PYTHIUM SPECIES IN 13 VARIOUS TYPES OF WATER BODIES OF N-E POLAND

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ABSTRACT

Pythium species and environmental factors in various types of water bodies (2 springs, 2 rivers, 3 ponds and 6 different trophic lakes) were studied. Samples of water were collected every two months (springs, rivers, ponds) and every three months (lakes) in the years 1996-1999 for hydrochemical analysis and in order to determine the *Pythium* species content. From springs rivers and ponds collected were also ice blocks for determinations of presence of *Pythium* species. Buckwheat- and hemp-seeds, cellophane and snake exuviae were used as bait.

Forty-five species of *Pythium* were found in various types of water bodies. *Pythium acanthicum, P. complectens, P. complens, P. diameson, P. dissimile, P. elongatum, P. lucens, P. megalacanthum, P. nagae, P. oedochilum, P. oryzae, P. palingenes, P. periilum* and *P. polysporum* were recorded for the first time in Poland.

The largest mean number of species was observed in spring Cypisek, a bit fewer in spring Jaroszówka and lake Białe (oligotrophic-like waters). The lowest mean number of *Pythium* species was noted in pond Akcent and Pałacowy (polytrophic waters). In all types of water bodies the higest mean number of species was found in winter,and the lowest in summer.

KEY WORDS: fungi, *Pythium*, springs, rivers, ponds, lakes, hydrochemistry.

INTRODUCTION

Since Pringsheim (1858) described the genus *Pythium*, a number of reports have appeared on taxonomic and parasitic problems of these fungi and the related losses in plant crops (Yu and Ma 1989). A considerably smaller number of publications have been devoted to the ecology of aquatic species of this genus (Plaats-Niterink 1981). Most of them report on the occurrence of new species (Johnson 1971; Paul 1986) or already known species (Meshcheryakova and Logvinenko 1970). Only the works of Park (1977, 1980) and Park and McKee (1978) are concerned with some environmental problems which affect the growth of certain species in river ecosystems.

Therefore, we decided to carry out a three-year systematic study on species composition in 13 limnologically diverse water reservoirs from springs to lakes of different trophicity, with regard to physico-chemical data.

STUDY AREA

The following types of water bodies of northeastern Poland were investigated: two springs, two rivers, three ponds and six lakes.

- Spring Cypisek – limnokrenic type, width 0.41 m, depth 0.17 m, discharge 0.6 l/s is, localized in the N part of Białystok, single pine trees (Czeczuga and Orłowska 1996). Around the spring there are cultivated fields. The bed is covered with sand.
- Spring Jaroszówka – limnokrenic type, width 0.65 m, depth 0.12 m, discharge 2.4 l/s, is in the N part of Białystok, without trees (Czeczuga et al. 1999a). The spring is surroundel by cultivated fields. The bed is covered with sand.
- River Biała – length 9.8 km is the left-bank tributary of the Supraśl River flowing through the city of Białystok. The samples were collected from the upper course of the river, the water was the least polluted (Czeczuga and Orłowska 2000). Around the site are meadows. The bed is covered with mud.
- River Supraśl – length 106.6 km, is the right-bank tributary of the middle part of the Narew river flowing through the Knyszyńska Forest. The samples were collected from the site above the municipal swimming pool at the sluice of an arm of the Supraśl River flowing just through the town of Supraśl (Czeczuga 1996a). The site is surrounded by meadows. A muddy bed.
- Pond Akcent – area 0.45 ha, max. depth 1.50 m, with wild ducks and breeding swans. The pond is surrounded by meadows with alder (*Alnus glutinosa* (L.) Gaertn.).
- Pond Dojlidy – area 34.2 ha, max. depth 2.85 m, its south shores border with coniferous woods and its western part with the town of Białystok. The samples were collected from the western part of this pond, which is used by the town inhabitans as a beach (Czeczuga and Orłowska 2000).

The bed is covered with sand.

- Pond Pałacowy – area 2.5 ha, max. depth 1.75 m, is in the Palace Park, and contains wild ducks and breeding swans as well as crucian carp and tench bred for anglers. The pond is surrounded by meadows with linden (*Tilia cordata* Mill.) and elm (*Ulmus carpinifolia* Gled.).
- Lake Białe named Wigierskie Białe, area 100.2 ha, max. depth 34.0 m, is located in Wigierski National Park, surrounded by extensive coniferous woods of the Augustów Forest. The site for sampling was on the northern side of the lake. The bed is covered with sand. The lake is oligotrophic.
- Lake Hańcza, area 291.5 ha, max. depth 108.5 m. This lake is located in the Suwałki Scenic Park. The sampling site was on the south-eastern side of the lake near of Błaskowizna village. The site is surrounded by meadows with alder (*Alnus glutinosa* (L.) Gaertn. The bed is covered with stones. It is a typical oligo-mesotrophic lake (Czeczuga and Grądzki 1970, Czeczuga 1994).
- Lake Konopniak, area 1.73 ha, max. depth 6.7 m, is surrounded by extensive coniferous woods of the Augustów Forest. It is a small forest lake of „suchar" type. The site for sampling was on the northern part of the lake. The bank is peaty, here peaty plants appear (*Sphagnum palustre* L., *Drosera rotundifolia* L., *Vaccinium oxycoccus* L., *Eriophorum latifolium* Hoppe and *Calla palustris* L.). A muddy bed.
- Lake Leszczewek, area 21.0 ha, max. depth 6.5 m, without trees, it is typical eutrophic lake (Czeczuga et al. 2000). The lake is surrounded by cultivated fields. The bank is marshy, here such plants appear as: *Phragmites australis* (Cav.) Trin. ex Steudel, *Glyceria aquatica* (L.) Wahlb. and *Typha angustifolia* (L.). The bed is covered with mud.
- Lake Suchar Zachodni, area 1.2 ha, max. depth 2.3 m., is surrounded by extensive coniferous woods of the Augustów Forest. The bank is peaty, here peaty plants occur (*Sphagnum palustre* L., *Scheuchzeria palustris* L., *Menyanthes trifoliata* L., *Vaccinium oxycoccus* L. and *Carex nigra* L.). A muddy bed. It is a typical distrophic lake of „suchar" type (Czeczuga 1995).
- Lake Wigry, area 2118 ha, max. depth 73 m, Lake Wigry is a mesotrophic lake (Czeczuga 1979, 1991b). The site for sampling was on the Słupiańska Bay in western part of Wigry lake. The bank and the bed of this site are covered with sand.

MATERIALS AND METHODS

In order to determine the composition of *Pythium*, species were collected in the years 1996 (September) - 1999 (August). Samples of water for chemical and *Pythium* species analyses were collected every two months (springs, rivers, ponds) and every three months (lakes), from each basin always at the same site in rivers, ponds and lakes, approximately 2 m from the shore and 30 cm under the surface. Water was collected in 5-litre Ruttner bucket from depth at which the bucket was immersed. For the determination of different chemical elements in the water the methods recommended by Standard Methods (Greenberg et al. 1992) were employed. For mycological analysis the water samples from each of the sites were transported in sterile glass containers of 1.5 l capacity. Subsequently, in the mycological laboratory, they were placed in sterilized beakers (capacity of 0.6 l), to which the appropriate baits were added (buckwheat-seeds, hemp-seeds, cellophane and snake exuviae) in accordance with the general culture principles (Fuller and Jaworski 1986). The cellophane and snake exuviae were cut into small pieces and boiled several times with the water being changed each time.

For the determination of presence of ice-water *Pythium* species, the following procedure was employed: in January, ice blocks (20-25 cm thick) were collected from water bodies to sterile containers. Then, in the laboratory they were rinsed with distilled water three times and transferred to sterile dishes to melt. A part of each water was poured into previously sterilized 0.5 l beakers, 300 ml in each, and bait was added. They were placed as bait in the containers with ice water from the various reservoires. For one month, a kind of cluster from a beaker bottom, side walls and surface film of water was examined under a light microscope.

The samples were kept in the laboratory for 1 month and precautions were taken to ensure that the thermo-lighting conditions were as close as possible to those prevalent outside the laboratory. The fungi species were distinguished by their morphological features, measurements being made of the shreds oogonia, and oospores (Czeczuga 1996b). Species of *Pythium* were identified using mycological keys (Waterhouse 1967, 1968; Dick 1990). Statistical calculations were performed in order to determine the relationship between the number of fungi species at a given site and various factors in the aquatic environment. For this purpose the multiple correlation coefficient was used (Czeczuga and Próba 1987). The regression programme with a choice of variables was applied on a digital computer. The water chemistry data and aquatic fungi flora of these water bodies were processed by the average linkage method (Hugh and Gauch 1982).

RESULTS

The results of chemical analysis of water collected in June of 1998 are presented in Table 1. These are typical values for the investigated water bodies. In the case of ammonium nitrogen, nitrite nitrogen and phosphates the minium mean values were noted in lake Białe whereas for nitrate nitrogen in spring Jaroszówka. The maximum mean values of ammonium nitrogen and phosphates were noted in pond Akcent, nitrite nitrogen in river Biała and nitrate nitrogen in pond Palacowy. PH, calcium, magnesium and total iron concentrations, were found to be lowest in the lakes „suchary" type – Konopniak and Suchar Zachodni.

During the three-years of study we found 45 *Pythium* species in 13 water reservoirs, among which 14 were new to Polish hydromycology (Table 2). Such species as *P. debaryanum*, *P. inflatum* and *P. rostratum* were noted in all the reservoirs examined, while *P. butleri* was not found only in lake Wigry. The remaining species were observed in some of the water basins. A few species appeared only once and in one water reservoir within the three year period. The included *P. artotrogus* which was found in the spring months in spring Cypisek, *P. complectens* observed in pond Dojlidy in winter, *P. echinocarpum* in pond Akcent in winter, *P. lucens* in spring Cypisek in autumn, *P. nagae* in pond Pałacowy in autumn, *P. oedochilum* in the river Supraśl in winter, *P. oryzae* in pond Dojlidy in winter, *P. palingenes* in the river Supraśl in winter and *P. polycarpum* in lake Wigry in autumn. During the three-year study the largest num-

TABLE 1. Chemical properties of water in particular water bodies.

Specification	Spring		River		Ponds		
	Cypisek	Jaroszówka	Biała	Supraśl	Akcent	Dojlidy	Pałacowy
Temperature (°C)	11.0	12.0	18.5	18.0	17.5	19.5	17.0
Transparency (m)							
pH	7.78	7.86	7.61	7.88	7.77	7.42	7.61
O_2 (mg L^{-1})	8.20	9.40	9.60	9.20	2.20	7.80	3.65
BOD_5 (mg L^{-1})	3.20	5.60	3.60	5.80	1.80	2.50	0.50
COD (mg L^{-1})	4.30	5.58	10.98	7.84	12.54	12.35	22.97
CO_2 (mg L^{-1})	15.40	12.20	19.80	11.95	24.20	11.15	18.80
Alkalinity in $CaCO_3$ (mval L^{-1})	5.20	2.30	5.00	5.10	7.40	3.70	4.50
$N-NH_3$ (mg L^{-1})	0.280	0.290	0.590	0.250	3.530	0.280	0.500
$N-NO_2$ (mg L^{-1})	0.014	0.020	0.042	0.005	0.012	0.005	0.007
$N-NO_3$ (mg L^{-1})	0.080	0.010	0.050	0.070	0.090	0.060	0.900
$P-PO_4$ (mg L^{-1})	0.530	0.680	2.160	1.530	12.720	0.120	0.670
Sulphates (mg L^{-1})	55.54	19.33	32.50	20.16	89.27	30.86	39.08
Chlorides (mg L^{-1})	28.00	15.00	42.00	36.05	49.15	43.05	52.15
Total hardness (mg Ca L^{-1})	105.80	110.16	80.64	72.25	137.52	60.48	56.16
Total hardness (mg Mg L^{-1})	21.07	15.19	27.52	15.91	21.93	11.61	11.50
Fe (mg L^{-1})	0.700	0.250	0.050	0.650	0.525	0.350	0.450
Dry residue (mg L^{-1})	473.0	465.0	369.0	242.0	640.0	280.0	444.0
Dissolved solids (mg L^{-1})	461.0	354.0	360.0	222.0	606.0	261.0	433.0
Suspended solids (mg L^{-1})	12.0	111.0	9.0	20.0	34.0	19.0	11.0

Specification	Lake					
	Białe	Hańcza	Konopniak	Leszczewek	Suchar Zachodni	Wigry
Temperature	21.0	21.0	23.8	23.0	22.0	21.50
Transparency	7.15	4.55	1.45	0.75	0.55	3.95
pH	7.95	8.30	4.50	8.11	5.20	8.26
O_2	9.60	9.20	8.80	7.20	8.00	12.62
BOD_5	1.80	1.85	3.20	4.00	4.20	3.00
COD	5.10	5.60	12.80	13.05	25.22	5.65
CO_2	2.20	2.25	2.20	4.40	4.40	0.15
Alkalinity in $CaCO_3$	2.15	2.60	0.70	4.20	0.80	2.70
$N-NH_3$	0.140	0.210	0.680	0.680	1.610	0.470
$N-NO_2$	0.003	0.008	0.005	0.006	0.011	0.008
$N-NO_3$	0.025	0.020	0.085	0.045	0.080	0.045
$P-PO_4$	0.100	0.295	0.130	0.390	0.135	0.445
Sulphates	7.41	13.58	11.10	17.69	9.46	25.05
Chlorides	16.00	19.00	85.00	49.00	86.15	21.00
Total hardness	41.76	36.72	5.76	56.16	6.48	41.85
Total hardness	6.02	9.89	0.0	15.05	0.0	13.33
Fe	0.010	0.012	0.010	0.025	0.015	0.015
Dry residue	124.0	212.0	59.0	306.0	183.0	294.0
Dissolved solids	55.0	142.0	32.0	278.0	126.0	260.0
Suspended solids	69.0	70.0	27.0	28.0	57.0	34.0

bers of species were found to grow in spring Cypisek (24) the fewest in pond Akcent (13). In all types of water reservoirs the fewest species were observed in summer, the most in spring, winter or autumn. Such of the genus *Pythium* as *P. echinocarpum*, *P. oedochilum*, *P. oryzae* and *P. palingenes* were found only in the water from melting ice collected from certain reservoirs.

DISCUSSION

Of 45 *Pythium* species 14 are new not only to Polish waters but also to Polish mycology in general. The new species include *P. acanthicum*, *P. oedochilum*, *P. palingenes* and *P. periilum*, previously described by Drechsler in various ecosystems, particularly in North America (1930).

P. acanthicum was isolated in Florida from fallen fruits of *Citrullus vulgaris* L., causing their blackening. It was also encountered in other States of America (Middleton 1943). In our study, *P. acanthicum* was found to grow on baits only in lake Leszczewek in winter and in melting ice water from pond Dojlidy. *P. oedochilum* was described from deacying roots of *Dahlia* sp. in Washington. In our study it was isolated from ice water from the river Supraśl. *P. palingenes* was first isolated from the roots of *Ambrosia trifida* L. near Delaplane. We found this fungus also in melting-ice water from the river Supraśl. *P.*

TABLE 2. *Pythium* species found in particular water bodies (s – spring, sm – summer, a – autumn, w – winter, i – ice).

Species of *Pythium*	Springs		Rivers		Ponds			Lakes					
	Cypisek	Jaroszówka	Biała	Supraśl	Akcent	Dojlidy	Pałacowy	Białe	Hańcza	Konopniak	Leszczewek	Suchar Zachodni	Wigry
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
**P. acanthicum* Drechsler						i					w		
P. afertile Kanouse, Humphrey		s				i							
P. aquatile Höhnk	a	s	a, i	s, w, i		a	s		s, a				
P. aristosporum Vanterpool		w	a	i					sm	a	s, a	s	
P. artotrogus de Bary	s												
P. butleri Subramaniam	s, a, w, i	s, sm, a	s, a, i	a, w, i	a, w, i	i	s, a, i	sm, a	s	a	w	s, a	
P. carolinianum Matthews			i	i				sm					
P. catenulatum Matthews	a, w	a, w, i	s, a	a	s, i		i	a			s, a		
**P. complectens* Braun						w, i							
* *P. complens* Fischer										a		s	
P. debaryanum Hesse	s, sm, a, w	s, a, w, i	s, sm, a, w, i	s, sm, s, w, i	s, a, i	s, sm, a, w, i	s, sm, a, w, i	s, a	s, sm, a	s	w	s, sm, a	s, sm, a, w
P. diacarpum Butler	a				i	s			s	s			
**P. diameson* Sideris		i							s				
**P.dissimile* Vaartaja	sm, i	i				a		s		s			
P. dissotocum Drechsler	s	s	s	s	a			sm	s			s, a	s, w
P. echinocarpum Ito, Tokunaga					i								
P. echinulatum Matthews								s	s				s
**P. elongatum* Matthews	w				s, i		a	s			w		sm
P. gracile Schenk	w	i	s	s, w			s, i		s	sm	s	s	
P. imperfectum Höhnk	s, sm, a, w	s, sm, w	sm, w, i	s, i	w, i	s, a	a		sm				sm, a
P. indicum Balakrishnan	s, a			i			i						
P. inflatum Matthews	s, sm, a, w, i	s, sm, w	s, sm, a, w, i	s, sm, a, i	s, a, w, i	s, a, w, i	s, i	sm, a	a	s, sm	s, sm, a	a	s, w
P. intermedium de Bary	i		a			s, w, i	s, a					s, sm, a	
P. irregulare Buisman			i	i			i		sm				
**P. lucens* Ali-Shtayeh	a												
**P. megalacanthum* de Bary	s				i								
P. middletonii Sparrow		s, sm	w	s, a, i	a	s	i	s, sm	s	s, a	a		
P. monospermum Pringsheim					a							s	
P. myriotylum Drechsler	s, a, i	s, a	s, a, w, i	s, i		s, a, i	i				w	s, sm	sm
**P. nagae* Ito, Tokunaga							a						
**P. oedochilum* Drechsler				i									
**P. oryzae* Ito, Tokunaga						i							
* *P. palingenes* Drechsler				i									
P. papillatum Natthews		a		i		a							
**P. periilum* Drechsler		s, i									w		
P. polycarpum Paul													a
* *P. polysporum* Sorokin		w	i										
P. pyrilobum Vaartaja	w					i	i	a					
P. rostratum Butler	s, a, w	s, sm, a, w	s, sm, a, w, i	s, a, w, i	sm, i	s, a, w, i	s, a.i	s, a	s, a	s	s, sm	s, a	s, a, w
P. spinosum Sawada, Chen	s, w		w	a		i	s		a			a	
P. tenue Gobi			a							sm, a		a	
P. torulosum Coker, Patterson	a	a		s, i		w, i	i	s		sm	a		
P. ultimum Trow	s	a						s, sm					
P. undulatum Petersen	w, i	sm				i	a, w	s, a		a		sm	s, a
P. vanterpoolii Kouyeas V, Kouveas H	s, sm, w	s, i	s, a	s, w, i		s, i	i	s, a			a		w
Total number	24: s – 13 sm – 5 a – 12 w – 14	22: s – 12 sm – 5 a – 8 w – 12	19: s – 9 sm – 4 a – 11 w – 11	21: s – 11 sm – 2 a – 7 w – 18	13: s – 4 sm – – a – 6 w – 10	21: s – 9 sm – 1 a – 8 w – 15	20: s – 8 sm – 1 a – 8 w – 13	16: s – 10 sm – 6 a – 8 w – –	15: s – 10 sm – 4 a – 5 w – –	13: s – 6 sm – 4 a – 6 w – –	14: s – 5 sm – 2 a – 6 w – 6	14: s – 10 sm – 4 a – 8 w – –	11: s – 6 sm – 4 a – 5 w – 5

* – were recorded for the first time from Poland

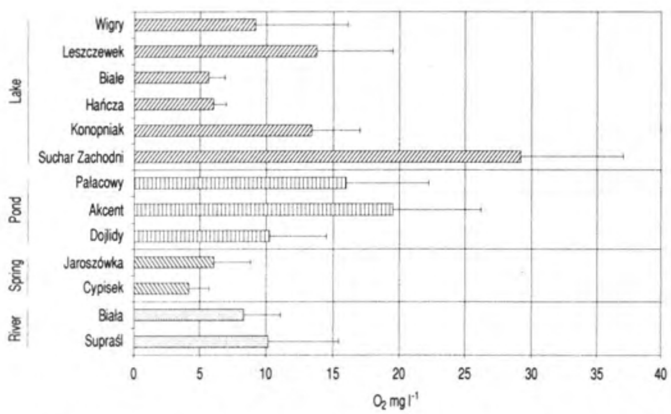

Fig. 1. Mean values of oxidability in the particular water bodies.

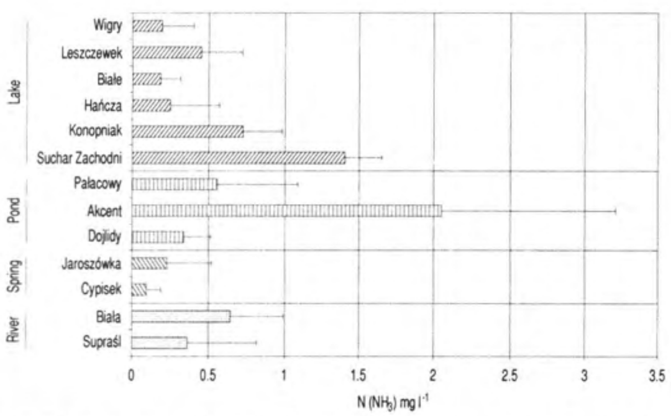

Fig. 2. Mean values of ammonium nitrogen in the particular water bodies.

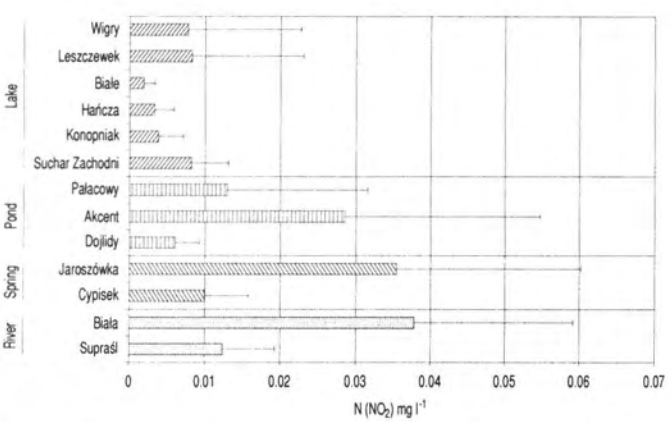

Fig. 3. Mean values of nitrate nitrogen in the particular water bodies.

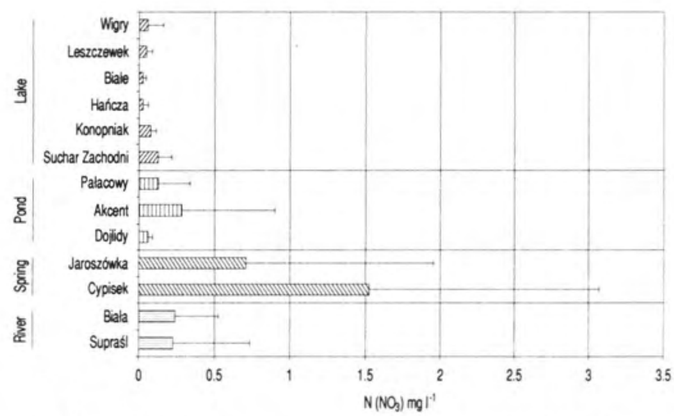

Fig. 4. Mean values of nitrite nitrogen in the particular water bodies.

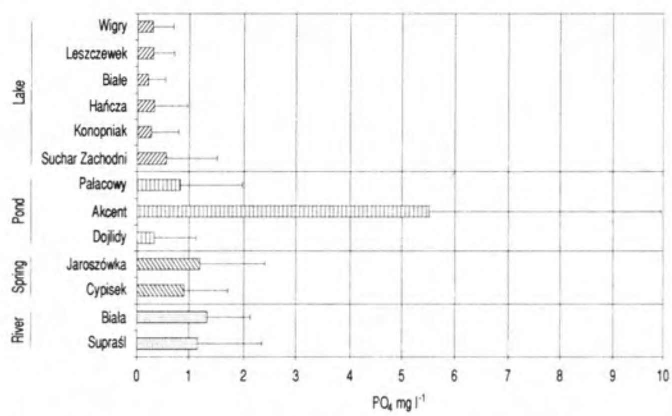

Fig. 5. Mean values of phosphates in the particular water bodies.

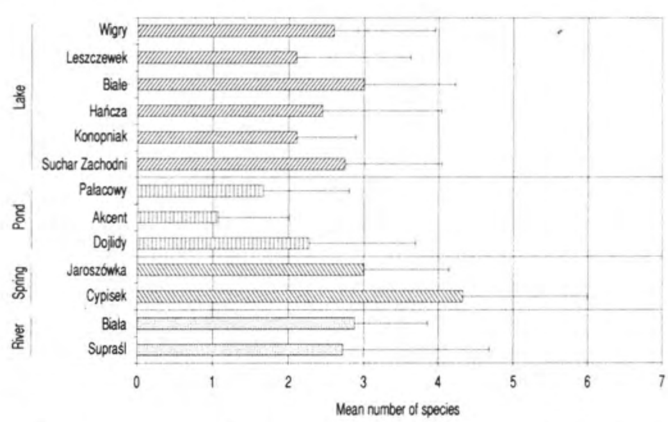

Fig. 6. Mean number of *Pythium* species in the particular water bodies.

periilum, the last fungus described by Drechsler (1930), was isolated together with *P. dissotocum* from rootlets *Saccharum officinarum* L. We observed its growth in spring months in melting-ice water collected from spring Jaroszówka and in winter from lake Leszczewek. *P. elongatum*, described by Matthews in the 30s (1931), was first isolated from sandy soil near Tabor in North Carolina. We found this fungus in different seasons of the year, also in ice from pond Akcent. *P. complectens* and *P. complens* are also new in Poland. The former was described by Braun (1924) as a parasite on *Coleus* and *Pelargonium* cuttings, the latter from water by Fischer (1982). In our study *P. complectens* was found to grow in winter in water and in melting ice in pond Dojlidy, while *P. complens* in autumn in lake Konopniak and in spring in Suchar Zachodni. *P. diameson*, also new to Polish waters, was described from diseased roots of *Ananas sativus* Ldl. (Sideris 1932). We found it in spring months in the lake Hańcza and in ice water in spring Jaroszówka. *P. dissimile*, another new species, was reported by Vaartaja (1965) from soil in South Australia. In our study this fungus was encountered in water and in melting ice from several reservoirs. *P. lucens*, never found in Poland before, was observed in spring Cypisek in autumn. *P. lucens* was first described from soil in Great Britain (Ali-Shtayeh and Dick 1985). *P. megalacanthum* described in the 19^{th} century by de Bary (1881) as a saprophyte *Lepidium*, was found in our study only in two water basins, namely in spring Cypisek in the spring months and in ice water from pond Akcent in winter. *P. nagae* and *P. oryzae* also new to Polish waters, were described in Japan (Ito and Tokunaga 1933). These two species were isolated from plantis novellis *Oryza sativa* L. We found *P. nagae* in autumn in the pond Pałacowy and *P. oryzae* in ice water in pond Dojlidy. *P. polysporum* was first isolated from dead flies in water in Russia (Sorokin 1873). In our study it appeared in winter in spring Jaroszówka and in ice water from the river Biała.

The water reservoirs included in the study differ from one another not only limnologically but also with regard to trophicity, which is manifested in the mean values of oxidability (Fig. 1), ammonium nitrogen (Fig. 2), and such biogenic elements as inorganic nitrogen (nitrates and nitrites) (Figs 3, 4) and inorganic phosphorus (Fig. 5). Of all water basins examined pond Akcent and Suchar Zachodni had the highest indices of oxidability (COD) and ammonium nitrogen. High mean oxidability was also observed in pond Pałacowy. Moreover, the mean phosphorus content was five-fold higher in pond Akcent than in other water reservoirs. Nitrates were found in the greatest amount in the two springs and pond Akcent, while nitrites in the river Biała, spring Jaroszówka and pond Akcent. In the three-year period the largest mean number of species was observed in spring Cypisek, at bit fewer in spring Jaroszówka and lake Białe. The lowest mean number of *Pythium* species was noted in pond Akcent and Pałacowy (Fig. 6).

Ponds Akcent and Pałacowy are the most polluted of all the aquatic reservoirs investigated. The abundance of organic matter in these ponds is manifested not only in a high oxidability but also by the fact that hydrogen sulphide appears in the water immediately after the ponds have become covered with ice. In summer, due to the eutrophic state, blooms of cyanobacteria are observed, mainly of *Anbaena spiroides* Klebahn, whose cells secrete substances which delimit the growth of aquatic conidial fungi (Czeczuga and Orłowska 2000). These environmental factors result in the smallest number of species of the genus *Pythium* growing in the water of these ponds. However, in the chemically purest water of Spring Cypisek, Jaroszówka and Lake Białe, with the smallest amount of organic matter, (apart from nitrates and nitrites), no blooms of cyanobacteria were observed and the largest number of *Pythium* species were found to grow. Thus, water poor in chemical substances and organic matter creates favourable conditions for species diversity of the genus *Pythium*.

The present study revealed the highest oxidability in the distrophic Lake Suchar Zachodni, where the mean number of *Pythium* species was similar to that found in oligotrophic-like types of lakes, such as Białe and Hańcza. High oxidability and a relatively small number of species were also observed in the other distrophic humus Lake Konopniak. Both distrophic lakes demonstrated large mean amounts of ammonia, thus revealing intense processes of organic matter decomposition. These forest lakes, with peat-covered shores, contain large amounts of humus compounds – hence high oxidability of their water. Humus reservoirs are known to be poor in bacterio-, phyto- and zooplankton species (Keskitalo and Eloranta 1999). This may also refer to *Pythium* species. The more so, as investigations of other zoosporic and conidial fungi carried out in humus reservoirs of a similar type showed a small number of species (Czeczuga 1995).

A comparison of nineteen physico-chemical parameters of water and of the number of species, separately for each limnological type of reservoir (springs, rivers, ponds and lakes),

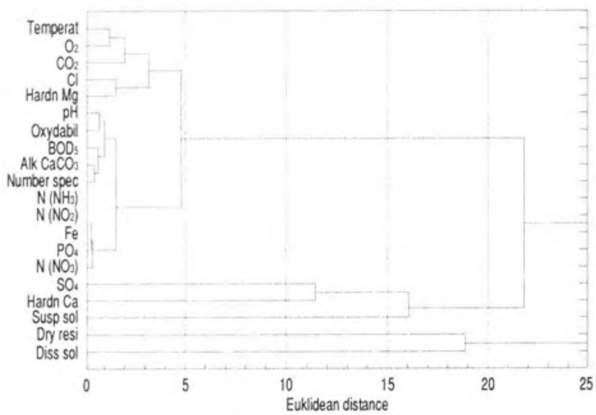

Fig. 7. Clustering of springs according of water chemistry data and to number of *Pythium* species.

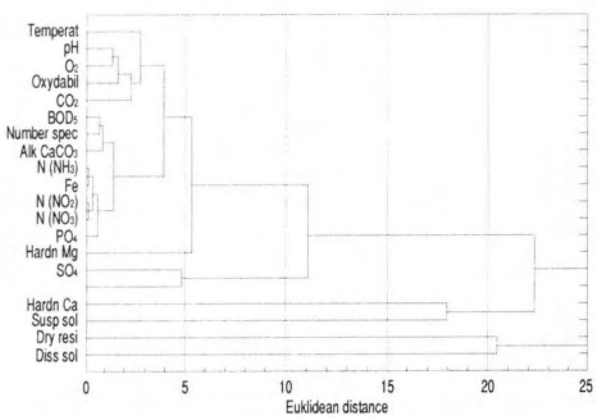

Fig. 8. Clustering of rivers according of water chemistry data and to number of *Pythium* species.

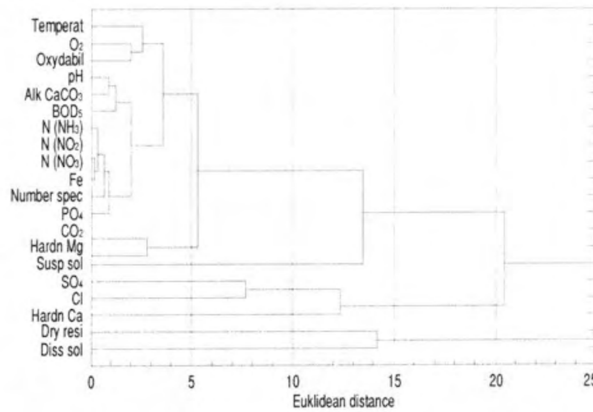

Fig. 9. Clustering of ponds according of water chemistry data and to number of *Pythium* species.

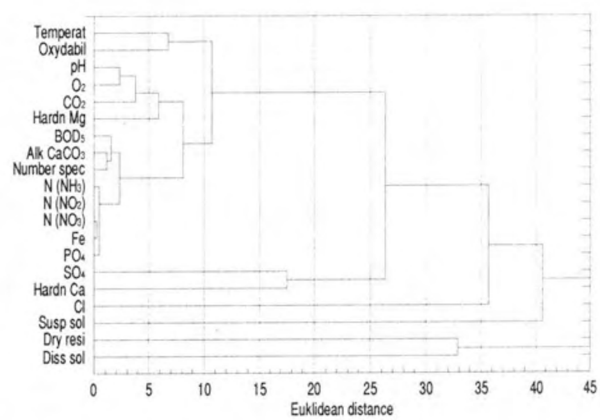

Fig. 10. Clustering of lakes according of water chemistry data and to number of *Pythium* species.

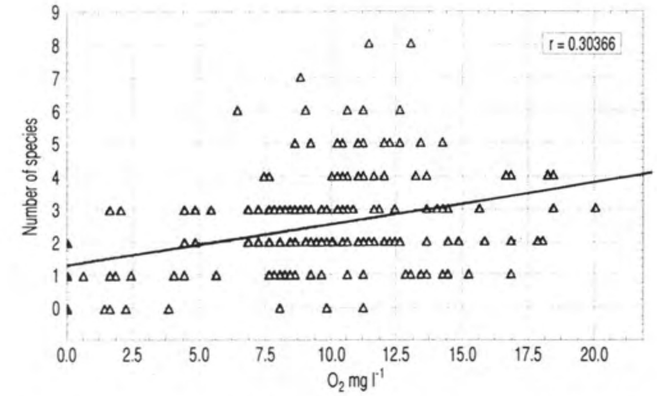

Fig. 11. Oxygen content and number of *Pythium* species in investigated water bodies.

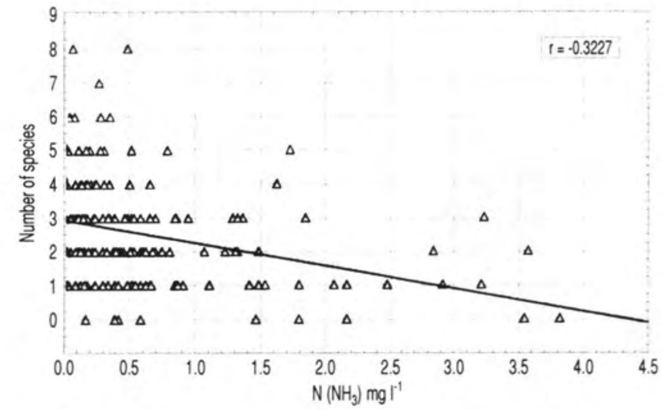

Fig. 13. Ammonium nitrogen content and number of *Pythium* species in the investigated water bodies.

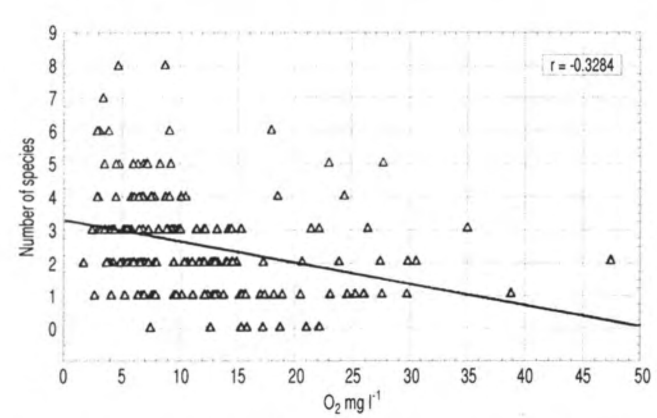

Fig. 12. Oxidability and number of *Pythium* species in the investigated of water bodies.

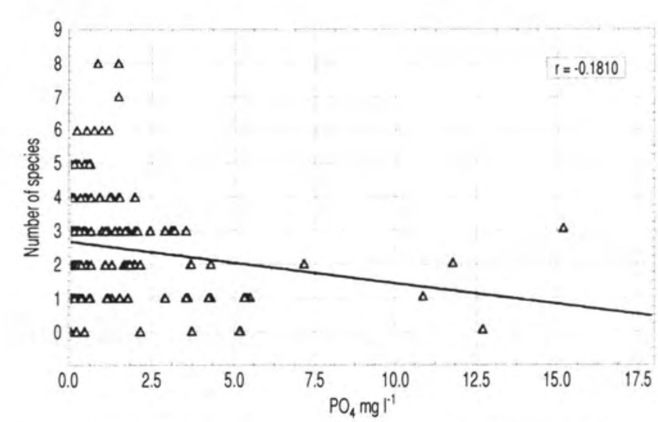

Fig. 14. Phosphates content and number of *Pythium* species in the investigated water bodies.

reveals that the number of fungus species of the genus *Pythium* in springs and lakes was related with alkalinity and BOD_5 (Figs 7, 10), in rivers with BOD_5 and alkalinity (Fig. 8), while in ponds with all the three nitrogen forms and phosphates (Fig. 9). This would indicate that alkalinity and BOD_5 affects the number of species in springs and lakes, nitrogen compounds and phosphates in ponds, while in rivers – biological five-day oxygen demand (BOD_5) and alkalinity known to be the intermediary index of organic compounds which are easily soluble in water. The general the number of *Pythium* species of the water bodies was affected by the level of oxygen, oxidability, ammonium nitrogen and phosphates. These are basic indicators of trophicity of water reservoirs. Oligotrophic-like waters are rich in oxygen, but their oxidability and the content of ammonia nitrogen and phosphates are low. The reverse occurs in the eutrophic and particularly polytrophic water types. A positive correlation was revealed in case of oxygen content in water, while a negative correlation was exerted by the oxidability, ammonium nitrogen and phosphates (Figs 11-14). In our earlier studies on physiological aquatic fungi, we observed a limitation of the number of aquatic fungus species by diverse environmental factors in different water reservoirs. For instance, we found sulphates, alkalinity and calcium to affect significantly the number of plant saprophytes in flood waters of the river Narew (Czeczuga and Próba 1987). We also found that substances soluble in water and dry residue influence the number of phytosaprophytic hyphomycetes species in 20 springs of the Knyszyńska Forest (Czeczuga and Orłowska 1996). The number of keratinophilic (Czeczuga and Muszyńska 1994) and chitinophilic species (Czeczuga and Godlewska 1998) in different water basins depends on such environmental factors as oxidability, ammonium nitrogen, nitrite nitrogen and phosphates.

Like in the case of hyphomycetes (Czeczuga and Orłowska 1999) and other zoosporic fungus species (Czeczuga et al. 1999b), a substantial number of *Pythium* species occurred in melting-ice water, compared with the water collected from the same site and at the same time from under the ice cover. Ice water contained a number of rare or new species to Polish mycology both in the case of hyphomycetes, zoosporic fungi and *Pythium*. Such exuberant accumulation of aquatic fungus spores in ice may be associated with surface tension which is the highest when water changes into ice. It appears as if it spores were accumulated to the surface from the bottom layer. This refers not only to aquatic fungus spores but also to other microorganisms, called neuston by Naumann (1917). According to Babenzien and Schwarz (1970) the neuston composition is varied, consisting of algae, bacteria as well as conidial and zoosporic aquatic fungi.

During the three-year study in all types of water bodies, the summer months were characterized by the fewest *Pythium* species (Figs 15, 16). This is consistent with our previous observations concerning hyphomycetes (Czeczuga and Orłowska 1993, 1996) and other zoosporic fungi of northeastern Poland (Czeczuga 1991a, 1995, 1996a). The high temperature of water in summer does not promote the growth of fungi of the genus *Pythium*. The competition with other organisms, like saprophitic bacteria, to get food may be of importance. However, in spring months the development of biological life in water reser-

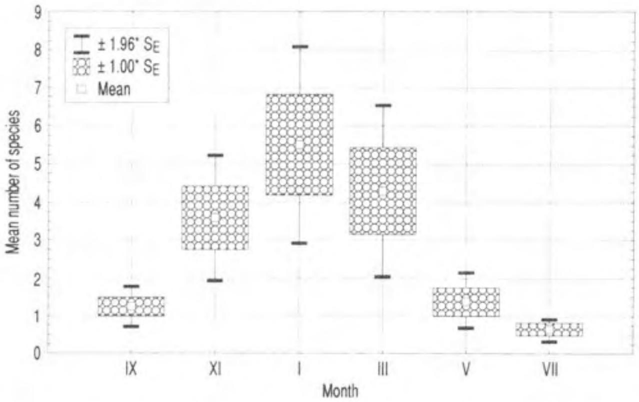

Fig. 15. Mean number of *Pythium* species in the particular months (together springs, ponds and rivers).

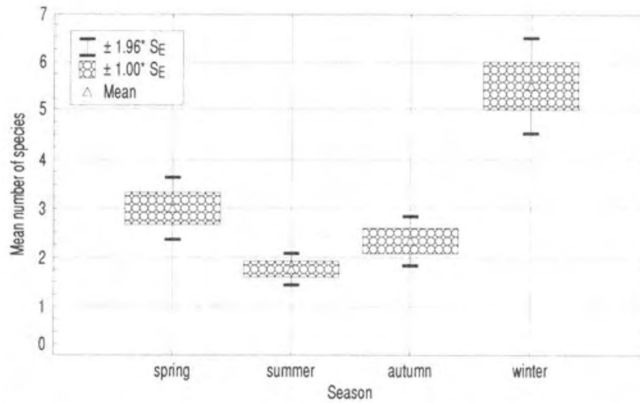

Fig. 16. Mean number of *Pythium* species in lakes in the particular seasons.

voirs does not depreciate the growth of fungi. In spring in all types of water bodies the number of aquatic fungus species was higher as compared with the summer.

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GATUNKI *PYTHIUM* W 13 RÓŻNYCH TYPACH ZBIORNIKÓW WODNYCH PÓŁNOCNO-WSCHODNIEJ POLSKI

STRESZCZENIE

Autorzy badali na tle chemizmu środowiska występowanie grzybów z rodzaju *Pythium* w wodzie dwóch źródeł, dwóch rzek, trzech stawów i sześciu jezior o różnej trofii. Próby wody pobierano w latach 1996-1999 co dwa miesiące z źródeł, rzek i stawów a z jezior co kwartał. Ponadto badano występowanie gatunków *Pythium* w lodzie niektórych zbiorników. Jako przynęty używano ziaren gryki, konopi, celofanu i wylinki węża.

W badanych 13 zbiornikach stwierdzono występowanie 45 gatunków należących do rodzaju *Pythium*. *Pythium acanthicum*, *P. complectens*, *P. complens*, *P. diameson*, *P. dissimile*, *P. elongatum*, *P. lucens*, *P. megalacanthum*, *P. nagae*, *P. oedochilum*, *P. oryzae*, *P. palingenes*, *P. periilum* oraz *P. polysporum* są gatunkami zarejestrowanymi po raz pierwszy w Polsce.

Średnio najwięcej gatunków grzybów z rodzaju *Pythium* rozwijało się w wodzie źródła Cypisek i Jaroszówka oraz jeziora Białego (wody zbliżone do oligotroficznych), najmniej zaś w stawie Akcent i Pałacowy (wody politroficzne). Z kolei w wodach wszystkich badanych zbiorników najwięcej gatunków *Pythium* występowało w miesiącach zimowych, najmniej zaś w miesiącach letnich.

SŁOWA KLUCZOWE: grzyby, *Pythium*, źródła, rzeki, stawy, jeziora, hydrochemia.