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Dedicated to Professor Maria Ławrynowicz on the occasion of the 45th anniversary of her scientific activity

Leaf-litter microfungal community on poor fen plant debris in Torfy Lake area (Central Poland)

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The purpose of this study was to initially evaluate the species diversity of microfungi growing on litter of 15 plant species occurring on the poor fen and neighbouring area of the Torfy Lake, Masovian voivodeship, Poland. The lake is located near the planned road investment (construction of the Warsaw southern express ring road S2). The place is biologically valuable as there are rare plant communities from *Rhynchosporion albae* alliance protected under the Habitats Directive adopted by the European Union. On the examined plant debris 73 taxa of fungi were recorded (3 basidiomycetes, 13 ascomycetes, 2 zygomycetes, 43 anamorphic ascomycetes, 12 unidentified). Two of them, *Dicranidion* sp. and *Wentiomyces* sp. are presented here as new to Poland. Among the plant species examined, the litter of *Rhododendron tomentosum* harbored the highest number of fungal taxa (16). The highest percents of substrate-specific microfungi (i.e. recorded only on one plant species) was noted on *R. tomentosum* (81.3 %), and *Pteridium aquilinum* (75%). It is emphasized that the lake area should be protected not only because of rare plant community but also because of the uniqueness and diversity of mycobiota.

Key words: microfungi, saprobic fungi, substrate-specificity, highway S2, *Dicranidion*, *Wentiomyces*

INTRODUCTION

Biology, ecology and diversity of fungi occurring in peatland ecosystems has been largely neglected in world mycology, at least until 1990's. Most older studies concentrated on microfungi occurring in peat soil, in natural ecosystems (e.g. Widden 1987), or disturbed by e.g. peat excavation (Dickinson, Dooley 1967; Dooley, Dickinson 1970). Together with

growing awareness of the pivotal role the peatland ecosystems play in carbon sequestration processes (Gorham et al. 2012) and possible danger of negative interactions of these with global warming (Gong et al. 2013), lack of knowledge about fungi – potentially the most important decomposer group in peatlands, became more and more pronounced. Publishing their work on microfungal communities on living and decomposing *Sphagnum* mosses, Thormann et al. (2001) started a series of studies dedicated exclusively to the diversity and ecology of fungi on peatlands (Thormann et al. 2001, 2003, 2004; Thormann 2006, 2007; Thormann et al. 2011), and from that time one can observe growing interest/and growing body of literature concerning this topic. However, although there have been published some studies covering aspects of macrofungal diversity (Stasińska 2011and literature cited there in), yeasts diversity (Thormann et al. 2007), microfungal diversity and ecology in peat (Tyszkiewicz 2003, 2004a,b, 2005; Andersen et al. 2010; Golovchenko et al. 2013), there are very few dedicated to leaf litter microfungi. In fact, with the exception of the abovementioned studies of Thormann et al. (2001, 2003, 2004), we know only about the recently published study of Peltoniemi et al. (2012), and the detailed research of micro- and macrofungi on raised bogs being currently conducted in Siberia (N. V. Filippova, The Yugra State University, Khanty-Mansiysk, Russia, pers. comm.). That is surprising, because this group of fungi, acting directly on plant material and in oxic conditions, potentially contributes the most to the process of decomposition, and possibly influences the rate of decay and the resultant composition of newly formed peat. Therefore the knowledge about the diversity, host- or substrate-specificity and ecology of fungal communities seems to be pivotal for proper understanding of mechanisms involved in decomposition on peatlands and possible reactions to environmental disturbances connected with global warming or anthropogenic pressure.

The aim of the present study was to prepare preliminary inventory of leaf-litter microfungi inhabiting debris of several plant species occurring on poor fen in the Torfy Lake area (Masovian voivodeship, Central Poland), evaluate potential substrate-specificity of those communities and to compare the results with previously published reports on this topic.

MATERIALS AND METHODS

Characteristics of the Torfy Lake area. Lake Torfy is situated in Wawer, the district of Warsaw in the northern part of the Masovian Landscape Park (MLP). The lake is located in temperate coniferous forest (*Leucobryo-Pinetum*), and its surface on the shores is partially covered with well developed poor fen with vegetation typical for *Rhynchosporion albae* alliance (Fig. 1). This type of habitat is listed in Habitats Directive as a "Natural habitat type of community interest whose conservation requires the designation of special areas of conservation". The vegetation of the fen comprises mostly the dense cover of *Sphagnum fallax* (Klinggr.) Klinggr. with *Eriophorum angustifolium* Honck., *Vaccinium oxycoccos* L. and *Drosera rotundifolia* L. Additionally, parts of the shore are covered with reed bed, mostly *Phragmites australis* (Cav.) Trin. ex Steud and *Typha latifolia* L. with trees and saplings of *Betula pendula* L. and *Populus tremula* L. In addition, *Rhododendron tomentosum* Harmaja occasionally occurs in the vicinity of the lake.

Although the Torfy Lake area is a biologically valuable habitat, the route of the Warsaw southern bypass is planned to be built in its close neighbourhood (Jarzombkowski, Sambor 2003). Three options of the highway's route were considered and all of them crossed the area of MLP. Finally the variant which crosses the northern part of MLP was chosen, because the area is supposed to be already the most anthropogenically modified. In order to minimize the influence of the highway on the unique habitat, the course of the route was moved one hundred meters northwards away from the Torfy Lake.

Plant species diversity of this area is relatively well documented (Sienkiewicz, Pawlikowski 2004), fungal diversity, however, still remains to be properly described. There are no published reports on macro- or microfungi occuring on this site. One of the authors conducted a preliminary screening of macromycetes growing in the vicinity of the lake in 2012 (Wrzosek, unpublished). The one-season observations resulted in finding of 58 taxa of basidiomycetes. Most of them were typical mycorrhizal species commonly found under pines, oaks, poplars and birch trees. The second large ecological group comprised parasites and saprotrophs on wood – for example *Inonotus obliquus* (Ach. ex Pers.) Pilát, protected by Nature Conservation Act from 2004 and *Peniophora rufa* (Fr.) Boidin – extremely rare in Poland. Additionally some slime moulds were also recorded, e.g. *Diderma deplanatum* Fr. that is described by Krzysztofiak (2010) as uncommon in Poland. These preliminary findings and the overall specificity of the habitat itself already suggest that further mycological studies in this area could bring much more interesting results.

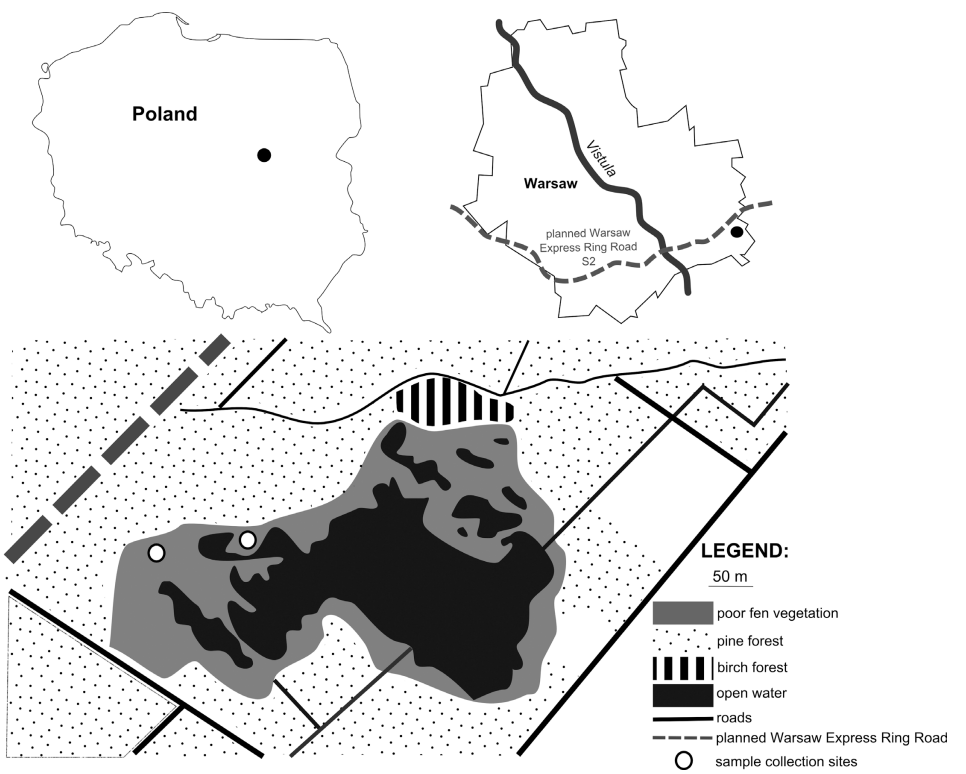

Fig. 1. Geographical location of research site and schematic representation of types of habitats.

Sampling. Samples were taken twice, at the beginning of December 2011 and in May 2012, from two locations: A) 52 11 19 N, 21 14 07 E and B) 52 11 20 N, 21 14 10 E (Fig. 1). Both are situated at an altitude of 107 m above sea level. For a given plant species and time of collection, plant material from both locations was pooled and treated as one composite sample in further analyses (i.e. there were no between-points comparisons). Dead plant material (approximately 10-15 fragments of dead or moribund leaves and stems/shoots, fit to loosely fill standard Petri dish) was sampled from the following 12 species growing on the fen: *Comarum palustre* L., *Sphagnum fallax* (Klinggr.) Klinggr., *Epilobium palustre* L., *Vaccinium oxycoccos* L., *Eriophorum angustifolium* Honck., *Carex nigra* Reichard, *Juncus* sp., *Lycopus europaeus* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Typha latifolia* L., *Rhododendron tomentosum* Harmaja (fragments of leaves), *Betula pendula* L. (fragments of leaves); additionally, plant debris of three more species found on the fen among mosses, but originating from neighboring area (i.e. brought there by wind or animals) were included: *Quercus robur* L. (fragments of leaves), *Pteridium aquilinum* (L.) Kuhn (fragments of leaves), and *Pinus sylvestris* L. (fragments of bark lying on the ground). Debris of fen plants were collected under correctly identified living specimens, and were therefore assumed to represent part of a given specimen and a given species. Debris of *Pinus*, *Quercus* and *Pteridium*, found on the ground, were easily identified by gross morphology. The precise age of the collected litter was impossible to determine, but majority of samples for each plant species probably comprised a mixture of litters of different age, but with the prevalence of "fresh" (i.e. this year) debris.

Isolation and identification techniques. Several fragments of each plant were placed separately in moist chambers as described in Krug (2004). In total 28 plates were analyzed (debris of *Typha latifolia* and *Pinus sylvestris* were collected only once, in spring and autumn, respectively). Plates were incubated for three months and inspected weekly for the presence of fungal structures. First morphological observations were taken using stereomicroscope Nikon SMZ800. After that, half-permanent microscope slides in lactophenol cotton blue were made to find and measure diagnostically significant structures. These observations were made using optical microscope Nikon Optiphot-2. An atlas of Ellis and Ellis (1997) was used for initial identification of taxa, further attempts were made with the use of monographs and keys (e.g. Ellis 1971; Matsushima 1971; von Arx 1974; Ellis 1976; Borowska 1986; Domsch et al. 1993; Watanabe 2002).

Ecological analyses. Several commonly used ecological indices (e.g. Wilsey, Stirling 2007) were calculated to describe fungal species richness in the Lake Torfy area: the Shannon index which describes diversity, species evenness which standardize abundance and range from "1" when species are equally abundant to "0", when majority of individuals belongs to few taxa and Jaccard similarity coefficient which shows how similar were fungal communities from autumn and spring (Odum 1982).

Fungal nomenclature follows *Index Fungorum* database (www.indexfungorum.org) and plant nomenclature is based on Integrated Taxonomic Information System (ITIS; www.itis.gov). For Fungi taxonomic system proposed in Mycobank (www.mycobank.org) was adopted. Whole documentation (slides, microphotographs and detailed descriptions of isolated taxa) is housed at the Department of Plant Systematics and Geography (University of Warsaw) and included in Banach (2012).

RESULTS

73 taxa of fungi were recorded (3 basidiomycetes, 13 ascomycetes, 2 zygomycetes, 43 anamorphic ascomycetes, 12 unidentified) on plant debris from Torfy Lake area (Tab. 1). Of these, 61 taxa were identified, and most of them to the genus level only, due to insufficient information obtained from prep-slides (e.g. lack of mature asci in case of teleomorphic ascomycetes or details of conidiogenesis for some anamorphs) and because isolations on synthetic culture media could not have been conducted. The remaining 12 taxa, although bearing distinctive features, could not have been identified even to a genus level and precise data will be collected the next year in order to their proper determination.

Table 1
List of taxa obtained, with plant hosts and time of collection indicated as "S" for spring, and "A" for autumn

No.	Isolated taxa	Plant host species
Cantharellales		
1.	*Alysidium* sp. 1	*Rhododendron tomentosum* (S)
2.	*Alysidium* sp. 2	*Comarum palustre* (S)
3.	*Alysidium* sp. 3	*Comarum palustre* (S)
Capnodiales		
4.	*Cladosporium cladosporioides* (Fresen.) G.A. de Vries	*Betula pendula* (A)
5.	*Cladosporium herbarum* (Pers.) Link	*Betula pendula* (A), *Comarum palustre* (A)
6.	*Cladosporium macrocarpum* Preuss	*Betula pendula* (A), *Eriophorum angustifolium* (A)
7.	cf. *Cladosporium* sp. 1	*Rhododendron tomentosum* (S)
8.	cf. *Cladosporium* sp. 2	*Vaccinium oxycoccos* (S)
9.	cf. *Cladosporium* sp. 3	*Rhododendron tomentosum* (S)
10.	cf. *Cladosporium* sp. 4	*Quercus robur* (A)
11.	*Ramichloridium apiculatum* (J.H. Mill., Giddens & A.A. Foster) de Hoog	*Pteridium aquilinum* (A)
Chaetospheriales		
12.	*Codinaea* sp.	*Vaccinium oxycoccos* (A)
Diaporthales		
13.	cf. *Gnomonia* sp. 1	*Betula pendula* (S), *Quercus robur* (S)
14.	cf. *Gnomonia* sp. 2	*Vaccinium oxycoccos* (S)
Eurotiales		
15.	*Paecilomyces* sp. 1	*Phragmites australis* (S)
16.	*Paecilomyces* sp. 2	*Pteridium aquilinum* (S)
17.	*Penicillium funiculosum* Thom	*Comarum palustre* (S), *Sphagnum fallax* (S), *Epilobium palustre* (A, S), *Vaccinium oxycoccos* (S), *Eriophorum angustifolium* (S), *Carex nigra* (S), *Juncus* sp. (S), *Lycopus europaeus* (S), *Phragmites australis* (S), *Quercus robur* (S), *Betula pendula* (S), *Pteridium aquilinum* (S), *Rhododendron tomentosum* (S), *Typha latifolia* (S)
Helotiales		
18.	cf. *Dactylaria* sp. 1	*Carex nigra* (A)
19.	*Dactylaria* sp. 2	*Betula pendula* (S), *Quercus robur* (S)
20.	*Dasyscyphus* cf. *rhytismatis* (W. Phillips) Sacc.	*Quercus robur* (A)
21.	*Dasyscyphus* sp. 1	*Juncus* sp. (S)
22.	*Dasyscyphus* sp. 2	*Rhododendron tomentosum* (S)
23.	*Helicodendron* sp.	*Betula pendula* (A)
24.	*Hyaloscypha* sp.	*Sphagnum fallax* (A, S), *Eriophorum angustifolium* (S)
25.	*Mollisia* sp.	*Quercus robur* (A)

Table 1 – cont.

26.	*Phialocephala virens* A.L. Siegfr. & Seifert	*Carex nigra* (S), *Eriophorum angustifolium* (S)
27.	*Varicosporium elodeae* W. Kegel	*Betula pendula* (A)
Hypocreales		
28.	*Acremonium* sp.	*Comarum palustre* (S)
29.	*Cladobotryum varium* Nees	*Pteridium aquilinum* (A)
30.	*Fusarium* sp. 1	*Rhododendron tomentosum* (S)
31.	*Fusarium* sp. 2	*Juncus* sp. (A)
32.	*Trichoderma harzianum* Rifai	*Pinus sylvestris* (A), *Rhododendron tomentosum* (S)
Microthyriales		
33.	*Microthyrium* sp.	*Rhododendron tomentosum* (S)
Mucorales		
34.	*Umbelopsis* sp.	*Betula pendula* (A)
Orbiliales		
35.	*Dicranidion* sp.	*Rhododendron tomentosum* (S)
36.	*Monacrosporium* sp.	*Comarum palustre* (A, S), *Juncus* sp. (S), *Lycopus europaeus* (A, S)
Pleosporales		
37.	*Alternaria alternata* (Fr.) Keissl. s.l.	*Epilobium palustre* (A), *Vaccinium oxycoccos* (A), *Lycopus europaeus* (A), *Comarum palustre* (A)
38.	*Alternaria tenuis* Nees s.l.	*Comarum palustre* (S)
39.	*Epicoccum nigrum* Link	*Juncus* sp. (A), *Phragmites australis* (A)
40.	cf. *Gibbera andromedae* (Rehm) E. Müll. & Arx	*Rhododendron tomentosum* (A, S)
41.	*Helicoön pluriseptatum* Beverw.	*Sphagum fallax* (A, S)
42.	*Periconia* cf. *minutissima* Corda	*Carex nigra* (A)
43.	*Phoma* s.l. sp. 1	*Pteridium aquilinum* (A, S)
44.	*Phoma* s.l. sp. 2	*Betula pendula* (A, S)
45.	*Phoma* s.l. sp. 3	*Rhododendron tomentosum* (A)
46.	*Phoma* s.l. sp. 4	*Betula pendula* (S)
47.	*Phoma* s.l. sp. 5	*Carex nigra* (A)
Sordariales		
48.	cf. *Sordaria* sp. 1	*Vaccinium oxycoccos* (A, S)
49.	cf. *Sordaria* sp. 2	*Rhododendron tomentosum* (S), *Pteridium aquilinum* (S)
50.	cf. *Sordaria* sp. 3	*Vaccinium oxycoccos* (S)
Xylariales		
51.	*Truncatella angustata* (Pers.) S. Hughes	*Betula pendula* (A)
Zoopagales		
52.	*Zoopage* sp.	*Betula pendula* (S), *Eriophorum angustifolium* (S)
Incertae sedis		
53.	*Chalara* sp. 1	*Pteridium aquilinum* (A)
54.	*Chalara* sp. 2	*Pinus sylvestris* (A)
55.	*Chalara* sp. 3	*Quercus robur* (S)
56.	cf. *Fusichalara* sp.	*Carex nigra* (A)
57.	cf. *Phialophora* sp.	*Rhododendron tomentosum* (S)
58.	*Polyscytalum pustulans* (M.N. Owen & Wakef.) M.B. Ellis	*Comarum palustre* (A)
59.	*Torula* sp.	*Pteridium aquilinum* (S)
60.	*Verticillium* sp.	*Juncus* sp. (S)
61	*Wentiomyces* sp.	*Rhododendron tomentosum* (A)
Others		
62.	Unidentified anamorphic ascomycete sp. 1	*Pteridium aquilinum* (A)
63.	Unidentified anamorphic ascomycete sp. 2	*Rhododendron tomentosum* (S)
64.	Unidentified ascomycete sp. 1	*Phragmites australis* (A)
65.	Unidentified ascomycete sp. 2	*Rhododendron tomentosum* (A)
66.	Unidentified ascomycete sp. 3	*Comarum palustre* (A)
67.	Unidentified ascomycete sp. 4	*Pteridium aquilinum* (S)
68.	Unidentified ascomycete sp. 5	*Typha latifolia* (S)

Table 1 – cont.

69.	Unidentified ascomycete sp. 6	*Typha latifolia* (S)
70.	Unidentified ascomycete sp. 7	*Pteridium aquilinum* (A)
71.	Unidentified basidiomycetous mycelium	*Sphagnum fallax* (A), *Pinus sylvestris* (A)
72.	Unidentified fungal sporomorph	*Sphagnum fallax* (A, S), *Vaccinium oxycoccos* (A, S), *Pteridium aquilinum* (A, S)
73.	Unidentified hyphopodiate mycelium	*Juncus* sp. (A)

As apparent from the Table 2, relatively high proportion of fungal taxa were recorded exclusively on one particular plant host, with highest percentages obtained for *Rhododendron tomentosum* and *Pteridium aquilinum*. It is also worth noting, that these two species hosted the highest numbers of fungal taxa.

Table 2
Number of fungal taxa obtained per plant species

Plant species	*Comarum palustre*	*Rhododendron tomentosum*	*Pteridium aquilinum*	*Sphagnum fallax*	*Epilobium palustre*	*Phragmites australis*	*Vaccinium oxycoccos*	*Eriophorum vaginatum*	*Carex nigra*	*Juncus* sp.	*Lycopus europaeus*	*Betula pendula*	*Quercus robur*
Total number of fungal taxa	11	16	12	5	2	5	8	5	6	7	3	13	7
Number of taxa found only on a given host species	7	13	9	1	0	2	5	0	4	3	0	7	4
Percent of taxa found only on a given host species (%)	63.6	81.3	75	20	0	40	62.5	0	66.7	42.9	0	53.8	57.1

When comparisons between fungal communities from autumn and spring were made, taxa recorded from *Pinus sylvestris* (debris collected only in the autumn) and *Typha latifolia* (debris collected only in the spring) were omitted to avoid misjudgment. Therefore 71 fungal taxa were compared and in both seasons the number of specific taxa was almost equal (tab. 3). This high number of apparently season-specific fungi was also reflected in the low value of Jaccard similarity index. Shannon diversity and species evenness indices were higher for the autumn community (3.598 and 0.975, respectively, vs. 3.349 and 0.908 for spring community).

Table 3
Comparison between fungal community in autumn and spring

Season	Autumn	Spring
Total number of taxa	41	40
Number of taxa shared by both trials	10	
Shannon diversity index	3.598	3.349
Species evenness	0.975	0.908
Jaccard similarity coefficient	0.141	

Although, as mentioned earlier, the full identification of most taxa could not have been completed, we have recorded several interesting micromycetes which could have been classified at least to the genus level with certainty. Two of them

appeared to be known only from rather incidental findings and, according to our knowledge (Mułenko et al. 2008; search in all volumes of Acta Mycologica; free search in Google Scholar), are new to Poland, and therefore described below in more detail.

Dicranidion sp. Fig. 1A

Orbiliaceae, Pezizomycotina

Characteristic hyaline bilobate-furcate conidia, 22.5 – 25 μm x 6 μm, borne solitary on short hyaline conidiophores arising from hyphae. Dimensions of conidiophores: 20 μm x 2.5 μm. This genus is recorded in Poland for the first time.

Host: *Rhododendron tomentosum* Harmaja

Season: Spring

The anamorphic genus *Dicranidion* comprises 12 species (*Index Fungorum* database; one additional species, *D. incarnatum* (G. W. Martin) Peak & Solheim, is denoted there under basionym as *Tetracrium incarnatum* G. W. Martin). In USDA Fungus-Host Distribution Database (Farr, Rossman 2014), there is some data on published reports for seven species, and these come from Asia (Guam, Hong Kong, India, Japan, Taiwan), South America (Argentina, Cuba), North America (Alabama, California, Canada), and South Africa. Recent reports come from Lithuania (Treigienė, Markovskaja 2003; Kutorga et al. 2013). Although the species of this genus were isolated during surveys of plant litter-inhabiting fungal communities (e.g. Matsushima 1971; Kutorga et al. 2013), the representatives of *Dicranidion* may rather exhibit predatory lifestyle like many other anamorphic *Orbiliaceae* (e.g. *Arthrobotrys*, *Monacrosporium*, *Dactylella*), as was observed by Drechsler (1934) in case of *D. dactylopaga* (Drechsler) Peek & Solheim capturing testaceous rhizopods. Our material is too scarce to try even preliminary species identification, as strong variability of conidia in some species of *Dicranidion* is known (Butterfield 1973).

Wentiomyces sp. Figs 1B, C

Pseudoperisporiaceae, Pezizomycotina

Strongly melanized, spherical perithecium with several melanized setae. Setae dichotomously branched, with blunt, digitate endings. Diameter of perithecium: 87.5 – 170 μm. Length of the setae 15 – 45 μm. No asci or ascospores were observed. This genus is recorded in Poland for the first time.

Host: *Rhododendron tomentosum* Harmaja

Season: Autumn

According to *Index Fungorum* database, this genus comprises 18 species and two subspecies (two additional species, *W. fuliginosus* (Woron.) E. Müll. and *W. hirtulus* (Speg.) E. Müll., are denoted there under basionyms, accordingly, *Antenullariella fuliginosa* Woron., and *Dimeriella hirtula* Speg.). The taxonomy of this genus is however still unclear and in need of proper revision (Barr 1997), one of the possible reasons being lack of preserved original specimen of type species, *W. javanicus* Koord. (Barr 1997), and the other – complete lack of any molecular data (NCBI database, accessed 04.01.2014). The genus includes lichenicolous fungi (Hawksworth 1980; Roux et al. 1994), as well as biotrophic (e.g. Barr 1968, 1987). According to the USDA Fungus-Host Distribution Database (Farr Rossman 2014), fungi belonging to this genus were recorded on 31 host plants (including one lichen species) from Europe (Austria, Germany, Italy, Norway, Russia, Sweden, United Kingdom), Africa (Malawi), South America (Brazil, Venezuela), North America (Canada), Asia

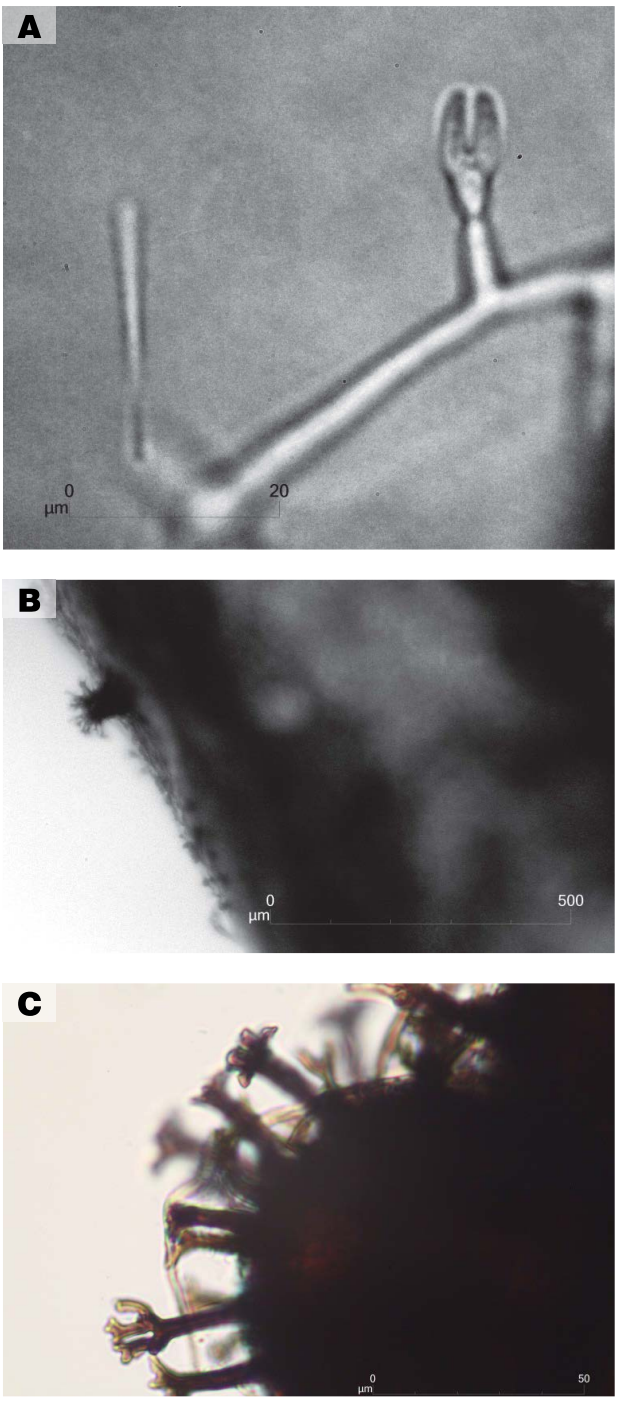

Fig. 1. Morphology of specimens representing two fungal genera new to Poland. A – *Dicranidion* sp. – bilobate conidia on short conidiophores. B, C – *Wentiomyces* sp.: B – setate perithecium on *Rhododendron tomentosum* leaf, C – details of setae.

(Brunei Darussalam, India, Myanmar) and Australia, New Zealand, and Papua New Guinea. *W. sibiricus* (Petr.) E. Müll. was recorded from *Vaccinium* sp. in Siberia and United Kingdom (Petrak 1934; Farr, Rossman 2014), and *W. oreophilus* (Speg.) E. Müll. from *Rhododendron ferrugineum* in Austria and Germany (Farr, Rossman 2014), and our finding could be conspecific with one of these species. Lack of asci and ascospores in our specimens, however, prevented any identification attempts.

DISCUSSION

Predominants. The most frequently observed taxon was *Penicillium funiculosum.* It was present on 14 substrates and mostly in the spring (13 records) (Tab. 1). However it is worth noting, that recent study made by Peltoniemi et al. (2012) which involved PCR-DGGE fingerprinting and direct sequencing of 18S rRNA of fungal communities inhabiting plant debris from peatland, showed complete absence of the genus *Penicillium* in this type of habitats. Similar results were also presented in other papers – e.g. in research employing DGGE fingerprinting of fungal communities in peat soil (Artz et al. 2007; Peltoniemi et al. 2009) or T-RLFP fingerprinting of fungal communities in soil profiles in *Pinus sylvestris* forest (Lindahl et al. 2006). While such discrepancies between results obtained from classical cultural studies of soil or litter fungi and studies involving molecular methods are generally attributable to the main disadvantage of the culturing methods, namely selectivity of media, activation of spores and favoring of fast-growing species (Artz et al. 2007; Peltoniemi et al. 2012), we feel that such differences should be less pronounced when damp-chamber method is employed, because it better reflects natural conditions (Krug 2004). The ubiquitous presence of *Penicillium* in our study is therefore even more surprising. *Penicillium funiculosum* is however reported as plant pathogen or as plant endophyte (Lim, Rohrbach 1980; Romero et al. 2001; Khan, Lee 2013) and is one of the most common species of the genus *Penicillium* (Domsch et al. 1993; Watanabe 2002). It was also noticed many times during soil fungi investigations in the Biebrza National Park (Boulahdjel 2010). Fungi from the genera *Alternaria* and *Cladosporium* are typical cosmopolitan saprotrophs which occur on a wide range of plant debris, but contain also a number of host-specific biotrophs (Domsch et al. 1993; Ellis, Ellis 1997; Crous et al. 2007; Schubert et al. 2007; Zalar et al. 2007; Bensch et al. 2010, 2012), and are commonly recorded in studies of leaf-litter mycobiota (e.g. Wong, Hyde 2001;Thormann et al. 2004). In our study these two genera were also numerous and have been recorded from 4 and 6 plant species, respectively, and in both seasons. *Monacrosporium* is a genus of well-known nematode-destroying fungi (e.g. Domsch et al. 1993), therefore its relatively high prevalence in our study (recorded from three plant hosts and both seasons) might rather be associated with the occurrence of nematodes, which inhabit the plant remains.

Season and host-specificity. The sample size was too small to make any conclusions about host or season-specificity of recorded fungi. Worth noting however is relatively high percentage of micromycetes recorded only on one particular plant host. Taking into account, that we have collected debris of plants growing often together, in close neighbourhood and on overall very small area of fen without any barriers for

dispersion, it may suggest at least some specificity of these fungi for particular plant substrate. Although with bigger sample size the differences in the numbers of "host-specific" fungal taxa recorded from investigated plant species could have been less pronounced, they nevertheless could reflect the differences in the chemical composition of the plant litter, which is known to be one of the main factors determining the mode and rate of decomposition (e.g. Aerts 1997; Strakova et al. 2011). The apparent season-specificity of many fungi in our study, as shown by the low value of Jaccard similarity index, is certainly influenced again by the small sample size, but can possibly also reflect the differences in the quality of "fresh" litter collected in the autumn, and overwintered one, collected in the spring. That could also be some explanation for the differences in the Shannon diversity and species evenness indices, with higher values for autumn communities experiencing significant supplies of fresh litter. However, these speculations require long-term ecological investigation with suitable sample size and inclusion of environmental data to be confirmed for this fungal community.

Comparison with other studies. As already mentioned in introduction, only Thormann et al. (2001, 2003, 2004) conducted surveys of fungi colonizing leaf-litter in peatland habitats, and Peltoniemi et al. (2012) investigated peatland leaf-litter fungal community with DGGE fingerprinting. However, none of these studies employed the moist chamber method for observation and isolation of fungi – isolations on synthetic media were carried out in case of Thormann's works (Thormann et al. 2003, 2004), while Peltoniemi et al. (2012) relied entirely on molecular methods. Besides, all of those studies investigated fungal communities developing during a course of decomposition examined using litter bag method.

In their study on fungi from three plant species (*Sphagnum fuscum*, *Carex aquatilis* and *Salix planifolia*) from Canadian bog and fen, Thormann et al. (2004) recorded 93 taxa, and among them many heavily-sporulating species from the genera *Penicillium*, *Trichoderma*, or *Aspergillus*, despite the application of surface sterilization procedure during isolation. Noteworthy was also relatively high prevalence of zygomycetes. Similar results were obtained by them earlier, when investigating fungi from *Sphagnum fuscum* – they have found 55 taxa (3 ascomycetes, 28 anamorphic ascomycetes, 3 basidiomycetes, 11 zygomycetes and 10 mycelia sterilia), and mostly common soil fungi (Thormann et al. 2001). Peltoniemi et al. (2012), who investigated 11 litter types from Finnish mires (and among them litter of *Eriophorum vaginatum*, *Sphagnum fallax*, and *Sphagnum fuscum*), attributed most of the obtained sequences to ascomycetes and basidiomycetes (almost equally per 40%), and the rest to chytridiomycetes (approx. 12%) and zygomycetes (approx. 6%). Such differences between those and our study (3 basidiomycetes, 13 ascomycetes, 2 zygomycetes, 43 anamorphic ascomycetes, 12 unidentified) reflect rather mainly differences in methodology. We could therefore state that results of Thormann et al. (2003, 2004) represent "potential" mycobiota, which may develop under favorable conditions (and it is interesting to note, that because of sterilization method applied, it would represent mainly fungi growing endophytically within the plant tissue). Results of Peltoniemi et al. (2012) represent "active" mycobiota (with some precautions to the use of rDNA), which in fact was present in the environment as living colonies, and our study locates somewhere in the middle, with results representing predominantly "active" mycobiota on natural

substrate, but with significant content of taxa activated under laboratory conditions.

SUMMARY

In our study 73 taxa of microfungi colonizing plant debris were recorded on debris of poor fen plants in the Torfy Lake area, and this number is well comparable with the numbers obtained in other studies on leaf-litter peatland microfungi (Thormann et al. 2003, 2004; Peltoniemi et al. 2012). Two fungal taxa recorded, *Dicranidion* sp. and *Wentiomyces* sp. appeared to be new to Poland. Moreover, we have recorded unexpectedly high numbers of potentially host- or substrate-specific taxa of fungi, however small sample number prevents us from drawing firm conclusions. Nonetheless, these results show clearly the great mycological potential of the Torfy Lake area, and confirm the attractiveness of peatland ecosystems as study sites for mycologists. In case of the Torfy Lake area, possible negative effects of the upcoming road investments raise serious concerns about the preservation status of the unique fungal communities occurring there.

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Grzyby mikroskopijne kolonizujące szczątki roślin z torfowiska przejściowego okolic jeziora Torfy (Polska Środkowa)

Streszczenie

Celem niniejszej pracy było wstępne oszacowanie różnorodności gatunkowej grzybów mikroskopijnych porastających szczątki 15 gatunków roślin występujących na torfowisku przejściowym oraz w jego najbliższej okolicy, w rejonie Jeziora Torfy, które znajduje się w pobliżu planowanej inwestycji drogowej (budowa południowej obwodnicy Warszawy – drogi ekspresowej S2). Miejsce to jest cenne przyrodniczo – występujące tam, a będące przedmiotem badań zbiorowiska roślinne ze związku *Rhynchosporion albae* są chronione na mocy Dyrektywy Siedliskowej. Na zebranych szczątkach roślinnych wykryto 73 taksony grzybów (3 Basidiomycota, 13 teleomorficznych Ascomycota, 2 Zygomycota, 43 anamorficzne Ascomycota, 12 niezidentyfikowanych). Dwa odnotowane taksony, *Dicranidion* sp. oraz *Wentiomyces* sp. są znaleziskami nowymi dla Polski. Spośród badanych gatunków roślin, najwięcej taksonów grzybów (16) odnotowano na szczątkach *Rhododendron tomentosum*, natomiast najwyższy procent taksonów grzybów „specyficznych" (tj. znalezionych tylko na danym gatunku rośliny), odnotowano na *R. tomentosum* (81,3%) oraz na *Pteridium aquilinum* (75%). Wykazano tym samym, że badane torfowisko w rejonie jeziora jest miejscem cennym nie tylko z uwagi na roślinność, ale także ze względu na różnorodność i specyficzność występujących tam zbiorowisk grzybów.