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**MICROSCOPIC FUNGI OF THE LITTORAL ZONE
IN SELECTED WATER BODIES
OF THE POJEZIERZE BOBOLICKIE LAKELAND
AND THE RÓWNINA GRYFICKA PLAIN**

**GRZYBY MIKROSKOPIJNE LITORALU
WYBRANYCH ZBIORNIKÓW WODNYCH POJEZIERZA BOBOLICKIEGO
I RÓWNINY GRYFICKIEJ**

Abstract: The occurrence of parasitic fungi colonising the vegetation in the littoral zone of selected water bodies (two intrafield ponds, a class I lake and a class III lake) was studied in the period between 2006 and 2008. The study area comprised the Pojezierze Bobolickie lakeland and the Równina Gryficka plain. A total of 64 plant species partly immersed in water or overgrowing the land were examined. The material was colonised by 90 species of fungi and fungi-like organisms. Anamorphic fungi predominated. The greatest number of fungi was represented by fungi of the genera *Septoria* and *Phyllosticta*. Only five species (*Cladosporium* sp., *Leptosphaeria caricis*, *Puccinia caricina*, *P. dioicae* and *Sphaerellopsis filum*) occurred in the littoral zones of all the water bodies. The majority of fungi observed in the study (63 % of species) were common in Europe while 33 species were identified as rare. Fungal species recorded in the study did not pose a pathogenic threat to crop plants. Diversified numbers of species found in individual water bodies resulted from the diversified species composition of the vegetation. Agrotechnical and chemical treatment conducted in adjacent fields and directly in the littoral zone of the water bodies considerably influence the species composition of fungi of intrafield ponds.

Keywords: fungi, parasitic fungi, *Ascochyta*, *Coniothyrium*, *Kuehneola*, *Leptosphaeria*, *Paraphaeosphaeria*, *Phaeosphaeria*, *Phyllosticta*, *Puccinia*, *Sphaerellopsis*, *Septoria*, *Stagonospora*, *Carex*, *Juncus*, Bobolice, Gościno, lake intrafield, intrafield pond, oligotrophic

The biological classification system of lakes is based on water productivity and distinguishes oligotrophic, mesotrophic and eutrophic lakes depending on nutrient richness and oxygen content. Oligotrophic reservoirs are low in mineral content and in organic substances in bottom sediments, and have well-oxygenated waters [1]. Water

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bodies in Pomerania are mostly of this type [2]. Several protected species (eg *Lobelia dortmanna* and *Isoetes lacustris*) occur in the littoral zone of such lakes while plants typical of eutrophic water bodies (eg *Acorus calamus*, *Phragmites australis*, *Typha angustifolia* or *T. latifolia* [3]) are not observed in them.

The composition of intrafield ponds depends on the condition of groundwaters in the drainage basin. Such ponds are often polluted with heavy metals [4–8], undergo devastation or backfilling and disappear following drainage. This leads to disturbances in the ecological balance of adjacent areas [9–13]. The species composition of the vegetation surrounding intrafield ponds varies while the number of species depends on the width of the zone around the pond [14, 15]. However, all communities occurring in such areas are characterised by a small surface and zonality of occurrence [15].

Habitat conditions favourable for the formation and dispersal of fungal spores are recorded near lakes and ponds. Water bodies are usually formed in terrain depressions; air humidity is increased there and plant density is high. However, plants of intrafield ponds are susceptible to pesticides, including fungicides and herbicides, used for cereal crops. This considerably influences the composition of plants and fungi in such habitats. Oligotrophic lakes, on the other hand, occur in areas outside agricultural production, often in forests, where plants and fungi are not similarly affected by anthropopressure.

The aim of the study was to determine the number of fungal species colonising the vegetation of intrafield ponds and class I and class III lakes and to compare the taxonomic structure of the organisms identified in the study.

Material and methods

Investigations were conducted in the vicinity of the villages of Porost (Pojezierze Bobolickie lakeland) and Goscino (Rownina Gryficka plain) from 2006 until 2008. An oligotrophic lake (lake Jezioro Piekielko near Porost), a class III lake (lake Jezioro Kamienica near Goscino) and two intrafield ponds connected by a small watercourse (situated near Porost) were selected for analysis. Leaves and stems of plants with pathological changes (leaf spots, chlorosis, wilting, outgrowths, oozing) and aetiological changes (an evident layer of mycelium and fungal sporulation) were used as the study material. The vegetation both partly immersed in water and overgrowing the land (up to 10 m from the lake shore) was examined.

Plant fragments were collected, transported to the laboratory, conserved and analysed. Small fragments of pathological tissues were cut out with a safety razor and cut into small strips. They were placed in a drop of lactic acid on a microscopic slide and covered with a cover slip. A microscopic analysis was conducted two days after slide preparation. Parasitic and saprotrophic fungi were identified using the size, structure and colour of the fruitbodies and spores.

Keys and guides [16–19] were used to determine the species. Fungi were identified and their occurrence was defined based on studies and monographs [20–25]. The systematics of fungi was accepted after Hawksworth et al [26] and only the previous division into the orders *Moniliales*, *Melanconiales* and *Sphaeropsidales* was retained for anamorphic fungi. The nomenclature of fungi was standardised and given after

Mulenko et al [25]. The plant material was deposited as a herbarium at the Department of Plant Protection, West Pomeranian University of Technology, Szczecin.

Only lists of fungi and brief descriptions of them are provided in previous publications reporting preliminary results of studies into fungi colonising selected intrafield ponds and lakes [27–29].

Results and discussion

The study material consisted of 64 plant species. Of them, 27 species were collected around the intrafield ponds, 33 species were collected in the littoral zone of lake Jezioro Piekielko and 20 species were collected in the littoral zone of lake Jezioro Kamienica. Species of the families *Cyperaceae* and *Poaceae* dominated among hosts, and *Carex* was the most frequently examined genus. Two species of fungi also served as hosts.

The study material was colonised by a total of 90 species of fungi and fungi-like organisms (FLO). Anamorphic species dominated among the taxa (63 species; 70 % of fungi) while representatives of *Oomycota* were the smallest group (4 species; 4.4 %). The greatest number of fungi identified in the study represented the order *Sphaeropsidales* (42 species; Table 1) and the smallest number represented the orders *Pythiales* and *Leotiales* (one taxon each).

Table 1

The species structure of fungi at individual study sites

Fungi	Lake Jezioro Kamienica	Lake Jezioro Piekielko	Intrafield ponds	Total
<i>Peronosporales</i>	2	1	—	3
<i>Pythiales</i>	1	—	—	1
<i>Erysiphales</i>	—	1	2	3
<i>Leotiales</i>	—	—	1	1
<i>Pleosporales</i>	3	8	3	9
<i>Uredinales</i>	4	5	7	10
<i>Moniliales</i>	3	8	5	15
<i>Melanconiales</i>	1	4	1	6
<i>Sphaeropsidales</i>	11	19	19	42

The fungi belonged to 41 genera. The greatest number of genera (28) represented anamorphic fungi while the smallest (3) – *Oomycota* and *Basidiomycota*. The genera *Septoria* and *Phyllosticta* were represented by the greatest number of species (12 taxa each).

Only two taxa were classified as polyfagous saprotrophs (*Alternaria alternata* and *Cladosporium* sp.). They colonised hosts belonging to different plant families in the study area. One taxon (*Sphaerellopsis filum*) was a hyperparasite commonly recorded in Poland [30, 31]. It colonised aecia of rusts and caused the destruction of aeciospores.

The vegetation overgrowing the ponds shores was colonised by 38 fungal species. Twenty four taxa were collected in the vicinity of lake Jezioro Kamienica and 46 taxa near lake Jezioro Piekielko.

Anamorphic fungi dominated in the littoral zone of the water bodies (Fig. 1). They constituted between 57 % of organisms recorded near lake Jezioro Kamienica and 67 % near lake Jezioro Piekielko. Fungi of the phylum *Ascomycota* had a higher percentage occurrence near lake Jezioro Piekielko (20 %) and a lower percentage occurrence near lake Jezioro Kamienica (13 %). The highest share of *Basidiomycota* was recorded near the intrafield ponds (18 %) and the smallest near lake Jezioro Piekielko (11 %). Fungi-like organisms of the phylum *Oomycota* occurred only in the littoral zone of lakes Kamienica and Piekielko, and were 13 % and 2 % of fungi identified in the study, respectively.

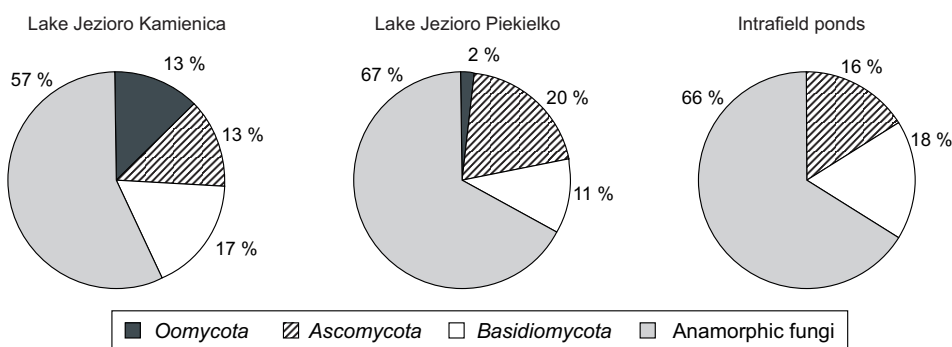


Fig. 1. The taxonomic structure of species of fungi and FLO recorded in the littoral zone of the lakes

Fungi of the order *Sphaeropsidales* predominated in the water bodies (Table 1). The smallest number of species (one taxon each) represented the orders *Melanconiales* and *Pythiales* in lake Jezioro Kamienica, the orders *Peronosporales* and *Erysiphales* in lake Jezioro Piekielko, and the orders *Leotiales* and *Melanconiales* in the intrafield ponds.

Cladosporium sp., *Leptosphaeria caricis*, *Puccinia caricina*, *P. dioicae* and *Sphaerolopsis filum* were fungal species collected in the littoral zone of all the water bodies. *L. caricis*, *P. caricina* and *P. dioicae* colonised leaves of many species of the genus *Carex* causing their frequent occurrence at the study sites. *S. filum* parasitized in aecia of *P. dioicae* and *P. caricina*.

Fungi of the genus *Septoria* (7 species) were the most numerous group of fungi recorded near lake Jezioro Piekielko although the genus *Stagonospora* (6 species) also had a relatively high number of representatives. Representatives of the genus *Puccinia* (4 species) predominated near lake Jezioro Kamienica and of the genus *Phyllosticta* near the intrafield ponds (7 species).

The occurrence frequency of fungi identified in the study in Poland was determined using *A preliminary checklist of micromycetes in Poland* [25]. The analysis showed that the majority of fungi recorded in the plant material (57 species; 63 % of the taxa) commonly occur in Poland. Thirty three species were classified as rarer taxa (recorded

at 1–3 sites in Poland), including *Ascochyta tussilaginis* (An*), *Coniothyrium psammae* (An), *Hendersonia culmiseda* (An), *Kuehneola uredinis* (B), *Leptosphaeria juncina* (A), *Massarina arundinacea* (A), *Paraphaeosphaeria michotii* (A), *Phaeosphaeria caricis* (A), *P. nigrans* (A), *Phyllosticta caricina* (An), *Septoria bresadoleana* (An), *S. rumicis* (An), *Stagonospora caricinella* (An) and *St. innumerosa* (An; *symbols: A – Ascomycota, B – Basidiomycota, An – anamorphic fungi). The majority of taxa rarer in Poland were recorded on plants of the genus *Carex*.

The occurrence frequency of the majority of fungi in the study material was high. Representatives of the genera *Puccinia* and *Stagonospora* were the most widespread organisms. Fungi colonising wild-living plants or their ornamental varieties only were the largest group; they did not pose a pathogenic threat to crop plants.

Fungi colonising the water bodies were characterised by a high biodiversity. The number of their taxa was always higher than that of hosts colonised by them. The taxonomic structure of fungi in the water bodies was typical of natural areas (low anthropopressure) as anamorphs predominated [11]. However, the vegetation of the intrafield ponds was colonised by a smaller number of parasitic and saprotrophic fungi than that in the littoral zone of the oligotrophic lake (Jeziro Piekielko) and higher than that in the class III lake (Jeziro Kamienica). The number of plant species forming the littoral zone most probably had the determining influence on the species composition of fungi in the reservoirs. Protective treatment conducted during agricultural production in fields adjacent to the pond or the destruction of dried plants (burning) in the spring may also have been an important factor in the case of the intrafield ponds.

Parasitic fungi colonising plants of the littoral zone were also examined in Western Pomerania [32, 33] and the Masurian Lakeland [34–36]. Anamorphic fungi always predominated at the study sites. Species of plant parasites commonly occurring in the study area were mostly recorded [36]. The greatest number of fungi near water bodies colonised plants of the genera *Phragmites* and *Carex* [33]. Water plants of the genera *Eloдея*, *Lemna*, *Nuphar* and *Potamogeton* showed the greatest resistance to fungal pathogens [36]. However, the floristic diversity of an association was not always positively correlated with the diversity of fungi colonising individual plants of the association [33]. According to Durska [35, 36], the number of biogens in the habitat influenced the biodiversity of fungi of the littoral zone. A higher number of species was recorded at sites with the substrate richer in organic content than in poor habitats. Obligatory parasites developed better on abundant and well-nourished plants while facultative parasites preferred weakened hosts [36]. Mazurkiewicz-Zapałowicz et al [33] also found a relationship between the occurrence of fungi and habitat conditions at the site, and especially the local climate and the location of the study site. Mazurkiewicz-Zapałowicz et al showed that open and airy sites were more favourable for the migration of spores than sites located in terrain depressions. The amount of light reaching the site was also important as strong insolation encouraged a more numerous occurrence of rusts and faster sporulation [36]. The structure of the host plant and the growth type also influenced the occurrence of fungi. A greater diversity of fungi was recorded on taller plants and on plants forming large clumps [33]; distinct preferences

of fungi for individual plant fragments were also shown (a different species composition of fungi was recorded on culms, stems and leaves of one plant [32]).

Conclusions

1. The number of fungal species colonising the vegetation of two intrafield ponds was lower than that of species recorded in the littoral zone of a class I lake and higher than that on plants of a class III water body.
2. The diversified composition of the vegetation overgrowing the shores resulted in a diversified number of fungi in individual water bodies.
3. The analysis of the taxonomic structure of fungi showed that anamorphic fungi predominated. This is typical of plants in natural communities.
4. Fungi colonising the vegetation of the littoral zone of the lakes and intrafield ponds did not pose a pathogenic threat to crop plants.
5. The lower biodiversity of fungi observed in the littoral zone of the intrafield ponds than in the oligotrophic lake was associated with chemical treatment conducted in cultivated fields and with the burning of plant remains.

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GRZYBY MIKROSKOPIJNE LITORALU WYBRANYCH ZBIORNIKÓW WODNYCH POJEZIERZA BOBOLICKIEGO I RÓWNINY GRYFICKIEJ

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Abstrakt: W latach 2006–2008 przeprowadzono badania nad występowaniem grzybów pasożytniczych zasiedlających roślinność litoralu wybranych zbiorników wodnych (oczka śródpolnego oraz jezior o wodach I i III klasy czystości). Teren badań obejmował Pojezierze Bobolickie i Równinę Gryficką. Badaniom poddano 64 gatunki roślin częściowo zanurzone w wodzie lub porastające ląd. Analizowany materiał zasiedlało 90 gatunków grzybów i FLO. Wśród nich dominowały grzyby anamorficzne. Największa liczba gatunków reprezentowała grzyby z rodzajów *Septoria* i *Phyllosticta*. Tylko pięć gatunków (*Cladosporium* sp., *Leptosphaeria caricis*, *Puccinia caricina*, *P. dioicae* i *Sphaerellopsis filum*) występowało równocześnie w litoralach wszystkich badanych zbiorników. Większość znalezionych grzybów (63 % gatunków) było pospolitych dla Europy, a 33 uznano za rzadkie. Rozpoznane gatunki grzybów nie stanowiły zagrożenia chorobowego dla roślin uprawnych. Powodem zróżnicowanej liczby gatunków znajdujących w poszczególnych zbiornikach był zróżnicowany skład gatunkowy roślinności. Na skład gatunkowy grzybów oczek śródpolnych duży wpływ mają zabiegi agrotechniczne i chemiczne prowadzone na przyległych polach oraz bezpośrednio w obrębie litoralu zbiornika.

Słowa kluczowe: grzyby, grzyby pasożytnicze, *Ascochyta*, *Coniothyrium*, *Kuehneola*, *Leptosphaeria*, *Paraphaeosphaeria*, *Phaeosphaeria*, *Phyllosticta*, *Puccinia*, *Sphaerellopsis*, *Septoria*, *Stagonospora*, *Carex*, *Juncus*, Bobolice, Gościno, jezioro śródpolne, oczko śródpolne, oligotroficzne