

Contribution to the Checklist of Basidiomycota for the Republic of North Macedonia

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Abstract

Basidiomycota is a species-rich group of fungi that was intensively studied in Republic of North Macedonia. In a recently published checklist 1766 macrofungal taxa of this group are noted as known for its territory. The research on diversity and ecology of different groups of fungi in various biogeographical regions is ongoing work. Additionally, the studies of hypogeous fungi were intensified during the last years. These surveys resulted in discovery of 23 taxa of Basidiomycota (13 epigeous and 10 hypogeous species) recorded for the first time in the Republic of North Macedonia.

Key words: fungi, diversity, ecology, hypogeous, *Melanogaster macrosporus*

Introduction

Fungi are a species-rich group of organisms with over 144000 taxa described of which around 50000 belong to the phylum Basidiomycota (Willis et al. 2018). Basidiomycota is the best studied phylum of fungi in the Republic of North Macedonia. Early publications on fungal diversity in the Republic of North Macedonia are mainly dating from the 1930's (Litschauer 1939, Petrak 1936, Pilát 1937, Pilát and Lindtner 1938, 1939) and latter Lindtner (1943) made a significant contribution to the knowledge of macrofungi in the area of Lake Ohrid and Galičica Mountain. A monumental contribution to the knowledge of fungal diversity was subsequently made by Tortić (1988) who noted 585 species of macrofungi in her *Materials for the mycoflora of Macedonia*.

In the last three decades the research on diversity and distribution of fungi in Republic of North Macedonia had been intensified. Numerous mycological forays had been conducted and published since then, either

focusing on diversity of selected areas (Karadelev 1994, Karadelev 1995a, Rusevska and Karadelev 2004, Karadelev et al. 2007) or focusing on specific taxonomic groups (Karadelev 1995b, Karadelev et al. 2008, Rusevska et al. 2014, Rusevska et al. 2019). Extensive research activities had generated an immense number of data and reference collections that were the basis for a recently published checklist with a total 1766 macrofungal taxa of Basidiomycota, including 497 taxa reported from North Macedonia the first time (Karadelev et al. 2018 and references there in). That was an important contribution to the knowledge, not only for the diversity and distribution of fungi in North Macedonia, but also for the knowledge about fungi of the whole Balkan Peninsula.

In scope of an increasing number of recorded species we aimed to continue with a field research focusing on macromycetes from various localities and specific habitats, as well as with a revision on already deposited samples in the Macedonian Collection of Fungi (MCF) from previous years. Target areas of recent stud-

ies were different biogeographical regions, as Bistra, Maleševski Planini, Osogovski Planini and Šar Planina. The analyses on the fungal specimens proved fructification of the taxa listed for the first time for North Macedonia in this paper.

Additionally, the intensity of studies of sequestrate and hypogeous fungi increased in past years, as field research activities were organized in collaboration with truffle collectors and truffle specialists. That resulted in numerous recent (last decade) samples deposited in the Macedonian Collection of Fungi (MCF) supplementing well the previously published data on diversity of basidiomyceteous hypogeous species reported by Chavdarova et al. (2011) and Karadelev et al. (2018). Thus, a complete revision of the deposited hypogeous samples was suggested and out taxonomic revisions uncovered the presence of several hypogeous taxa, which were not recorded for the area of North Macedonia before.

The new recorded taxa for North Macedonia are presented in this paper as a contribution to the recently published checklist of macrofungal species from the Basidiomycota phylum (Karadelev et al. 2018) in order to increase the knowledge on diversity and distribution of this group.

Material and methods

The epigeous species, reported in this check list, were collected during spring-summer and summer-fall field research of 2019 in the biogeographical regions Bistra and Maleševski Planini, while some of them were collected in the previous years from Osogovski Planini and Šar Planina. Identifications were performed on fresh collections from 2019, and on dried specimens deposited to MCF collection in past years. The hypogeous and sequestrate fungi were collected during field research in various regions (Bistra, Galičica, Gradištan-ska Planina, Kitka, Korab, Kožuf, Plačkovica, Skopska Crna Gora, Taorska Klisura and Badar) and for multiple years and seasons.

All studied collections were deposited in the Macedonian Collection of Fungi (MCF) under accession numbers given in the list and were registered in the database (MACFUNGI). The microscopical analyses for determination of the species were conducted on an LW Scientific i4 microscope using appropriate reagent for visualization or specific chemical reactions (Meltzer's

Reagent, 5% KOH, H₂O). The determination of the species was based on the available literature, recently published papers and identification keys (Horak 2005, Knudsen and Vesterholt 2012, Montecchi and Sarasini 2000). The precise taxonomic status of the species follows Index Fungorum (Kirk 2019) and MycoBank (Stalpers and Cock 2019).

Results and discussion

Twenty-three species are registered as new for the mycobiota in Republic of North Macedonia. Among the listed species 13 are epigeous and 10 are hypogeous species, all belonging to phylum Basidiomycota. These are members of 13 different families (Agaricaceae, Albatrellaceae, Boletaceae, Botryobasidiaceae, Cortinariaceae, Gomphaceae, Lyophyllaceae, Melanogastraceae, Meruliaceae, Psathyrellaceae, Russulaceae, Strophariaceae and Tricholomataceae). In the following list of the species, their synonyms and family affiliation are provided, as well as data for the locality, as biogeographical region and code of the region (Melovski et al. 2013), the habitat type where the specimens were found, the date and number of exsiccata in the MCF collection.

1. **Baorangia emileorum** (Barbier) Vizzini, Simonini & Gelardi

Syn. *Boletus emilei* Barbier, *Boletus emileorum* Barbier;
Family: Boletaceae.

Bistra (10309), 1100 m a.s.l., chestnut forest, soil, 16.10.2019, MCF 2019/17575.

2. **Botryobasidium danicum** J. Erikss. & Hjortstam
Family: Botryobasidiaceae.

Šar Planina (10102), 1800 m a.s.l., spruce forest, dry branch of spruce, 10.07.1995, MCF 95/4382.

3. **Botryobasidium medium** J. Erikss.
Family: Botryobasidiaceae.

Šar Planina (10102), 1800 m a.s.l., spruce forest, log of spruce, 10.7.1995, MCF 95/1413.

4. **Cortinarius crustulinus** Malençon
Family: Cortinariaceae.

Bistra (10309), 1100 m a.s.l., mixed deciduous forest (*Quercus*), soil, 16.10.2019, MCF 2019/17587.

5. **Cortinarius lustratus** Fr.
Syn. *Phlegmacium lustratum* (Fr.) M.M. Moser;
Family: Cortinariaceae.
Bistra (10309), 1100 m a.s.l., mixed deciduous forest, soil, 16.10.2019, MCF 2019/17589.
6. **Gautieria morchelliformis** Vittad.
Family: Gomphaceae; hypogeous.
Kožuš (51148), 550 m a.s.l., kermes oak forest, 02.07.2014, MCF 2014/17081. Skopska Crna Gora (62078) 570 m a.s.l., oak forest, 11.6.2015, MCF 2015/17128.
7. **Hemimycena cucullata** (Pers.) Singer
Syn. *Mycena cucullata* (Pers.) Bon & Chevassut;
Family: Tricholomataceae.
Maleševski Planini (72492), 1400 m a.s.l., beech and pine forest, soil, 13.10.2019, MCF 2019/17538.
8. **Hymenogaster citrinus** Vittad.
Family: Strophariaceae; hypogeous.
Kitka (20619b), 680 m a.s.l., oak-hornbeam forest, 01.11.2014, MCF 2014/17092.
9. **Hymenogaster griseus** Vittad.
Family: Strophariaceae; hypogeous.
Galičica (30837), 680 m a.s.l., deciduous forest with oak, 08.01.2018, MCF 2018/17009.
10. **Hymenogaster populetorum** Tul. & C. Tul.
Family: Strophariaceae; hypogeous.
Bistra (10309), 1250 m a.s.l., beech dominated forest with individual *Populus tremula* trees, 10.12.2015, MCF 2015/17140.
11. **Hymenogaster rechteneri** Bucholtz
Family: Strophariaceae; hypogeous.
Gradištanska Planina (61874), 400 m a.s.l., oak-hornbeam forest, 29.05.2018, MCF 2018/17024.
12. **Lepiota xanthophylla** P.D. Orton
Family: Agaricaceae.
Bistra (10309), 1055 m a.s.l., deciduous forest, 16.10.2019, MCF 2019/17622.
13. **Leucogaster nudus** (Hazsl.) Hollós
Syn. *Hydnangium nudum* Hazsl.;
Family: Albatrellaceae; hypogeous.
Bistra (10309), 1300 m a.s.l., beech and fir forest, 11.01.2014, MCF 2014/17051.
14. **Lyophyllum deliberatum** (Britzelm.) Kreisel
Syn. *Tricholoma deliberatum* (Britzelm.) Sacc.;
Family: Lyophyllaceae.
Bistra (10309), 1055 m a.s.l., deciduous forest, 16.10.2019, MCF 2019/17626.
15. **Melanogaster ambiguus** (Vittad.) Tul. & C. Tul.
Syn. *Octaviania ambigua* Vittad.;
Family: Melanogastraceae; hypogeous.
Taorska Klisura and Badar (61975), 350 m a.s.l., deciduous forest (under *Quercus pubescens*), 03.07.2014, MCF 2014/17088.
16. **Melanogaster macrosporus** Velen.
Family: Melanogastraceae; hypogeous.
Plačkovica (72386), 1300 m a.s.l., beech forest, 16.07.2014, MCF 2014/13409. Plačkovica (72386), 1400 m a.s.l., beech forest, 18.07.2014, MCF 2014/13397. Korab (10103), 1500 m a.s.l., beech and fir forest, 16.7.2013, MCF 2013/14890.
17. **Melanogaster variegatus** (Vittad.) Tul. & C. Tul.
Family: Melanogastraceae; hypogeous.
Taorska Klisura and Badar (61975), 350 m a.s.l., deciduous forest (under *Quercus pubescens*), 03.07.2014, MCF 2014/17085.
18. **Pholiota tuberculosa** (Schaeff.) P. Kumm.
Syn. *Pleuroflammula tuberculosa* (Schaeff.) E. Horak;
Family: Strophariaceae.
Bistra (10309), 1100 m a.s.l., mixed deciduous forest (*Acer*, *Castanea*, *Corylus*, *Populus*, *Quercus*), 16.10.2019, MCF 2019/17611.
19. **Psathyrella lutensis** (Romagn.) M.M. Moser
Family: Psathyrellaceae.
Bistra (10309), 1100 m a.s.l., deciduous forest, 16.10.2019, MCF 2019/17613.
20. **Russula mistiformis** (Mattir.) Trappe & T.F. Elliott
Syn. *Martellia mistiformis* Mattirollo;
Family: Russulaceae; hypogeous.
Skopska Crna Gora (62078), 700 m a.s.l., oak forest, 02.06.2002, MCF 2002/8845.
21. **Russula pectinatoides** Peck
Family: Russulaceae.
Osogovski Planini (72283), 1000 m a.s.l., beech forest, 20.06.2018, MCF 2018/16668.

22. *Russula pelargonica* Niolle

Family: Russulaceae.

Osogovski Planini (72283), 1060 m a.s.l., beech forest with individual *Populus tremula* trees, 03.07.2018, MCF 2018/16705.

23. *Scopuloides leprosa* (Bourdot & Galzin) Boidin

Syn. *Phanerochaete leprosa* (Bourdot & Galzin) Jülich,

Family: Meruliaceae.

Šar Planina (10102), 1520 m a.s.l., beech forest, rotten wood, 28.04.2013, MCF 13/14397.

The species reported for the first time in North Macedonia, *Lepiota xanthophylla*, *Lyophyllum delibatum* and *Pholiota tuberculosa* are rare species, categorized in several national red lists as threatened and important for conservation (Knudsen and Vesterholt 2012, Jordan et al. 2017). The diversity of the genus *Cortinarius* is relatively well studied in North Macedonia with 121 species recognized until now (Karadelev et al. 2018). The observed *Cortinarius crustulinus* is thermophilic species distributed in South Europe originally described from the Mediterranean region (Malençon and Bartault 1970), while *C. lustratus* has a worldwide distribution. Also, *Baorangia emileorum* is a species with southern distribution, found only in the Mediterranean area (Assyov 2018). The rest of the epigeous species listed in this contribution, *Hemimycena cucullata*, *Psathyrella lutensis*, *Russula pectinatoides*, *Russula pelargonica* are common species with a wide geographic distribution. Three of the species in this list, *Botryobasidium danicum*, *B. medium* and *Scopuloides leprosa* are corticioid with little information on their distribution.

Within the group of hypogeous fungi, most of the listed species belong to the *Hymenogaster* genus, which is highly diverse, with more than 100 taxa worldwide (Kirk et al. 2008). Recent revision of the genus (Stielow et al. 2011) proposed a broad concept for species delimitation with only 12 species present in Europe. However, the key provided by Stielow and its collaborators (2011) is not applicable for determination of already dried samples, thus for identification of the deposited samples in MCF we followed the key of Montecchi and Sarasini (2000). Due to the changed morphological features of the sporocarps of the dried samples and due to high variability of the spore characteristics for some of the collections deposited in MCF a molecular identifica-

tion is needed. Until now only four species of this genus were known from North Macedonia, *H. arenarius* Tul. & C. Tul., *H. luteus* Vittad., *H. lycoperdineus* Vittad. and *H. olivaceus* Vittad. (Chavdarova et al. 2011). *Melanogaster* is the second most numerous hypogeous genus presented here with three new species for North Macedonia. *Melanogaster ambiguus* is noted as a rare species in the literature for Bulgaria (Lacheva 2015), but was also found in Greece and Serbia (Kaounas 2012, 2013, Konstantinidis 2015, Ivančević 2016) and is likely to have worldwide distribution. *Melanogaster variegatus* is a common thermophilus species distributed mainly at lower altitudes (Diamandis and Perlerou 2008, Lacheva 2011, Konstantinidis 2014, Ivančević 2016). *Melanogaster macrosporus*, on the other hand, was predominantly found at higher altitudes in Macedonia, in beech forest zone at 1300-1400 m a.s.l. *Melanogaster macrosporus* is a rare species and our record is first from the Balkan Peninsula (Moreau et al. 2011, Elliott et al. 2016, GBIF 2019). *Gautieria morchelliformis* is commonly found hypogeous species, widely distributed across Europe and North America (Nedelin 2016), while *Leucogaster nudus* is not common and is only distributed in Europe (Denchev and Assyov 2010, Nedelin et al. 2018, Ivančević 2016). *Russula mistiformis* is a sequestrate species, in Macedonia only recorded at Skopska Crna Gora from oak forest, most probably endemic to the Mediterranean region (Vidal et al. 2019).

Conclusions

Twenty-three taxa were found as new to North Macedonia, so the total number of species known within Basidiomycota is 1789. In this contribution to the checklist, significant are the finding of three species regarded as threatened in national red lists of European countries. For the knowledge of the diversity of hypogeous fungi, this is also an important contribution with 10 new species for the mycobiota in North Macedonia and first record of *Melanogaster macrosporus* on the Balkan Peninsula.

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Придонес кон листата на видови од групата Basidiomycota за Република Северна Македонија

Славица Тофиловска, Катерина Русевска, Тине Гребенц, Герхард Кост и Митко Караделев

Истражувањето на диверзитетот на габите во Република Северна Македонија е интензивирао во последните 20 години. Посебно внимание е посветено на типот Basidiomycota во рамки на кој досега се познати 1766 таксони, наведени во листата на видови макрофунги (Караделев и сор. 2018). Истражувањата на диверзитетот и екологијата на габите во различни биогеографски региони во текот на изминатата година како и ревизијата на депонирани примероци во Националната збирка на габи во Македонија (Macedonian Collection of Fungi, MCF), придонесе да се евидентираат досега непознати видови за Северна Македонија. Во овој труд се прикажани вкупно 23 вида од типот Basidiomycota, а за видот *Melanogaster macrosporus* ова е прво евидентирање на Балканскиот Полуостров. За секој од видовите се наведени биогеографските региони, периодот и хабитатот каде што се најдени примероците. Со овој придонес кон листата на макромисети за Република Северна Македонија досега вкупно се познати 1789 таксони од типот Basidiomycota.

Клучни зборови: габи, диверзитет, екологија, *Melanogaster macrosporus*, подземни габи