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SPATIAL DIFFERENTIATION AND CHANGES IN TIME OF ZOOMICROBENTHOS IN THREE MASURIAN LAKES

(Ekol. Pol. 20: 733–745). A relatively small variability in zoomicrobenthos numbers has been observed within one station and different ones at the same depth in the lake. When comparing the zoomicrobenthos occurrence in succession from littoral deep into the reservoir a distinct number dynamics but a similar qualitative zoomicrobenthos composition was observed. Changes in number on the same stations (examined in two lakes) in six successive years were greater in Mikołajskie Lake than in lake Śniardwy, just the opposite to the changes of the qualitative composition.

Several methodical problems connected with the studies of the so-called microbenthos in lake environments are still a matter of discussion. Some of them are already elaborated and were previously described (Stańczykowska 1966, Stańczykowska and Przytocka-Jusiak 1968, Prejs 1970), other problems, which are either supplementary or a continuation of these studies, are presented here.

The following problems have been analysed:

1) Differences in zoomicrobenthos samples within one station and between particular stations on the same depth in the same lake.

2) Numer dynamics and changes of qualitative composition in three profiles[1] in an annual cycle.

3) Changes in number and qualitative composition of zoomicrobenthos on the same stations in 6 successive years of studies (in 2 lakes during summer).

AREA AND METHODS

The studies have been conducted in three Masurian lakes (Masurian Lakeland, Northern Poland): eutrophic, holomictic Mikołajskie Lake, eutrophic, polymictic lake Śniardwy and mezotrophic, holomictic lake Tałtowisko. The material from Mikołajskie Lake was the most essential. 850 samples were taken.

Zoomicrobenthos samples in a profundal environment were taken using a tube sampler of a surface 10 cm^2 (Kajak, Kacprzak, Polkowski 1965). The top, 4 cm thick, mud layer was analysed. Because of the difficulties in applying this apparatus in littoral the samples were taken with a glass tube of a surface about 0.6 cm^2. The contents of three tubes provided material for one sample. Thus sampled material was preserved in 4% formalin, washed on a sieve of a mesh size 45 μ, and then surveyed under a stereoscopic microscope. The following groups of zoomicrobenthos were distinguished: the *Nematoda*, *Oligochaeta*, *Copepoda*, *Cladocera*, *Ostracoda*, *Chironomidae* and *Tardigrada*.

The biomass of dominant zoomicrobenthos groups was calculated as following: for *Copepoda* and *Cladocera* acc. to Morduchaj-Boltovski (1954), for *Nematoda* acc. to Wieser (1960), for *Chironomidae* acc. to Konstantinov (1962). The studies were conducted in the years 1963–1968.

Detail data on the amount and places of sampling will be discussed separately with each problem.

DIFFERENCES BETWEEN PARTICULAR ZOOMICROBENTHOS SAMPLES WITHIN ONE AND SEVERAL STATIONS ON THE SAME DEPTH

Spatial differentiation of zoomicrobenthos was determined by sampling few series of samples from the examined lakes but only once. Each series illustrated the differences within one station.

Successive series were sampled on stations on the same depth in the lake but about 200 m distant from one another. Analysed were: in the littoral of

[1]Succession of stations from littoral towards the middle of the lake.

Mikołajskie Lake (depth about 0.50 m) – 5 series of samples, in the profundal of Mikołajskie Lake (depth about 16 m) – 5 series of samples, in the profundal of lake Śniardwy (depth about 4 m) – 7 series of samples, in the profundal of lake Śniardwy (depth about 7 m) – 2 series of samples, and in the profundal of lake Tałtowisko (depth about 20 m) – 2 series of samples. Each series consisted of 25 samples, with the exception of lake Śniardwy (depth 4 m), where each series consisted of 10 samples.

Differentiation in number (thousands of ind./m²) of zoomicrobenthos in particular series (arithmetic mean and its error)

Tab. I

Sampling series	Environment				
	Profundal				Littoral
	Mikołajskie (Depth 16 m)	Tałtowisko (Depth 20 m)	Śniardwy (Depth 4 m)	Śniardwy (Depth 7 m)	Mikołajskie (Depth 0.50 m)
a	10.2 ± 1.7	35.1 ± 7.0	23.8 ± 7.3	3.6 ±0.3	51.0 ±12.2
b	11.2 ± 1.9	30.4 ±12.7	25.6 ±15.2	4.9 ±0.4	29.5 ± 8.9
c	10.0 ± 2.8	–	28.0 ± 5.0	–	21.5 ± 8.9
d	13.6 ± 7.9	–	21.5 ± 8.9	–	11.2 ± 0.6
e	47.0 ±10.0	–	24.0 ±13.2	–	36.3 ± 3.4
f	–	–	21.0 ± 5.1	–	–
g	–	–	42.0 ±16.3	–	–

Variation coefficients of zoomicrobenthos numbers in various series on different stations of examined lakes

Tab. II

Environment, lake		Sampling series							Variation coefficient from all samples of all series from each lake
		a	*b*	*c*	*d*	*e*	*f*	*g*	
Profundal	Mikołajskie	1.24	0.37	0.54	0.71	0.24			0.44
	Tałtowisko	0.40	0.35						0.27
	Śniardwy 4 m	0.34	0.46	0.16	0.52	0.51	0.14	0.36	0.50
	Śniardwy 7 m	0.60	0.66						0.50
Littoral	Mikołajskie	0.22	0.30	0.39	0.34	0.20			0.35

In order to draw a comparison of zoomicrobenthos differentiation within one station the following were calculated for each series of samples: arithmetic

mean and its standard error, variance and variation coefficient. Thus obtained data (Tab. I and II) prove the relatively small zoomicrobenthos differentiation of one series of samples (i.e. within one station). In the case of macrobenthos, Kajak (1963) found that the amounts of organisms simultaneously sampled from the same station may differ considerably.

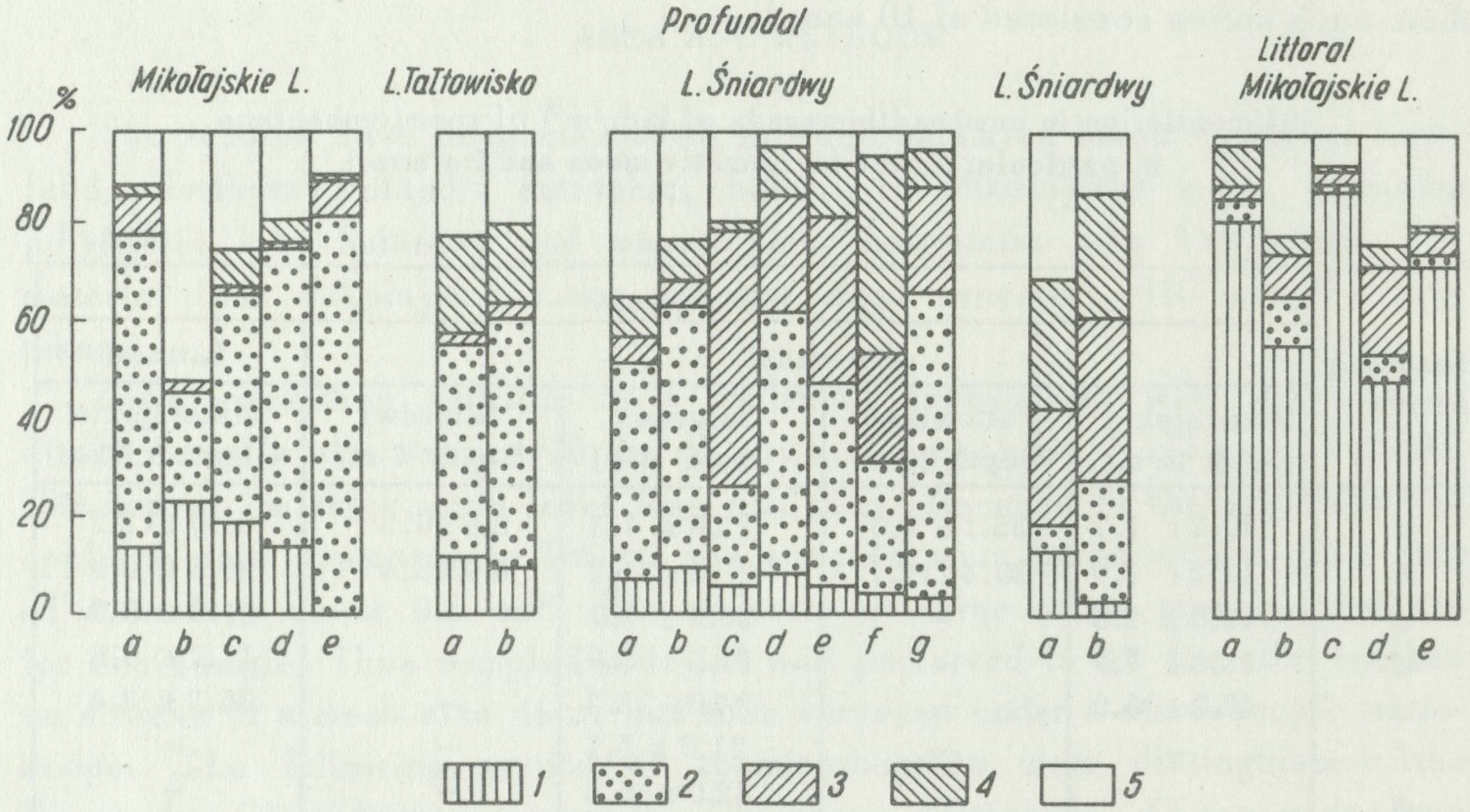

Fig. 1. Quantitative and qualitative zoomicrobenthos differentiation in particular series of samples

1 – Nematoda, 2 – Copepoda, 3 – Chironomidae, 4 – Ostracoda, 5 – Others

a – e – sampling series

The differentiation of zoomicrobenthos is small almost in all series sampled on various stations (Tab. II). An exception is only the series *a* from Mikołajskie Lake. Taking into consideration all the other series it can be said that the differences between the successive samples within one station were of an approximate order in the profundal of Mikołajskie Lake and lake Śniardwy, and only slightly smaller in the lake Tałtowisko.

Also a comparison of the differences within one station in the littoral and profundal of Mikołajskie Lake did not show the existence of any greater differences. A comparison of the number and qualitative composition of zoomicrobenthos on various stations on the same depth and in the same reservoir, also, did not point to any greater differences (Fig. 1 and Tab. I). In Mikołajskie Lake (in 4 series) the numbers were of a similar order: 10–13 000 ind./m^2, and the *Copepoda*, *Nematoda* and "others" were mainly found. Only in the

series *e*, sampled the nearest to the town, the number was about 4 times higher, and the dominance of the *Copepoda* quite distinct, and almost a total absence of the *Nematoda*. Also, no special differences were observed in the numbers on particular stations in lake Śniardwy (with the exception of the station where series *g* was sampled). The qualitative composition of zoomicrobenthos groups was very similar. In lake Tałtowisko the number and qualitative composition were also approximate on the two examined stations.

The greatest differences between particular series of samples taken on various stations but at the same depth were found in the littoral, which is naturally due to the considerable mosaicity of this environment.

COMPOSITION AND NUMBER DYNAMICS OF ZOOMICROBENTHOS IN THREE PROFILES OF MIKOŁAJSKIE LAKE

To determine the differentiation of zoomicrobenthos within one reservoir the material was sampled in three profiles from the shore towards the middle

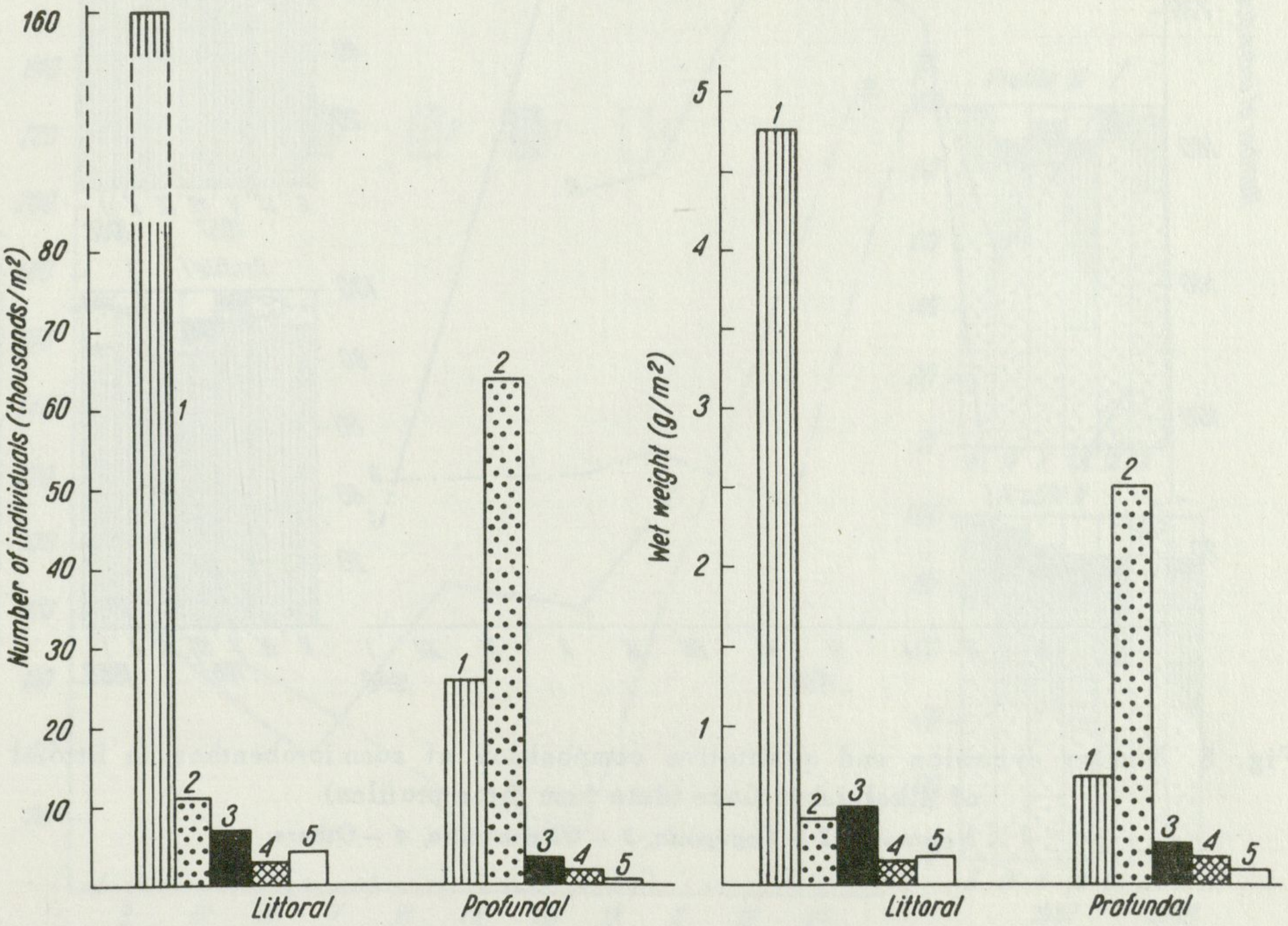

Fig. 2. Mean number and biomass of zoomicrobenthos in littoral and deep profundal (16 m) of Mikołajskie Lake

1 – Nematoda, 2 – Copepoda, 3 – Oligochaeta, 4 – Cladocera, 5 – Others

of the lake to the depth of 16 m. From each profile the samples were taken from three stations. The studies were conducted seven times from February 1967 to January 1968.

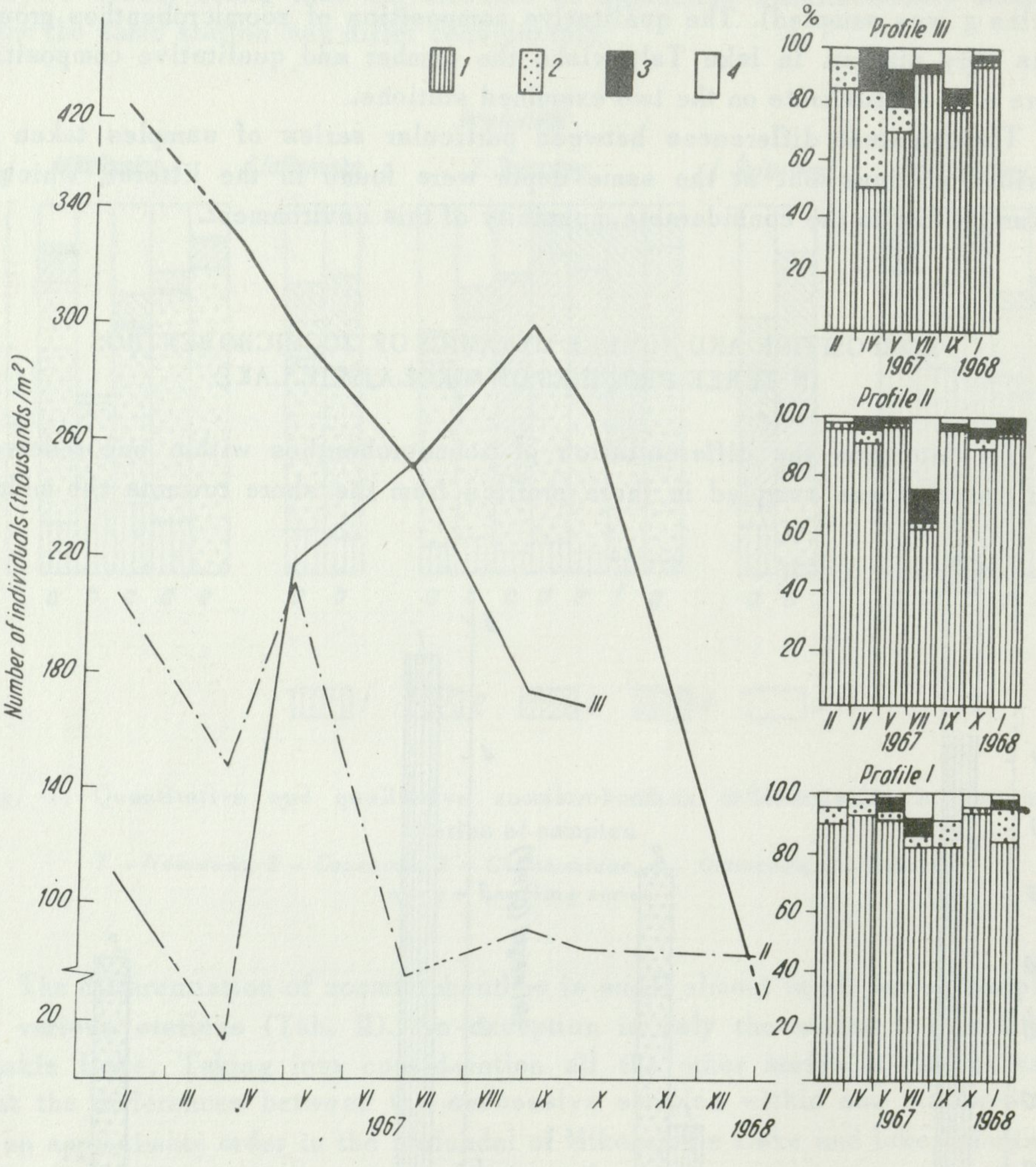

Fig. 3. Number dynamics and qualitative composition of zoomicrobenthos in littoral of Mikołajskie Lake (data from three profiles)

1 – Nematoda, 2 – Copepoda, 3 – Oligochaeta, 4 – Others

Profile I, station 1 – littoral overgrown with reed, 0.40 m deep, gravel--sandy bottom, station 2 – sublittoral, 4 m deep, sandy bottom abundant in mollusc shells, station 3 – profundal, 16 m deep, gyttja with plenty of sand.

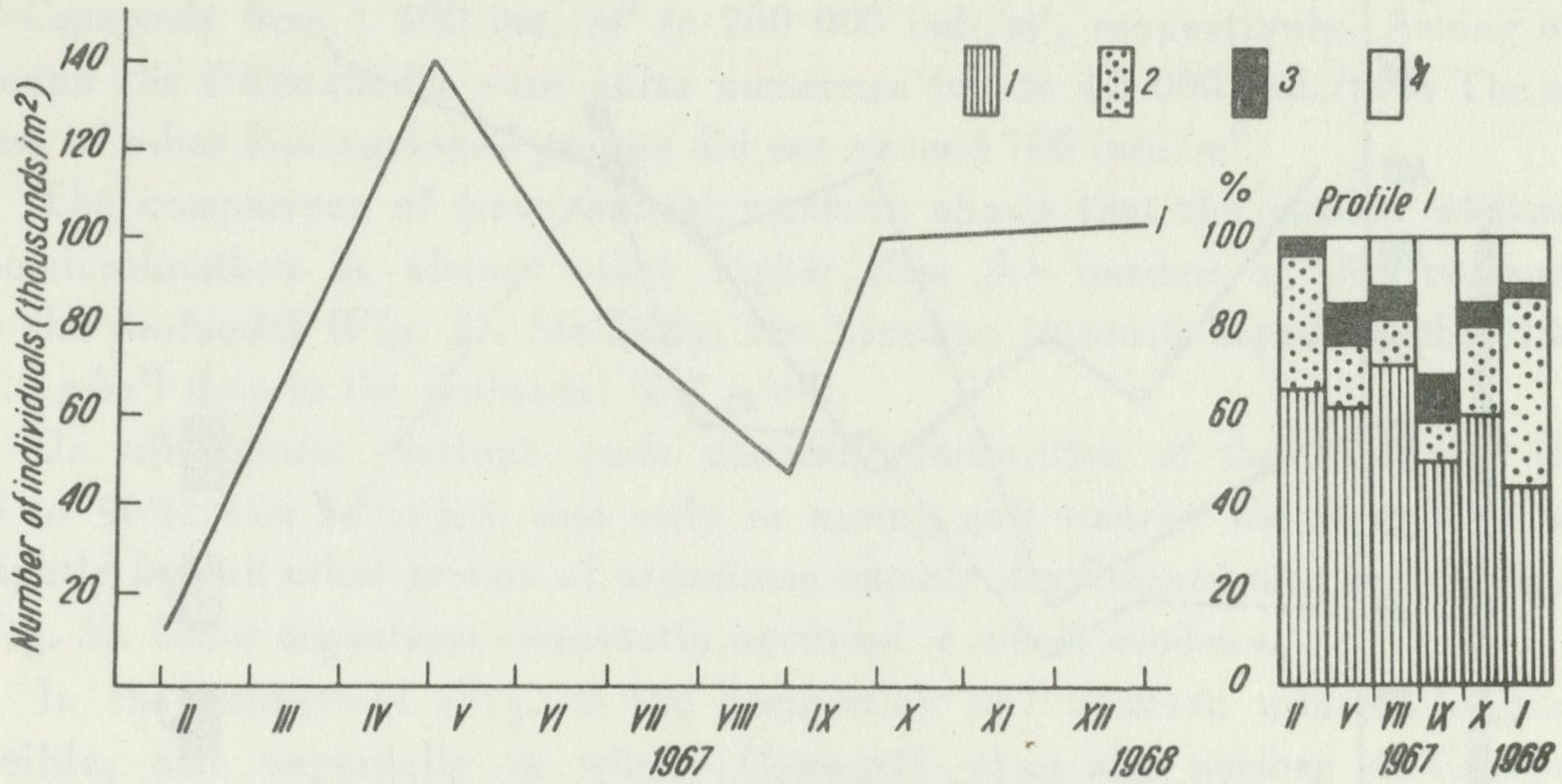

Fig. 4. Number dynamics and qualitative composition of zoomicrobenthos in sublittoral of Mikołajskie Lake (profile I)

Symbols as for Fig. 3

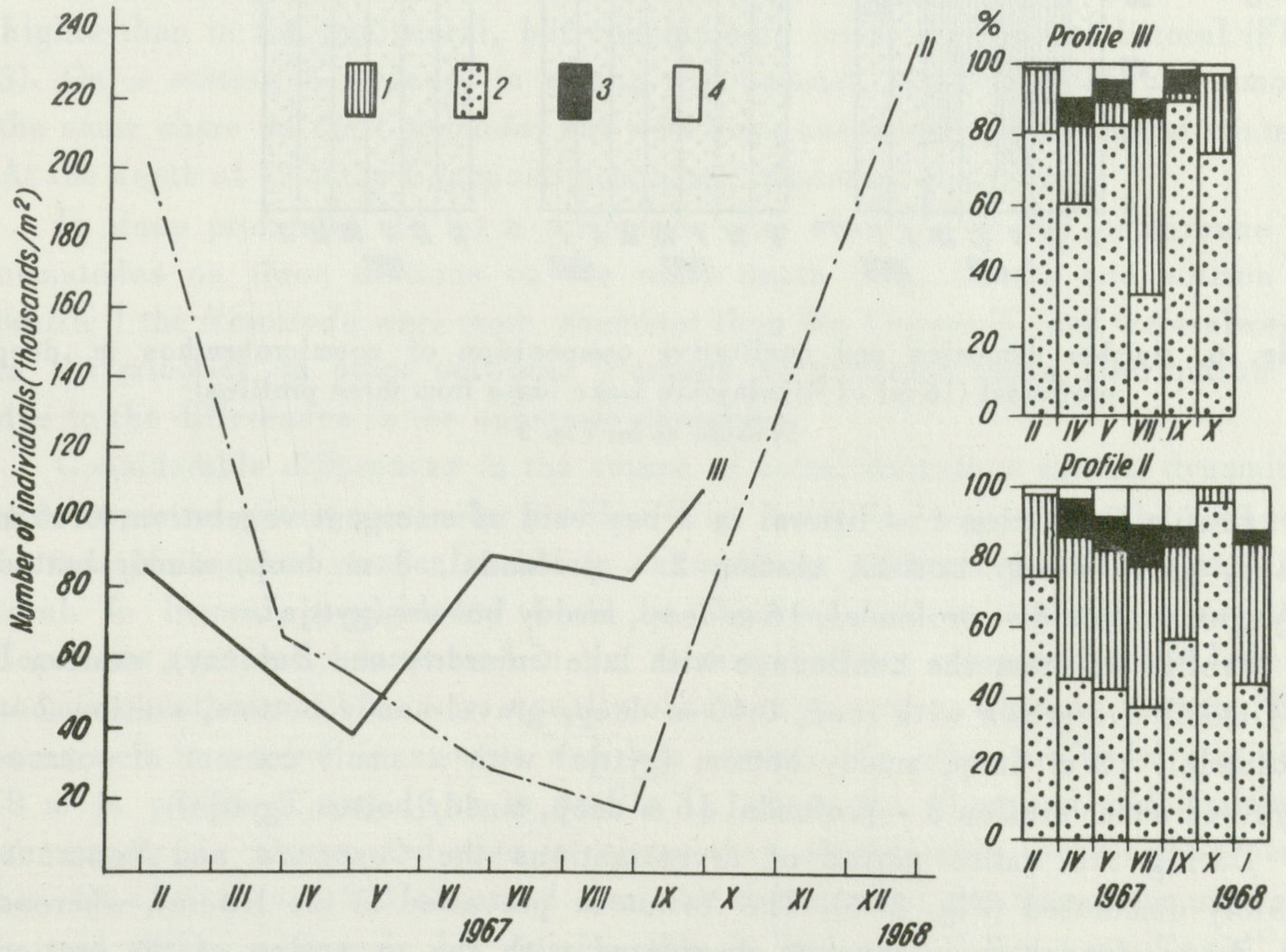

Fig. 5. Number dynamics and qualitative composition of zoomicrobenthos in shallow profundal (8 and 12 m) of Mikołajskie Lake (data from two profiles)

Symbols as for Fig. 3

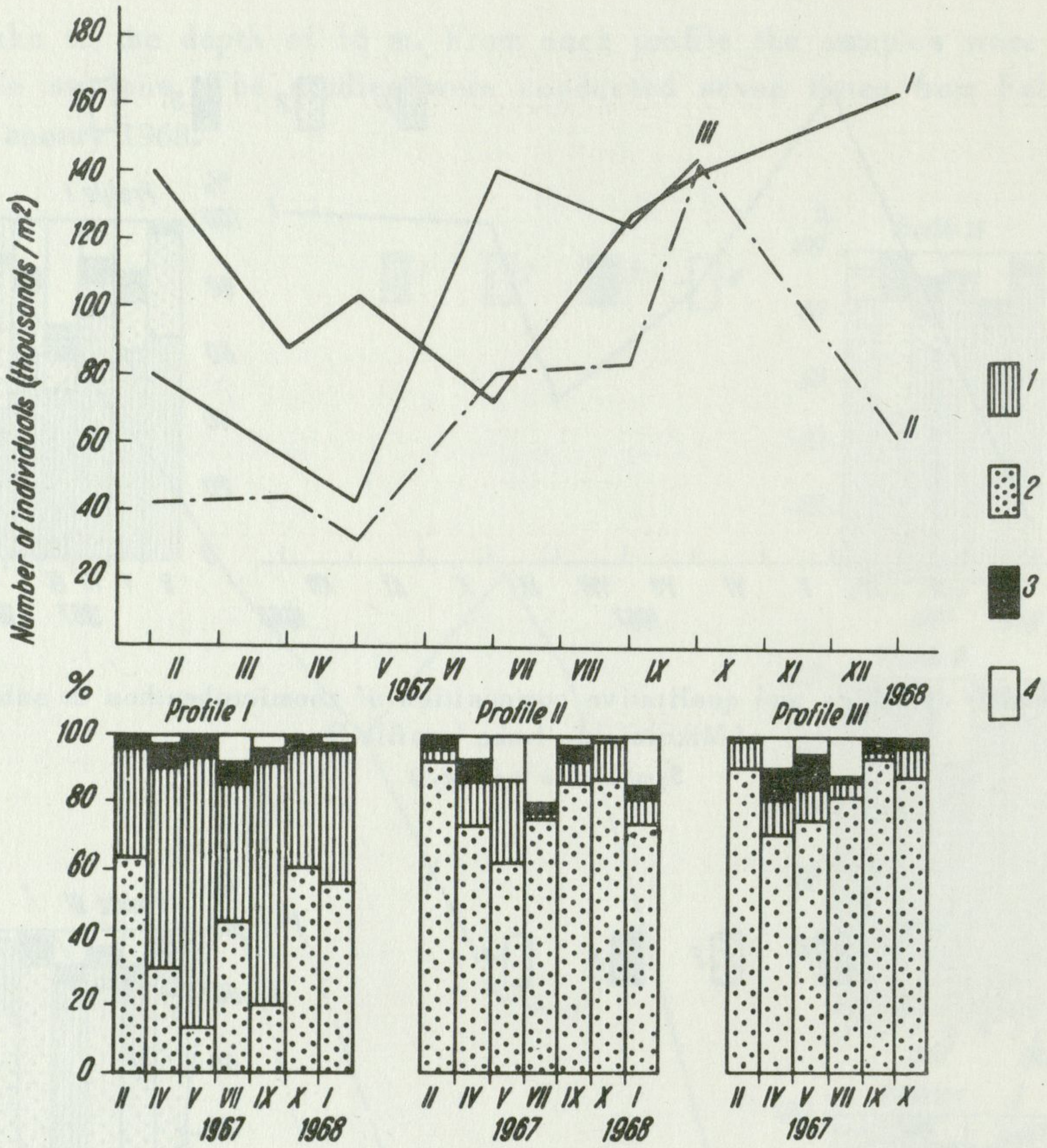

Fig. 6. Number dynamics and qualitative composition of zoomicrobenthos in deep profundal (16 m) of Mikołajskie Lake (data from three profiles)
Symbols as for Fig. 3

Profile II, station 1 – littoral in a bay void of emergent vegetation, 0.40 m deep, gravel-sandy bottom, station 2 – profundal, 8 m deep, muddy bottom (gyttja), station 3 – profundal, 16 m deep, muddy bottom (gyttja).

Profile III (near the confluence with lake Śniardwy and Bełdany), station 1 – littoral overgrown with reed, 0.40 m deep, gravel-sandy bottom, station 2 – profundal, 12 m deep, muddy bottom (gyttja) with a small content of coarse-grained sand, station 3 – profundal 16 m deep, muddy bottom (gyttja).

During the entire period of investigations the *Copepoda* and *Nematoda* visibly dominated (Fig. 2–6). The *Nematoda* prevailed in the littoral, whereas in the profundal the *Copepoda* dominated with the exception of the station 16 m deep in profile I. The numbers of *Nematoda* ranged from 380 000 ind./m² in the littoral to 1 500 individuals/m² in the profundal, whereas the numbers

of *Copepoda* from 1 500 ind./m² to 200 000 ind./m², respectively. Among other groups the *Oligochaeta* were quite numerous (up to 12 000 ind./m²/. The numbers of other distinguished groups did not exceed 700 ind./m².

The comparison of mean annual numbers shows that the number of littoral zoomicrobenthos is almost twice higher than the number of this community in the profundal (Fig. 2). Similarly, the biomass is much higher in the littoral (6.0 g/m²) than in the profundal (3.7 g/m²).

On all littoral stations quite constant domination of the *Nematoda* (from 50 to 90%) was recorded, and only in spring and summer the *Nematoda* were slightly behind other groups of organisms namely the *Oligochaeta* and *Copepoda* (Fig. 3). Other organisms constantly occurred in small numbers.

In the sublittoral (Fig. 4) the domination of *Nematoda* was no longer so visible, and especially in winter (January) when the number of *Copepoda* increased considerably. In spring the numbers of *Oligochaeta*, *Cladocera* and *Ostracoda* increased. In the same time also the presence of small numbers of young larval stages of *Ephemeroptera* and *Coleoptera* was recorded. These groups are not found in microbenthos in other seasons of the year.

In shallow profundal (8 and 12 m) the zoomicrobenthos number was slightly higher than in the sublittoral, but considerably lower than in the littoral (Fig. 5). On a station 8 m deep, in spring and summer, the *Nematoda* had almost the same share as the *Copepoda*, but were less numerous in autumn and winter. At the depth of 12 m the *Copepoda* dominated almost all the time.

In deep profundal (16 m) a difference was observed in the occurrence of nematodes on three stations on the same depth (Fig. 6). On one station in profile I the *Nematoda* were more abundant than the *Copepoda*, and were always in the minority on other stations. Perhaps so different fauna distribution is due to the differences in the substrate character.

Considerable differences in the course of zoomicrobenthos number dynamics were observed within particular profiles (Fig. 3–6). And especially the changes in zoomicrobenthos number varied in character in different profiles in the littoral. In littoral, a regularity could be observed i.e. on stations where the *Copepoda* constantly dominated in the zoomicrobenthos composition the lowest zoomicrobenthos numbers were usually observed in spring, whereas they rapidly increased in number in summer and late autumn. On other profundal stations (8 m in profile II and 16 m in profile I), where the *Copepoda* did dominate constantly, in autumn and also in winter they considerably increased in number. Sacharova (1970)observed also the decrease of the *Copepoda* number in mud during spring. In her opinion this is because of the mass "exit" to pelagial of wintering copepodite stages of a majority of *Cyclopoida* species. From summer to winter she observed the increase in zoomicrobenthos number thanks to the gradual change of various *Cyclopoida* species to the profundal

way of life. A considerable increase in the *Copepoda* number in mud connected with the passage of various species from pelagial to profundal in some seasons of the year was recorded by many authors (Smyly 1961, Wierzbicka 1962, Kasymow and Slepuchina 1969). It remains a subject for discussion how many Copepoda of the Cyclopoida order found abundantly in mud at considerable depths, are in the resting stage, and what is the share of organisms, for which the bottom of the reservoir is the normal life habitat. In the analysed material the actively moving forms and females with eggs were found, but only very few *Nauplii*.

CHANGES IN NUMBER AND QUALITATIVE COMPOSITION OF ZOOMICROBENTHOS IN 6 YEARS OF STUDIES

An analysis of several years of changes in zoomicrobenthos number and composition is based on the material compiled in the years 1963–1968, in the profundal of Mikołajskie Lake (16 m deep) and lake Śniardwy (7 m deep). Samples were taken in July in one series (each counting 5 to 20 samples) on each station.

Zoomicrobenthos numbers (thousands of ind./m²) on the same profundal stations in successive years of studies (during the summer)

Tab. III

Lake	Years					
	1963	1964	1965	1966	1967	1968
Mikołajskie (16 m)	25	16	11	42	81	71
Śniardwy (7 m)	25	10	25	11	15	18

In both lakes the distinct character of changes in the zoomicrobenthos number and composition was observed. In Mikołajskie Lake the numbers varied considerably in the successive years ranging from 11 000 to 81 000 ind./m² with a visible tendency to increase in the last years (Tab. III). The qualitative composition did not change much during these years. The *Copepoda* visibly dominated (Fig. 7). In lake Śniardwy the total zoomicrobenthos number during the entire period of investigations was relatively a subject to very small changes (Tab. III). However, the share of particular zoomicrobenthos components (*Copepoda*, *Cladocera*, *Chironomidae* and *Ostracoda*) changed quite considerably in the successive years. In the first year none of these

groups dominated visibly, whereas in the following years successively dominated: *Cladocera*, *Copepoda*, *Ostracoda*, then *Cladocera* again, and in the last year the *Copepoda* (Fig. 7).

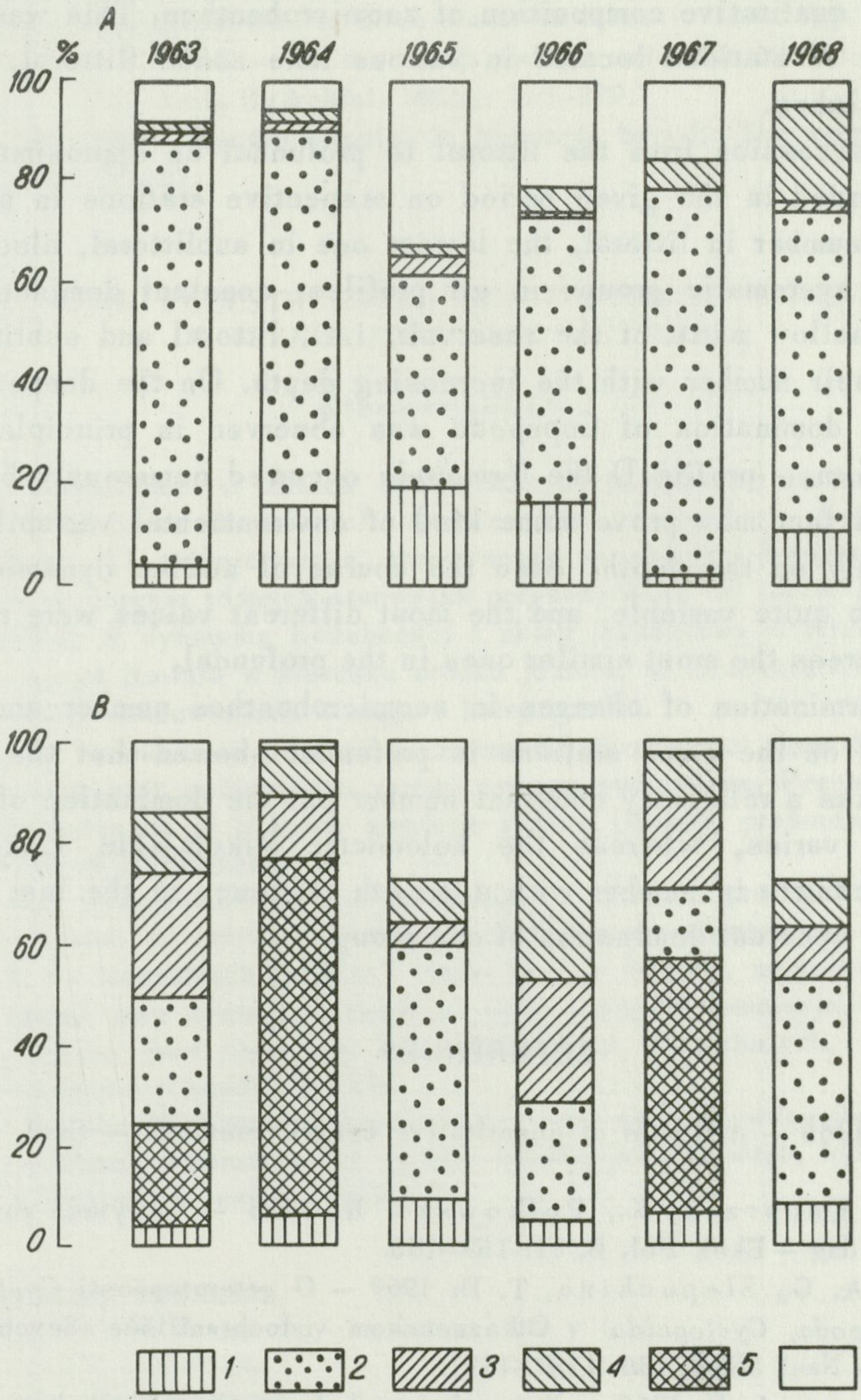

Fig. 7. Domination of particular zoomicrobenthos groups in Mikołajskie Lake (16 m) – *A*, and in lake Śniardwy (7 m) – *B*

1 – Nematoda, 2 – Copepoda, 3 – Chironomidae, 4 – Ostracoda, 5 – Cladocera, 6 – Others

CONCLUSIONS

1. Differences in zoomicrobenthos numbers within one series of samples taken from the same place (station) were not great and were independent of the density and qualitative composition of zoomicrobenthos. This was observed on the example of stations located in various lake zones (littoral, profundal) and in different lakes.

2. In the succession from the littoral to profundal an approximate number level was observed in the given period on respective stations in all profiles at the highest number in littoral, the lowest one in sublittoral, also a similar distribution of systematic groups in all profiles, constant domination of the *Nematoda* in shallow parts of the reservoir, i.e., littoral and sublittoral, and adecrease in their number with the increasing depth. On the deepest stations (profundal) the domination of *Copepoda* was observed in principle. Only on one station (16 m – profile I) the *Nematoda* occurred numerously besides the *Copepoda*. This fact may prove some kind of environmental variability, which depends not only on the depth. Also the course of number dynamics in each profile was also quite variable, and the most different values were recorded in the littoral, whereas the most similar ones in the profundal.

3. The determination of changes in zoomicrobenthos number and composition in 6 years on the same stations in profundal showed that the polymictic lake Śniardwy has a relatively constant number but the domination of particular animal groups varies, whereas the holomictic Mikołajskie Lake displays considerable changes in number with a growth tendency in the last years, but has a relatively constant domination of one group.

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ZRÓŻNICOWANIE PRZESTRZENNE I ZMIANY W CZASIE ZOOMIKROBENTOSU W TRZECH JEZIORACH MAZURSKICH

Streszczenie

Badania prowadzono w latach 1963–1968 w jeziorach: Mikołajskie, Śniardwy, Tałtowisko (Pojezierze Mazurskie). Analizowano następujące problemy dotyczące zoomikrobentosu: 1) zróżnicowanie przestrzenne w obrębie jednego stanowiska, 2) zróżnicowanie w obrębie różnych stanowisk położonych na tej samej głębokości w tym samym zbiorniku, 3) dynamikę liczebności i skład jakościowy w trzech profilach stanowiących ciąg od litoralu w kierunku środka jeziora, 4) liczebność i skład jakościowy na tych samych stanowiskach w ciągu 6 kolejnych lat.

Stwierdzono stosunkowo niewielką zmienność liczebności zoomikrobentosu w obrębie jednej serii prób pobieranych z tego samego stanowiska. Przeanalizowano to na stanowiskach leżących w różnych strefach jeziora (litoral, profundal) oraz znajdujących się w różnych zbiornikach.

Porównując występowanie zoomikrobentosu w różnych profilach Jeziora Mikołajskiego stwierdzono: a) zbliżony poziom liczebności zoomikrobentosu na odpowiednich stanowiskach we wszystkich profilach (najwyższy w litoralu, najniższy w sublitoralu), b) podobny układ grup systematycznych – stała i ciągła dominacja *Nematoda* na stanowiskach płytkich oraz *Copepoda* na stanowiskach najgłębszych, c) dość zmienną dynamikę liczebności w każdym profilu.

Zmiany liczebności zoomikrobentosu na tych samych stanowiskach w ciągu 6 kolejnych lat badań, odwrotnie niż zmiany składu jakościowego, były większe w Jeziorze Mikołajskim niż w jeziorze Śniardwy.

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