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DIFFERENCES IN ABUNDANCE OF BENTHOS AND RELIABILITY OF ITS ASSESSMENT IN SEVERAL LAKE HABITATS

An analysis was made of the differences in the abundance of benthos fauna within small and apparently uniform habitats of the central part of three Mazurian lakes. Examination has been made of the influence of sample size and sample series size, and also the type of sampler used, on the estimate of abundance obtained.

In view of the fact that considerable differences have often been found in the abundance of benthos organisms, even within small and apparently uniform sectors of the habitat (Kajak 1958, 1963, Bitjukov 1962) the question of the reliability of estimates of the abundance of these organisms is still a controversial one.

The aim of the present study was to examine, using a large amount of material, the differences in abundance of benthos within small sectors of the central part of three Mazurian lakes. Attention was also paid to the influence of sample size and sample series size on the estimated numbers and the significance of the type of sampler used.

I. AREA AND METHOD

Material was obtained from the central part of the following lakes:

1) Mikołajskie Lake – eutrophic, holomictic, 470 ha in area, maximum depth 27.8 m, mean depth 11.3 m;

2) Lake Śniardwy – eutrophic, polymictic, 10,970 ha in area, maximum depth 23.4 m, mean depth 5.9 m;

3) Lake Tałtowisko – mesotrophic, holomictic, 313 ha in area, maximum depth 39.5 m, mean depth 14.0 m.

Sampling was carried out at depths of 16 m (Mikołajskie Lake and lake Tałtowisko) and 8 m (lake Śniardwy). The habitats examined were marked by a rope stretched between two buoys anchored 25 m apart. This ensured that material would be taken from the same stations during the next trip to the centre of the lake. Material was taken from each lake over a 2-day period. Within each habitat sampling was carried out on 5 stations at intervals of 5 m, moving from one station to the next along the line of the rope. Tubular pneumatic samplers (Kajak, Kacprzak and Polkowski 1965) and Ekman dredges were used for sampling.

Sampling was carried out on each of the five stations as follows:

– 20 samples with a tubular pneumatic sampler with sampling area of 10 cm^2 (T–10)[1];

– 5 samples with a tubular pneumatic sampler with sampling area of 45 cm^2 (T–45);

– 3 samples with an Ekman dredge with sampling area of 225 cm^2 (Ek–225–m), 20 cm high, with an upper opening covered by net;

– 1 sample with an Ekman dredge with sampling area of 225 cm^2 (Ek–225–h), 40 cm high, with upper opening closed by flaps;

– 2 samples with an Ekman dredge with sampling area of 500 cm^2 (Ek–500), 40 cm high, with upper opening covered by flaps.

The following total number of samples were taken: 300 samples with T–10, 75 samples with T–45, 45 samples with Ek–225–m, 15 samples with Ek–225–h, 30 samples with Ek–500, which corresponds to an area of 34,875 cm^2.

The samples were preserved immediately after sampling in a 4% formalin solution. The material contained 3,710 individuals of *Oligochaeta*, 3,400 *Chironomidae* larvae, 490 *Chaoborus flavicans* (Meig) larvae; the following were sporadically present: *Mermithidae* (*Nematoda*), *Mysis oculata* f. *relicta* Lov. and *Pallasea quadrispinosa* Sars. Samples obtained with an T–10 apparatus were rinsed on a metal sieve with 0.2 × 0.2 mm mesh, and the other samples on a 0.4 × 0.4 mm sieve. The whole of the material examined was sorted by the flotation method, using a sugar solution with specific gravity of 1.14. This solution ensured minimum soaking of the organisms and a long period of floating on the surface (Anderson 1959, Kajak, Dusoge and Prejs 1968) and thus made it possible to see and recover all the individuals.

[1]The symbols used for the various samplers in this study are given in brackets.

II. ASSESSMENT OF DIFFERENCES IN ABUNDANCE OF BENTHOS WITHIN A HABITAT

The ratio $\frac{M\ max}{M\ min}$, i.e. the mean numbers per 1 m² in the "richest" point of a given station (M max) to mean numbers on the "poorest" point (M min), was used as the index of difference. This index was applied to material obtained with a given type of apparatus and jointly (combined index) for material obtained by several samplers, if the mean numbers per 1 m² obtained from each of them were similar (were not conditioned by the type of apparatus and fineness of the mesh of the sieve). Differences in the total numbers of the more numerous species and different age classes (size classes) were analysed.

1. *Oligochaeta*

In the habitats examined in Mikołajskie Lake and lake Tałtowisko *Oligochaeta* were represented by the species *Ilyodrylus hammoniensis* Michaelsen, which attained similar numbers of the order of 1,500–2,200 individuals per 1 m² in these two lakes. The habitat examined was relatively evenly occupied in lake Tałtowisko (Tab. I), where the indices $\frac{M\ max}{M\ min}$ were close to the value 1, and differences in numbers estimated by means of different types of samplers (different sizes of samples and series of samples) differed by only a few percent. In Mikołajskie Lake (Tab. I) differences in abundance between the various stations were greater (combined index $\frac{M\ max}{M\ min} = 1.4$) and the results obtained by means of different samplers more varied than was the case in lake Tałtowisko, which indicates that the distribution of the species is less even than in lake Tałtowisko. It was found that the greater evenness of distribution in the habitat in lake Tałtowisko than in Mikołajskie Lake was maintained in all the age classes distinguished. Differences in the numbers of the various age classes exceeded, in the majority of cases, the differences in the total abundance of this species. The far more frequent differences between the quantitative results obtained in series of samples taken with different samplers indicate that these series were still not large enough to be able correctly to assess differences in numbers in different age classes on their basis. The combined mean values[2] point in the cases of both lakes to the more even occupation of the habitat by the oldest individuals (those allocated to the third class).

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[2]The combined mean value means the arithmetical mean of numbers of organisms per 1 m² obtained from the various types of sampler.

Values of the index of differences in abundance $\left(\frac{M\,max}{M\,min}\right)$ of *Ilyodrylus hammoniensis* in Mikołajskie Lake (A) and lake Tałtowisko (B)

Material obtained using different samplers

Index $\frac{M\,max}{M\,min}$ indicates the ratio of mean numbers (per 1 m²) on the "richest" station in the given habitat (M max) to mean abundance on the "poorest" station (M min)

Tab. I

Mean number of individuals per 1 m² of bottom surface*	T–10	T–45	Ek–225	Ek–500	All samplers
	Number of samples				
	100	25	15	10	150 (50)**
Total for all classes of size					
A 1,700	1.3	1.6	1.5	1.8	1.4
B 1,450 (2,200)	1.2	1.3	1.1	1.3	1.1**
I class of size (1–5 mm)					
A 450 (780)	1.4	1.6	2.3	1.4	1.7**
B 180 (650)	2.1	2.5	2.1	2.4	1.4**
II class of size (6–10 mm)					
A 830	2.5	2.0	1.8	2.6	1.7
B 620	1.2	1.7	1.2	1.8	1.2
III class of size (> 10 mm)					
A 470	2.2	2.3	1.4	2.5	1.4
B 750	1.4	2.1	1.3	1.2	1.2

– *One number without brackets refers to the mean abundance for all samples rinsed on a 0.2 × 0.2 mm mesh sieve (T–10 sampler) and 0.4 × 0.4 mm mesh sieve (T–45, Ek–225 and Ek–500). Two numbers in this column indicate: first, without brackets – mean abundance per 1 m² obtained from samples rinsed on 0.4 × 0.4 mesh sieve (T–45, Ek–225 and Ek–500 samplers); second, in brackets – mean abundance per 1 m² obtained from samples rinsed on 0.2 × 0.2 mm mesh sieve (T–10 sampler).

**Without T–10 sampler (number of samples in these cases – 50).

2. *Chironomidae*

Chironomidae in the lake habitats examined were represented by the following species:

Mikołajskie Lake – *Chironomus anthracinus* Zett.;

Lake Tałtowisko – *Chironomus plumosus* (L.), *Sergentia coracina* (Zett.), *Procladius choreus* (Meig.);

Lake Śniardwy – *Orthocladinae* gen.? *orielica*, *Einfeldia carbonaria* (Meig.),

Differences in total abundance and numbers in different classes of size for *Chironomus anthracinus* in the central part of Mikołajskie Lake

A – index of differences in numbers $\left(\frac{M\ max}{M\ min}\right)$,
B – numbers per 1 m^2 on the "poorest" station (M min),
C – numbers per 1 m^2 on the "richest" station (M max)

Tab. II

Elements compared	T–10	T–45	Ek–225	Ek–500	All samplers
	Number of samples				
	100	25	15	10	150
Total for all classes of size					
A	3.6	4.2	4.7	3.5	2.5
B	400	200	350	290	350
C	1,450	850	1,660	1,030	870
I class of size (1–4 mm)					
A	4.5	–	5.4	5.1	2.2
B	100	0	50	100	90
C	450	290	270	510	200
II class of size (5–8 mm)					
A	–	–	9.1	6.0	5.7
B	0	0	150	50	100
C	350	610	1,370	300	570
III class of size (> 8 mm)					
A	13.0	3.0	1.4	3.1	1.9
B	50	90	150	90	140
C	650	270	210	280	270

Tanytarsus gregarius Kieff., *Chironomus plumosus* (L.), *Procladius choreus* (Meig.), *Cryptochironomus conjugens* Kieff., *Cryptochironomus fridmanae* Tshern., *Cryptochironomus viridulus* (Fabr.), *Cryptochironomus defectus* (Kieff.), *Polypedilum nubeculosum* (Meig.), *Limnochironomus tritomus* (Kieff.).

The maximum variations in numbers were found in the habitat examined in Mikołajskie Lake (Tab. II) where, with a singlespecies composition of *Chironomidae* in samples taken with different samplers, the differences in total numbers between different stations were 3 or 4 times as great. The combined mean values calculated for different stations also vary fairly considerably and point to the uneven distribution of *Chironomus anthracinus*, the series of samples taken with different samples being too small to enable a correct estimate to be made of the numbers of this species. The unevenness of distribu-

Value of the index of differences in total abundance $\left(\frac{M\ max}{M\ min}\right)$ of *Chironomidae* in lakes Tałtowisko (A) and Śniardwy (B)

Material obtained using different samplers

Tab. III

Mean number of larvae per 1 m² of bottom surface*			T–10	T–45	Ek–225	Ek–500	All samplers**
			Number of samples				
			100	25	15	10	50
A	360	(620)	1.7	1.4	1.1	1.4	1.2
B	2,000	(4,100)	1.7	1.6	1.2	1.4	1.5

*See explanations to Table I.
**Without sampler T–10.

tion of the different size classes of this species (which is connected with reduction in the mean abundance from 600 larvae per 1 m² to 150–200 larvae in different classes) is even more clearly marked. For example: in 20 samples taken on station no. 1 with a tubular pneumatic sampler with a sampling area of 10 cm² no larvae qualifying for class II were found. On the same station, out of three samples taken with an Ek–225 sampler, a mean number of 1,370 larvae in class II per 1 m² was obtained. Similar differences in the numbers of larvae in classes I and II were found in samples taken with a T–45 sampler on stations 1 and 2. Class III, the most numerous in the habitat examined, is inferior to other age classes on three stations out of five in respect of mean numbers. This fact also is evidence of the marked unevenness of occupation of this sector of the lake by the larvae of this species[3]. *Chironomidae* in the two other lakes, represented by three (lake Tałtowisko) and eleven (lake Śniardwy) species, were characterized by smaller variations in numbers. The estimate of variations in total numbers (Tab. III) obtained from samples taken with different types of samplers was similar and did not greatly differ from the combined mean value, and forms evidence of the relatively slight differences in numbers between the stations examined. The values of the index of differences $\left(\frac{M\ max}{M\ min}\right)$ obtained from analysis of the distribution of different species were in all cases higher than the corresponding indices obtained from analysis of total numbers (Tab. IV). Results from the series of samples taken with different samplers indicated that numbers varied greatly,

[3] Similar considerable differences in the numbers of another species of the genus *Chironomus* – *Chironomus* F.L. *Salinarius* Kieff. were observed by Bitjukov (1962) in his studies on a homogeneous habitat in lake Čany, in which this species formed 95% of the *Chironomidae* fauna.

Value of the index of differences in abundance $\left(\frac{M\ max}{M\ min}\right)$ of different species of *Chironomidae* in lakes Tałtowisko and Śniardwy

Material obtained using different samplers

Tab. IV

Species	Mean number of larvae per 1 m² of bottom surface*	T–10	T–45	Ek–225	Ek–500	All samplers
		Number of samples				
		100	25	15	10	150 (50)**
Lake Tałtowisko						
Sergentia coracina	70 (125)	4.0	3.0	3.5	2.2	2.0**
Chironomus plumosus	240 (460)	2.4	2.0	1.5	1.9	1.4**
Procladius choreus	50 (70)	3.0	2.0	2.0	2.7	2.0**
Lake Śniardwy						
Orthooladinae	590 (100)	1.5	1.4	–	2.6	2.6**
Einfeldia carbonaria	440 (850)	2.8	1.8	–	1.8	1.4**
Tanytarsus gregarius	280 (600)	3.0	15.0	–	3.9	2.3**
Chironomus plumosus	250	2.0	4.5	–	2.3	2.4

*See explanations to Table I.
**Without sampler T–10.

e.g. the difference 15 times as great in the numbers per 1 m² of *Tanytarsus gregarius* between the "richest" station and "poorest" station in lake Śniardwy recorded in samples taken with a T–45 sampler (Tab. IV). Such results were characteristic of species represented in small numbers, for which the series of samples taken by different samplers were too small to make a correct estimate of numbers possible. Proof of this is formed by the combined means based on a larger amount of material, pointing to lesser variations in numbers than appeared to be the case from data obtained with different samplers. Differences in numbers in samples taken with a T–10 sampler were in general greater than in material obtained with the other samplers. This would seem to argue in favour of less even distribution, in the habitats examined, of the youngest

larvae, which form a greater percentage in samples taken with T–10 sampler and rinsed through a fine sieve of 0.2 × 0.2 mm mesh.

Despite the frequently great differences in the numbers of different species, domination relations with both low (lake Tałtowisko) and high numbers (lake Śniardwy) were characterized by a considerable degree of stability, and the main dominants retained their position in each of the five study points. Assessment of domination relations based on results obtained by means of different samplers was close to the combined mean value based on a larger amount of material. In samples taken with all the samplers used, both in lake Śniardwy and lake Tałtowisko, the main dominants – *Orthocladinae* gen.? *orielica* and *Chironomus plumosus*, maintained their position (Fig. 1) on each of the study stations.

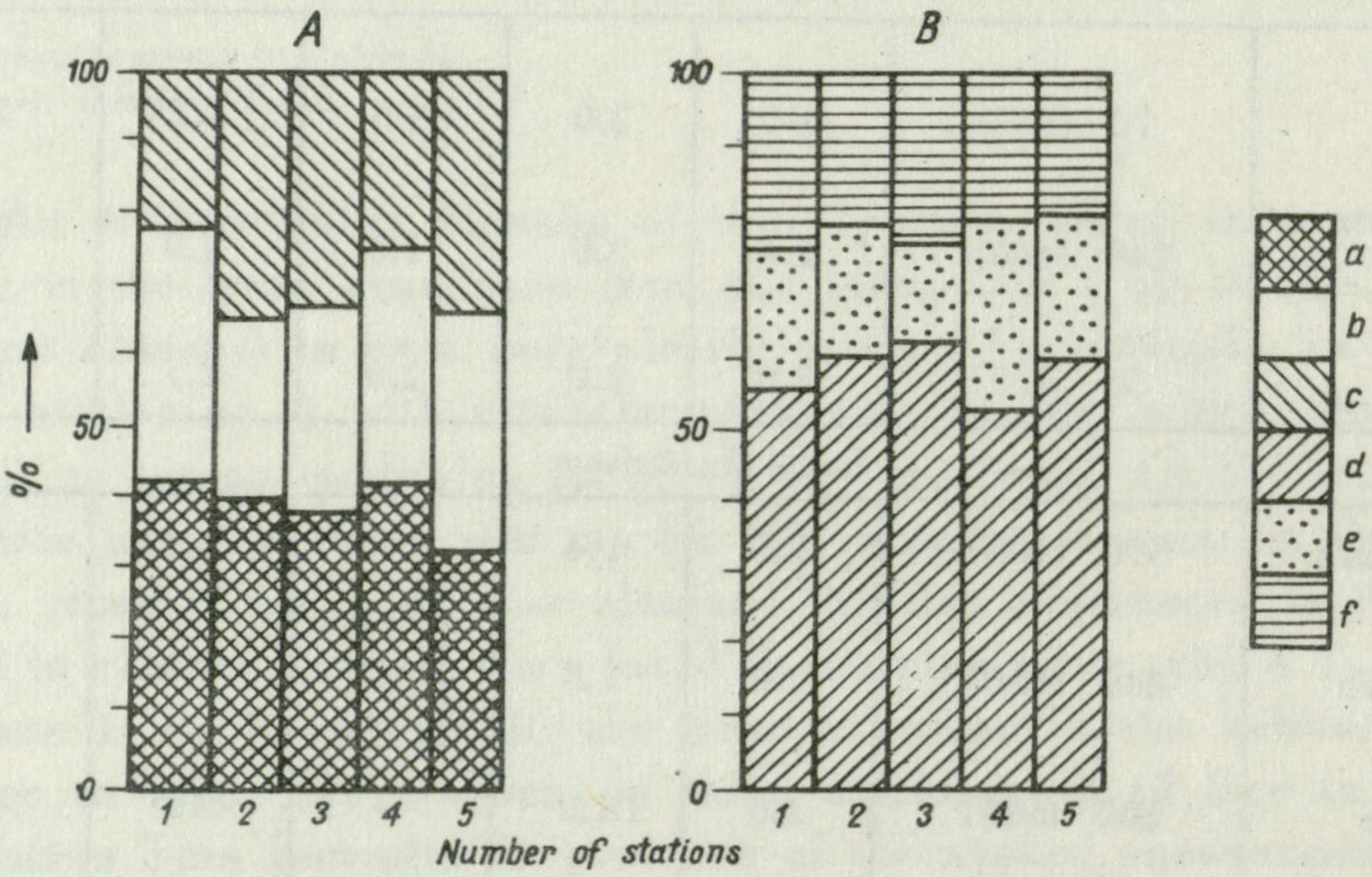

Fig. 1. Occurrence of dominating species on different stations in the central part of lakes Śniardwy and Tałtowisko

A – lake Śniardwy, estimate on the basis of 35 samples from T–45 and Ek–500 samplers, B – lake Tałtowisko, estimate on the basis of 50 samples from T–45, Ek–225 and Ek–500 samplers

a – *Orthocladinae* gen.? *orielica*, b – *Einfeldia carbonaria*, c – *Tanytarsus gregarius*, d – *Chironomus plumosus*, e – *Sergentia coracina*, f – *Procladius choreus*

3. *Chaoborus flavicans* (Tab. V)

When the mean numbers obtained for different stations in the habitat examined in Mikołajskie Lake are compared it can be seen that on stations 1 and 2 the numbers obtained by means of tubular samplers are two (T–45) to nine (T–10) times smaller than those obtained from samples taken by means of Ekman dredges. This might form evidence of the great opportunities of escape from a sampler with a small sampling area. The mean numbers on stations 3, 4 and 5, however, are balanced and do not provide confirmation of these assumptions. It is possible that the above differences are due to variations over the

Differences in the mean numbers of *Chaoborus flavicans* (per 1 m² of bottom surface) within the sector of the central part of Mikołajskie Lake (distance between stations approx. 5 m)

Tab. V

Samplers	Station numbers				
	1	2	3	4	5
T–10	50	50	600	400	450
T–45	120	200	600	320	400
Ek–225	250	350	500	400	450
Ek–500	400	450	550	420	500

course of the day in the capacity of larvae of *Chaoborus flavicans* for escaping from the lowered sampler, which in turn may be connected with the daily migrations of this species (Sikorowa 1966, Stahl 1966, Teraguchi and Northcote 1966). Actual differences in numbers within the habitat studied may have been small, as is indicated by the very even results obtained from samples taken with an Ekman dredge with a 500 cm² sampling area.

III. INFLUENCE OF SAMPLE SIZE, SIZE OF SERIES OF SAMPLES AND TYPE OF SAMPLER USED ON THE RELIABILITY OF THE ESTIMATE OF NUMBERS

Description of the abundance of benthos fauna in a given body of water, or in a large sector of it, is based on a small number (2–3) of samples taken on one station. It would appear that this type of description, even in an apparently uniform habitat, may be burdened with serious error, as is shown by Morduchaj-Boltovskoj (1956), Kajak (1958, 1963), Pankratova (1959) and Bitjukov (1962). Despite a certain number of studies forming an attempt at accurate estimation of the reliability of benthos materials (Špet and Rotovskaja 1962, Horka 1963, Kajak 1963), it is difficult to say how large the series should be in order to guarantee obtaining reliable results and how the different samples should be distributed. It appears from the results obtained that different samples taken even in lakes with only small differences in the total numbers of certain groups of fauna (*Oligochaeta* – Mikołajskie Lake and lake Tałtowisko, *Chironomidae* – lakes Śniardwy and Tałtowisko) often differed from each other greatly (Tab. VI). Mean numbers from the series of samples taken were however similar in such cases and in principle each of these series taken on only one of five study stations correctly described the quantitative relations in the habitat (Tab. VI). Differences in numbers between different samples were greater in material obtained with the tubular sampler with a 45 cm² sampling area than with Ekman dredges of 225 cm² and 500 cm² sampling areas.

Comparison of the mean numbers of *Chironomidae* (per 1 m² of bottom surface) obtained from samples taken by different samples in the central part of lake Tałtowisko

The range of variations in number between different samples is given in brackets.

Tab. VI

Samplers	Number of samples on one station	Station numbers					Total for all stations
		1	2	3	4	5	
T–45	5	443 (0–808)	322 (202–606)	322 (202–606)	444 (0–606)	402 (0–606)	386
Ek–225	4	315 (267–352)	349 (267–400)	298 (267–311)	334 (222–400)	319 (222–400)	323
Ek–500	2	390 (230–460)	320 (300–340)	330 (300–360)	460 (410–510)	340 (320–360)	368
				Mean numbers based on the whole of the material			359

This relation between the sample size (sampling area of the sampler) and reliability of the results obtained was observed only when different samples were compared. Comparison of series of several samples made with samplers with sampling areas of different size does not confirm this relation. Mean numbers obtained from five samples using a T–45 sampler were on the whole just as close to the combined mean value as the mean values from two-samples series using an Ek–500 sampler (Tab. VI), despite the fact that the latter covered an area of the bottom four times as great and contained a far larger amount of material. A similar absence of regular relations between the quantitative results obtained and the size of the area covered by the series of samples taken, and in consequence the amount of material obtained, was found when analysing the numbers of forms characterized by greater unevenness of distribution (some classes of size of *Oligochaeta*, part of the species of *Chironomidae* from lake Tałtowisko and Mikołajskie Lake). In these cases, however, the quantitative results obtained from series of samples taken from one only of the stations, irrespective of the type and sampling area of the sampler, not infrequently failed to convey the actual state of numbers in the habitat examined. Results similar to the combined results (based on the whole of the material) were obtained only after taking series of samples, with any one of the samplers, which were of the size previously given, and were taken

Comparison of mean numbers (per 1 m² of bottom surface) of *Oligochaeta* and *Chironomidae* obtained from samples taken by different samplers

The range of variations in numbers between different stations is given in brackets
A – Mikołajskie Lake, B – lake Tałtowisko, C – lake Śniardwy

Tab. VII

Group of invertebrates	T–10	T–45	Ek–225–m	Ek–225–h	Ek–500
A *Oligochaeta*	2,150 (1,900–2,450)	1,600 (1,250–2,050)	1,650 (1,315–1,820)	1,890 (1,280–2,620)	1,850 (1,250–2,050)
B		1,600 (1,410–1,860)	1,400 (1,230–1,440)	1,500 (1,300–1,730)	1,380 (1,180–1,510)
A	610 (400–1,450)	450 (200–840)	700 (350–1,650)	630 (270–1,060)	590 (290–1,030)
B *Chironomidae*		390 (320–440)	300 (270–330)	350 (308–400)	340 (320–460)
C		2,070 (1,790–2,820)	1,200 (1,110–1,390)	1,930 (1,550–2,040)	2,030 (1,730–2,380)

on two or three stations in the habitat examined, at intervals of a few or several metres. With very considerable differences in numbers such as characterized *Tanytarsus gregarius* (lake Tałtowisko) and different classes of size of *Chironomus anthracinus* (Mikołajskie Lake), taking series of samples even on three stations with one of the samplers used often failed to ensure correct assessment of numbers. For example: the mean numbers of larvae of *Chironomus anthracinus*, allocated to class II of size, from three optionally compared stations (e.g. no. 1, 2, 3, or no. 3, 4, 5 etc.) varied from 15 to 290 larvae per 1 m² (sampler T–45) and from 175 to 605 (sampler Ek–225), whereas the combined mean was 225 larvae per 1 m².

Matters no less important to methods of benthos research than those discussed above are those connected with the structural properties of the various types of samplers used. Comparison of results obtained by different samplers points to the general comparability of results obtained by the tubular pneumatic samplers and those obtained by the Ekman type samplers (Tab. VII). The situation is exceptional in lake Śniardwy, which we studied, where in samples taken with an Ek–225 sampler of stereotype height (20 cm) and upper opening covered with net, numbers of *Chironomidae* per 1 m² were found to be almost twice smaller than in samples taken by means of the other samplers. In view of the fact that the bottom sediments (in particular their superficial layers) in the habitat examined in lake Śniardwy are more fluid than in the other lakes, displacement by this sampler of the superficial, most densely occupied

layers of mud was probably greater here. The results obtained with this sampler were compared with the results from 5–sample series taken with an Ek–225 sampler 40 cm high. The cover on the top opening of this sampler, consisting of metal flaps which open as the sampler descends, prevents the washing away of the superficial layers of sediment, and the container 40 cm high ensured that the sample does not spill over the top of the sampler. It was found that the greatest differences in numbers occurred among species with the smallest body dimensions and among the youngest stages of other species which, as Kajak (1958), Kajak and Dusoge (unpublished data) and Assman (1962) found, live mainly in the superficial layers of sediments. For purposes of comparison: the mean numbers of *Orthocladinae* larvae obtained from samples taken with an Ek–225–m sampler were 460 per 1 m^2, while the numbers of this species in samples taken with an Ek–225–h samples were as high as 815 larvae. Similar results were recorded in the case of the species *Cryptochironomus conjugens* and *Tanytarsus gregarius*. The numbers of the large species, *Chironomus plumosus*, more frequently living in the deeper layers of sediment were however similar in samples taken by both samplers, as follows: Ek–225–m – 210 larvae per 1 m^2, Ek–225–h – 235 larvae per 1 m^2. Similar comparisons of the results obtained by these samplers made in the habitats examined in Mikołajskie Lake and lake Tałtowisko did not exhibit any important differences in numbers.

IV. COMPARISON OF RESULTS

1) Differences in the total numbers of *Chironomidae* and *Oligochaeta* in lake habitats with multi-species composition of *Chironomidae* (lakes Śniardwy and Tałtowisko) and the mono-species composition of *Oligochaeta* (Mikołajskie Lake and lake Tałtowisko) were relatively slight (differences in numbers between the "poorest" and "richest" stations did not exceed 50%), despite the fact that the habitats referred to differed considerably in respect of the numbers of these groups.

2) The only species of *Chironomidae* in the habitat examined in Mikołajskie Lake, *Chironomus anthracinus* (with numbers close to the total numbers of *Chironomidae* in lake Tałtowisko) was distributed very unevenly. Differences in the numbers obtained from samples taken with all the samplers on the "poorest" and "richest" stations were as much as 250%, and in the case of individual samplers even as much as 460%.

3) The domination relations of *Chironomidae*, both when their numbers were low (lake Tałtowisko) and high (lake Śniardwy), were characterized by a high degree of stability. The estimate of domination relations based on results obtained with different samplers was similar to the combined estimate based on a larger amount of material (Fig. 1).

4) Differences in numbers increased in the majority of cases together with a decrease in abundance (analogically to the situation found in Kajak's material, 1963). Differences in the numbers of different species and classes of size were in consequence greater than differences in total numbers. This relation is more distinct in the case of *Chironomidae* (Tab. II–IV) than *Oligochaeta* (Tab. I).

5) In lakes with slight differences in numbers in the groups of fauna examined an estimate close to the combined estimate was as a rule obtained when taking one of the following series of samples, i.e. 20 samples with T–10 sampler, 5 samples with T–45 sampler, 3 samples with Ek–225 sampler or 2 samples with Ek–500 sampler on one of the stations in the habitat examined.

6) Series of this size were often too small to permit of correct assessment of the numbers of different species and age classes on this basis. In such cases results close to combined results were usually obtained by taking a series of samples (of the size described previously) on several stations, that is, doubling or trebling these series and dispersing them over the habitat examined. In the case of species characterized by very great differences in numbers (*Tanytarsus gregarius* – Tab. IV and different classes of size of *Chironomus anthracinus* – Tab. II) even so large a number of samples often proved insufficient to obtain a reliable estimate of numbers.

7) The results obtained prove that the active escape of *Chironomidae* from the apparatus described by Kajak (1958) in riverside pools (old river bed) did not take place in the habitats examined.

8) Data were obtained forming evidence of the influence of the sampling area of the sampler on estimates of the number of larvae of *Chaoborus flavicans* (Tab. V); the numbers of this species were markedly lower when sampled with apparatus with a smaller sampling area.

9) Examination of the relations of the quantitative results obtained to the structural properties of the samplers used showed that in principle it is possible to compare results obtained by means of tabular pneumatic samplers with the results obtained by Ekman type dredges in which the upper opening is covered by flaps.

10) The use of Ekman type sampler 20 cm high with a sampling area of 225 cm^2 and the upper opening covered by net, for sampling from the soft bottom with a fluid superficial layer of mud would appear undesirable. When the sampler is lowered into the water the net, by pushing a column of water before it, causes violent displacement of the sediment, and in consequence the samples taken by means of this sampler in lake Śniardwy give almost twice lower numbers of *Chironomidae* than those obtained using the other samplers (Tab. VII).

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ZRÓŻNICOWANIE LICZEBNOŚCI BENTOSU I MIARODAJNOŚĆ JEJ OCENY W KILKU ŚRODOWISKACH JEZIORNYCH

Streszczenie

Celem pracy była analiza zróżnicowania liczebności bentosu w obrębie niewielkich i pozornie jednolitych środowisk jeziornych. Analizowano także wpływ wielkości próby i wielkości serii prób oraz typu stosowanego chwytacza na miarodajność oceny liczebności. Pracę przeprowadzono w śródjezierzu jezior Śniardwy, Mikołajskie i Tałtowisko (odpowiednio na głębokości 8, 16 i 16 m). Stwierdzono co następuje:

1) Zróżnicowanie liczebności ogólnej *Chironomidae* i *Oligochaeta* w środowiskach jeziornych o wielogatunkowym składzie *Chironomidae* (jeziora Śniardwy i Tałtowisko)

i jednogatunkowym składzie *Oligochaeta* (jeziora Mikołajskie i Tałtowisko) było stosunkowo niewielkie, mimo iż omawiane środowiska różniły się znacznie pod względem liczebności tych grup;

2) Jedyny występujący w badanym środowisku Jeziora Mikołajskiego gatunek *Chironomidae*, *Chironomus anthracinus*, był rozmieszczony bardzo nierównomiernie;

3) Stosunki dominacji wśród *Chironomidae*, zarówno przy niskiej (jezioro Tałtowisko) jak i wysokiej (jezioro Śniardwy) liczebności charakteryzowały się dużą stabilnością (fig. 1);

4) Zróżnicowanie liczebności w większości wypadków zwiększało się wraz ze zmniejszaniem się liczebności. Zróżnicowanie liczebności poszczególnych gatunków i klas wielkości było w związku z tym większe niż zróżnicowanie liczebności ogólnej (tab. I–IV).

Na podstawie analizy zróżnicowania bentosu wysunięto sugestie co do niezbędnej liczby i sposobu rozmieszczenia prób dla uzyskania miarodajnej oceny liczebności. Ponadto wykazano, że wyniki uzyskane przy pomocy pneumatycznych chwytaczy rurowych są porównywalne z wynikami uzyskanymi przy pomocy aparatów typu Ekmana (tab. VII). W aparacie typu Ekmana o otworze górnym przykrytym siatką uzyskano w jeziorze Śniardwy prawie dwukrotnie niższą liczebność niż w innych aparatach (tab. VII). Prawdopodobnie był to skutek rozmywania przez ten aparat powierzchniowych warstw mułu, bardziej płynnych niż w pozostałych badanych jeziorach. Uzyskano dane świadczące o wpływie powierzchni chwytnej aparatu na ocenę liczebności larw *Chaoborus flavicans* (tab. V).

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