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

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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; O s t r o w s k i and S y m o n i d e s 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 (P i o t r o w s k a 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 *Vermiculariella 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 parasiting 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; Bujakiewicz and Lisiewska 1983; Hueck 1932 after Lisiewska 1983; Dominik 1952, 1963; Dominik and Pachlewski 1955; Lisiewska 1983), arbuscular mycorrhizal fungi (Błaszkowski 1993, 1995; Tadych and Błaszkowski 2000), *Complexipes moniliformis* Walker emend. Yang et Korf (Tadych and Błaszkowski 2000), an ectendo- or ectomycorrhizal fungus, and *Endogone maritima* Błaszk., 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 permanent 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 m^2. The plant associations of the plots were determined according to the Braun-Blanquet method (1964) and classified after Matuszkiewicz (1984).

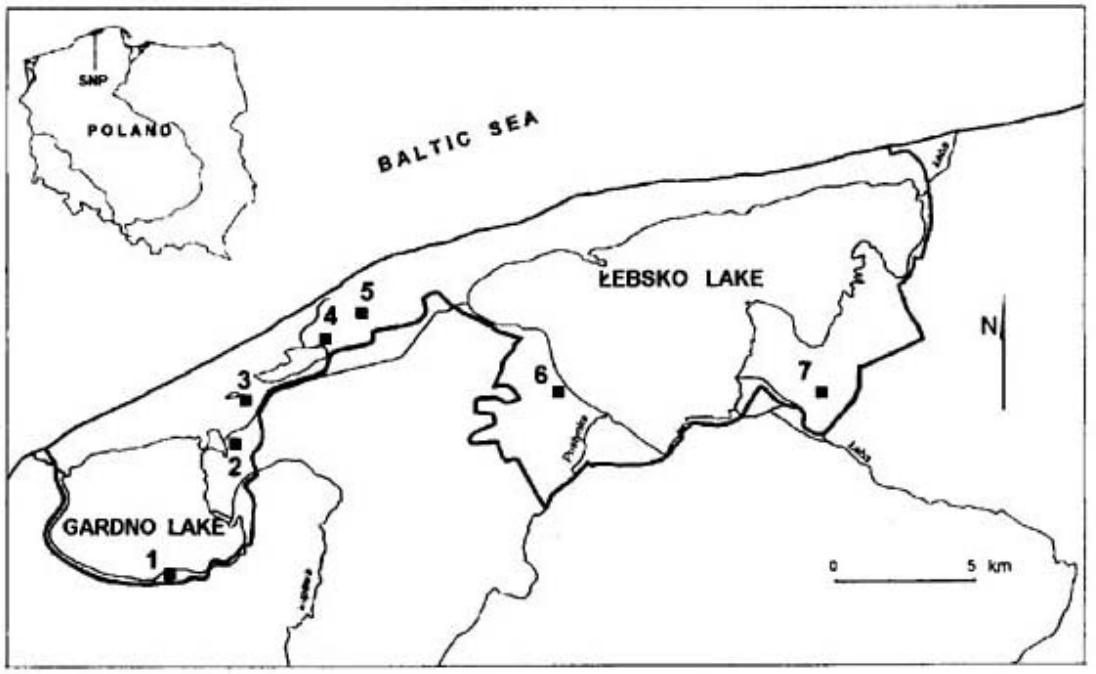

Fig. 1. Permanent plots with plant associations of the Słowiński National Park in which the occurrence of fungus-like organisms and fungi was investigated: 1 — *Phragmitetum australis*, 2 — *Betulo-Quercetum roboris*, 3 — *Betuletum pubescentis*, 4 — *Ribo nigri-Alnetum*, 5 — *Myrico-Salicetum auritae*, 6 — *Cirsio-Polygonetum*, 7 — *Filipendulo-Geranietum*

Plant species were recognized after S z a f e r, K u l c z y ń s k i and P a w ł o w s k i (1969). Nomenclature of plants is that of M i r e k 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 Dołgie Małe lake with the plant association *Betuletum pubescentis* 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 Dołgie 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 numerously 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 Barnett 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 H_2O), $N—NO_3$, 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 Słowiński National Park in the years 1996–1998 compared with averages of these parameters of the years 1956–1980

Month	Temperature (°C)				Rainfalls (mm)			
	Monthly average of the years	Deviation from the average of the years 1951–1980			Monthly of the sum of the years	Deviation from the average of the years 1951–1980		
	1951–1980	1996	1997	1998	1951–1980	1996	1997	1998
I	−1.2	−2.8	−2.6	2.4	48	8	3	58
II	−1.2	−3.9	2.4	3.3	34	32	45	36
III	1.3	−0.4	2.9	2.0	30	6	25	43
IV	5.1	6.7	4.5	7.8	38	18	40	57
V	9.6	9.0	9.5	12.0	43	109	89	25
VI	14.2	13.8	15.0	14.7	56	27	36	101
VII	16.4	14.8	17.0	15.5	91	85	38	72
VIII	16.4	17.0	19.3	15.2	78	68	3	117
IX	13.2	10.8	14.5	13.8	74	91	91	36
X	8.9	9.2	8.2	8.3	69	58	203	133
XI	4.4	4.9	3.5	0.2	52	53	18	56
XII	0.9	−2.4	1.5	−0.4	54	19	45	56

Compared with the years 1951–1980, the sums of rainfalls in 1996 and 1997 were lower by 14% and 5%, respectively, and higher by 18% in 1998. According to the classification of Radomski (1973), the year 1996 was dry, 1997 moderate, and 1998 humid. April was very dry in 1996, moderate in 1997, and humid in 1998. June of 1996 and 1997 was dry, but very humid in 1998. July of 1996 and 1998 was moderate, but very dry in 1997. August was moderate in 1996, exceptionally dry in 1997, and humid in 1998. September was moderate in 1996 and 1997, but dry in 1998. October of 1996 was moderate, exceptionally humid in 1997, and very humid in 1998.

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 (Cooke 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 (Danilkiewicz 1987; Durska 1974; Mułenko 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; Mułenko 1988a; Romaszewska-Sałata 1977), (2) usually frequent and abundant occurrence of members of Basidiomycota independently of the vegetative season (Cooke 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 Słowiński National Park in the years 1996–1998

Years	Plant associations							
	Pa	*B-Qr*	*Bp*	*Rn-A*	*M-Sa*	*C-P*	*F-G*	Total
Oomycota								
1996	0	0	2	0	1	2	4	9
1997	0	2	1	2	2	6	3	16
1998	0	4	2	5	2	6	7	19
Ascomycota								
1996	2	11	13	10	18	15	12	51
1997	5	14	16	9	18	17	16	53
1998	4	18	15	17	14	31	26	64
Basidiomycota								
1996	2	10	5	10	8	8	7	35
1997	2	12	7	8	10	11	6	47
1998	6	14	22	25	25	28	24	83
Mitosporic fungi								
1996	2	13	11	10	14	11	14	52
1997	3	9	15	7	10	20	13	54
1998	4	9	22	16	20	27	19	71

Explanations: *Pa* – *Phragmitetum australis*, *M-Sa* – *Myrico-Salicetum auritae*, *B-Qr* – *Betulo-Quercetum roboris*, *C-P* – *Cirsio-Polygonetum*, *Bp* – *Betuletum pubescentis*, *F-G* – *Filipendulo-Geranietum*, *Rn-A* – *Ribo 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 (C o o k 1979). The plant associations listed above also contained many complementary plant host species enabling members of Uredinales to realize their full developmental cycle (K u ć m i e r z 1973, 1976; A l e x o p o u l o s 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 hypodytes*). 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 rumicis, 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 rumicis* (*R. hydrolapathum*), and *Ramularia decipiens* (*R. hydrolapathum*).

T a b l e 3

Similarity coefficients for fungal communities of seven plant associations of the Słowiński National Park

Plant association	*P. a.*	*B.-Q. r.*	*B. p.*	*R. n. A.*	*M.-S. a.*	*C.-P.*	*F.-G.*
*P. a.**	100	8.79	13.54	11.45	6.08	9.02	8.39
B.-Q. r.	8.79	100	22.39	20.90	18.00	20.45	18.67
B. p.	13.54	22.39	100	21.13	24.67	21.98	22.22
R. n.-A.	11.45	20.90	21.13	100	21.71	15.79	18.48
M.-S. a.	6.08	18.00	24.67	21.71	100	25.00	21.35
C.-P.	9.02	20.45	21.98	15.79	25.00	100	40.31
F.-G.	8.39	18.67	22.22	18.48	21.35	40.31	100

* – 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 (D u r s k a 1974) and some other sites dispersed in the whole Poland (D u r s k a 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 (D u r s k a 1974). This probably resulted from that only one such plant association was studied in SNP.

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

In the *Betulo-Quercetum roboris* 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 alphitoides* (*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 roboris* association included *Triphragmium filipendulae* (on *Filipendula vulgaris*), *Kabatiella microcticta* (*Polygonatum multiflorum*), *Phyllosticta aucupariae* (*Sorbus aucuparia*), *Phyllosticta hieracii* (*Hieracium laevigatum*), *Ramularia ulmariae* (*F. vulgaris*), *Septoria agrimoniae* (*Agrimonia eupatoria*), *Septoria mougeotti* (*Hieracium laevigatum*), *Septoria ulmariae* (*F. vulgaris*), and *Pucciniastrum agrimoniae* (*A. eupatoria*).

Of the species infrequently found in the other sites investigated, plants of the *Betulo-Quercetum roboris* 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 roboris* association were most similar to those of *Betuletum pubescentis*, *Ribo nigri-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*), *Melampsoridium 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* (*Melandium 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* (*Melandium album*), *Phragmidium rubi-idaei* (*Rubus idaeus*), *Puccinia behenis* (*Melandrium album*), *P. littoralis* (*Sonchus arvensis*), *P. moliniae* (*Molinia caerulea*), *Urocystis trientalis* (*Trientalis europaea*), *Ascochyta euphrasiae* (*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 *Phragmitetum 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. galeopsidis* (*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* (*Alliaria petiolata*), *P. urticae* (*Urtica dioica*), *Erysiphe knautiae* (*Succisa pratensis*), *Microsphaera syringae* (*Syringa vulgaris*), *Nectria cinnabarina* (*Ribes* sp.), *Phyllactinia guttata* (*Carpinus betulus*), *Sphaerotheca mors-uvae* (*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*), *Urocystis violae* (*Viola palustris*), *Uromyces inaequialtus* (*Silene inflata*), *Ustilago grandis* (*Phragmites australis*), *Cercospora tragopogonis* (*Tragopogon pratensis*), *Pestaloziella 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-Alnetum* association along with that of *Sphagno squarrosi-Alnetum* belongs to the group of the *Carici elongatae-Alnetum* associations (Matuszkiewicz 1984), whose microscopic fungus-like organisms and fungi were investigated in Poland by Danilkiewicz (1982, 1987), Majewski (1967, 1971), and Mułenko (1988a, b). The total number of species found in this study most resembled that determined in the Łęczyńsko-Włodawskie Lake District (Mułenko 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 (Mułenko 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 alphitoides* (*Quercus petraea*), *Puccinia arenariae* (*Cerastium sylvaticum*), and *Marssonina rosae* (*Rosa canina*).

The specific species of this site were *Peronospora trifolii-arvensis* (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 depazeaeformis* (*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. euphrasiae* (*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. cynoglossi* (*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*), *Sphaerotheca fusca* (*Euphrasia gracilis*), *S. plantaginis* (*Plantago lanceolata*), *Uromyces polygoni-avicularіae* (*Polygonum aviculare*).

The specific species of this site were *Ascochyta plantaginis* (found on *Plantago major*), *Cercosporidium galii* (*Galium saxatile*), *Coleroa circinans* (*Geranium robertianum*), *Erysiphe convolvuli* var. *calystegiae* (*Calystegia sepium*), *E. cynoglossi* (*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 rhoeas*), *Ramularia plantaginis* (*Plantago lanceolata*), *R. sambucina* (*Sambucus nigra*), *Septoria crepidis* (*Crepis paludosa*), *S. gracilis* (*Agropyron repens*), *S. heracleicola* (*H. sphondylium*), *Sphaerotheca macularis* (*Humulus lupulus*), *Uromyces baeumlerianus* (*M. albus*), *U. polygoni-avicularіae* (*Polygonum aviculare*), and *U. punctatus* (*Astragalus glycyphyllos*).

The species infrequently occurring in the other plots were *Erysiphe biocellata* (found on *Mentha x citrata*), *Mycosphaerella killiani* (*Trifolium repens*), *Puccinia menthae* (*Mentha x citrata*), *P. pulverulenta* (*Epilobium 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* var. *cichoracearum* (*Helianthus tuberosus, Tanacetum vulgare*), *E. convolvuli* var. *convolvuli* (*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 caryophyllacearum* (*Cerastium holosteoides*), *Peronospora aestivalis* (*Medicago sativa*), *P. agrostemmatis* (*Agrostemma githago*), *P. Mayorii* (*Vicia cracca*), *P. parasitica* (*Capsella bursa-pastoris*), *P. sisymbrii-officinalis* (*Sisymbrium officinale*), *Phyllosticta 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* (*Cerastium holosteoides*), *S. endiviae* (*Cichorium intybus*), *S. rumicis* (*Rumex obtusifolius*), *S. sisymbrii* (*Sisymbrium officinale*), *S. tanaceti* (*Tanacetum vulgare*), *Uromyces lupinicolus* (*Lupinus luteus*), and *Ustilago cichorii* (*C. intybus*).

The species present in the *Filipendulo-Geranietum* 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. podagrariae* (*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. menthae* (*Mentha arvensis*), *Sphaerotheca epilobii* (*Epilobium hirsutum*), and *S. euphorbiae* (*E. helioscopia*).

The highest similarity in the species composition regarded the *Filipendulo-Geranietum/Cirsio-Polygonetum* comparison (Table 3).

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

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Mikroskopijne organizmy grzybopodobne i grzyby Słowińskiego Parku Narodowego. I.

Streszczenie

W latach 1996–1998 badano występowanie mikroskopijnych organizmów grzybopodobnych i grzybów w zbiorowiskach siedmiu stałych powierzchni Słowińskiego Parku Narodowego. Zbiorowiskami tymi były *Betuletum pubescentis*, *Betulo-Quercetum roboris*, *Cirsio-Polygonetum*, *Filipendulo-Geranietum*, *Myrico-Salicetum auritae*, *Phragmitetum australis* i *Ribo nigri-Alnetum*. Łącznie zebrano 1509 prób roślin, które reprezentowały 272 gatunki roślin z 48 rodzin. Rozpoznano 310 gatunków z 79 rodzajów organizmów grzybopodobnych i grzybów. Najwięcej gatunków stwierdzono w cieplejszym i bardziej wilgotnym roku 1998. Najwięcej gatunków reprezentowało grzyby mitosporowe, a najmniej pochodziło z gromady *Oomycota*. Stosunkowo często również znajdywano grzyby z *Basidiomycota*. Największe zróżnicowanie gatunkowe badanych mikroorganizmów ujawniono w zbiorowiskach *Cirsio-Polygonetum* i *Filipendulo-Geranietum*.