Microscopic fungus-like organisms and fungi of the Słowiński National Park. I.

IWONA ADAMSKA¹ and JANUSZ BŁASZKOWSKI²

Department of Plant Pathology, Agricultural Academy in Szczecin
Słowackiego 17, PL-71434 Szczecin, Poland
¹iwonaadamska@interia.pl
²jblaszkowski@agro.ar.szczecin.pl


In the years 1996–1998, the occurrence of microscopic fungus-like organisms and fungi in plant associations of seven permanent plots of the Słowiński National Park, Poland, was investigated. The plant associations included Betuletum pubescentis, Betulo-Quercetum roboris, Cirsio-Polygonetum, Filipendulo-Geranietum, Myrico-Salicetum auritae, Phragmitetum australis, and Ribo nigri-Alnetum. A total of 1509 plant samples representing 272 species in 48 families were collected. Three hundred and ten species in 79 genera of fungus-like organisms and fungi were found. Most species were recognized in the warmer and more humid year 1998. The highest number of species represented mitosporic fungi, and the lowest came from the phylum Oomycota. The fungi relatively frequently found also were those of Basidiomycota. The greatest diversity of species of the microorganisms was revealed in the Cirsio-Polygonetum and Filipendulo-Geranietum plant associations.

Key words: microscopic fungus-like organisms and fungi, occurrence, Słowiński National Park.

INTRODUCTION

One of the unique and floristically richest areas of Poland is the Słowiński National Park (SNP; Ostrowski and Symonides 1994). Its uniqueness mainly results from the presence of a large number of extremely different ecosystems. There neighbour, e.g., the Baltic Sea, the Łebsko Lake, rivers, sand dunes, maritime crowberry, cup-moss and pine forests, swampy birch wood, alder carr, cyperaceous communities, and heaths. The exceptional peculiarities of SNP are active mobile dunes and deflation hollows (Piotrowska 1991). Additionally, SNP is an area of a specific climate. Winters and autumns are relatively mild, springs late, and summers short.
and not very hot. The annual temperature range is the lowest in Poland and
the relative humidity is relatively high, usually over 80%. Mean annual
precipitation is 640 mm. The growing season ranges from 200—220 days.
The most distinctive characteristic of the climate of SNP is strong winds
from the southwest, south or northwest.

The flora of SNP comprises ca. 900 species (Piotrowska 1997),
of which 41 and 11 are fully or partly protected, respectively. One hundred
and twelve plant species are included in the “Red list” of the Western
Pomerania, among which 28 are disappearing, threatened or rare taxa for
Poland (Piotrowska, Żukowski and Jackowiak 1997).

The knowledge of microscopic saprotrophic and parasitic fungus-like
organisms and fungi of above-ground parts of plants of SNP is exceptionally
poor, being represented by only two reports. Dominik (1963) found
Phoma inconspicua Speg. on Drosera intermedia growing in a deflation
hollow located between the Łebsko Lake and the Baltic Sea and Vermicula-
riella elymi Oudem. associated with Elymus arenarius colonizing maritime
dunes placed near Łeba. Adamska et al. (1999) presented results of
introductory investigations on microscopic saprophytic and parasitizing
fungus-like organisms and fungi of this area, which, however, constituted
a small part of the results included in this paper. Other literature data
inform of the occurrence of macromycetous fungi (Bujakiewicz 1986;
fungi (Błaszkowski 1993, 1995; Tadych and Błaszkowski 2000), Complexipes montiformis Walker emend. Yang et Korf (Tadych and Błaszkowski 2000), an ectendo- or ectomycorrhizal
fungus, and Endogone maritima Błasz., a saprotrophic or ectomycorrhizal
fungus (Błaszkowski, Tadych and Madej 1998).

The aim of this 2-part work is to present the results of a 3-year
investigation on the occurrence of microscopic saprophytic and parasitic
fungus-like organisms and fungi found in seven natural plant associations of
SNP. Part I presents the physical, biotic, and soil chemical properties of the
permanent plots selected, as well as numeral and species composition of
the microorganisms revealed in a particular plant associations.

MATERIALS AND METHODS

Study site. The investigations were conducted in seven perma-
nent plots with natural vegetation of SNP (54°38’—54°46’N,
17°03’—17°03’—17°33’E; Fig. 1). The area of each plot was 400 m². The plant
associations of the plots were determined according to the Braun-Blan-
quet method (1964) and classified after Matuszkiewicz (1984).
Plant species were recognized after Szafer, Kulpzyski and Pawloowski (1969). Nomenclature of plants is that of Mirek et al. (1995).

Plot 1. A site adherent to the southern bank of the Gardno lake. Its plant association was Phragmitetum australis with the dominant species Phragmites australis forming dense standings.

Plot 2. A site adherent to the northeastern part of the Gardno lake harbouring the Betulo-Quercetum roboris plant association with dominating Quercus robur. The trees occurring less frequently were Betula pendula and Fagus silvatica. The undergrowth layer was mainly formed by Quercus robur and Betula pendula. Sorbus aucuparia and Fagus silvatica also occurred frequently. The ground flora was dominated by Deschampsia flexuosa, Holcus mollis, and Dactylis glomerata. The plants frequently present also were Milium effusum, Majanthemum bifolium, Polygonatum multiflorum, and Oxalis acetosella.

Plot 3. A site located ca. 1 km south of the Dolgie Male lake with the plant association Betuletum pubescens and the dominant Betula pubescens. The plants frequently present also included Betula pendula and Alnus glutinosa. The undergrowth is dominated by Betula pubescens and Salix aurita occurs more infrequently. In the ground flora, Calamagrostis canescens and Molinia caerulea predominated and bryophyta had a high participation.
Plot 4. A site located ca. 0.5 km east of the Dolgie Duże lake and covered by the *Ribo nigri-Alnetum* plant association. The dominant plant species was *Alnus glutinosa*, and *Betula pendula* occurred infrequently. *Alnus glutinosa* dominated in the undergrowth, and the ground flora mainly consisted of *Dryopteris spinulosa* and bryophyta. The plants frequently recorded were *Carex elongata*, *Lysimachia vulgaris*, *Galium palustre*, and *Calamagrostis canescens*.

Plot 5. A site placed ca. 3 km west of Czołpino. Its plant association was *Myrico-Salicetum auritae* with the dominant species *Salix aurita*. *Myrica gale* and *Salix cinerea* also frequently occurred. The plants frequently present in the ground flora were *Calamagrostis canescens*, *Lysimachia vulgaris*, and *Comarum palustre*. A layer of bryophyta was good developed.

Plot 6. A site placed ca. 2 km north of Kluki. Its plant association was *Cirsio-Polygonetum* with no dominating species. The plants very numerousy occurring were *Festuca pratensis*, *Poa pratensis*, *Deschampsia caespitosa*, *Polygonum bistorta*, *Geum rivale*, *Cirsium oleraceum*, and *Rumex acetosa*.

Plot 7. A site located ca. 2 km south of Gać. The dense *Filipendulo-Geranietum* plant association contained many specimens of *Filipendula ulmaria*, *Lythrum salicaria*, *Cirsium palustre*, *Epilobium hirsutum*, and *Urtica dioica*. Collection of samples. In each year, samples of diseased plants were collected three times, i.e., in July, August and September.

Isolation and identification of fungus-like organisms and fungi. The fungi forming pycnidia, perythecia, and apothecia were identified based on morphological properties of their intact frutbodies and sections cut from them. Plant samples with disease symptoms not harbouring fungal structures or associated with immature developmental stages of these microorganisms were placed in damp chambers to initiate or prolong development and sporulation. Saprophytic species were cultured on agar media, mainly on Potato Dextrose Agar (Difco laboratories). The microorganisms revealed were identified according to *Barrett and Hunter* (1999), *Braun* (1987), *Ellis* (1971, 1976), *Kochman* and *Majewski* (1970, 1973), *Majewski* (1977, 1979), *Sutton* (1980), and *Vánky* (1994).

The microorganisms found only in a mitomorphic stage were classified to particular phyla having considered the properties of their meiomorphic stages given by *Hawksworth et al.* (1995).

Soil physical and chemical properties. Soil physical and chemical properties were determined based on 21 soil samples randomly collected from the seven permanent plots considered (3 samples from each site). The parameters determined were bulk density, pH (in H₂O), N—NO₃, P, K, Ca, Mg, Cl, Na, KCl (in g KCl l⁻¹), the contents of humus and organic C (%).
Climatic conditions. Compared with the 1951—1980 mean temperature of SNP (Table 1), the mean annual temperature of the years 1997—1998 was higher by 0.7 and 0.6°C, respectively. April of 1996 and 1998 was warmer by 1.6 and 2.7°C, respectively, but colder by 0.6°C in 1997, when compared with the mean temperature of 1951—1980. May was colder in 1996 and 1997 by 0.6 and 0.1°C, respectively, and warmer in 1998 (by 2.4°C). The temperature of June of 1997 and 1998 was higher by 0.8 and 0.5°C, respectively, and lower by 0.4°C in 1996. July of 1996 and 1998 was colder by 1.6 and 0.9°C, respectively, but warmer by 0.6°C in 1997. In 1996 and 1997, August was warmer by 0.6 and 2.9°C, respectively, and colder by 1.2°C in 1998. September of 1997 and 1998 was warmer by 1.3 and 0.6°C, respectively, but colder by 2.4°C in 1996. The mean temperatures of October of 1997 and 1998 compared with the long-term mean 1951—1980 was lower by 0.7 and 0.6°C, respectively; October of 1996 was relatively warmer by 0.3°C.

Table 1
Air temperature and rainfalls in the Słowinski National Park in the years 1996—1998 compared with averages of these parameters of the years 1956—1980

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature (°C)</th>
<th>Rainfalls (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monthly average of the years</td>
<td>Deviation from the average of the years 1951—1980</td>
</tr>
<tr>
<td>I</td>
<td>-1.2</td>
<td>-2.8</td>
</tr>
<tr>
<td>II</td>
<td>-1.2</td>
<td>-3.9</td>
</tr>
<tr>
<td>III</td>
<td>1.3</td>
<td>-0.4</td>
</tr>
<tr>
<td>IV</td>
<td>5.1</td>
<td>6.7</td>
</tr>
<tr>
<td>V</td>
<td>9.6</td>
<td>9.0</td>
</tr>
<tr>
<td>VI</td>
<td>14.2</td>
<td>13.8</td>
</tr>
<tr>
<td>VII</td>
<td>16.4</td>
<td>14.8</td>
</tr>
<tr>
<td>VIII</td>
<td>16.4</td>
<td>17.0</td>
</tr>
<tr>
<td>IX</td>
<td>13.2</td>
<td>10.8</td>
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<tr>
<td>X</td>
<td>8.9</td>
<td>9.2</td>
</tr>
<tr>
<td>XI</td>
<td>4.4</td>
<td>4.9</td>
</tr>
<tr>
<td>XII</td>
<td>0.9</td>
<td>-2.4</td>
</tr>
</tbody>
</table>

Statistical analyses. The populations of microorganisms revealed in the seven plant associations were compared following the calculation of Jaccard’s coefficient of similarity ($Q$):

$$Q = \frac{c}{a + b - c} \times 100,$$

where: $a$ – number of species in one of the plant association compared, $b$ – number of species in the second plant association, $c$ – number of species common in both plant associations.

RESULTS AND DISCUSSION

During the three years of investigation of the occurrence of microscopic fungus-like organisms and fungi in SNP, a total of 1509 plant samples representing 272 species in 48 families were collected. The plant families most frequently examined were the Asteraceae (with 45 species), followed by the Poaceae (41), Fabaceae (25), Rosaceae (16), and Polygonaceae (14). The plant species most frequently studied were Agropyron repens (59 times) and Taraxacum officinale (32).

In the seven permanent plots, a total of 310 species in 79 genera of fungus-like organisms and fungi were found (Adamska et al., in press). Most species were recognized in 1998, and least in 1996 (Table 2). The vegetative period of 1998 was relatively warmest and most humid in the 3-year study and therefore promoted the development, sporulation, and dissemination of spores of the microorganisms investigated (Cook 1979). It also favored the vitality of plants and, thereby, the obligate biotrophs of the orders Erysiphales and Uredinales frequently associated with them (Alexopoulos, Mims and Blackwell 1996).

The highest number of species comes from mitosporic fungi, and the lowest from the phylum Oomycota. The fungi relatively frequently found also were those of Basidiomycota, among which species of the order Uredinales dominated (84; 84.8% of all species of this phylum). Mitosporic fungi most numerously occur in summer and autumn (Daniłkiewicz 1987; Durška 1974; Muženko 1988a); in this study, affected plants were collected in summer. Three main reasons may explain the high participation of fungi of the Basidiomycota found: (1) a good adaptation of the dominant fungi of the order Uredinales to a wide range ecological conditions (Majewski 1971, 1977; Muženko 1988a; Romaszewska-Salata 1977), (2) usually frequent and abundant occurrence of members of Basidiomycota independently of the vegetative season (Cook 1979), and (3) the low incidence of hyperparasites of Basidiomycota; only infrequent occurrence of Ascochyta graminicola (= Eudarluca caricis) on spores of fungi of Uredinales.
was found. The infrequent records of members of Oomycota probably resulted from the lack of sampling of plants in spring, i.e., in the period being especially conductive to the appearance of these microorganisms (Alexopoulos et al. 1996; Cook 1979). Longer and more frequent sampling could also increase the number of species of Ascomycota (constituting 25.6% of the microorganisms recognized), as from suggestions of, e.g., Truszkowska (1960) and Truszkowska and Chlebicki (1983) result. The relatively low participation of ascomycetous fungi may have also resulted from that SNP is an area of a low level of air contamination. According to Dynowska and Wnorowska (1999), decreasing air contamination retards the development of fungi of the order Erysiphales that dominated among the members of Ascomycota found.

Table 2
The number of species of fungus-like organisms and fungi found in seven plant associations of the Slowiński National Park in the years 1996–1998

<table>
<thead>
<tr>
<th>Years</th>
<th>Plant associations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pa</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Oomycota</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0</td>
</tr>
<tr>
<td>1997</td>
<td>0</td>
</tr>
<tr>
<td>1998</td>
<td>0</td>
</tr>
<tr>
<td>Ascomycota</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2</td>
</tr>
<tr>
<td>1997</td>
<td>5</td>
</tr>
<tr>
<td>1998</td>
<td>4</td>
</tr>
<tr>
<td>Basidiomycota</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2</td>
</tr>
<tr>
<td>1997</td>
<td>2</td>
</tr>
<tr>
<td>1998</td>
<td>6</td>
</tr>
<tr>
<td>Mitosporic fungi</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2</td>
</tr>
<tr>
<td>1997</td>
<td>3</td>
</tr>
<tr>
<td>1998</td>
<td>4</td>
</tr>
</tbody>
</table>

Explanations: Pa — Phragmitetum australis, M-Sa — Myrico-Salicetum auritaec, B-Qr — Betulo-Quercetum roboris, C-P — Cirsio-Polygonetum, Bp — Betuletum pubescantis, F-G — Filipendulo-Geranietum, Rn-A — Rhigo nigri-Alnetum

The greatest diversity of species of Oomycota, Basidiomycota, and the group of mitosporic fungi were revealed in the Cirsio-Polygonetum association. Although the highest species diversity of ascomycetous fungi occurred in Filipendulo-Geranietum, relatively high number of species of these fungi was also recognized in Cirsio-Polygonetum. The Cirsio-Polygonetum and
Filipendulo-Geranietum associations harbour dense and many-species plant communities. The higher species diversity of plants growing in dense communities, the more diverse populations of microorganisms (Cook 1979). The plant associations listed above also contained many complementary plant host species enabling members of Uredinales to realize their full developmental cycle (Kucmielz 1973, 1976; Alexopoulos et al. 1996).

Fungi of the Phragmitetum australis plant association

In Phragmitetum australis, eight species in 6 plant families were examined. Most species belonged to the Poaceae (3). In this site, only 22 fungal species were found (Table 2). No member of Oomycota was encountered. The fungal genus represented by the highest number of species was Puccinia (8 species; 36.4% of all the fungi of this site).

The plant species associated with the highest number of fungal species was Agropyron repens (8 species: Aschochyta graminicola, Epichloë typhina, Phyllachora graminis, Puccinia coronata, P. graminis, Pyrenophora graminea, Urocystis agropyri, Ustilago hrypodytes). Frequently affected plants also were Phragmites australis (by Puccinia magnusiana and P. phragmitis), Stellaria media (P. arenariae, Septoria stellariae), Iris pseudacorus (Mycosphaerella iridis), Alisma plantago-aquatica (Ramularia alismatis), and Rumex hydrolapathum (Erysiphe polygoni, Uromyces ruminis, Ramularia decipiens).

The specific fungi, i.e., found only in one plot, of this site were Mycosphaerella iridis (found on Iris pseudacorus) and Ramularia alismatis (Alisma plantago-aquatica).

The species present in the plant association considered, but infrequently occurring in the other sites examined, were Erysiphe polygoni (on Rumex hydrolapathum), Uromyces ruminis (R. hydrolapathum), and Ramularia decipiens (R. hydrolapathum).

Table 3
Similarity coefficients for fungal communities of seven plant associations of the Słowski National Park

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>P. a.*</td>
<td>100</td>
<td>8.79</td>
<td>13.54</td>
<td>11.45</td>
<td>6.08</td>
<td>9.02</td>
<td>8.39</td>
</tr>
<tr>
<td>B.-Q. r.</td>
<td>8.79</td>
<td>100</td>
<td>22.39</td>
<td>20.90</td>
<td>18.00</td>
<td>20.45</td>
<td>18.67</td>
</tr>
<tr>
<td>R. n.-A.</td>
<td>11.45</td>
<td>20.90</td>
<td>21.13</td>
<td>100</td>
<td>21.71</td>
<td>15.79</td>
<td>18.48</td>
</tr>
<tr>
<td>M.-S. a.</td>
<td>6.08</td>
<td>18.00</td>
<td>24.67</td>
<td>21.71</td>
<td>100</td>
<td>25.00</td>
<td>21.35</td>
</tr>
<tr>
<td>C.-P.</td>
<td>9.02</td>
<td>20.45</td>
<td>21.98</td>
<td>15.79</td>
<td>25.00</td>
<td>100</td>
<td>40.31</td>
</tr>
<tr>
<td>F.-G.</td>
<td>8.39</td>
<td>18.67</td>
<td>22.22</td>
<td>18.48</td>
<td>21.35</td>
<td>40.31</td>
<td>100</td>
</tr>
</tbody>
</table>

* — see Table 2
As from the similarity coefficients result (Table 3), the species composition of fungi of *Phragmitetum australis* highly differs from that of the other plant associations investigated.

In the other regions of Poland, fungi of the *Phragmitetum australis* association were earlier investigated only at the banks of water reservoirs of the Masurian Lake District (Durśka 1974) and some other sites dispersed in the whole Poland (Durśka 1969). However, both the total number of species and the number of species of particular phyla of the microorganisms identified in the Masurian Lake District were higher than those of SNP (Durśka 1974). This probably resulted from that only one such plant association was studied in SNP.

**Fungus-like organisms and fungi of the Betulo-Quercetum roboridis plant association**

In the *Betulo-Quercetum roboridis* association, 35 species in 17 plant families were examined. Most species came from the families Asteraceae (7) and Rosaceae (4).

In this site, 77 fungus-like organisms and fungi were found (Table 2). Mitosporic fungi were most frequently encountered; they represented 26 species, i.e., 33.8% of all microorganisms of this site. Only six species were from Oomycota (7.8% of all microorganisms). The fungal genera represented by the highest number of species were *Puccinia* (8 species; 10.4% of all species of this site), *Ramularia* (7; 9.1%), *Septoria* (6; 7.8%), and *Erysiphe* (6; 7.8%).

The taxa most frequently identified were *Erysiphe aquilegiae* (on *Ranunculus repens*), *E. galeopsidis* (*Galeopsis tetrahit, Lamium purpureum*), *Microsphaera alphioides* (*Quercus robur*), *Peronospora ranunculi* (*Ranunculus repens*), *Plasmopara umbelliferarum* (*Aegopodium podagrariae*), *Puccinia punctiformis* (*Cirsium arvense*), and *Sphaerotheca fusca* (*Taraxacum officinale*).

The specific species of the *Betulo-Quercetum roboridis* association included *Triphragmium filipendulae* (on *Filipendula vulgaris*), *Kabatiella microcictia* (*Polygonatum multiflorum*), *Phyllosticta aucupariae* (*Sorbus aucuparia*), *Phylllosticta hieracii* (*Hieracium laevigatum*), *Ramularia ulmariae* (F. vulgaris), *Septoria agrimoniae* (*Agrimonia eupatoria*), *Septoria mougeoti* (*Hieracium laevigatum*), *Septoria ulmariae* (F. vulgaris), and *Pucciniastraum agrimoniae* (A. eupatoria).

Of the species infrequently found in the other sites investigated, plants of the *Betulo-Quercetum roboridis* harboured *Puccinia hieracii* (*Hieracium sabaudum, H. laevigatum*), *Ramularia taraxaci* (H. laevigatum), *Septoria veronicae* (*Veronica chamaedrys*), *Urocystis anemones* (*Anemone nemorosa*), and *Urocystis ranunculi* (*Ranunculus repens*).

The communities of the fungus-like organisms and fungi coming from the *Betulo-Quercetum roboridis* association were most similar to those of *Betuletum pubescentis*, *Ribo nigr-Alnetum*, and *Cirsio-Polygonetum* (Table 3).
There are no Polish literature data on microscopic parasitic and saprophytic fungus-like organisms and fungi in the Betulo-Quercetum roboris plant association.

Fungus-like organisms and fungi of the Betuletum pubescentis plant association

Forty-three species in 21 plant families were investigated in the Betuletum pubescentis association. The plants most frequently sampled were those of the families Poaceae (7 species) and Asteraceae (4).

A total of 89 species of fungus-like organisms and fungi were recognized (Table 2). The microorganisms most frequently found were members of mitosporic fungi (33 species; 37.1% of all taxa of this site).

The fungal genera with the highest number of species were Puccinia (13 species; 14.6% of all species of this site), Septoria (11; 12.3%), Ramularia (9; 10.1%), and Erysiphe (7; 7.8%).

The species most frequently observed were Elsinöe veneta (on Rubus plicatus), Didymella applanata (R. idaeus), Erysiphe galeopsidis (Galeopsis tetrahit), E. heraclei (Anthriscus sylvestris), Puccinia chaerophylli (A. sylvestris), Puccinia graminis (Avena fatua), Coleosporium tussilaginis (Melampyrum pratense), Melampсидium betulinum (Betula pendula), and Ramularia pratensis (Rumex acetosella).

The specific species of this site were Peronospora alsinearum (present on Stellaria media), P. conglomerata (Geranium dissectum), P. violae (Viola arvensis), Didymella applanata (Rubus idaeus), Elsinöe veneta (Rubus plicatus), Erysiphe buhrii (Melandrium album), Herpotrichia juniperi (Juniperus communis), Lophodermium pinastri (Pinus sylvestris), Microsphaera ornata var. europaea (Betula pubescens), Pyrenophora avenae (Avena fatua), Exobasidium vaccinii (Vaccinium vitis-idaea), Microbotryum lychnidis-dioicae (Melandrium album), Phragmidium rubi-idaei (Rubus idaeus), Puccinia behenis (Melandrium album), P. litoralis (Sonchus arvensis), P. molinae (Molinia caerulea), Urocystis tristantis (Tridentis europaea), Ascochyta euphorbiae (Linaria vulgaris), Didymaria linariae (Linaria vulgaris), Phyllosticta leptidae (Vaccinium vitis-idaea), P. violae (Viola arvensis, V. tricolor), Pleiochaeta setosa (Lembotropis nigricans), Ramularia anthrisci (Anthriscus sylvestris), R. didyma (Ranunculus bulbosus), R. lapsanae (Lapsana communis), Septoria betulina (Betula pubescens), S. galeopsidis (Galeopsis tetrahit), and S. silenicola (Melandrium album).

Of the species infrequently occurring in the areas studied, plants of the Betuletum pubescentis association hosted Erysiphe orontii (Linaria vulgaris, Viola arvensis), Mycosphaerella epilobii-montani (Epilobium montanum), Sphaerotheca fugax (Geranium dissectum), Puccinia arenariae (Melandrium album), P. violae (Viola tricolor), Ramularia geranii (G. dissectum), Ramularia lactea (Viola arvensis, V. tricolor), Septoria epilobii (Epilobium montanum), and S. geranii (G. dissectum).
Except for the community of microorganisms coming from *Phragmites australis*, all the others were similar to each other (Table 3).

In Poland, there is lack of data on the occurrence of microscopic saprophytic and parasitic fungus-like organisms and fungi in *Betuletum pubescentis*.

**Fungus-like organisms and fungi of the Ribo nigri-Alnetum plant association**

In *Ribo nigri-Alnetum*, 61 species in 24 plant families were examined. The plants most frequently studied were those of the *Asteraceae* (9 species) and *Poaceae* (6).

A total of 85 species of fungus-like organisms and fungi were identified (Table 2). Most species came from Basidiomycota (31; 36.5% of all microorganisms of this site), and least from Oomycota (6; 7.1%).

The fungal genera comprising the highest number of species were *Puccinia* (17 species; 20.0% of microorganisms of this site), then *Septoria* (8; 9.4%), *Erysiphe* (8; 9.4%), and *Ramularia* (5; 5.9%).

The species most frequently observed were *Erysiphe cichoracearum* var. *cichoracearum* (on *Lapsana communis*), *E. galeopsis* (Galeopsis tetrahit), *Sawadaea tulasnei* (*Acer platanoides*), and *Phragmidium bulbosum* (*Rubus plicatus*).

The specific species of this site were *Peronospora gei* (on *Geum rivale*), *P. niessleana* (*Allaria petiolata*), *P. urticae* (*Urtica dioica*), *Erysiphe knautiae* (*Succisa pratensis*), *Microsphaera syringae* (*Syringa vulgaris*), *Nectria cinnabarina* (*Ribes* sp.), *Phyllactinia guttata* (*Carpinus betulus*), *Sphaerotheca morsuvae* (*Ribes nigrum*), *Melampsora allii-fragilis* (*Salix fragilis*), *Phragmidium violaceum* (*Rubus plicatus*), *Puccinia angelicae* (*Angelica sylvestris*), *P. bromina* (*Bromus hordeaceus*), *P. Fergussonii* (*Viola palustris*), *P. poarum* (*Tussilago farfara*), *Urocytis violae* (*Viola palustris*), *Uromyces inaequaltus* (*Silene inflata*), *Ustilago grandis* (*Phragmites australis*), *Cercospora tragopogonis* (*Tragopogon pratensis*), *Pestalozziella subsessilis* (*Geranium palustre*), *Ramularia lamii* (*Galeopsis tetrahit*), *Septoria diedickei* (*Galeobdolon luteum*), *S. senecionis* (*Senecio sp.*), and *Stenella subsanguinea* (*Maianthemum bifolium*).

Of the species infrequently encountered in the other areas investigated, plants of *Ribo nigri-Alnetum* hosted *Albugo tragopogonis* (*Tragopogon pratensis*), *Erysiphe orontii* (*Veronica montana*), *E. polygoni* (*Rumex conglomeratus*), *Peronospora ranunculi* (*Ranunculus auricomus*), *Puccinia hysterium* (*Tragopogon pratensis*), *P. punctata* (*Geum rivale*), *P. menthae* (*Mentha longifolia*), *Septoria scabiosicola* (*Succisa pratense*), *Sphaerotheca aphanis* var. aphanis (*Alchemilla monticola*, *Comarum palustre*), and *S. balsaminae* (*Impatiens noli-tangere*).

The species composition of the microorganisms associated with plants of *Ribo nigri-Alnetum* most resembled that of *Betulo-Quercetum roboris*, *Betuletum pubescentis*, and *Myrico-Salicetum auritae* (Table 3).
The Ribo nigri-Abnetum association along with that of Sphagno squarroso-Abnetum belongs to the group of the Carici elongatae-Abnetum associations (Matuszkiewicz 1984), whose microscopic fungus-like organisms and fungi were investigated in Poland by Danilkiewicz (1982, 1987), Majewski (1967, 1971), and MULENKO (1988a, b). The total number of species found in this study most resembled that determined in the Łęczyńsko-Włodawskie Lake District (MULENKO 1988a). The species composition of members of the order Peronosporales of SNP was most similar to that of the valley of the middle Bug river (Danilkiewicz 1987). The species diversity of fungi of the order Erysiphales in SNP was lower only compared with that of the Łęczyńsko-Włodawskie Lake District (MULENKO 1988a). The highest species richness of fungi of the order Uredinales was found in SNP. The species diversity of members of the order Ustilaginales in the sites compared was similar. In contrast, decidedly most members of mitosporic fungi were harboured by plants of SNP.

Fungus-like organisms and fungi of the Myrico-Salicetum auritae plant association

In Myrico-Salicetum auritae, 61 species in 26 plant families were examined. Most plant species were of the families Asteraceae (9), Poaceae (7), and Salicaceae (6).

A total of 100 species of fungus-like organisms and fungi were identified (Table 2). The species most frequently found were members of Basidiomycota (34 species; 34.0% of all microorganisms of this site) and mitosporic fungi (32; 32.0%). Five species came from Oomycota (5.0%).

The fungal genera represented by the highest number of species were Puccinia (18 species; 18.0% of all microorganisms of this site), Septoria (10; 10.0%), Ramularia (6; 6.0%), Erysiphe (6; 6.0%), and Melampsora (6; 6.0%).

The taxa most frequently recovered included Plasmopara umbelliferarum (on Aegopodium podagraria), Rhytisma acerinum (Acer platanoides), Erysiphe cichoracearum var. cichoracearum (Lapsana communis), E. depressa (Arctium lappa), E. pisi var. pisi (Lupinus luteus), Microsphaera albitoides (Quercus petraea), Puccinia arenariae (Cerastium sylvaticum), and Marssonina rosae (Rosa canina).

The specific species of this site were Peronospora trifolii-avensis (found on Trifolium arvense), Diplocarpon rosae (Rosa canina), Podosphaera myrtillina var. myrtillina (Vaccinium myrtillus), Rhytisma acerinum (Acer platanoides, A. pseudoplatanus), Sawadaea bicornis (Acer campestre, A. negundo), Sphaerella depazaeformis (Oxalis acetosella), Sphaerotheca pannosa (Rosa canina), Venturia populina (Populus tremula), Melampsora amygdalinae (Salix triandra), M. caprearum (S. caprea), M. larici-pentandrae (Salix pentandra),
M. larici-populina (Populus nigra), Phragmidium mucronatum (Rosa canina), P. tuberculatum (Rosa canina), Puccinia limosae (Lysimachia vulgaris), P. magelhaenica (Arrhenatherum elatius), P. opizii (Carex spicata), Uromyces ficariae (Ficaria verna), Cercospora chaerophylli (Chaerophyllum hirsutum), C. euphrasii (Odontites serotina), Phyllosticta lappae (Arctium lappa), Ramularia gei (Geum urbanum), Septoria campanulae (Campanula rapunculoides), S. gei (G. urbanum), and Stagonospora arenaria (Elymus arenarius).

Of the species infrequently encountered in the other sites, the Myrico-Salicetum auritae association hosted Albugo tragopogonis (found on Tragopogon dubius), Mycosphaerella tassiana (Carex spicata), Puccinia chaerophylli (Chaerophyllum hirsutum), P. phragmitis (Rumex crispus), Uromyces striatus (Trifolium arvense), Ovularia sphaeroidea (Lotus corniculatus, Vicia sativa), and Septoria scabiosicola (Knautia arvensis).

Only the species composition of microorganisms of the Phragmitetum australis and Betulo-Quercetum roboris associations markedly differed from that of Myrico-Salicetum auritae (Table 3).

In Poland, no studies of the occurrence of fungus-like organisms and fungi in the Myrico-Salicetum auritae association was earlier conducted.

Fungus-like organisms and fungi of the Cirsio-Polygonetum plant association

In the Cirsio-Polygonetum association, 103 species in 26 plant families were investigated. The plant families most frequently sampled were the Poaceae (19 species), Asteraceae (15), and Fabaceae (14).

A total of 129 species of fungus-like organisms and fungi were recognized (Table 2), among which mitosporic fungi constituted the greatest part (44 species; 34.1% of all microorganisms of this site).

The fungal genera with the highest number of species were Puccinia (23 species; 17.8% of all microorganisms of this site), followed by Septoria (11; 8.5%), Erysiphe (12; 9.3%), Ramularia (11; 8.5%), Peronospora (8; 6.2%), and Uromyces (6; 4.6%).

The taxa most frequently found included Erysiphe aquilegiae var. ranunculi (on Ranunculus repens), E. cichoracearum var. cichoracearum (Lapsana communis), E. crenulata (Echium vulgare, Myosotis arvensis), E. depressa (Arctium lappa), E. heraclei (Heracleum sphondylium), E. pisi var. pisi (Melilotus alba), E. polygoni (Polygonum aviculare), E. sordida (Plantago major), Phyllachora graminis (Agropyron repens), Pseudopeziza trifolii (Trifolium pratense), Sphaerotherca fusca (Euphrasia gracilis), S. plantaginis (Plantago lanceolata), Uromyces polygoni-aviculare (Polygonum aviculare).

The specific species of this site were Ascochyta plantaginis (found on Plantago major), Cercosporidium galii (Galium saxatile), Colerua circinans (Geranium robertianum), Erysiphe convolvuli var. calystegiae (Calystegia sepium), E. crenulata (Anchusa officinalis, Echium vulgare), Leptotrochila ranunculi (Ranunculus acris), Melampsorella symphyti (Symphytum officinale),
Microsphaera vanbruntiana var. sambuci-racemosae (Sambucus racemosa), Mycosphaerella ranunculi (Ranunculus acris), Ovularia decipiens (Ranunculus repens), Peronospora agrestis (Veronica arvensis), P. de-Baryi (Urtica urens), P. meliloti (Melilotus alba), P. myosotidis (Myosotis caespitosa), P. trifoliorum (Trifolium alpestre), P. viciae (Vicia sativa), Phoma complanata (Heracleum sphondylium), Phyllosticta symphyti (S. officinale), Plasmopara epilobii (Chamaenerion angustifolium), Puccinia cerinthes-agropyrina (Myosotis arvensis, M. caespitosa), P. cnici-oleracei (Achillea millefolium), P. glechomatis (Glechoma hederacea), P. holcina (Holcus lanatus), Pyrenophora calvescens (Papaver rhoes), Ramularia plantaginis (Plantago lanceolata), R. sambucina (Sambucus nigra), Septoria crepidis (Crepis paludosa), S. gracilis (Agropyron repens), S. heracleicola (H. spondylium), Sphaerotheca macularis (Humulus lupulus), Uromyces baemulerianus (M. albus), U. polygoni-aviculare (Polygonum aviculare), and U. punctatus (Astragalus glycyphyllos).

The species infrequently occurring in the other plots were Erysiphe biocellata (found on Mentha x citrata), Mycosphaerella kiliiana (Trifolium repens), Puccinia menthae (Mentha x citrata), P. pulverulenta (Epileobium adnatum), Ramularia lactea (Viola palustris), Septoria cruciatae (Galium saxatile), S. menthae (Mentha x citrata), Sphaerotheca balsaminae (Impatiens parviflora), and S. euphorbiae (Euphorbia peplus).

The species composition of the microorganisms of the Cirsio-Polygonetum association most resembled that of Filipendulo-Geranietum (Table 3).

There are no Polish literature data on fungus-like organisms and fungi of the Cirsio-Polygonetum association.

Fungus-like organisms and fungi of the Filipendulo-Geranietum plant association

One hundred and one species in 30 plant families were sampled. The plants most frequently studied were those of the Asteraceae (18 species), Poaceae (15), and Fabaceae (13).

A total of 117 species of fungus-like organisms and fungi were found. Mitosporic fungi were most frequently encountered (38 species; 32.5% of all microorganisms of this site).

The genera comprising the highest number of species were Puccinia (18; 15.4% of all microorganisms of this site), Erysiphe (14; 12.0%), Septoria (13; 11.1%), Ramularia (7; 6.0%), and Peronospora (7; 6.0%).

The species frequently occurring in this site were Mycosphaerella epilobii-montani (present on Plantago lanceolata), Pseudopeziza trifolii (Trifolium pratense), Erysiphe artemisiae (Artemisia vulgaris), E. cichoracearum (Helianthus tuberosus, Tanacetum vulgare), E. convolvoli var. convolvoli (Convolvulus arvensis), E. galii var. galii (Galium aparine), E. sordida (Plantago major), Sphaerotheca fusca (Chamomilla suaveolens), Urocystis agropyri (Agropyron repens), Puccinia calcitrapae (Cirsium oleraceum), P. caricina
(Carex hirta), P. cyani (Centaurea cyanus), Melampsora euphorbiae (Euphorbia peplus), and Ramularia rubella (Rumex obtusifolius).

The specific species of this site included Coleosporium senecionis (present on Senecio fuchsii), Diplodina medicaginis (Medicago sativa), Erysiphe artemisiae (Artemisia vulgaris), Melampsorella Caryophylleaearum (Cerasium holosoteoides), Peronospora aestivalis (Medicago sativa), P. agrostemmatis (Agrostemma githago), P. Mayori (Vicia cracca), P. parasitica (Capsella bursa-pastoris), P. sisymbri-officinalis (Sisymbrium officinale), Phylllosticta plantaginis (Plantago lanceolata), Plasmopara leptosperma (Matricaria maritima subsp. inodora), Podosphaera clandestina var. clandestina (Crataegus monogyna), P. tridactyla var. tridactyla (Padus avium), Pseudocercosporella capsellae (Capsella bursa-pastoris), Puccinia allii (Allium porrum), P. cyani (Centaurea cyanus), Ramularia tanaceti (Tanacetum vulgare), Septoria cerastii (Cerasium holosoteoides), S. endiviae (Cichorium intybus), S. rumicis (Rumex obtusifolius), S. sisybrii (Sisymbrium officinale), S. tanaceti (Tanacetum vulgare), Uromyces lupinicolus (Lupinus luteus), and Ustilago cichorii (C. intybus).

The species present in the Filipendulo-Geranietaum association, but infrequently found in the other plots, were Diaporthe woodii (on Lupinus luteus), Erysiphe cruciferarum (Berteroa incana, Capsella bursa-pastoris, Raphanus raphanistrum, Sisymbrium officinale), Melampsora euphorbiae (Euphorbia helioscopia), Mycosphaerella epilobii-montani (Plantago lanceolata), M. podagricae (Aegopodium podagraria), M. superflua (Urtica urens), Puccinia hieracii (Cichorium intybus), P. hysterium (Tragopogon orientalis), P. punctata (Galium uliginosum), Pyrenophora bromi (Bromus inermis), Ramularia dubia (Atriplex patula), R. plantaginis (Plantago major), Septoria epilobii (Epilobium hirsutum), S. menthaceae (Menta arvensis), Sphaerotheca epilobii (Epilobium hirsutum), and S. euphorbiae (E. helioscopia).

The highest similarity in the species composition regarded the Filipendulo-Geranietaum/Cirsio-Polygonetaum comparison (Table 3).

No investigations of fungus-like organisms and fungi associated with plants of the Filipendulo-Geranietaum association were earlier conducted in Poland.

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Streszczenie