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CHECKLIST

New Record of Macrofungi for the Mycobiota of the Cieszyn Municipality (Polish Western Carpathians) Including New Species to Poland

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Abstract

In this paper, we present the results of mycological research carried out between 2015 and 2018 in the Cieszyn township, in the Silesian Foothills (Outer Western Carpathians). The list of 417 species of macrofungi from the Cieszyn area reported in our previous study, has been expanded further by the addition of 37 taxa found in the current study. Among these, the following deserve special attention: fungi that are new to Poland's mycobiota (six species: *Bryoscyphus dicrani*, *Discina martinii*, *Elaphomyces aculeatus*, *Tuber brumale*, *T. foetidum*, and *Russula cerea*), taxa subject to legal protection (four species: *Disciotis venosa*, *Grifola frondosa*, *Mitrophora semilibera*, and *Sparassis brevipes*), as well as fungi that are rare in Poland, included in national or regional red lists, and in the registers of rare and endangered species (24 species including *Amanita echinocephala*, *Arrhenia retiruga*, *A. spathulata*, *Catinella olivacea*, *Elaphomyces maculatus*, *Hygrophorus discoxanthus*, *Ophiocordyceps entomorrhiza*, *Pluteus diettrichii*, *Tuber aestivum*, and *T. fulgens*). This paper presents the distribution and location of 32 species of fungi along with a short description and illustration of the macro- and micromorphological features of select species and their habitats.

Keywords

Ascomycota; Basidiomycota; hypogeous fungi; mycorrhizal fungi; parasitic fungi; saprotrophic fungi

1. Introduction

Information about the various species of macrofungi that exist in the Cieszyn township should be considered relatively comprehensive. Between 2013 and 2015, the authors of this paper carried out extensive research in the area, which resulted in the inventarization of 417 species of fungi that grow in the administrative limits of the municipality (Chachuła et al., 2015). As a result of continued mycological exploration of the area in the following years, additional 37 species of fungi have been found. Among these are fungi that are protected and rare in Poland as well as species hitherto not reported in Poland. The article presents detailed description about their localities and ecology.

2. Material and Methods

The materials presented originate from the mycological collection and observation carried out in the Cieszyn area (within its administrative borders) (Figure 1)

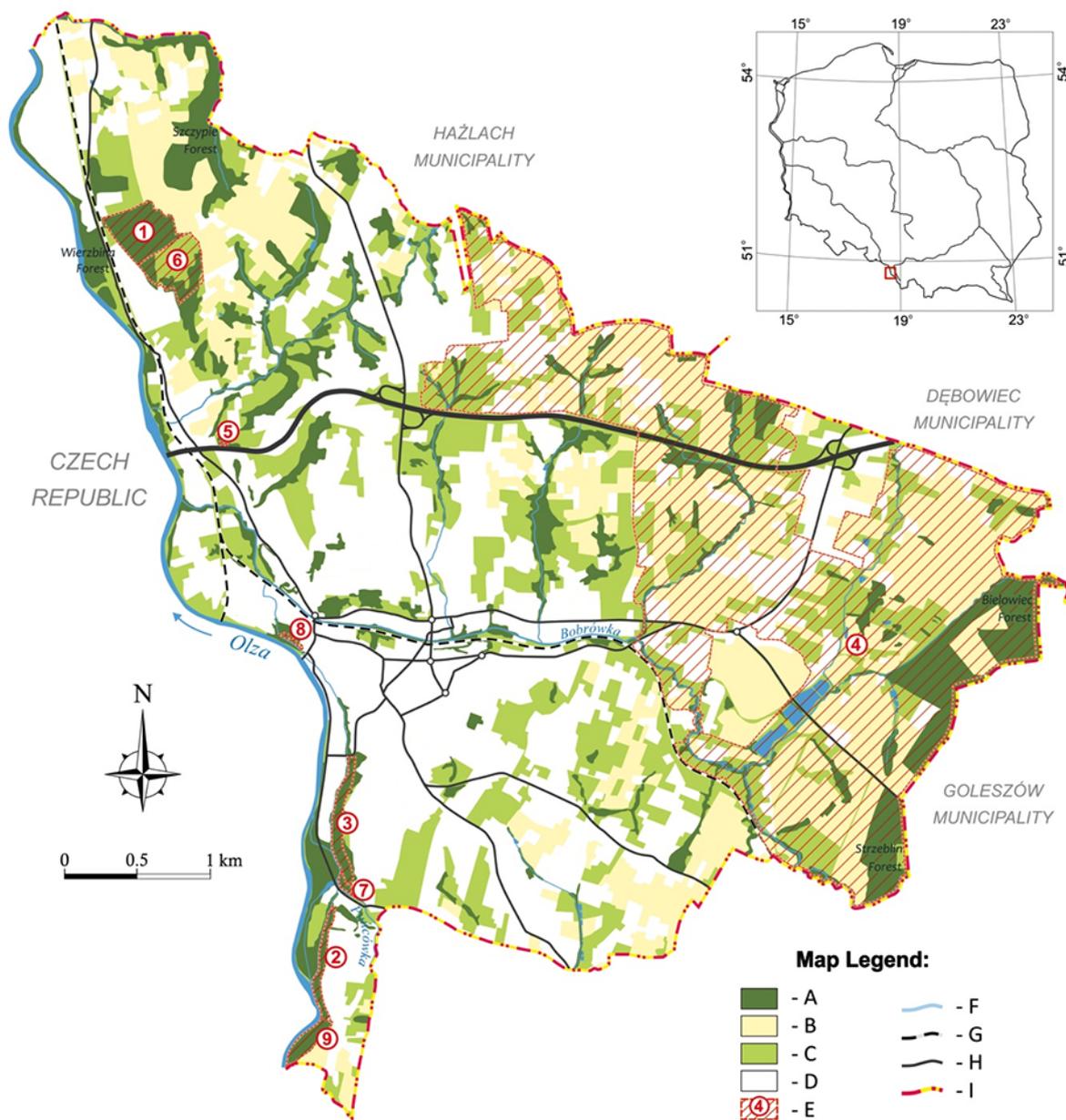


Figure 1 Map of Cieszyn municipality area. A – forests and tree stands; B – farmlands; C – meadows, pastures, orchards, and allotments; D – urbanized areas (industrial, service, and residential buildings); E – areal form of nature protection; F – surface water (streams, rivers, and ponds); G – railway; H – roads; I – commune border: 1 – “Kopce” nature reserve; 2 – “Lasek Miejski nad Olzą” nature reserve; 3 – “Lasek Miejski nad Puńcówką” nature reserve; 4 – “Cieszyńskie Pogórze” protected landscape area; 5 – documentation stand-out of teschenite opencast at Kręta Street; 6 – “Łąki na Kopcach” ecological use; 7 – “Łęg nad Puńcówką” ecological use; 8 – “Bluszcze na Górze Zamkowej” nature and landscape complex; 9 – “Lasek Miejski w Błogocicach” nature and landscape complex.

between 2015 and 2018. Mycological material was examined with a PZO (Polskie Zakłady Optyczne, Warsaw, Poland) Biolar light microscope with Nomarski interference contrast (NIC) and digital camera Delta Optical (Delta Optical, Warsaw, Poland) DLT-Cam PRO 10 MP (Figure 4A,E,F,H–J). Microscopic images (Figure 4B–D,G) were captured with an AxioScope A1 light microscope (Carl Zeiss, Jena, Germany) equipped with DIC system and digital camera AxioCam MRC5 in the Institute of Botany, Jagiellonian University in Kraków.

Microscopic slides were prepared from the dried fruiting bodies. For the new species of the Polish mycobiota, the measurements were made using 30 samples ($n = 30$) for each characteristic structure (including spores, spines, asci, and cystyds).

Spores were measured in side view, and without ornamentation and hilar appendix. Melzer's reagent, Congo red solution (in ammonia), and cotton blue solution (in water) were used for staining for observation of the micromorphological characters (Clemençon, 2009). Identification of the species was made according to mycological keys (Hansen & Knudsen, 2000; Knudsen & Vesterholt, 2008; Montecchi & Sarasini, 2000). Nomenclature of the taxa followed the Index Fungorum (<http://www.indexfungorum.org/>). The specimen of *Pluteus ephebeus* was additionally identified using molecular methods at the Institute of Botany, Polish Academy of Sciences in Kraków. The species are presented in alphabetical order, according to the phyla Ascomycota and Basidiomycota. When a taxon is subject to species protection (Regulation of the Minister of Environment, 2014) or included in the red list of macrofungi endangered in Poland (Wojewoda & Ławrynowicz, 2006) and in Polish Carpathians (Wojewoda, 1991), a square bracket with appropriate labeling follows the species name. It should be noted that the information on the occurrence included in the GREJ register (Kujawa et al., 2018), literature database (Kujawa, 2018), and in the checklists (Chmiel, 2006; Wojewoda, 2003) were also considered.

The description of localities include information about the localization including ATPOL squares (Komsta, 2016), habitat conditions including substrate or potential ectomycorrhizal plant partners observed in their surroundings, the number of fruiting bodies found, the date of observation, and individuals that collected and identified the specimens. The herbarium materials were deposited at the Jagiellonian University Herbarium in Kraków (KRA), as well as in P. Chachuła's private collection (PCh). In the case of rare hypogeous fungi, the authors have chosen not to provide more detailed information about the site/location of the species to protect and conserve the species.

The municipality of Cieszyn is situated in the western part of the Silesian Voivodeship. It covers an area of ca. 2,861 ha. According to the physiogeographical division of Poland (Kondracki, 2002) the municipality of Cieszyn belongs to the Cieszyn Foothills, which is the westernmost part of the Silesian Foothills mezoregion, and in turn a part of the Western Beskidian Foothills in the Outer Western Carpathians.

Geologically, the area is located within two units – the Podśląska Nappe (in small part) and the Cieszyn Nappe. The latter consists mainly of the lower and upper Cieszyn schists divided by layers of Cieszyn limestone. In these layers, teschenites – intrusions of igneous rock – can also be found. In the hilly areas, the rock waste of Cieszyn Nappe forms silty clay, roughing clay, sand, gravel, and loess. In the river valleys, coarse-grained gravels covered with alluvial mud soil, minerals, and organic mules may be found (Kasprowska & Ciborowski, 2010).

Upland and hilly landscape dominates the topography of Cieszyn, 80% of which is covered by synanthropic systems (urban areas, farmlands, wastelands, and green areas). Relatively small areas, occupying less than 12% of the township, are overgrown with dispersed forest complexes and other wooded areas. In terms of composition, the forests comprise of pockets of fertile carpathian beech forests (Figure 2A), oak-hornbeam forests, riverside riparian ash-alder forests, and piedmont riparian ash forests. Less than 8% of the township area is occupied by meadows and pastures.

3. Results

During the mycological research conducted in the Cieszyn area between 2015 and 2018, 38 species of macrofungi were found, of which 37 had not been reported previously from the area. One species – *Calvatia gigantea* – was mentioned in the literature (Kujawa & Gierczyk, 2011), but its presence was not confirmed during the comprehensive mycological research carried out previously in this area between 2013 and 2015 (Chachuła et al., 2015). Of the 38 fungal species, 15 belonged to the phylum Ascomycota and 23 to Basidiomycota. Of special interest are taxa not reported in Poland (six species), fungi subject to legal protection (four species), as well as rare taxa included in national or regional red lists and in the registers of rare and endangered species.

Among the six taxa found in Cieszyn, and not mentioned in any prior publication from Poland, five species belong to Ascomycota – *Bryoscyphus dicrani*, *Discina martinii*, *Elaphomyces aculeatus*, *Tuber brumale* and *T. foetidum*, and one species belongs to hypogeous Basidiomycota – *Russula cerea*.

In addition, owing to continued research on the mycobiota of Cieszyn, four more protected species were observed within the city limits, including *Disciotis venosa* (subject to strict protection) and *Mitrophora semilibera*, *Grifola frondosa*, and *Sparassis brevipes* (under partial protection) (Regulation of the Minister of Environment, 2014). Thus, the number of species subject to legal protection and occurring in the administrative limits of the township increased to 10, including the species already reported from the area: *Clavariadelphus pistillaris*, *Fistulina hepatica*, *Ganoderma lucidum*, *Hericium coralloides*, *Holwaya mucida*, *Trichoglossum hirsutum* (Chachula et al., 2015).

Among the species presented in this paper, 14 belong to taxa that are red-listed macrofungi of Poland (Wojewoda & Ławrynowicz, 2006), including one species that has been given an extinct category (Ex) – *Tuber aestivum*, two endangered (E) species – *Arrhenia retiruga* and *A. spathulata*, four vulnerable (V) species – *Elaphomyces maculatus*, *Grifola frondosa*, *Mycena renati*, and *Sparassis brevipes*, six rare (R) species – *Auricularia mesenterica*, *Disciotis venosa*, *Gyroporus castaneus*, *Mitrophora semilibera*, *Pluteus ephebeus*, and *Stropharia pseudocyanea*, and one in the I category (indeterminate) – *Hebeloma radicosum*.

Further, 25 species belong to taxa that are included in the GREJ register (Kujawa et al., 2018) and four (*Auricularia mesenterica*, *Calvatia gigantea*, *Grifola frondosa*, and *Hebeloma radicosum*) are also included in the red-listed macrofungi of the Polish Carpathians (Wojewoda, 1991).

Of note are taxa found relatively rarely in Poland, including: *Amanita echinocephala*, *Catinella olivacea*, *Entoloma saundersii*, *Gymnopilus junonius*, *Helvella leucomelaena*, *Hygrophorus discoxanthus*, *Octospora leuocoloma*, *Ophiocordyceps entomorrhiza*, *Pluteus diettrichii*, and *Tuber fulgens*.

In the following section, we present a list of the 31 most interesting fungal species not previously reported from Cieszyn (and *Calvatia gigantea*), with their localities and details about their morphology and distribution. It should be noted that, due to their relatively frequent occurrence in Poland, six species are not included in the list, although they also belong in the group of 37 new species of mycobiota of Cieszyn, and these are: *Agrocybe erebia* (Fr.) Kühner ex Singe, *Helvella acetabulum* (L.) Quél., *Hemipholiota populnea* (Pers.) Bon., *Mycena polygramma* (Bull.) Gray, *Pluteus romellii* (Britzelm.) Lapl., and *Strobilurus tenacellus* (Pers.) Singer.

Abbreviations: * – new taxon for Polish mycobiota; GREJ – a species included in the GREJ register; RLP – species listed on red list of macrofungi in Poland with appropriate the category of threat (Ex – extinct and probably extinct; E – endangered; V – vulnerable; R – rare; I – indeterminate); RLK – species included in the red list of the macrofungi of the Polish Carpathians with appropriate conservation status (R – rare); § – species protection (SP – strict protection; PP – partial protection); phot. – photography; initials of the authors: AD – Aleksander Dorda; AH – Anna Hreczka; MF – Marek Fiedor; MP – Marcin Piątek; PC – Piotr Chachula; PM – Piotr Mleczek; RR – Ryszard Rutkowski; *det.* – identified; *leg.* – collected; *mat.* – materials; *unpb.* – unpublished; *obs.* – observed; *nat. res.* – nature reserve.

3.1. List of Recorded Species: Ascomycota

3.1.1. *Bryoscyphus dicrani* (Ade & Höhn.) Spooner [*] (Figure 2B)

Localities and Habitat. Cieszyn, landslide area near Błogocka Street, on the periphery of “Lasek Miejski nad Puńcówką” *nat. res.*, DG00, few groups of ascomata on *Bryum argenteum* and *B. caespiticium* mosses, cocreating initial habitats on geotextile surfaces lined on exposed surfaces due to the mass movements, 2017-12-26, *leg.* RR and MF *det.* RR (PCh 1/26122017).

Notes. Species thus far not reported from Poland. Occurs in Northern, Western, and Central Europe, but not common (Hansen & Knudsen, 2000; Kirk & Spooner, 1984; Knutsson, 2005). It is a parasite of moss. Its occurrence time is during the cold period of year, often from fall to spring.

Description of Examined Specimens. Apothecia flat, round, 1–3 mm in diameter, 1–2 mm thick, short-stipitate, white to pale pink. Stipe relatively thick, 1–2 mm in diameter, up to 2 mm long. Spores $10.7\text{--}16.7 \times 5.3\text{--}9.3 \mu\text{m}$ (on average: $14 \times 7.3 \mu\text{m}$), smooth, fusoid and rhomboid. Asci with nonamyloid pore.

3.1.2. *Catinella olivacea* (Batsch) Boud. [GREJ] (Figure 3D)

Localities and Habitat. 1. Cieszyn, “Kopce” nat. res., DF90, in a beech forest formed on limestone soil, on the underside of a rotten trunk of a *Fagus sylvatica*, over a dozen ascomata, 2017-09-09, *obs.* & *det.* MF and RR. 2. Cieszyn, “Lasek Miejski w Błogocicach” nature and landscape complex, DG00, in the undergrowth of riparian forest on a flood terrace of Olza River, several ascomata on fallen, rotten branch of deciduous tree, 2018-10-06, *leg.* & *det.* MF and PC (KRA 2018-9).

Notes. Despite its global distribution, covering North and South America and Asia, it occurs in considerable dispersion and is rarely reported (Piątek, 2001). Data about occurrence in Poland comes from Wiśnickie Foothills (“Bukowiec” nat. res.), Ciężkowickie Foothills (St. Martin’s Peak in Tarnów), Knyszyńska Primeval Forest (Czołnowo area), Western Polesie (Ludwin Colony), Wigierski National Park, Wielkopolska region, and Bieszczady Mts (Gierczyk et al., 2019; Halama & Romański, 2010; Miśkiewicz, 2000; Nita & Bujakiewicz, 2004; Piątek, 2001; Snowarski, 2018).

3.1.3. *Discina martinii* (Donadini & Astier) Donadini & Astier [*] (Figure 2M, Figure 4A)

Localities and Habitat. Cieszyn, “Lasek Miejski w Błogocicach” nature and landscape complex, DG00, in the undergrowth of riparian forest on a flood terrace of Olza River, ascomata grew on fallen, rotten boughs and branches of deciduous trees, 2016-05-20 and 2017-05-17, *leg.* & *det.* RR (KRA 2017-37).

Notes. Species not previously reported from Poland, though it has been observed in the Magurski National Park (AH – mat. unpb.). Known from a few countries in the Mediterranean (Spain, France, Italy, and Montenegro) (van Vooren, 2015). A similar species to *Discina martinii* is *D. parma*, which also has spore poles with of the fingerlike, however, *D. parma* has smaller spores ($26\text{--}30 \times 11.5\text{--}13.5 \mu\text{m}$) (Hansen & Knudsen, 2000).

Description of Examined Specimens. Apothecia brown, flat, round in outline wrinkled, 6 (7.5) cm in diameter, with short and veined stem. Outer layer clearly brighter from hymenium layer. Spores oval, $30\text{--}32 \times 13\text{--}15 \mu\text{m}$, usually with one central and two smaller oil drops on the sides and of the fingerlike $1.5 \mu\text{m}$ long appendages.

3.1.4. *Disciotis venosa* (Pers.) Arnould [S-SP, RLP-R, GREJ]

Localities and Habitat. 1. Cieszyn, “Lasek Miejski w Błogocicach” nature and landscape complex, DG00, riparian forest in Olza River valley, three ascomata on soil, 2016-04-26 and 2016-05-20, *obs.* & *det.* RR. 2. Cieszyn, Wierzbina forest in Marklowice, DF90, three ascomata among *Petasites hybridus* complex, on the edge of riparian forest 2017-05-03, *obs.* MF, *det.* PC and RR.

Notes. In Poland, observed in small populations, mainly in the Polish Carpathian Mountains and their foothills, more rare in the Upper Silesia, Kuyavia, and Gdańsk Pomerania (Chmiel, 2006; Snowarski, 2018; Wojewoda, 2003).

3.1.5. *Elaphomyces aculeatus* Vittad. [*] (Figure 2D,E, Figure 4C,D)

Localities and Habitat. Cieszyn, DF90, in oak-hornbeam forest with *Carpinus betulus* and *Acer campestre*, formed on limestone soil, several ascomata, 2017-05-17, *leg.* & *det.* RR (KRA 2017-33).

Notes. Species not reported before in Polish mycological literature (Chmiel, 2006; Kujawa, 2018; Ławrynowicz, 1988; Skirgiełło & Wosińska, 1963). For over a decade, it has been observed at another site in the Cieszyn Foothills – Tuł Mt area (RR – mat. unpb.). This hypogeous, ectomycorrhizal fungus is known from its few localities in western, central, and northern part of Europe, but some of the data is obsolete. It is considered as a relic species for deciduous and mixed forest with *Corylus*, *Quercus*, and *Carpinus* (Minter, 2013).

Description of Examined Specimens. Ascomata spherical, 1–4 cm in diameter, surrounded by a crust, consisting of closely interwoven hyphae, pink in color, strongly connected to the surface of the peridium. Peridium black and pink (if without crust), 1 mm thick, covered with acute pyramidal warts protruding above the surface of the crust. Gleba homogeneous powdery at maturity, black-brown. Spores globose, 13.3–18 µm in diameter (average 15.6 µm), rusty brown, densely and evenly ornamented with small spines, 0.5–0.8 µm high. The macro- and micromorphological features of examined specimens correspond to other descriptions published (Paz et al., 2017).

3.1.6. *Elaphomyces maculatus* Vittad. [RLP-V, GREJ] (Figure 2C, Figure 4B)

Localities and Habitat. Cieszyn, DF90, in an oak-hornbeam forest with *Carpinus betulus* and *Acer campestre*, formed on limestone soil, over a dozen spherical ascomata, 2017-05-17, leg. RR, det. PM (PCh 1/17052017).

Notes. Very rare species known from two sites in the country, not recorded for several years (Ławrynowicz, 1988; Schroeter, 1889; Skirgiełło & Wosińska, 1963).

Description of Examined Specimens. Ascomata spherical, 1–3 cm in diameter, sometimes deformed. Usually occurs in groups in the subsurface layer of soil. Ascomata are surrounded by loosely adherent mycelium, with a characteristic gray-green color. This fungus is characterized by black, suede peridium and relatively large spores (28–42 µm in diameter) (Paz et al., 2017).

3.1.7. *Helvella leucomelaena* (Pers.) Nannf. [GREJ]

Localities and Habitat. Cieszyn, “Wzgórze” gardening allotments area near Długa Street, DG00, two ascomata under the canopy of *Pinus sylvestris*, 2016-04-26, leg. & det. RR (KRA 2016-93).

3.1.8. *Mitrophora semilibera* (DC.) Lév. [S-PP, RLP-R, GREJ]

Localities and Habitat. Cieszyn, Wierzbina forest, DF90, fertile, riverside riparian forest on limestone soil in Olza River valley, among *Petasites* under the canopy of *Fraxinus excelsior* and *Salix* sp., several ascomata, 2017-05-03, obs. & det. MF.

3.1.9. *Octospora leucoloma* Hedw. [GREJ]

Localities and Habitat. Cieszyn, Kościelna Street region, DF90, on *Bryum argenteum* and *B. dichotomum* mosses, several ascomata, 2017-10-26, leg. & det. RR (PCh 1/26102017).

Notes. Apothecia round, flat or slightly concave, 1–3 mm in diameter, without stipe. Coloring of apothecia ranges from yellow to orange. Ascomata occur singly and grow directly from moss. *Octospora leucoloma* is a parasitic species, growing on *Bryum* mosses which are widespread in Poland (Chmiel, 2006).

3.1.10. *Ophiocordyceps entomorrhiza* (Dicks.) G. H. Sung, J. M. Sung, Hywel-Jones & Spatafora [GREJ] (Figure 3F,G)

Localities and Habitat. 1. Cieszyn, “Kopce” nat. res. DF90, beech forest, conidial form on the sterile part of the stroma growing from the body of *Carabus* sp. larvae, 2016-12-18, obs. & det. RR. 2. Cieszyn, between Majowa and Kościelna streets, DF90, hornbeam-oak forest, two stromata growing from two bodies of *Carabus* sp. larvae, 2017-05-23, leg. MF, det. PC (KRA 2017-34). 3. Cieszyn, “Kopce” nat. res., DF90, beech forest, stroma growing from body of *Carabus violaceus*, 2017-08-24, obs. & det. MF.

Notes. Relatively rare taxon in Poland from the Cordycipitaceae family, parasitizing mainly on beetles from the Carabidae family and also on the Hemiptera of the Nabidae family. Typical stromata develop on beetles located in the subsurface layer of soil, several cm layer of soil. Perithecia of *O. entomorrhiza* develop on stromata. Observed on atrophied beetles in conidial form, also known under the synonymous name *Tilachlidiopsis nigra* (Bałazy, 1982). In Cieszyn, the perfect stages and conidial forms were observed developing on larvae and imago beetles of the *Carabus* (mainly *Carabus violaceus*).

3.1.11. *Tuber aestivum* Vittad. [RLP-Ex, GREJ] (Figure 2G, Figure 4G)

Localities and Habitat. Cieszyn, DF90, in hornbeam-oak forest with *Carpinus betulus*, *Tilia* sp., *Acer campestre*, and *Quercus robur* on limestone soil; several ascomata, shallowly buried in the soil, 2017-08-15, leg. MF and RR, det. PC and RR (KRA 2017-30).

Notes. Very rarely recorded fungus, until 2006 considered extinct (Wojewoda & Ławrynowicz, 2006). Few sites concentrated in the south Polish highlands belt (Ławrynowicz et al., 2008).

Description of Examined Specimens. Ascomata irregularly globose, often with hollow base or slightly deformed, with diameter 2–10 cm, recessed in the subsurface layer of soil. The outer surface of ascomata is covered with conical, black, polygonal, furrowed warts 3–5 mm in diameter. Gleba brownish with a white-veined labyrinth. Mature ascomata have intense odor. Spores elliptic, surrounded by openwork regular reticulum are usually gathered in ascus (two–six spores).

3.1.12. *Tuber brumale* Vittad. [*] (Figure 2H, Figure 4E)

Localities and Habitat. Cieszyn, DF90, hornbeam-oak forest with *Carpinus betulus*, *Crataegus* sp., and *Acer campestre* with poorly developed undergrowth, on limestone soil. Over a dozen ascomata in the subsurface layer of soil, 2016-12-18, leg. MF and RR, det. PC and RR (KRA 2016-90).

Notes. Not reported from Poland yet. *Tuber brumale* is a fairly common in the Europe (Montecchi & Sarasini, 2000). The red-brown color in the grooves between the verrucae distinguishes *T. brumale* from the other black *Tuber* found in Poland.

Description of Examined Specimens. Ascomata irregularly oval, 1–2 cm in diameter. Surface black, covered with four–six angled, distinct warts, between which reddish colored fragments of the peridium were visible. Gleba light to dark brown, depending on the maturity of ascomata with white veins. Odor fruity, intense at maturity. Spores ellipsoid, 23.3–34 × 15.3–23.3 μm, Q = 1.5 on average, covered with long-spiny ornamentation, 2–5 μm long (up to 6 μm long in the case of spores formed singly in ascus).

3.1.13. *Tuber foetidum* Vittad. [*] (Figure 2J,K, Figure 4F)

Localities and Habitat. Cieszyn, DF90, single ascocarp found in the underground, in hornbeam-oak forest with *Carpinus betulus*, *Tilia cordata*, and *Fagus sylvatica* with poorly developed underground, 2017-08-15, leg. & det. RR (KRA 2017-29).

Notes. Species of so-called white truffle, relatively rare reported from Europe (Montecchi & Sarasini, 2000), not previously reported from Poland, but observed in the Stołowe Mountains National Park (PC – mat. unpb.). This species among the other truffles from the *Tuber puberulum* group distinguished by the morphology of peridium surface – brown plates on a yellowish background, and by pseudoparenchymatus peridium structure consisting of round cells (Montecchi & Sarasini, 2000; Orczán et al., 2010). There is a light gleba in young ascomata, which becomes darker as it matures, becoming russet-brown with white veins. Fungus gives off an unpleasant odor, these traits also distinguish *T. foetidum* from another similar *Tuber*.

Description of Examined Specimens. The ascomata 1.5 cm in diameter with deformed, irregular surface and red-brown color of thin cover. Spores yellow-brown, ellipsoid, 24.7–36.7 × 15.3–26.7 μm, Q = 1.5 on average, with reticulum 4–5 mm high.

3.1.14. *Tuber fulgens* Quél. [GREJ] (Figure 3B)

Localities and Habitat. 1. Cieszyn, “Kopce” nat. res., under the canopy of *Crataegus* sp., *Carpinus betulus* and *Fagus sylvatica*, over a dozen ascomata, 2015-12-18, obs. MF and RR, det. PC and RR. 2. Cieszyn, east from the Motokrosowa Street, DF90, in fertile oak-hornbeam forest on limestone soil, in the immediate proximity of *Carpinus betulus*, several ascomata, 2017-03-25, leg. MF, det. PC (KRA 2017-40).

Notes. Species rare in Poland, reported for the first time in 2007 in the “Zielona Góra” nat. res. near Częstochowa (Ławrynowicz, 2009), next observed in several localities in Świętokrzyskie Voivodeship (Kujawa & Gierczyk, 2011), the Cieszyn Foothills (Rutkowski et al., 2014), and Przemyśl Foothills (Gierczyk et al., 2018).

Description of Examined Specimens. Ascomata 1–3 cm in diameter, characteristic with intensive, orange color of wart peridium. Mature gleba takes on the cocoa color. Asci 120–130 × 90–100 mm, containing one–four spores. Spores spherical or slightly ellipsoidal, 34–50 × 30–40 mm, with reticulum of wide alveolae with relatively high walls.

3.2. Basidiomycota

3.2.1. *Amanita echinocephala* (Vittad.) Quél. [GREJ] (Figure 2I)

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, gap in the forest on limestone soil, under the canopy of *Tilia* sp., *Carpinus betulus*, and *Fagus sylvatica*, four basidiomata, 2017-09-06, obs. & det. MF, PM, and RR.

Notes. *Amanita* species very rare in Poland, associated with warm deciduous forests with beech and oak, formed on limestone base rock. For the first time *Amanita echinocephala* was reported from Poland in 2008 (Świętokrzyskie Mountains and Kaczawskie Mountains) (Kasprowska & Ciborowski, 2010).

Description of Examined Specimens. Basidiomata with pyramidal patches, densely arranged on the surface of gray-white pileus. White stipe, clearly thicker at the bottom, with the durable ring. Smell unpleasant, like a phenol. Spores ellipsoid, 9–12 × 6.5–8 μm. Description similar to other collections (Hagara, 2014).

3.2.2. *Arrhenia retiruga* (Bull.) Redhead [RLP-E, GREJ] (Figure 3E)

Localities and Habitat. Cieszyn, landslide area near Błogocka Street, on the periphery of “Lasek Miejski nad Puńcówką” nat. res., DG00, on *Ceratodon purpureus* moss, cocreating initial habitats on surfaces exposed due to the mass movements, ca. 30 basidiomata, 2017-12-23, leg. MF, det. PC and MF (PCh 1/23122017).

3.2.3. *Arrhenia spathulata* (Fr.) Redhead [RLP-E, GREJ]

Localities and Habitat. Cieszyn, Bielowiec forest, DG00, within plagiotropic moss – *Brachytecium salebrosum*, which flat turf growing on rotten stumps, over a dozen basidiomata, 2016-09-25, leg. AD, det. PC (PCh 1/25092016).

3.2.4. *Auricularia mesenterica* (Dicks.) Pers. [RLP-R, RLK-R, GREJ]

Localities and Habitat. Cieszyn, “Lasek Miejski nad Puńcówką” nat. res., DG00, on a cut stump of *Ulmus* sp., aggregation of many, overgrown basidiomata, 2017-04-21, leg. AD and MF, det. PC.

3.2.5. *Calvatia gigantea* (Batsch) Lloyd [RLK-R, GREJ]

Localities and Habitat. 1. Cieszyn, in the garden of kindergarten near Bolesław Chrobry Street, DG00, under the canopy of *Picea abies*, two basidiomata, 2016-09-28, obs. & det. MF. 2. Cieszyn, Bielowiec forest, DG00, two basidiomata in oak-hornbeam forest, 2018-09-23, obs. & det. AD and MF.

Notes. Species moderately widespread in Poland, but relatively rare reported in the Carpathians. Found once in Cieszyn (Kujawa & Gierczyk, 2011), but not confirmed during the mycological research carried out in this area in 2013–2015 (Chachuła et al., 2015).

3.2.6. *Entoloma saundersii* (Fr.) Sacc. [GREJ] (Figure 4J)

Localities and Habitat. Cieszyn, near Kościelna Street, DF90, within sunshine roadside slope, in the thicket of *Crataegus* sp., *Rosa canina*, and *Corylus avellana*, three basidiomata, 2016-05-08, *leg.* MF, *det.* PC (KRA 2016-91).

Notes. Spring fungus, reported from Świętokrzyskie Mts and from the Kurnik Arboretum (Łuszczynski, 2007; Rudawska & Leski, 2013).

3.2.7. *Grifola frondosa* (Dicks.) Gray [S-PP, RLP-V, RLK-E, GREJ]

Localities and Habitat. **1.** Cieszyn, oak-hornbeam forest near Dzika Street, DF90, one basidioma on rotting hornbeam stump, 2018-09-16, *obs.* MF, *det.* PC. **2.** Cieszyn, Bielowiec forest, DG00, two basidiomata under an oak tree, 2018-09-16, *obs.* AD, *det.* PC and RR. **3.** Cieszyn, Szczypie forest, DF90, one basidioma under an oak tree, 2018-09-18, *obs.* MF, *det.* PC.

Notes. Basidiocarps of *G. frondosa* grow at the base or close to the live or dead deciduous trees of *Quercus*, *Fagus*, and *Carpinus*. Basidiomata do not appear every year – despite the search the species was not observed in the Cieszyn area in the 2013–2017 seasons.

3.2.8. *Gymnopilus junonius* (Fr.) P. D. Orton [GREJ]

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, group of over a dozen basidiomata at the base of dead, breaking up stump of *Fagus sylvatica*, 2017-10-02, *leg.* MF, *det.* PC (KRA 2017-36).

3.2.9. *Gyroporus castaneus* (Bull.) Quél. [RLP-R, GREJ]

Localities and Habitat. Cieszyn, oak-hornbeam forest near Dzika Street, DF90, several basidiomata on the soil formed from the stream deposits, 2018-09-16, *leg.* MF, *det.* PC (KRA 2018-8).

3.2.10. *Hebeloma radicosum* (Bull.) Ricken [RLP-I, RLK-R, GREJ] (Figure 3A)

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, *Fagus sylvatica* with *Tilia* sp. old forest, several basidiomata, 2017-10-07, *leg.* & *det.* PC and RR (KRA 2017-38, 2017-39).

Notes. Species not often observed in the country. Of the other *Hebeloma*, it is distinguished by a elongated root-like stipe base, occurrence of ring on stipe and a very strong odor, resembling marzipan or bitter almonds (rarely described like a smell of fennel or prussic acid) (Halama et al., 2017). Documented are a few cases of the correlation between the presence of the fungus with the presence of underground nests of mice, moles, voles, or badgers (Sagara et al., 2006, 2008).

3.2.11. *Hygrophorus discoxanthus* (Fr.) Rea [GREJ] (Figure 3C)

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, in beech forest, several basidiomata, 2017-10-07, *obs.* & *det.* PC and RR.

Notes. The species was recorded so far only in the Tatra National Park, Bieszczady Mts, and Przemyśl Foothills (Gierczyk et al., 2018, 2019; Ronikier, 2012).

3.2.12. *Mycena renati* Quél. [RLP-V, GREJ]

Localities and Habitat. **1.** Cieszyn, “Lasek Miejski w Błogocicach” nature and landscape complex, DG00, on fallen trunks and boughs of *Fagus sylvatica* and *Fraxinus excelsior*, 2016-05-20, *obs.* & *det.* MF and RR. **2.** Cieszyn, “Lasek Miejski nad Olzą” nat. res., DG00, on fallen trunks and boughs of *Fagus sylvatica*, 2017-04-21, *obs.* & *det.* MF and RR. **3.** Cieszyn, “Lasek Miejski nad Puńcówką” nat. res., DG00, on a surface of fallen trunk of *Ulmus* sp., several groups of basidiomata, 2017-04-22, *obs.* & *det.* MF.

3.2.13. *Octaviania lutea* R. Hesse (Figure 2F, Figure 4I)

Localities and Habitat. Cieszyn, “Lasek Miejski w Błogocicach” nature and landscape complex, DG00, several basidiomata in the ground near *Quercus robur* and *Carpinus betulus*, 2017-08-22, *leg.* MF and PC, *det.* PC and PM (KRA 2017-32).

Notes. Species previously reported from Poland only from Bieszczady Mts (Gierczyk et al., 2019), although in view of taxonomic revision published in 2016 (Paz et al., 2016), it is justified to verify specimens collected in the country, identified as *Octaviania asterosperma* Vittad, because in Poland occur only *O. mutabilis* and *O. lutea*. The basic differences between the two species concern on color of peridium: *O. lutea* – peridium usually thick, colored grayish white or yellowish, with faint spots bluish or greenish that, with manipulation, hardly redden. Finally it is yellow ochraceous covered with blackish-gray fibrils. Peridium meat that does not redden to the cut; *O. mutabilis* – peridium generally thin, initially pure white with light bluish or greenish spots, which oxidizes quickly with vinous red manipulation and, more slowly, to blackish-gray. Peridium meat from pink color to the cut (Paz et al., 2016).

3.2.14. *Pluteus diettrichii* Bres. [GREJ]

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, on dead wood of rotten stump of *Fagus sylvatica*, one basidioma, 2015-10-02, leg. RR and PM, det. PM.

Notes. Species observed in Poland only in the Kampinos National Park and Przemysł Foothills (Gierczyk et al., 2018; Karasiński et al., 2015).

3.2.15. *Pluteus ephebeus* (Fr.) Gillet [RLP-R, GREJ]

Localities and Habitat. Cieszyn, Wierzbina forest, DF90, at the base of a *Populus* sp. trunk, two basidiomata, 2014-06-07, leg. MF and PM, det. MP.

Notes. The species in Poland observed on several localities (Kujawa, 2018; Wojewoda, 2003).

3.2.16. *Russula cerea* (Soehner) J. M. Vidal [*] (Figure 2L, Figure 4H)

Localities and Habitat. Cieszyn, “Kopce” nat. res., DF90, several basidiomata, *Fagus sylvatica* old forest, 2017-08-15, leg. & det. RR (KRA 2017-28).

Notes. Species not mentioned in mycological literature from Poland (Kujawa, 2018; Wojewoda, 2003). Widely distributed in temperate and submediterranean regions of Europe, mycorrhizal species with *Abies*, *Picea*, *Pinus*, *Castanea*, *Corylus*, *Fagus*, and *Quercus* (Vidal et al., 2019).

Description of Examined Specimens. Basidiomata irregularly spherical, up to 1.8 cm in diameter, initially white, browning as they mature. Hymenophore loculate, with white-cream color, brown in mature basidiomata. Spores subglobose, yellowish at light microscope, 9.3–11.3 µm in diameter, ornamentation of slender, conical, and cylindrical amyloid spines of length 1.3–2.3 µm.

3.2.17. *Sparassis brevipes* Krombh. [S-PP, RLP-V, GREJ]

Localities and Habitat. Cieszyn, near Pikiety Street, DF90, in forested stream buffer, at the base of the living, *Quercus robur*, single basidioma, 2017-08-22, obs. & det. MF i PC.

Notes. Species closely related with a similar species of the genus – *S. spathulata*. In a narrow view only individuals growing in Europe are included to the species (Petersen et al., 2015; Wang et al., 2004).

3.2.18. *Stropharia pseudocyanea* (Desm.) Fr. [RLP-R, GREJ]

Localities and Habitat. Cieszyn, near Rolna Street, DF90, on the edge of the pasture, 2017-10-28, obs. & det. RR.

4. Discussion

Continued research on the mycobiota of the Cieszyn has contributed significantly to enhancement of knowledge and information about the regional mycological biodiversity, including rare or previously unreported taxa in the country. The discovery of 37 more fungal species in the Cieszyn area has increased the total number of mycobiota species studied area to 454 taxa (Chachuła et al., 2015).

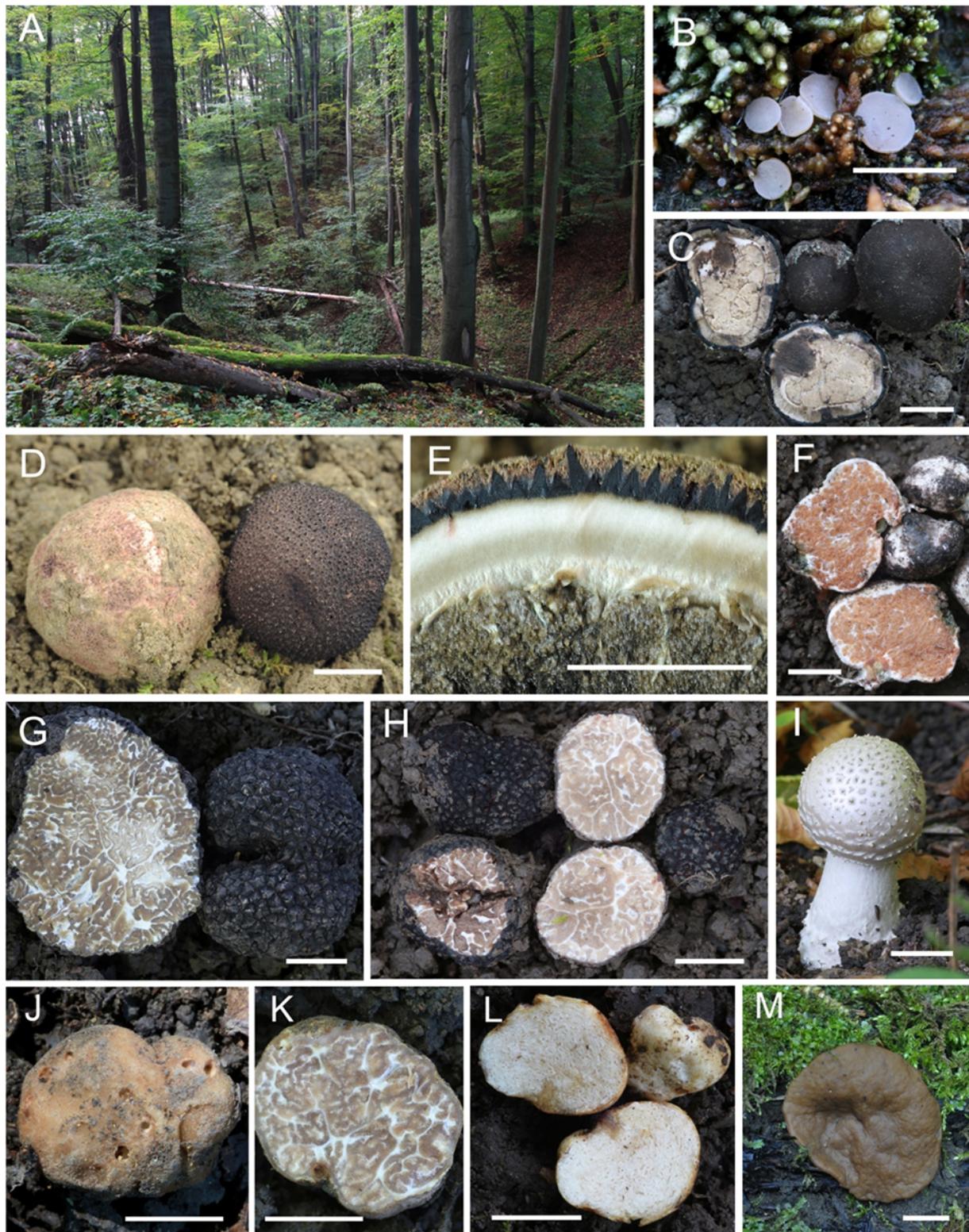


Figure 2 Selected fungi species found in the Cieszyn area. (A) Characteristic type of forest community for the Silesian Foothills – calcareous beech forest in the “Kopce” nature reserve. (B) Group of *Bryoscyphus dicrani* ascomata on *Bryum argenteum* sporophytes. (C) Ascomata of *Elaphomyces maculatus* from the outside and in section. (D) Ascomata of *E. aculeatus* – with pink crust on the left side, without crust with black and pink peridium on the right side. (E) *Elaphomyces aculeatus*, cross section through the ascoma, with black acute warts within the peridium. (F) Basidiomata of *Octaviania lutea* in section. (G) Ascomata of *Tuber aestivum* from the outside and in section. (H) Ascomata of *T. brumale* from the outside and in section. (I) Young basidioma of *Amanita echinocephala*. (J,K) *Tuber foetidum*, surface (J) and cross section of the basidioma (K). (L) Basidiomata of *Russula cerea* from the outside and in section. (M) Ascoma of *Discina martinii*. Scale bars: (B–M) 10 mm. Photographs by M. Fiedor (A–C, F–L) and R. Rutkowski (D, E, M).



Figure 3 Selected species of rare fungi observed in 2016–2017 in Cieszyn. (A) Mature basidiomata of *Hebeloma radicosum*. (B) Ascomata of *Tuber fulgens* from the outside and in section. (C) Basidiomata of *Hygrophorus discoxanthus*. (D) Ascomata of *Catinella olivacea*. (E) Basidiomata of *Arrhenia retiruga*. (F,G) Stromata of *Ophiocordyceps entomorrhiza* growing from mummified body of *Carabus violaceus*. Scale bars: 10 mm. Photographs by M. Fiedor (B,D–G) and R. Rutkowski (A,C).

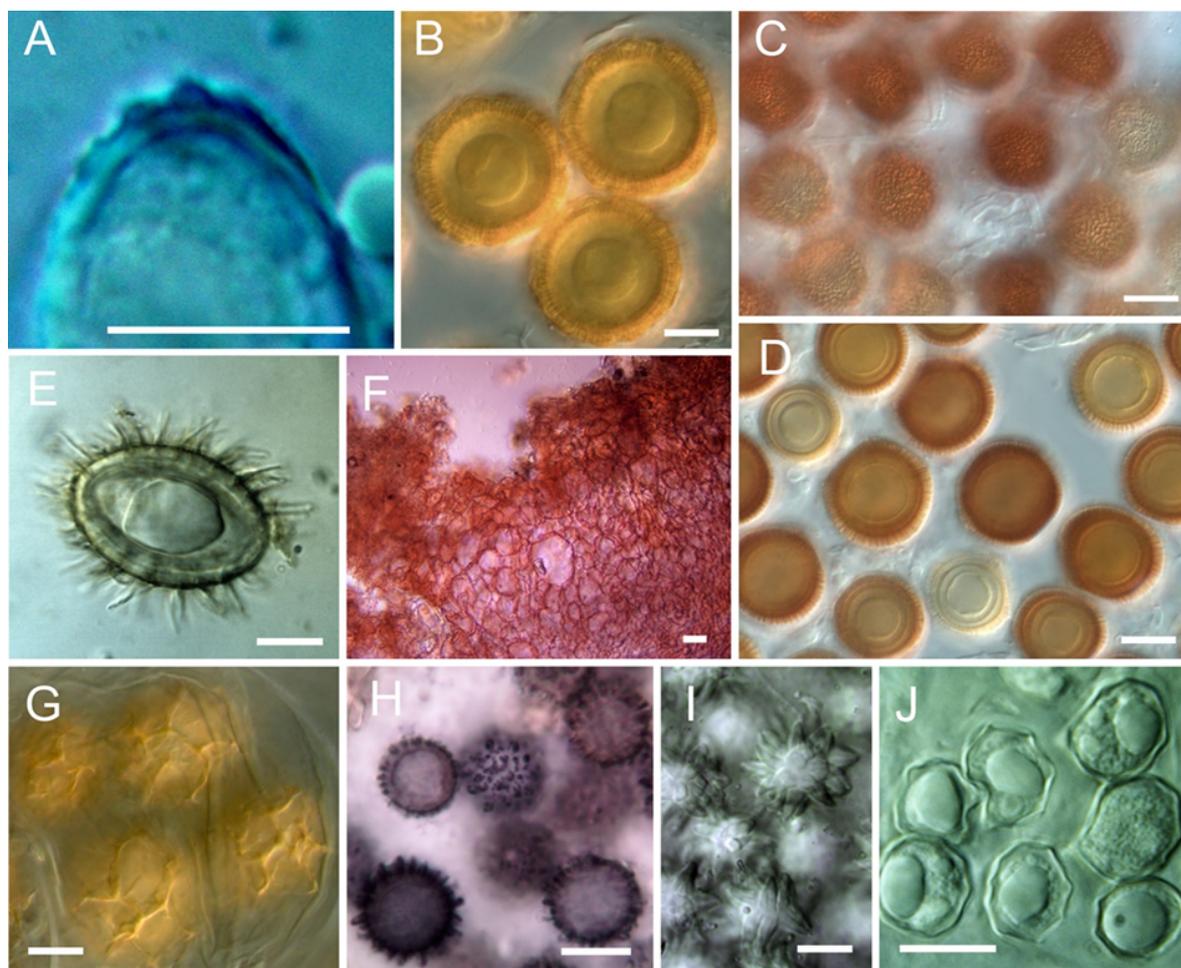


Figure 4 Micromorphological features of selected rare fungi species observed in Cieszyn. (A) Spore of *Discina martinii*. (B) Spores of *Elaphomyces maculatus*. (C,D) Spores of *E. aculeatus* with grainy surface from light microscope: Surface view (C) and optical section (D). (E) Spore of *Tuber brumale*, covered with dense spines. (F) Peridium of *T. foetidum* ascoma with pseudoparenchymatous structure (stained with Congo red). (G) Spores of *T. aestivum* covered with irregular reticulum. (H) Spores of *Russula cerea* with spiny, amyloid ornamentation. (I) Spores of *Octaviania lutea* with ornamentation in form of pyramidal-conic warts. (J) Polygonal spores of *Entoloma saundersii*. (A,I,J) Preparations in KOH; (B–E,G,H) stained in Melzer's reagent. Scale bars: 0 μm . Photographs by P. Chachula.

Among them, 99 species belong to the phylum Ascomycota, 350 to Basidiomycota, and five to Mucoromycota.

The number of valuable species in the supraregional categories (protected, rare, and endangered) increased to 127 taxa. Among them are 13 species of fungi whose first national reports come from Cieszyn. Finding additional four protected fungal species has increased the total number of legally protected taxa to 10 (one with strict protection and nine with partial) (Regulation of the Minister of Environment, 2014). As a result of the comprehensive research of mycobiota of Cieszyn, the number of macrofungi taxa that figure in the red list of macrofungi in Poland (Wojewoda & Ławrynowicz, 2006) that were observed in the township increased by 14 taxa and currently includes 82 such fungal species in Cieszyn (Ex – 1, E – 13, V – 21, R – 44, I – 3).

Another interesting aspect of the study that merits discussion is the relatively large number of hypogeous fungi that were found despite the small size of the forest area and the fact they were found accidentally – 15 hypogeous fungi were found within the administrative limits of Cieszyn, including four reported for the first time in Poland: *Elaphomyces aculeatus*, *Tuber brumale*, *T. foetidum*, and *Russula cerea*.

Despite the small size of the total area of the township analyzed (ca. 2,861 ha) and the relatively limited area that could be considered good for the development of mycobiota (nonurbanized) there were suitable microclimate, soil, and phytocoenosis

conditions (mild-climate with high precipitation sum and higher average annual temperature, presence of limestone soil covered with deciduous forests) that supported the growth of such interesting and rarely recorded taxa in Europe, including: *Amanita echinocephala*, *Elaphomyces aculeatus*, *E. maculatus*, or *T. brumale*. These discoveries provide a reason of intensification of further mycological research in the remaining areas of the Cieszyn Foothills, which are abundant in various age-old complexes of beech, oak-hornbeam, and riparian forest growing in limestone soil. No such comprehensive mycological research has been conducted in the Cieszyn Foothills area, although several causative character publications have appeared in the recent times (Beczala, 2016; Chachula et al., 2015, 2018; Krotoski, 2009; Rutkowski et al., 2014). Previous observations and reports clearly indicate that the Cieszyn Foothills are one of the national centers of mycological biodiversity.

Also worth mentioning is the fact that majority of the rare and protected macrofungal species found in the Cieszyn township were found in different types of nature protection areas including “Lasek Miejski w Błogocicach” nature and landscape complex, “Cieszyńskie Pogórze” protected landscape area, “Kopce,” “Lasek Miejski nad Olza,” and “Lasek Miejski nad Puńcówką” natural reserve. The occurrence of the protected fungal species increases the natural value of the nature protection areas, and also indicates a properly functioning system of nature protection in the Cieszyn township.

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