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Department of Hydrobiology, Institute of Zoology, University of Warsaw, Warszawa

Head: Dr. E. Pieczyńska

Krystyna PREJS

SOME PROBLEMS OF THE ECOLOGY OF BENTHIC NEMATODES (*NEMATODA*) OF MIKOŁAJSKIE LAKE

(Ekol. Pol. 18: 225–242). It was shown that the species composition and structure of dominance of benthic nematodes groupings in the littoral is more differentiated than in the profundal. A gradual decrease of the numbers of nematodes was observed together with the increase of depth. Three trophic groups of nematodes were distinguished: herbivorous, predators and detritus-feeders. A dependence was found between the abundance of herbivorous forms and the quantities of algae in the surface layers of bottom sediments in littoral.

Among the papers on benthic nematodes a large majority is of papers on systematics and faunistics, but only some are dealing with their ecology. The investigations by Borner (1921), Schneider (1922), Stefański (1924, 1938), Micoletzky (1925), Allgen (1942) have shown, among the others, that benthic nematodes can be an indicator of a trophic type of water-body. Oligotrophic lakes are characterized most frequently by the occurrence of a large number of species, while the dominant species are difficult to determine. Nematodes fauna of eutrophic and even of some dystrophic lakes is most often more numerous than that of oligotrophic lakes, but the species number is lower. Dominant species can be generally determined in eutrophic and dystrophic lakes. The differences in the species composition of nematodes depending on the trophy of water-body are also significant. In the mountain oligotrophic lakes the species from the family *Chromadoridae*, which are so characteristic for eutrophic lakes, are absent. Apart from that nematodes of the genus *Tobrilus* are very important in eutrophic lakes – *Tobrilus gracilis* is one of dominant species there, while in typical oligotrophic lakes this species is of secondary importance. An occurrence of *Monhystera stagnalis* and *Dorylaimus stagnalis* in eutrophic lakes, which are characteristic species for small warm ponds, but are never found in cold mountain lakes, should be also noticed.

There are not many data on the benthic nematodes of eutrophic lakes from the Middle Europe. Attention should be paid to papers by: Stefański (1923) on Kujawskie lakes, Rzóska (1935) on the Kierskie Lake, Paesler (1939) on free-living nematodes of various environments of Silesia, Stradowski (1964) on nematodes of psammolittoral of lakes Mamry and Śniardwy, Biro (1968) on lake Balaton, and Stańczykowska and Przytocka-Jusiak (1968) on microbenthos of some Mazurian lakes. The research carried out in Poland shows that the nematodes fauna of our eutrophic lakes is similar to that of East-Holshtinian and Danish lakes investigated by Schneider (1922) and Micoletzky (1925).

On the basis of papers by Borner (1921) and Schneider (1922) it is known that in the littoral zone of lake the nematodes fauna is much more abundand than in profundal. For an example Borner (1921) found in the littoral of lake St. Moritzer 25 species of nematodes, in sublittoral 19, and in profundal only 8, with only 2 species found on the deepest sites (26 m).

The aim of this paper is to analyse the species composition and the numbers dynamics of nematodes from various bottom environments of eutrophic Mikołajskie Lake. The structure of dominance and trophic groups of groupings of nematodes were analysed. Taking into consideration gaps in the knowledge of biology of freshwater nematodes a number of experiments was carried out in order to determine their life cycle.

I. AREA AND METHODS

The investigations were carried out in Mikołajskie Lake which is eutrophic, holomictic, with the surface area 460 ha, maximum depth 27.8 m and the mean depth 11.3 m. The littoral zone occupies 87.2 ha which is 19% ot the total lake area. Littoral overgrown with the emergent vegetation occupies 39.2 ha. *Phragmites communis* Trin. is a dominant among emergent plants, and occupies 82% of the area of littoral overgrown with emergent plants (Kowalczewski and Wasilewski 1965).

Samples were collected on three profiles, from the lake shore to open water up to the depth of 16 m. On each profile three sampling sites were established.

Profile I – in the central part of the lake:

Site 1 – littoral overgown with reeds, depth 0.4 m, gravel and sand at the bottom;

Site 2 – sublittoral, depth 4 m, sandy bottom with a large number of moluscs shells;

Site 3 – profundal, depth 16 m, muddy bottom with a lot of sand.

Profile II – in the central part of the lake:

Site 1 – littoral in a bay without emergent vegetation, depth 0.4 m, gravel with sand at the bottom;

Site 2 – profundal, depth 8 m, muddy bottom (gyttja);

Site 3 – profundal, depth 16 m, muddy bottom (gyttja).

Profile III – near the junction with lakes Śniardwy and Bełdany:

Site 1 – littoral with reeds, depth 0.4 m, gravel with sand at the bottom;

Site 2 – profundal, depth 12 m, muddy bottom with small quantities of coarse sand;

Site 3 – profundal, depth 16 m, muddy bottom (gyttja).

The materials were collected seven times: in February, April, May, July, September and October 1967, and in January 1968. On each site in sublittoral and profundal four samples were collected each time with the help of pneumatic sampler with the surface 10 cm^2 (Kajak, Kacprzak and Polkowski 1965). The type of bottom in littoral did not allow to use this apparatus, so the samples were collected with the help of a glass tube of the diameter 0.85 cm. Each sample consisted of the contents of three tubes with the total surface of 1.7 cm^2.

It is known from the Stańczykowska's (1966) investigations, that microbenthos in Mikołajskie Lake groups mainly in the surface layers of sediments. In the top 4 cm layer 90% of all organisms is usually found, at the depth of 16 cm – only some individuals. This is why in this paper a sample of bottom 4 cm deep was treated as a representative sample. Totally 720 samples were collected.

The material was fixed with formalin, washed on the sieve made of perlon net with the mesh size about 45 μ, and then the whole sample was examined 50 times magnified. Nematodes were transferred on to watch-glasses with diluted glycerine, left for evaporation of water, and then their species were determined under the microscope.

II. THE DOMINANCE STRUCTURE OF GROUPINGS OF NEMATODES IN VARIOUS ZONES OF THE LAKE

A total of 39 species of nematodes were found in the analysed material. The systematic composition (taxonomic order according to Meyl 1960) of determined species of nematodes is as follows:

Rhabditidae: *Bunonema* sp.; *Diplogasteridae*: *Diplogaster rivalis* (Leydig 1854); *Cephalobidae*: *Teratocephalus demani* Stefański 1924; *Aphelenchidae*:

Aphelenchoides parietinus (Bastian 1865); *Plectidae*: *Plectus cirratus* Bastian 1865, *P. granulosus* Bastian 1865, *P. longicaudatus* Bütschli 1873, *Plectus* sp., *Anonchus mirabilis* (Hofmänner and Menzel 1914); *Camacolaimidae*: *Aphanolaimus attentus* de Man 1880; *Monhysteridae*: *Monhystera dispar* Bastian 1865, *M. paludicola* de Man 1881, *M. vulgaris* de Man 1880, *Monhystera* sp., *Prismatolaimus intermedius* (Bütschli 1873); *Chromadoridae*: *Chromadorita leuckarti* (de Man 1876), *Prochromadorella bioculata* (Schultze 1858), *P. viridis* (v Linstow 1876)[1], *Punctodora ratzeburgensis* (v Linstow 1876); *Cyatholaimidae*: *Achromadora terricola* (de Man 1880), *Ethmolaimus pratensis* de Man 1880, *Prodesmodora circulata* (Micoletzky 1913); *Ironidae*: *Ironus tenuicaudatus* (de Man 1876); *Tripylidae*: *Tobrilus gracilis* (Bastian 1865), *T. longus* (Leidy 1852), *T. medius* (G. Schneider 1916), *T. stefańskii* (Micoletzky 1925), *T. pellucidus* (Bastian 1865), *T. grandipapillatus* Andrassy 1959, *Tripyla monohystera* de Man 1880, *Tripyla* sp.; *Alaimidae*: *Alaimus primitivus* de Man 1880; *Mononchidae*: *Mononchus macrostoma* Bastian 1865; *Dorylaimidae*: *Dorylaimus stagnalis* Dujardin 1845, *D. helveticus* Steiner 1919, *D. holsaticus* Schneider 1925, *D. montanus* Stefański 1923, *D. flavomaculatus* v Linstow 1876; *Actinolaimidae*: *Actinolaimus macrolaimus* (de Man 1884).

30 individuals were not determined (0.5% of the total). These were mainly larvae and damaged individuals.

Among 39 species of nematodes found in Mikołajskie Lake only 13 were found in the profundal, and 11 of them were found on the deepest sites (16 m). In sublittoral 27 species were found. All species found in the lake were present in the littoral (Tab. I). It can be said generally, that profundal sites were characterized by a small number of nematodes species, with *Tobrilus gracilis* as a dominant. On the littoral sites much more species were present but their numbers were more or less equal (Tab. I).

Great differences in the percentage composition of nematodes species were found on each littoral site. The littoral sites of profile I and III (located in the reed-bed) were characterized by the occurrence of the large number of species, among which the dominant species were difficult to determine, but the representants of family *Chromadoridae* attained here on average 60% of all found individuals. Species composition of groupings of nematodes at the littoral site of profile III was slightly different. Nematodes of the genus *Tobrilus* were there clearly determined as dominants (on the average 60%).

A smaller number of species was found in the sublittoral site, but with a definite majority of *Ironus tenuicaudatus* – about 50%, and *Chromadorita leuckarti* – about 20% of all nematodes from this site.

In the profundal only nematodes from 4 genera were numerous: *Tobrilus*, *Monhystera*, *Ethmolaimus* and *Chromadorita*. Species: *Dorylaimus flavomaculatus*,

[1]Meyl (1960) gives for these species a genus name *Chromadorina*, but in this paper a genus name *Prochromadorella* was used, as it is usually met in the literature.

The percentage share of different species of nematodes in different zones of the Mikołajskie Lake

x – < 5%, xx – 5–15%, xxx – 15–30%, xxxx – > 30% of the total number of nematodes

Tab. I

Species	Littoral	Sublittoral	Shallow profundal	Deep profundal
Tobrilus graoilis	xx	x	xxxx	xxxx
T. medius	x	x	xxx	xxx
Monhystera paludicola	x	x	xxx	xxx
M. vulgaris	x	x	x	xx
M. dispar	x	x	x	x
Monhystera sp.	x	x	xx	x
Ethmolaimus pratensis	x	x	xx	xx
Dorylaimus flavomaculatus	x	x	x	x
Diplogaster rivalis	x	x	x	x
Anonchus mirabilis	x	x	x	x
Chromadorita leuckarti	xxx	xxx	x	x
Prismatolaimus intermedius	x	x	x	
Aphanolaimus attentus	x	x	x	
Prochromadorella bioculata	xx	x		
Punctodora ratzeburgensis	xx	x		
Prochromadorella viridis	x	x		
Prodesmodora circulata	xxx	x		
Ironus tenuicaudatus	xx	xxxx		
Tripyla sp.	x	xx		
Plectus granulosus	x	x		
Plectus sp.	x	x		
Alaimus primitivus	x	x		
Dorylaimus stagnalis	x	x		
D. helveticus	x	x		
D. montanus	x	x		
Tobrilus stefańskii	x	x		
T. pellucidus	x	x		
T. longus	xx			
T. grandipapillatus	x			
Dorylaimus holsaticus	x			
Achromadora terricola	x			
Actinolaimus macrolaimus	x			
Mononchus macrostoma	x			
Tripyla monohystera	x			
Plectus cirratus	x			
P. longicaudatus	x			
Bunonema sp.	x			
Teratocephalus demani	x			
Aphelenchoides parietinus	x			

Aphanolaimus attentus, *Diplogaster rivalis*, *Anonchus mirabilis* and *Prismatolaimus intermedius* were sporadic. On all profundal sites nematodes of the genus *Tobrilus* and *Monhystera* were the majority. It is worth noticing, that in the littoral 6 species of the genus *Tobrilus* were found, while in the profundal only 2.

III. THE NUMBERS DYNAMICS OF NEMATODES DURING A YEAR

Data concerning the changes of numbers of benthic nematodes in time are not fully satisfactory. More detailed investigations in this matter were done on soil nematodes, however they do not provide uniform results. Micoletzky (1921) found the maximum numbers of soil nematodes in spring and the minimum in winter. Seidenschwartz (1923 – after Pieczyńska 1964) noted a considerable fluctuations of nematodes numbers during a year. The highest numbers was observed in summer, the lowest – in winter. He also says that various nematodes species reach their maximum numbers in various seasons. Dziuba and Witkowski (1959) observed definite changes of nematodes numbers within a year, different in soils with different crops. Pieczyńska's (1964) investigations upon nematodes from periphyton overgrowing common reed supported the detailed data on this subject. She found that yearly variation of nematodes numbers can be characterized by a clearly distinguished peak which takes place in spring. During other seasons regular and visible variations were not found. Stańczykowska and Przytocka-Jusiak (1968) found that the peak of numbers of profundal nematodes in Mikołajskie Lake appeared in spring. During the vegetation period, with the progressing stagnation, the numbers of nematodes clearly decreased.

In this paper the changes of benthic nematodes numbers during a year, and the age structure of dominant species were analysed. In order to simplify the material three age groups of nematodes were distinguished: young larvae, old larvae and adults. While analysing the mass of material it is very difficult to determine the proper larval stage (development stages in between successive exuviae). This classification was based on the size of particular individuals and on the differences in the anathomical structure (the extent of gonads' development, the change of the oesophagus length to body length ratio). It seams that such division is good enough to draw conclusions as to the occurrence and the share of larval and adult forms (such division was used by Pieczyńska 1964).

Nematodes numbers per 1 m^2 in the investigated lake varied from 2,000 individuals in profundal (16 m, profile II, July) to 380,000 individuals in littoral (profile I, February) (Fig. 1). A gradual decrease of the nematodes numbers

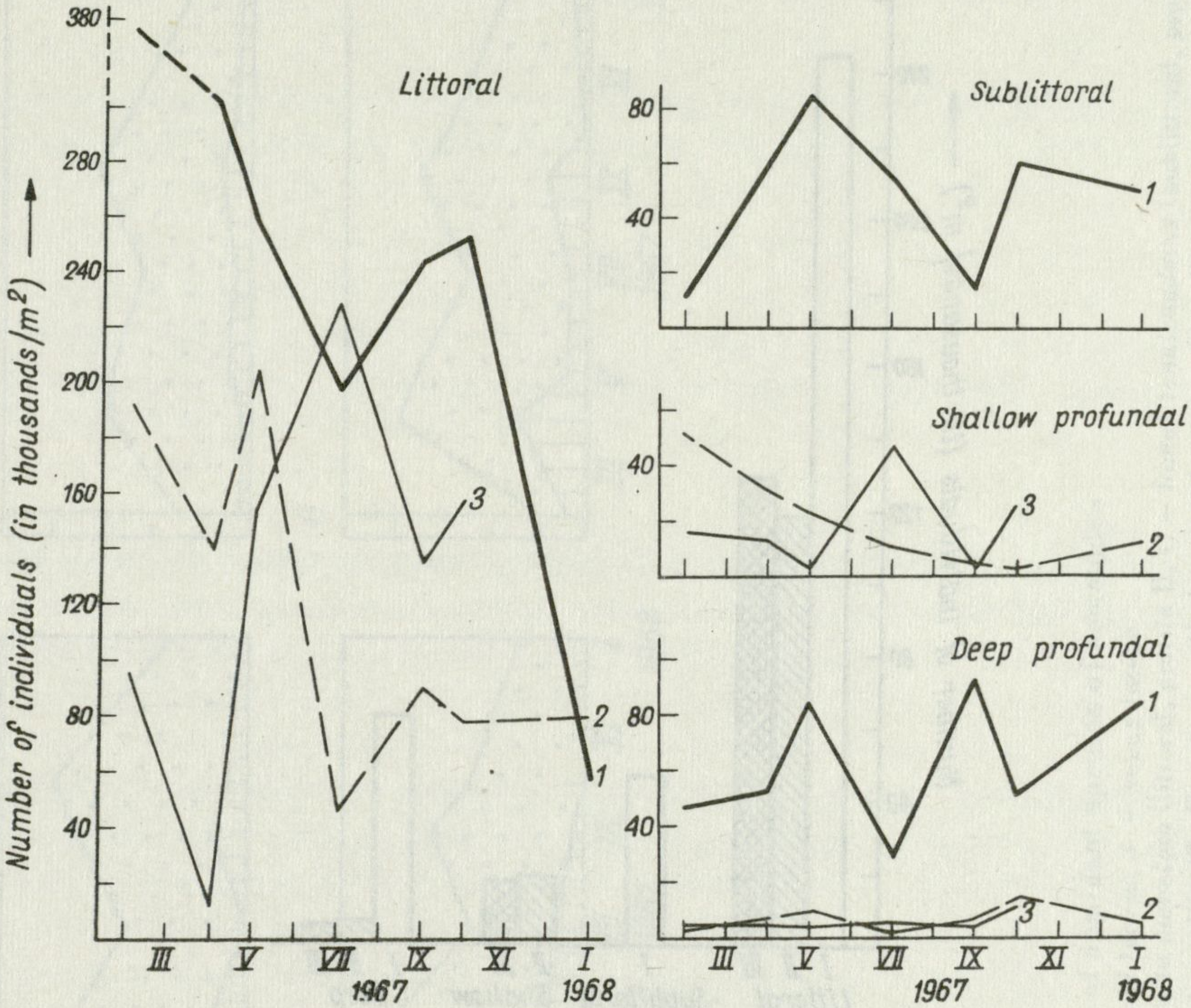

Fig. 1. The numbers dynamics of nematodes in various zones of Mikołajskie Lake
1 – profile I, *2* – profile II, *3* – profile III

from the littoral to profundal was observed together with the increase of depth (Fig. 2). An exception was the site 16 m deep on profile I, where the yearly average numbers of nematodes was up to 10 times higher than on the equivalent sites on profile II and III, and it was also higher than in the shallow profundal and even higher than in sublittoral.

A summer decrease of nematodes numbers was observed on the majority of sites on the profiles located in the central part of the lake (Fig. 1). In other periods changes of the nematodes numbers were different on various sites. In many cases very high numbers was noticed during spring and fall. Great differences were noticed on the sites in sublittoral and littoral of these profiles during the winters of 1967 and 1968.

The numbers dynamics of nematodes on profile III was reverse to ones above. The maximum numbers on the sites in littoral and shallow profundal of this profile were observed in summer (Fig. 1). In the deep profundal the numbers was low and only slightly variable within a year. A different character of the numbers dynamics of nematodes on that profile can result from the

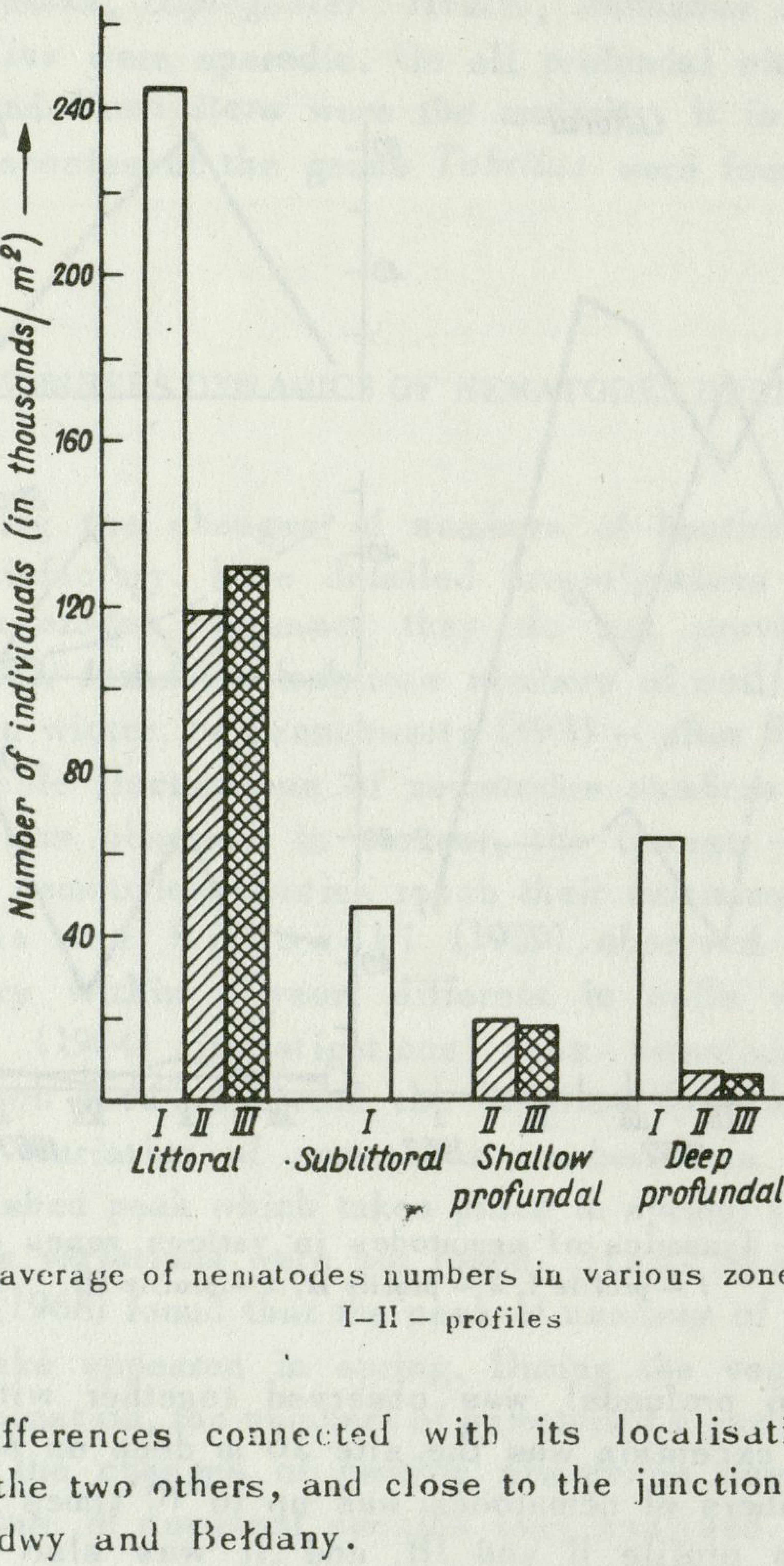

Fig. 2. The yearly average of nematodes numbers in various zones of Mikołajskie Lake
I–II – profiles

environmental differences connected with its localisation. Profile III was located far from the two others, and close to the junction of Mikołajskie Lake with lakes Śniardwy and Bełdany.

The age structure of particular nematodes species was characterized, similarly to the numbers dynamics, by a large variation. In many cases, however, a regularity was observed: an increased share of larval forms in nematodes groupings in the periods of their numbers increase. Especially distinctive was this regularity during the spring and fall increase of the nematodes numbers, but it was not observed during the winter. An illustration of this problem is given by presenting changes of the age structure of dominant species on profile I and II (Fig. 3).

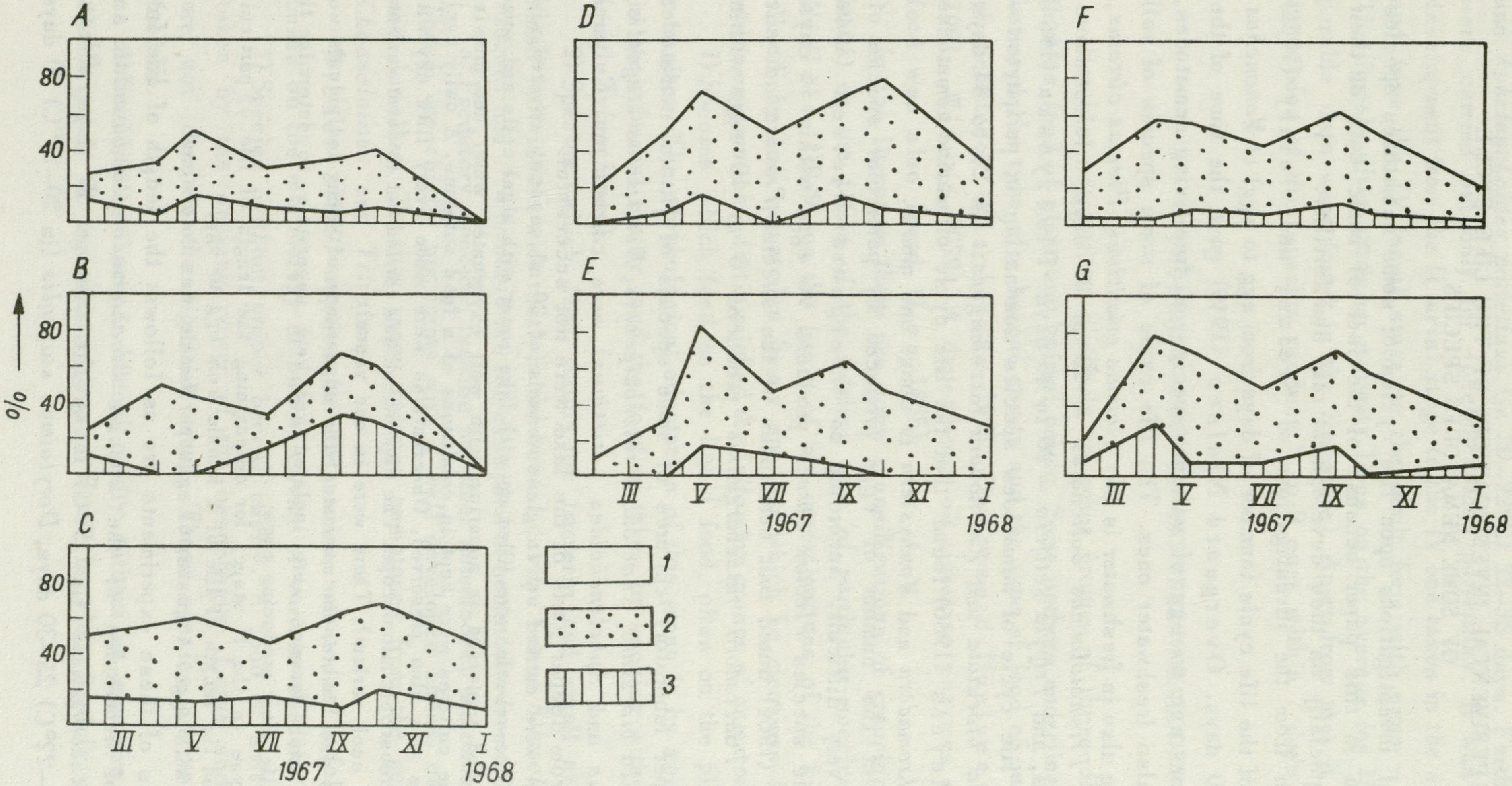

Fig. 3. The age structure of dominant species of nematodes

1 – adults, *2* – old larvae, *3* – young larvae

A – *Punctodora ratzeburgensis* (littoral, profile I), B – *Prochromadorella bioculata* (littoral, profile I), C – *Ironus tenuicaudatus* (sublittoral, profile I), D – *Tobrilus gracilis* (littoral, profile II), E – *T. medius* (littoral, profile II), F – *T. gracilis* (deep profundal, profile I), G – *T. medius* (deep profundal, profile I)

IV. EXPERIMENTAL INVESTIGATIONS OF THE LIFE CYCLE OF SOME NEMATODES SPECIES

Experimental investigations upon life cycles of some nematodes species were undertaken in this paper because of the lack of basic data on their biology, and especially on their development rate and fertility.

It is known from the investigations of Steiner and Heinly (1922) that the length of the life cycle (number of days from egg to egg) of *Mononchus papillatus* is 50 days. Overgaard Nielsen (1949) gave the time of the development from egg to egg of various species of free-living nematodes, among others also freshwater ones. The life cycle of some species of soil nematodes living also in freshwater is for: *Alaimus primitivus*, *Plectus cirratus*, *P. granulosus*, *Prismatolaimus dolichurus* – 20 to 30 days, *Achromadora dubia* – 20 days, and *Tripyla setifera* – 30 to 40 days. Pieczyńska (1964) found that the life cycle of nematodes species dominating in periphyton – *Prochromadorella bioculata* and *Punctodora ratzeburgensis* is 26 to 34 days. Hopper and Meyers (1966) found that the life cycle of marine nematodes of the genus *Chromadora* and *Monhystera* is about one month.

Estimation of the number of eggs produced by particular species of nematodes is very difficult. According to Overgaard Nielsen (1949) a female of the species *Plectus parvus* produces 96 eggs within 16 days. Pieczyńska (1964) noted that nematodes of the species *Prochromadorella bioculata* and *Punctodora ratzeburgensis* produced 3 to 10 eggs within 10 days.

In this paper laboratory cultures of some species of littoral nematodes (*Prochromadorella bioculata*, *Punctodora ratzeburgensis*, *Dorylaimus stagnalis*, *Plectus cirratus* and *Aphelenchoides parietinus*) were carried out. Cultures of nematodes from deeper parts of the lake were not successful.

The cultures were carried out in glass vessels of 20 ml capacity covered with a bolting cloth. The vessels were filled up with lake water with algal cells and some detritus added, and immersed in aquarium with well oxygenated water and growing macrophytes. The cultures were kept in conditions of a food surpluss. A daily cycle of light changes was also preserved. Observations were made every fifth day with the help of a stereoscopic microscope. The experiment was carried out in some variants (5 repetitions of each variant). There were in one vessel:

1) 2 females and 1 male; the moment of the appearance of young individuals was observed, then adult females were isolated and kept separately to determine the length of their life after producing eggs;

2) Some larvae in the II stage, for determining the length of life of particular larval stages, and the length of life of a female from egg to egg;

3) 1 female with eggs. A number of eggs per female was determined.

The results of these experiments are as follows: the length of life from egg to egg of nematodes of the species *Prochromadorella bioculata* and *Punctodora ratzeburgensis* (in 19° C) is on the average 30 days, *Plectus cirratus* (in 20–22°C) 25–30 days, *Dorylaimus stagnalis* (in 20–22°C) 40 days, and *Aphelenchoides parietinus* (in 20–22°C) 32–35 days. Further observations were carried out only for *Aphelenchoides parietinus*. It was found that the development from the II larval stage to the IV one takes in the average 20 days, and from the IV larval stage to the adult form with eggs – 10 to 13 days. The female after attaining maturity lives on the average for 15 days (no comparable data were found in the literature). Apart from that it was found that nematodes of this species produce 5 to 8 eggs within 7 days.

V. TROPHIC GROUPS OF BENTHIC NEMATODES

Benthic nematodes, similarly to other groups of these animals feed on various food of plant and animal origin. Some authors underline the connection between the type of a buccal cavity and the type of food of particular species of nematodes (Micoletzky 1925, Overgaard Nielsen 1949, Hyman 1951, Wieser 1959). A dependence of digestive enzymes on the type of food was also found (Lee 1965).

In the literature there are some classifications of groupings of nematodes made on the basis of the feeding type of particular species. Overgaard Nielsen (1949) on the basis of his investigations of the kind of food consumed by soil nematodes (many species which he mentions live also in the water environment) distinguished the following groups of nematodes:

1) Species which feed on the liquid food, often on the plant sap; mainly parasites. The morphological adaptation of this group is by means of a stiletto in their buccal cavity, and the food is taken by sucking with the oesophagus (e.g. *Tylenchinae*).

2) Species which feed mainly on bacteria and small algae. These are small individuals with teeth in the buccal cavity. Genus *Ethmolaimus*, *Plectus*, *Alaimus* and *Achromadora* are the examples of nematodes from this group.

3) Predatory species, feeding on other nematodes, protozoans and rotifers. These are chiefly big forms with a well developed buccal cavity with teeth and lamellas. To this group belongs nematodes from the genus *Mononchus*, *Choanolaimus* and *Tripyla*.

Wieser (1959) applied for the marine nematodes a following division based on the morphology of buccal cavity of various species:

1) Species without proper buccal cavity. A food of soft consistence is taken by the sucking power of the oesophagus. Large and solid particles are not found in the digestive truck. These species are selective deposit-feeders.

2) Species with proper buccal cavity without an armature. Food is taken similarly as in the former group. Food is also basicly similar, but the

particles are larger, mainly diatoms are present. Probably non selective deposit-feeders.

3) Species with buccal cavity with a not very strong armature. These species scrape out the food or pierce plant cells and suck out their contents. These are mainly epigrowth-feeders.

4) Species with large, strong and differentiated armature in their buccal cavity. Mainly predators. (or omnivorous?). Prey can be swallowed entirely or pierced with stiletto or teeth and the contents sucked in.

The results of investigations of digestive trucks of marine nematodes and the results of laboratory experiments done by Perkins (1959) are to a large extent in agreement with Wieser's (1959) data.

Hyman (1951) divided free-living nematodes into:

Saprophagous – feeding on detritus and on material of plant or animal origin during destruction. Bacteria and fungi are also included as food;

Herbivorous – feeding mainly on algae;

Predators – feeding on other nematodes, rotifers, tardigrades and small oligochaetes.

On the basis of the data of above quoted authors, and other references on feeding characteristics of particular species of nematodes, three trophic groups were distinguished in this paper:

1) Herbivorous – species feeding on minute green algae, blue greens and diatoms;

2) Predators – feeding on protozoans, rotifers, tardigrades, small oligochaetes and other nematodes;

3) Detritus-feeders – feeding on detritus with bacteria and fungi.

The following species were included in the first group: *Punctodora ratzeburgensis* (acc. Meschkat 1934, Overgaard Nielsen 1949, Hyman 1951, Goodey 1963). *Prochromadorella viridis*, *P. bioculata*, *Chromadorita leuckarti* (acc. Hyman 1951, Goodey 1963), *Aphelenchoides parietinus* (acc. Overgaard Nielsen 1949).

To the group of predators the following species were included: *Actinolaimus macrolaimus* (acc. Hyman 1951, Lee 1965), *Ironus tenuicaudatus* (acc. Filipjev and Schuurmans Stekhoven 1941, Goodey 1963), *Mononchus macrostoma* (acc. Micoletzky 1921, Overgaard Nielsen 1949, Hyman 1951, Goodey 1963, Esser 1963), *Tripyla* sp. sp. (acc. Micoletzky 1921, Overgaard Nielsen 1949, Hyman 1951, Goodey 19631, *Tobrilus* sp. sp. (acc. Menzel 1920, Lapage 1937 quoted after Overgaard Nielsen 1949, Hyman 1951; Goodey 1963 determined the nematodes of this genus as omnivorous).

To the group of detritus-feeders the species of the following genera were included (on the basis of data of Overgaard Nielsen 1949, Hyman

1951, Goodey 1963): *Ethmolaimus*, *Plectus*, *Anonchus*, *Teratocephalus*, *Bunonema*, *Alaimus*, *Prismatolaimus*, *Monhystera*, *Diplogaster* and *Achromadora*.

The feeding type of following species of nematodes: *Dorylaimus stagnalis*, *D. helveticus*, *D. montanus*, *D. holsaticus*, *D. flavomaculatus*, *Prodesmodora circulata* and *Aphanolaimus attentus* was not determined because of a lack of data in literature.

A trophic structure of nematodes groupings in the investigated lake environments: littoral, sublittoral and profundal was analysed. It was found that the differences in the trophic structure of groupings in these environments were similar all the time during the investigations. The average data from three months (May, July and September) are shown (Fig. 4) to illustrate the discussed problem.

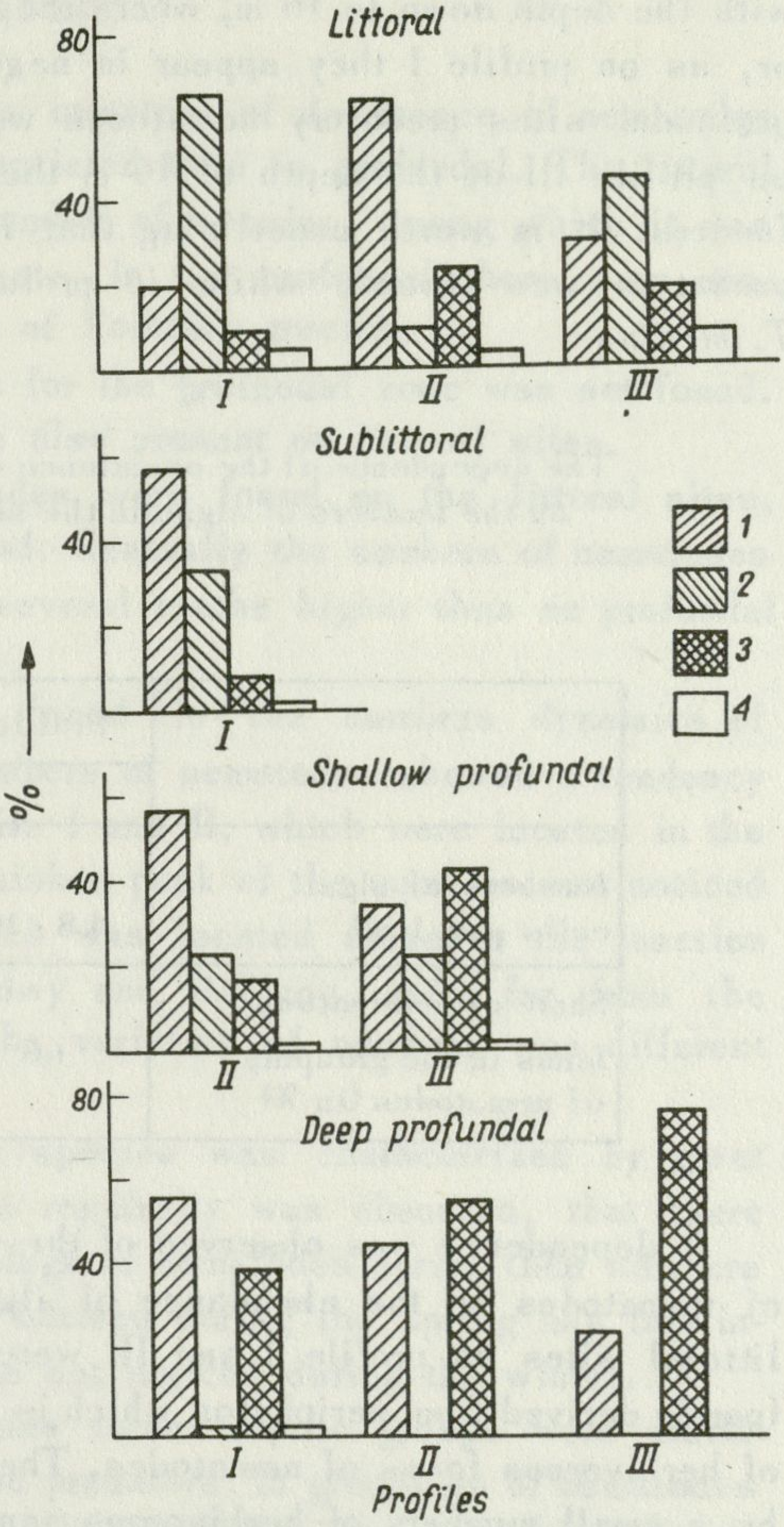

Fig. 4. The percentage share of different trophic groups of nematodes in their total numbers in various zones of Mikołajskie Lake
1 — predators, 2 — herbivorous, 3 — detritus-feeders, 4 — food not determined

In the littoral environment the share of each group of nematodes was different on various sampling sites. In the littoral overgrown with reed (profile I and III) herbivorous species were dominants with detritus-feeders being the least numerous. The site on profile II (littoral without macrophytes) was characterized by the dominance of predatory species with the lowest numbers of herbivorous species (Fig. 4).

A dominace of predators (among them *Ironus tenuicaudatus* was a real dominant) was observed in sublittoral, where they formed about 60% of all nematodes. Herbivorous forms reached 30%, and the detritus-feeders made only a low percentage.

In the profundal zone the share of herbivorous forms decreases together with the depth down to 16 m, where they are not found at all (profile II and III) or, as on profile I they appear in negligable percentage. On the majority of profundal sites predatory nematodes were very numerous (35–60%), but only on profile III at the depth of 16 m they were second in numbers to detritus-feeders. It is worth underlining that in the littoral 10 species belonging to predators were found, while in profundal only 2 – *Tobrilus gracilis* and *T. medius*.

The dependence of the occurrence of herbivorous forms of nematodes on the numbers of algae in the surface layer of bottom sediments

Tab. II

	Profile I	Profile II	Profile III
	Depth 0.40 m		
Numbers of algal cells per 1 m²	$4.8 \cdot 10^9$	$1.2 \cdot 10^9$	$3.0 \cdot 10^9$
Share of herbivorous forms in the grouping of nematodes (in %)	66	10	46

A dependence was observed of the share of herbivorous forms in groupings of nematodes on the abundance of algae in bottom sediments (Tab. II). The littoral sites on profile I and III were characterized by very abundant algae (partly derived from periphyton which is very abundant there), and the dominance of herbivorous forms of nematodes. The littoral on profile II was characterized by a small numbers of herbivorous nematodes and also by insignificant share of algae in bottom sediments.

It is possible that the differentiation of the numbers of predatory forms of nematodes results, among the others, from the different kind of bottom sediment in these environments. The littoral sites on profile I and III were characterized by very hard sediment – only a small share of predators was observed there. The sediments on sites on profile II were very soft and sandy – the predatory forms were dominants there. It is possible that the penetration of predatory forms is more difficult in hard, compressed sediment, which is thus their limiting factor.

Among the groupings of nematodes inhabiting various littoral sites greater differences were noticed in the trophic structure than on the profundal sites.

CONCLUSIONS

1. The species composition and the structure of dominance of nematodes groupings in littora were more differentiated than in profundal. The littoral sites were characterized by a large number of species, among which it was difficult to determine the true dominants. In the profundal there were considerably less species with domination of *Tobrilus gracilis*.

2. A specific species of nematodes for the profundal zone was not found. All species occurring in profundal were also present on littoral sites.

3. The highest numbers of nematodes were found on the littoral sites, the lowest on the sites in deep profundal. Generally the numbers of nematodes on the littoral sites were several to several tenths higher than on profundal sites.

4. Considerable differences were found in the numbers dynamics of nematodes on various profiles. The numbers of nematodes showed a tendency to decrease during the summer on profile I and II, which were located in the central part of the lake. A well distinguished peak of the numbers was noticed during the summer on profile III, which was located close to the junction of Mikołajskie Lake with lakes Śniardwy and Bełdany, quite far from the two other profiles. In other periods the variation of numbers was different at various sites.

5. The age structure of particular species was characterized by great variability. In many cases, however, a regularity was observed, that there is an increased share of larvae in groupings of nematodes during their numbers increase. This dependence was easily noticed during the spring and fall increase of nematodes numbers, and it was not noticed during the winter.

6. Among the investigated nematodes three trophic groups were distinguished: herbivorous, detritus-feeders and predators. In groupings of nematodes inhabiting particular sites in the littoral larger differences were observed in their trophic structure than in those from the profundal sites.

7. A dependence was found of the share of herbivorous forms on the abundance of algae in bottom sediments in the littoral. A majority of herbivorous forms was observed on the sites with large numbers of algae, but where the algae were not very numerous only a small numbers of herbivorous nematodes was found.

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WYBRANE ZAGADNIENIA Z EKOLOGII NICIENI (*NEMATODA*) BENTOSOWYCH JEZIORA MIKOŁAJSKIEGO

Streszczenie

Tematem pracy była analiza składu gatunkowego i dynamiki liczebności nicieni zasiedlających różne środowiska denne eutroficznego Jeziora Mikołajskiego. Analizowano strukturę dominacyjną i troficzną zgrupowań *Nematoda*. Przeprowadzono także szereg eksperymentów laboratoryjnych mających na celu określenie cyklu życiowego kilku gatunków nicieni. Badania prowadzono od lutego 1967 r. do stycznia 1968 r. Próby pobierano siedmiokrotnie w trzech profilach, od brzegu w głąb jeziora (do głębokości 16 m). W każdym profilu analizowano stanowiska usytuowane w litoralu, sublitoralu, płytkim profundalu i profundalu głębokim.

Stanowiska litoralne charakteryzowały się dużą liczbą gatunków (39) występujących w zbliżonych liczebnościach. W sublitoralu znaleziono 27 gatunków, w tym dwa zdecydowanie przeważające (*Ironus tenuicaudatus* i *Chromadorita leuckarti*). Na stanowiskach profundalnych notowano tylko 13 gatunków, wśród których najliczniej występował *Tobrilus gracilis* (tab. I).

Liczebność nicieni (na 1 m^2 powierzchni dna) wahała się od 2 tys. osobników w profundalu do 380 tys. osobników w litoralu (fig. 1). W większości przypadków (oprócz stanowiska o głębokości 16 m w profilu I) zmniejszanie się liczebności nicieni od litoralu do głębokiego profundalu następowało stopniowo, wraz ze wzrostem głębokości (fig. 2).

Stwierdzono znaczne różnice w przebiegu zmian liczebności nicieni w obrębie poszczególnych profilów. W obu profilach położonych w centralnej części jeziora (profile I i II) liczebność nicieni wykazała tendencję spadkową w okresie letnim. W pozostałych okresach zmiany liczebności miały różny charakter na rozmaitych stanowiskach. W profilu III, znacznie oddalonym od dwu pozostałych i leżącym w pobliżu połączenia Jeziora Mikołajskiego z jeziorami Śniardwy i Bełdany, na stanowiskach w litoralu i płytkim profundalu stwierdzono wyraźne szczyty liczebności

w okresie letnim. Na stanowisku najgłębszym tego profilu liczebność nicieni była niewielka i mało zmienna w cyklu rocznym.

Przeprowadzono badania struktury wiekowej dominujących gatunków. Wyróżniono trzy stadia wiekowe: larwy młode, larwy starsze i formy dorosłe. Struktura wiekowa poszczególnych gatunków nicieni charakteryzowała się, podobnie jak dynamika liczebności, dużą zmiennością. W wielu wypadkach obserwowano jednak prawidłowość polegającą na zwiększonym udziale form larwalnych w zgrupowaniach nicieni w okresach wzrostu liczebności. Szczególnie wyraźnie zależność tę notowano w czasie wiosennego i jesiennego wzrostu liczebności nicieni, nie obserwowano jej natomiast w okresie zimowym.

Wyróżniono wśród nicieni trzy grupy troficzne: fitofagi, detrytusofagi i drapieżne. W zgrupowaniach nicieni zasiedlających poszczególne stanowiska litoralne zauważono większe różnice w strukturze troficznej niż na stanowiskach profundalnych.

W litoralu obserwowano zależność między udziałem form roślinożernych w zgrupowaniach nicieni a obfitością glonów w osadach dennych.

AUTHOR'S ADDRESS:
Mgr Krystyna Prejs
Zakład Hydrobiologii
Instytutu Zoologicznego
Uniwersytetu Warszawskiego
Warszawa, ul. Nowy Świat 67
Poland.