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Species of *Pythium* isolated from eggs of fresh-water fish

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In the present study species from the genus *Pythium* were isolated from eggs of fresh water fish. Altogether sixteen species of fungi were found on fish eggs including 13 species noted for the first time from fish.

Key words: fungi, *Pythium*, fish eggs.

INTRODUCTION

Species of *Pytium* are found in various habitats. A large number of these species are recognized as saprophytes and parasites of higher plants. Not only are they parasites of terrestrial plants and aquatic alga-type plants (S p a r r o w, 1931), but are also found on eggs of crabs (A t k i n s, 1955) and fish (S c o t t, O'B i e r, 1962). In fish, only *Pythium ultimum* and a few unidentified species were observed on eggs, which questioned (S c o t t, W a r r e n, 1964; S t u a r t, F u l l e r, 1968) their parasitic nature. These data were confirmed by other authors (W i l s o n, 1976; N e i s h, H u g h e s, 1980; S r i v a s t a v a, 1980; D u d k a et al., 1989). F l o r i n s k a j a (1969), who found *Pythium proliferum* on fish eggs in hatcheries, while C z e c z u g a and W o r o n o w i c z (1993) noted *Pythium artotrogus* on eggs of *Coregonus lavaretus*, *C. albula* and *Esox lucius*. The above data as well as very scant evidence of the occurrence of species of *Pythium* on fish eggs inclined us to carry out detailed investigations, which would provide more information about the biological properties of some of these fungi species.

MATERIALS AND METHODS

Water samples were taken from three bodies of water: River Supraśl, pond-moat in Branicki Park and Lake Komosa. In water samples eighteen parameters were determined (Table 1) according to the generally accepted methods (G o l t e r m a n, C l y m o, 1969).

Table 1

Chemical composition (in mg l^{-1}) of the different water (September, 1995)

Specification	Water from		
	Pond-moat	Lake Komosa	River Supraśl
Temperature (°C)	11.6	13.8	12.4
pH	7.0	7.6	7.5
O_2	8.2	12.8	16.7
Oxidability	13.5	7.4	7.2
CO_2	22.0	13.2	17.6
Alkalinity (mval dm^{-3})	4.4	3.9	4.1
N (NH_3)	0.442	0.101	0.218
N (NO_2)	0.0	0.012	0.005
N (NO_3)	0.008	0.034	0.041
P (PO_4)	1.912	0.255	0.311
Cl	70.0	23.5	26.2
Total hardness in Ca	88.56	68.40	83.52
Total hardness in Mg	40.85	28.81	31.82
S (SO_4)	28.38	12.75	19.75
Fe	0.524	1.542	0.512
Dry residue	358	375	317
Dissolved solids	282	312	305
Suspended solids	76	61	12

In order to determine the presence of *Pythium* species on eggs, the following procedure was applied: fish eggs (100-200) were transfered to two for each water a 1.0 litre vessel (together for each species was six vessel) and kept in laboratory at a temperature approaching that of the given hatchery. Some eggs from each vessel was observed under a microscope and the mycelium (form zoospore and oogonia) of aquatic fungi growing on the eggs was recorded. The methods were described in more detail in the paper of S m i t h et al. (1985) and F u l l e r, J a w o r s k i (1986). The eggs of the various fish species were examined for 1-1.5 weeks. The eggs were mostly live but sometimes dead.

The following keys were used to determine the species of *Pythium*: S p a r r o w (1960), P l a a t s - N i t e r i n k (1981) and D i c k (1990).

RESULTS

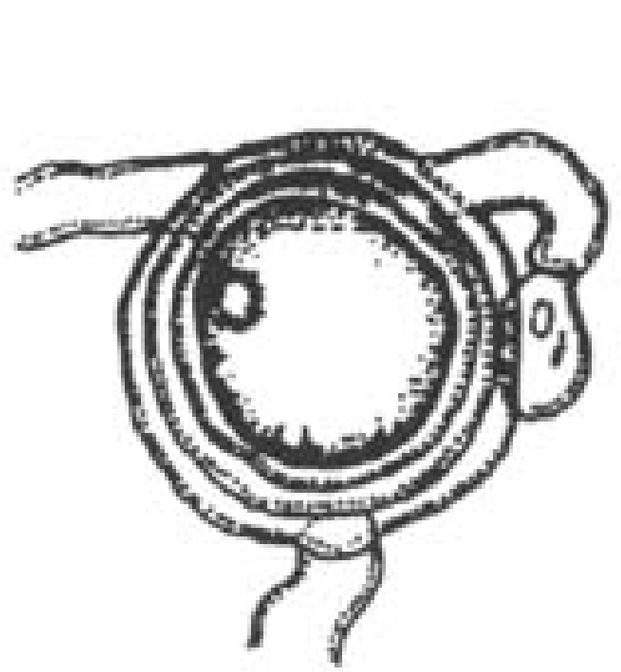
The data indicated a range trophicity in the bodies of water investigated defined by the concentration of phosphate and various forms of nitrogen.

We observed the growth of sixteen fungi species of the genus *Pythium* on the eggs of fresh-water fish (Table 2 and Fig. 1). Some of them were observed sporadically, while such species as *P. artotrogus* var. *macranthum*, *P. middletonii*, or *P. ultimum* occurred commonly. In addition thirteen species of *Pythium* had never been observed on fish eggs before.

T a b l e 2

Fungi of the genus *Pythium* were found on the eggs of fish in the different water

Species	Water from		
	pond	lake	river
P. aristosporum Vanterpool		x	
P. artotrogus var. *macranthum* Sideris	x	x	x
P. debaryanum Hesse	x	x	x
P. echinulatum Matthews		x	
P. inflatum Matthews			x
P. intermedium de Bary	x	x	x
P. manillatum Meurs	x	x	
P. marsipium Drechsler	x	x	
P. middletonii Sparrow	x	x	x
P. oligandrum Drechsler	x		
P. pulchrum Minden in Falck		x	
P. rostratum Butler	x		x
P. spinosa Sawada	x		
P. sylvaticum Campbell et Hendrix		x	x
P. torulosum Coker et Patterson	x	x	x
P. ultimum Trow	x	x	x
Number of species	11	12	9



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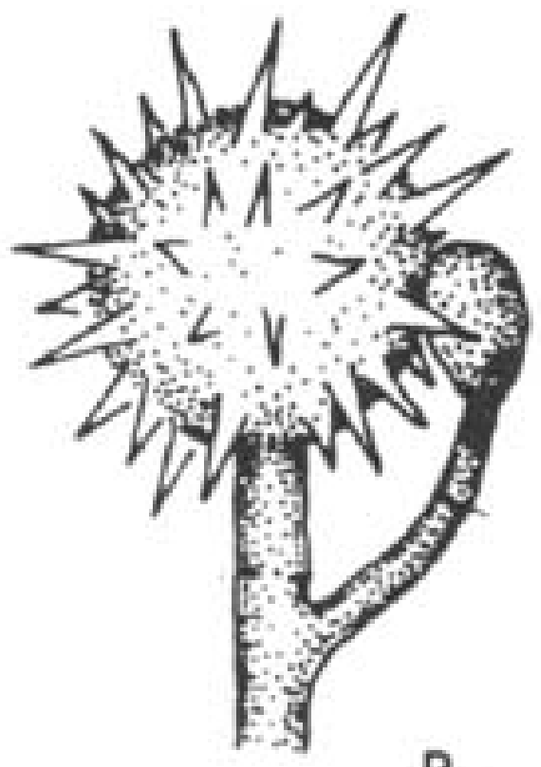

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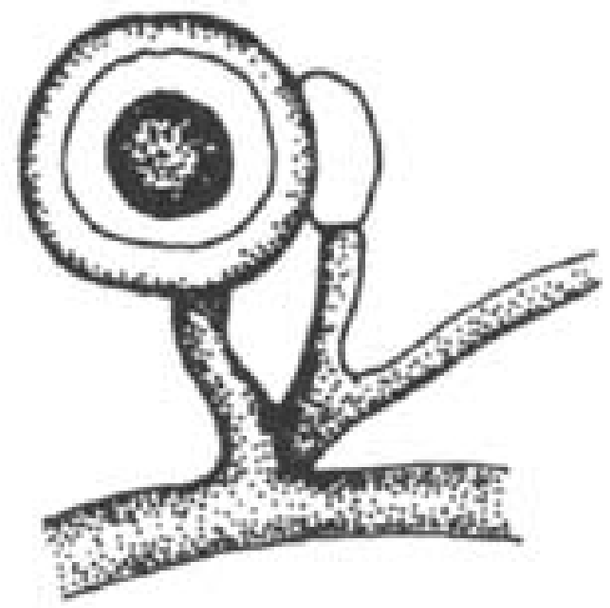

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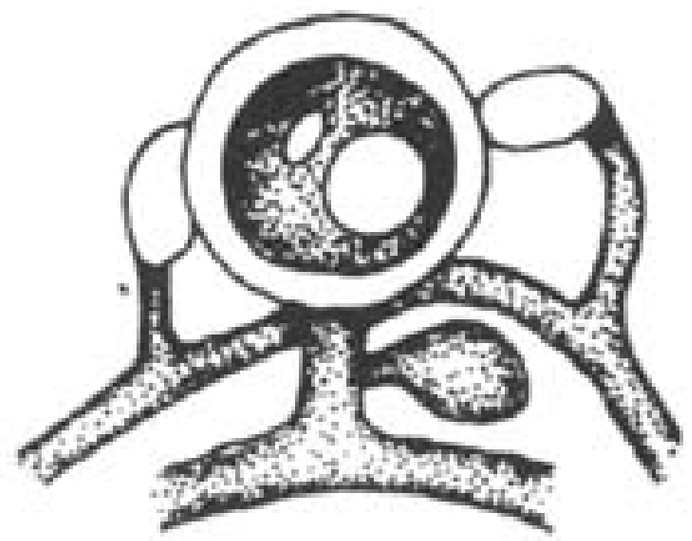

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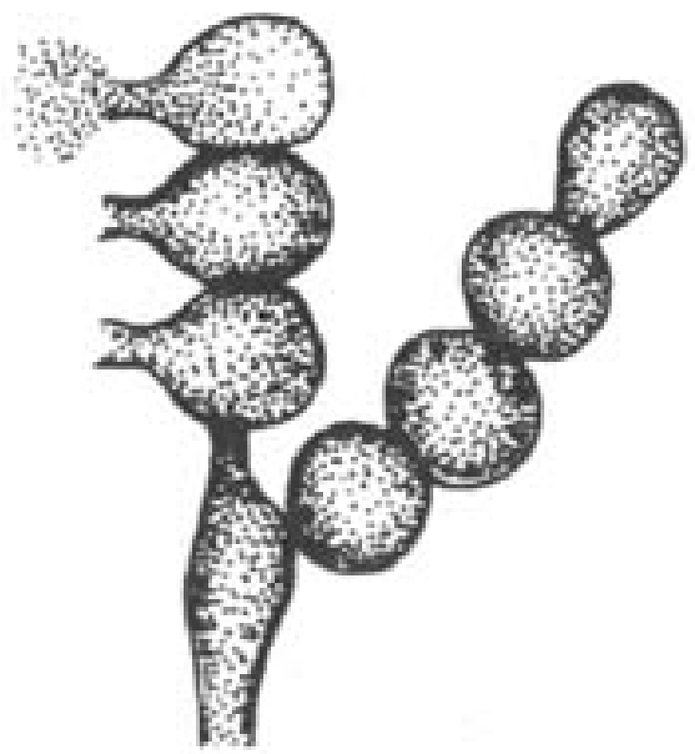

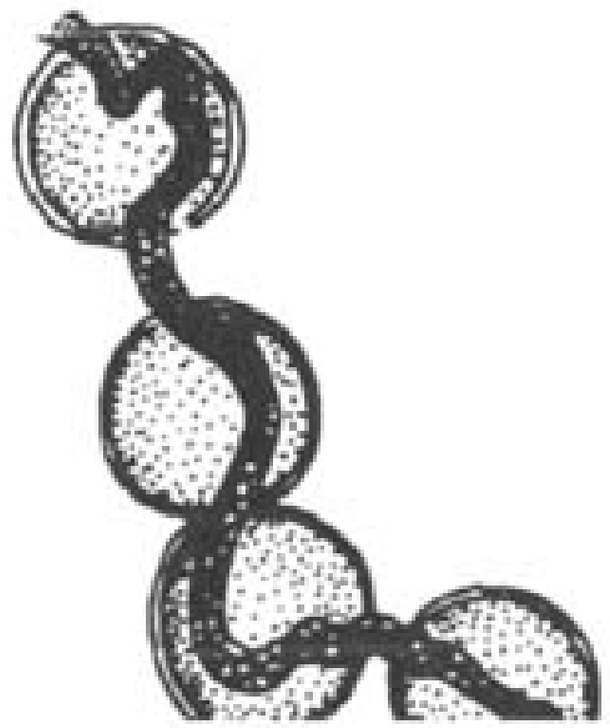

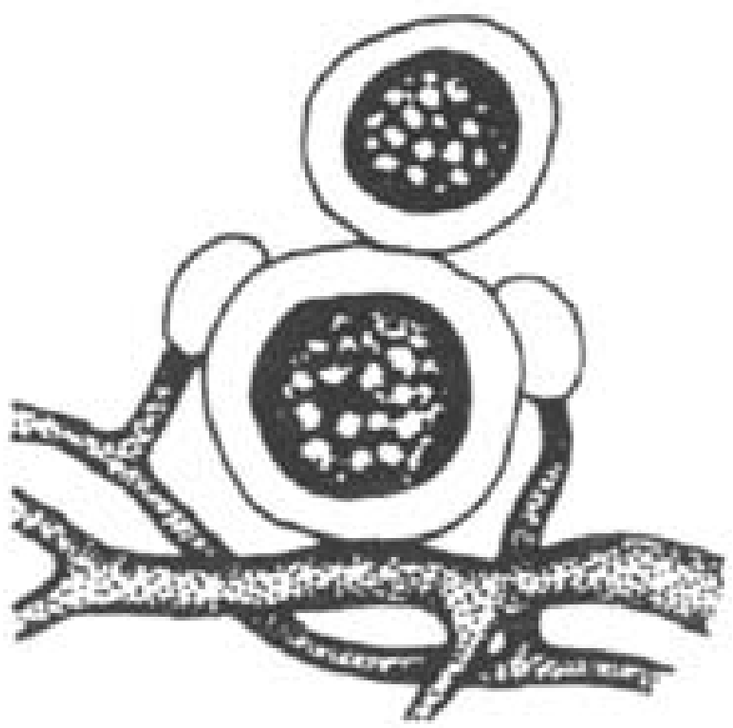

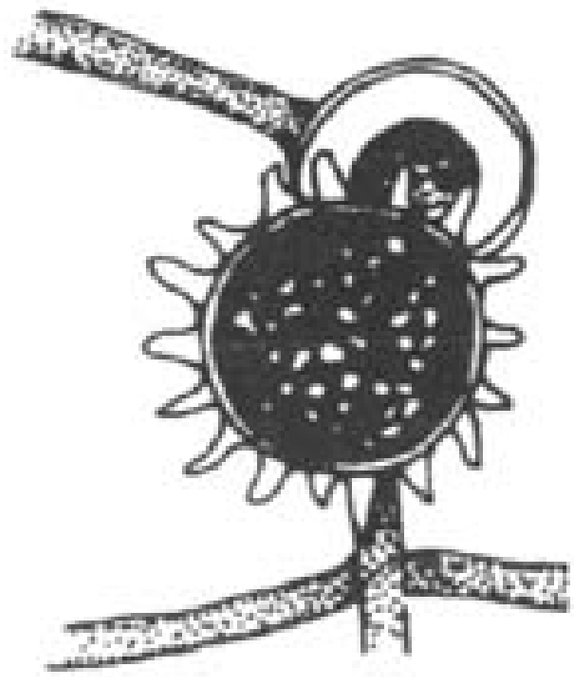

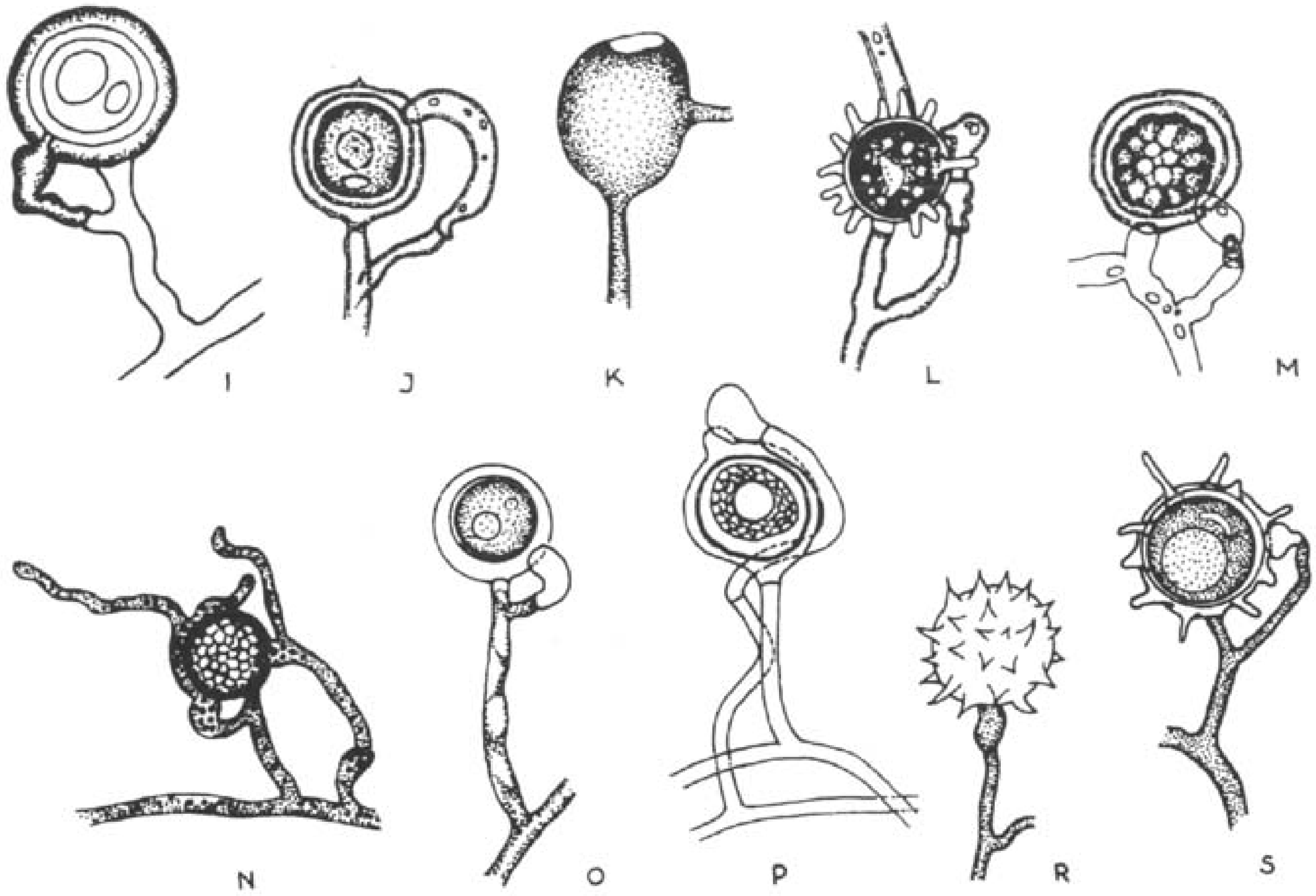

Fig. 1. Species of *Pythium* growing on fish eggs

A — *P. aristosporum* (oospore – 35 µm diamet.), B — *P. artotrogus* var. *macranthum* (oogonium – 25 µm), C — *P. debaryanum* (oogonium – 22 µm), D — *P. inflatum* (oogonium – 22 µm), E — *P. intermedium* (sporangium – 20 µm), F — *P. marsipium* (proliferating sporangia), G — *P. middletonii* (oogonium – 22 µm), H — *P. oligandrum* (oogonium – 27 µm and antheridium), I — *P. pulchrum* (oogonium – 19-23 µm and antheridium), J — *P. rostratum* (oogonium – 20 µm and antheridium), K — *P. rostratum* (sporangium – 30 µm), L — *P. spinosum* (oogonium – 21.8 µm and antheridium), M — *P. torulosum* (mature oogonium – 15 µm and antheridium), N — *P. torulosum* (young oogonium with two antheridia), O — *P. ultimum* (oogonium – 21.5 µm), P — *P. sylvaticum* (oogonium – 20 µm with aplerotic oospores and diclinous antheridium), R — *P. echnulatum* (oogonium – 13.8-24.2 µm), S — *P. manillatum* (oogonium – 13.5-18.5 µm and antheridium)

* *P. aristosporum* Vanterpool 1938; it was reported for the first time from Canada in infected wheat roots. In Japan it caused root decay of various plants, and was noted in rice fields (Iwaizako et al., 1976; Ichitani, Kang, 1988; Ichitani, Kinoshita, 1990). We observed the growth of this species on the eggs of *Leuciscus cephalus* only in the lake.

P. artotrogus var. *macranthum* Sideris 1932; it was described as a saprophyte. It is mainly recognized as a saprophyte living on vegetative parts as a water phytosaprophyte of plants and on dead insects in water (Skirgiełło, 1954), and as water phytosaprophyte (Czeczuga, 1995 c). We observed it on eggs of *Coregonus lavaretus, Coregonus albula* and *Esox lucius* in hatcheries in north-eastern Poland (Czeczuga, Woronowicz, 1993), on eggs of *Acipenser nudiventris* (Czeczuga et al., 1995) and other fish species.

* *P. debaryanum* Hesse 1874. Since the second half of XIX century it has been recognized as a phytopathogenic fungus as well as a soil (Johnson, 1971) and aquatic (Batko, 1975) saprophyte. In the aquatic environment it occurrs in springs (Czeczuga et al., 1989), running waters (Milko, 1965; Czeczuga, 1991 a, 1995 b) and stagnant lake-type waters of various trophicity (Meshcheryakova, Logvinenko, 1970; Czeczuga, Woronowicz, 1993) in spring, autumn and winter (Czeczuga, 1991 b, 1995 a). In fish, it was found to grow on the eggs of *Leuciscus cephalus.*

* *P. echinulatum* Matthews 1931 was described as a saprophyte from soil in the United States. It was found to be a saprophyte of waters in Ukraine (Meshcheryakova, 1970) and Iceland (Johnson, 1971). We observed it on eggs of *Leucaspius delineatus* in the lake.

* *P. inflatum* Matthews 1931 was described as a soil saprophyte. It has been hitherto encountered as an aquatic saprophyte (Meshcheryakova, Logvinenko, 1970). We observed it on eggs of *Cobitis taenia* and *Ictalurus nebulosus.*

* *P. intermedium* de Bary 1881. The species was noted for the first time in soil. It is recognized as a soil saprophyte (Ali-Shtayeh et al., 1986; Haednan, Dick, 1987), parasitizing on prothalia of horsetail and fern, and on seedlings of cross plants (Skirgiełło, 1954; Batko, 1975). It also occurs on in water (Meshcheryakova, Logvinenko, 1970). We observed it on eggs of *Ctenopharyngodon idella.*

* *P. mamillatum* Meurs 1928. It was first described from the Netherlands. Meshcheryakova and Logvinenko (1970) noted this species in a body of water in Ukraine; Johnson (1971) isolated it from soil in Iceland. We found it on eggs of *Alburnoides bipunctatus* in the pond and lake.

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* noted for the first time from fish

* *P. marsipium* Drechsler 1941, was first described as *Pythium carolianum* from Kyoto in Japan (I t o, 1936). The above author (I t o, 1942, 1944) recognized it as the species formerly described by Drechsler. This relatively rare species was noted in Japan in the 1940's in water purification deviced in the former Soveit Union (M e s h c h e r y a k o v a, 1970) and in Taiwan (H s i e h, C h a n g, 1976; H s i e h, 1978). It has been recently isolated from a pond in Osaka, Japan (A b d e l z a h e r et al., 1933, 1994 a) and from lakes in Ukraine (M e s h c h e r y a k o v a, L o g v i n e n k o, 1970). We observed this species on eggs of *Rhodeus sericeus amarus*.

P. middletonii Sparrow. It has been recognized as *Pythium proliferum* de Bary since XIX century (de B a r y, 1860). S p a r r o w (1960) initiated a new name, *Pythium middetonii*. The fungus was found to be a saprophyte of ditch water (S z w a n k e, 1938), in lakes (J o h n s on, 1971), decaying algae and dead insects in water (N a u m o v, 1954; K a r l i n g, 1967). In fish, it was observed for the first time by F l o r i n s k a y a (1969) in a hatchery on eggs of several fish species. We observed this species on eggs of many fish species in north-eastern Poland. It has been hitherto recognized as an aquatic saprophyte of rivers and large lakes (C z e c z u g a, 1991 c, 1994 b).

* *P. oligandrum* Drechsler 1930, was first described as a saprphyte and is also recognized as as agressive mycoparasite (D e a c o n, 1976; M a d s e n et al., 1995). It occurrs in the soil of vegetable field (K i n o s h i t a et al., 1994). We observed its growth on eggs of *Pungitius pungitius*.

* *P. pulchrum* Minden 1916. This species was isolated for the first time from soil samples in Germany. It was also found to occur in bodies of waters in Ukraine (M e s h c h e r y a k o v a, L o g v i n e n k o, 1970) and soil samples in Iceland (J o h n s o n, 1971). W e observed the growth of this species on eggs of *Noemacheilus barbatulus* in the pond.

* *P. rostratum* Butler 1907. It is a very common aquatic and soil fungus (L u n d, 1934; S k i r g i e ł ł o, 1954; I c h i t a n i et al., 1992). It was isolated from soil samples in India. This species occurs in various types of water bodies ranging from sunk wells (C z e c z u g a et al., 1987), rivers (S t p i c z y ń s k a - T o b e r, 1965; C z e c z u g a, 1995 b), post-peat pits (S t p i c z y ń s k a, 1962), ponds (M e s h c h e r y a k o v a, 1970) to lakes of various trophicity (C z e c z u g a, 1991 c, 1994 a, 1995 a). We found it on eggs of *Gobio gobio*.

* *P. spinosum* Sawada. It was noted for the first time in Taiwan (S a w a d a, C h e n, 1926) on the damping-off of *Antirrhinum majus*. It is also known to occur in roots systems of other plants (I c h i t a n i et al., 1989 a). We found it only on eggs of *Cottus gobio* in the pond.

* *P. sylvaticum* Campbell ex Hendrix 1976. The fungus was found to grow on eggs of *Alosa sapidissima*. It was reported for the first time from the south of the United States, and since then it has been recognized as a saprophyte. Recently it has

been recognized in Japan as a pathogen of barley causing browning root rot in these plants (K u s o n o k i, I c h i t a n i, 1994). We observed its growth on eggs of *Pelecus cultratus.*

* *P. torulosum* Coker et Patterson 1927. Described for the first time as a saprophyte and recognized as a free-living fungus of different types of grass (I c h i t a n i et al., 1989 b). It also occurs in aquatic habitats (M e s h c h e r y a k o v a, L o g v i n e n k o, 1970; J o h n s o n, 1971; H a l l e t, D i c k, 1981). In fish, it was found to grow on gonads in the 3rd stage of *Anguilla anguilla.*

P. ultimum Trow 1901, described as a soil saprophyte. The species ia a parasite of tulip bulbs (M o o r e, B u d d i n, 1937; M o o r e, 1940, 1979; H u m p h r e y s - - J o n e s, de R o o y, 1975) causing great damage (I c h i t a n i et al., 1991) in crops, and of other plants (M a z e n et al., 1985; T o j o et al., 1992, 1993; K u s u n o k i, I c h i t a n i, 1994). It tolerates high levels of salinity (H a s s a n, F a d l - A l l a h, 1993). In the aquatic environment this saprophyte occurs in a variety of bodies of water ranging from rivers (C z e c z u g a, P r ó b a, 1987) to lakes of various trophicity (C z e c z u g a, 1991 c, 1994 b, 1995 a; C z e c z u g a, W o r o n o w i c z, 1992). In fish, it was observed on eggs of *Lepomis macrochirus* (S c o t t, O'B i e r, 1962) and *Acipenser nudiventris* (C z e c z u g a et al., 1995). In our studies *Pythium ultimum* was found on eggs of many fish species.

DISCUSSION

Most species of *Pythium* developed on fish eggs in Lake Komosa (12); lowest number of theses species was noted in the River Supraśl (9) (Table 2). The water of Lake Komosa had the lowest alkalinity and concentration of CO_2, N-NH_3, PO_4, chloride, calcium, manganese and sulphate and the highest concentrations of N-NO_2 and iron.

The water of the River Supraśl was characterized by a considerably high concentration of oxygen and N-NO_3, and low of oxydability.

Such species as *P. artotrogus* var. *macranthum, P. debaryanum, P. intermedium, P. middletonii, P. torulosum* and *P. ultimum* were noted on fish eggs in all the bodies of water investigated. *P. aristosporum* was found to grow on fish eggs only in water the lake whereas *P. inflatum* occurred only in the river. *Pythium spinosum* was only observed on fish eggs from the pond. The water of this pond did not contain detectable amounts of N-NO_2 and was characterized by high of oxidability, alkalinity and CO_2, N-NH_3, PO_4, chloride, calcium, manganeses and sulphate concentrations.

Species of the genus *Pythium* have been generally recognized as soil parasites of grass and cultivated. The present study showed that many species of *Pythium* colonize eggs of fresh-water fish. This is particularly important for those fish species which have lost their reproduction ability under natural conditions due to eutrophication and pollution of water, and thus have to be reproduced under controlled

conditions in hatcheries. Consequently this may lead to the mass-development of parasitic fungi which are responsible for the damage of a considerable number of incubated eggs (Lartseva, Altufiev, 1987; Hatai, Hoshiai, 1992) or sometimes even all eggs are lost (Sati, Khulbe, 1981; Dudka et al., 1989). It should be assumed that species of *Pythium*, except for *Saprolegnia* and *Achlya*, contribute significantly to mycosis.

REFERENCES

Abdelzaher H. M. A., Ichtiani T., Elanaghy M. A., 1993. Effect of temperature, hydrogen-ion concentration and osmotic potential on oospore germination of five aquatic *Pythium* spp. Transactions of the Nish-Nippon Division (Mycological Society of Japan) 3: 16.

Abdelzaher H. M. A., Ichtiani T., Elanaghy M. A., 1994. *Pythium marsipium* from pond water in Osaka. Mycol Res. 98: 920-922.

Ali-Shtayeh M. S., Lim-ho Chee Len, Dick M. W., 1986. The phenology of *Pythium* (*Peronosporomycetideae*) in soil. J. Ecol. 74: 823-840.

Atkins D., 1955. *Pythium thalassium*, sp. nov. infecting the egg-mass of the pea-crab, *Pinnotheres pisum*. Trans. Br. mycol. Soc. 38: 31-46.

Bary A. de, 1860. Einige neue Saprolegnieen. Jahrb. Wiss. Bot. 2: 169-192.

Bary A. de, 1881. Zur Kenntnis der Peronosporeen. Bot. Zeit. 33-39: 521-625.

Batko A., 1975. Zarys hydromikologii. Hydromycology – an overview. PWN. Warszawa.

Butler E. J., 1907. An account of the genus *Pythium* and some *Chytridiaceae*. Mem. Dept. Agril. India, Bot. Ser. 1, 5: 1-84.

Campbell W. A., Hendrix F. F., Jr., 1976. A new heterothallic *Pythium* from southern United States. Mycologia 59: 274-278.

Cooker W. C., Patterson P. M., 1927. A new species of *Pythium*. J. Elisha Mitchell Sci. Soc. 42: 247-250.

Czeczuga B., 1991 a. Aquatic fungi of the river Pisa and its tributary, the river Skroda. Acta hydrochim. hydrbiol. 19: 57-65.

Czeczuga B., 1991 b. Aquatic fungi in lake Śniardwy and eighteen neighbouring lakes. Int. Revue ges. Hydrobiol. 76: 121-135.

Czeczuga B., 1991 c. The mycoflora of Lake Wigry and seven adjacent lakes. Arch. Hydrobiol. 120: 495-510.

Czeczuga B., 1994 a. Aquatic fungi of lake Hańcza in the Suwałki Scenic Park and of some adjacent lakes (northeastern Poland). Acta Hydrobiol. 36: 371-385.

Czeczuga B., 1994 b. Aquatic fungi of twelve Augustów Lakes with reference to the chemistry of the environment. Acta Mycol. 29: 217-227.

Czeczuga B., 1995 a. Hydromycoflora of thirty-one lakes in Elk Lake District and adjacent waters with reference to the chemistry of the environment. Acta Mycol. 30: 49-63.

Czeczuga B., 1995 b. Mycoflora of the Narew river and its tributaries in the stretch between Tykocin and Ostrołęka. Acta Mycol. 30: 181-191.

Czeczuga B., 1995 c. Hydromycoflora fungi of small forest lakes "Suchary" in the Wigry National Park. Acta Mycol. 30: 167-180.

Czeczuga B., Muszyńska E., Wossughi Gh., Kamaly A., Kiziewicz B., 1995. Aquatic fungi growing on the eggs of several species of acipenserid fish. Acta Ichthyol. Piscat. 25: 71-79.

Czeczuga B., Próba D., 1987. Mycoflora of the upper part of the river Narew and its tributaries in a differentiated environment. Nova Hedwigia 44: 151-161.

Czeczuga B., Woronowicz L., 1992. Studies on aquatic fungi. The Lake Mamry complex. Acta Mycol. 27: 93-103.

Czeczuga B., Woronowicz L., 1993. Aquatic fungi developing on the eggs of certain fresh-water fish species ad their environment. Acta Ichthol. Piscat. 23: 39-57.

Czeczuga B., Woronowicz L., Brzozowska K., 1987. Badania grzybów wodnych. Mikoflora wody kilku studni kopanych. Roczn. PZH, 38: 69-74.

Czeczuga B., Woronowicz L., Brzozowska K., Chomutowska H., 1989. Mycoflora of different types of spring. Acta Hydrobiol. 31: 273-283.
Deacon J. W., 1976. Studies on *Pythium oligandrum*, an aggressive parasite of other fungi. Trans. Br. mycol. Soc. 66: 383-391.
Dick M. W., 1990. Key to *Pythium*. College Estate Management Whiteknights. Reading. U.K.
Drechsler C., 1930. Three species of *Pythium* with proliferous sporangia. Phytopathology 31: 478-507.
Dudka I. A., Isayeva N. M., Davydov O. N., 1989. *Saprolegniaceae* inducing fish mycosis. Mikol. Phtytopath. 23: 488-498.
Florinskaja A. A., 1969. Materiały po vidovomu sostavu i ekologii plesnevyvh gribov – vozbuditelej saprolegniozov ryb Leningradskoj oblastii. Izv. Gos. NIORCH 69: 103-123. (in Russian).
Fuller M. S., Jaworski A., 1986. Zoosporic fungi in teaching and research. Southeastern Publ. Corpor. Arhens.
Golterman H. L., Clymo R. S., 1971. Methods for physical and chemical analysis of fresh water. IBP Handbook No 8, Oxford.
Hallett I. C., Dick M. W., 1981. Seasonal and diurnal fluctuations of oomycete propagule numbers in the free water of a freshwater lake. J. Ecol. 69: 671-692.
Hardman J. M., Dick M. W., 1987. Short-term fluctuations in availability of *Pythium* propagules for isolation from soil. Trans. Br. mycol. Soc. 88: 29-39.
Hassan S. K. M., Fadl-Allah E. M., 1993. Effect of salinity on biology of *Saprolegnia ferax* and *Pythium ultimum*. Acta Mycol. 28: 39-43.
Hatai K., Hoshiai G. -J., 1992. Saprolegniasis in cultured coho salmon (*Oncorhynchus kisutch*). Gyobyo Kenkyu 27 (4): 233-234.
Hesse R., 1874. *Pythium de-Baryanum* ein endophytischer Schmarotzer. Inaugr. Dissert., Gottingen, 76 p.
Hsieh H. J., 1978. An annotated list of *Pythium* in Taiwan. Bot. Bull. Acad. Sinica 19: 199-205.
Hsieh H. J., Chang H. S., 1976. Five species of *Pythium*, two species of *Pythiogeton* new for Taiwan and *Pythium afertile*. Bot. Bull. Acad. Sinica 17: 141-150.
Humphreys-Jones D. R., de Rooy, 1975. Control of *Pythium* root rot in five-degree tulips in the Netherlands and the United Kingdom. Acta Hort. 47: 83-90.
Ichitani T., Fukunishi T., Kang H. T., Kashimoto T., 1989 a. Isolation of *Pythium spinosum* from tulip showing retarded growth. Ann. Phytopath. Soc. Japan. 55: 100 (England abstract).
Ichitani T., Kang H. T., 1988. Materials for *Pythium* flora of Japan (I). Plantpathogenic *Pythium irregulare*. Bull. Univ. Osaka Pref., Ser. B, 40: 19-26.
Ichitani T., Kang H. T., Mine K., 1989 b. Materials for *Pythium* flora of Japan (II). *Pythium torulosum* and *P. vanterpoloo* from golf greens of manilagrass or bentgrass. Bull. Univ. Osaka Pref., Ser. B, 41: 9-19.
Ichitani T., Kashimoto T., Fukunishi T., 1991. Root rot of tulip caused by three *Pythium* species. Ann. Phytopath. Soc. Japan 57(2): 174-179.
Ichitani T., Kinoshita T., 1990. Materials for *Pythium* flora of Japan (III). *Pythium aristosporum* from rhizosphere soil of zyosia green. Bull. Univ. Osaka Pref., Ser. B, 42: 1-8.
Ichitani T., Kinoshita T., Okumura T., 1992. Materials for *Pythium* flora in Japan (V). Three species of *Pythium* from soil of a vegetable garden in winter. Bull. Univ. Osaka Pref., Ser. B, 44: 13-23.
Ito T., 1936. Studies on aquatic fungi from Kyoto and their pathogenicity on rice seedlings. Ann. Phytpath. Soc. Japan 6: 79-80.
Ito T., 1942. On some aquatic species of *Pythium* found in Kyoto. J. Jap. Bot. 18: 309-316.
Ito T., 1944. Some aquatic species of *Phycomycetes* found in Kyoto. J. Jap. Bot 20: 51-60.
Iwaizako C., Watanabe B., Sato T., Iwasaki M., 1976. Identification of root rot fungus of konnyaka. Ann. Phytopath. Soc. Japan 42: 100.
Johnson T. W., 1971. Aquatic fungi of Iceland: *Pythium*. Mycologia 73: 517-538.
Karling J. S., 1967. Some zoosporic fungi of New Zealand. XIII. *Traustochytriaceae, Saprolegniaceae* and *Pythiaceae*. Sydowia 20: 226-234.
Kinoshita T., Ichitani T., and Okumura T., 1994. Materials for *Pythium* flora of Japan VIII. Two species of *Pythium: P. pyrilobum* and *P. oligandrum*. Mycoscience 35: 191-198.
Kusunoki M., Ichitani T., *Pythium* spp. causing browing root rot of barley. Ann. Phytopath. Soc. Japan. 60: 305-309.
Lartseva L. V., Altufiev Yu. V., 1987. Pathogenicity of saprolegnial fungi for sevruga spawn during its artificial cultivation. Hydrobiol. J. 23 (2): 51-57.

Lund A., 1934. Studies on Danish freshwater *Phycomycetes* and notes on their occurrence particularly relative to the hydrogen ion concentration of the water. Mem. Acad. Roy. Sci. Danemark, sectsci. 6: 1-97.

Madsen A. M., Robinson H. L., Deacon J. W., 1995. Behaviour of zoospore cysts of the mycoparasite *Pythium oligandrum* in relation to their potential for biocontrol of plant pathogenus. Mycol. Res. 99: 1417-1424.

Matthews V. D., 1931. Studies on the genus *Pythium*. 136pp. Illust. Univ. North Carolina Press, Chapel Hill.

Mazen M. B., Moubasher A. H., Sharouny H. M. El., 1985. Studies on the genus *Pythium* in Egypt. V. Test of pathogenicity of some common root-infecting fungi. Acta Mycol. 21: 117-124.

Meshcheryakova R. I., 1970. *Pythium* fungi from puryfying constructions. Mikrobiol. Zh. 32: 210-215.

Meshcheryakova R. I., Logvinenko L. I., 1970. Species composition of the genus *Pythium* Pringsh. in water basin of the Ukrainian Soveit Socialist Republic. Mikolog. Fitopath. 4 (6): 541-543.

Meurs A., 1928. Vortelrot, Veroozaakt door Schimmels with de Geslachten *Pythium* Pringsheim en Aphanomyces de Bary. Proetschr. Verkrijg. Graad Doct. Rijsk-univ. Ultrecht, 1928: 1-94.

Milko A. A., 1965. Fungi isolated from water of the soviet part of the Danube. Mikrobiol. Zh. 27: 38-44.

Minden M. von, 1916. Beitrage zur Biologie und Systematik einheimischer submerser Phycomyceten. Mycol. Untersuch. Betrichte, Jena 2: 146-255.

Moore W. C., 1940. New and interesting plant diseases. Trans. Br. mycol. Soc. 24: 59-63.

Moore W. C., 1979. Diseases of Bulbs. Minist. Agric. Fish. F.D., London, pp. 21-22.

Moore W. C., Buddin W., 1937. A new disease of tulip caused by species of *Pythium*. Ann. appl. Biol. 24: 752-761.

Naumov N. A., 1954. Flora gribov Leningradskoj oblasti. M.L., Nauka 182 pp. (in Russia).

Neish G. A., Hughes G. C., 1980. Diseases of fishes. Book 6: Fungal diseases of fishes. Neptune: T.F.H. Publication, 155.

Plaats-Niterink A. J., Van der, 1981. Monograph of the genus *Pythium*. Stud. in Mycol. 21: 1-242.

Sati S. C., Khulbe R. D., 1981. A new host record for the fungal genus *Achlya*. Curr. Sci. (India) 50 (16): 313.

Sawada K., Chen C. C., 1926. On the damping – off of *Antirrhinum majus*. Taiwan Hakub, Gak. Kaiho 87: 199-212 (In Japanese with England summary).

Scott W. W., O'Bier A. H., 1962. Aquatic fungi associated with diseased fish and eggs. Progr. Fish. Cult. 24: 3-15.

Scott W. W., Warren C. O., 1964. Studies on the host range and chemical control of fungi associated with diseased tropical fish. Va agric. exp. Stn., Blacksburg. Tech. Bull, 171: 1-24.

Sideris C. P., 1932. Taxonomic studies in the family *Pythiaceae*. II. *Pythium*. Mycologia 24: 14-61.

Skirgiełło A., 1954. Grzyby niższe. Grzyby i glonowce. PWN, Warszawa.

Smith S. N., Armstrong R. A., Springate J. and Barker G., 1985. Infection and colonization of trout eggs by *Saprolegniaceae*. Trans. Br mycol. Soc. 85: 719-723.

Sparrow F. K., Jr. 1931. Two new species of *Pythium* parasitic in green algae. Ann. Bot. London 45: 257-277.

Sparrow F. K., 1960. Aquatic *Phycomycetes*. Ann. Arbor, Mich. USA. University of Michigan Press.

Srivastava R. C., 1980. Studies in fish-mycopathology – a review. Mykosen 23: 325-332.

Stuart M. R., Fuller H. T., 1968. Mycological aspects of diseased Atlantic salmon. Nature, London 217: 90-92.

Stpiczyńska E., 1962. Grzyby wodne dołów potorfowych koło wsi Całowanie. Monogr. Bot. 13: 87-120.

Stpiczyńska-Tober E., 1965. Flora grzybów wodnych rzek: Jeziorka i Świder. Acta Mycol. 1: 53-75.

Szwanke A., 1938. Przyczynek do znajomości flory grzybów wodnych okolic Warszawy. Planta Polonica 7: 1-25.

Tojo M., Fujita Y., Awad H. M., Ichitani T., 1993. Preparation of *Pythium* inocula using bentgrass seeds for glasshouse studies. Proc. Kansai Pl. Prot. 35: 1-5.

Tojo M., Nakazono E., Hotta K., Ichitani T., 1992. Seasonal variations of *Pythium* spp. in vegetable field sol. Proc. Kansai Pl. Prot. 34: 11-16.

Trow A. H., 1901. Observatons on the biology and cytology of *Pythium ultimum* n. sp. Ann. Bot. 15: 263-312.

Vanterpool T. C., 1938. Some species of *Pythium* parasitic on wheat in Canada and England. Ann. appl. Biol. 25: 528-543.

Wilson J. G. M., 1976. Immunological aspects of fungal disease in fish. [In:] Jones E.G.B. (Ed.): Recent advances in aquatic mycology. London, Elex Science: 573-601.