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Zoosporic fungi growing on bird excrements in the water of the river Biała

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The coprophilic fungi in the water of river Biała were studied. Samples of water were collected every other month for hydrochemical analysis and once (1994/95) in order to determine the fungus content. The excrements of 9 species of bird were used as bait.

Thirty-one species of coprophilic fungi were found in the water of the river Biała. *Apodachlya punctata*, *Pythium catenulatum*, *Saprolegnia asterophora* and *S. megasperma* new records for Poland.

Key words: Coprophilic fungi, river, hydrochemical study.

INTRODUCTION

Our studies on aquatic fungi in respective water bodies in north-eastern Poland with regard to the chemism of water (C z e c z u g a, 1991 a, b; 1995 a) have also included investigations of particular physiological groups of fungi. We have investigated vegetable saprophytes, examined species that parasitize on aquatic alga species (C z e c z u g a, W o r o n o w i c z, 1994) and described the occurrence of fungi of prey in the north-eastern region (C z e c z u g a, 1993). We have also established species growing on a keratin-containing substratum (C z e c z u g a, M u s z y ń s k a, 1994) and chitin-containing substratum (C z e c z u g a, G o d l e w s k a, 1994) and on fish eggs (C z e c z u g a, W o r o n o w i c z, 1993).

The present work refers to the species growing on bird excrements, water birds in particular.

MATERIALS AND METHODS

The investigations included the excrements of the 9 bird species (Table 3).

The water for experiments were collected from the river Biała.

Eighteen parameters of these water samples 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 properties of water river Biała in particular quarter*

Specification	1 (XII, I, II)	2 (III, IV, V)	3 (VI, VII, VIII)	4 (IX, X, XI)
Temperature (°C)	0.500	7.200	16.800	5.200
pH	6.930	7.680	7.780	7.640
Oxidability	12.800	12.670	13.160	10.170
CO_2	16.500	26.400	11.000	13.200
Alkalinity (mval dm^{-3})	3.420	5.000	2.860	4.320
N (NH_3)	0.535	0.630	0.662	1.210
N (NO_2)	0.024	0.047	0.017	0.024
N (NO_3)	0.000	0.208	0.590	0.180
P (PO_4)	1.102	0.255	2.824	0.406
S (SO_4)	76.109	48.550	46.900	49.780
Cl	98.000	98.200	48.000	83.520
Total hardness in Ca	75.640	108.720	64.080	83.520
Total hardness in Mg	19.350	20.640	11.180	12.040
Fe	0.675	0.545	0.672	0.350
Mn	0.080	0100	0.060	0.100
Dry residue	246.000	454.000	258.000	241.000
Dissolved solids	225.000	417.000	220.000	227.000
Suspended solids	21.000	37.000	38.000	14.000

* Samples were collected in third decade of each month

For the determinations of the presence of aquatic fungus species on the excrements, the following procedure was employed: certain amont of dry excrements (0.5-1.0 g) of each species of bird were transferred to two a 1.0 litre vessel and placed in the laboratory at a temperature approaching that of the given environment. The part of the excrements from each vessel was observed under a microscope and the mycelium (from zoospore, oognia and conidia) of aquatic fungi growing on the excrements was recorded. The methods were described in detail in paper F u l l e r and J a w o r s k i (1986). The excrements of the various bird species were examined for one to one and half weeks.

For determinations of the fungi six keys were used (J o h n s o n, 1956; S p a r r o w, 1960; S e y m o u r, 1970; K a r l i n g, 1977; K r e g e r van R i j, 1984; D i c k, 1990).

RESULTS

In a one-year period, thirty-one zoosporic fungus species were found to grow in river water on excrements of 9 water birds or living on wet ground (Table 2). Most species were observed on excrements of white stork and mallard, fewest on excrements of marsh harrier and herrin gull (Table 3). The most common species in the respective months were *Dictyuchus monosporus* (marsh harrier, Roman-nosed goose, mute swan, grey heron and herrin gull), *Leptomitis lacteus* (mallard), *Saprolegnia ferax* (white stork, mallard) and *Nowakowskiella elegans* (greylag goose, muscovy duck) (Table 4). Several aquatic fungus species found on bird excrements were either new to the Polish mycoflora (*Apodachlya punctata, Pythium catenulatum, Saprolegnia asterophora, Saprolegnia megasperma* (Fig. 1), or rare (*Pythium inflatum, Pythium rostratum* and *Pythium undulatum).*

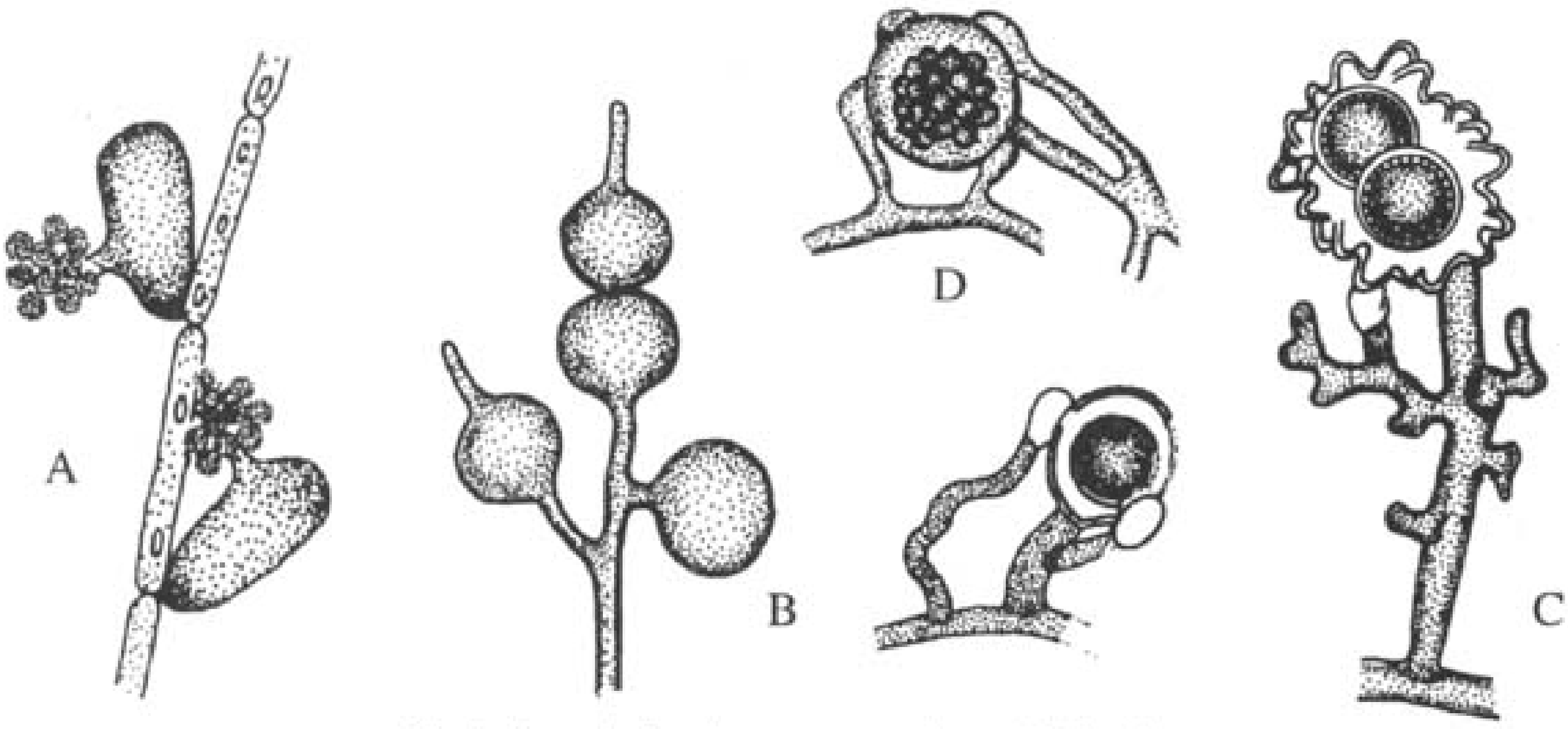

Fig. 1. Aquatic fungi new to mycoflora of Poland

A – *Apodachlya punctata* (spore – 24 x 52 µm); B – *Pythium catenulatum* (fragment hyphae and oogonium – 20-40 µm); C – *Saprolegnia asterophora* (oogonium – 24-42 µm); D – *Saprolegnia megasperma* (oogonium – 38-54 µm)

Table 2

Aquatic fungi were found on the excrements of bird

Fungi	Bird (see Table 3)
Chytridiomycetes	
1. *Nowakowskiella elegans* (Nowak.) Schroeter	1, 2, 3, 4, 5, 8
2. *Rhizophlyctis petersenii* Karling	1, 2, 3, 4, 6
Oomycetes	
3. *Achlya colorata* Pringsheim	2, 6
4. *Achlya dubia* Coker	3, 5, 7, 9
5. *Achlya glomerata* Coker	4
6. *Achlya orion* Coker et Couch	1, 6
7. *Achlya papillosa* Humphrey	6
8. *Achlya polyandra* Hildebrand	6, 9
9. *Achlya racemosa* Hildebrand	2, 6
10. *Aphanodictyon papillatum* Huneycutt	9
11. *Aphanomyces laevis* de Bary	1, 2, 3, 5, 6, 8
12. *Aphanomyces irregularis* Scott	6
13. *Aphanomyces stellatus* de Bary	4, 6
14. *Apodachlya pyrifera* Zopf	4, 8
15. *Apodachlya punctata* Minden	8
16. *Cladolegnia unispora* (Coker et Couch) Joh.	6
17. *Dictyuchus monosporus* Leitgeb	1, 2, 3, 4, 5, 6, 7, 8, 9
18. *Leptomitus lacteus* (Roth) Agardh	2, 3, 4, 6, 8, 9
19. *Pythium catenulatum* Matthews	2
20. *Pythium debaryanum* Hesse	1, 2, 5, 6, 8
21. *Pythium inflatum* Matthews	1, 2, 3, 4, 6
22. *Pythium rostratum* Butler	2, 5, 6, 8
23. *Pythium undulatum* Petersen	4, 5, 6, 7
24. *Pythium* sp.	2
25. *Saprolegnia asterophora* de Bary	3, 8
26. *Saprolegnia diclina* Humphrey	2
27. *Saprolegnia ferax* (Gruith) Thurnet	2, 4, 5, 6, 7, 8, 9
28. *Saprolegnia megasperma* Coker	2, 6
29. *Saprolegnia monoica* Prigsheim	6
30. *Saprolegnia parasitica* Coker	6, 8
31. *Zoophagus insidians* Sommerstorff	6, 9

Table 3

Aquatic fungi were found on the excrements of particular bird

Bird	Fungi (see Table 2)	Number of species
1. *Anas moschata* L. – muscovy duck	1, 2, 6, 11, 17, 20, 21	7
2. *Anas platyrhynchos* L. – mallard	1, 2, 3, 9, 11, 17, 18, 19, 20, 21, 22, 24, 26, 27, 28	15
3. *Anser anser* (L.) – greylag goose	1, 2, 4, 11, 17, 18, 21, 25	8
4. *Anser cygnoides* (L.) – roman-nosed goose	1, 2, 5, 13, 15, 17, 18, 21, 23	9
5. *Ardea cirenea* L. – grey heron	1, 4, 11, 17, 20, 22, 23, 27	8
6. *Ciconia ciconia* (L.) – whiter stork	2, 3, 6, 7, 8, 9, 11, 12, 13, 16, 17, 18, 20, 21, 22, 23, 27, 28, 29, 30, 31	21
7. *Circus aeruginosus* (L.) – marsh harrier	4, 17, 23, 27	4
8. *Cygnus olor* (Gmel.) – mute swan	1, 11, 14, 15, 17, 18, 20, 22, 25, 27, 30	11
9. *Larus argentatus* Pont. – herrin gull	4, 8, 10, 17, 18, 27, 31	7

Table 4

Aquatic fungi were found on the excrements of particular months

Fungi	1994				1995							
	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII
Chytridiomycetes												
1. *Nowakowskiella elegans* (Nowak.) Schroet.	–	–	–	–	–	x	x	x	–	x	x	x
2. *Rhizophlyctis petersenii* Karling	–	–	–	–	–	x	–	x	–	x	x	x
Oomycetes												
3. *Achlya colorata* Pringsheim	–	–	–	–	–	x	x	x	–	–	–	–
4. *Achlya dubia* Coker	–	–	–	–	–	–	–	–	–	x	x	–
5. *Achlya glomerata* Coker	–	–	–	–	–	–	–	x	–	–	–	–
6. *Achlya orion* Coker et Couch	–	–	–	x	–	–	–	x	–	–	–	–
7. *Achlya papillosa* Humphrey	x	–	–	–	–	–	–	–	–	–	–	–
8. *Achlya polyandra* Hildebrand	–	–	–	–	x	x	–	–	x	–	–	x
9. *Achlya racemosa* Hildebrand	–	–	–	x	x	–	–	x	–	–	–	–
10. *Aphanodictyon papillatum* Huneycutt	–	–	–	–	–	–	–	–	–	–	x	–
11. *Aphanomyces irregularis* Scott	–	–	–	–	–	–	–	–	x	–	–	–
12. *Aphanomyces laevis* de Bary	–	x	x	x	x	x	x	–	–	x	x	x
13. *Aphanomyces stellatus* de Bary	–	–	–	–	–	x	x	–	–	–	–	–
14. *Apodachlya pyrifera* Zopf	–	–	–	–	x	–	–	x	–	–	–	–
15. *Apodachlya punctata* Minden	–	–	–	x	–	–	–	–	–	–	–	–
16. *Cladolegnia unispora* (Coker et Couch) Joh.	–	–	–	–	–	–	x	x	–	–	–	–
17. *Dictyuchus monosporus* Leitgeb	x	x	x	x	–	–	x	–	x	x	x	x
18. *Leptomitus lacteus* (Roth) Agardh	x	–	–	x	x	x	–	x	x	x	–	–
19. *Pythium catenulatum* Matthews	–	–	–	–	–	x	–	–	–	–	–	–
20. *Pythium debaryanum* Hesse	–	–	–	–	x	x	x	–	x	x	x	x
21. *Pythium inflatum* Matthews	–	–	–	–	–	–	x	–	–	x	–	x
22. *Pythium rostratum* Butler	–	–	–	–	x	x	x	–	–	–	–	x
23. *Pythium undulatum* Petersen	–	–	–	–	–	–	–	–	x	x	x	–
24. *Pythium* sp.	–	–	–	x	–	–	–	–	–	–	–	–
25. *Saprolegnia asterophora* de Bary	–	–	–	–	x	–	–	–	–	–	–	–
26. *Saprolegnia diclina* Humphrey	–	–	–	x	–	–	–	–	–	–	–	–
27. *Saprolegnia ferax* (Gruith) Thurnet	x	x	x	–	x	x	x	x	x	x	–	x
28. *Saprolegnia megasperma* Coker	–	–	–	–	–	x	–	–	–	–	–	–
29. *Saprolegnia monoica* Prigsheim	–	–	–	–	x	–	–	x	–	–	–	–
30. *Saprolegnia parasitica* Coker	–	–	x	–	x	–	–	x	–	–	x	–
31. *Zoophagus insidians* Sommerstorff	x	–	–	–	–	–	–	–	–	x	–	–

DISCUSSION

The fungus species observed on bird excrements, except those new to hydromycology of Poland, have been already found in a number of water bodies. Moreover, such species as *Aphanomyces laevis, Aphanomyces irregularis, Achlya dubia, Saprolegnia ferax, Cladolegnia unispora* and *Leptomitus lacteus* have been observed on chitin-containing substrata (C z e c z u g a, M u s z y ń s k a, 1994).

We have observed all species of the genus *Achlya*, except *Achlya papillosa*, several *Saprolegnia* species – *Saprolegnia diclina, Saprolegnia ferax, Saprolegnia monoica, Saprolegnia parasitica*, as well as *Leptomitus lacteus* and *Dictyuchus monosporus* on the eggs of a number of fish species (C z e c z u g a, W o r o n o w i c z, 1993). This would indicate a wide substratum spectrum mineralized in water by the above mentioned zoosporic fungus species.

Worth special noting is the finding of four new and three rare fungus species on the bird excrements examined. Until the present study those fungus species have not been observed in the river Biała (C z e c z u g a et al., 1986) nor in other water bodies nor in the water of the river Biała, rich in baits, used for the studies of chitino- and keratinophilic fungi (C z e c z u g a, G o d l e w s k a, 1994; C z e c z u g a, M u s z y ń s k a, 1994). This would suggest that bird excrements used for the studies constitute a favourable substratum for the growth of these fungi. *Apodachly punctata* was found in December on excrements of mute swan. B a t k o (1975) found it on branches in water. Species of the genus *Pythium* is also knew to Poland, namely *Pythium catenulatum*. This species, known as an aquatic saprophyte (D i c k, 1990), was observed in our studies in February on excrements of mallard. *Saprolegnia asterophora*, a new species to Poland lives, according to S e y m o u r (1970), in water and soil of acidified nature. In waters it was encountered on sphagnum bogs on dead fish (H a y r e n, 1928). In our studies *Saprolegnia asterophora* developed only in January on excrements of greylag goose and mute swan. *Saprolegnia* was found in our studies on excrements of white stork and mallard only in February. In other countries it was observed in water and soil (S e y m o u r, 1970). We also found three rare species of the *Pythium* (*Pythium inflatum, P. rostratum* and *P. undulatum*). *P. inflatum*, also known as and aquatic saprophyte (P l a a t s - N i t e r i n k, 1981), was observed in our studies on excrements of white stork (March), Roman-nosed goose (June, August), greylag goose (June) and muscovy duck (June). *P. inflatum* was earlirt encountered in the autumn in the river Węgorapa (C z e c z u g a, 1991 c). *P. rostratum*, known as a soil saprophyte (W a t a n a b e, 1988, 1991; I c h i t a n i et al., 1992), rarely aquatic (S k i r g i e ł ł o, 1954), in our studies was found on excrements of white stork (January, March), mallard (February, March), mute swan (January) and grey heron (August). Thus, it was found mainly in winter. It should be mentioned that I c h i t a n i et al. (1992) isolated the mycelium of *P. rostratum* from soil also in witner months. The other rare species – *P. undulatum* was observed in spring and summer months on excrements of marsh harrier, white stork, Roman--nosed goose and grey heron. *P. rostratum* was earlier eccountered in the late

autumn in the river Biebrza near Osowiec (C z e c z u g a et al., 1990) and in the autumn in the oligotrophic lake Hańcza (C z e c z u g a, 1994), while *P. undulatum* in the heavily polluted river Gać in the same season (C z e c z u g a, 1995 b).

The bird species used for the studies can be divided according to the type of nourishment into two groups: typically carnivorous (marsh harrier, white stork and grey heron) and with domination of vegetable food. In the latter group, the numbers of fungus species found on excrements of the respective animals are almost the same, while significant differences are found in the carnivorous group, which mainly referes to marsh harrier and white stork.

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Grzyby zoosporowe rosnące na ptasich odchodach w rzece Białej

Streszczenie

Badano grzyby koprofilne w wodach rzeki Białej. Próbki wody pobierano co miesiąc dla wykonania analizy hydrochemicznej oraz oznaczenia grzybów.

W próbach stwierdzono obecność 31 gatunków, które wyrosły na odchodach ptaków wodnych. Gatunkami nowymi dla mikoflory Polski okazały się: *Apodachlya punctata*, *Pythium catenulatum*, *Saprolegnia astrophora* i *S. megasperma*.

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Effects of vitamins, temperature and pH on the biomass production by ectomycorrhizal fungi

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Studies were carried out to determine the effect of vitamins, temperature and pH on the biomass production by ectomycorrhizal fungi: *Laccaria bicolor, Hebeloma crustuliniforme, Suillus bovinus* and *Pisolithus arhizus*. Responses of particular organisms were different. Three-factor ANOVA which enables the comparison of the effect of experimental factors on biomass yield has shown that the pH of the medium had a stronger effect on *L. bicolor, H. crustuliniforme* and *S. bovinus* than vitamins. Temperature was the factor exerting the strongest effect on the growth of *P. tinctorius*.

INTRODUCTION

Vitamins are essential for the metabolism of animals, plants and microorganisms. They are components of coenzymes catalyzing important biochemical reactions (Oertli, 1987). Many soil bacteria and saprophytic, pathogenic as well as symbiotic fungi are capable of producing and excreting into the environment vitamins like thiamine, folic acid, nicotinic acid, biotin (Hussain, Vančura, 1970; Strzelczyk, Leniarska, 1980, 1985; Dahm, Strzelczyk, Reddy, 1989; Strzelczyk, Dahm, Pachlewski, 1991). At the same time some microorganisms are not able to produce one or several vitamins. Requirements of mycorrhizal fungi regarding vitamins were described by Norkrans (1950), Melin (1953), Slankis (1973). Among vitamins thiamine seems to be the most important one. According to Palmer (1971) thiamine must and biotin ought to be added to a satisfactory synthetic medium. Inositol, nicotinic acid and panthotenic acid also increase the growth of some fungal species (Palmer, 1971).

The ecological importance of vitamins as growth stimulators of ectomycorrhizal fungi and mycorrhizae formation is far from being elucidated. It seems that vitamins