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## A survey of rare species of agaricoid fungi (Basidiomycota) from South Siberia, Russia

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**Summary.** In a survey of the agaricoid fungi from the territory of Sayano-Shushensky Biosphere Reserve, Western Sayan Mountains, South Siberia, fifteen species representing thirteen genera are revealed for the first time; among them: one (*Mythicomycetes corneipes*) is new to Asian mycobiota, one (*Pluteus rugosidiscus*) is new to Russia while all fifteen are new records from the studied region. Descriptions and photos of all species are given with a brief discussion on their taxonomy and distribution. For some studied collections, new nrITS sequences were generated and their GenBank accession numbers are provided.

## Обзор редких видов агарикоидных грибов (Basidiomycota) из Южной Сибири, Россия

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**Ключевые слова:** Алтае-Саянский экорегион, видовое разнообразие, микобиота, редкие виды.

**Аннотация.** При обследовании агарикоидных грибов с территории Саяно-Шушенского биосферного заповедника (Западный Саян, Южная Сибирь) впервые выявлено пятнадцать видов, относящихся к тринадцати родам. Среди них один вид (*Mythicomycetes corneipes*) является новым для азиатской микобиоты, один вид (*Pluteus rugosidiscus*) – новым для территории России, и все пятнадцать видов являются новыми находками для изучаемого региона. В статье приводятся краткие описания и фотографии всех видов с информацией об их систематическом положении и географическом распространении. Для некоторых изученных коллекций были секвенированы нуклеотидные последовательности ITS-участка яДНК (их номера в базе данных GenBank даны в тексте).

## Introduction

The agaricoid fungi are traditionally known for their mushroom-like basidiocarps and are mostly included in Agaricomycetes clade with seven orders: Agaricales, Boletales, Cantharellales, Gloeophyllales, Hymenochaetales, Polyporales and Russulales (Hibbett et al., 2007, 2014; Webster, Weber, 2007). Morphologically, they are very diverse and widely distributed in all ecosystems (Hibbett et al., 2007; Kirk et al., 2008).

Our expeditions to the Western Sayan Mountains region in 2015 and 2020 have revealed a rather high diversity of macrofungi in the territory while three species were described as new to science based on specimens collected in Sayano-Shushensky Biosphere Reserve (Malysheva et al., 2016; Crous et al., 2017; Malysheva, 2017). The unique ecological systems of Western Sayan Mountains – the centre of the biogeographical province of the Altai-Sayans highland relating to a biome of the mixed mountain forests and mountain systems of Palaearctic area, provide a wide range of ecological niches for fungi. With the increasing number of investigations being conducted on the diversity of agaricoid fungi in this region, the uniqueness of this territory becomes apparent. The present work is mostly based on the authors' own material collected in Sayano-Shushensky Biosphere Reserve.

This investigation aims to accumulate previous and provide new data and contributes to the knowledge of the agaricoid fungi diversity from South Siberia, with particular reference to rare or interesting species.

## Materials and Methods

### Study sites

This study has been carried out in Sayano-Shushensky Biosphere Reserve, South Siberia (51°50'–52°30'N, 91°15'–92°30'E) (Fig. 1). The reserve has an area of 3904 km<sup>2</sup> and is located in the Western Sayan Mountains region in the south of the Krasnoyarsk Territory on the left bank of the Yenisei River in the influence zone of Sayano-Shushenskaya reservoir. The reserve's territory covers eastern spurs of Kantegirsky, part of the Main (Axial) Sayan's and northern slope of the Khemchiksky Ridge. The minimal heights are 500–540 m a. s. l., the prevailing ones of watershed ridges – 1100–2000 m a. s. l. This territory was undergone one or several glaciation cycles which affected on the contemporary landscapes. The climate of the studied territory in general is cold and severe with duration of snow

covering 150–165 days on low altitudes and up to 240 days in highlands. Due to peculiarities of the Main Western Sayan Ridge extension, the reserve is divided into two climatic parts: humid (northern part) and arid (southern part). North slopes have up to 1235 mm precipitations per year and south ones – up to 250–350 mm only. At the same time, the average year values of temperature in lower mountain belt fluctuate only from –0.8 °C in the northern part to –0.5 °C in the southern part. Sayano-Shushensky Reserve is located in the area of contact between the Siberian taiga and the Central Asian steppes, which, together with the mountainous relief, leads to a high diversity of vegetation cover. The forest communities belong to subtaiga type and are represented by siberian pine, larch, pine, fir, birch and aspen formations dominated by *Pinus sibirica* Du Tour, *Pinus silvestris* L., *Larix sibirica* Ledeb., *Abies sibirica* Ledeb., *Picea obovata* Ledeb., *Betula pendula* Roth, *Salix caprea* L., *Sorbus sibirica* Hedl. and *Populus tremula* L. The species *Pinus silvestris* and *Populus laurifolia* Ledeb. also occur in the forest-steppe zone (Sonnikova, 2016).

### Morphological identification

The specimens were studied and preserved following traditional methods used in mycology (Muller et al., 2004). Micro- and macroscopic characters of the basidiocarps were described according to Largent et al. (1977) and Largent (1986). Macromorphological observations were based on fresh basidiocarps. Colour codes are based on the RAL K7 Classic colour range system (<https://www.ralcolour.com/>). Microscopic observations were made from dried material mounted in 5 % KOH, 10 % Congo Red in NH<sub>4</sub>OH or Melzer's reagents using a Zeiss Axio Scope.A1, Axio Imager A1 light microscope with differential interface contrast (DIC). Images were captured using a TouPCam 14 MP digital camera with TopView software. For statistical evaluation of microstructures dimensions, at least 20–30 basidiospores and 15–20 basidia, cheilo- and pleurocystidia as well as elements of pileipellis and stipitipellis were measured from each basidiocarp. Spore dimensions are provided as (a)b–c(d), with b–c containing at least 90 % of all values and the extremes (a, d) enclosed in parentheses. Q indicates the basidiospore length/width ratio, Q<sub>av</sub> represents the mean length/width quotient of the total basidiospores measured.

All examined specimens are deposited in the Mycological Herbarium of the Komarov Botanical Institute (LE F, Saint Petersburg, Russia).

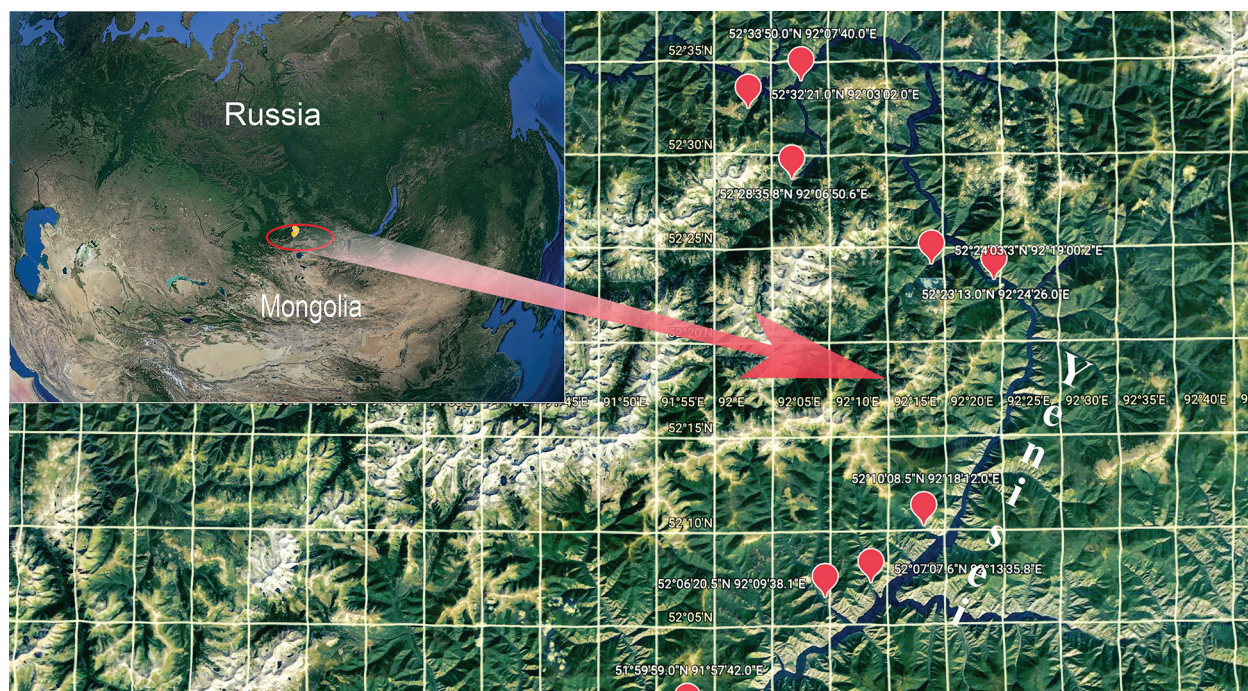


Fig. 1. Map of study region showing the main collection sites.

### Molecular techniques

We performed PCR directly from small fragments of dried basidiocarps without prior DNA extraction using Phire Plant Direct PCR Kit (Thermo Scientific, USA) according to the manufacturer's instructions. The primers ITS1F-ITS4B were used for both amplification and sequencing (White et al., 1990; Gardes, Bruns, 1993) for the ITS1-5.8S-ITS2 region. The PCR products were purified applying the GeneJET Gel Extraction Kit (Thermo Scientific, USA). Sequencing was performed with an ABI model 3500 Genetic Analyzer (Applied Biosystems, CA, USA). Raw data were edited and assembled in MEGA 7 (Kumar et al., 2016). Newly generated sequences were deposited in GenBank with corresponding accession numbers.

All microscopic and molecular studies of specimens were carried out at the Centre for Collective Use of Scientific Equipment "Cellular and molecular technology of studying plants and fungi" (Komarov Botanical Institute, Russian Academy of Sciences, St. Petersburg, Russia).

### Results

A total 15 species are revealed in the studied territory for the first time. One species, *Mythicomycetes corneipes*, is new to Asian mycobiota, one species, *Pluteus rugosidiscus*, is new for Russia, and 13 species are firstly recorded for Sayano-Shushensky Biosphere Reserve. These are listed

in the following taxonomic part, along with photos of their basidiocarps, brief notes on morphology, ecology and geographic distribution. For some more interesting species or species for which data or illustrations are limited in the literature, more detailed descriptions and illustrations of microstructures are also provided.

### Species new to Asian mycobiota

#### *Mythicomycetaceae* Vizzini, Consiglio et M. Marchetti

*Mythicomycetes corneipes* (Fr.) Redhead et A.H. Sm., 2011, Mycotaxon 118: 456 (Fig. 2).

Basidiocarps small or medium-sized, mycenoid. Pileus 10–20 mm in diam., obtusely conical, with broad low umbo, striate, hygrophanous, greasy shine, smooth, slightly viscid, brown red (RAL 3011), coral red (RAL 3016) or tomato red (RAL 3013), pastel orange (RAL 2003) or deep orange (RAL 2011) at margin. Lamellae crowded, adnate to narrowly adnate, with lamellulae, first beige (RAL 1001), later quartz grey (RAL 7039). Stipe 45–60 × 2.0–2.5 mm, cylindrical, slightly flexuous, cartilaginous, smooth or slightly pruinose, oxide red (RAL 3009) or chestnut brown (RAL 8015). Smell and taste indistinct. Basidiospores (5.5)6.5–8.5 × 3.7–5.0 μm (Q = 1.3–1.8, Q<sub>av</sub> = 1.5), variable in size, ovoid to ellipsoid, surface minutely punctate-verruculose, thick-walled, inamyloid. Cheilo- and

pleurocystidia numerous, metuloid, similar in shape and size,  $55\text{--}69 \times 14\text{--}20 \mu\text{m}$ , ventricose-fusiform, sometimes with crystals at apex, thick-walled at upper part, amyloid in apical part. Clamps present.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, valley of Talovka River on the right side, herb-rich fir – spruce forest, on litter and twigs,  $52^{\circ}23'24.3''\text{N}$ ,  $92^{\circ}17'36.0''\text{E}$ .  $\approx 572 \text{ m a. s.}$  09 IIX 2020. A. A. Kiyashko” (LE 313674).

“Vic. of Golaya field station, mixed forest (*Picea obovata*, *Pinus sibirica*, *Abies sibirica*, *Betula pendula*), on soil (buried wood?),  $52^{\circ}32'56.0''\text{N}$ ,  $92^{\circ}04'31.4''\text{E}$ .  $\approx 557 \text{ m a. s.}$  24 IIX 2020. V. F. Malysheva” (LE 313648, GenBank accession number – OL739887).

**Habitat:** The species is usually found in wet places – along the margins of bogs, in sites flooded in the spring, brook ravines. It grows solitary or in small groups on wood, plant debris or soil.

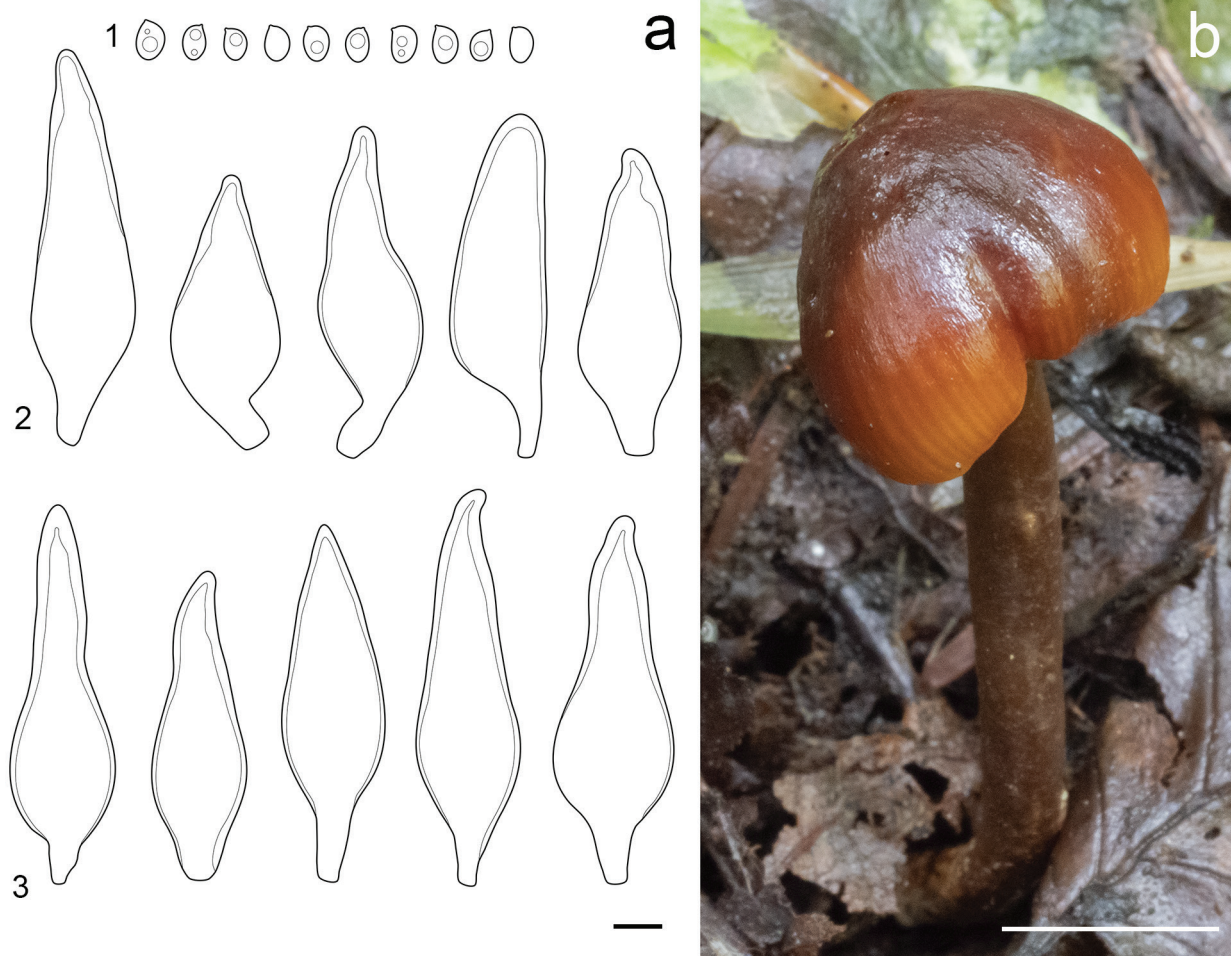


Fig. 2. *Mythicomycetes corneipes* (LE 313648): a – microstructures: 1 – spores, 2 – cheilocystidia, 3 – pleurocystidia (scale bar =  $10 \mu\text{m}$ ); b – basidiocarp *in situ* (scale bar = 1 cm).

**General distribution:** The species is known from Europe (mainly from Fennoscandia, where the number of its finds is limited – Huhtinen, Vauras, 1992; Gulden, 2008) and from North America (where it is also very rare – Redhead, Smith, 1986). In its distribution, *M. corneipes* is associated with coniferous forests. On the territory of Russia, the species was first recorded in the Pechoro-Ilychsky Nature Reserve in 2004, in a mountain landscape area (Yanypupuner Ridge), in a spruce-fir forest (Palamarchuk, 2012).

**Comments:** *Mythicomycetes corneipes* is distinguished by its brightly coloured basidiocarps with smooth, shiny, reddish-brown pelei. At the microscopic level, the characteristic features are numerous thick-walled metuloid hymenial cystidia and similar caulocystidia, as well as ellipsoid, dextrinoid spores with punctate-verruculose surface.

We carried out morphological and molecular study of our collection and compared it with all available data. The GenBank international database (<https://www.ncbi.nlm.nih.gov/genbank/>) contains

an unpublished nrITS sequence from a specimen found in Pakistan (KY648897). However, it is quite different from our nrITS sequence, therefore it is possible that the Pakistani specimen may represent a new species of the genus *Mythicomycetes*. Therefore, we provisionally mark our collection as the first finding of the species not only in Siberia, but also in Asia.

In the Sayano-Shushensky Biosphere Reserve, the fungus was found twice, both on mountain slopes in its typical habitat – mixed forests dominated by spruce and fir.

### Species new to Russia

*Pluteus rugosidiscus* Murrill, 1917, N. Amer. Fl. (New York) 10(2): 129 (Fig. 3e).

Basidiocarps rather small. Pileus 10–15 mm in diam., convex becoming plano-convex to applanate, umbonate; hygrophanous, margin translucently striate or sulcate; sand yellow (RAL 1002), brown beige (RAL 1011) or ochre yellow (RAL 1024) slightly darker at centre – khaki grey (RAL 7008), green-brown (RAL 8000) or olive brown (RAL 8008); surface glabrous, distinctly rugulose at centre. Lamellae free, subdistant, ventricose, pinkish, with concolorous and crenulate edges. Stipe 15–25 × 1–2 mm, cylindrical or tapering upwards, smooth, pale yellow at upper half to sulfur yellow (RAL 1016) or zinc yellow (RAL 1018) at base. Basidiospores (5.7)6.0–7.8(8.0) × 5.0–6.7(7.3) μm (Q = 1.1–1.4; Q<sub>av</sub> = 1.2), broadly ellipsoid, ovoid, subglobose to globose, thick-walled. Pleurocystidia 40–65 × 11–15 μm, scattered, rather numerous, broadly lageniform or fusoid-ventricose, hyaline, thin-walled. Cheilocystidia 27–60 × 10–22 μm, abundant, forming sterile edge of lamellae, predominantly inflated lageniform with short neck or broadly utriform, occasionally clavate, hyaline, thin-walled. Pileipellis an euhymeniderm, made up of broadly clavate and spheropedunculate elements, 20–45 × 12–25 μm, with yellow-brown intracellular pigment, slightly thick-walled. Caulocystidia absent. Clamps absent.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, transect Karakem, slope, mixed forest (*Larix sibirica*, *Abies sibirica*, *Populus tremula*, *Betula pendula*), on decayed wood of *Populus tremula*, 52°23'13"N, 92°24'26"E. 21 IIX 2015. E. F. Malysheva” (LE 303676, GenBank accession number – KX216323).

**Habitat:** It grows in small groups on wood of deciduous trees, particularly on *Populus*.

**General distribution:** Until now, the species was known only from North America and Slovakia (Ševčíková, Borovička, 2019). The studied collection is the first record of the species in Russia (Malysheva et al., 2016). Its actual distribution in Eurasia requires further investigation.

**Comments:** The olive or greenish tint in the pileus colour and the yellow stipe are notable macroscopic features of this species. Based on these macroscopic characters it differs from closely related species, *P. phlebophorus* and *P. chrysophlebius*, from which it is almost indistinguishable microscopically. In the field, it also could be somewhat confused with *P. romellii*, if the greenish tint is not so conspicuous, but it is easily distinguished from the latter under the microscope based on the shape of pleuro- and cheilocystidia.

### Species new to the Sayano-Shushensky Biosphere Reserve

#### Amanitaceae E.-J. Gilbert

*Amanita friabilis* (P. Karst.) Bas, 1974, Bulletin Mensuel de la Société Linnéenne de Lyon 43: 18 (Fig. 4).

Basidiocarps medium-sized. Pileus 40–45 mm in diam., convex when young, becoming plano-convex to applanate with low central umbo, glabrous, dry, densely covered with universal veil remnants as large patches, brown grey (RAL 7013) or grey brown (RAL 8019), olive drab (RAL 6022) at centre and khaki grey (RAL 7008) at margin; margin distinctly sulcate-striate or tuberculate-striate. Lamellae free, just touching stipe or almost narrowly adnate, rather crowded, whitish, with concolorous or faintly brownish serrulate edge. Stipe 45–55 × 3–9 mm, broaden downward evenly, hollow, pebble grey (RAL 7032) or silk grey (RAL 7044), surface entirely densely flocculose. Basal bulb undeveloped. The volva present as brownish, wartlike remnants with a narrow, adnate vaginate volva. Smell and taste not distinctive. Basidiospores 4.5–6.5 × 3.7–5.5 μm (Q = 1.1–1.5, Q<sub>av</sub> = 1.3), subglobose to broadly ellipsoid, sometimes obovoid, inamyloid, thin-walled, hyaline. Lamellar edge sterile, composed of numerous, clavate or ovoid cheilocystidia, 20–45 × 10–20 μm, thin- or slightly thick-walled, hyaline or slightly yellowish brown. Clamps absent.



Fig. 3. Basidiocarps *in situ*: a – *Pseudoarmillariella ectypoides* (LE 310516); b – *Calocybe obscurissima* (LE 312982); c – *Lignomphalia lignicola* (LE 312742), d – *Pluteus fenzlilii* (LE 303697); e – *Pluteus rugosidiscus* (LE 303676), f – *Pluteus umbrosoides* (LE 312735), g, h – *Lactarius alpinus* (LE 312940); scale bar = 1 cm.

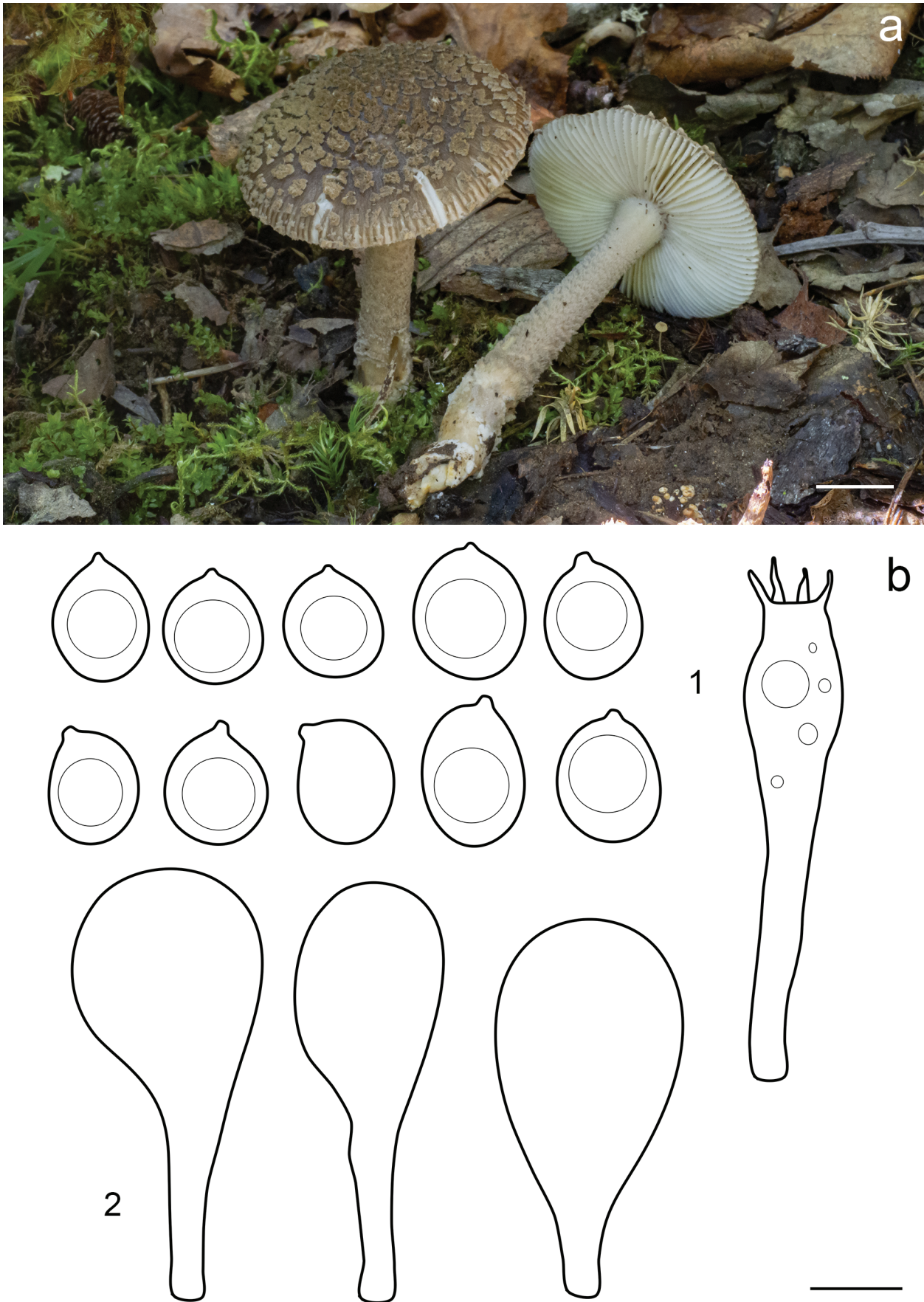


Fig. 4. *Amanita friabilis* (LE 312994): a – basidiocarps *in situ* (scale bar = 1 cm); b – microstructures: 1 – basidium and spores, 2 – cheilocystidia (scale bar = 10  $\mu$ m).

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, floodplain of Malaya Golaya River, alder forest (*Alnus glutinosa*), 52°32'21"N, 92°03'02"E. 17 IIX 2015. E. F. Malysheva” (LE 312994, GenBank accession number – OL739884).

**Habitat:** *Amanita friabilis* is ectomycorrhizal exclusively with *Alnus* spp. (*A. glutinosa*, *A. incana*, *A. viridis*) in forests, groves and bushes in wet to temporarily flooded biotopes. It is restricted to wet soils, tolerates temporary flooding but sensitive to soil fertilization.

**General distribution:** Widespread in Europe (boreal, continental and alpine regions). Also reported in Turkey, in Eastern Siberia (single record, Petrov, 1991) and the Western Caucasus (Kovalenko, Sopina, 2007).

**Comments:** A rare species throughout its distribution range included in the Red Data Books of 11 countries – Austria, Great Britain, Germany, Spain, the Netherlands, Norway, Slovakia, France, Switzerland, Sweden, Estonia. It is considered as one of the priority species in need of protection on the Joint Nature Conservation Committee list ([http://jncc.defra.gov.uk/\\_speciespages/2026.pdf](http://jncc.defra.gov.uk/_speciespages/2026.pdf)) and is also included in the list of protected species in the Bern Convention by the European Council for Conservation of Fungi (ECCF).

Outside Europe, the species is apparently also rare, but its distribution has not been studied. The mentioned collection is the first record for the Sayano-Shushensky Biosphere Reserve (Malysheva et al., 2017) and the second record of the species in Asia.

### Crepidotaceae (S. Imai) Singer

*Crepidotus tobolensis* Kapitonov, Biketova et Zmitr., 2019, in Crous et al., Persoonia 42: 405 (Fig. 5a).

Basidiocarps small to medium-sized, fleshy, soft and brittle. Pileus up to 30 × 41.5 mm, at first more or less reniform to semicircular or plane with inflexed margin, then flabelliform, undulate, with straight or descending margin, hygrophanous, margin not striated but becoming somewhat marble when dried, surface matt, tomentose, non-squamulose, pale maize yellow (RAL 1006) to sand yellow (RAL 1002) at periphery, dirty-whitish at centre, fading when drying. Lamellae crowded, with 1–3 series of lamellulae, thin, up to 4 mm broad, at first whitish to beige (RAL 1001), then darken up to ochre brown (RAL 8001), with concolorous serrulate

edge. Stipe reduced. Flesh soft, off-white. Smell not recorded. Basidiospores 5.5–7(7.7) × (4.2)4.5–6 μm ( $Q = (1.1)1.2–1.5$ ,  $Q_{av} = 1.3$ ), broadly-lacrymoid, subspherical with the tapered base in frontal view, slightly inaequilateral in side view, punctate-warty, light yellowish-ochre. Basidia 19–27.3 × 6–6.9 μm, 4-spored, clavate, clamped. Cheilocystidia numerous, edge more or less sterile, (26)31–48(60) × 5.3–13.5 μm, variable in shape, quaint, utriform to almost cylindrical with rounded or more or less elongated projections, thin-walled, hyaline. Pleurocystidia absent. Pileipellis a transition between a loose cutis and a trichoderm, hyphae 3–5 μm wide, thin-walled, hyaline, terminal cells cylindrical, sometimes with small swellings, in general poorly differentiated. Clamp connections present on all hyphae.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushenskiy Biosphere Reserve, valley of Malye Ury River in the downstream, herbaceous-grass spruce-larch forest with birch and aspen admixture, on rotten trunk of larch, 51°59'59"N, 91°57'42"E. ≈ 540 m a. s. l. 14 IIX 2020. A. A. Kiayshko” (LE 313671, GenBank accession number – OL739885).

**Habitat:** In small group on rotten woody debris of deciduous (*Populus*) and coniferous (*Larix*) trees.

**General distribution:** All known today localities are found in Siberia (Tyumen Region, Krasnoyarsk Territory).

**Comments:** Our specimen matches at 100 % level with ITS sequence of the *C. tobolensis* type specimen (MK522393, holotype) and at 99.85 % with another specimen of this taxon (MK522392) from the Tyumen Region. At the same time, the similarity between ITS sequences of our specimen and those of the closest species *C. macedonicus* Pilát from Hungary (MH780921, MH780922) is 98.24 %. Based on ITS sequences, these species differ each other at least by 9 point mutations and 1 indel of 3 bp. Our specimen was found to be very similar morphologically with the *C. tobolensis* type specimen LE 287655 but larger and fits by size to *C. macedonicus* (Senn-Irlet, 1992, 1995). Dimensions of spores, basidia and basidiocarps as well as  $Q$  of *C. tobolensis*, *C. macedonicus* and some more distant species were summarized in the supplementary material to description of *C. tobolensis* (Crous et al., 2019). According to these data, there are no clear morphological distinctions between two discussed species. The main differences are only different woody substrates, basidiocarp size and brighter yellow tint of *C. tobolensis* pileus. Besides basidi-



ocarps size, our specimen has less bright colouration than *C. toboensis* and inhabits on substrate, which corresponds neither *C. toboensis* nor *C. macedonicus* (*Larix sibirica*). Hughes et al. (2009) noted that 2–3 % value of ITS sequence divergence is an upper limit for species delimitation of agaric fungi. However, a 2 % sequence divergence value may result in an underestimate of true biological species' diversity for geographically dispersed species, whereas 3 % divergence for geographically restricted species increases the possibility that recent or cryptic species would be considered as conspecific. Our value is 1.75 % that is somewhat lesser than was proposed for widely distributed fungi. Further, *C. toboensis* is known today by three findings only that is not enough for elicitation of its ecological preferences. *C. macedonicus* is a rare and protected species also known from not numerous specimens. It may be assumed that both species are not comprehensive studied, therefore, to solve the problem of *C. macedonicus* – *C. toboensis* complex further research is needed using more material of both species.

#### Cyphellaceae Lotsy

*Baeospora myriadophylla* (Peck) Singer, 1938, Revue Mycol., Paris 3: 191 (Fig. 5c, 5d).

The main morphological features of the species are: rather small basidiocarps with smooth, at first greyish-purple or greyish-lilac, then purple-grey-brown, with aging and drying ochre-brown pilei; very crowded, purple or brownish-purple lamellae; stiff stipes; small amyloid, ellipsoid basidiospores and cylindrical cheilocystidia.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushenskiy Biosphere Reserve, floodplain of the Bolshaya Golaya River, mixed forest (*Betula pendula*, *Abies sibirica*, *Picea obovata*, *Pinus sibirica*), on rotten trunk of *Abies sibirica*, 52°28'35.8"N, 92°06'50.6"E. 25 IIX 2020. E. F. Malysheva” (LE 313651).

**Habitat:** It occurs in coniferous and mixed old-growth forests, saprotrophic on fir, spruce, less often deciduous species. Basidiocarps grow solitary or in small groups, in July – August.

**General distribution:** The species is distributed in boreal montane forests in the territory of Europe, Asia and North America but rare or very rare throughout the geographic range.

**Comments:** In Russia, the species is known from single finds from the European territory, the Caucasus, Siberia and the Far East (Bolshakov et al., 2021). It is listed in many regional Red Data Books.

In the Sayano-Shushensky Reserve, the fungus was found once in a mixed forest, on *Abies sibirica* wood. According to available information (<http://mycoweb.ru/GIF/apic.php?level=picture&id=476457>), the species was also recorded in the neighboring area – Ergaki Nature Park.

#### Hygrophoraceae Lotsy

*Arrhenia discorosea* (Pilát) Zvyagina, A.V. Alexandrova et Bulyonk., 2015, Mikol. Fitopatol. 49(1): 21 (Fig. 5b).

Basidiocarps small or medium-sized, omphalioid. Pileus 15–30 mm in diam., slightly concave to deeply infundibuliform, silky or ingrown-fibrous, finely scaly, hygrophanous, dry, with translucent-striate margin, cooper brown (RAL 8004), oxide red (RAL 3009) or wine red (RAL 3005). Lamellae decurrent, rather crowded, beige red (RAL 3012), antique pink (RAL 3014) or red violet (RAL 4002), with concolorous or sometimes darker edge. Stipe 15–25 × 1.5–2.5 mm, central or slightly eccentric, cylindrical or broaden downward, usually concolorous with lamellae or pastel violet (RAL 4009) and bright red violet (RAL 4002), in some specimens smooth, in some covered with pink felt, with bright pink mycelium at base. Smell and taste not distinctive. Basidiospores 6.0–7.5 × 3.0–5.0 μm ( $Q = 1.6–2.0$ ,  $Q_{av} = 1.8$ ), ellipsoid, dacryoid, with papillose-tuberos surface, hyaline, inamyloid. Clamps present.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, floodplain of Bolshiye Ury River, 51°58'16"N, 91°55'34"E. ≈ 536 m a. s. l. mixed forest, on fallen trunk of *Picea*, 14 IIX 2020. E. F. Malysheva” (LE 313650). “Vic. of Kerema field station, valley of Bolshaya Kerema River at the downstream, pine-larch forest with birch, on very rotten birch trunk, 52°07'07"N, 92°13'36"E. ≈ 600 m a. s. l. 23 IIX 2015. A. A. Kiyashko” (LE 288554). “Vic. of Kerema field station, the mouth of the Uzun-Suk River, mixed forest (*Pinus sibirica*, *Larix sibirica* and *Betula pendula*), on fallen trunk of *Betula*, 52°03'42"N, 92°05'02"E. 25 IIX 2015. N. V. Psurtseva” (LE 288377).

**Habitat:** *Arrhenia discorosea* is a wood-inhabiting saprotrophic fungus, which is mainly confined to coarse trunks of *Populus* species, more rarely growing on *Fraxinus*, *Ulmus*, *Tilia* or *Betula*. This species depends on moist and decayed wood and occurs in old-growth deciduous forests and in dark conifer forests mixed with deciduous trees.



Fig. 5. Basidiocarps *in situ*: a – *Crepidotus tobolensis* (LE 313671); b – *Arrhenia discorosea* (LE 313650); c, d – *Baeospora myriadophylla* (LE 313651); E, f – *Notholepista subzonalis* (LE 313672); scale bar = 1 cm.

**General distribution:** The species has a Holarctic distribution and is found in Europe, Asia and North America. On the territory of Russia, the species was repeatedly found mainly in the Asian part of the country (Zvyagina et al., 2015; Bolshakov et al., 2021). The studied collections are the first records for Sayano-Shushensky Biosphere Reserve.

The species is rare throughout its distribution range and is proposed for inclusion in The Global Fungal Red List IUCN (Krisai-Greilhuber, 2019).

**Comments:** *Arrhenia discorosea* is very noteworthy species that can be easily distinguished in nature due to its bright-coloured reddish-purple-violet basidiocarps with pink mycelium at the base of the stipe.

***Pseudoarmillariella ectypoides*** (Peck) Singer, [as 'ectyloides'], 1956, *Mycologia* 48(5): 725 (Fig. 3a).

Basidiocarps large or medium-sized, omphaloid. Pileus 40–45 mm in diam., slightly concave to deeply infundibuliform, glabrous, dry, opaque, grey beige (RAL 1019), olive grey (RAL 7002) or khaki grey (RAL 7008), appressed-fibrillose. Lamellae decurrent, forked, pebble grey (RAL 7032) or green beige (RAL 1000). Stipe 45–55 × 3–9 mm, central or slightly eccentric, cylindrical or broaden downward, olive yellow (RAL 1020), minutely squamulose. Smell not distinctive, taste mild. Basidiospores 7.5–9.0 × 4.5–5.7 μm (Q = 1.5–1.8, Q<sub>av</sub> = 1.6), ellipsoid, smooth, hyaline, distinctly amyloid, acyanophilic. Cheilocystidia and pleurocystidia absent. Clamps present.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, valley of Talovka River, mixed forest (*Picea obovata*, *Pinus sibirica*, *Abies sibirica*, *Larix sibirica*, and *Betula pendula*), on decayed wood of conifer, 52°24'03.3"N, 92°19'00.2"E. 20 IIX 2015.E. F. Malysheva” (LE 310516, strain LE-BIN 3837, GenBank accession number – OL739886). “Vic. of Kerema reserve station, valley of Sarla River not far from the mouth, Siberian pine forest with fir, larch and birch, in woody dust on very rotten trunk, 52°10'08.5"N, 92°18'12.0"E. ≈ 509 m a. s. l. 27 IIX 2015. A. A. Kiyashko” (LE 313672).

**Habitat:** *Pseudoarmillariella ectypoides* is lignicolous (preferably coniferous), often occurs on mossy logs and branches, growing solitary or in small groups.

**General distribution:** The species is widespread in North America (USA, Canada, Mexico), it is known from Costa Rica (GBIF database, URL: <https://www.gbif.org/ru/occurrence/>

search?taxon\_key=2531561; last accessed date: 29 Nov. 2021). On the territory of Russia, only sporadic records of the species in the Far East (Vassiljeva, 1973; Bunkina, Nazarova, 1978) and Southern Siberia (Malysheva et al., 2017; Krom et al., 2021) were known. The close taxon, *P. bacillaris* Zhu L. Yang, B. Feng et Y. J. Hao, was described from mountainous Western China in 2013 (Yang et al., 2013). Third member of *Pseudoarmillariella* – *P. fistulosa* (G. Stev.) E. Horak – is distributed in New Zealand (Horak, 1971). Thus, the origin and distribution of *Pseudoarmillariella* may turn out not the same as it is considered today and needs further studies.

**Comments:** There are three known species in the genus *Pseudoarmillariella* (*P. ectypoides*, *P. fistulosa* and *P. bacillaris*). All species differ from each other mainly in the colour of the basidiocarps and the morphology of spores (Peck, 1872; Horak, 1971; Bigelow, 1982; Singer, 1986; Phillips, 1991; Bessette et al., 1997; Zhu-Liang et al., 2013). Recent molecular study showed phylogenetic position of *Pseudoarmillariella* as a sister clade to *Cantharellula* (Lodge et al., 2014). In this work the authors demonstrated that *Pseudoarmillariella* shares with *Cantharellula* a unique combination of spores that are amyloid and elongated, and tridirectional lamellar trama, but differs from the latter in presence of encrusting pigments on the cuticular hyphae and bright ochraceous pigments in the hymenium.

### Incertae sedis

***Notholepista subzonalis*** (Peck) Vizzini et Contu, 2012, *Mycosphere* 3(1): 85 (Fig. 5e, 5f).

Basidiocarp medium-sized, tricholomatoid. Pileus 32 mm in diam., plane with deflexed margin, dry, matt, hygrophanous, margin not striate but slightly grooved, pale colza yellow (RAL 1021) to pale signal yellow (RAL 1003) when moist, evenly coloured, fading when dried up to pallid with maize yellow (RAL 1006) spots in the centre. Lamellae medium-spaced, with lamellulae, arcuate to decurrent, light pinkish-buff, with distinct pinkish hue, edge concolorous. Stipe 54 × 5 mm, cylindrical, slightly broadened towards base, dry, solid, faintly fibrous, colza yellow (RAL 1021) to signal yellow (RAL 1006), with white mycelium at the base. Flesh bright yellow, concolorous with surfaces of pileus and stipe at periphery and whitish in the centre. Smell not distinctive. In our specimen basidiospores few in number, many not matured and connected with basidia, free-lying basidiospores (5.8)6.2–7.8 × (3.6)3.8–4.5 μm (Q = 1.5–1.8, Q<sub>av</sub> = 1.7)

broadly ellipsoid, with rather coarse amyloid ornamentation consisted of few big warts and many fine ones between them. Basidia mostly 2-spored with long sterigmata (up to 11  $\mu\text{m}$ ), but 1- and 4-spored cells were observed also. Cheilo- and pleurocystidia absent. Pileipellis is a tomentum with colourless, not incrusting hyphae, terminal cells 4–6  $\mu\text{m}$  wide, cylindrical with rather tapering ends.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, valley of Talovka River near the mouth, mixed forest (*Pinus sibirica*, *Abies sibirica*, *Betula pendula*, and *Populus tremula*), on soil among mosses, 52°23'59"N, 92°18'44"E. h  $\approx$  626 m a. s. l. 19 IIX 2015. A. A. Kiyashko” (LE 313672, strain LE-BIN 3657, GenBank accession number – MG720560).

**Habitat:** In small or large groups, more rarely solitary, on soil among mosses.

**General distribution:** A rare species with a large area. It was described firstly from North America and now seems to be distributed across all Holarctic region including Europe (mostly Fennoscandia but also Denmark, Estonia, Switzerland, and France) (GBIF, <https://www.gbif.org/species/8230745>) and China (Yunnan) (Vizzini et al., 2012). In Russia, it was found previously in Khanty-Mansi Autonomous Area – Yugra (northern part of Western Siberia) (Zvyagina, Baykalova, 2017). Our specimen is the second record in the country.

**Comments:** The studied specimen have not many apparently free-lying and presumably fully matured basidiospores. They all are only broadly ellipsoid ( $Q = 1.5\text{--}1.8$ ) but not subglobose as it was pointed out before in literature (Christensen, 2008). Besides, spores of our specimen are somewhat longer (up to 7.8  $\mu\text{m}$ ) and conformed more to the size adduced to *Pseudoclitopilus rhodoleucus* (Sacc.) Vizzini et Contu [= *Leucopaxillus rhodoleucus* (Romell) Kuehner] with pinkish gills than *N. subzonalis* (Christensen, 2008). Our specimen also possesses pinkish lamellae but has distinctly yellow rest parts of basidiocarp and its spores are narrower. However, its ITS sequence is very distant from those of *P. rhodoleucus* (KP453696; KP453701) obtained by M. Sanchez-Garcia for her PhD dissertation (Sanches-Garcia, 2016) and matches those of *N. subzonalis* from the same work (KP453695, KP453702) at 99.85–99.70 % level. It is interesting to note that one European collection of *N. subzonalis* examined by us (LE 231790, series “Fungi exiccati Suecici, praesertim Upsalienses” by S. Ryman and S. Pettersson) also is characterized by the presence

of unusual large basidiospores (up to 10.4  $\times$  6.9  $\mu\text{m}$ ) and two-spored basidia. Another pinkish-gilled species, *Pseudoclitopilus salmonifolius* (M. M. Moser et Lamoure) Vizzini et Contu [= *Leucopaxillus salmonifolius* M. M. Moser et Lamoure], differs in having somewhat smaller spores (4.5–6  $\times$  3.5–5  $\mu\text{m}$ ) and whitish to gray-brown fruitbodies.

### Lyophyllaceae Jülich

***Calocybe obscurissima*** (A. Pearson) M. M. Moser. 1967, Kleine Kryptogamenflora von Mitteleuropa - Die Blätter- und Baupilze (Agaricales und Gastromycetes) IIB/2: 101 (Fig. 3b).

Basidiocarps medium-sized, tricholomatoid. Pileus 20–50 cm in diam., convex to applanate, often umbonate, not hygrophorous, dry, smooth, with incurved margin, when young honey yellow (RAL 1005) or lemon yellow (RAL 1012), then broom yellow (RAL 1032), maize yellow (RAL 1006) or ochre yellow (RAL 1024). Lamellae crowded, emarginated with tooth, whitish. Stipe 25–65  $\times$  3–8 mm, cylindrical, longitudinally fibrillose, concolorous with pileus. Smell farinaceous, taste mild. Basidiospores 5.5–6.5  $\times$  2.5–3.0  $\mu\text{m}$  ( $Q = 2.0\text{--}2.6$ ,  $Q_{\text{av}} = 2.4$ ), almost cylindrical or narrowly ellipsoid, smooth, thick-walled, inamyloid. Cheilo- and pleurocystidia absent. Clamps present.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vicinity of Kerema field station, the mouth of the Malye Ury River, mixed forest (*Larix sibirica* and *Betula pendula*, with *Picea obovata*), on litter, 52°00'03"N, 91°57'56"E. 26 IIX 2015. A. A. Kiyashko” (LE 312982, strain LE-BIN 3656).

**Habitat:** It grows usually in small groups on plant debris or soil in deciduous or mixed forests.

**General distribution:** A rare species, until recently considered to be distributed in Europe only, including eastern Europe. The species was found beyond the Urals only twice, and both times in the Altai-Sayan mountain region. In addition to ours, another collection is known from Altai (Gorbunova, 2018). From the European part of Russia, only few records are still known (from the Pskov and Moscow regions).

**Comments:** At least at a young age, the basidiocarps of *C. obscurissima* have rather dark and distinct purple tones, especially in the colouration of the stem (Kalamees, 1995, 2008). Our collection studied is distinguished by the absence of such dark brown and purple shades, but all other morphological characters correspond to the diagnosis features

of the species (together with molecular data based on nrITS). The colouration of basidiocarps is known to be a variable trait and, being determined by environmental conditions, may differ for fungi from arid regions (for example, growing in beech forests of Europe) or from more humid boreal deciduous or mixed forests.

### Marasmiaceae Roze ex Kühner

*Lignomphalia lignicola* (Lj. N. Vassiljeva) Antonín, Borovička, Holec et Kolařík, 2019, Fungal Biology 123(6): 443 (Fig. 3c).

Basidiocarps medium-sized, omphalinoid. Pileus 8–30 mm in diam., clitocyboid or omphaloid, usually distinctly infundibuliform with deeply depressed centre, glabrous or slightly pruinose to minutely scaly at centre, hygrophanous, margin straight to slightly flexuous and involute, slightly to strongly translucently striate up to one half a radius when moist, variable in colour: sand yellow (RAL 1002), maize yellow (RAL 1006), pastel yellow (RAL 1034), sun yellow (RAL 1037) or yellow orange (RAL 2000). Lamellae distant, thin, deeply decurrent on stipe, whitish, light ivory (RAL 1015) or ivory (RAL 1014). Stipe 35–60 × 2–5 mm, cylindrical or broadened towards base, pruinose or minutely pubescent, hygrophanous, concolorous with pileus or lighter, with tomentose base. Smell indistinct. Basidiospores 6.0–8.0 × 5.2–6.0 µm ( $Q = 1.0–1.4$ ,  $Q_{av} = 1.3$ ), broadly ellipsoid or subglobose, thin-walled, hyaline, strongly amyloid. Cheilocystidia 50–70 × 7–13 µm, numerous, forming sterile heteromorphic edge, variable in shape, mostly fusoid with mucronate apex 2.7–4.5 µm wide (sometimes bifurcated or branched) or sublageniform or lageniform with long neck, hyaline, thin- or slightly thick-walled. Pleurocystidia absent. Pileocystidia 30–80 × 9–16 µm, very abundant, fusoid or lageniform with very long and often capitate apex, clavate, almost cylindrical, thick-walled, hyaline or pigmented by brown intraparietal or slightly incrusting pigment. Caulocystidia numerous, variable in shape, mostly similar to pileocystidia but larger, hyaline, thin- or slightly thick-walled. Clamp connections present.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, mixed forest, on wood of coniferous tree, 52°23'59"N, 92°18'44"E. 19 IIX 2015. E. F. Malysheva” (LE 312742). “Vic. of Talovka field station, transect Karakem, slope, mixed forest (*Larix sibirica*, *Abies sibirica*, *Populus tremula*, *Betula pendula*), on larch bark, 52°23'13"N, 92°24'27"E.

21 IIX 2015. N. V. Psurtseva” (LE 288396, strain LE-BIN 3724). “Vic. of Kerema reserve station, valley of Sarla River not far from the mouth, mixed forest (*Abies sibirica*, *Picea obovata*, *Pinus sibirica*, *Larix sibirica*, *Populus tremula*, *Betula pendula*), on very rotten, mossy conifer trunk, 52°10'13"N, 92°18'07"E. ≈ 561 m a. s. l. 27 IIX 2015. A. A. Ki-yashko” (LE 288556).

**Habitat:** It grows solitary or in small groups on trunks or decayed wood of coniferous, more rarely deciduous trees.

**General distribution:** *Lignomphalia lignicola* originally described from the Primorye Territory (Vassiljeva, 1973) is distributed in Siberia and the Russian Far East (Malysheva et al., 2011; Bolshakov et al. 2021). In 2016, some collections from the European part of Russia and Ural were published (Palamarchuk, Kirillov, 2016; Shiryaeva, 2016). The species is rather rare for the entire geographic range.

**Comments:** The genus *Lignomphalia* was recently proposed to accommodate *Pseudoomphalina lignicola* Lj. N. Vassiljeva (Antonín et al., 2019) and, at the present state of knowledge, contains only the type species. This species is morphologically similar to some species of *Leucoincocybe* but differs from them by its lignicolous way of life. Phylogenetically, it has an isolated position outside of *Clitocybula* and *Leucoincocybe* species.

### Mycenaceae Overeem

*Hydopus atramentosus* (Kalchbr.) Kotl. et Pouzar, 1962, Česká Mykol. 16(3): 182 (Fig. 6).

Basidiocarps small or medium-sized, mycenoid. Pileus 10–30 mm in diam., obtusely conical, bell-shaped with broad low umbo or plano-convex, hygrophanous, not striate, pruinose, often slightly rugulose, brown beige (RAL 1011), fawn brown (RAL 8007), grey brown (RAL 8019), or finally black. Lamellae crowded, adnate with a decurrent tooth, first whitish, later blackish. Stipe 20–40 × 2.5–5.5 mm, broadened towards base, pruinose to pubescent, grey beige (RAL 1019) or blackish. Basidiospores 5.0–6.5 × 3.5–4.7 µm ( $Q = 1.3–1.7$ ,  $Q_{av} = 1.4$ ), globose to subglobose or broadly ellipsoid, smooth, amyloid. Cheilocystidia numerous, 25–40 × 6.7–14.0 µm, ventricose-fusiform, sublageniform. Clamps present.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, mixed forest, on wood of coniferous tree. 19 IIX 2015. E. F. Maly-

sheva” (LE 312736). The same place, “spruce forest, on large mossy trunk of spruce, 52°24′01.4″N, 92°18′57.6″E. ≈ 575 m a. s. l. 07 IIX 2020. A. A. Ki-yashko” (LE 313673).

**Habitat:** It grows in small groups on trunks or strongly decomposed coniferous wood, most often on *Abies* and *Picea*.

**General distribution:** *Hydropus atramentosus* is a rare lignicolous fungus with a predominantly Holarctic distribution. In Europe, it is known from its western, central, eastern and southern parts and is included in the Red Lists of 6 countries (Holec, 2008).

**Comments:** The strong and rapid blackening of the basidiocarps, as well as the release of a transparent liquid blackening in air, in case of damage, makes it quite easy to distinguish *H. atramentosus* from mycenens and other small lignicolous fungi.

The species clearly prefers old-growth forests and therefore can be used as a bioindicator of conservationally valuable forest stands (natural vegetation, presence of dead wood: fallen trunks and stumps in later stages of decay, stable meso- and microclimate), especially when combined with other species of similar character (Holec, 2008).

In Russia, it is known from the protected areas of the Western Caucasus, Siberia and Far East. In the Altai-Sayan region, it was also found in the Tigireksky and Altai Nature Reserves. The mentioned collection is the first record in the Sayano-Shushensky Biosphere Reserve.

### Pleurotaceae

***Pleurotus abieticola*** R. H. Petersen et K. W. Hughes, 1997, Mycologia 89(1): 175 (Fig. 7).

Basidiocarps medium-sized. Pileus up to 74 × 70 mm, at first convex with incurved margin, then rounded fan-shaped or spatulate, plane with straight or slightly incurved, not striate and sometimes lobed margin, slightly hygrophanous, surface matt, at centre tomentose, light orange-brown (RAL 8023) to clay-brown (RAL 8003) when young, more pallid at maturity, whitish streaked at periphery. Lamellae decurrent, medium-spaced to distant, up to 5 mm broad, whitish at first, then cream (RAL 9001), sometimes with orange-brown (RAL 8023) edge (may be when dried). Stem eccentric to lateral, short to almost reduced, up to 60 mm in diam., tomentose, whitish to cream (RAL 9001). Flesh whitish. Smell faint, with weak aromatic component, taste not recorded. Basidiospores (9.0)10.3–11.6(11.9) × 4.3–5.1 μm ( $Q = 2.1–2.5$ ,  $Q_{av} = 2.3$ ),

cylindrical, with faint suprahyalar depression. Basidia 4-spored, narrowly clavate to almost cylindrical, 30.8–40.4 × 6.9–8.0 μm, clamped, thin-walled, colourless. Cheilocystidia abundant, lamellae edge more or less sterile, 30.0–47.2 × (6.1)9.1–10.4(15.8) μm, usually septate, versiform, lageniform to nearly cylindrical with tapering apex, thin-walled or with slightly thickened walls, uncoloured. Pleurocystidia absent. Lamellar trama monomitic, composed of irregularly interwoven more or less thin-walled hyaline hyphae. Pileipellis a thick cutis, composed of cylindrical thin-walled colourless or light brownish hyphae 3.4–5.2 μm wide. Terminal cells repent, cylindrical, 3.2–6.1 μm wide, often with small swellings up to 7.2 μm wide. Stipitipellis composed of hyphae resembling those of pileipellis and the same dimension.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, vic. of Talovka field station, right side of valley of Talovka River near the mouth, coniferous forest dominated by Siberian pine and fir with birch and aspen, on rather fresh fallen trunk of fir, 52°23′59″N, 92°18′44″E. 19 IIX 2015. A. A. Kiayshko” (LE 310496, strain LE-BIN 3551, GenBank accession number – MG720573).

**Habitat:** In small group on a rather fresh fallen trunk of fir with bark.

**General distribution:** Russian Far East (Primorye Territory), Western China (Jilin, Sichuan and Gansu Province, Tibet Autonomous Region), Eastern Siberia (Krasnoyarsk Territory), north-western part of European Russia (Leningrad Region) (Petersen, Hughes, 1997; Albertó et al., 2002; Liu et al., 2015; Li et al., 2020).

**Comments:** Up to date this species was known from eastern Europe (one collection in the Leningrad Region, Russia) and eastern Asia (several collections from mountain territories of Sikhote-Alin in Russia and Northwest and Southwest China). Our finding fills the gap between European and Asian parts and emphasizes trans-Eurasian areal of this taxon. Our specimen was found on conifer wood (*Abies*), which corresponds to other Asian collections (*Abies*, *Picea*), whereas in eastern Europe this species was collected on deciduous tree (*Alnus* or *Salix*). Microscopically, our specimen has spore dimension coinciding with Chinese specimens and distinctly larger than given in the first description (9.0)10.3–11.6(11.9) × 4.3–5.1 μm vs (8.0)8.8–10.4 × 4.0–4.8 μm. Besides, studied specimen is notable for the shape of cheilocystidia that are neither broadly clavate nor subspheropedunculate but

mostly lageniform to nearly cylindrical with slightly tapering apex and usually septate. Nevertheless, its nrITS sequence matches with all existing sequences of *P. abieticola* at level more than 99 %.

**Pluteaceae** Kotl. et Pouzar

*Pluteus fenzlii* (Schulzer) Corriol et P.-A. Moreau, 2007, *Persoonia* 19 (2): 248 (Fig. 3d).

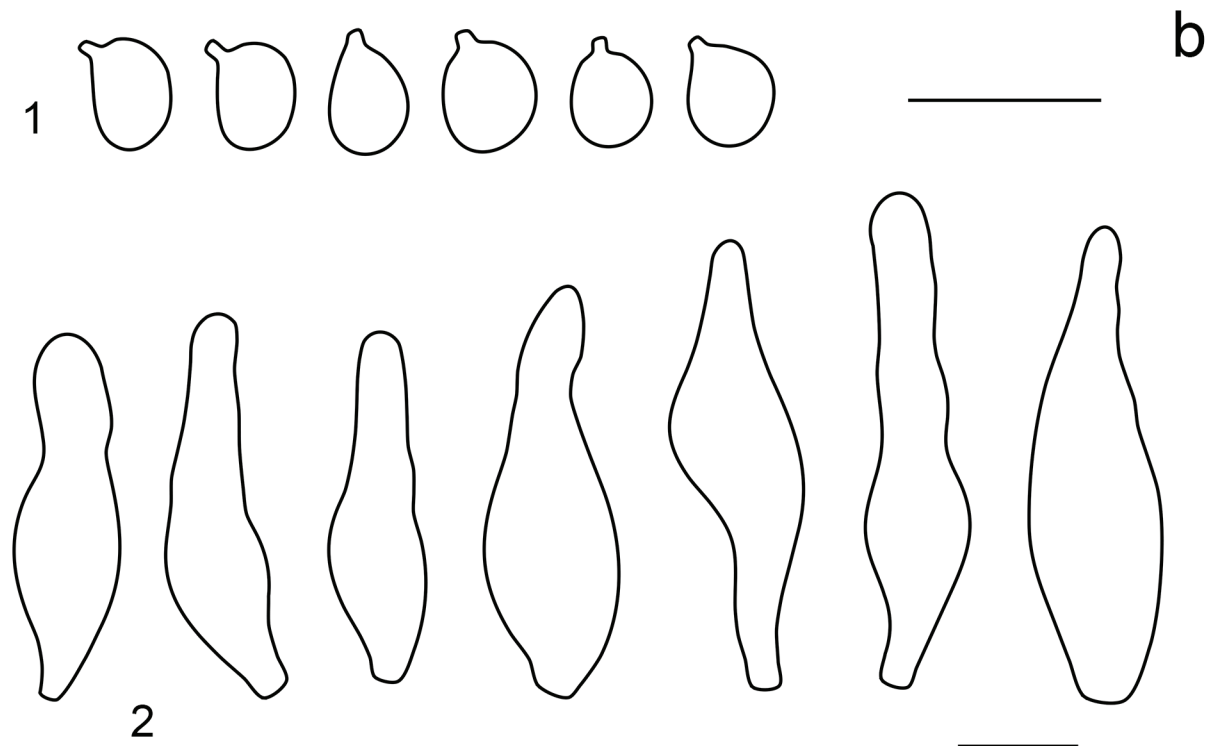


Fig. 6. *Hydropus atramentosus* (LE 312736): a – basidiocarps *in situ* (scale bar = 1 cm); b – microstructures: 1 – spores, 2 – cheilocystidia (scale bar = 10  $\mu$ m).

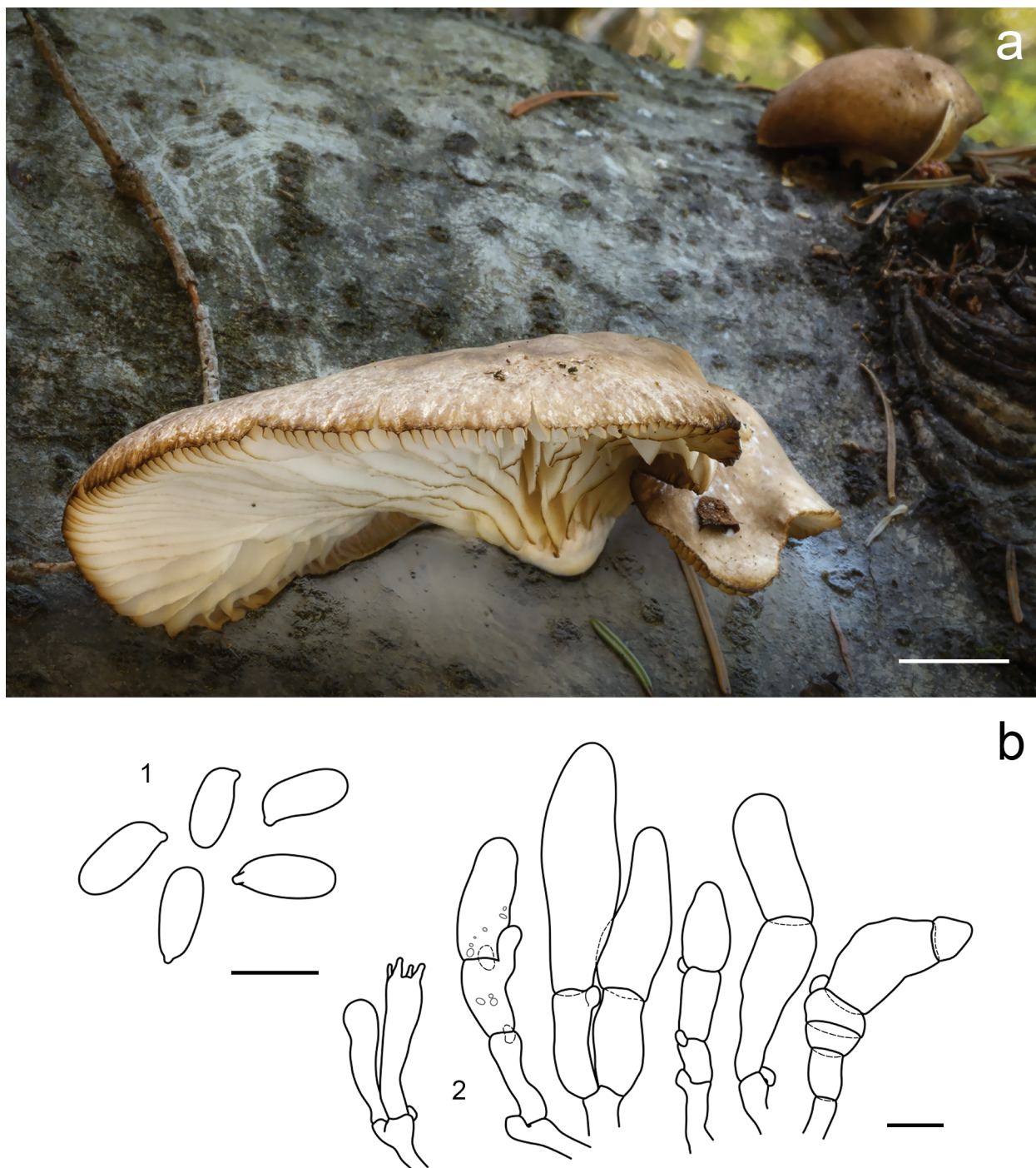


Fig. 7. *Pleurotus abieticola* (LE 310496): a – basidiocarps *in situ* (scale bar = 1 cm); b – microstructures: 1 – spores, 2 – cheilocystidia (scale bar = 10 µm).

Basidiocarps small or medium-sized. Pileus 15–50 mm in diam., initially obtuse-conical, then campanulate-convex to plano-convex, with broad low umbo, striate at margin, not hygrophanous, dry, surface radially fibrillose-squamulose, sometimes cracked when old, zinc yellow (RAL 1018), colza yellow (RAL 1021) or signal yellow (RAL 1003), often with ochre brown centre (RAL 8001). Lamel-

lae crowded, free, with lamellulae, pinkish to beige red (RAL 3012), with entire edge, which can be concolorous, white or distinctly yellowish. Stipe 35–50 × 4–8 mm, cylindrical, slightly broadened towards base but without bulb, smooth, whitish or zinc yellow (RAL 1018) at base. Annulus entire, sheathing, fluffy or flake like but often fragmentary and evanescent, remains as a ring zone, white to yel-



lowish white, disposed on central or lower part of stipe. Smell and taste not distinctive. Basidiospores  $4.0\text{--}7.5 \times 4.0\text{--}6.5 \mu\text{m}$  ( $Q = 1.0\text{--}1.3$ ,  $Q_{\text{av}} = 1.2$ ), subglobose, ovoid or broadly ellipsoid, smooth, thick-walled. Cheilocystidia abundant, variable in appearance, predominantly clavate, narrow-fusoid, clavate-ventricose or fusoid-ventricose. Pleurocystidia numerous, mainly lageniform. Clamps absent.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushenskiy Biosphere Reserve, 2 km upstream of the Bolshaya Golaya River, slope, *Betula pendula* forest with solitary *Populus tremula* and *Abies sibirica*, on fallen trunk of *Betula pendula*,  $52^{\circ}33'50.0''\text{N}$ ,  $92^{\circ}07'40.0''\text{E}$ . 16 IIX 2015. E. F. Malysheva” (LE 303697). “Vic. of Kerema field station, the mouth of Bolshaya Kerema River, *Betula pendula* forest with *Pinus sylvestris* and *Larix sibirica*, on decayed wood of *Betula pendula*,  $52^{\circ}07'07.6''\text{N}$ ,  $92^{\circ}13'35.8''\text{E}$ . 23 IIX 2015. A. A. Kiyashko” (LE 303661, GenBank accession number – KX216339).

**Habitat:** It grows solitary or in small groups on wood of deciduous trees, particularly on *Tilia*, *Acer* and *Betula*.

**General distribution:** *Pluteus fenzlii* is a rare Eurasian lignicolous fungus known from only six countries in Europe and from Japan (Holec et al., 2018; Kučera et al., 2019) and from twelve regions of Russia, where it is represented by sporadic finds (Malysheva et al., 2007; Bolshakov et al., 2021). It is listed in many regional Red Data Books.

**Comments:** This is a very beautiful and iconic species that attracts attention by a combination of characters: bright yellow or orange colouration of its basidiocarps and the presence of a ring on a stipe, which is unusual for members of the genus *Pluteus*. Recent work devoted to the study of *Pluteus fenzlii* in Europe showed that on the phylogenetic tree nrITS sequences of *P. fenzlii* form a strongly supported monophyletic clade sister to the clade of *P. mammillatus*, a related North American species. Both species are separated by a clear barcoding gap (Holec et al., 2018). Also, *P. fenzlii* is similar to *P. mammillatus* in its habitus, pileus colour, type of pileipellis and form of cheilocystidia. It differs from the latter only by the presence of yellow lamellae edge. The similarity of these species has been mentioned by Singer (1975). One more species, *P. leoninus*, has some morphological resemblance to *P. fenzlii* but differs by absence of annulus, less squamulose pileus and possessing of pleurocystidia with excrescences.

***Pluteus umbrosoides*** E. F. Malysheva, 2016, *Mycological Progress* 15(8): 880 (Fig. 3f).

Basidiocarps medium-sized to large. Pileus 30–50 mm in diam., hemispherical at first, then expanding to applanate with low umbo or depressed at centre; brown beige (RAL 1011), pale towards margin; surface squamulose, sometimes looking velvety, with erect fawn brown (RAL 8007) or nut brown (RAL 8011) squamules densely located at centre and forming pattern of veins radiating from centre towards margin, and scarce at margin showing whitish background of surface. Lamellae free, moderately crowded, pink, with concolorous edges. Stipe 40–55  $\times$  4–6 mm, cylindrical or thickened downwards, longitudinally fibrillose and minutely squamulose, shiny, beige (RAL 1001), with darker, brown beige (RAL 1011) base. Basidiospores  $5.5\text{--}7.0 \times 4.5\text{--}5.8 \mu\text{m}$  ( $Q = 1.1\text{--}1.3$ ,  $Q_{\text{av}} = 1.2$ ), predominantly ellipsoid and broadly ellipsoid, occasionally subglobose, thick-walled. Pleurocystidia 50–85  $\times$  10–25  $\mu\text{m}$ , numerous, broadly to narrowly lageniform or broadly fusiform, tapering into apex generally bearing a globular head, rarely apex with 1–2 irregularly shaped excrescences, hyaline, thin-walled. Cheilocystidia 55–65  $\times$  19–25  $\mu\text{m}$ , rather numerous, broadly utriform or broadly lageniform with short neck and obtuse apex, hyaline, thin-walled. Pileipellis a trichohymeniderm consisting of narrowly to broadly fusiform terminal elements with tapering or obtuse apexes, 100–360  $\times$  10–30  $\mu\text{m}$ , with yellow-brown intracellular pigment. Clamps absent.

**Specimens examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushenskiy Biosphere Reserve, the mouth of the Malye Ury River, mixed forest (*Larix sibirica*, *Picea obovata*, *Betula pendula*, *Salix* sp.), on fallen trunk of *Betula pendula*,  $52^{\circ}00'03.4''\text{N}$ ,  $91^{\circ}57'56.6''\text{E}$ . 26 IIX 2015. E. F. Malysheva” (LE 312735, holotype, GenBank accession number – KX216321). The same place, “on rotten wood of *Betula pendula*. 14 IIX 2020. V. F. Malysheva” (LE 313675). “Floodplain of Shignata River, mixed forest (*Pinus sylvestris*, *Larix sibirica*, *Betula pendula*), on rotten wood of *Betula pendula*.  $52^{\circ}06'20.5''\text{N}$ ,  $92^{\circ}09'38.1''\text{E}$ . 13 IIX 2020. V. F. Malysheva” (LE 313676).

**Habitat:** It grows in small groups on wood of deciduous trees, particularly on *Betula*.

**General distribution:** The species was also found in the Primorsky Territory, the Leningrad Region and the Samara Region of Russia (Malysheva et al., 2016; Bolshakov et al., 2020), which indicates its rather extensive geographical distribution.

**Comments:** Based on macromorphological characters, *P. umbrosoides* is similar to the European *P. umbrosus* (Pers.) P. Kumm. and the North American *P. granularis* Peck., but in the phylogenetic tree it clustered in a different clade sister to the umbrosus/granularis clade (Malysheva et al., 2016). *Pluteus umbrosoides* differs from *P. umbrosus* in its lamellae never having brown edges, from both *P. umbrosus* and *P. granularis* in the absence of over-hanging floccules on the pileus margin, smooth stipe without brown squamules, shape of pleurocystidia, longer elements of pileipellis, shape and size of caulocystidia, and nrITS sequences.

### Russulaceae Lotsy

***Lactarius alpinus*** Peck, 1875, Annual Report on the New York State Museum of Natural History 27: 96 (Fig. 3g, 3h).

Basidiocarps small or medium-sized. Pileus 25–40 mm in diam., slightly concave to infundibuliform with incurved and undulating margin, with or without central umbo, dry, squamulose to velvety, from sand yellow (RAL 1002) or pastel yellow (RAL 1034) to signal yellow (RAL 1003) and sun yellow (RAL 1037). Lamellae rather distant, decurrent, with lamellulae, concolorous with pileus or lighter. Stipe 30–60 × 5–10 mm, central or slightly eccentric, cylindrical or slightly flattened, hollow, concolorous with pileus or lighter, slightly pubescent or smooth. Smell indistinct, taste very acrid. Milk white, unchanging. Basidiospores 8.0–9.5 × 5.7–7.2 μm ( $Q = 1.3–1.5$ ,  $Q_{av} = 1.4$ ), ellipsoid, surface verrucous-reticulate, distinctly amyloid. Cheilo- and pleurocystidia fusiform, 43–65 × 6–8 μm. Clamps absent.

**Specimen examined:** “Russia, Krasnoyarsk Territory, Sayano-Shushensky Biosphere Reserve, floodplain of Malaya Golaya River, alder forest (*Alnus glutinosa*), on soil near river, 52°32′21″N, 92°03′02″E. 17 IIX 2015. E. F. Malysheva” (LE 312940, GenBank accession number – OL739888).

**Habitat:** *Lactarius alpinus* is ectomycorrhizal with *Alnus* spp. (*Alnus glutinosa*, *Alnus viridis* and others), less often with *Betula* spp. It grows in montane areas and arctic tundra, mainly in wet spots – along the banks of mountain streams, in shady seepage areas, on bare or mossy soil among stones, singly or in groups. A typical representative of the sub-alpine mycobiota.

**General distribution:** *Lactarius alpinus* was originally described from North America by Peck (Peck, 1875), but now its finds from Europe and Asia are known (Kalamees, Vaasma 1981; Basso, 1999). The species is rare or very rare throughout its distribution area. In Russia, infrequent records are known from the northern regions of the European part, from Siberia and Far East (Bolshakov et al., 2021).

**Comments:** It is a very distinctive *Lactarius* species due to its rather unique habitat and conspicuous bright yellow-orange basidiocarps. The studied collection is the first record in the Sayano-Shushensky Biosphere Reserve.

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