species, and so far, they were only known from the northwestern corner of the boreal taiga (Fennoscandia). A few very rare boreonemoral (subnemoral) elements were also found, such as *C. nodosiporus*.

The material consists otherwise mainly of typical boreal species with a wide Eurasian distribution. The *Cortinarius* species composition in Altay, both in *Pinus*, *Betula* and *Alnus* forests, were strikingly similar to that of North Western Europe (Brandrud et al., 1990–2018, Niskanen et al., 2012). See further under species comments below.

Compared to Western Europe, a few shifts in habitat preferences were observed. This applied especially to a couple of taxa that are regarded as temperate-nemoral-boreonemoral *Quercus* – *Corylus* – *Tilia* species in Europe; *C. olearioides* (Brandrud, Bendiksen, 1991) and *C. nodosiporus* (Liimatainen, 2014) which here were recorded in (southern boreal) *Betula pendula* forests without thermophilous deciduous trees like *Quercus*, *Tilia* and *Corylus*. These lowland *Betula* forests of Gorno-Altaysk had some thermophilous, boreonemoral (subnemoral) traits, and *Betula pendula* can here probably be regarded as a substitute host in the absence of *Quercus*, *Corylus* and *Tilia*.

In general, a comparatively high portion of our Altay species were found in *Betula* spp. forest stands or assumingly connected to *Betula* trees, both to *Betula pendula* and *B. pubescens*. Along Teletskoye, approx. half of the species (22) were found mainly or only under *Betula*, and at Gorno-Altaysk all 13 species were collected from pure *Betula* stands. Many of the *Betula* associates were in the Altay Reserve found in almost pristine/virgin forests, very little disturbed by man, but more or less structured by forest-fires. These mixed pristine forests with *Betula* probably represent the basic, primarily habitat of these species, which in Europe mainly occur under *Betula* in secondary, culturally influenced habitats such as grazed woodlands, road-bor-

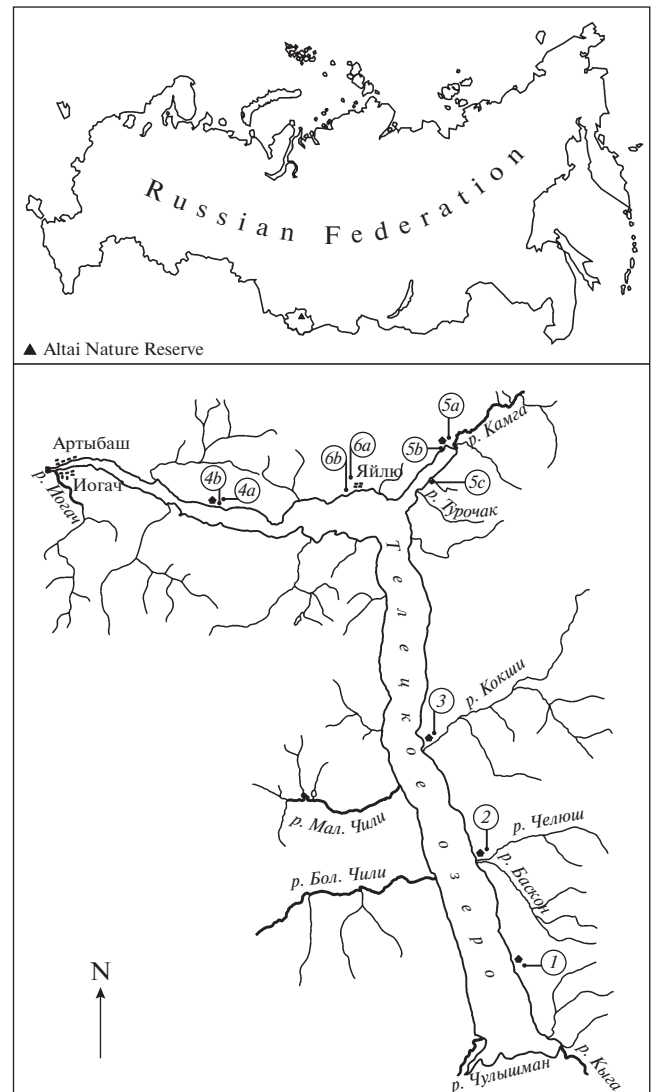


Fig. 1. Map of the Altaiskiy Nature Reserve along the Teletskoye Lake with the localities studied.

ders, parks, etc. See further comments in the annotated list.

Apart from *Betula*-associates, a number of species were found under *Pinus sylvestris* at sand-pebble deposits on deltas (see below). Only a few *Cortinarius* species were found under *Pinus sibiricus* and *Abies sibirica* (only *C. spilomeus* with certainty under *P. sibirica*). These results are corresponding also with the study of *Pinus* forests in the Tomsk region (Vaishlya et al., 2017). Here, most *Cortinarius* species were found in *Pinus sylvestris* stands, and only very few *Cortinarius* species were found in association with *P. sibirica*. These findings are also well in accordance with the poor *Cortinarius* fungi reported from the five-needled *Pinus cembra* forests of the Alps in Europe (Moser, 1961).

However, the lack of cortinarii in the *Abies sibirica* forests is more surprising, considering the many *Cortinarius* species found in mixed *Abies sibirica* – *Picea*

Table 1. *Cortinarius* species found in various forest types during Altay expedition 2018

Species	Forest communities				Field numbers	Herbarium numbers	GenBank numbers
	1	2	3	4			
Telamonioid species							
<i>C. adustorimosus</i>	+				TEB 154-18	!LE 312101	MN308187
<i>C. agathosmus</i>					TEB 223-18	LE 213080	
<i>C. alborufescens</i>	+				TEB 153-18	!LE 315537	MN308188
					TEB165b-18	LE 315538	
<i>C. balaustinus</i>	+				TEB 217-18	LE 315524	
<i>C. bivelus</i>	+	+			TEB 215-18	LE 312067	
					TEB 192-18	LE 312091	
					TEB 159-18	LE 312098	
<i>C. casimiri</i> coll.	+				TEB 178-18	!LE 312096	MN308189
					TEB 228-18	LE 312086	
<i>C. comptulus</i>	+				TEB 224-18	!LE 312085	MN308190
<i>C. decipiens</i>	+			+	TEB 244-18	!LE 312089	MN308191
					TEB 246-18	LE 315530	
					TEB 163-18	LE 315532	
<i>C. diasemospermus</i> var. <i>leptospermus</i>					TEB 161-18	!LE 295100	MN308192
					TEB 180-18	!LE 315540	MN308193
					TEB 173-18	LE 312099	
<i>C. disjungendus</i>	+			+	TEB 218-18	!LE 312064	MN308194
					TEB 235-18	!LE 315525	
					TEB 219-18	LE 315526	
					TEB 249-18	LE 312068	
<i>C. flabellus</i>	+				TEB 164-18	LE 295101	
<i>C. gentilis</i>	+				TEB 162-18	LE 315515	
<i>C. hemitrichus</i>	+				TEB 225-18	LE 315523	
<i>C. hinnuleus</i> coll.	+	+		+	TEB 167b-18	LE 312095	
					TEB 227-18	LE 312084	
					TEB 232-18	LE 315528	
<i>C. lux-nymphae</i>	+				TEB 231-18	LE 312059	
<i>C. melitosarx</i>	+				TEB 229-18	LE 312090	
<i>C. nodosiporus</i>				+	TEB 237-18	!LE 213081	MN308195
					TEB 238-18	LE 312083	
<i>C. parvannulatus</i> s. auct.	+				TEB 226-18	!LE 312060	MN308196
<i>C. privignipallens</i> coll.	+				TEB 157-18	!LE 312097	
					TEB164b-18	LE 312372	
<i>C. pseudofallax</i> coll.				+	TEB 247-18	!LE 312087	
<i>C. raphanoides</i>	+				TEB 160-18	LE 312100	
<i>C. saniosus</i>				+			
<i>C. aff. roseocastaneus</i>				+	TEB 245-18	!LE 312088	
<i>C. subheterocyclus</i>	+				TEB 230-18	!LE 315527	MN308197
<i>C. testaceofolius</i>	+				TEB 156-18	LE 315518	
<i>C. traganus</i>	+						
<i>C. turgidoides</i>	+				TEB 155-18	!LE 315539	MN308198
					TEB 222-18	LE 312062	
<i>C. umbrinolens</i>				+	TEB 179-18	!LE 312094	MN308199
<i>C. aff. vernus</i>			+		TEB 207-18	!LE 315519	MN308200
Dermocyboid species							
<i>C. croceus</i>	+				TEB 138-18	LE 315535	
					TEB 177-18	LE 315533	

Table 1. (Contd.)

Species	Forest communities				Field numbers	Herbarium numbers	GenBank numbers
	1	2	3	4			
<i>C. malicorius</i>		+			TEB 194-18	LE 312076	
<i>C. semisanguineus</i> coll.	+				TEB163b-18	LE 315517	
Anomaloid species							
<i>C. albocyaneus</i>	+	+		+	TEB 220-18 TEB 242-18	!LE 312063 !LE 315522	MN308201 MN308202
<i>C. azureovelatus</i>	+			+	TEB 221-18 TEB 243-18	!LE 312082 !LE 315531	MN308203 MN308204
<i>C. caninus</i>					TEB 158-18 TEB 191-18	!LE 312071 LE 315516	MN308205
<i>C. epsomiensis</i>		+			TEB 188-18	!LE 312077	MN308206
<i>C. lepidopus</i>	+				TEB 165-18	!LE 315536	MN308207
<i>C. spilomeus</i>		+			TEB 187-18	!LE 312073	MN308208
Phlegmacioid species							
<i>C. infractus</i> s. str.	+			+	TEB 213-18 TEB 239-18 TEB 214-18	!LE 312061 !LE 312065 LE 315529	MN308209 MN308210
<i>C. largus</i>				+	TEB 248-18	LE 312066	
<i>C. olearioides</i>				+	TEB 233-18 TEB 234-18	!LE 312078 LE 312079	MN308211
<i>C. porphyropus</i>	+	+			TEB 151-18 TEB 186-18 TEB 204-18	LE 315512 LE 312070 LE 312069	
<i>C. subporphyropus</i>			+		TEB 176-18 TEB 195-18	LE 315514 LE 315521	
<i>C. triumphans</i>	+	+		+	TEB 184-18 TEB 185-18 TEB 241-18	!LE 312074 LE 312092 LE 312058	
Myxacioid species							
<i>C. croceocrystallinus</i> var. <i>alneti</i>			+				
<i>C. delibutus</i>	+	+			TEB 189-18	LE 312075	
<i>C. vibratilis</i>	+						
Other groups							
<i>C. boreicyanites</i>	+				TEB 152-18	!LE 315511	MN308212
<i>C. caperatus</i>	+						
Total: 49	33	9	3	14	72	72	26

Note. Forest communities: 1 – *Pinus sylvestris* (*Betula*), mossy delta forest on sand/pebbles, 2 – *Pinus sibirica* – *Abies sibirica* – *Betula* mixed tall herb forests, 3 – *Alnus viridis* ssp. *fruticosa* – *Salix viminalis* (*Betula*) riparian delta forests, 4 – calciphilous semi-open, partly grazed *Betula pendula* woodlands. Sequenced collections are marked with an exclamation mark (!).

obovata – *Pinus* forests in the Khanty Mansiysk area (Filippova, Bulyonkova, 2017). Furthermore, a very rich *Cortinarius* funga is reported from e.g. *Abies alba* forests of Central Europe, especially in calcareous ones (Krieglsteiner, 1977). The *A. sibirica* forests of Siberia obviously need further studies, to reveal more of the *Cortinarius* diversity, in particular there is a need for search for calcareous *A. sibirica* forests rich in mycorrhizal species. In the slope forests studied in the northern part of Teletskoye Lake, it seems that the compar-

atively high nitrogen level in the lush tall-herb-vegetation could be a limiting factor for the cortinari. *Cortinarius* is one of the most sensitive groups of macrofungi with regard to critical levels of nitrogen (Brandrud, Timmerman, 1998; Jonsson et al., 2000). For some reason, the *Cortinarius* species found here, were all associated with *Betula*.

Forest types of Altay rich in *Cortinarius* species. Of the forest types visited, the mossy *Pinus sylvestris* (*Betula pendula*) forests on sand/boulder fields on deltas

and the calcareous, grazed, semi-open *Betula pendula* woodlands were standing out with a rich *Cortinarius* funga, including a number of rare and little known species, and these habitats will be focused in the following.

The other forest types had few and/or more trivial *Cortinarius* species. The tall-herb, mixed *Pinus sibirica* forests covered considerable area on the steep slopes along northern and central parts of Teletskoye Lake, and some *Cortinarius* species (altogether 9) were found also there, but mainly widespread species associated with *Betula*, and apparently taxa being tolerant to the rather high nitrogen levels in these extremely luxuriant tall-herb forest types.

Larix forests are known to harbour only a few *Cortinarius* species, and not a single species was found under *Larix* during our expedition. Moreover, this calcareous, semi-open steppe-forest had a very dense, meadow-like vegetation of herb and grasses, and very few mycorrhizal fungi at all were found in these spice-smelling meadows. Finally, the *Alnus* forests on deltas of Teletskoye Lake were partly rich in mycorrhizal species, but as normal for such wetland forests, not with many *Cortinarius*. The Danish mycologist Henning Knudsen made in 2001 a very interesting find of *Cortinarius moseri* under *Alnus viridis* subsp. *fruticosa* in the most southeastern bay of Teletskoye Lake. The find of this species, which is otherwise known only from the Alps, was published by Moser (2002).

Mossy/grassy, herb-rich *Pinus sylvestris* (*Betula pendula*) forests on deltas of Teletskoye Lake were found on a couple of deltas with sandy-gravelly-stony sediments, apparently so rarely flooded and with so coarse substratum that the sites were not occupied by riparian forests, but by a mossy, herb/grass-rich kind of sandy pine forests, resembling those sandy pine forests found on glacial-glacifluvial sediments e.g. in Novosibirsk-Tomsk regions of Western Siberia. This was the most *Cortinarius*-rich habitat visited along Teletskoye Lake, and was investigated in detail, especially the well-developed, rich pine forest of the Kokshi delta. At Kokshi, the forest was dominated by *Pinus sylvestris*, with scattered *Betula pendula*, a few *Larix sibirica* (which prevails in the surrounding forests) and *Pinus sibirica*. The outer margins of the forest towards the lake were dominated by wind-blown sand, whereas the inner parts were partly dominated by larger, moss-covered pebbles, and there were also a few small rock outcrops of soft, easy weathered, calcareous shales. The forest had a well-developed moss layer (*Pleurozium*, *Hylocomium*, *Dicranum*), with more or less grasses (*Calamagrostis*), low-herbs (*Rubus saxatilis*, *Polygonatum*, *Carex*, patchwise *Bergenia*), sometimes ericaceous plants (*Vaccinium* spp.) and sometimes a well-developed shrub-layer of e.g. *Spiraea chamaedryfolia* and *Rhododendron dauricum*. The genus *Cortinarius* was dominating the funga here, with 33 species recorded at Kokshi alone. Among them, some belong to a typical sandy pine forest element, with taxa such as *C. luxnymphae*, *C. adustorimosus* and *C. albo-rufescens* (the

latter probably with *Betula*). Furthermore, a number of more or less demanding *Betula* taxa were found, such as *C. bivelus*, *C. balaustinus*, *C. albocyanus*, *C. boreicyanites* and *C. infractus* s. str. The element is very similar to that of *Pinus* and *Betula* forests in northwestern Europe, but many of the species are new to Siberia, and apparently new to Russia and to Asia, as well (see notes below).

Calcareous, grazed, semi-open *Betula pendula* woodland around Gorno-Altaysk. A band of calcareous bedrocks (limestones and shales) is found at Gorno-Altaysk and in the direction southeastward from the city. We visited a few sites within this area, which were adjacent to villages, influenced by traditional management, with grazing or former grazing. Here we found elements of a calciphilous *Cortinarius* funga in semi-open *Betula pendula* forests on (steep) slopes with rather thin soil. These were herb-rich, rather open stands, and some of the hotspots were in fact at forest borders towards open pastures. Fragments of this habitat were also observed in the southeastern part of Teletskoye Lake, in the vicinity of the small farm at Bele, where a mixed calcareous *Larix-Betula* woodland was found along small roads. Here a few calciphilous *Betula* associates were observed, and more intensive collecting might have revealed more of this element also along Teletskoye Lake, within the Altaiskiy Nature Reserve.

Annotated list of species. Comments on the 49 species of *Cortinarius* recorded in the Altay Republic in 2018 are presented here.

Telamonioid species

The subgenus *Telamonia* sensu Brandrud et al. (1990–2018) and Niskanen et al. (2012), now referable as “telamonioid species” consists of mainly small to medium-sized species with a hygrophanous pileus (changing colour when water-soaked) (see Brandrud et al. 1990–2018). Many are ochraceous to greyish or reddish brown, and include a number of taxonomic, intricate complexes that hardly can be solved without molecular methods. These are here verified by sequencing data. This group was the dominating in our material, with 25 species recorded in the Altay Nature Reserve (29 species when Gorno-Altaysk included), and included many rare and little known taxa new to this part of Eurasia, especially those found in the mossy-herb-rich *Pinus-Betula* delta forests.

***Cortinarius adustorimosus* Rob. Henry (= *C. pseudorubicosus* Reumaux) – Kokshi, TEB 154-18 (LE 312101) (Fig 2a).

This species has also been called *C. pseudorubicosus*, and it is possible that the older name *C. procax* Melot (1980) covers the same species. This is a large fungus in the sect. *Brunnei*, when young resembling *C. suberi*, with an innately fibrillose to marbled pileus, and browning with age, like e.g. *C. brunneus* (but never so dark). The species has characteristic, very small



Fig. 2. *Cortinarius adustorimosus* (a), *C. alborufescens* (b), *C. disjungendus* (c), *C. nodosiporus* (d).

spores, smaller than e.g. *C. suberi*. In Altay the species was found in mossy, herb-rich *Pinus sylvestris* forest on sand-pebble deposits in the Kokshi delta. This species seems to prefer sandy pine forests, and is so far reported from a few places in Fennoscandia (Niskanen et al., 2009) and North America (Niskanen et al., 2013). This is the first report from Russia, Siberia, and apparently also from Asia.

**Cortinarius agathosmus* Brandrud, H. Lindstr. et Melot – Kokshi, TEB 223-18 (LE 213080).

This was found once in the mossy *Pinus* – *Betula* forest at the Kokshi river delta. The species seems to be a typical boreal taiga species, in northwestern Europe known mainly from *Picea* forests, but also recorded in (subalpine) *Betula* forests (Brandrud et al., 1990–2018). It is reported with sequence-verified material from Western Siberia by Vaishlya et al. (2017).

**Cortinarius alborufescens* Imler – Kokshi, river delta, TEB 153-18 (LE 315537), TEB 165b-18 (LE 315538) (Fig 2b).

This large and robust species resembles *C. laniger* and *C. solis-occasus*, having thick fibrillose veil remnants on pileus, and a thick, almost membranaceous

veil girdle at the stipe. However, *C. alborufescens* differs from the other by its small, amygdaloid spores. The species seems to prefer sandy pine forests, but apparently mainly associated with *Betula* spp., which can occur here and there in sandy pine forests. In Altay it was found in the pine-birch forest of the sandy-stony delta of Kokshi. This was also collected by Meinhard Moser along Teletskoe Lake in 2001 (bay in SE; collection under the name *C. lanigeroides*, in Herbarium IBF Ferdinandeum Innsbruck; U. Peintner pers. comm.). In 2018 it was found also in the Tomsk region (pers. obs.), and recently also in the Khanty-Mansiysk region (Filippova, Bulyonkova, 2017), representing the first report of *C. alborufescens* for Russia and for Asia. However, the report of *C. pearsonii* from dry *Betula* forests in the Volga basin by Iwanow and Durandin (1996), very probably refer to the same species. Apart from these records, this species is reported only from (North) Western Europe; from Fennoscandia (Jeppesen et al., 2012, Brandrud, 1990–2018), Scotland (Orton, 1958, as *C. pearsonii*) and Belgium (Imler, 1955). The species seems to be rare everywhere.



Fig. 3. *Cortinarius comptulus* (a), *C. umbrinolens* (b), *C. aff. vernus* (c), *C. epsomiensis* (d).

**Cortinarius balaustinus* Fr. – Kokshi, TEB 217-18 (LE 315524).

C. balaustinus is with its small, subglobose spores, a characteristic *Betula* associate, which occurs scattered in boreal coniferous forests with *Betula*, in northwestern Europe more frequently in subalpine birch woodlands (Brandrud et al., 1990–2018). It is reported from *Picea* – *Abies* – *Betula* forests of Western Siberia by Filippova and Bulyonkova (2017). Altogether, it is now recorded from 11 regions of Russia.

**Cortinarius bivelus* (Fr.) Fr. – Kokshi, TEB 159-18 (LE 312098), TEB 215-18 (LE 312067); Baygazan, TEB 192-18 (LE 312091).

C. bivelus was one of the more frequent *Betula*-associated species at along Teletskoye Lake, found in herb-rich sites, both in the pristine forest slopes of Baygazan, the sand-boulder delta forests of Kokshi and Chelush, as well as on grazed semi-natural sites around the village of Yaylu.

**Cortinarius casimiri* (Velen.) Huijsman – Chelush, TEB 17818 (LE 312096); Kokshi, TEB 22818 (LE 312086).

Cortinarius casimiri in traditional morphological concept (sensu Brandrud et al., 1990–2018), is a collective species comprising more small, *C. decipiens* – *C. vernus*-like taxa with large spores > 11 µm long. We believe that the present, widespread species, with a rather pronounced pink/vinaceous staining stipe base, is the true *C. casimiri*.

Cortinarius comptulus M.M. Moser – Kokshi, river delta, TEB 224-18 (LE 312085) (Fig. 3a).

This is a small red-brown or grey-brown telamonioid species, with glossy pileus, initially fine fibrillose to somewhat scaly at margin. Many groups of small, anonymously brown telamonioid taxa have been little understood, and their habitat and distribution thus also little known. This applies also to *C. comptulus*, even though this one is characterized by very small, almost subglobose spores. The species resembles taxa in the *C. flexipes* group, but differs e.g. on the lack of a pelargonium smell. A few taxa in the *C. flexipes* group also possess broadly ellipsoid-subglobose spores, but not so small as in *C. comptulus*. *Cortinarius comptulus* also resembles *C. hemitrichus*, but the latter is more strongly white scaly-flocculose on the pileus when young, and

has larger, ellipsoid spores. The species is found mainly in moderately rich to calcareous, herb-rich to grassy *Picea* and *Pinus* forests (Brandrud et al., 1990–2018; pers. obs.). In Altay, *C. comptulus* was found in large groups in the sandy near-shore margin of the Kokshi delta, growing under *Pinus*. Several reports exist of this from Western Siberia (Kudashova et al., 2013; Filippova, Bulyonkova, 2017; Vaishlya et al., 2017).

Cortinarius decipiens (Pers.) Fr. – Kokshi, TEB 163-18 (LE 315532). Gorno-Altaysk, south of Mayma River, TEB 244-18 (LE 312089); TEB 246-18 (LE 315530).

This sequence-verified collection was found in calcareous *Betula* forest. The species, which here is treated in the sense of Brandrud et al. (1990–2018) probably has rather wide host preferences, but is in north-western Europe most frequently found under *Populus tremula* and *Salix* spp., including alpine habitats.

**Cortinarius diasemospermus* Lamoure var. *leptospermus* H. Lindstr. – Kokshi, TEB 161-18 (LE 295100). Chelush, TEB 173-18 (LE 312099). Bele, TEB 180-18 (LE 315540).

This little known species was found by us both during the Altay expedition as well as the Tomsk mycological workshop prior to the expedition. It seems to preferentially occur in rich deciduous forests, in Altay probably with *Betula*. *Cortinarius diasemospermus* s.l. is reported from Western Siberia by Filippova and Bulyonkova (2017).

**Cortinarius disjungendus* P. Karst. – Kokshi, river delta, TEB 218-18 (LE 315525), TEB 219-18 (LE 315526). Gorno-Altaysk, south of Mayma River, east of ski-lift, TEB 235-18 (LE 312064); Biryula Village near Mayma River, TEB 249-18 (LE 312068) (Fig. 2c).

Cortinarius disjungendus belongs to a large complex of semi-cryptic species (sect. *Disjungendi*; Liimatainen et al., 2014b). The complex is characterized by rather large (grey-)brown species, with somewhat grey discolouring stipe context, and also stipe surface, at least when bruised. With these features, the sect. *Disjungendi* species resembles those of sect. *Bovini*, but the former are usually distinguished on the slightly large spores, normally being > 6 µm wide (Niskanen et al., 2012). *Cortinarius disjungendus* is the most frequent species in the complex, but still pretty rare, and associated with *Betula*. In Altay the species was found in large populations in the most calcareous hotspots of the grazed, semi-open *Betula* woodlands around Gorno-Altaysk, and appears to be character species for this habitat. But it was found also once under *Betula* in herb-rich vegetation at the Kokshi delta of Altaiskiy Nature Reserve.

**Cortinarius flabellus* (Fr.) Fr. – Kokshi, TEB 164-18 (LE 295101).

This unit is treated here as a collective morpho-species, including non-scaly, strongly pelargonium-smelling variants in the *C. flexipes*-complex, corresponding

to *C. flabellus* sensu Brandrud et al. (1990–2018). The species is published in several regional lists of Russia.

Cortinarius gentilis (Fr.) Fr. – Kokshi, TEB 162-18 (LE 315515).

This frequent species in the western, boreal taiga regions, was found only once during our Alai expedition. The species is reported from 18 regions of Russia.

Cortinarius hemitrichus (Pers.) Fr. – Kokshi, TEB 225-18 (LE 315523).

The species is a characteristic and very widespread *Betula* associate, distinguished e.g. on the initially white, flocculose pileus surface. In Altay, it was found on the sandy-gravelly delta at Kokshi, in mixed birch-pine forest. The species is reported from many regions of Russia, and recently with sequence-verified material from Western Siberia by Vaishlya et al (2017).

Cortinarius hinnuleus Fr. coll. – Chelush, TEB 167b-18 (LE 312095); Kokshi, TEB 227-18 (LE 312084).

This is a complex of semi-cryptic species; that is, phylogenetically well-circumscribed taxa with overlapping morphological variation. One of the Altay collections (from Chelush) was sequenced, and corresponds with *C. garciae*. *C. garciae* is one of few taxa in the *C. hinnuleus*-complex/group that seems to occur mainly in boreal coniferous-birch forests. However, since the phylogeny including nomenclature of the group is not settled, we treat this for the time being as *C. hinnuleus* coll. All the Altay collections were found under *Betula*. Most of the taxa in this complex in Europe preferentially occur in thermophilous deciduous forests or parks.

**Cortinarius lux-nymphae* Melot – Kokshi, TEB 231-18 (LE 312059).

This is another species typical of sandy pine forests, most frequently growing in short pioneer mosses along small tracks or paths. It was first reported from Western Siberia by Filippova and Bulyonkova (2017).

***Cortinarius melitosarx* Soop – Kokshi, TEB 229-18 (LE 312090).

This rather anonymous species is often difficult to identify in the field, due to similarity with other taxa, such as the strongly polymorphic *C. biformis*. However, *C. melitosarx* is distinguished from *C. biformis* in the more vivid ochre yellowish staining stipe and context, and the lack of bluish (-grey) tinges in young stages. Both of these species are typical of mossy, sandy pine forests. To our knowledge, this is new to Russia, Altay and Asia as a whole.

***Cortinarius nodosiporus* Kytöv., Niskanen et Liimat. – Gorno-Altaysk, south of Mayma River, east of ski-lift, TEB 237-18 (LE 213081), TEB 238-18 (LE 312083) (Fig. 2d).

This species resembles *C. uraceus* and *C. colymbadinus* on the olive-grey-brown colours, including an olive-grey colour of veil remnants, and the darkening (blackening) of stipe context. However, it differs from these by the habitat in warm deciduous forests, and by

the very strongly verrucose to spiny spore ornamentation. The species seems extremely rare, formerly only documented from two sites in Norway; the type site from the inner Sognefjord in rich (but not calcareous) *Tilia cordata* scree forest (Liimatainen, 2014) and another site from the inner Oslofjord, in calcareous *Tilia* – *Corylus* forest (Brandrud et al., 2016). The report of *C. zinziberatus* in Ivanov and Durandin (1996) from dry *Betula* forests of the Volga basin, might, however, possibly cover our species. *Cortinarius zinziberatus* is nowadays usually regarded as a synonym to *C. colymbadinus* (Dima et al., 2014), a coniferous forest species resembling *C. nodosiporus*. There is a remarkable hiatus between these two verified localities in Norway, and our new, verified find in Gorno-Altaysk. Furthermore, also the habitat is different; in Gorno-Altaysk the species was found in calcareous *Betula pendula* forest, together with e.g. *Cortinarius olearioides*. This species is also occurring in the habitats where *C. nodosiporus* was found in Norway, and it is possible that these species more or less follow each other in the same, apparently quite discontinuous habitats throughout Eurasia. But it should be added that *C. nodosiporus* probably is much rarer than the former one. In fact, *C. nodosiporus* must be one of the rarest and most interesting finds during our Altay-expedition.

**Cortinarius parvannulatus* Kühner s. auct. – Kokshi, TEB 226-18 (LE 312060).

This collection, verified by sequencing, is corresponding with *C. parvannulatus* sensu Brandrud et al. (1990–2018). As other taxa in this group, this seems to prefer habitats with *Salix* and *Populus* and other boreal deciduous trees. Our Altay collection was very probably associated with *Betula*.

***Cortinarius privignipallens* Kytöv., Niskanen et Liimat. coll. – east part, Kokshi, river delta, TEB 157-18 (LE 312097); TEB 164b-18 (LE 312372).

C. privignipallens is here treated collectively, including two, apparently dissimilar but close genotypes. The species in wide sense is sister to *C. privignatus*, and these taxa are little known and apparently only weakly morphologically differentiated (Schmidt-Stohn et al., 2017). The *C. privignipallens*–*C. privignatus*-complex resembles the frequent *C. biformis*, but the former has a more greybrownish pileus, lacks a yellow discolouring stipe (base), and has smaller, broadly ellipsoid spores. The *C. privignipallens* – *C. privignatus*-complex is presented in more detail by Schmidt-Stohn et al. (2017). Up to now, *C. privignipallens* was only reported from Sweden and Finland (Schmidt-Stohn et al., 2017). In Altay, the species was found and confirmed by rDNA ITS sequencing from a richer mossy-herb-rich *Pinus* (*Betula*) forest at the Kokshi delta, Teletskoye Lake. In Fennoscandia, this complex seems to be mainly associated with *Picea abies*. More samples are needed to see if it possible to distinguish the taxa in this complex by morphology and ecology.

***Cortinarius pseudofallax* Carteret coll. – Gorno-Altaysk, TEB 247-18 (LE 312087).

This sequence-verified collection from calcareous *Betula* forest of Gorno-Altaysk belongs to the complex of *C. pseudofallax* – *C. parvannulatus*. Apparently, this one represents an undescribed taxon. The *C. pseudofallax*-complex will be taxonomically-phylogenetically treated in another paper (Toivonen, Dima, Brandrud et al., in prep.).

Cortinarius raphanoides (Pers.) Fr. – Kokshi, TEB 160-18 (LE 312100).

The species was found under *Betula* at the delta of Kokshi. This is one of the more widespread and common *Betula*-associated cortinariii, both occurring in oligotrophic-acid and richer/eutrophic sites (Brandrud et al., 1990–2018). The species is very widespread in Russia (known from 23 regions).

Cortinarius saniosus (Fr.) Fr. – Gorno-Altaysk, Bir-yula Village near Mayma River.

This widespread species is associated mainly with *Betula*, *Populus* and *Salix*. It is recorded from 20 regions of Russia.

***Cortinarius* aff. *roseocastaneus* Niskanen, Liimat. et Kytöv. – Gorno-Altaysk, TEB 245-18 (LE 312088).

This species resembles taxa such as *C. decipiens* and *C. subcastaneus*. According to the ITS sequence, this represent a new, undescribed species, close to *C. roseocastaneus*.

***Cortinarius subheterocyclus* Liimat., Niskanen et Kytöv. – Kokshi, TEB 230-18 (LE 315527).

Based on ITS-barcoding, it appears that the species formerly treated as *C. heterocyclus*, consists of three very close, semi-cryptic species. In addition to *C. heterocyclus* s.str., which was described by Soop (1990), the second and third taxa in the complex were recently described as *C. subheterocyclus* and *C. heterocycloideus* by Liimatainen et al. (2017). The complex constitutes of medium-sized, slender species with reddish (vinaceous brown) veil girdles or fibrils on stipe, sometimes also with vinaceous tinges at base. The complex belongs in sect. *Brunneotincti*. The reddish veil colour, possibly due to anthraquinonoid pigments, apparently often develops and becomes stronger with age (or on bruising), in contrast to the red anthraquinonoid pigments occurring in the veils of sect. *Armillati* species (see Niskanen et al., 2011). Even though their reddish tinged veil make the species of the *C. heterocyclus* complex rather striking and easy recognisable at the group level, the species are rarely collected, and they seem to be rare everywhere. *Cortinarius subheterocyclus* is so far only reported from Finland, Sweden and Norway (Liimatainen et al., 2017). According to the protologue, the species grows in mixed deciduous forests, but always with *Betula* present (Liimatainen et al., 2017). Additional material sequenced from boreonemoral southwestern Norway confirms this habitat (pers. obs.). In Altay the species was found in mixed *Pinus* – *Betula* stand at the Kokshi delta. Based on the habitat knowledge, we assume that the species at Kokshi was associated with *Betula*.

***Cortinarius testaceofolius* H. Lindstr. et Soop – Kokshi, TEB 156-18 (LE 315518).

The species is characterized by an often conico-campanulate pileus, vivid redbrown to brick-red lamellae (reminiscent of those of *C. laniger*), and an attenuate to subradicate stipe (Brandrud et al., 1990–2018). The species occurs in mossy pine-spruce forests, and our find from pine forest at Kokshi is the first report from Russia and Asia (Siberia).

**Cortinarius traganus* (Fr.) Fr. – Kokshi, Chelush.

It is one of the more well-known and frequent cortinariid of the boreal taiga regions.

***Cortinarius turgidoides* Rob. Henry – Kokshi, TEB 155-18 (LE 315539); TEB 222-18 (LE 312062).

This is a little-known and apparently rare species associated with rich sandy pine forests and more calcareous pine forests. The species resembles *C. quarciticus*, but is slenderer and has a slightly fibrillose pileus. This one is also apparently new to Russia and new to Asia.

**Cortinarius umbrinolens* P.D. Orton – Bele, TEB 179-18 (LE 312094) (Fig. 3b).

The species was found in calcareous, semi-open *Betula* (*Larix*) steppe forest at Bele in the southeast part of Teletskoye Lake. *C. umbrinolens* is apparently strictly associated with *Betula*, usually in rather oligotrophic, acid, sometimes peaty habitats. The site at Bele apparently does not correspond well with these habitat-preferences, but the species was found growing directly on a much decayed, coarse *Betula* log, which probably provides a rather acidic, organic habitat.

***Cortinarius* aff. *vernus* H. Lindstr. et Melot – Kamga bay, river delta, TEB 207-18 (LE 315519) (Fig. 3c).

The species was found in riparian forest with *Betula pendula*, *Salix viminalis* and *Alnus viridis* ssp. *fruticosa* at the large delta of Kamga bay. *Cortinarius* aff. *vernus* belongs to a complex with an entire series of genotypes, of which this seems to have no applicable species name. However, more studies in this complex is needed to draw firm conclusions about taxonomy and nomenclature. The species resembles *C. casimiri*, *C. subcastaeus* and *C. vernus*, becoming faintly vinaceous basally when bruised. The taxon might be an eastern one associated with *Alnus viridis* ssp. *fruticosus*, but could also be much overlooked. It is here reported new to Siberia, Russia and probably Asia as a whole.

Dermocyboid species

Dermocyboid species, that is taxa with a fibrillose pileus and with yellow and red antraquinonoid pigments, were not much found during our stay in Altay.

Cortinarius croceus (Schaeff.) Gray – Chelush, TEB 177-18 (LE 315533); TEB 138-18 (LE 315535).

Cortinarius malicorius Fr. – Baygazan, TEB 194-18 (LE 312076).

Cortinarius semisanguineus (Fr.) Gillet coll. – Kokshi, TEB 163b-18 (LE 315517).

Anomalioid species

The *Anomali* section was well-developed in Altay, with five species recorded, plus *Cortinarius spilomeus*, which belongs to a sister group (sect. *Spilomei*) and is here included. All taxa (except *C. spilomeus*) were found under *Betula*, both in grazed woodland, forest borders or along tracks near our village at Yaylu, but also under *Betula* in the mixed *Pinus sibirica* – *Betula pendula* (*Abies sibirica*) pristine forests on the steep slopes. This group seems to be among the most tolerant cortinariid for the luxuriant tall-herb vegetation and the eutrophic-nitrogen-rich conditions at these slopes. In Europe these are usually found in secondary, culturally influenced forests, but in Altay it was clear that these also have a place in primary, virgin forests, maybe favoured by forest-fire successions. Here, typical *Betula* associates, such as *Cortinarius albocyaneus* and *C. azureovelatus* (= *C. xanthocephalus*) were found.

**Cortinarius albocyaneus* Fr. – Kokshi, TEB 220-18 (LE 312063), Gorno-Altaysk, TEB 242-18 (LE 315522).

The species belongs to a critical complex of more or less bluish species with rather pale, greyish pileus and with a slightly viscid pileus surface in moist weather (glossy and micaceous in dry weather – Dima et al., 2016). Different names such as *C. tabularis* and *C. viscidulus* have been applied here, and at the moment, sequencing is needed to distinguish with certainty the species in the complex. We have sequence-verified material of *C. albocyaneus* from calcareous *Betula* forest of Gorno-Altaysk. The species is not formerly reported from the region.

**Cortinarius azureovelatus* P.D. Orton (= *C. xanthocephalus* P.D. Orton) – Kokshi, TEB 221-18 (LE 312082). Gorno-Altaysk, TEB 243-18 (LE 315531).

This is a stout, ochraceous species usually almost without bluish tinges. It often occurs in rather open, grassy woodlands, parks and margins of forests. In Altay we had sequence-verified collections from calcareous *Betula* woodlands (near Gorno-Altaysk) and *Betula* – *Pinus sylvestris* forest (Kokshi). The species is new to Siberia, but is known from several reports from European Russia (under the name *Cortinarius xanthocephalus*).

Cortinarius caninus (Fr.) Fr. – Kokshi, TEB 158-18 (LE 315516); Baygazan, TEB 191-18 (LE 312071).

The species is normally easy distinguished from other *Anomali* by its more vividly brown pileus and distinctly brown girdle on stipe. In Europe, this is a typical species of young *Picea* plantations after clear-cutting, but sometimes also with *Betula* (e.g. at margins of summer farms). Along the lake Teletskoye, it was also sequence-verified from pristine *Pinus sibirica* – *Abies* – *Betula* forest.

***Cortinarius epsomiensis* P.D. Orton (= *C. pastoralis* Soop, H. Lindstr., Dima, Niskanen, Liimat. et Kytöv.; = *C. anomalus* subsp. *campestris* Soop) – Baygazan, TEB 188-18 (LE 312077) (Fig. 3d).

This taxon is an ecologically deviating *Anomali*, in that it often occurs in quite open, dry, calcareous habitats with *Helianthemum*, but is also reported several times from deciduous forests (Liimatainen, Ainsworth, 2018). The species was described as *C. pastoralis* by Dima et al. (2016). However, recently one has been able to sequence the old type of *C. epsomiensis*, described by Orton (1958), and has shown that this is conspecific with *C. pastoralis*, which then becomes a later synonym (Liimatainen, Ainsworth, 2018). The species is so far with certainty reported only from Sweden, Finland and Estonia (Dima et al., 2016), as well as Great Britain (Liimatainen, Ainsworth, 2018), and is new to Russia and Asia. In Altay, it was found in semi-open, tall-herb mixed virgin forest, probably associated with *Betula pendula*, possibly also with *Populus tremula*. The species probably has a wide boreal-temperate Eurasian distribution, as many other *Anomali* taxa.

**Cortinarius lepidopus* Cooke – Kokshi, TEB 165-18 (LE 315536).

This is a slender species, being the most frequent taxon in oligotrophic coniferous forests with *Picea* and *Abies*. Formerly, this was frequently named *C. anomalus*. *C. lepidopus* was firstly reported from Western Siberia by Filippova and Bulyonkova (2017).

**Cortinarius spilomeus* (Fr.) Fr. – Baygazan, TEB 187-18 (LE 312073).

The species was collected under *Pinus sibirica* in tall-herb forest of Baygazan. The material is sequence-verified, and represents *C. spilomeus* s.str. *C. spilomeus* s.str. is the most frequent taxon in the *C. spilomeus*-complex, and most reports of *C. spilomeus* from Russia probably refers to this (but should be verified by sequencing).

Phlegmacioid species

Remarkably few species of subgenus *Phlegmacium* were recorded during our Altay expedition. Only four phlegmacioid species were recorded at the Teletskoye Lake, all under *Betula*. Two additional ones were recorded under *Betula* at Gorno-Altaysk. *C. porphyropus* and *C. triumphans* were rather frequent along the Teletskoye Lake, and with the same habitat-requirements as the *Anomali* species discussed above; both in grazed forest (margins) near the settlements, as well as in the pristine mixed *Betula*-conifer forests. It should be noted that another, very rare phlegmacioid species, *C. moseri*, was collected here in 2001 by Henning Knudsen, in *Alnus viridis* subsp. *fruticosa* tickets (Moser, 2002).

This subgenus may show a very high diversity in some calcareous regions of Europe, but might almost lack in others. Also other studies from Western Siberia have found a low portion of phlegmacioid species, es-

pecially that of the Khanty-Mansiysk Region, where only 5 out of 69 *Cortinarius* species recorded were phlegmacioid (Filippova, Bulyonkova, 2017).

The reason for the scarcity of phlegmacioid species in the Teletskoye area seems to be the lack of calcareous forests suitable for cortinariid and many other mycorrhizal fungi. The calcareous sites visited apparently either had a too luxuriant and dense herb vegetation and/or the sites were apparently too eutrophic/nitrogen-rich. The only calcareous sites that showed a rich mycorrhizal funga, was the grazed *Betula* woodlands near Gorno-Altaysk, and here, the phlegmacioid species were playing a more important role (especially *C. olearioides*; see below). Calcareous *Abies* – *Picea* forests with calciphilous soil-dwelling fungi are very little documented from Siberia so far. M. Moser apparently found a couple of hotspots with some calciphilous *Phlegmacium* species (such as *C. caesiocanescens*) in *Picea subovata*-dominated forests along Chuya River (tributary to Katun) in Altay 2001 (according to herbarium IBF Ferdinandeum Innsbruck list provided by U. Peintner). Otherwise, the nearest well-documented hotspots with calciphilous, mycorrhizal fungi in black taiga are from the Ural in European Russia (Shiryaev et al., 2010).

Cortinarius infractus (Pers.) Fr. s.str. – Kokshi, river delta, TEB 213-18 (LE 312061), TEB 214-18 (LE 315529). Gorno-Altaysk, south of Mayma River, east of ski-lift, TEB 239(240)-18 (LE 312065) (Fig. 4a).

According to recent sequencing studies, this unit was divided into a number of genetically well-supported semi-cryptic taxa, with little morphological differentiation, but often well differentiated ecological (unpublished data). Material both from Teletskoye Lake (Kokshi) and from Gorno-Altaysk were sequenced, and both appear to be identically with *C. infractus* s.str., which is the only taxon in the group that seems to be occurring also in *Betula* forests. Our Altay finds were from a pine-dominated forest, but under *Betula* (Kokshi), and from pure *Betula pendula* forest (Gorno-Altaysk). So far, *C. infractus* s.str. is the only *Infracti* that is verified from Siberia. The species of the *Infracti*-group, although consisting of fleshy fungi with phlegmacioid characters such as viscid pileus, is phylogenetically isolated and rather far from the major phlegmacioid clades (Garnica et al., 2016; Soop et al., 2019).

Cortinarius largus Fr. – Gorno-Altaysk, Biryula Village near Mayma River, TEB 248-18 (LE 312066).

The species was recorded at the margin of a grazed, calcareous *Betula* forest. This is a widespread Eurasian species both in thermophilous deciduous forests as well as in *Betula* forests.

**Cortinarius olearioides* Rob. Henry (= *C. subfulgens* P.D. Orton) – Gorno-Altaysk, south of Mayma River, east of ski-lift, TEB 233-18 (LE 312078), 234-18 (LE 312079) (Fig. 4b).

This was the only calciphilous phlegmacioid species observed during the expedition, and moreover, it was



Fig. 4. *Cortinarius infractus* (a), *C. olearioides* (b), *C. porphyropus* (c), *C. triumphans* (d).

the only member of the large sect. *Calochroi* s.l. that was found. The species was found in a calcareous *Betula pendula* forest on steep slope adjacent to ski-lift, south of Mayma River at the south-east side of the city of Gorno-Altaysk. Here, the species produced fairy rings in a hot-spot also with large rings of the calciphilous telamonioid *C. disjungendus* and *C. nodosiporus*. In Europe *Cortinarius olearioides* is associated with calcareous, thermophilous deciduous forests with *Quercus*, *Corylus*, *Carpinus* and *Tilia* in nemoral-bore-nemoral regions. In Scandinavia, the species follows more or less calcareous *Corylus* woodlands, or *Corylus* screes into the southern boreal zone (Brandrud, Bendiksen, 2001). The occurrences of *C. olearioides* in (warm) *Betula*-forests seem to be unique to Siberia. The species is also found and verified by sequence data from the Tomsk Region (Vaishlya, pers. comm.), and the species is probably associated with *Betula* also here, since there is no natural *Quercus* – *Corylus* – *Tilia*-forests in W. Siberia. The species is reported from 11 regions of Russia, and also reports under the name *C. subfulgens*, such as that from *Quercus* forests of the Volga basin (Iwanow, Durandin, 1996), very probably

belong here. The species is not known from North America, and may not be distributed much farther east in Siberia, due to lack of, or strong discontinuity of such thermophilous, calcareous *Betula* (or *Quercus* – *Tilia*) sites.

Cortinarius porphyropus (Alb. et Schwein.) Fr. – Kokshi, TEB 151-18 (LE 315512); Chelush, TEB 176-18 (LE 315514); Baygazan, TEB 186-18 (LE 312070); Kamga bay in northeast, TEB 204-18 (LE 312069) (Fig. 4c).

The species, characterized by initially bluish colours and lilac staining when bruised, was one of the most common cortinariid in Altay, and it was also collected here by M. Moser in 2001. As far as we know, this is strictly associated with *Betula* (Saar et al., 2014). The species is known from 22 regions of Russia, and sequence-verified from the Tomsk region (Vaishlya et al., 2017). It seems to be very widely distributed and frequent throughout the boreal taiga-zone, from Scandinavia to Siberia-Altay, where *Betula pendula* or *B. pubescens* are everywhere important components of the coniferous forest. In montane Central and South

Europe, the species is much rarer, due to scarcity of *Betula*.

***Cortinarius subporphyropus* Pilát – Kamga bay in northeast, TEB 195-18 (LE 315521).

This is distinguished from *C. porphyropus* on the small, tiny basidiocarps and the larger spores. Furthermore, the habitat requirements of *C. subporphyropus* are not so strict, and it occurs with various deciduous trees. In Altay reserve it was found in riparian forest under *Betula*, *Alnus* and *Salix*. The species is new to Russia and new to Siberia and Asia.

**Cortinarius triumphans* Fr. – Yaylu Village, TEB 184-18 (LE 312074). Gorno-Altaysk, south of Mayma River, east of ski-lift, TEB 241-18 (LE 312058) (Fig. 4d).

This well-characterized species with thick ochre brown veil girdles on stem and strict association with *Betula* spp. is used in Siberia as an edible mushroom. Along the Teletskoye Lake this was one of the more frequent cortinariid, occurring in various herb-rich habitats with *Betula pendula*. It was also collected along Teletskoe Lake by M. Moser in 2001 (list from herbarium IBF Ferdinandeum Innsbruck, provided by U. Peintner). Both this and *C. porphyropus* were in the tall-herb, pristine mixed forest slopes found mainly in places with remnants from former forest fires. This might indicate that these species prefer forest floors with thinner organic humus, with low nitrogen-levels, but it might also simply be due to the overrepresentation of *Betula* trees in successions after fire. According to Nezdjominogo (1983) the species is widespread in different parts of Russia, including Siberia. The species was, however, not noted in the study of the *Abies – Pinus* forests near Khanty-Mansiysk, including succession stages with much *Betula pubescens*. This might indicate that the species is more frequent in the southern boreal zone with *B. pendula*, than further north with *B. pubescens*, which is in correspondence with the situation in Scandinavia (Brandrud, 1996).

Myxacioid species

The morphology circumscribed subgenus *Myxaciium* in phylogeny “falls apart” into some quite distantly related clades (Garnica et al., 2016). However, for practical reasons, we keep the grouping “myxacioid species”.

***Cortinarius croceocrystallinus* Rob. Henry var. *alneti* Bidaud – Kamga bay in northeast, TEB 196-18.

This is a small, white, bitter myxacioid species, characteristic of *Alnus* riparian forests. Unfortunately our tiny, single specimen found under *Alnus viridis* ssp. *fruticosus* got lost during the process of drying.

Cortinarius delibutus Fr. – Baygazan, TEB 189-18 (LE 312075).

The species was one of the few of our *Cortinarius* species which was not infrequent in the nitrogen-rich, tall-herb *Pinus sibirica – Abies – Betula* forests at Baygazan.

Cortinarius vibratilis (Fr.) Fr. – Kokshi.

The species is recorded from 14 regions of Russia, including Altay (Gorbunova, 2008).

Other groups

***Cortinarius boreicyanites* Kytöv., Liimat., Niiskanen et A.F.S. Taylor – Kokshi, TEB 152-18 (LE 315511).

According to recent studies, three phylogenetically well-supported species in the *C. cyanites* complex can be distinguished; *C. cyanites* s.str., *C. boreicyanites* and *C. violaceorubens* (Liimatainen et al., 2014a), of which *C. boreicyanites* seems to be the most frequent in boreal coniferous/birch forests. According to present data, these seem to be semi-cryptic species, and further studies on character variation are needed to see if these can be separated morphologically. This is the first report outside the Nordic countries for *C. boreicyanites*.

C. caperatus (Pers.) Fr. [= *Rozites caperata* (Pers.) P. Karst.] – Kokshi.

The species was met with once, in the *Pinus – Betula* forest at Kokshi delta. This well-known, edible species is widely distributed in Eurasia and North America, and is frequent in oligotrophic coniferous and deciduous forests of boreal North Europe. In Russia it is reported from 49 regions, including 13 in Siberia.

CONCLUSION

Altogether 49 *Cortinarius* species were found along Teletskoye Lake and around Gorno-Altaysk during the Altay expedition, of which 32 species are new to Altay and 14 species are new to Russia. In both regions, the material was dominated by species from “telamonioid taxa” (29 species) and consisted mainly of typical boreal species with a wide Eurasian distribution. In general, the *Cortinarius* fauna of the *Pinus – Betula – Abies* forests of Altay appears very similar to that of boreal North Europe, and indicates a remarkable uniformity of the boreal taiga from Scandinavia to W Siberia, with respect to fungal communities. Compared to (the Western) Europe, a few shifts in habitat preferences were observed, with *Betula pendula* favoured as a substitute host in the absence of thermophilous trees such as *Quercus*, *Corylus* and *Tilia*.

A comparatively high number of *Betula*-associates were recorded, both in grazed, semi-open woodlands (including calcareous sites), and in *Betula* successions of pristine forests along Teletskoye Lake. The mixed pristine forests with *Betula* probably represent the basic, primarily habitat of many of these *Cortinarius* species. Most *Cortinarius* species (33) were found in mossy/grassy, herb-rich *Pinus sylvestris* (*Betula pendula*) forests on deltas of Teletskoye Lake. Among the recorded *Cortinarius* species, the telamonioid taxa *Cortinarius privignipallens* coll. (boreal element), *C. subheterosporus* (boreal-subalpine element) and *C. nodosiporus* (subnemoral element) seem to be truly rare Eur-

asian species. Furthermore, a few non-described, small, telamonioid species were found, belonging to complexes that needs further phylogenetic studies.

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НОВЫЕ СВЕДЕНИЯ О ГРИБАХ РОДА *CORTINARIUS* (*AGARICALES*, *BASIDIOMYCOTA*) ИЗ АЛТАЙСКОГО ЗАПОВЕДНИКА И ОКРЕСТНОСТЕЙ ГОРНО-АЛТАЙСКА (ЮГО-ЗАПАДНАЯ СИБИРЬ, РОССИЯ)

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В ходе экспедиции 2018 года на Телецкое озеро – участок Алтайского заповедника – и окрестности Горно-Алтайска (Республика Алтай) было выявлено 49 видов рода *Cortinarius* (29 теламониоидных, 3 дермоцибидных, 6 аномалоидных, 6 флегмациоидных, 3 миксациоидных и 2 без четкой групповой принадлежности). 32 образца были верифицированы посредством ITS-секвенирования. Впервые для Алтая отмечено 32 вида, 14 оказались новыми для России. Видовой состав рода *Cortinarius* сосново-березово-пихтовых лесов Алтая, по-видимому, очень близок к таковому бореальных лесов Северной Европы и указывает на явную однородность грибных сообществ таежных лесов от Скандинавии до Западной Сибири. *Cortinarius privignipallens* coll., *C. subheterocyclus*, *C. nodosisporus* являются редкими евроазиатскими видами. Также было найдено несколько пока не описанных таксонов. Наибольшее число видов (33) было отмечено в сосново-березовых (*Pinus sylvestris* – *Betula* spp.) влажных лесах на песчано-галечных почвах в дельтах рек, и только 9 видов было найдено в смешанных (*Pinus sibirica* – *Abies sibirica* – *Betula*) высокотравных лесах на горных склонах. Три вида обнаружено в приречных лесах с *Alnus viridis* subsp. *fruticosa* – *Salix viminalis* (*Betula*). В полуткрытых, умеренно выпасаемых сообществах с *Betula pendula* на карбонатных почвах в окрестностях Горно-Алтайска было отмечено 13 видов рода *Cortinarius*.

Ключевые слова: микобиота Алтая, морфология, новые для России виды, тайга, ITS-баркодирование