

## New data on agaricoid and boletoid fungi (Basidiomycota) of the Sverdlovsk Region (Russia)

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**Abstract.** Twenty-six species of agarics and boletes are reported for the first time for the Sverdlovsk Region. Among these, three species (*Echinoderma echinaceum*, *Pluteus variabilicolor*, *Phlegmacium boreicyanites*) are new to the Urals. Newly generated nrITS sequences of five species were deposited in the GenBank. The previously published information on agarics and boletes from the Sverdlovsk Region was corrected. As result of a revision of the mycological collections, *Pseudoclitopilus rhodoleucus* was excluded as misidentification from the species list of fungi of the Sverdlovsk Region and the Urals.

**Keywords:** diversity, geographic distribution, rare species, Russia, Ural Mountains.

## Новые данные об агарикоидных и болетоидных грибах (Basidiomycota) Свердловской области (Россия)

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**Резюме.** Впервые для Свердловской обл. приведены 26 видов агарикоидных и болетоидных грибов, из них три вида (*Echinoderma echinaceum*, *Pluteus variabilicolor*, *Phlegmacium boreicyanites*) – новые для Урала. Для пяти образцов получены и депонированы в международную базу данных GenBank нуклеотидные последовательности nrITS. Уточнена ранее опубликованная информация о видовом составе грибов Свердловской обл. В результате ревизии микологических коллекций из списка видов грибов Свердловской обл. и Урала исключен *Pseudoclitopilus rhodoleucus* как ошибочно идентифицированный.

**Ключевые слова:** географическое распространение, разнообразие, редкие виды, Россия, Уральские горы.

The Sverdlovsk Region is situated at the border of Europe and Asia on the territory of the Ural Mountains and the West Siberian Plain. It covers an area of 194800 km<sup>2</sup>. The northern, middle and southern boreal forests, hemiboreal forests and the forest-steppe zone grade from north to south. In the north of the region, in the mountainous area, in addition to boreal forests there are also mountain forest-tundra, and mountain tundra (Kulikov *et al.*, 2013). In urban areas artificial habitats such as parks and lawns expand and replace natural environments.

The fungi diversity has been studied here for over 150 years. Detailed information on the research history of agarics and boletes in the Sverdlovsk Region was published earlier (Shiryayeva, 2015). According to the published data, 832 species of agarics and boletes have been found in the region (Shiryayeva, 2015; Stavishenko, Zmitrovich, 2017; Shiryayeva, 2018; Shiryayeva, Malysheva, 2018; Shiryayeva, Palamarchuk, 2019, Shiryayev *et al.*, 2021, 2022a, b, 2023a, b, 2024). The aim of

the study is to compile a list of species previously not mentioned for the Sverdlovsk Region, based on the results of a revision of the mycological collections, as well as the field studies, and to correct previously published information.

### Material and Methods

The referred species were collected by O. S. Shiryayeva in the Sverdlovsk Region. In addition, the specimens kept at the Museum of the Institute of Plant and Animal Ecology (SVER) and the Herbarium of the Komarov Botanical Institute (LE) were re-examined. There are collections of A. G. Shiryayev, N. T. Stepanova, L. V. Marina, M. M. Storozheva, O. B. Tarchevskaya, A. V. Sirko, E. V. Zhivtsova, V. V. Valdanova and Yu. A. Srebovskiy.

All specimens were examined using light microscope Leica DM 2000. The macroscopic features were studied on fresh material. The microscopic features were observed from the examined material mounted in 5% KOH, Melzer's reagent and

1% Congo Red in concentrated  $\text{NH}_4\text{OH}$ . The vouchers are deposited at the SVER and at the Fungarium of Yugra State University (YSU-F).

Molecular techniques. The PCR was made using the Taq Turbo Buffer Mg free (Evrogen) without DNA extraction. PCR reactions were performed in 20  $\mu\text{L}$  of reaction mixtures containing 4  $\mu\text{L}$  of ScreenMix (Evrogen), 0.4  $\mu\text{L}$  of each PCR primer, 14  $\mu\text{L}$  of deionized  $\text{H}_2\text{O}$ , and 1.2  $\mu\text{L}$  of template DNA. For amplification of the ITS region the primers ITS1-F (Gardes, Bruns, 1993) and ITS4 (White *et al.*, 1990) were used. PCR cycle parameters were as follows: initial denaturation for 5 min at 95 °C, 30 cycles (denaturation for 30 sec at 95 °C, primers annealing for 35 sec at 54 °C, extend DNA for 60 sec at 72 °C), final extension for 10 min at 72 °C. PCR and sequence reaction products were purified using Ex-S-Pure Enzymatic PCR purification kit (NimaGen) and Dynabeads™ Sequencing Clean-Up kits (Thermo Fisher Scientific). Sequencing was performed with BrilliantDye™ Terminator (v3.1) Cycle Sequencing kit (NimaGen) using Applied Biosystems® Sanger Sequencing 3500 Series Genetic Analyzer. Newly generated sequences were deposited in the GenBank (PV206772 – PV206776).

Species identification using DNA sequence was confirmed by analyzing sequence similarity using the BLAST algorithm on the NCBI portal (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>) (Altschul *et al.*, 1990). Sequences with 99–100% similarity to reference specimens were assigned to the corresponding species. Only sequences of type specimens or specimens verified in peer-reviewed studies were considered reliable matches.

## Results

Based on the results of the field research and the revision of fungi collections kept at the SVER, twenty-six species not mentioned previously for the Sverdlovsk Region are reported. The taxa are arranged below in alphabetic order, and the names of fungi follow “Index Fungorum” (2025). Species new to the Urals marked by asterisk (\*). The borders of the Ural Physiographic Country were defined according to A. A. Chibilyov and A. A. Chibilyov (2012). An annotation record includes the data on species location in physico-geographical area (according to Chibilyov, Chibilyov, 2012) and vegetation belt or zone (according to Kulikov *et al.*, 2013). If the species was found in anthropogenic habitat, the vegetation belt / zone abbreviation (see below) is written in brackets.

List of abbreviations: Botanical Garden – Botanical Garden of the Ural Branch of the Russian Academy of Sciences; FS – forest-steppe; HB – hemiboreal pine and birch forests; NB – northern boreal forests; SB – southern boreal forests; U – the Ural Physiographic Country; WS – the West Siberian Plain.

## Contribution to species list of agarics and boletes of the Sverdlovsk Region

**Agaricus xanthodermus** Genev. – U: (SB) – Ekaterinburg city, Stepan Razin street, 56°82'N, 60°61'E, lawn, on soil, 7 VI 2024, *Shiryayeva*, det. *Filippova*, *Shiryayeva*, SVER 910208, YSU-F-14357 (GenBank: PV206776).

Comparison of the obtained ITS nucleotide sequence of *A. xanthodermus* (PV206776) with the data deposited in the GenBank showed 99.8–100% similarity with AY899271, DQ185563 nucleotide sequences from France (Kerrigan *et al.*, 2005).

**Boletus paluster** Peck [= *Boletinus paluster* (Peck) Peck] – U: NB – Severouralsk District, “Denezhkin Kamen” Nature Reserve, the vicinity of the Sharp cordon, the southern slope of Mount Zhuravlev Kamen, 60°30'N, 59°41'E, pine forest, on soil, 5 VIII 1962, *M. M. Storozheva*, det. *Shiryayeva*, SVER 915989.

**Bonomyces sinopicus** (Fr.) Vizzini – U: SB – Nevyansk District, vicinity of Lake Tavatuy, 57°05'N, 60°10'E, pine forest, on soil, 9 VIII 1970, *N. T. Stepanova*, det. *Shiryayeva*, SVER 910089; vicinity of Ekaterinburg city, Mount Pshenichnaya, 56°54'N, 60°18'E, at the base of bedrock outcrop, on old fire place, on litter, 9 VII 2015, *Shiryayeva*, SVER 910093.

**Coprinopsis jonesii** (Peck) Redhead *et al.* – U: (SB) – Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, lawn, on soil among the garbage, 3 IX 1984, *O. B. Tarchevskaya*, det. *Shiryayeva*, SVER 745547; *ibid.*, stand of planted trees (*Acer negundo* L., *Malus* sp.), on soil near the stump, 20 VI 2022, *Shiryayeva*, SVER 910235.

**C. lagopus** (Fr.) Redhead *et al.* – U: (SB) – Ekaterinburg city, Ural Garden of Medicinal Crops named after Professor L. I. Vigorov, 56°49'N, 60°39'E, stand of planted *Pyrus* sp., on soil, 24 VI 2022, *Shiryayeva*, SVER 910205.

**Cortinarius camphoratus** (Fr.) Fr. – U: SB – Shalya District, vicinity of Shigaevo settlement, 57°21'N, 58°41'E, *Vaccinium myrtillus*-*Picea* forest, on soil, VIII 1960, *N. T. Stepanova*, SVER 910087.

**Crinipellis scabella** (Alb. et Schwein.) Murrill – WS: HB, U: FS – Talitsa District, “Pripyshminskie bory” National Park, vicinity of Talitsa settlement, 57°01'N, 63°48'E, sand hills along the Pyshma River, dry grassland, on grasses, 19 IX 2000, *A. G. Shiryayev*, det. *K. Kalamees*, SVER 910070; Arti District, vicinity of Sverdlovskoe settlement, 56°11.18'N, 58°19.36'E, steppe, on grasses, 27 VII 2020, *Shiryayeva*, SVER 910191; *ibid.*, 56°11.15'N, 58°19.20'E, steppe, on grasses, 27 VII 2020, *Shiryayeva*, SVER 910194; Krasnoufimsk District, “Aleksandrovskie sopki” Reserve, 56°43.04'N, 57°47.40'E, steppe, on grasses, 18 IX 2021, *Shiryayeva*,

SVER 910192; *ibid.*, 18 IX 2021, A. G. Shiryayev, det. *Shiryayeva*, SVER 910193.

**Cyclocybe erebia** (Fr.) Vizzini et Matheny – U: (SB) – Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, lawn, on soil, 6 IX 2018, *Shiryayeva*, SVER 910261.

\***Echinoderma echinaceum** (J. E. Lange) Bon – U: SB – Ekaterinburg city, “Yugo-Zapadnyi” Forest Park, 56°47'N, 60°35'E, old growth pine forest with *Malus baccata* (L.) Borkh., *Acer negundo* and *Prunus padus* L. in understory, on litter and cones of *Pinus sylvestris* L., 17 VIII 2017, *Shiryayeva*, det. *Filippova*, *Shiryayeva*, SVER 910179, SVER 910180, SVER 910181, YSU-F-14324 (GenBank: PV206772); *ibid.*, on soil, 19 IX 2017, *Shiryayeva*, det. *Filippova*, *Shiryayeva*, SVER 910182.

Comparison of the obtained ITS nucleotide sequence of *E. echinaceum* (PV206772) with the data deposited in the GenBank showed 99.8–100% similarity with PQ152703, PP594620, PQ152702, PQ152704, PQ152701 nucleotide sequences from Germany and 99.2% similarity with MN810155 nucleotide sequence from China (Sarawi *et al.*, 2025).

**Flammulaster muricatus** (Fr.) Watling – U: SB – Ekaterinburg city, “Yugo-Zapadnyi” Forest Park, 56°47'N, 60°35'E, on stump of deciduous tree, 15 IX 2017, *Shiryayeva*, SVER 910236.

**Inocybe muricellata** Bres. – U: SB – Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, stand of *Prunus padus*, on soil, 13 VIII 2013, *Shiryayeva*, SVER 745734.

**Laccaria amethystina** Cooke – U: SB – Shalya District, vicinity of Shigaev settlement, 57°21'N, 58°41'E, mixed forest, on soil, VIII 1970, *M. M. Storozheva*, SVER 910078.

**L. bicolor** (Maire) P. D. Orton – U: SB – Shalya District, bank of the Sylva River, 57°21'N, 58°41'E, forest, on soil, VIII 1955, *N. T. Stepanova*, SVER 910079.

**L. pumila** Fayod – U: NB, (SB) – Severouralsk District, Mount Kumba, riparian spruce forest, among mosses, 60°8'N, 59°38'E, VIII 1949, *N. T. Stepanova*, det. *H. Knudsen*, SVER 910080; Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, collection of dwarf *Juniperus* sp., among mosses, on soil, 4 X 2014, *Shiryayeva*, SVER 910081.

**Lactarius camphoratus** (Bull.) Fr. – U: HB – Sysert District, vicinity of Dvurechensk settlement, Biological station of the Ural Federal University, 56°36'N, 61°03'E, mixed *Pinus* – *Betula* forest, on soil, 17 VIII 1958, *M. M. Storozheva*, det. *K. Kalamees*, SVER 910071; *ibid.*, mixed *Pinus* – *Betula* forest, on soil, 9 VIII 1997, *E. V. Zhivtsova*, SVER 746012.

**L. chrysorrheus** Fr. – U: FS – Krasnoufmsk District, “Nizhneirginskaya dubrava” Reserve, 56°53'N, 57°26'E, mixed forest with *Pinus sylvestris* and *Quercus robur* L., on soil, 30 VIII 1977, *N. T. Stepanova*, SVER 910107.

**L. musteus** Fr. – WS: FS – Kamensk District, 56°25'N, 61°31'E, pine forest, on sandy soil, 20 VIII 1965, *N. T. Stepanova*, det. *K. Kalamees*, SVER 910092.

**Mycena inclinata** (Fr.) Quél. – U: FS – Arti District, “Berezovskaya dubrava” Reserve, slope of Mount

Dubovaya, 56°11.08'N, 58°58.1'E, herb-rich mixed forest (*Betula* sp., *Quercus robur*, *Tilia cordata* Mill., *Abies sibirica* Ledeb., *Populus tremula* L.), on trunk of *Quercus robur*, 5 IX 2021, *Shiryayeva*, SVER 910196, SVER 910197; *ibid.*, herb-rich spruce forest with *Betula* sp., *Tilia cordata*, on trunk of *Tilia cordata*, 12 IX 2022, A. G. Shiryayev, det. *Shiryayeva*, SVER 910234.

**Parasola auricoma** (Pat.) Redhead *et al.* – U: (SB) – Ekaterinburg city, Dendrological Park and Exhibition (8<sup>th</sup> March Street), 56°49'N, 60°36'E, lawn, on soil, 25 VI 2022, *Shiryayeva*, SVER 910207.

**P. lactea** (A. H. Sm.) Redhead *et al.* – U: (SB) – Ekaterinburg city, Ural Garden of Medicinal Crops named after Professor L. I. Vigorov, 56°49'N, 60°39'E, on trunk of *Berberis* sp., 24 VI 2022, *Shiryayeva*, det. *Filippova*, *Shiryayeva*, SVER 910206, YSU-F-14327 (GenBank: PV206773).

Comparison of the obtained ITS nucleotide sequence of *P. lactea* (PV206773) with the data deposited in the GenBank showed 99.5% similarity with KY928612, KY928614, KY928613 nucleotide sequences from Hungary (Szarkándi *et al.*, 2017).

\***Phlegmacium boreicyanites** (Kytöv. *et al.*) Niskanen *et Liimat.* – U: HB – Sysert District, vicinity of Shelkun settlement, 56°28'N, 61°03'E, herb-rich birch forest, on litter, 14 VII 2024, V. V. Valdanova, Yu. A. Srebovskiy, det. *Filippova*, *Shiryayeva*, SVER 910257, YSU-F-14356 (GenBank: PV206775).

Comparison of the obtained ITS nucleotide sequence of the *P. boreicyanites* (PV206775) with the data deposited in the GenBank showed 99.8% similarity with nucleotide sequence of type specimen (NR\_130214) from Finland (Liimatainen *et al.*, 2014).

**Pleurotus abieticola** R. H. Petersen *et K. V. Hughes* – U: SB – Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, edge of herb-rich pine forest, on old trunk of *Pinus sylvestris*, 17 X 2023, A. G. Shiryayev, det. *Shiryayeva*, SVER 910259.

\***Pluteus variabilicolor** Babos – U: FS – Krasnoufmsk District, “Nizhneirginskaya dubrava” Reserve, 56°92'N, 57°45'E, mixed forest (*Quercus robur*, *Tilia cordata*, *Betula* sp., *Populus tremula*, *Pinus sylvestris*), on trunk of *Quercus robur*, A. G. Shiryayev, det. *Filippova*, *Shiryayeva*, 28 VI 2024, SVER 910258, YSU-F-14353 (GenBank: PV206774).

Comparison of the obtained ITS nucleotide sequence of *P. variabilicolor* (PV206774) with the data deposited in the GenBank showed 99.5% similarity with nucleotide sequence of type specimen of *P. variabilicolor* (NR\_153253) from Hungary (Lezzi *et al.*, 2014).

**Psathyrella pygmaea** (Bull.) Singer – U: SB – Ekaterinburg city, Botanical Garden, 56°47'N, 60°36'E, willow thickets, on decayed stump of *Salix* sp., 6 IX 2018, *Shiryayeva*, SVER 910260.

**Psilocybe coronilla** (Bull.) Noordel. [= *Stropharia coronilla* (Bull.) Quél.] – U: (FS) – Arti District, Starye Arti settlement, 56°19'N, 58°35'E, garden, on soil, VIII 1976, A. V. Sirko, SVER 910091.

**Suillus bresadolae** (Quél.) Gerhold var. **flavogriseus** Cazzoli *et Consiglio* [= *S. nueschii* Singer] – U: NB – Ivdel District, 61°34'N, 59°47'E, *Picea* and *Larix* mountain forest near timberline, among *Sphagnum*

spp., VIII 1949, N. T. Stepanova, det. K. Kalamees (as *S. nueschii* Singer), SVER 910094.

Excluded species from the list of agarics and boletes of the Sverdlovsk Region

**Pseudoclitopilus rhodoleucus** (Sacc.) Vizzini et Contu [= *Leucopaxillus rhodoleucus* (Sacc.) Kühner] (Marina, 2006).

Specimens examined: Sverdlovsk Region, Visim Nature Reserve, 84 square of Sulemskoye Forestry, Kirovograd – Galashki road, at roadside with young *Betula*, 18 VIII 2000, L. V. Marina, SVER 747768, *ibid.*, 18 VIII 2000, L. V. Marina, LE 258273.

The samples belong to *Lactarius pubescens* Fr.

### Discussion

In total, 26 species are reported for the first time for the Sverdlovsk Region. In the mountain part of the region, 25 species were found, and two species were revealed in the West Siberian Plain (Table 1).

In natural habitats, 19 species were found. Some of them have restricted distribution in the studied area due to their specialization in a habitat type or substrate. For example, *Lactarius chrysorrheus* and *Mycena inclinata* associate with temperate broadleaved trees that have the northeastern border of their species ranges in the region. *Crinipellis scabella* inhabits steppe-type communities. These plant communities have a limited distribution in the region. They are present in the south of the Sverdlovsk Region in the forest-steppe zone and, less frequently, in specific locations in the southern part of the forest zone, particularly on sunny, dry, and limestone slopes, in river valleys, and on limestone outcrops. Eight species are found

in anthropogenic habitats of the urban areas: lawns and planted trees and shrubs.

Three species — *Echinoderma echinaceum*, *Pluteus variabilicolor*, *Phlegmacium boreicyanites* are new to the Urals.

*Echinoderma echinaceum* is a species known in Russia from the several locations in the European part, Siberia and the Far East (Bolshakov *et al.*, 2021). The nearest known localities are in the southern part of the Komi Republic (Koygorodsky National Park and the surroundings of Syktyvkar city), where the northern limit of the species range is suggested (Krasnaya..., 2019; Palamarchuk, 2024). In the Komi Republic, *E. echinaceum* inhabits riparian forests (Palamarchuk, 2024). The first record in the Sverdlovsk Region is in the urban forest park. Basidiomes of *E. echinaceum* were found in the old growth pine forest in the area with dense understory of *Malus baccata*, *Acer negundo* and *Prunus padus* and the low cover (5%) of ground vegetation (*Glehoma hederacea* L., *Urtica dioica* L., etc.).

*Pluteus variabilicolor* is a little collected species. It has been found mainly in sawdust piles and on decaying hardwood (e. g., *Quercus*, *Castanea*, *Populus*, *Betula*). It was thought to have been introduced to Europe with imported timber (Babos, 1978). Later, increasing numbers of records from native habitats, as well as morphological and molecular evidence that *Pluteus luteus* (Redhead et B. Liu) Redhead, described from China (as “*Macrocyttidia lutea*”), and *P. castroae* Justo et E. F. Malysheva, described from Russia and Japan, are synonyms of *P. variabilicolor*, showed

Table 1

#### Distribution of newly recorded species by physico-geographical areas and vegetation belts or zones (subzones)

Physico-geographical area	Vegetation belt / zone, subzone	Species
The Urals	Northern boreal forests	<i>Boletus paluster</i> , <i>Laccaria pumila</i> , <i>Suillus bresadolae</i> var. <i>flavogriseus</i>
	Southern boreal forests	( <i>Agaricus xanthodermus</i> ), <i>Bonomyces sinopicus</i> , ( <i>Coprinopsis jonesii</i> ), ( <i>C. lagopus</i> ), <i>Cortinarius camphoratus</i> , ( <i>Cyclocybe erebia</i> ), <i>Echinoderma echinaceum</i> , <i>Flammulaster muricatus</i> , <i>Inocybe muricellata</i> , <i>Laccaria amethystina</i> , <i>L. bicolor</i> , ( <i>L. pumila</i> ), ( <i>Parasola auricoma</i> ), ( <i>P. lactea</i> ), <i>Pleurotus abieticola</i> , <i>Psathyrella pygmaea</i>
	Hemiboreal pine and birch forests	<i>Lactarius camphoratus</i> , <i>Phlegmacium boreicyanites</i>
	Forest-steppe	<i>Crinipellis scabella</i> , <i>Lactarius chrysorrheus</i> , <i>Mycena inclinata</i> , <i>Pluteus variabilicolor</i> , ( <i>Psilocybe coronilla</i> )
The West Siberian Plain	Hemiboreal pine and birch forests	<i>Crinipellis scabella</i>
	Forest-steppe	<i>Lactarius musteus</i>

Note: the species found in anthropogenic habitats are given in brackets.

that *P. variabilicolor* is native to temperate zone of Eurasia (Justo *et al.*, 2011; Lezzi *et al.*, 2014; Ševčíková, Dima, 2021). In Russia, it is found in the Moscow, Samara, Tula and Novosibirsk regions (Justo *et al.*, 2011; Svetasheva, 2021; Bulyonkova, Ageev, 2025). The new record is in the natural habitat (i. e., hemiboreal forest) in the temperate zone of Eurasia within the species' native range.

*Phlegmacium boreicyanites* is a poorly known species in the *P. cyanites* complex (Liimatainen *et al.*, 2014). This is the second find in Russia, the first was recorded in the Altai Republic, in *Pinus sylvestris*-dominated forest with *Betula* (Brandrud *et al.*, 2019). Most of the records are known from the boreal zone of northern Europe (Liimatainen *et al.*, 2014).

*Pseudoclitopilus rhodoleucus* was excluded from the species list of agarics of the Sverdlovsk Region and the Urals.

So, the paper brings the number of agarics and boletes species of the Sverdlovsk Region up to 857 and supplements information on the distribution of some rare and little collected species. New records of *Echinoderma echinaceum*, *Pluteus variabilicolor*, *Phlegmacium boreicyanites* fill the gaps in species distribution ranges between localities in Europe and Asia.

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**Conflicts of Interest.** The authors declare no conflict of interest.

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