

Original Scientific Paper

New data on the diversity of fungi and fungus-like organisms in the coniferous forests of Shar Planina National Park with two species registered for North Macedonia for the first time

Hasime JASHARI^{1,2*}, Slavica TOFILOVSKA², Mitko KARADELEV² and Katerina RUSEVSKA²¹ Simce Nastovski Primary School, 1200 Tetovo, The Republic of North Macedonia² Ss Cyril and Methodius University, Faculty of Natural Science and Mathematics, Institute of Biology, Arhimedova 5, 1000 Skopje, The Republic of North MacedoniaCorresponding author: jasharihasime@gmail.com

ABSTRACT:

The present study investigates the diversity of macromycetes in the coniferous forest communities of Shar Planina, a newly designated national park in the Republic of North Macedonia. Despite the recognised ecological importance of these forests, research on fungal diversity has remained scarce. This study aims to fill that gap by documenting fungal species newly recorded from coniferous communities during field surveys conducted in 2022 and 2023. The research was carried out across six localities at elevations ranging from 715 m to 1,800 m, encompassing various coniferous forest associations: *Abieti-Piceetum scardicum*, *Piceetum subalpinum scardicum*, and black pine (*Pinus nigra*) plantations. A total of 54 macromycetes were recorded for the first time in these habitats, increasing the known fungal diversity of coniferous communities in Shar Planina from 214 to 268 species. Of these, 259 species belong to the phylum Basidiomycota and 9 to Ascomycota. Additionally, one fungus-like organism belonging to Myxomycota (now Protozoa) was recorded. The highest species richness was observed in the mixed spruce-fir forests of Jelak (*Abieti-Piceetum scardicum*), where 29 taxa were recorded for the first time. The study also reports two species, *Geastrum quadrifidum* and *Leucopaxillus cerealis*, as the first records for the Republic of North Macedonia. Ecologically, 33 of the 55 identified species are saprotrophic, occurring on soil, wood or organic debris, while 22 are ectomycorrhizal, forming symbiotic associations with coniferous and broadleaf tree species. The findings contribute to the expanding knowledge of fungal diversity in Shar Planina's coniferous forests, emphasising the need for continued research and conservation efforts. Given the ecological role of fungi in forest ecosystems, these results underscore the importance of preserving and monitoring fungal diversity within this newly protected area.

Keywords: Ascomycota, Basidiomycota, coniferous forests, first records, macromycetes, Shar Planina.Received:
06 April 2025Revision accepted:
12 October 2025

INTRODUCTION

Shar Planina is the largest mountain range in the Republic of North Macedonia. Recently, it was designated as a National Park on account of its remarkable species diversity, resulting from the array of climate and vegetation features across the entire region. It is distinguished by the outstanding diversity of forest ecosystems, comprising broadleaf, coniferous, and mixed forest communities (UNEP 2020). A significant 75% of the areas under forest consist of pure tree stands, primarily beech and oak (*Fagus sylvatica* L. and *Quercus* spp.), while the higher altitudes are dominated by coniferous communities, emerging as mixed or pure forests of fir and spruce (*Abies alba* Mill. and *Picea abies* (L.) H. Karst.), with the sporadic occurrence of the five-needle pine (*Pinus*

UDC: 581.95:582.28(497.7)

Published by Institute of Botany and Botanical Garden Jevremovac, Belgrade
Faculty of Biology, University of Belgrade, Belgrade, Serbia
www.cpb.bio.bg.ac.rs© 2026 The authors. This is an open access article under the Creative Commons
Attribution 4.0 International License.

peuce Griseb.) (MILEVSKI *et al.* 2020). In Shar Planina, coniferous forest communities cover smaller areas in comparison with broadleaf communities, and are less studied in terms of fungal diversity.

Consistent with the published data on mycodiversity in the Republic of North Macedonia, there are 1789 macromycetes, i.e. fungi which produce large, visible sporocarps which can be seen with the naked eye, usually larger than 2 mm, such as mushrooms, puffballs, truffles, stinkhorns, and bracket fungi. The majority of them are species, varieties, and forms belonging to the phylum Basidiomycota (KARADELEV *et al.* 2018; TOFILOVSKA *et al.* 2019), while 255 species (including varieties and forms) belong to the phylum Ascomycota (KARADELEV *et al.* 2019). Until recently, published data on the mycodiversity of the coniferous communities in Shar Planina was very scarce, with only 50 species reported from the surveys conducted by NASTOV *et al.* (1996) and KARADELEV *et al.* (2002). The first comprehensive mycological studies of the coniferous communities in Shar Planina were implemented during 2021 and 2022, which resulted in an increase in the number of recorded macromycetes by 164 (JASHARI *et al.* 2023). Accordingly, the total number of known species amounts to 214, of which 206 are affiliated to the phylum Basidiomycota, whereas the phylum Ascomycota is represented by 8 species (JASHARI *et al.* 2023). Subsequent research into the aforesaid associations sought to obtain a more detailed overview of the fungal diversity in these pivotal coniferous forest communities. The aim of this study is to present data concerning species observed for the first time in the surveyed areas, thus complementing the knowledge on fungal diversity.

MATERIALS AND METHODS

The research was conducted in the coniferous forests on the Republic of North Macedonian territory of Shar Planina, at an altitude ranging between 715 m and 1,800 m. The fungal specimens were collected during the autumn season of 2022 and 2023. The surveyed localities are summarised in Table 1, accompanied by coordinates, altitudes and forest communities.

The fungi were collected from a variety of substrata, such as soil, fallen branches, stumps, old trunks, trees, etc. Some of the specimens were identified in the field, whereas others were determined in the Mycological Laboratory within the Institute of Biology, Faculty of Natural Science and Mathematics in Skopje. Identification was carried out in line with the morphological and ecological characteristics of the fungi. Along with the macroscopic morphological features, the macro-chemical reactions of the sporocarps were also tested (with phenol, 30% KOH, ferrous sulphate and NH_4OH), while the microscopic features were analysed under a light microscope (LW Scientific i4, USA). Taxonomically relevant microscopic characteristics (spores, basidia, cystidia, pileipellis structure, clamp connections, asci, paraphyses, and capillitium) were examined in KOH (5%), Melzer's reagent, methylene blue or Congo red. For species identification, relevant and contemporary literature was consulted (monographs and identification keys), such as: BREITENBACH & KRÄNZLIN (1991, 1995, 2000) and KNUDSEN & VESTERHOLT (2012). The majority of the specimens (agarics, in particular) were identified while still in fresh condition, while others, such as, for instance, crust or lignicolous species (*Neolentinus lepideus*, *Panellus mitis*, *Tapinella atrotomentosa*), were identified after drying. A portion of the collected specimens, representing the best-preserved fruiting bodies and including at least one specimen per species from each surveyed locality, were deposited in the Macedonian Collection of Fungi (MCF) as reference material for future taxonomic and ecological studies. The complete dataset was digitised and incorporated into the MACFUNGII database. For precise naming of the fungi and following the current nomenclature, the authors consulted the Index Fungorum (<https://www.indexfungorum.org/names/names>).

Table 1. Summarised data on the study localities.

No.	Locality	Coordinates	Altitude (m)	Forest community
1.	Adzina Reka river	41°48'45.68" N 20°38'17.12" E	1,450	<i>Abieti-Piceetum scardicum</i>
2.	Jelak	42°1'57.81" N 20°51'36.34" E	1,750	<i>Abieti-Piceetum scardicum</i>
3.	Lesnica	42°1'26.50" N 20°47'20.86" E	1,500	<i>Piceetum subalpinum scardicum</i>
4.	Lesnica	42°1'37.86" N 20°47'23.19" E	1,550	<i>Abieti-Piceetum scardicum</i>
5.	Orasje	42°7'45.47" N 21°8'40.28" E	715	Black pine plantations
6.	Popova Sapka	42°00'41.6" N 20°52'30.2" E	1,800	<i>Abieti-Piceetum scardicum</i>

asp, accessed on 16 May 2024) and Mycobank (<https://www.mycobank.org>, accessed on 16 May 2024) databases.

RESULTS AND DISCUSSION

The newly recorded taxa increase the known fungal diversity of Shar Planina's coniferous forests, providing a basis for further ecological and taxonomic studies. According to the data published so far, a total of 214 species had been reported from these associations (NASTOV *et al.* 1996; KARADELEV *et al.* 2002; JASHARI *et al.* 2023). Hence, with the newly documented fungi, the total number of known fungal species amounts to 268, of which 259 species are affiliated to the phylum Basidiomycota and 9 to the phylum Ascomycota.

The majority of the species documented at these localities for the first time were located in the mixed spruce-fir forest of Jelak (*Abieti-Piceetum scardicum*), i.e. 29 species. At the Lesnica locality, 9 species were observed for the first time in the mixed spruce-fir forest with beech (*Abieti-Piceetum scardicum*), with 4 species observed in the pure spruce forest (*Piceetum subalpinum scardicum*). A smaller number of newly documented species were found in the spruce-fir forest associations (*Abieti-Piceetum scardicum*) near the Adzina Reka – 3 species, and Popova Sapka – 2 species; while 8 species were spotted for the first time in the black pine plantations of Orasje. The number of first records at these localities is also linked to the number of surveys undertaken. Namely, prior to this study, the woodland of the Adzina Reka and Popova Sapka had been studied more comprehensively than that of Jelak and Lesnica (NASTOV *et al.* 1996; JASHARI *et al.* 2023).

Of the 55 newly recorded species, as many as 52 belong to the phylum Basidiomycota, whose species diversity was the primary goal of the present research. In addition, two species from the phylum Ascomycota and one fungus-like organism (FLO, now reclassified as Protozoa) were also registered.

According to the Index Fungorum and Mycobank databases, the documented fungal species belong to 27 different families, with the three most represented being Cortinariaceae (9), Mycenaceae (6), and Hyghrophoraceae (5). Ecology-wise, 33 of the newly recorded species are saprotrophic (some of them grow on soil, and some are lignicolous species such as *Neolentinus lepideus*, *Lentinellus flabeliformis*, *Kuehneromyces mutabilis*, and *Paragyromitra infula*), and 22 are ectomycorrhizal. Although 55 species were reported for the first time from the coniferous forest communities of Shar Planina, a portion of the species are not specific to coniferous communities. Some are typical grassland species found in forest clearings, while others such as *F. sylvatica* are associated with deciduous trees, resulting in their occurrence in coniferous forest communities.

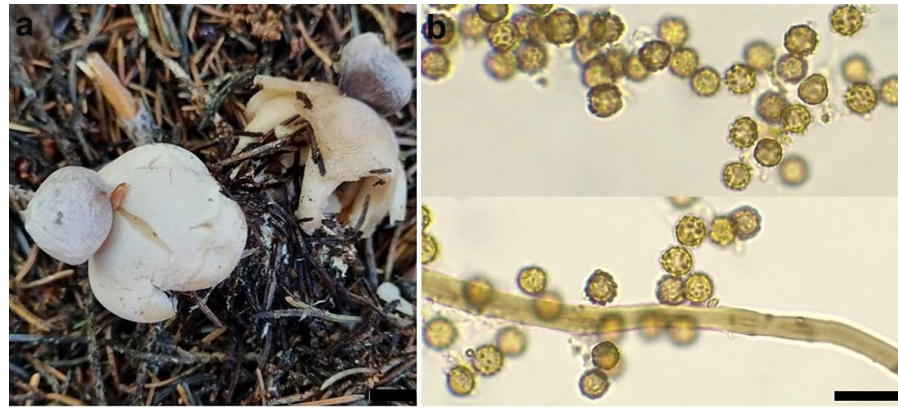


Fig. 1. *Geastrum quadrifidum*: **a.** Fresh basidiocarps. **b.** Globose basidiospores with warts and capillitium. Scale bars: **a.** = 1 cm, **b.** = 10 μ m.

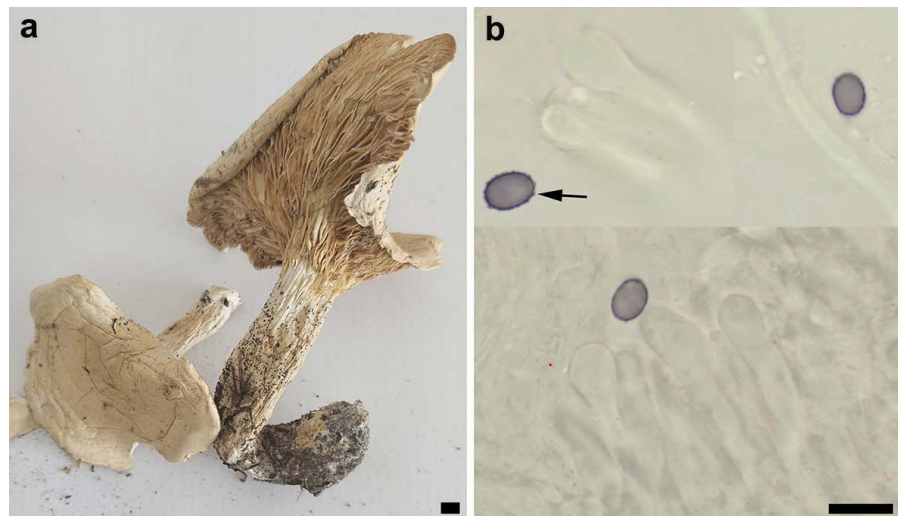


Fig. 2. *Leucopaxillus cerealis*. **a.** Dried basidiocarps. **b.** Ellipsoid basidiospores with amyloid reaction; small warts barely visible (the black arrow). Scale bars: **a.** = 1 cm, **b.** = 10 μ m.

Two species are recorded for the first time: *Geastrum quadrifidum* Pers. (Fig. 1) and *Leucopaxillus cerealis* (Lasch) Singer (Fig. 2).

List of fungi recorded for the first time from the coniferous forest communities of Shar Planina National Park in the Republic of North Macedonia, with one additional fungus-like organism

The list includes the species recorded for the first time in the coniferous communities of Shar Planina. Family and phylum names are given in brackets, followed by locality, altitude, coordinates, substratum, collection date and the type of record (field note or the voucher number from the MCF).

1. *Agaricus campestris* L. (Agaricaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, note;
2. *Atheniella flavoalba* (Fr.) Redhead, Moncalvo, Vilgalys, Desjardin & B.A. Perry (syn. *Mycena flavoalba* (Fr.) Quél.) (Mycenaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, 25 September 2023, MCF2022_19363;
3. *Bolbitius titubans* (Bull.) Fr. (Bolbitiaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19366;

4. *Chlorophyllum rhacodes* (Vittad.) Vellinga (Agaricaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, spruce mixed with fir and beech, *Abieti-Piceetum scardicum*, 25 September 2023, note;
5. *Chroogomphus rutilus* (Schaeff.) O.K. Mill. (Gomphidiaceae, Basidiomycota), Popova Sapka, 1,800 m a.s.l., 42°00'41.6" N, 20°52'30.2" E, on soil, *Abieti-Piceetum scardicum*, 11 September 2022, note;
6. *Chrysomphalina grossula* (Pers.) Norvell, Redhead & Ammirati (Hygrophoraceae, Basidiomycota), Lesnica, 1,500 m a.s.l., 42°1'26.50" N, 20°47'20.86" E, on rotten wood, *Piceetum subalpinum scardicum*, 8 October 2023, note;
7. *Clavulina rugosa* (Bull.) J. Schröt (Hydnaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, note;
8. *Collybia ozes* (Fr.) P. Karst (syn. *Lyophyllum ozes* (Fr.) Singer) (Clitocybaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, 25 September 2023, note;
9. *Cortinarius cf. casimirii* (Velen.) Huijsman (Cortinariaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19375;
10. *Cortinarius lividoviolaceus* (Rob. Henry ex M.M. Moser) M.M. Moser (Cortinariaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, under *Fagus sylvatica*, 25 September 2023, MCF 2022_19355;
11. *Cortinarius opimus* Fr. (Cortinariaceae, Basidiomycota), Lesnica, 1,500 m a.s.l., 42°1'26.50" N, 20°47'20.86" E, on soil, *Piceetum subalpinum scardicum*, 25 September 2023, note;
12. *Cortinarius trivialis* J.E. Lange (Cortinariaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, under *Betula*, 8 October 2022, note;
13. *Cortinarius varius* (Schaeff.) Fr. (Cortinariaceae, Basidiomycota), Jelak, 1,550 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19259;
14. *Cortinarius venetus* (Fr.) Fr. (Cortinariaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19380;
15. *Cortinarius violaceus* (L.) Gray (Cortinariaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, 25 September 2023, note;
16. *Cuphophyllum virgineus* (Wulfen) Kovalenko (Hygrophoraceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, *Abieti-Piceetum scardicum*, on soil, 25 September 2023, MCF 2022_19360;
17. *Cystoderma fallax* A.H. Sm. & Singer (Squamanitaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19262;
18. *Entoloma sericeoides* (J.E. Lange) Noordel. (Entolomataceae, Basidiomycota), the Adzina Reka, 1,450 m a.s.l., 41°48'45.68" N, 20°38'17.12" E, on soil, *Abieti-Piceetum scardicum*, 18 September 2022, note;
19. *Gaeastrum quadrifidum* Pers. (Gaeastraceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2022, MCF 2022_19379;
20. *Gymnopilus odini* (Fr.) Bon & P. Roux (Hymenogastraceae, Basidiomycota), Lesnica, 1,500 m a.s.l., 42°1'26.50" N, 20°47'20.86" E, on soil, *Piceetum subalpinum scardicum*, 2 October 2023, note;
21. *Hebeloma sinapizans* (Paulet) Gillet (Strophariaceae, Basidiomycota), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on soil, *Abieti-Piceetum scardicum*, 25 September 2023, note;

22. *Hygrocybe ceracea* (Sowerby) P. Kumm (Hygrophoraceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, MCF 2022_19433;
23. *Hygrocybe reidii* Kühner, (Hygrophoraceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19376;
24. *Hygrophorus gliocyclus* Fr. (Hygrophoraceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, note;
25. *Hymenoscyphus epiphyllus* (Pers.) Rehm ex Kauffman, (Helotiaceae, Ascomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, *Abieti-Piceetum scardicum*, on fallen leaves of *Fagus*, 2 October 2023, MCF 2022_19372;
26. *Kuehneromyces mutabilis* (Schaeff.) Singer & A.H. Sm (Strophariaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on a fir stump, *Abieti-Piceetum scardicum*, 8 October 2022, note;
27. *Lactarius aurantiacus* (Pers.) Gray (Russulaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19385;
28. *Lentinellus flabelliformis* (Bolton) S. Ito, (Auriscalpiaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on a spruce log, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19369;
29. *Lepista densifolia* (J. Favre) Singer & Cléménçon (Clitocybaceae, Basidiomycota), the Adzina Reka, 1,450 m a.s.l., 41°48'45.68" N, 20°38'17.12" E, on soil, *Abieti-Piceetum scardicum*, 18 September 2022, note;
30. *Leucocybe candicans* (Pers.) Vizzini, P. Alvarado, G. Moreno & Consiglio (syn. *Clitocybe candicans* (Pers.) P. Kumm.) (Lyophyllaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19285;
31. *Leucopaxillus cerealis* (Lasch) Singer *sensu lato* (incl. *L. albissimus* (Peck) Singer, *L. paradoxus* (Costantin & L.M. Dufour) Boursier, *L. piceinus* (Peck) Pomerl., *L. lentus* (H. Post ex Sacc.) Singer) (Tricholomataceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2023_19711;
32. *Melanoleuca melaleuca* (Pers.) Murrill (Melanoleucaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, note;
33. *Melanoleuca substrictipes* Kühner (Melanoleucaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 8 October 2022, note;
34. *Mycena epipterygia* (Scop.) Gray. (Mycenaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, note;
35. *Mycena galericulata* (Scop.) Gray (Mycenaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on decaying wood, *Abieti-Piceetum scardicum*, 8 October 2022, note;
36. *Mycena rosella* (Fr.) P. Kumm. (Mycenaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19389;
37. *Mycena rubromarginata* (Fr.) P. Kumm. (Mycenaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on decaying wood, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19388;
38. *Myochromella inolens* (Fr.) V. Hofst., Cléménçon, Moncalvo & Redhead (syn. *Tephrocybe inolens* (Fr.) M.M. Moser) (Lyophyllaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19378;

39. *Neolentinus lepideus* (Fr.) Redhead & Ginns (Gloeophyllaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on a fir log, *Abieti-Piceetum scardicum*, 2 October 2022, MCF 2022_19427;
40. *Panaeolus papilionaceus* (Bull.) Quél. (Galeropsidaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19367;
41. *Panellus mitis* (Pers.) Singer (Mycenaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on fallen branches, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19370;
42. *Paragyromitra infula* (Schaeff.) X.C. Wang & W.Y. Zhuang (syn. *Gyromitra infula* (Schaeff.) Quél.) (Discinaceae, Ascomycota), Lesnica, 1,500 m a.s.l., 42°1'26.50" N, 20°47'20.86" E, on soil, *Piceetum subalpinum scardicum*, 25 September 2023, MCF 2022_19362;
43. *Phaeoclavulina abietina* (Pers.) Giachini (syn. *Ramaria abietina* (Pers.) Quél.) (Gomphaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, note;
44. *Phlegmacium argutum* (Fr.) Niskanen & Liimat. (syn. *Cortinarius argutus* Fr.) (Cortinariaceae, Basidiomycota), the Adzina Reka, 1,450 m a.s.l., 41°48'45.68" N, 20°38'17.12" E, on soil, *Abieti-Piceetum scardicum*, 18 September 2022, note;
45. *Phlegmacium balteatum* (Fr.) A. Blytt (Cortinariaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19365;
46. *Pseudolyophyllum metachroum* (Fr.) Raithelh. ex Z.M. He & Zhu L. Yang (syn. *Clitocybe metachroa* (Fr.) P. Kumm.) (Clitocybaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, 2 October 2023, MCF 2022_19374;
47. *Rhizopogon roseolus* (Corda) Th. Fr. (Rhizopogonaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, MCF 2022_19435;
48. *Ripartites metrodii* Huijsman (Paralepistaceae, Basidiomycota), Popova Sapka, 1,800 m a.s.l., 42°00'41.6" N, 20°52'30.2" E, on soil, *Abieti-Piceetum scardicum*, 9 October 2022, MCF 2022_19310;
49. *Russula badia* Quél. (Russulaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, MCF 2022_19432;
50. *Russula sanguinea* Fr., (Russulaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, note;
51. *Russula torulosa* Bres. (Russulaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, on soil, black pine plantation, 9 October 2022, note;
52. *Tapinella atrotomentosa* (Batsch) Šutara (Tapinellaceae, Basidiomycota), Orasje, 715 m a.s.l., 42°7'45.47" N, 21°8'40.28" E, wood remains of pine, black pine plantation, 2 November 2023, MCF 2022_19428;
53. *Tephrocye confusa* (P.D. Orton) P.D. Orton (Lyophyllaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, *Abieti-Piceetum scardicum*, on soil, 2 October 2023, MCF 2022_19382.
54. *Tubaria furfuracea* (Pers.) Gillet *sensu lato* (incl. *T. anthracophila* P. Karst., *T. hiemalis* Bon, *T. romagnesiana* Arnolds) (Tubariaceae, Basidiomycota), Jelak, 1,750 m a.s.l., 42°1'57.81" N, 20°51'36.34" E, on soil, *Abieti-Piceetum scardicum*, under beech, 8 October 2023, MCF 2023_19712.
55. *Fuligo septica* (L.) F.H. Wigg. (Physaraceae, Protozoa), Lesnica, 1,550 m a.s.l., 42°1'37.86" N, 20°47'23.19" E, on fallen branches, *Abieti-Piceetum scardicum*, 2 October 2023, note.

Two fungal species new to the Republic of North Macedonia

Geastrum quadrifidum (Pers.)

The morphological features correspond to those provided in the mycological literature (BREITENBACH & KRÄNZLIN 1995; JORJADZE 2009; KNUDSEN & VESTERHOLT 2012). The species is characterised by its non-sulcate and well delimited peristome, non-hygroscopic exoperidium, stipitate endoperidium body, fornicate and mostly four-rayed basidiocarps (therefore commonly known as the four-footed earthstar), and by basidiospores measuring 5–6 µm in diameter (including ornament) (Fig. 1). It grows on soil, mostly in coniferous or mixed coniferous-deciduous forests, and is distributed in Europe, North America, Asia, Africa (southern part), and Australia (incl. New Zealand) (GMINDER *et al.* 2000; SARASINI 2005). *Geastrum quadrifidum* is widespread in Europe, common to rather rare, depending on the area. It is an endangered species in Denmark (BUCHWALD & HEILMANN-CLAUSEN 2020). In the Republic of North Macedonia, it was observed in an *Abieti-Piceetum scardicum* community at the locality of Jelak, at an altitude of approximately 1,700 m, in the month of October, and it represents the first data pertaining to this species in the country.

Leucopaxillus cerealis (Lasch) Singer

The morphological features are compatible with those specified in KNUDSEN & VESTERHOLT (2012) and KUO (2007). *Leucopaxillus cerealis* is treated here in a broader sense, including *L. albissimus*, *L. paradoxus*, *L. piceinus*, and *L. lentus*. The species is characterised by a white to whitish pileus with a smooth and matt, non-cracking surface; cream, crowded, adnate to decurrent gills; a central stem; and ellipsoid, amyloid basidiospores with warts (Fig. 2). According to GMINDER *et al.* (2001) and KNUDSEN & VESTERHOLT (2012), it mostly occurs in coniferous associations, on litter, but also in deciduous forests, and is a rare to very rare species in Europe, recorded in about 10 countries. It is included in the Red List of Fungi in Finland (as near threatened - NT), Norway (NT), and Sweden (as endangered - EN) (KNUDSEN & VESTERHOLT 2012). In the Republic of North Macedonia, it was found in a community of *Picea abies* and *Abies alba*, at the Jelak locality, at an altitude of around 1,700 m, in the month of October. This is the first record of *L. cerealis* for the Republic of North Macedonia.

CONCLUSION

This study advances the knowledge of fungal diversity in Shar Planina's coniferous forests, an underexplored mountain habitats in the country. The new records underline the ecological and conservation importance of these communities. Continued surveys and the integration of fungi into biodiversity research will be essential for their effective protection.

REFERENCES

- BREITENBACH J & KRÄNZLIN F. 1991. *Fungi of Switzerland, Volume 2: Non-gilled fungi*. Verlag Mykologia, Switzerland.
- BREITENBACH J & KRÄNZLIN F. 1995. *Fungi of Switzerland, Volume 4: Agarics, 2nd Part*. Verlag Mykologia, Switzerland.
- BREITENBACH J & KRÄNZLIN F. 2000. *Fungi of Switzerland, 5*. Verlag Mykologia, Switzerland.
- BUCHWALD E & HEILMANN-CLAUSEN J. 2020. How well do conservation sites based on annex II species of the EU Habitats Directive cover other threatened species relevant for the 2020 biodiversity targets? In: BUCHWALD E (ed.), *Analysis and prioritization of future efforts for Danish*, pp. 23–68, Faculty of Science, University of Copenhagen.

- GMINDER A, KRIEGLSTEINER GJ & KAISER A. 2001. *Die Großpilze Baden-Württembergs Band 3*. Verlag Eugen Ulmer GmbH & Co., Germany.
- GMINDER A, KRIEGLSTEINER GJ, WINTERHOFF W & KAISER A. 2000. *Die Großpilze Baden-Württembergs Band 2*. Verlag Eugen Ulmer GmbH & Co., Germany.
- JASHARI H, TOFILOVSKA S, KARADELEV M & RUSEVSKA K. 2023. Diversity of larger fungi in coniferous communities of Shar Mountain National Park (Republic of North Macedonia) with new country records. *Ecologia Balkanica* **15**(2): 83–97.
- JORJADZE A. 2009. New records of *Geastrum* Persoon (Gasteromycetes) for Georgia. *Proceedings of the Georgian Academy of Sciences, Series B: Biological Sciences* **3–4**: 14–17.
- KARADELEV M, NASTOV Z & RUSEVSKA K. 2002. Qualitative and quantitative research of macromycetes on Šar Planina Mt. *Bulletin of Biological Students' Research Society* **2**: 71–78.
- KARADELEV M, RUSEVSKA K, KAJEVSKA I & MITIĆ KOPANJA D. 2019. Checklist of larger ascomycetes in the Republic of Macedonia. *CONTRIBUTIONS, Section of Natural, Mathematical and Biotechnical Sciences, MASA* **40**(2): 239–253. <https://doi.org/10.20903/cs-nmbs.masa.2019.40.2.148>
- KARADELEV M, RUSEVSKA K, KOST G & KOPANJA DM. 2018. Checklist of macrofungal species from the phylum Basidiomycota of the Republic of Macedonia. *Acta Musei Macedonici Scientiarum Naturalium* **21**(1): 23–112.
- KNUDSEN J & VESTERHOLT J. 2012. *Funga Nordica: Agaricoid, Boletoid, Clavarioid, Cyphelloid and Gastroid Genera. 2nd edition*. Nordsvamp, UK.
- KUO M. 2007. The Genus *Leucopaxillus*. Available at: <https://www.mushroomexpert.com/leucopaxillus.html> [Accessed 16 December 2024]
- MILEVSKI I, TEMOVSKI M, MADARÁSZ B, KERN Z & RUSZKICZAY-RÜDIGER Z. 2020. Geomorphometry of the cirques of Shar Mountain. In: *Proceedings of the Geomorphometry 2020 Conference*, Perugia, Italy, 22–26 June 2020, pp. 91–94.
- NASTOV Z, CILKOVSKA M, SKANDEVA M & KARADELEV M. 1996. Contribution to the knowledge of macromycetes on Shar Mountain. *Bulletin of Biological Students' Research Society* **1**: 39–43.
- SARASINI M. 2005. *Gasteromiceti epigei*. A.M.B., Trento.
- TOFILOVSKA S, RUSEVSKA K, GREBENC T, KOST G & KARADELEV M. 2019. Contribution to the checklist of Basidiomycota for the Republic of North Macedonia. *Acta Musei Macedonici Scientiarum Naturalium* **22**: 27–33.
- UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP). 2020. *Valorization study of Shar Planina*. Regional Office in Vienna, Austria.



REZIME

Novi podaci o diverzitetu gljiva i organizama sličnih gljivama u četinarskim šumama Nacionalnog parka Šar planina, uključujući dve vrste prvi put registrovane za Severnu Makedoniju

Hasime JASHARI, Slavica TOFILOVSKA, Mitko KARADELEV i Katerina RUSEVSKA

Ova studija istražuje raznolikost makromiceta u četinarskim šumskim zajednicama Šar planine, novoproglašenog nacionalnog parka u Republici Severnoj Makedoniji. Uprkos prepoznatom ekološkom značaju ovih šuma, istraživanja diverziteta gljiva su i dalje oskudna. Cilj ove studije je da popuni tu prazninu gljivama novozabeleženim u četinarskim šumskim zajednicama tokom terenskih istraživanja 2022. i 2023. godine. Istraživanje je sprovedeno na šest lokaliteta na nadmorskoj visini od 715 m do 1.800 m, obuhvatajući različite četinarske šumske zajednice: *Abieti-Piceetum scardicum*, *Piceetum subalpinum scardicum* i plantaže crnog bora (*Pinus nigra*). Ukupno 54 makromiceta je prvi put zabeleženo na ovim staništima, čime je diverzitet gljiva u četinarskim zajednicama Šar planine povećan sa 214 na 268 vrsta. Od toga, 259 vrsta pripada tipu Basidiomycota, a 9 tipu Ascomycota. Pored toga, zabeležen je jedan organizam sličan gljivi koji pripada porodici Myxomycota (sada Protozoa). Najveće bogatstvo vrsta primećeno je u mešovitim smrčevo-jelovim šumama na lokalitetu Jelak (*Abieti-Piceetum scardicum*), gde je prvi put zabeleženo 29 taksona. Zabeležena su, takođe, i dva nova podatka za Republiku Severnu Makedoniju - *Geastrum quadrifidum* i *Leucopaxillus cerealis*. Ekološki, 33 od 55 identifikovanih vrsta su saprotrofne, javljaju se na zemljištu, drvetu ili organskim ostacima, dok su 22 ektomikorizne, formirajući simbiotske asocijacije sa četinarskim i širokolisnim vrstama drveća. Nalazi doprinose proširenju znanja o diverzitetu gljiva u četinarskim šumama Šar planine, naglašavajući potrebu za kontinuiranim istraživanjem i naporima za njeno očuvanje. S obzirom na ekološku ulogu gljiva u šumskim ekosistemima, ovi rezultati naglašavaju važnost očuvanja i praćenja njihove raznolikosti unutar ovog novozaštićenog područja.

Ključne reči: Ascomycota, Basidiomycota, četinarske šume, prvi nalaz, makromicete, Šar planina