

Article ID: 5514
DOI: 10.5586/am.5514

Publication History
Received: 2019-07-16
Accepted: 2019-11-14
Published: 2020-06-05

Handling Editor
Andrzej Szczepkowski; Warsaw
University of Life Sciences –
SGGW, Poland;
<https://orcid.org/0000-0002-9778-9567>

Authors' Contributions
Both authors participated in the field research and contributed to the manuscript preparation.

Funding
The study was privately funded.

Competing Interests
No competing interests have been declared.

Copyright Notice
© The Author(s) 2020. This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits redistribution, commercial and noncommercial, provided that the article is properly cited.

ORIGINAL RESEARCH PAPER in MYCOLOGY

Fungi of the Wolin National Park – New Data on Macromycetes

Małgorzata Stasińska ^{*}, Zofia Sotek

Institute of Marine and Environmental Sciences, University of Szczecin, Adama Mickiewicza 16, Szczecin, 70-383, Poland

^{*}To whom correspondence should be addressed. Email: stasinsk@univ.szczecin.pl

Abstract

The paper contains results of mycological examinations conducted in the Wolin National Park from May to October 2017, and data previously unpublished. Exploration was carried out using the route method in the whole Park, with particular emphasis on its western part. The paper includes 205 taxa (25 from Ascomycota and 180 from Basidiomycota), including 32 new ones for the Wolin National Park. Among the identified taxa, 17 were threatened. The endangered species (Category E) were represented by *Aleurodiscus disciformis*, *Calcipostia guttulata*, and *Geastrum triplex*, the vulnerable species (V) included *Inocybe grammata*, *Inocutis rheades*, and *Xylobolus frustulatus*, and the rare species (R) consisted of 10 taxa, including *Helvella lacunosa*, *Gloeoporus taxicola*, *Mycena crocata*, *Plicaturopsis crispa*, and *Pseudomerulius aureus*. Some species are known only from a few sites in Poland, e.g., *Hohenbuehelia auriscalpium* and *C. guttulata*. Currently, the number of macromycetes species known from the Wolin National Park is 508.

Keywords

mycobiota; macrofungi; rare and threatened fungi; protected area; Poland

1. Introduction

Large protected areas, such as national parks, have become particular points of interest in the mycological explorations conducted in Poland in recent years. They are characterized by a great richness of mycobiota (Gierczyk et al., 2009; Halama & Romański, 2010; Karasiński et al., 2015; Kujawa et al., 2012, 2015; Ławrynowicz, 2012; Ruszkiewicz-Michalska et al., 2015; Wojewoda et al., 2016). The specificity in the appearance of fruiting bodies means that subsequent years of research will still provide new data on macromycetes of the studied area (e.g., Gierczyk et al., 2017; Gierczyk, Szczepkowski, et al., 2019a, 2019b; Grzesiak et al., 2017). This is also reflected in the case of the Wolin National Park (WNP). The first mention of macromycetes of the current area of the WNP dates back to the 1930s (Stier, 1939; Ulbrich, 1932). They consisted of several macrofungi species. A comprehensive study on macromycetes of the WNP was conducted by Lisiewska (1966), presenting the share of macroscopic fungi in plant communities – dunes (*Elymo-Ammophiletum* and *Helichryso-Jasionetum*), coastal pine forest (*Empetro nigri-Pinetum*), and mixed forests (*Quercu roboris-Pinetum*), as well as beech forests (*Galio odorati-Fagetum* and *Fago-Quercetum petraeae*). At that time, a total of 283 species and 11 varieties and forms of macrofungi were found. It was only after 50 years that another study was published on the biota of macrofungi occurring in the forest communities of the Park (Stasińska & Sotek, 2016). The study mainly covered the areas of strict protection, within which well-developed patches of *Cephalanthero rubrae-Fagetum*, *Galio odorati-Fagetum*, *Luzulo pilosae-Fagetum*, and *Fago-Quercetum petraeae* complexes have been preserved. It constitutes a significant contribution to the knowledge on mycobiota of the WNP, since the study caused the number of fungi taxa recorded in this area to increase to 476. However, they did

not fully exhaust the existing richness of mycobiota in this area. This is evidenced by continued research, which has resulted in the discovery of many species that were not previously recorded. This study is treated as the second part of the article “New data to the knowledge of macrofungi of Wolin National Park,” and presents new data supplementing the knowledge on the diversity of macrofungi in the Park.

2. Material and Methods

The location and physiographic and floristic characteristics of the WNP were presented in the article by Stasińska and Sotek (2016), which is the first part of the research on macromycetes in this area. Currently, the list of macrofungi species contains data from field studies conducted from May to October 2017 and earlier data that were not included in the first article. The list includes only new, unpublished locations of fungi species. The study was conducted using the route method in the whole Park, with particular emphasis on its western part.

Due to the significant mutual similarity of *Russula sardonica* and *R. xerampelina* basidiomes and the high variability of their morphological structure, molecular methods were used to identify these species. DNA was extracted using the GeneMATRIX Plant & Fungi DNA Purification Kit (EURx, Poland). Each sample consisted of a dry fragment of basidiocarp. DNA samples were analyzed based on PCR amplification (with primers ITS-1F and ITS-4 and a Type-it Microsatellite PCR Kit; Qiagen, Germany) and sequencing of the internal transcribed spacer (ITS) of nuclear ribosomal DNA (rDNA) (Gardes & Bruns, 1993; White et al., 1990). Amplification was confirmed using gel electrophoresis. The PCR products obtained were sequenced using an ABI Prism 3130XL Analyzer (Applied Biosystems, USA) sequencer with ITS-1F/ITS-4 primers, in the Laboratory of Molecular Biology at the Adam Mickiewicz University in Poznań (Poland). The consensus sequence was created and unclear readings were corrected manually using BioEdit 7.2. The sequences were compared to the GenBank and UNITE databases using BLAST search (Altschul et al., 1990).

The specimens were identified by examining macroscopic and microscopic features, using standard methods of studying macrofungi, and monographs by Aronsen and Læssøe (2016), Bernicchia and Gorjón (2010), Breitenbach and Kränzlin (1984, 1986, 1991, 1995, 2000), Knudsen and Vesterholt (2012), Kränzlin (2005), Romagnesi (1996), and Stangl (1989). The fungal nomenclature and the synonyms were given according to the Index Fungorum database (<http://www.indexfungorum.org/>). The names of vascular plants in the present paper follows the description by Mirek et al. (2002), and the names of the plant communities follows the description by Matuszkiewicz (2006). The identified specimens were deposited in the Herbarium of the University of Szczecin (SZUB-F), Poland.

3. Results

On the basis of mycological exploration conducted in 2017 and taking into account previously unpublished data, 205 species of macrofungi were found in total, including 25 from Ascomycota and 180 from Basidiomycota. Among them, 32 were species new to the WNP, while 17 were classified as threatened taxa (Wojewoda & Ławrynowicz, 2006). The endangered species (Category E) were represented by *Aleurodiscus disciformis*, *Calcipostia guttulata*, and *Geastrum triplex*, the vulnerable species (V) by *Cortinarius* cf. *cyanites*, *Inocybe grammata*, *Inocutis rheades*, and *Xylobolus frustulatus*, and the rare species (R) by 10 taxa, including *Helvella lacunosa*, *Meruliopsis taxicola*, *Mycena crocata*, *Plicaturopsis crispa*, and *Pseudomerulius aureus*.

More than half of the macromycetes included in this study were recorded outside well-developed patches of plant communities, while 89 species were found in *Luzulo pilosae-Fagetum*, and only one species in *Galio odorati-Fagetum* and *Fago-Quercetum petraeae*. Taking into account the substrate on which the fungi grew, the group of saprotrophic wood decay fungi was the most abundant, as it was represented by 95 species. Among this group, macrofungi on deciduous trees dominated, i.e.,

27 species were recorded on *Fagus* and 18 on *Quercus*. The share of macrofungi growing on coniferous wood was also noticeable, i.e., 22 species were found on *Pinus*. Thirty-two species of fungi were found on wood, whose taxonomic affiliations were difficult to determine. Terrestrial and litter saprotrophic fungi were not numerous groups, 25 and 19 species, respectively. On the other hand, mycorrhizal fungi were numerous – 58 taxa, which constituted almost 1/3 of the species included in this study. Parasitic fungi were represented by nine species.

Among the recorded species, the following were found most frequently: *Amanita fulva* (10 localities), *Diatrype stigma* (10 localities), *Calocera viscosa* (nine localities), *Gymnopus dryophilus* (nine localities), *Lactarius camphoratus* and *L. fluens* (eight localities each). Macromycetes were present in one locality only, i.e., 83 taxa, and constituted 40% of the species found. This group included both rare in Poland species, such as *Hohenbuehelia auriscalpium*, *H. grisea*, and *Laxitextum bicolor*, as well as more common ones, such as *Clavulina rugosa*, *Mycena inclinata*, *M. pura*, *Peziza vesiculosa*, and *Russula ochroleuca*.

The following abbreviations are used in the list of species: BDSP – strict protection area of Dr B. Dyakowski; SJSP – strict protection area of Doc. S. Jarosz. Plant community: FQ – *Fago-Quercetum petraeae*; GF – *Galio odorati-Fagetum*; LF – *Luzulo pilosae-Fagetum*. Category of threat (according to Wojewoda & Ławrynowicz, 2006): E – endangered; V – vulnerable; R – rare; * – species new for WNP; # – species confirmed using the DNA barcoding technique; div. – forest division number; May, August 2017 – observation date.

3.1. List of Species: Ascomycota

Ascocoryne sarcooides (Jacq.) J. W. Groves & D. E. Wilson – on wood; div. 16; October 2017.

Bertia moriformis (Tode) De Not. – on twigs; LF; div. 17, 18, 88, 107, 116; May–October 2017.

Bisporella citrina (Batsch) Korf & S. E. Carp. – on branches; LF; div. 88, 118; October 2017.

Colpoma quercinum (Pers.) Wallr. – on twigs of *Quercus*; LF; div. 118; May 2017.

Dialonectria episphaeria (Tode) Cooke [= *Nectria episphaeria* (Tode) Fr.] – on *Diatrype stigma*; LF; div. 68, 88, 107, 116; May–October 2017.

Diatrype disciformis (Hoffm.) Fr. – on branches of *Fagus*; LF; div. 17, 107, 118; May–October 2017.

D. stigma (Hoffm.) Fr. – on twigs of *Fagus* and *Quercus*; LF; div. 16, 18, 67, 88, 89, 107, 116–119; May–October 2017.

Diatrypella favacea (Fr.) Ces. & De Not. [= *D. verruciformis* (Ehrh.) Nitschke] – on branches of *Betula*; LF; div. 16, 46, 106; May–October 2017.

D. quercina (Pers.) Cooke – on branches of *Quercus*; LF; div. 106, 117, 118; May–October 2017.

Helvella crispa (Scop.) Fr. – on ground; LF; div. 16, 88; August–September 2017.

H. lacunosa Afzel. – on ground; LF; div. 16; September 2017; R.

H. macropus (Pers.) P. Karst. [= *Macropodia macropus* (Pers.) Fuckel] – on ground; div. 88c; August 2017.

Humaria hemisphaerica (F. H. Wigg.) Fuckel – on ground; div. 88; July 2017.

Hypoxylon fragiforme (Pers.) J. Kickx f. – on branches and logs of *Fagus*; LF; div. 17, 18, 107, 119; May–October 2017.

Jackrogersella multiformis (Fr.) L. Wendt, Kuhnert & M. Stadler [= *Hypoxylon multiforme* (Fr.) Fr.] – on branch of *Betula*; div. 68; September 2017.

Kretzschmaria deusta (Hoffm.) P. M. D. Martin [= *Ustulina deusta* (Hoffm.) Maire] – on stumps of *Fagus*; LF; div. 16, 46, 88; May–October 2017.

Lachnum virgineum (Batsch) P. Karst. [= *Dasyscyphus virgineus* (Batsch) Gray] – on litter; LF; div. 68, 88, 89, 117; June 2017.

Mollisia cinerea (Batsch) P. Karst. – on wood; LF; div. 17, 68, 88, 89, 106, 118; June, October 2017.

Nectria cinnabarina (Tode) Fr. – on twigs; div. 17, 88; October 2017.

Peziza micropus Pers. – on log of *Fagus*; div. 16; October 2017.

P. vesiculosa Bull. – on ground; div. 46; September 2017.

Rhizina undulata Fr. – on burnt ground; Międzyzdroje (Nadbrzeżna Street, near div. 68); August 2017.

Xylaria carpophila (Pers.) Fr. – on cupules of *Fagus*; LF; div. 17, 18, 67, 89, 107; May–October 2017.

X. hypoxylon (L.) Grev. – on wood; LF; div. 16, 89, 117; June–October 2017.

X. longipes Nitschke – on wood; LF; div. 88g; August 2017.

3.2. Basidiomycota

**Agaricus campestris* L. – on ground; div. 88; July 2017.

**A. xanthodermus* Genev. – on ground; div. 46, 67; July–August 2017.

**Aleurodiscus disciformis* (DC.) Pat. [= *Aleurocystidiellum disciforme* (DC.) Boidin, Terra & Lanq.] (Figure 1) – on bark of trunk of living *Quercus*; div. 88c; June 2017; E.



Figure 1 Basidiomata of *Aleurodiscus disciformis* from the Wolin National Park (June 13, 2017). Photography by MS.

Amanita citrina Pers. – on ground; LF; div. 16, 18, 116; August–October 2017.

A. fulva Fr. – on ground; LF; div. 18, 46, 67, 68, 88, 106, 116–119; July–October 2017.

A. gemmata (Fr.) Bertill. – on ground; div. 116; September 2017.

A. pantherina (DC.) Krombh. – on ground; div. 67, 88, 117; July–August 2017.

A. phalloides (Vaill. ex Fr.) Link – on ground; div. 117; August 2017.

A. rubescens Pers. – on ground; LF; div. 17, 46, 68, 88, 89, 118; June–October 2017.

Ampulloclitocybe clavipes (Pers.) Redhead, Lutzoni, Moncalvo & Vilgalys [= *Clitocybe clavipes* (Pers.) P. Kumm.] – on ground; div. 116, 117; October 2017.

- Apioperdon pyriforme* (Schaeff.) Vizzini [= *Lycoperdon pyriforme* Schaeff.] – on stump; div. 67; August–September 2017.
- Armillaria ostoyae* (Romagn.) Herink – on wood; div. 16–18; October 2017.
- Atheliachaete sanguinea* (Fr.) Spirin & Zmitr. [= *Phanerochaete sanguinea* (Fr.) Pouzar] – on twigs; div. 118; October 2017.
- Auricularia auricula-judae* (Bull.) Quél. – on trunks of *Fagus*; div. 17, 88; June, October 2017.
- Auriscalpium vulgare* Gray – on cone of *Pinus*; LF; div. 16, 68, 88, 106, 119; June–October 2017.
- Baeospora myosura* (Fr.) Singer – on cone of *Picea*; div. 117b; October 2017.
- Bjerkandera adusta* (Willd.) P. Karst. – on wood of *Quercus*; div. 17; October 2017.
- **Boletus reticulatus* Schaeff. – on ground; div. 46, 67, 68, 88; July–August 2017.
- B. subtomentosus* L. [= *Xerocomus subtomentosus* (L.) Quél.] – on ground; div. 18, 88; July–October 2017.
- **Bovistella utrififormis* (Bull.) Demoulin & Rebriv [= *Calvatia utrififormis* (Bull.) Jaap] – on ground; div. 67, 117; August 2017.
- Calcipostia guttulata* (Sacc.) B. K. Cui, L. L. Shen & Y. C. Dai [= *Postia guttulata* (Sacc.) Jülich] – on logs of *Pseudotsuga*; div. 68; August 2017; E.
- Calocera cornea* (Batsch) Fr. – on wood of deciduous trees; LF; div. 16, 116; July–October 2017.
- C. viscosa* (Pers.) Fr. – on stumps of *Pinus*; div. 46, 67, 68, 88, 107, 116–119; July–September 2017.
- Cantharellus cibarius* Fr. – on ground; LF; div. 46, 106, 116, 117; July–August 2017.
- Craterellus tubaeformis* (Fr.) Quél. – on ground; div. 88, 106; August 2017.
- Cerioporus mollis* (Sommerf.) Zmitr. & Kovalenko [= *Datronia mollis* (Sommerf.) Donk] – on log and trunk of *Fagus*; div. 107, 117; July 2017.
- C. varius* (Pers.) Zmitr. & Kovalenko [= *Polyporus varius* (Pers.) Fr.] – on branch of *Fagus*; div. 107; September 2017.
- Chlorophyllum rhacodes* (Vittad.) Vellinga [= *Macrolepiota rhacodes* (Vittad.) Singer var. *rhacodes*] – on ground; div. 107; October 2017.
- **Clavulina rugosa* (Bull.) J. Schröt. – on ground; div. 116; October 2017.
- Clitocybe metachroa* (Fr.) P. Kumm. – on litter; div. 2 (SJSP); November 2012.
- C. nebularis* (Batsch) P. Kumm. – on ground; LF; div. 16, 17; October 2017.
- Coniophora arida* (Fr.) P. Karst. – on logs and branches of *Pinus*; div. 46, 68, 116, 117; September–October 2017.
- **C. puteana* (Schumach.) P. Karst. – on stumps of *Pinus*; div. 89, 117; October 2017.
- **Conocybe pulchella* (Velen.) Hauskn. & Svrček [= *C. digitalina* (Velen.) Singer] – on ground; on the forest path between div. 69d, h, and 70d; September 2014; det. B. Gierczyk.
- Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson – on stumps; div. 18, 67, 70, 117; September–October 2017.
- Cortinarius bolaris* (Pers.) Fr. – on ground; LF; div. 88, 106, 117; July–August 2017.
- **C. brunneus* (Pers.) Fr. – on ground, under *Betula* and *Pinus*; div. 25b; November 2012.
- **C. cf. cyanites* Fr. – on ground, under *Fagus*; div. 16; September 2016; V.
- C. flexipes* (Pers.) Fr. – on ground, under *Fagus* and *Pinus*; LF; div. 68; October 2012.
- **C. cf. hemitrichus* (Pers.) Fr. – on ground; under *Fagus*, *Quercus*, and *Pinus*; LF; div. 109a; October 2012.
- **C. hinnuleus* Fr. – on ground; LF, GF; div. 2j (SJSP), 11, 48, 122, 125 (BDSP); October–November 2012.

- C. semisanguineus* (Fr.) Gillet – on ground; div. 88, 117; August 2017.
- **Crepidotus mollis* (Schaeff.) Staude – on log of *Fagus*; LF; div. 67g; July 2017.
- C. variabilis* (Pers.) P. Kumm. – on litter; div. 16; October 2017.
- Cystoderma amianthinum* (Scop.) Fayod – on ground; div. 17; October 2017.
- Dacrymyces stillatus* Nees – on wood; div. 17, 68, 70, 107, 117; May–October 2017.
- Daedalea quercina* (L.) Pers. – on log of *Quercus*; div. 117; July 2017.
- Daedaleopsis confragosa* (Bolton) J. Schröt. – on trunk of *Fagus*; div. 107; May 2017.
- Exidia nigricans* (With.) P. Roberts (= *Exidia plana* Donk) – on wood of deciduous trees; div. 16, 46, 67, 116–119; May–November 2017.
- Fomes fomentarius* (L.) Fr. – on logs and trunks of *Fagus* and *Quercus*; div. 17, 88, 118; May–October 2017.
- Fomitiporia robusta* (P. Karst.) Fiasson & Niemelä [= *Phellinus robustus* (P. Karst.) Bourdot & Galzin] – on trunks of *Quercus*; LF; div. 88, 117; May–September 2017.
- Fomitopsis betulina* (Bull.) B. K. Cui, M. L. Han & Y. C. Dai [= *Piptoporus betulinus* (Bull.) P. Karst.] – on wood of *Betula*; LF; div. 16, 106; May–October 2017.
- F. pinicola* (Sw.) P. Karst. – on logs of *Pinus*; div. 67, 117, 119; May–October 2017.
- Fuscoporia ferruginosa* (Schrad.) Murrill [= *Phellinus ferruginosus* (Schrad.) Pat.] – on branches of *Quercus*; div. 16, 117, 118; July–October 2017.
- Geastrum fimbriatum* Fr. – on ground; LF; div. 88; October 2017; R.
- G. triplex* Jungh. – on ground; LF; div. 16; October 2017; E.
- **Gloeophyllum odoratum* (Wulfen) Imazeki – on stump of *Pinus*; div. 70m (N lakeside of Czajcze Lake); May 2017.
- G. sepiarium* (Wulfen) P. Karst. – on log of *Pinus*; div. 67g; July 2017.
- **Gloeoporus taxicola* (Pers.) Gilb. & Ryvarden [= *Meruliopsis taxicola* (Pers.) Bondartsev] – on branch of *Pinus*; LF; div. 68; October 2012; R.
- Gymnopilus penetrans* (Fr.) Murrill – on wood; div. 88, 116, 117; October 2017.
- Gymnopus androsaceus* (L.) Della Magg. & Trassin. – on litter; div. 18, 67, 88, 106; July–October 2017.
- G. dryophilus* (Bull.) Murrill – on litter; LF; div. 17, 46, 67, 70, 88, 116–119; July–October 2017.
- Hapalopilus rutilans* (Pers.) Murrill [= *H. nidulans* (Fr.) P. Karst.] – on branches of *Quercus*; div. 89; August 2017.
- Heterobasidion annosum* (Fr.) Bref. – on stump of *Pinus*; div. 119; July 2017.
- **Hohenbuehelia auriscalpium* (Maire) Singer – on log of *Fagus*; GF; div. 125 (BDSP); October 2012.
- **H. grisea* (Peck) Singer – on stump; div. 88; August 2017.
- H. serotina* (Pers.) Singer [= *Panellus serotinus* (Pers.) Kühner] – on logs of *Fagus*; LF; div. 16, 46; October 2017.
- Hygrophorus eburneus* (Bull.) Fr. – on ground; LF; div. 16, 17; October 2017.
- Hymenochaete rubiginosa* (Dicks.) Lév. – on stumps of *Quercus*; LF; div. 16, 46, 117, 118; May–October 2017.
- Hymenopellis radicata* (Relhan) R. H. Petersen [= *Xerula radicata* (Relhan) Dörfelt] – on roots of *Fagus*; LF; div. 17, 46; August–October 2017.
- Hyphoderma setigerum* (Fr.) Donk – on wood; LF; div. 16, 88, 117; August, September–October 2017.
- Hypholoma fasciculare* (Huds.) P. Kumm. – on wood; LF; div. 16, 17, 18, 117, 119; July–October 2017.
- Imleria badia* (Fr.) Vizzini – on ground; div. 67, 88; August–September 2017.
- Inocybe geophylla* (Bull.) P. Kumm. var. *geophylla* – on ground; div. 67, 89; July 2017.
- I. geophylla* (Bull.) P. Kumm. var. *lilacina* – on ground; LF; div. 16; October 2017.

- **I. grammata* Quél. – on sandy soil, under *Pinus*; div. 88c (near road); July 2017; V.
- I. lanuginosa* (Bull.) P. Kumm. – on ground, among mosses; LF; div. 46, 68, 88; July–August 2017.
- **I. margaritispora* (Berk.) Sacc. – on ground; LF; div. 14 (Gosań Mt); August 2012.
- **Inocutis rheades* (Pers.) Fiasson & Niemelä [= *Inonotus rheades* (Pers.) Bondartsev & Singer] – on log of *Fagus*; LF; div. 116a; October 2012; V.
- Kuehneromyces mutabilis* (Schaeff.) Singer & A. H. Sm. – on wood of deciduous trees; LF; div. 16, 46, 68; October 2017.
- Laccaria amethystina* Cooke – on ground; LF; div. 16, 46, 88, 89, 106, 117, 118; July–August, October 2017.
- L. laccata* (Scop.) Cooke – on ground; LF; div. 68; August 2017.
- L. proxima* (Boud.) Pat. – on ground; div. 46; August 2017.
- Lactarius camphoratus* (Bull.) Fr. – on ground, under *Fagus* and *Pinus* LF; div. 46, 67, 68, 88, 106, 116–118; July–August 2017.
- **L. cf. decipiens* Quél. – on ground, under *Fagus* and *Quercus*; LF; div. 14 (Gosań Mt); August 2012.
- L. fluens* Boud. – on ground; LF; div. 16, 17, 46, 68, 88, 106, 117, 118; August–October 2017.
- L. quietus* (Fr.) Fr. – on ground; LF; div. 17, 46, 88, 106, 116–118; July–August, October 2017.
- L. rufus* (Scop.) Fr. – on ground; div. 116–118; September–October 2017.
- L. tabidus* Fr. – on ground; div. 106, 116–118; July–August 2017.
- L. vellereus* (Fr.) Fr. – on ground; LF; div. 88; August–September 2017.
- **Laxitextum bicolor* (Pers.) Lentz – on log of *Fagus*; div. 104; August 2012.
- Lentinus substrictus* (Bolton) Zmitr. & Kovalenko (= *Polyporus ciliatus* Fr.) – on branches; div. 16, 17, 116; June, October 2017.
- Lepiota cristata* (Bolton) P. Kumm. – on ground, among grass; Międzyzdroje (Nadbrzeźna Street, near div. 68); July 2017.
- Lepista nuda* (Bull.) Cooke – on ground; div. 16; October 2017.
- Lycoperdon perlatum* Pers. – on ground; LF; div. 16, 88; July–October 2017.
- Macrolepiota procera* (Scop.) Singer – on ground; div. 67, 68; July–September 2017.
- Marasmiellus confluens* (Pers.) J. S. Oliveira [= *Gymnopus confluens* (Pers.) Antonín, Halling & Noordel.] – on litter; div. 88, 107; August 2017.
- M. peronatus* (Bolton) J. S. Oliveira [= *G. peronatus* (Bolton) Gray] – on litter; div. 18, 46, 88, 117, 118; August–October 2017.
- Megacollybia platyphylla* (Pers.) Kotl. & Pouzar – on wood of deciduous trees; LF; div. 17, 46, 88, 107, 116–118; June–October 2017.
- Mensularia nodulosa* (Fr.) T. Wagner & M. Fisch. [= *Inonotus nodulosus* (Fr.) P. Karst.] – on trunks of *Fagus*; LF; div. 88; May–September 2017.
- Mucidula mucida* (Schrad.) Pat. [= *Oudemansiella mucida* (Schrad.) Höhn.] – on logs of *Fagus*; LF; div. 16, 88; August–October 2017.
- Mycena crocata* (Schrad.) P. Kumm. – on litter; LF; div. 16; October 2017; R.
- M. galericulata* (Scop.) Gray – on stumps of deciduous trees; div. 17, 106, 116–118; July–October 2017.
- M. galopus* (Pers.) P. Kumm. – on litter; div. 16, 67, 68, 88, 106, 117; June–October 2017.
- M. haematopus* (Pers.) P. Kumm. var. *haematopus* – on logs of *Fagus*; LF; div. 16, 17, 68, 118; August, October 2017.
- M. inclinata* (Fr.) Quél. – on stump of *Quercus*; LF; div. 16; October 2017.
- M. pura* (Pers.) P. Kumm. – on ground and litter; LF; div. 16; October 2017.

- M. sanguinolenta* (Alb. & Schwein.) P. Kumm. – on litter; LF; div. 68, 106, 116, 117; July–August 2017.
- M. stylobates* (Pers.) P. Kumm. – on leaves of *Fagus*; LF; div. 68; July 2017.
- M. vitilis* (Fr.) Quél. – on litter; div. 88, 106, 107, 117, 118; July–August 2017.
- Mycetinis alliaceus* (Jacq.) Earle ex A. W. Wilson & Desjardin [= *Marasmius alliaceus* (Jacq.) Fr.] – on wood of *Fagus*; LF; div. 17, 88g, 107; July–August, October 2017.
- Neoboletus erythropus* (Pers.) C. Hahn (= *Boletus luridiformis* Rostk. var. *luridiformis* = *B. erythropus* Pers.) – on ground; LF; div. 46, 67, 68; August 2017.
- Panellus stipticus* (Bull.) P. Karst. – on stump of *Quercus*; div. 16; October 2017.
- Paralepista flaccida* (Sowerby) Vizzini [= *Lepista flaccida* (Sowerby) Pat.] – on litter; div. 16, 67, 118; August, October 2017.
- Paxillus involutus* (Batsch) Fr. – on ground; LF; div. 16, 17, 18, 88; July–October 2017.
- Peniophora cinerea* (Pers.) Cooke – on branches; LF; div. 17, 67, 106; May–October 2017.
- P. quercina* (Pers.) Cooke – on branches of *Quercus*; div. 17, 88, 106, 117, 118; May–October 2017.
- Phaeolus schweinitzii* (Fr.) Pat. – on roots of *Pinus*; div. 67, 88; September 2017.
- Phallus impudicus* L. – on ground; LF; div. 68, 88, 117, 118; August–August 2017.
- Phellinus pini* (Brot.) Pilát [= *Porodaedalea pini* (Brot.) Murrill] – on trunks and log of *Pinus*; LF; div. 67, 88, 89, 106, 107, 118; May–October 2017; R.
- Phlebia radiata* Fr. – on logs of *Fagus*; div. 16, 68; October 2017.
- Ph. tremellosa* (Schrad.) Nakasone & Burds. – on logs of *Fagus*; LF; div. 16, 17; October 2017.
- Pholiota aurivella* (Batsch) P. Kumm. – on trunk of the living *Fagus*; LF; div. 46d; September 2016.
- Ph. lenta* (Pers.) Singer – on litter; LF; div. 16; October 2017.
- **Piloderma* cf. *bicolor* (Peck) Jülich [= *P. fallax* (Lib.) Stalpers] – on litter; div. 13 (Gosañ Mt); August 2012.
- **Plicaturopsis crispa* (Pers.) D. A. Reid – on branch of *Fagus*; LF; div. 16; October 2017; R.
- Pluteus cervinus* (Schaeff.) P. Kumm. – on wood of deciduous trees; LF; div. 16, 67, 88; July–October 2017.
- Polyporus lipsiensis* (Batsch) E. H. L. Krause [= *Ganoderma lipsiense* (Batsch) G. F. Atk.] – on logs of *Fagus*; LF; div. 17, 46; May–October 2017.
- P. tuberaster* (Jacq. ex Pers.) Fr. – on branches; div. 16, 88; October 2017; R.
- Postia caesia* (Schrad.) P. Karst. [= *Oligoporus caesius* (Schrad.) Gilb. & Ryvarden] – on wood of *Pinus*; div. 67, 68, 88, 106, 107; July–September 2017.
- P. ptychogaster* (F. Ludw.) Vesterh. [= *O. ptychogaster* (F. Ludw.) Falck & O. Falck] – on logs of *Pinus*; div. 68; October 2017; R.
- Psathyrella piluliformis* (Bull.) P. D. Orton – on wood of *Quercus*; div. 88; September 2017.
- Pseudomerulius aureus* (Fr.) Jülich – on logs of *Pinus*; LF; div. 68, 88; October 2017; R.
- Pseudosperma rimosum* (Bull.) Matheny & Esteve-Rav. [= *I. rimosum* (Bull.) P. Kumm. = *I. fastigiata* (Schaeff.) Quél.] – on ground; LF; div. 88c; July 2017.
- Radulomyces molaris* (Chaillet ex Fr.) M. P. Christ. – on branch of *Quercus*; div. 67; July 2017.
- Ramaria stricta* (Pers.) Quél. – on ground; LF; div. 16; October 2017.
- **Rhizopogon roseolus* (Corda) Th. Fr. – on ground; on a forest road to Zielonka Hill (div. 128h); September 2016.

- Rhodocollybia butyracea*** (Bull.) Lennox f. *butyracea* – on ground; LF; div. 16–18; October 2017.
- Rickenella fibula*** (Bull.) Raithelh. – among mosses; LF; div. 16, 68, 116, 117; July–August, October 2017.
- Russula adusta*** (Pers.) Fr. (= *R. nigricans* Fr.) – on ground; div. 17; October 2017.
- R. cyanoxantha*** (Schaeff.) Fr. – on ground; LF; div. 68, 89, 117; July 2017.
- R. emetica*** (Schaeff.) Pers. – on ground; div. 88; August 2017.
- R. nobilis*** Velen. (= *R. mairei* Singer) – on ground; LF; div. 2 (SJSP), 46, 67, 68, 88; November 2012, August 2017.
- R. ochroleuca*** Fr. – on ground; div. 118; October 2017.
- R. risigallina*** (Batsch) Sacc. [= *R. lutea* (Huds.) Gray] – on ground; div. 68; August 2017.
- *#***R. sardonica*** Fr. – on ground, under *Pinus* and *Quercus*; FQ, grey dune; div. 1A (confirmed by T. Leski), 1B, 69t (by the forest road; *det.* T. Leski), 70g; September 2014, 2017, October 2015.
- R. torulosa*** Bres. – on ground, under *Pinus* on a grey dune; div. 1A, 1B; September 2017.
- #***R. xerampelina*** (Schaeff.) Fr. – on ground, under *Pinus*; on a grey dune; div. 1A (confirmed by T. Leski); September 2013.
- Schizophyllum commune*** Fr. – on wood; div. 67; July 2017.
- Schizopora paradoxa*** (Schrad.) Donk [= *Xylodon paradoxus* (Schrad.) Chevall.] – on wood; div. 88, 116–118; May–September 2017.
- Scleroderma citrinum*** Pers. – on ground; div. 46, 67; September 2017.
- ****Skeletocutis amorpha*** (Fr.) Kotl. & Pouzar – on logs and stump of *Pinus*; div. 67, 117; October 2017.
- ****S. nivea*** (Jungh.) Jean Keller – on log of *Fagus*; LF; div. 2j (SJSP); November 2012.
- Sparassis crispa*** (Wulfen) Fr. – at the base of *Pinus*; div. 118; September 2017; R.
- Stereum hirsutum*** (Willd.) Pers. – on wood; LF; div. 17, 67, 88, 106, 107, 118; July–October 2017.
- ****S. ochraceoflavum*** (Schwein.) Sacc. – on wood; div. 88 (near forest road); October 2017.
- S. rugosum*** Pers. – on wood; div. 18, 46, 107; July–October 2017.
- S. sanguinolentum*** (Alb. & Schwein.) Fr. – on branches of *Pinus*; div. 67, 68, 88, 106; July–September 2017.
- Strobilurus stephanocystis*** (Kühner & Romagn. ex Hora) Singer – on cone of *Pinus*; div. 16, 88, 89; May, October 2017.
- Stropharia aeruginosa*** (Curtis) Quéf. – on ground and wood; div. 16, 17; October 2017.
- Suillus bovinus*** (L.) Roussel – on ground; div. 88, 117; August 2017.
- S. granulatus*** (L.) Roussel – on ground; div. 68, 106, 117; August 2017.
- S. grevillei*** (Klotzsh) Singer – on ground; div. 67; June–July 2017.
- Tapinella atrotomentosa*** (Batsch) Šutara [= *Paxillus atrotomentosus* (Batsch) Fr.] – on logs and stumps of *Pinus*; div. 46, 68, 88, 106; July–August 2017.
- T. panuoides*** (Fr.) E.-J. Gilbert [= *P. panuoides* (Fr.) Fr.] – on logs of *Pinus*; div. 88c; August 2017.
- Thelephora terrestris*** Ehr. – on ground and wood; div. 17, 46, 68, 88, 117; July–October 2016–2017.
- Trametes gibbosa*** (Pers.) Fr. – on stumps and logs of *Fagus*; LF; div. 16, 67g, 88g; July, October 2017.
- T. hirsuta*** (Wulfen) Lloyd – on wood; div. 16, 17, 46; September 2016, October 2017.

T. versicolor (L.) Lloyd – on wood; div. 16, 18; October 2017.

Trichaptum abietinum (Pers. ex J. F. Gmel.) Ryvarden – on logs of *Pinus*; div. 88, 118; May–September 2017.

T. fuscoviolaceum (Ehrenb.) Ryvarden – on logs of *Pinus*; div. 88, 118; May–September 2017.

Tricholoma sulphureum (Bull.) P. Kumm. – on ground; LF; div. 16; October 2017.

T. terreum (Schaeff.) P. Kumm. – on ground; div. 17; October 2017.

Tylophilus felleus (Bull.) P. Karst. – on ground; LF; div. 68, 106, 117; August–September 2017.

Vuilleminia comedens (Nees) Mraire – on branches of *Quercus*; LF; div. 16, 88, 107, 118; May–October 2017.

**Xenasmatella vaga* (Fr.) Stalpers [= *Phlebiella vaga* (Fr.) P. Karst.] – on log of *Pinus*; div. 68d; July 2017.

Xerocomellus chrysenteron (Bull.) Šutara – on ground; div. 16, 17, 46; August, October 2017.

**X. cisalpinus* (Simonini, H. Ladurner & Peintner) Klofac – on ground; div. 16; October 2017.

Xeromphalina causticinalis (Fr.) Kühner & Maire – on ground and needles; div. 17; October 2017.

Xylobolus frustulatus (Pers.) P. Karst. (Figure 2) – on old logs of *Quercus*; LF; div. 117, 66 (the Międzyzdroje Forest District, near the eastern border of the WNP); June–October 2017; V.



Figure 2 Basidiomata of *Xylobolus frustulatus* from the Wolin National Park (August 13, 2017). Photography by MS.

4. Discussion and Conclusions

The results of this study have contributed to a better recognition of the mycobiota of the WNP. The number of fungi species known from the Park area increased by 32 that were previously unreported, and currently it amounts to 508 taxa. New localities were recorded for more than 35% out of 476 previously observed fungi species

(Czubiński & Urbański, 1951; Dominik, 1957; Friedrich, 2011; Lisiewska, 1966; Ławrynowicz, 1983, 1989; Ronikier, 2005; Skirgiełło, 1970; Stasińska & Sotek, 2016; Stier, 1939; Ulbrich, 1932; Wojewoda, 2002; Wojewoda et al., 2002).

The macromycetes new to the Park include taxa that were rarely recorded in Poland, most often in well-preserved old stands under protection. In this group of fungi, *Aleurodiscus disciformis* and *Calcipostia guttulata* attracted special attention, and were included in the endangered category (E) of the “Red list of the macrofungi in Poland” (Wojewoda & Ławrynowicz, 2006). *Aleurodiscus disciformis* was reported from only a few localities, including nature reserves “Trębaczew” and “Parkowe,” the Białowieża Primeval Forest (Wojewoda, 2003), and the Kashubian Landscape Park (Karasiński, 2016). This species is critically endangered (CR) in the Czech Republic (Holec & Beran, 2006) and is known mainly from the southern part of this country (Zíbarová, 2015). According to Bernicchia and Gorjón (2010), it has a wide range in Europe, including Denmark, France, Germany, Italy, Portugal, Slovakia, Sweden, and Ukraine. In Poland, *C. guttulata* is rarely found as the previous species, e.g., in the Beech Forest near Szczecin (Kujawa & Gierczyk, 2019), the Białowieża Primeval Forest (Karasiński et al., 2009; Szczepkowski et al., 2008), and the Kaczawskie Mts (Gierczyk et al., 2018). In neighboring Germany, on the other hand, it has been reported from a number of localities (Dämmrich et al., 2019). In Finland, until recently, it was red-listed in the category: near threatened (NT) and has now been downgraded to the category: least concern (LC) (Kotiranta et al., 2019). Other species of fungi newly recorded in the Park are also known from single or a few sites in Poland, such as *Hohenbuehelia auriscalpium* – from the Wigry National Park (Halama & Romański, 2010), the “Ostrzycki Las” reserve (Kujawa & Gierczyk, 2016), and the Bieszczady Mts (Gierczyk, Kujawa, et al., 2019), and *Hohenbuehelia grisea* – from Częstochowa Upland (Adamczyk, 2011), the Kampinos National Park (Karasiński et al., 2015), and the Bieszczady Mts (Gierczyk, Kujawa, et al., 2019).

A large number of the saprotrophic wood decay fungi (95 species) resulted from a significant accumulation of substrate in the form of decaying logs and trunks, which were left to naturally decay, and have become suitable habitats for the development of this group of organisms. The share of mycorrhizal fungi (58 taxa; 28.3%) in the studied western part of the Park indicates the good health condition of the stand. Moreover, few parasitic fungi (nine species; 4.4%), of which *Phellinus pini* was the most frequent (it grew on old pines), do not pose a threat to it.

The significant species diversity of mycobiota of the WNP shown in the current and previous studies (Czubiński & Urbański, 1951; Dominik, 1957; Friedrich, 2011; Lisiewska, 1966; Ławrynowicz, 1983, 1989; Ronikier, 2005; Skirgiełło, 1970; Stasińska & Sotek, 2016; Stier, 1939; Ulbrich, 1932; Wojewoda, 2002; Wojewoda et al., 2002), confirms the very high natural value of this area. The number of macrofungi (508 species) found in the WNP is almost 1/5 higher than the number of species recorded in two other national parks in Pomerania, the Słowiński National Park (429) (Bujakiewicz & Lisiewska, 1983) and the Drawa National Park (379) (Stefaniak, 2013, as cited in Karasiński et al., 2015). In terms of the number of identified taxa, the WNP is only slightly inferior to the Bory Tucholskie National Park (517) (Grzesiak et al., 2017). National parks located in other regions of Poland are much richer in species of fungi, e.g., the Białowieża National Park (1585) (Karasiński et al., 2010, as cited in Karasiński et al., 2015), and the Kampinos National Park (1,611) (Gierczyk, Szczepkowski, et al., 2019a). Differences in the number of species observed between the WNP and other national parks are related, inter alia, to the duration and intensity of mycological research, as well as to the size of objects, the diversity of ecosystems, and the plant communities.

The presented data only, to some extent, supplement the knowledge about macromycetes in the Park. Due to unfavorable weather conditions for macromycetes occurrence in recent years, their biology, and the lack of systematic mycological observations, the list of fungi species illustrating the richness of the WNP biota is still open.

Acknowledgments

The authors would like to thank dr hab. Tomasz Leski and dr hab. Błażej Gierczyk for their help in identifying and confirming some of the fungal species.

References

- Adamczyk, J. (2011). *Strukturalno-funkcjonalna charakterystyka zbiorowisk macromycetes w fitocenozach leśnych projektowanego Jurajskiego Parku Narodowego* [Structural and functional characteristic of macrofungal communities in forest phytocoenoses of the projected Jurajski National Park]. Wydawnictwo Uniwersytetu Łódzkiego.
- Altschul, S. F., Gis, W., Miller, W., Myers, E. W., & Lipman, D. J. (1990). Basic local alignment search tool. *Journal of Molecular Biology*, 215, 403–410. [https://doi.org/10.1016/S0022-2836\(05\)80360-2](https://doi.org/10.1016/S0022-2836(05)80360-2)
- Aronsen, A., & Læssøe, T. (2016). *The genus Mycena s. l.* The Danish Mycological Society.
- Bernicchia, A., & Gorjón, S. P. (2010). *Corticiaceae s. l.* Edizioni Candusso.
- Breitenbach, J., & Kränzlin, F. (1984). *Fungi of Switzerland. Vol. 1. Ascomycetes*. Verlag Mycologia.
- Breitenbach, J., & Kränzlin, F. (1986). *Fungi of Switzerland. Vol. 2. Non gilled fungi. Heterobasidiomycetes, Aphyllophorales, Gastromycetes*. Verlag Mycologia.
- Breitenbach, J., & Kränzlin, F. (1991). *Fungi of Switzerland. Vol. 3. Boletes and agarics (Part 1). Strobilomycetaceae and Boletaceae, Paxillaceae, Gomphidiaceae, Hygrophoraceae, Tricholomataceae, Polyporaceae (lamellate)*. Verlag Mycologia.
- Breitenbach, J., & Kränzlin, F. (1995). *Fungi of Switzerland. Vol. 4. Boletes and agarics (Part 2). Entolomataceae, Pluteaceae, Amanitaceae, Agaricaceae, Coprinaceae, Bolbitiaceae, Strophariaceae*. Verlag Mycologia.
- Breitenbach, J., & Kränzlin, F. (2000). *Fungi of Switzerland. Vol. 5. Boletes and agarics (Part 3). Cortinariaceae*. Verlag Mycologia.
- Bujakiewicz, A., & Lisiewska, M. (1983). Mikoflora zbiorowisk roślinnych Słowińskiego Parku Narodowego [The mycoflora of plant communities in the Słowiński National Park]. *Badania Fizjograficzne nad Polską Zachodnią B*, 34, 49–77.
- Czubiński, Z., & Urbański, J. (1951). Park Narodowy na wyspie Wolin [National Park on the Wolin Island]. *Chrońmy Przyrodę Ojczyznę*, 7–8, 3–56.
- Dämmrich, F., Gminder, A., Hardtke, H. J., Karasch, P., & Wehr, K. (2019). *Datenbank der Pilze Deutschlands, Deutsche Gesellschaft für Mykologie e. V. (DGfM)* [Database of Mushrooms in Germany, German Mycological Society e. V. (GMS)]. <http://www.pilze-deutschland.de/>
- Dominik, T. (1957). Badania mikotrofizmu zespołów buka nad Bałtykiem [Investigations on the mycotrophy of beech association on the Baltic Coast]. *Ekologia Polska*, A(5), 213–256.
- Friedrich, S. (2011). New locations of threatened and protected *Gasteromycetes s. l.* in northwestern Poland. *Polish Journal of Environmental Studies*, 20(3), 559–564.
- Gardes, M., & Bruns, T. D. (1993). ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. *Molecular Ecology*, 2, 113–118. <https://doi.org/10.1111/j.1365-294X.1993.tb00005.x>
- Gierczyk, B., Chachuła, P., Karasiński, D., Kujawa, A., Kujawa, K., Pachlewski, T., Snowarski, M., Szczepkowski, A., Ślusarczyk, T., & Wójtowski, M. (2009). Grzyby wielkoowocnikowe Polskich Bieszczadów. Część I [Macrofungi of the Polish Bieszczady Mountains. Part I]. *Parki Narodowe i Rezerваты Przyrody*, 39(3), 3–100.
- Gierczyk, B., Kujawa, A., Szczepkowski, A., Ślusarczyk, T., Pachlewski, T., Chachuła, P., & Domian, G. (2019). Macrofungi of the Bieszczady Mountains. *Acta Mycologica*, 54(2), Article 1124. <https://doi.org/10.5586/am.1124>
- Gierczyk, B., Soboń, R., Pachlewski, T., & Ślusarczyk, T. (2018). Contribution to the knowledge of mycobiota of the Western Sudety Mountains and Western Sudety Foothills (SW Poland). Part 1. *Acta Mycologica*, 53(2), Article 1106. <https://doi.org/10.5586/am.1106>
- Gierczyk, B., Szczepkowski, A., Kujawa, A., Ślusarczyk, T., & Zaniewski, P. (2017). Contribution to the knowledge of fungi of the Kampinos National Park (Poland) with particular emphasis on the species occurring in burnt places. *Acta Mycologica*, 52(1), Article 1093. <https://doi.org/10.5586/am.1093>
- Gierczyk, B., Szczepkowski, A., Ślusarczyk, T., & Kujawa, A. (2019a). Contribution to knowledge of the fungal biota of Kampinos National Park (Poland): Part 3. *Acta Mycologica*, 54(2), Article 1129. <https://doi.org/10.5586/am.1129>
- Gierczyk, B., Szczepkowski, A., Ślusarczyk, T., & Kujawa, A. (2019b). Contribution to knowledge of the mycobiota of Kampinos National Park (Poland): Part 2. *Acta Mycologica*, 54(1), Article 1116. <https://doi.org/10.5586/am.1116>

- Grzesiak, B., Kochanowska, M., & Kochanowski, J. (2017). Macromycetes of Central European lichen Scots pine forests of the *Cladonio-Pinetum* Juraszek 1927 type in the “Bory Tucholskie” National Park (NW Poland). *Acta Mycologica*, 52(1), Article 1092. <https://doi.org/10.5586/am.1092>
- Halama, M., & Romański, M. (2010). Grzyby makroskopijne (macromycetes) [Macrofungi (macromycetes)]. In L. Krzysztofiak (Ed.), *Śluzowce Myxomycetes, grzyby Fungi i mszaki Bryophyta Wigierskiego Parku Narodowego* [Myxomycetes, Fungi and Bryophyta of the Wigry National Park] (pp. 87–201). Stowarzyszenie “Człowiek i Przyroda”.
- Holec, J., & Beran, M. (2006). Červený seznam hub (makromycetů) České republiky [Red list of fungi (macromycetes) of the Czech Republic]. *Příroda*, 24, 1–282.
- Karasiński, D. (2016). Grzyby afyloforoidalne Kaszubskiego Parku Krajobrazowego. Tom 1. Charakterystyka mykobioty [Aphylloroid fungi of the Kaszuby Landscape Park. Vol. 1. Characteristics of the mycobiota]. *Acta Botanica Cassubica, Monographiae*, 7, 1–198.
- Karasiński, D., Kujawa, A., Gierczyk, B., Ślusarczyk, T., & Szczepkowski, A. (2015). *Grzyby wielkoowocnikowe Kampinoskiego Parku Narodowego* [Macrofungi of the Kampinos National Park]. Kampinoski Park Narodowy.
- Karasiński, D., Kujawa, A., Piątek, M., Ronikier, A., & Wołkowycki, M. (2009). Contribution to biodiversity assessment of European primeval forests: New records of rare fungi in the Białowieża Forest. *Polish Botanical Journal*, 54(1), 55–97.
- Knudsen, H., & Vesterholt, J. (Eds.). (2012). *Funga Nordica. Agaricoid, boletoid, clavarioid, cyphelloid and gastroid genera*. Nordsvamp.
- Kotiranta, H., Junninen, K., Halme, P., Kytövuori, I., Bonsdorff, T., Niskanen, T., & Liimatainen, K. (2019). Aphylloroid fungi. In E. Hyvärinen, A. Juslén, E. Kemppainen, A. Uddström, & U. M. Liukko (Eds.), *The 2019 red list of Finnish species* (pp. 234–247). Ministry of the Environment and Finnish Environment Institute.
- Kränzlin, F. (2005). *Fungi of Switzerland. Vol. 6. Russulaceae*. Verlag Mycologia.
- Kujawa, A., & Gierczyk, B. (2016). Rejestr grzybów chronionych i zagrożonych w Polsce. Część IX. Wykaz gatunków przyjętych do rejestru w roku 2013 [Register of protected and endangered fungi in Poland. Part IX. A list of species recorded in 2013]. *Przegląd Przyrodniczy*, 27(3), 3–55.
- Kujawa, A., & Gierczyk, B. (2019). *Rejestr gatunków grzybów chronionych i zagrożonych* [Register of protected and endangered fungi species]. Atlas grzybów Polski [Mushrooms and fungi of Poland]. <http://www.grzyby.pl/rejestr-grzybow-chronionych-i-zagrozonych.htm>
- Kujawa, A., Gierczyk, B., Domian, G., Wrzosek, M., Stasińska, M., Szkodzik, J., Leski, T., Karliński, L., Pietras, M., Dynowska, M., Henel, A., Ślusarczyk, D., & Kubiak, D. (2015). Preliminary studies of fungi in the Biebrza National Park. Part IV. Macromycetes – new data and the synthesis. *Acta Mycologica*, 50(2), Article 1070. <https://doi.org/10.5586/am.1070>
- Kujawa, A., Wrzosek, M., Domian, G., Kędra, K., Szkodzik, J., Rudawska, M., Leski, T., Karliński, L., Pietras, M., Gierczyk, B., Dynowska, M., Ślusarczyk, D., Kałucka, I., & Ławrynowicz, M. (2012). Preliminary studies of fungi in the Biebrza National Park (NE Poland). II. Macromycetes. *Acta Mycologica*, 47(2), 235–264. <https://doi.org/10.5586/am.2012.027>
- Lisiewska, M. (1966). Grzyby wyższe Wolińskiego Parku Narodowego [Higher fungi of Wolin Island National Park]. *Acta Mycologica*, 2, 25–77. <https://doi.org/10.5586/am.1966.005>
- Ławrynowicz, M. (1983). *Coenococcum graniforme* w Polsce [*Coenococcum graniforme* in Poland]. *Acta Mycologica*, 19(1), 31–40. <https://doi.org/10.5586/am.1983.003>
- Ławrynowicz, M. (1989). Chorology of the European hypogeous Ascomycetes. I. Elaphomycetales. *Acta Mycologica*, 25(1), 3–41. <https://doi.org/10.5586/am.1989.001>
- Ławrynowicz, M. (2012). Inwentaryzacja grzybów wielkoowocnikowych na terenie PNBT [Inventory of macrofungi in the PNBT]. In J. M. Matuszkiewicz (Ed.), *Świat roślin i grzybów Parku Narodowego “Bory Tucholskie”* [Plants and fungi of the “Bory Tucholskie” National Park] (pp. 358–395). Park Narodowy “Bory Tucholskie”.
- Matuszkiewicz, W. (2006). *Przewodnik do oznaczania zbiorowisk roślinnych Polski* [A guide for marking Poland’s plant communities]. Wydawnictwo Naukowe PWN.
- Mirek, Z., Piękoś-Mirkowa, H., Zając, A., & Zając, M. (Eds.). (2002). *Flowering plants and pteridophytes of Poland – a checklist*. W. Szafer Institute of Botany, Polish Academy of Sciences.
- Romagnesi, H. (1996). *The russulas of Europe and North Africa*. ARG Gantner Verlag K-G.
- Ronikier, A. (2005). *Xerula radicata* (Relhan: Fr.) Dörfelt. In W. Wojewoda (Ed.), *Atlas of the geographical distribution of fungi in Poland. Fascicule 3* (pp. 129–145). W. Szafer Institute of Botany, Polish Academy of Sciences.

- Ruszkiewicz-Michalska, M., Bałazy, S., Chełkowski, J., Dynowska, M., Pawłowska, J., Sucharzewska, E., Szkodzik, J., Tkaczuk, C., Wilk, M., & Wrzosek, M. (2015). Preliminary studies of fungi in the Biebrza National Park (NE Poland). Part III. Micromycetes – new data. *Acta Mycologica*, 50(2), Article 1067. <https://doi.org/10.5586/am.1067>
- Skirgiełło, A. (1970). Materiały do poznania rozmieszczenia geograficznego grzybów wyższych w Europie. III [Materials to knowledge of the geographical distribution of higher fungi in Europe. III]. *Acta Mycologica*, 6(1), 101–123. <https://doi.org/10.5586/am.1970.011>
- Stangl, J. (1989). Die Gattung *Inocybe* in Bayern [The genus *Inocybe* in Bayern]. *Hoppea*, 46, 5–388.
- Stasińska, M., & Sotek, Z. (2016). New data to the knowledge of macrofungi of Wolin National Park. *Acta Mycologica*, 51(2), Article 1089. <https://doi.org/10.5586/am.1089>
- Stier, M. (1939). Die Röhrlinge der Insel Usedom – Wolin [The boletes of the island of Usedom – Wolin]. *Dohrniana*, 18, 94–96.
- Szczepkowski, A., Kujawa, A., Karasiński, D., & Gierczyk, B. (2008). Grzyby zgromadzone na XIV Wystawie Grzybów Puszczy Białowieskiej [Fungi gathered for the XIV Fungi Exposition of the Białowieża Forest]. *Parki Narodowe i Rezerваты Przyrody*, 27(4), 115–133.
- Ulbrich, E. (1932). Über den Formenkreis von *Phallus impudicus* [On the *Phallus impudicus*]. *Berichte der Deutschen Botanischen Gesellschaft*, 50, 276–326.
- White, T. J., Bruns, T., Lee, S., & Taylor, J. W. (1990). *Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics*. Academic Press. <https://doi.org/10.1016/B978-0-12-372180-8.50042-1>
- Wojewoda, W. (2002). *Fomitiporia hippophaeicola* (H. Jahn) Fiasson & Niemelä. In W. Wojewoda (Ed.), *Atlas of the geographical distribution of fungi in Poland. Fascicule 2* (pp. 55–59). W. Szafer Institute of Botany, Polish Academy of Sciences.
- Wojewoda, W. (2003). *Checklist of Polish larger Basidiomycetes*. W. Szafer Institute of Botany, Polish Academy of Sciences.
- Wojewoda, W., Heinrich, Z., & Komorowska, H. (2002). *Trichaptum bifforme* (Fr.) Ryvarden. In W. Wojewoda (Ed.), *Atlas of the geographical distribution of fungi in Poland. Fascicule 2* (pp. 119–126). W. Szafer Institute of Botany, Polish Academy of Sciences.
- Wojewoda, W., Kozak, M., Mleczko, P., & Karasiński, D. (2016). *Grzyby makroskopijne Gorców (Karpaty Zachodnie)* [Macrofungi of the Gorce Mts (Western Carpatians)]. Instytut Botaniki im. W. Szafera Polskiej Akademii Nauk.
- Wojewoda, W., & Ławrynowicz, M. (2006). Red list of the macrofungi in Poland. In Z. Mirek, K. Zarzycki, W. Wojewoda, & Z. Szeląg (Eds.), *Red list of plants and fungi in Poland* (pp. 53–70). W. Szafer Institute of Botany, Polish Academy of Sciences.
- Zíbarová, L. (2015). Hojný výskyt vzácné houby škrobnatce terčovitého (*Aleurocystidiellum disciforme*) v severozápadní části Džbánu (okr. Louny) [An abundant occurrence of the rare fungus *Aleurocystidiellum disciforme* in a northwest part of Džbán (Louny District)]. *Severočeskou Přírodou*, 47, 81–85.