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PHYLLOSPHERE MICROORGANISMS AND STATE OF HEALTH OF SPECIES OF *CAREX* IN THE DRAWA NATIONAL PARK

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Abstract

Studies were carried out on eight species of *Carex,* i.e. *C. acuta, C. acutiformis, C. paniculata, C. pseudocyperus, C. remota, C. riparia, C. rostrata* and *C. vesicaria,* in littoral communities around Marta and Sitno lakes in the Drawa National Park, in 2005–2006. Microorganisms were isolated from tissues with symptoms of diseases and were identified on the basis of their morphology. Fungi like organisms and fungi included 54 taxa, with none occurring epiphytically. The greatest numbers of microorganisms, i.e. 38, 13, and 12 taxa, were isolated respectively from *C. acutiformis, C. riparia* and *C. pseudocyperus*. Pucciniomycetes were represented by *Puccinia caricina* var. *caricina* and *P. dioicae* var. *dioicae*. Extensive (15–25 mm length), greyish-brown, spreading lesions with watery centres on leaves of *C. acuta* and *C. acutiformis* were colonized by *Phaeosphaeria eustoma* and *P. fuckelii*. Small (1–2 mm diameter), round, brown-coloured lesions on leaves of sedges were colonized by *Didymella proximella* and four species of *Stagonospora,* i.e. *S. anglica, S. caricinella, S. caricis* and *S. vitensis*.

Key words: *Carex*, the Drawa National Park, fungi, Oomycetes, healthiness

Introduction

The genus *Carex* (sedges) includes species which contribute to form plant communities of the *Magnocaricion* alliance. As part of the littoral zone, sedges play an important role in the processes of overgrowing the embankments of water reservoirs, land drainage and land reclamation. Since the lower surfaces of sedges are used by many fish in the family Cyprinidae (carp) to shed their eggs they are also important for the lake fishing industry.

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Fungal communities concomitant with the sedge vegetation are poorly known elements of the littoral associations. The phytopathogenic and saprotrophic micobiota contribute not only to the biodiversity of the plant associations but also to their state of health. The recognition of micobiota is particularly important in national parks where it may indicate the direction of changes occurring in the ecosystem where biological regulation (e.g. homeostasis) tends to depend only on natural processes.

Therefore, the objective of this study carried out in the Drawa National Park (DNP) was to identify the range of microorganisms colonizing species of *Carex* in relation to disease symptoms caused by them on different parts of sedge plants.

Materials and methods

Studies were carried out in two growing seasons, in 2005–2006, on eight species of *Carex*: *C. acuta* (slender tufted sedge), *C. acutiformis* (lesser pond sedge), *C. paniculata* (greater tussock sedge), *C. pseudocyperus* (cypress-like sedge), *C. remota* (remote sedge), *C. riparia* (great pond sedge), *C. rostrata* (beaked sedge) and *C. vesicaria* (blister sedge). These contribute to the plant associations around the Marta and Sitno lakes in the Drawa National Park. The sedges were collected four times each year, from June until the end of October, at chosen locations. Leaves, stems and inflorescences with visible symptoms of disease were used for mycological studies. They were surface-disinfected in 70% ethanol for 1 min rinsed three times in distilled water and incubated in sterile moist chambers at 20±2°C for 14–21 days. Microorganisms growing on plant tissues that were chlorotic, necrotic or had signs of decay were either identified directly, on the basis of their morphology and sporulation on plant tissues, or after transfer to SNA (Nirenberg 1976; KH_2PO_4 – 1 g, KNO_3 – 1 g, $MgSO_4 \cdot 7H_2O$ – 0.5 g, KCl – 0.5 g, glucose – 0.2 g, sucrose – 0.2 g, agar – 20 g, distilled water – 1 l) for incubation. Their pure cultures were obtained after single-spore isolation (Király et al. 1977). From the pure cultures microorganisms were successively identified on the basis of their morphology and sporulation on CDA, PDA, SA and MEA, according to Skirgiełło (1954), Ellis (1971), Barron (1972), Kochman and Majewski (1973), Majewski (1979), Sutton (1980), Brandenburger (1985), Borowska (1986), Kwaśna et al. (1991).

The Jaccard index (= Jaccard similarity coefficient) modified by Sörensen (Trojan 1978) was used to measure the similarity and diversity of the communities of micobiota colonizing the sedges.

Results and discussion

The phyllosphere and caulosphere of the sedges in the Drawa National Park were colonized by 54 taxa of fungi and only three taxa of Oomycetes. More than 50% of fungi were represented by Hyphomycetes (32 species). Much rarer were Ascomy-

cota (eight taxa), Sphaeropsidales (seven taxa) and Basidiomycota (four taxa). Oomycetes were represented by *Achlya* sp., *Apodachlya pyrifera* and *Pythium* sp.

The greatest species diversity was recorded on *C. acutiformis* (38 taxa of microorganisms), *C. riparia* (13 taxa) and *C. paniculata* (12 taxa). The sedges that were less or only sporadically colonized by microorganisms were *C. pseudocyperus* and *C. rostrata* (four taxa in each), and *C. remota* (one taxon).

The Jaccard-Sörensen index showed that most similarity occurred between communities of micobiota colonizing *C. acutiformis* and *C. riparia* (six species, i.e. 23.52% of microorganisms in common), *C. acutiformis* and *C. paniculata* (six species, i.e. 24.0% in common), and *C. acutiformis* and *C. acuta* (five species, i.e. 21.74% in common) (Table 1).

Table 1

Similarity between microbial communities on species of *Carex* spp. (sedges) in the Drawa National Park (%)

Number of microorganism species		38	8	12	4	13	1	4	8
	Host plant	CA	CAa	CP	CPs	CR	CRe	CRo	CV
38	CA	X	21.74	24.0	4.76	23.52	2.56	9.52	6.52
8	CAa	•	X	15.0	16.67	9.25	11.11	16.67	18.75
12	CP	•	•	X	6.25	16.00	7.69	12.50	20.00
4	CPs	•	•	•	X	11.76	20.00	12.50	16.67
13	CR	•	•	•	•	X	7.14	11.76	9.52
1	CRe	•	•	•	•	•	X	20.00	11.11
4	CRo	•	•	•	•	•	•	X	8.33
8	CV	•	•	•	•	•	•	•	X

CA – *Carex acutiformis*, CAa – *Carex acuta*, CP – *Carex paniculata*, CPs – *Carex pseudocyperus*, CR – *Carex riparia*, CRe – *Carex remota*, CRo – *Carex rostrata*, CV – *Carex vesicaria.*

Among the micobiota recorded on sedge leaves there were two rust fungi (Pucciniomycetes, Basidiomycota). The rust fungi are usually dangerous and pathogenic on plants, causing foliar infections. They form yellow-brown, often long, thick and extensive pustules filled with spores and, at the later stages in their development, leaf deformation and damage. *Puccinia caricina* var. *caricina* DC. (currant clustercup rust) was recorded on *C. acuta, C. acutiformis, C. paniculata, C. riparia* and *C. vesicaria,* and *P. dioicae* var. *dioicae* on *C. acuta* (Table 2). Both pathogens produce uredia and telia on leaves of secondary host-plants. *Puccinia caricina* var. *caricina* is the rust fungus most often recorded on sedges, which are secondary hosts of this fungus. Other results show that *P. caricina* var. *caricina* is the main pathogen of all the sedges listed above and of other sedges (Majewski 1979, Brandenburger 1985, Mułenko 1988/1989).

It should be emphasized that this is the first record of *P. caricina* var. *caricina* on *C. vesicaria* in West Pomerania and of *P. dioicae* var. *dioicae* on *C. acuta* in Poland. It

Table 2

Micobiota on leaves and stems of *Carex* spp. (sedges) around the Marta and Sitno lakes in the Drawa National Park

No.	Taxon	Marta lake		Sitno lake							
		CA	CR	CA	CAa	CP	CPs	CR	CRe	CRo	CV
1	2	3	4	5	6	7	8	9	10	11	12
1	*Achlya* sp.			+							
2	*Alternaria alternata*	+		+	+	+	+	+	+	+	+
3	*Anguillospora longissima*					+					
4	*Anthracoidea* sp.			+							
5	*Apodachlya pyrifera*	+	+								
6	*Arthrinium phaeospermum*	+	+	+							
7	*Arthrinium puccinioides*	+								+	
8	*Arthrinium sporophleum*			+							
9	*Aspergillus* sp.			+							
10	*Cephalosporium* sp.	+		+	+					+	
11	*Cercospora caricis*	+									
12	*Chaetomium globosum*						+				+
13	*Chloridium virescens* var. *chlamydosporum*							+			
14	*Cladosporium cladosporioides*	+		+		+					
15	*Cladosporium herbarum*	+	+	+				+			
16	*Didymella proximella*				+	+					+
17	*Drechslera* sp.			+							
18	*Epicoccum nigrum*	+									
19	*Fusarium incarnatum*	+		+							
20	*Fusarium oxysporum*										+
21	*Fusarium poae*	+		+		+					
22	*Fusarium sacchari*			+							
23	*Fusarium* sp.				+						
24	*Fusarium sporotrichioides*	+		+							
25	*Geotrichum candidum*	+									
26	*Gibberella avenacea*			+				+			
27	*Gliomastix murorum* var. *murorum*					+					
28	*Gliomastix* sp.	+									
29	*Helminthosporium* sp.					+					
30	*Metasphaeria cumana* f. *macrospora*			+				+			
31	*Mollisia caricina*			+							
32	*Monographella nivalis* var. *nivalis*	+									
33	*Myrothecium verrucaria*						+				
34	*Papulaspora* sp.	+									

Table 2 – cont.

1	2	3	4	5	6	7	8	9	10	11	12
35	*Penicillium expansum*		+								
36	*Periconia cookei*			+							
37	*Periconia hispidula*							+			
38	*Phaeoseptoria caricicola*			+							
39	*Phaeoseptoria vermiformis*										+
40	*Phaeosphaeria eustoma*	+		+	+						
41	*Phaeosphaeria fuckelii*	+									
42	*Phyllachora graminis* var. *graminis*										+
43	*Puccinia caricina* var. *caricina*			+	+	+		+			+
44	*Puccinia dioicae* var. *dioicae*			+							
45	*Pythium* sp.					+					
46	*Rotula graminis*		+	+	+		+				
47	*Schizonella melanogramma*					+					
48	*Septoria caricis*			+		+		+		+	
49	*Stagonospora anglica*			+							
50	*Stagonospora caricinella*	+	+	+		+					+
51	*Stagonospora caricis*			+							
52	*Stagonospora vitensis*				+						
53	*Ulocladium atrum*			+							
54	*Verticillium albo-atrum*	+		+							

CA, CAa, CP, CPs, CR, CRe, CRo, CV – see Table 1.

must be mentioned that, exceptionally, only *C. acuta* was infected simultaneously by two species of *Puccinia*: *P. caricina* var. *caricina* and *P. dioicae* var. *dioicae* (Table 2). The latter was not recorded on *C. acutiformis* although lesser pond sedge grew in the majority of locations surveyed in the DNP and was listed as the host-plant of *P. dioicae* var. *dioicae* in West Pomerania (Mazurkiewicz-Zapałowicz et al. 2006). There was no record of *P. opizii* (Table 2), which is considered to be rather a pathogen on leaves of *C. chordorrhiza* and *C. muricata* (= *C. echinata*) (Mułenko 1988/1989, Adamska et al. 1999). There was also no record of *P. urticae-vesicariae* on *C. vesicaria* (Table 2) although the latter sedge was reported as the host-plant of this rust fungus in the littoral plant associations in the Masurian Lake District (Durska 1974). Durska (1974) also reported other rust fungi occurring on sedges, including *P. urticae-acutae* (on *C. gracilis*), *P. ribis nigri-paniculatae* (on *C. panniculata*), *P. ribesii-pseudocyperi* and *P. urticae-acutiformis* (on *C. pseudocyperus*), *P. urticae-ripariae* (on *C. riparia*) and *P. urticae-inflatae* (on *C. rostrata*). After a taxonomic revision of Uredinales (Merwe et al. 2007) all species listed by Durska (1974) belong, however, to the *P. caricina* complex. Its representatives can colonize different sedges. The area of leaf surface of sedges infected by the rust fungi never exceeded 25% and disease never reached epidemic level by the end of the growing season.

Unlike Pucciniomycetes, the Ustilaginomycetes fungi (true smut fungi) infected sedges in the DNP only sporadically (Table 2). *Schizonella melanogramma*, the only representative of the smut fungi, was recorded on *C. paniculata* (Table 2). In the literature there are no data on the *S. melanogramma–C. paniculata* association and it seems that this is the first record of *S. melanogramma* on greater tussock sedge in Poland. So far, *S. melanogramma* was reported on *C. caryophyllea, C. curvula, C. digitata, C. ericetorum, C. flacca, C. fusca, C. michelii* and *C. rigida* (Kochman and Majewski 1973, Ellis and Ellis 1985).

The very large, 15–25 mm length greyish-brown lesions with dark, sharp edges and watery centres, which were spread over the leaf surfaces of *C. acuta* and *C. acutiformis* were colonized by *Phaeosphaeria eustoma* and *P. fuckelii*. Some species of *Phaeosphaeria* cause very destructive diseases in agricultural crops. Usually they are parasitic necrotrophs, obtaining nutrients from dead cells and tissues of their host organisms. This paper presents the first records of *P. eustoma* and *P. fuckelii* on lesions of sedges. Up to now, five other *Phaeosphaeria* species, *P. caricicola, P. caricis, P. herpotrichioides* and *P. nigricans*, were reported as associated with lesions on sedges (Ellis and Ellis 1985). *Phaeosphaeria eustoma* has been recorded also on dead leaves of grasses, including *Poa* spp. (Smith 1994).

The small (1–2 mm diameter), round, brown-coloured lesions, which occurred on the leaf surfaces of *C. acutiformis, C. paniculata* and *C. vesicaria* were colonized by *Didymella proximella*. Similar lesions were also colonized, however, by *Stagonospora,* i.e. *S. anglica* (on *C. acutiformis*), *S. caricinella* (on *C. acutiformis, C. riparia, C. paniculata* and *C. vesicaria*), *S. caricis* (on *C. acutiformis*) and *S. vitensis* (on *C. acuta*). In the DNP there was no *S. gigaspora, S. macropycnidia* or *S. paludosa*, which were three out of seven species of *Stagonospora* found on sedges by Sutton (1980) and Ellis and Ellis (1985). *Stagonospora caricinella* was associated with the greatest number of sedge species and *C. acutiformis* was the host-plant for three out of four *Stagonospora* species recorded in DNP (Table 2).

This paper presents the first records of *S. caricinella* on *C. paniculata* and *C. vesicaria,* and *S. vitensis* on *C. acuta*. Neither Sutton (1980) nor Ellis and Ellis (1985) reported these associations. Differences in host-plant range and distribution of the particular pathogens can, however, result from their versatility and adjustment to climatic changes.

Conclusions

1. Oomycetes (FLO) and fungi on sedges in the Drawa National Park included 54 species, with none occurring epiphytically.

2. Rust of sedges was caused by *Puccinia caricina* var. *caricina* and *P. dioicae* var. *dioicae*.

3. Sedges with no rust infection were *C. pseudocyperus*, *C. remota* and *C. rostrata*.

4. Extensive (15–25 mm diameter), greyish-brown and watery lesions on leaves of *C. acuta* and *C. acutiformis* were colonized by *Phaeosphaeria eustoma* and *P. fuckelii*.

5. Small (1–2 mm diameter), round, brown-coloured lesions on leaves of sedges were colonized either by *Didymella proximella* or four species of *Stagonospora,* i.e. *S. anglica, S. caricinella, S. caricis* and *S. vitensis*.

6. *Stagonospora caricinella* was the species associated with the greatest number of sedge species, i.e. *C. acutiformis, C. riparia, C. paniculata* and *C. vesicaria*.

7. *Carex acutiformis* was the host-plant for three out of four *Stagonospora* species recorded in the DNP.

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Streszczenie

MIKROORGANIZMY FYLLOSFERY A ZDROWOTNOŚĆ GATUNKÓW RODZAJU *CAREX* (TURZYCE) W DRAWIEŃSKIM PARKU NARODOWYM

Badania prowadzono na ośmiu gatunkach rodzaju *Carex* (*C. acuta, C. acutiformis, C. paniculata, C. pseudocyperus, C. remota, C. riparia, C. rostrata* i *C. vesicaria*), w zbiorowiskach szuwarowych wokół jezior Marta i Sitno w Drawieńskim Parku Narodowym, w latach 2005–2006. Mikroorganizmy były izolowane z tkanek z objawami chorobowymi i identyfikowane na podstawie morfologii. Organizmy grzybopodobne i grzyby właściwe były reprezentowane przez 54 taksony. Żaden nie wystąpił epifitozyjnie. Najwięcej gatunków mikobioty, tj. 38, 13 i 12 taksonów, wyizolowano z – odpowiednio – *C. acutiformis, C. riparia* i *C. pseudocyperus*. Klasa Pucciniomycetes była reprezentowana przez dwa gatunki: *Puccinia caricina* var. *caricina* i *P. dioicae* var. *dioicae*. Rozległe, o długości 15–25 mm, szarobrunatne, w centrum wodniste plamy na liściach *C. acuta* i *C. acutiformis* były zasiedlone przez *Phaeosphaeria eustoma* i *P. fuckelii*. Okrągłe, brązowe, małe, o średnicy 1–2 mm plamy na liściach turzyc były zasiedlone przez *Didymella proximella* i cztery gatunki *Stagonospora*: *S. anglica, S. caricinella, S. caricis* i *S. vitensis*.

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