DOI: 10.2428/ecea.2012.19(12)148 ECOL CHEM ENG A. 2012;19(12):1547-1553

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FUNGAL DISEASES ON THE REED-BED VEGETATION OF THE EUTROPHIC WASOSZE LAKE

CHOROBY GRZYBOWE ROŚLINNOŚCI SZUWAROWEJ EUTROFICZNEGO JEZIORA WĄSOSZE

Abstract: In 2006–2008 occurrence of pathogenic fungi on the reed-bed vegetation of the eutrophic Wasosze lake (West Pomerania, Drawsko district, Zlocieniec subdistrict) was examined. A total of 68 species of fungi colonizing 40 species of reed-bed plants and growing in the littoral zone of the lake were identified. The greatest number of taxa (24) belonged to the Ascomycetes, constituting 35 % of all fungal species collected. A slightly smaller number of species (22) were represented by anamorphic fungi (32 %). Basidiomycetes were represented by 19 taxa (28 %). Only three fungi-like organisms belonging to *Peronosporales* (5 %) were recorded (*Bremia lactucae*, *Peronospora myosotidis* and *P. ranunculi*). Three fungal species that are hyperparasites of parasitic fungi were recorded in the plant material: *Ampelomyces quisqualis*, *Ramularia uredinis* and *Sphaerellopsis filum*.

Keywords: parasitic fungi, eutrophic lake, Wasosze, *Sphaerellopsis*, *Ramularia*, *Peronospora*, *Erysiphe*, *Puccinia*, *Septoria*, *Septoriella*, *Leptosphaeria*

The Wasosze lake is located in the West Pomerania province, Drawsko district and Zlocieniec subdistrict. It is a long, narrow and relatively shallow (mean depth 3.5 m, maximum depth 8.5 m) water body with a total area of 326.4 ha. The coast line is not varied and the lake bottom is quite level with small local depressions. The lake basin is constricted and divided into northern and southern parts. The Wasawa river, the primary tributary of the Drawa river, flows through the lake. The waters of the Wasosze lake are rich in oxygen and nutrient mineral substances (phosphorus, nitrogen). Such conditions are favourable for the development of plankton and other forms of aquatic life, especially in the summer, and inhibit mineralization processes. This leads to water body ageing and dying of living organisms (*eg* fish) as well as slime accumulation [1–2]. An improvement in the quality of lake waters, biogenic compound concentration and

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phytoplankton abundance has been observed in the last few years. An increase in water transparency and oxygenation has not been recorded.

The Wasosze lake is an indirect receiver of wastewater from the village treatment plant in Wierzchowo. Local pollution from the northern region which covers the Bobrowo village also influences the water quality of the lake. The lake is no longer intensively exploited by the tourist industry [3]. The vegetation is uniform in eutrophic lakes and usually consists of *Phragmites australis*, *Schoenoplectus lacustris*, *Typha angustifolia* and *T. latifolia*. In shoaled areas, *Schoenoplectus lacustris* is replaced by sedge vegetation (tall sedges): *Carex acutiformis*, *C. acuta*, *C. rostrata*, *C. vesicaria*, which border on willow scrub and alder forests at the lake shore [4]. Despite recent studies, the knowledge on parasitic fungi on reed-bed plants both in Poland and worldwide is relatively poor [5–23]. The aim of this study was to identify species of pathogenic fungi occurring on reed-bed plants of the eutrophic Wasosze lake.

Material and methods

Overground parts (leaves, stems, inflorescence) of reed-bed plants growing in the littoral zone of the Wasosze lake exhibiting symptoms of colonization by parasitic fungi were examined. Plants were sampled once a month from May to November between 2006 and 2008. The floristic material was determined in the laboratory [24] and the species composition of parasitic fungi occurring in the material was identified.

Parasitic fungi caused pathological symptoms (*eg* different types of leaf spot diseases and necrosis) and aetiological symptoms (*eg* white coating and rusty pustules) on overground organs of the plants. Fragments of plants with pathological changes were cut with a razor blade under a stereoscopic microscope to identify pathogens. Plant fragments were mounted in a drop of diluted lactic acid and observed under a light microscope. Observations were usually conducted after three days as lactic acid clears the structures of the fungi and host tissue. Fungi were identified using morphological features of uninfected fruitbodies or cut plant fragments with fruitbody elements [25–31]. The nomenclature of fungi and fungi-like organisms was accepted after Mulenko et al [32].

Results and discussion

Preliminary results of investigations on parasitic fungi were discussed in the study "Grzyby pasożytnicze roślinności szuwarowej eutroficznego jeziora Wąsosze" [8]. However, only the results on fungi colonizing 13 selected plant species of the genera *Carex*, *Juncus*, *Phragmites* and *Typha* were reported. They are expanded in this work and supplemented with the data on all the other plant species collected together with parasitic fungi colonising them. Forty species of reed-bed plants growing in the littoral zone of the Wasosze lake were selected for the study: *Acorus calamus*, *Alnus glutinosa*, *A. incana*, *Caltha palustris*, *Calamagrostis arundinacea*, *Carex acuta*, *C. acutiformis*, *C. rostrata*, *C. vesicaria*, *C. vulpina*, *Chrysosplenium alternifolium*, *Crepis paludosa*, *Eleocharis palustris*, *Epilobium hirsutum*, *E. pariflorum*, *Glyceria maxima*, *Iris pseudo-*

acorus, *Juncus articulatus*, *J. bufonius*, *J. compressus*, *J. effusus*, *J. inflexus*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Mentha aquaitca*, *Myosotis palustris*, *Oenanthe aquatica*, *Phalaris arundinacea*, *Phragmites australis*, *Ranunculus repens*, *Rumex hydrolapathum*, *Sagittaria sagittifolia*, *Salix fragilis*, *Schoenoplectus lacustris*, *Sium latifolium*, *Sparganium emersum*, *S. erectum*, *Stachys palustris*, *Typha angustifolia*, *T. latifolia*. A total of 68 fungal taxa were identified. These were plant pathogens traditionally considered to be fungi. *Peronosporales*, which were excluded from the kingdom *Fungi*, were the only exception. Pathogens of the genus *Peronosporales* were classified in the kingdom *Chromista* and were labelled as fungi-like organisms [33]. All fungi occurring on living organs of plants or on the mycelium of parasitic fungi were considered to be parasites in this study although they may belong to three ecological groups of parasites (obligate parasites, facultative saprotrophs, facultative parasites) based on the interaction with the host organism [34–35].

The greatest number of taxa (24) belonged to the Ascomycetes, constituting 35 % of all fungal species collected. A slightly smaller number of species (22) were represented by anamorphic fungi (32 %). Basidiomycetes were represented by 19 taxa (28 %). Only three fungi-like organisms belonging to *Peronosporales* (5 %) were recorded.

Fungi-like organisms: *Bremia lactucae*, *Peronospora myosotidis*, *P. ranunculi*.

Fungi-like organisms caused numerous, small, yellowish spots on the upper leaf surface of host plants (*Crepis paludosa*, *Myosotis palustris*, *Ranunculus repens*). A fine coating of sporangia and sporangiophores formed on the lower leaf surface at the site of the spots. Despite excellent environmental conditions (high humidity) favourable for their occurrence, *Peronosporales* constituted the smallest percentage of the pathogens recorded in the study (three species, 5 %). As reported in the literature, fungi-like organisms occur relatively frequently. However, pathological symptoms caused by them are difficult to notice as plants that are infected systemically, usually occur at the beginning of the vegetative season and are easy to spot. They are usually deformed, lighter in colour than healthy individuals due to a mass formation of sporangiophores on all parts of systematically infected plants, making them visible from a distance, or only on lower leaf surfaces. Later infections are usually local (for instance only leaves or other overground plant organs are infected) and their symptoms are usually difficult to notice [27, 36–37].

Ascomycetes: *Blumeria graminis*, *Claviceps microcephala*, *Epichloë typhina*, *Erysiphe aquilegiae* var. *aquilegiae*, *E. aquilegiae* var. *ranunculi*, *E. biocellata*, *E. cynoglossi*, *E. galeopsidis*, *E. heraclei*, *E. lythri*, *E. polygoni*, *Leptosphaeria caricina*, *L. culmifraga*, *L. sparganii*, *Metasphaeria cumana*, *Phaeosphaeria caricis*, *P. culmorum*, *P. eustoma*, *P. juncina*, *P. typharum*, *Paraphaeosphaeria michotii*, *P. vectis*, *Phyllachora junci*, *Sphaerotheca epilobii*.

Ascomycetes were diagnosed from 26 host plant species: *Acorus calamus*, *Caltha palustris*, *Calamagrostis arundinacea*, *Carex acuta*, *C. acutiformis*, *C. rostrata*, *C. vesicaria*, *C. vulpina*, *Epilobium pariflorum*, *Glyceria maxima*, *Iris pseudoacorus*, *Juncus effusus*, *Lythrum salicaria*, *Mentha aquaitca*, *Myosotis palustris*, *Oenanthe aquatica*, *Phalaris arundinacea*, *Phragmites australis Ranunculus repens*, *Rumex*

hydrolapathum, *Schoenoplectus lacustris*, *Sium latifolium*, *Sparganium emersum*, *Stachys palustris*, *Typha angustifolia*, *T. latifolia*

As many as ten species of the 24 ascomycetes collected were causal agents of powdery mildew (*Blumeria graminis*, *Erysiphe aquilegiae* var. *aquilegiae*, *E. aquilegiae* var. *ranunculi*, *E. biocellata*, *E. cynoglossi*, *E. galeopsidis*, *E. heraclei*, *E. lythri*, *E. polygoni*, *Sphaerotheca epilobii*). The fungi formed a distinctive, white coating of the mycelium and conidial germination on overground plant parts. Causal agents of powdery mildew had a high tolerance to habitat conditions. They preferred moderate temperature and precipitation. They also infected plants during droughts as fungal spores contained a considerable amount of water (55–75 %) and could germinate without a drop of water. Spores of most pathogenic fungi germinate only in a drop of water as water content in their spores rarely exceeds 20 % [38]. Other ascomycete species formed highly numerous, small black spots on overground plant parts (mostly on stems and leaves). *Epichloë typhina* and *Claviceps microcephala* were the only exceptions. The former developed a yellowish-orange coating on culms of *Calamagrostis arundinacea* while the latter was recorded in reed inflorescences where it formed small sclerotia. Other species formed globose fruitbodies such as perithecia (*Epichloë typina* and *Phyllachora junci*) or pseudothecia (*Leptosphaeria caricina*, *L. culmifraga*, *L. sparganii*, *Metasphaeria cumana*, *Phaeosphaeria caricis*, *P. culmorum*, *P. eustoma*, *P. juncina*, *P. typharum*, *Paraphaeosphaeria michotii*, *P. vectis*) in pathological tissue fragments.

Basidiomycetes: *Melampsora epitea*, *Melampsoridium betulinum*, *Puccinia calthae*, *P. caricina* var. *caricina*, *P. chrysosplenii*, *P. coronata*, *P. dioicae* var. *dioicae*, *P. iridis*, *P. limosae P. magnusiana*, *P. menthae*, *P. scirpi*, *Pucciniastrum epilobii*, *Tolyposporium junci*, *Urocystis ranunculi*, *Uromyces rumicis*, *Ustilago filiformis*, *U. grandis*, *U. striiformis*.

Basidiomycetes were represented by 19 fungal species (28 % of all species). They were collected from 20 host plant species: *Alnus glutinosa*, *A. incana*, *Caltha palustris*, *Carex acuta*, *C. acutiformis*, *C. vesicaria*, *Chrysosplenium alternifolium*, *Epilobium hirsutum*, *Glyceria maxima*, *Iris pseudoacorus*, *Juncus bufonius*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Mentha aquaitca*, *Phalaris arundinacea*, *Phragmites australis*, *Ranunculus repens*, *Rumex hydrolapathum*, *Salix fragilis*, *Schoenoplectus lacustris*. Rusts dominated and were represented by 14 species (*Melampsora epitea*, *Melampsoridium betulinum*, *Puccinia calthae*, *P. caricina* var. *caricina*, *P. chrysosplenii*, *P. coronata*, *P. dioicae* var. *dioicae*, *P. iridis*, *P. limosae P. magnusiana*, *P. menthae*, *P. scirpi*, *Pucciniastrum epilobii*, *Uromyces rumicis*). They formed elongated, light-brown pulverulent uredinia on the lower leaf surface. Elongated, fine, black thelia developed on the lower leaf surface slightly later. Smuts represented five species (*Tolyposporium junci*, *Urocystis ranunculi*, *Ustilago filiformis*, *U. grandis*, *U. striiformis*). They caused the formation of black agglutinated (*T. junci*) or pulverulent (*U. grandis*) spore masses at the infection site. Only *Tolyposporium junci* was recorded in the inflorescences of the plants. Other species were observed on culms and leaves. Smut infections can cause considerable plant underdevelopment and deformation, and can inhibit plant growth [10, 21, 28, 31, 36].

Anamorphic fungi: *Ampelomyces quisqualis*, *Asteroma alnetum*, *Cladosporium* spp., *Marssonina betulae*, *Mascostroma innumerosum*, *Passalora montana*, *Phyllosticta caricis*, *Ramularia calthae*, *R. didyma*, *R. lysimachiae*, *R. rumicis*, *R. uredinis*, *Septoria caricis*, *S. epilobii*, *S. lysimachiae*, *Stagonospora elegans*, *S. junciseda*, *S. paludosa*, *Septoriella junci*, *Sphaerellopsis filum*, *Stagonospora caricis*, *Tubercularia vulgaris*.

Anamorphic fungi were represented by 22 species, which constituted 32 % of all fungi. They were recorded on 18 host plant species: *Alnus glutinosa*, *A. incana*, *Caltha palustris*, *Carex vesicaria*, *C. vulpina*, *Eleocharis palustris*, *Epilobium hirsutum*, *E. pariflorum*, *Juncus articulatus*, *J. bufonius*, *J. compressus*, *J. inflexus*, *Lysimachia vulgaris*, *Mentha aquaitca*, *Phragmites australis*, *Ranunculus repens*, *Rumex hydrolapathum*, *Salix fragilis*, *Sparganium erectum*,

Anamorphic fungi formed either numerous and fine black spots with conidiomata embedded in the tissue (acervulus or picnidium) or a coating consisting of conidiophores and conidiospores [25–26, 39] on overground parts of the plants. Only *Tubercularia vulgaris* on dying and wooded organs of *Alnus incana* developed orange mycelium masses with sporodiocha. A mass production of conidiospores inside spordiocha was observed. A mass release of conidiospores was recorded especially in humid weather [40–41]. Three fungal species that are hyperparasites of parasitic fungi were recorded in the plant material: *Ampelomyces quisqualis*, *Ramularia uredinis* and *Sphaerellopsis filum*. Hyperparasites can limit the occurrence of their hosts by colonising and destroying the mycelium, oidia, uredinia and aecia of pathogens. A frequent occurrence of hyperparasites was observed in the studies on the presence of parasitic fungi on reed-bed plants. As literature data show, some hyperparasites of Uredinales can reduce rusts by up to 98 % in experimental conditions [7, 42–46].

Conclusions

Reed beds play an important role as natural filters in the process of self-purification of water, especially from pollution such as fertilizers or plant protection agents arriving from adjacent fields. Pathogenic fungi can contribute to the weakening and dying of the reed-bed vegetation. Some fungal species, so called hyperparasites, can naturally reduce plant pathogens and contribute to an improvement in the developmental condition of reed-bed plants.

Acknowledgement

Studies were conducted as part of project no. N 304 064 32/2602.

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CHOROBY GRZYBOWE ROŚLINNOŚCI SZUWAROWEJ EUTROFICZNEGO JEZIORA WĄSOSZE

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Abstrakt: W latach 2006–2008 przeprowadzono badania nad występowaniem gatunków grzybów chorobotwórczych na roślinności szuwarowej jeziora eutroficznego Wąsosze (Zachodniopomorskie, gmina Drawsko, leśnictwo Złocieniec). Łącznie zidentyfikowano 68 gatunków grzybów zasiedlających 40 gatunków roślin występujących w strefie przybrzeżnej jeziora. Największa liczba taksonów (24) należała do Ascomycetes stanowiących 35 % wszystkich zidentyfikowanych grzybów. Niewiele mniejszą grupę stanowiły grzyby anamorficzne reprezentowane przez 22 gatunki (32 %). Basidiomycetes reprezentowało 19 taksonów (28 %). W trakcie badań stwierdzono obecność tylko organizmów należących do *Peronosporales* (*Bremia lactucae*, *Peronospora myosotidis* i *P. ranunculi*). Trzy gatunki grzybów reprezentowały grupę nadpasożytów: *Ampelomyces quisqualis*, *Ramularia uredinis* i *Sphaerellopsis filum*.

Słowa kluczowe: grzyby pasożytnicze, jezioro eutroficzne, Wąsosze, *Sphaerellopsis*, *Ramularia*, *Peronospora*, *Erysiphe*, *Puccinia*, *Septoria*, *Septoriella*, *Leptosphaeria*