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Investigations on intensification of carp fingerling production

8. Number and biomass of zoobenthos

Edward Krzyżanek

Polish Academy of Sciences, Institute of Freshwater Biology, Hydrobiological Station, 43-230 Goczałkowice, Poland

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Abstract — The results of an investigation on the zoobenthos in experimental ponds with different trophic conditions are presented. The investigation performed in 1981 showed that carp farming carried out from 1976—1980 in ponds with a higher production level created better conditions for zoobenthos development. In the studies of 1982 and 1983 the highest values of zoobenthos numbers and biomass were found in a pond where organic fertilization was applied and the lowest in an unfertilized pond.

Key words: ponds, carp fingerlings, intensification, zoobenthos, numbers, biomass.

1. Introduction

From 1981—1983 in the Fish Culture Experimental Station Gołysz of the Polish Academy of Sciences complex investigations on the optimization of intensive production of carp fingerlings was carried out (Szumiec 1987). A study on development of the zoobenthos was included in the work.

In 1981 the aim of the investigation was to determine the consequential effects of different intensification levels applied in rearing second year carp in the period 1976—1980, and in 1982 and 1983 differentiated fertilization on the development of the zoobenthos.

2. Material and methods

The general outline of the study has been given by Szumiec (1987).

In 1981 the investigation covered four selected ponds. In one of them carp farming at a superintensive level of production had been carried out from 1976—1980 (SI), in two other ponds an intensive production level (I-30 and I-40), and in the fourth one a control level (K) were maintained.

In the years 1982—1983 the benthos was investigated in four ponds where differentiated fertilization was applied: pond O — no fertilization, NP — mineral fertilization, G — organic fertilization, and M — mineral--organic fertilization.

In each pond samples were taken at 2 stations: near the inflow and near the outflow. In the sampling an Ekman-Birge mud scraper with a 100 cm² catching area was used (4 scrapers for 1 sample). The contents were washed on a sieve covered with 0.5 mm mesh bolting cloth. The animals selected from the samples were fixed in 4% formalin. The results obtained (number and biomass) were calculated per 1 m². The samples were collected at intervals of one week — in 1981 in the period May 26 — September 29 (16 samples), in 1982 from May 26 to September 28 (18 samples), and in 1983 from May 26 to September 27 (18 samples).

Attention was chiefly paid to Chironomidae larvae which were sometimes difficult to identify as to species. For this reason, in some cases the differentiated taxa were given successive Roman figures (Lehman 1971). In the case of Oligochaeta the names of species are in accordance with Limnofauna Europaea (Illies 1978).

3. Results

3.1. Characteristics of the different groups of zoobenthos

Chironomidae larvae formed the dominant group in the zoobenthos, hence their systematics was more thoroughly elaborated (Tables I, II).

The Chironomidae sub-family, Chironomini tribe, were most numerously represented, the dominant being *Chironomus* sp. I (? *Ch. plumosus* L.), particularly numerous in 1981 and 1982. *Polypedilum* sp. I (? *P. nubeculosum* Mg.) constituted a large percentage. In 1981 it occurred in pond I-40 in numbers approximating those of *Chironomus* sp. I (? *Ch. plumosus* L.), while in 1983 it was in ponds O and M that the largest percentage share of this taxon was noted. *Glyptotendipes* spp. larvae occurred frequently and in large numbers, particularly in pond M in 1983. Of other forms of this tribe pelophilous *Microchironomus* sp. (? *M. tener* L.) and *Cryptochironomus defectus* L. and phytophilous *Microtendipes* sp. and *Dicrotendipes* sp. (? *D. nervosus* Staeg.) should be mentioned.

The tribe Tanytarsini was usually represented by two forms, i.e. *Cladotanytarsus* sp. (? *C. mancus* Wulp.) and *Tanytarsus* spp.

In the Tanypodinae sub-family the dominant representative was the genus *Tanypus*, chiefly the form *Tanypus* sp. I (? *T. punctipennis* Mg.).

Table I. Percentage composition of species of Chironomidae larvae in experimental ponds in the period 1981 - 1983

Taxa \ Ponds	1981				1982				1983			
	K	I-30	I-40	SI	O	NP	G	M	O	NP	G	M
Ablabesmyia sp.			0.2		0.2	3.0	0.6	0.6	0.5			
Clinotanypus sp. /?C.nervosus Mg./						0.3		0.3				
Procladius sp.	2.1	1.7	1.8	1.4	8.9	6.6	8.6	6.4	3.8	6.6	4.1	4.8
Psectrotanypus sp. /?P.varius Fabr./						2.6	0.1	1.2				
Tanypus sp. I /?T.punctipennis Mg./	12.4	5.6	12.1	1.4	5.4	5.6	8.1	10.0	12.3	7.0	10.0	6.2
- sp. II /?T.Kraatzi Kief./	0.3		0.6	1.5	0.3		0.7	0.8	0.8	1.4	1.6	2.3
Cladotanytarsus sp. /?C.mancus Wulp./				0.8	3.0	0.4	4.4	1.2	1.1	0	0.4	
Micropsectra spp.					0.7	0.5		0.1	1.0	0.4	0.2	
Paratanytarsus sp.					0.3	0.2	0.2					
Tanytarsus spp.	0.3				5.7	6.2	4.5	5.2	5.3	0.5	0.8	3.4
Chironomus sp. I /?Ch.plumosus L./	37.5	41.6	37.2	52.4	43.8	32.5	35.8	36.1	22.3	46.5	54.0	18.9
- sp. II /?Ch. thummi K./								0.4		2.5		
Cryptochironomus defectus K.	2.4		0.9		5.4	8.6	5.3	7.0	2.7		2.0	3.2
Dicrotendipes sp. /?D.nervosus Staeg./	6.0	0.5	1.7	0.3	0.4	0.6	0.7	0.2		0.5	1.1	1.2
Einfeldia sp.					0.2		0.9			0.9	0.5	
Endochironomus sp.					0.2		0.2	0.4	0.3		0.5	0.9
Glyptotendipes spp.	16.7	2.0	9.1	17.1	11.0	15.6	14.2	14.0	5.9	12.3	8.4	23.6
Microchironomus sp. /?M. tener K./	0.7		0.2		0.9			1.1	4.6	0.4	0.5	3.2
Microtendipes sp.		0.3				0.6	0.2		0.8	0.5		
Paratendipes sp.									0.5	0.2		
Polypedilum sp. I /?P.nubeculosum Mg./	18.7	27.7	34.2	23.6	10.5	11.0	9.5	7.8	31.4	15.3	14.0	24.5
- sp. II /?P.convictum Walk./		0.9	0.9	0.3	0.3	1.3	0.7	0.2	1.9		0.2	1.6
- sp. III			0.7			1.2	0.5					
- sp. IV				0.4								
Cricotopus sylvestris /Fabr./	2.7	0.2	0.2	0.8	2.2	2.0	2.8	3.6	1.6	1.8	9.5	3.5
Cricotopus spp.	0.2		0.2						1.6	1.8	0.2	1.8
Psectrocladius spp.		0.5			0.6	0.6	2.0	2.0	0.5	0.9	1.0	0.9
Tissocladius sp.									0.3			
Chironomidae non det.						0.6		1.4	0.8	0.5		

Table II. Zoobenthos of experimental ponds from 1981 - 1983.
Mean annual number of specimens - N (indiv. m^{-2})
and biomass - B (g m^{-2})

Pond	Year	Chironomidae		Oligochaeta		Other		Total	
		N	B	N	B	N	B	N	B
K	1981	1868	10.2	1131	2.8	42	0.2	3041	13.2
I-30	1981	2606	11.4	1472	3.3	144	0.2	4222	14.9
I-40	1981	2765	10.6	2450	5.5	100	0.3	5315	16.4
SI	1981	2231	9.2	325	0.8	32	0.2	2588	10.2
O	1982	3047	9.3	431	0.7	14	0.3	3492	10.3
	1983	1042	5.3	403	0.8	76	0.3	1521	6.4
NP	1982	3661	8.2	903	1.8	-	-	4564	10.0
	1983	1575	12.9	902	1.6	17	0.1	2494	14.6
G	1982	3224	13.8	351	0.8	41	0.1	3616	14.7
	1983	1224	12.3	611	1.0	9	0.1	1844	13.4
M	1982	4284	10.9	317	0.8	39	0.3	4640	12.0
	1983	1205	3.2	486	0.9	106	0.3	1797	4.4

In 1982 the predatory *Procladius* sp. reached a larger percentage, while *Ablabesmyia* sp., *Clinotanypus* sp. (*C. nervosus* Mg.), and *Psectrotanypus* sp. (? *P. varius* Fabr.) were rarely encountered.

Larvae of the sub-family Orthocladinae constituted the smallest percentage, *Cricotopus sylvestris* (Fabr.), *Cricotopus* spp., and *Psectrocladius* spp. being most numerous in this group.

The family Chironomidae, chiefly the polycyclic forms *Chironomus* sp. (? *Ch. plumosus* L.) and *Polypedilum* sp. I (? *P. nubeculosum* Mg.), with 2—3 generations a year, dominated, constituting the most valuable food of the fish.

Oligochaeta formed another large group in the zoobenthos, though their share was much smaller and the taxonomical composition poorer than that of Chironomidae. Seven species were identified, with a distinct domination of *Limnodrilus hoffmeisteri* Clap., *Nais* sp., and *Tubifex tubifex* (Müll.). The other four (*Limnodrilus* spp., *Nais pseudobtusa* Pig., *Stylaria lacustris* L. and *Tubifex sp.* were found in small numbers and rarely, hence their role in the food base of fish was slight.

Among the remaining organisms were found Nematodes, Hirudinea, Ephemeroptera, Coleoptera, Trichoptera, Heleidae, and Sialidae, not identified more exactly. In a few cases single specimens of *Lymnaea peregra* Müll. (Gastropoda) were noted.

3.2. Numbers and biomass in 1981

The composition of the zoobenthos and its seasonal variation was fairly differentiated in the individual years (Table II, fig. 1). In 1981 in ponds I-30 and I-40 the largest numbers and biomass, a similar taxonomic composition, and a similar pattern of seasonal variation of Chironomidae were observed. In pond SI smaller numbers and biomass of the zoobenthos but a similar seasonal variation was observed. Already in May an intensified development of this group with a distinct domination of *Chironomus* sp. I (? *Ch. plumosus* L.) was found. The maximum development of Chironomidae occurred in the period June 24—July 8, with the dominance of several species, chiefly *Polypedilum* sp. I (? *P. nubeculosum* Mg.), *Glyptotendipes* spp., and *Tanypus* sp. I (? *T. punctipennis* Mg.). This was followed by a constant reduction in numbers while a slight increase was observed in ponds I-30 and Si towards the end of the season. In the period August 4—11 an increase in biomass was found, chiefly owing to *Chironomus* sp. I (? *Ch. plumosus* L.) larvae.

The results suggest that in these ponds the dominant *Chironomus* sp I (? *Ch. plumosus* L.) developed two generations in the year, the imagines probably emerging in the periods June 9—24 and August 18—25.

A different pattern of seasonal variation was found in the control pond K. Early in the season the entire family Chironomidae was not numerous and the share of *Chironomus* sp. I (? *Ch. plumosus* L.) small. On July 8 a mass development of Chironomidae larvae, chiefly *Polypedilum* sp. I (? *P. nubeculosum* Mg.) took place. Up to August 18 the biomass of larvae was maintained at a uniform level. After 2—3 weeks, when a decrease in numbers and biomass occurred, another increase

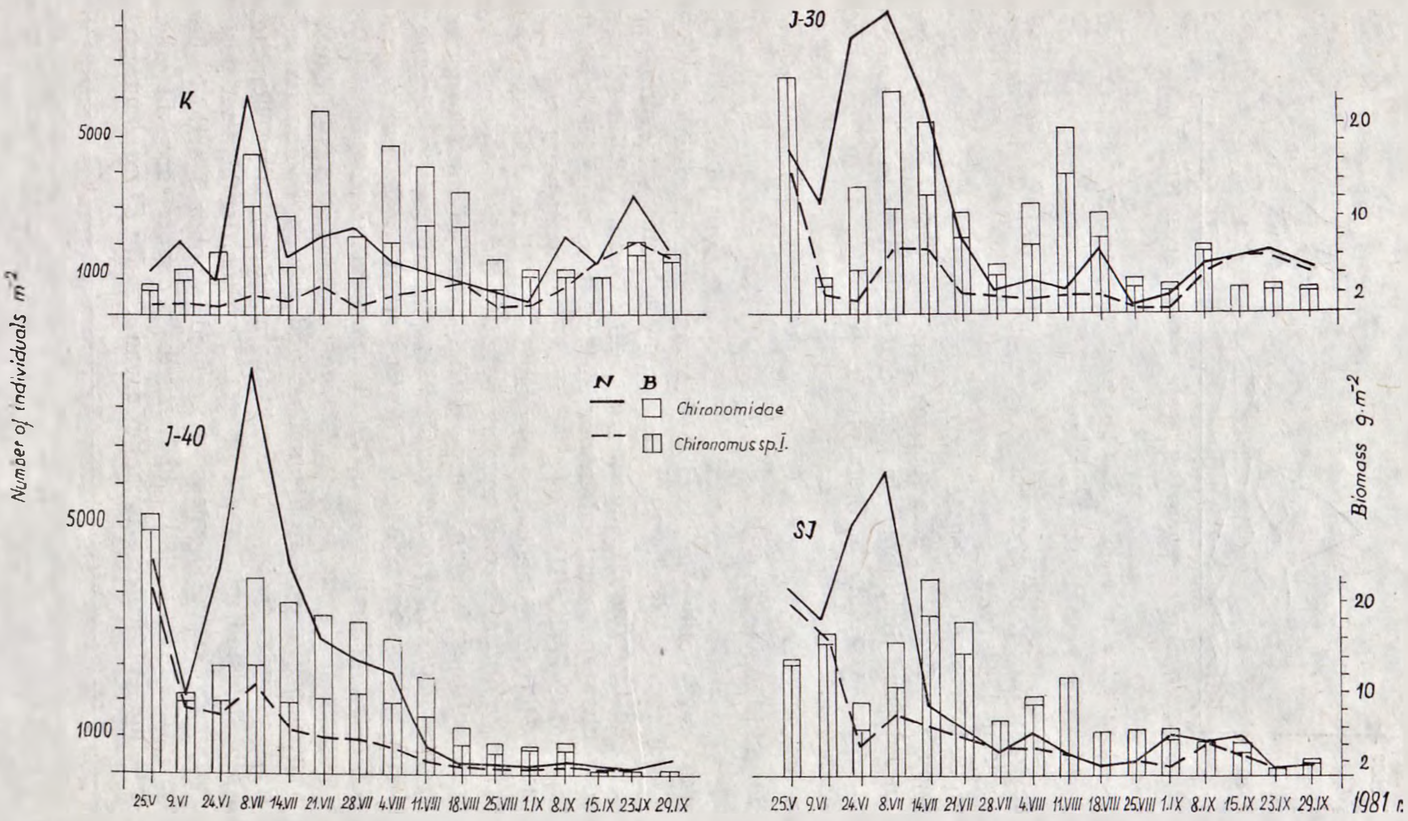


Fig. 1. Seasonal variation in number and biomass of Chironomidae and *Chironomus* sp. I (? *Ch. plumosus* L.) larvae in ponds K, I-30, I-40, and SI in 1981. N — number; B — biomass

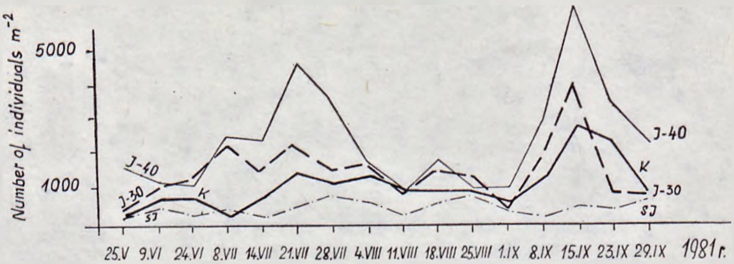


Fig. 2. Seasonal variation in numbers of Oligochaeta in ponds K, I-30, I-40, and SI in 1981

took place towards the end of the season, chiefly in *Chironomus* sp. I (? *Ch. plumosus* L.) larvae.

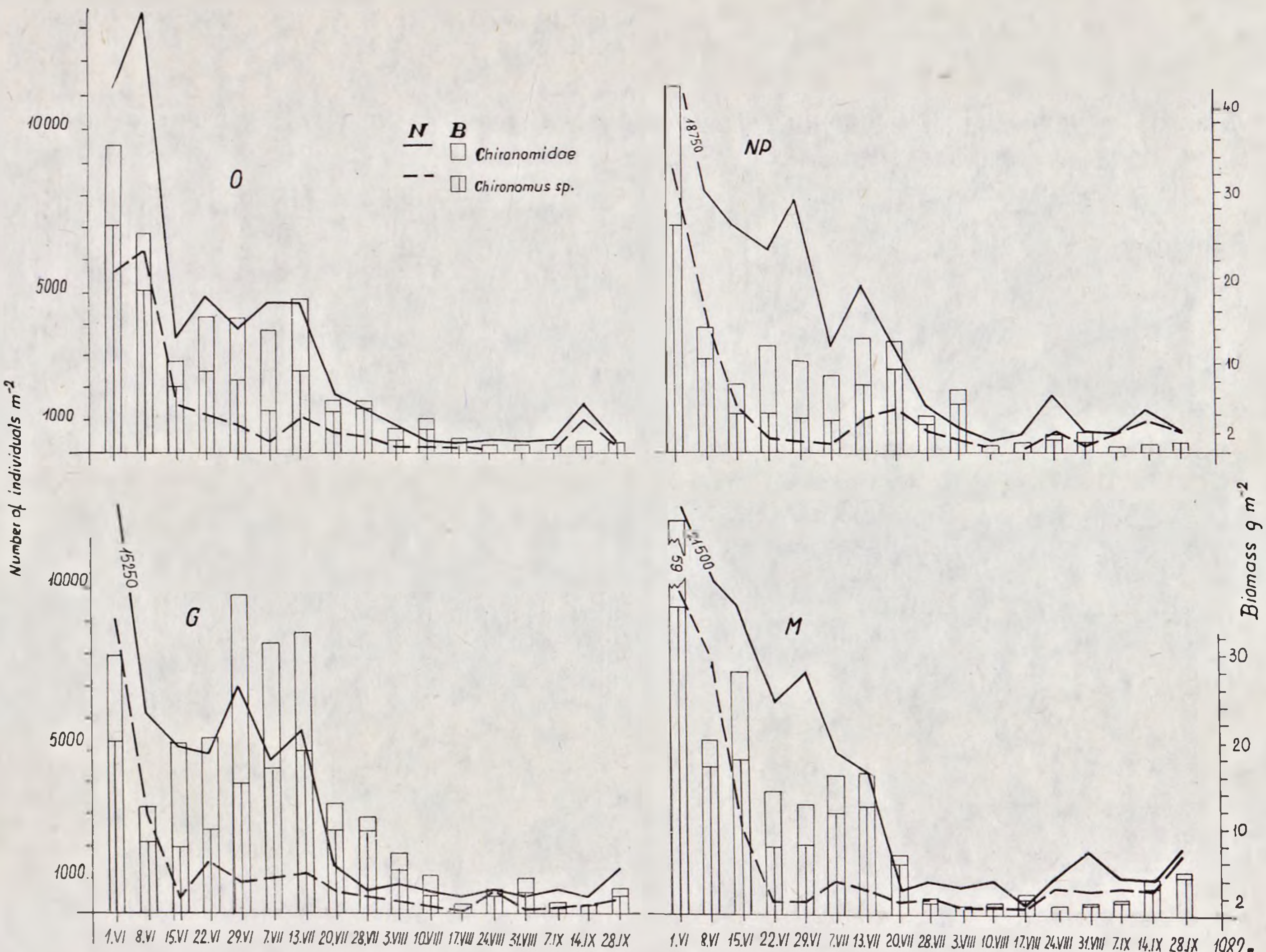
The population of Oligochaeta (fig. 2) was most numerous in pond I-40, followed by I-30 and K. The seasonal variation showed the greatest densities in July and September. In pond S the numbers and biomass of Oligochaeta were very small, therefore it was difficult to trace their seasonal variation.

3.3. Number and biomass in 1982 and 1983

The numbers of zoobenthos and its biomass in the individual ponds differed in the two years. In 1982 the greatest biomass was noted in pond G followed by pond M and the smallest in pond NP. The largest numbers of zoobenthos occurred in pond M, next in pond NP, and the smallest in pond O (Table II). However, the differences were not great, while the tiny Chironomidae larvae played the chief role. 25 taxa were identified (this being the largest number noted in the investigated years (Table I), some of them having a large participation, chiefly *Chironomus* sp. I (? *Ch. plumosus* L.), *Procladius* sp., *Glyptotendipes* spp., *Polypedilum* sp. I (? *P. nubeculosum* Mg.), *Tanypus* sp. I (? *T. punctipennis* Mg.), *Tanytarsus* spp., and *Cryptochironomus defectus* K.

At all stations the dynamics of the seasonal variation of Chironomidae was similar (fig. 3). Large numbers and values of biomass were maintained from the beginning of June to the middle of July. Then there was a fall which lasted until the end of the season. In the first period particularly large values of biomass were noted in ponds G and M where the organic fertilization with liquid manure probably brought about a strong development of bacteriophage larvae, chiefly *Chironomus* sp. I.

Fig. 3. Seasonal variation in number and biomass of Chironomidae and *Chironomus* sp. I (? *Ch. plumosus* L.) larvae in ponds O, NP, G, and M in 1982. N — number; B — biomass



N
B
Chironomidae
Chironomus sp.
O
NP
G
M
Number of individuals m-2
Biomass g m-2
10000
5000
1000
40
30
20
10
2
18750
15250
21500
59
1.VI 8.VI 15.VI 22.VI 29.VI 7.VII 13.VII 20.VII 28.VII 3.VIII 10.VIII 17.VIII 24.VIII 31.VIII 7.IX 14.IX 28.IX
1982 r.

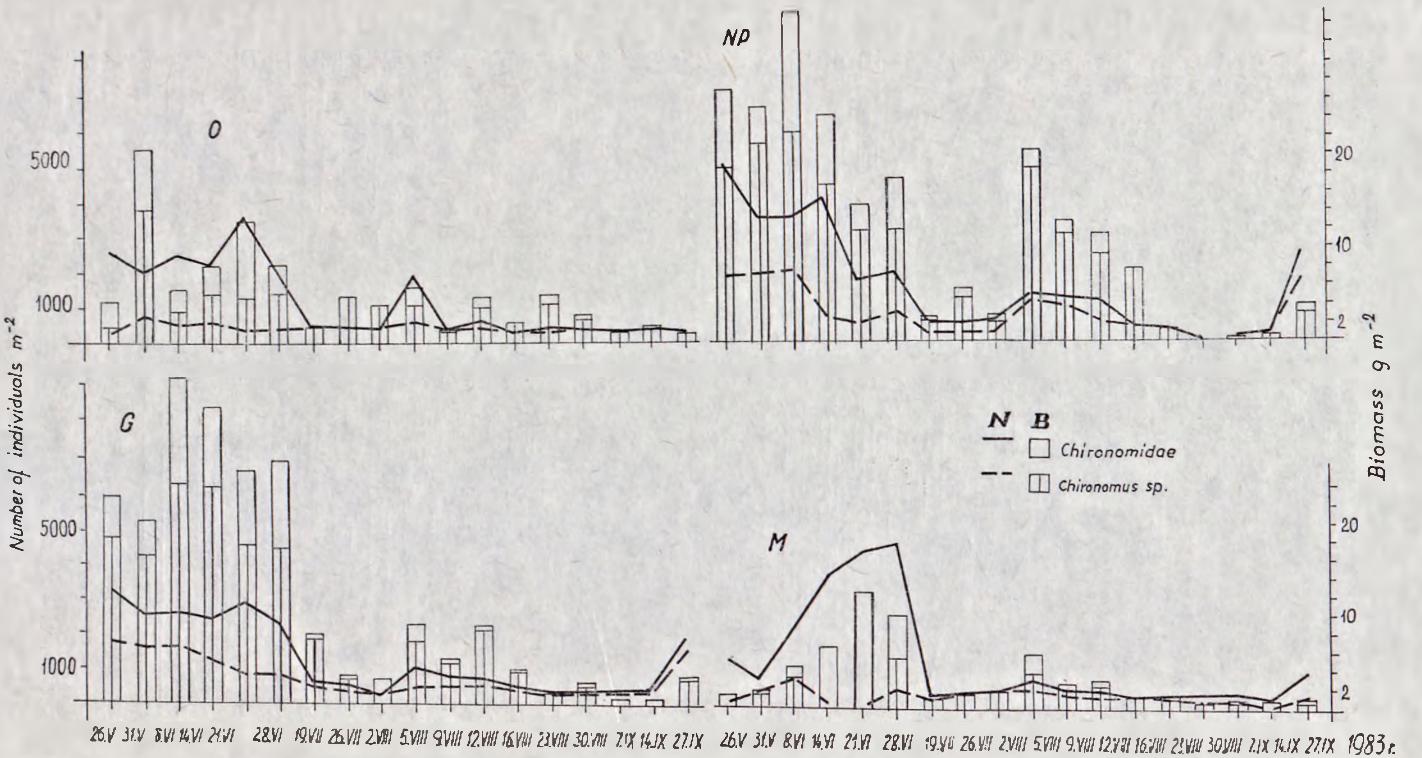


Fig. 4. Seasonal variation in number and biomass of Chironomidae and *Chironomus* sp. I (? *Ch. plumosus* L.) larvae in ponds O, NP, G, and M in 1983. N — number; B — biomass

The latter probably had two or even three generations in the year with lengthened periods of emergence of imagines. The first emergence may have taken place in May, the second one in the period June 15—29, and the third from August 3—17.

Oligochaeta appeared in very small numbers throughout the season. Larger numbers and biomass were found only at the beginning of the season especially in pond NP (fig. 5).

The highest production of fish in the ponds selected for investigations on the zoobenthos was achieved in pond O, followed by ponds M, and NP, and the smallest in pond G.

In 1983 the numbers of zoobenthos were reduced almost by half (Table II). The largest number was found in pond NP, then in G, but the greatest biomass occurred in pond G and NP. The lowest values of numbers and biomass were noted in ponds M and O.

Seasonal variation of Chironomidae was similar to that in 1982. Early in the season (up to June 28) both numbers and biomass were fairly large. After that, however, they were small (fig. 4). *Chironomus* sp. I probably developed two generations a year but the periods of emergence of imagines were late in comparison with those in 1982. The first emergence took place in the middle of July and the second towards the end of August. The largest numbers of Oligochaeta were observed in pond NP and the smallest in pond O. Their seasonal variation was characterized by constant changes in numbers and biomass (fig. 5).

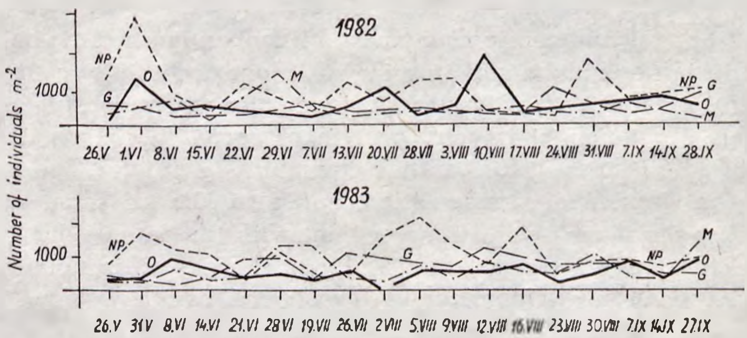


Fig. 5. Seasonal variation in number of Oligochaeta in ponds O, NP, G, and M in the years 1982 and 1983

4. Discussion

Investigation of the production results showed that the highest production of carp fingerlings in the ponds selected for zoobenthos studies was achieved in 1981 in ponds I-30 and SI, followed by pond I-40. However, in pond I-40, with the largest mean weight of fingerlings reaching 47 g (Szumiec 1987), the greatest losses (84%) were recorded. The numbers and biomass of zoobenthos were greatest in ponds I-40 and I-30 the zoobenthos being smaller in pond SI while the seasonal variation in these ponds was similar. The least zoobenthos and a different range of seasonal variation were noted in the control pond K. These results suggest that the intensive and highly intensive fish farming in the years 1976—1980 had a favourable affect on the level of zoobenthos development and improved the results of fingerling production in these ponds in 1981.

The investigation carried out in 1982 and 1983 showed that in 1982 the highest values of zoobenthos biomass were noted in pond G with organic and pond M with mineral-organic fertilization. The largest numbers were found in pond M and in pond NP (with mineral fertilization). In 1983 the largest numbers and biomass of zoobenthos was found in ponds NP and G, but the two values were half those in 1982. However, the results of fish farming in the ponds selected for zoobenthos studies showed the highest production of fingerlings in the unfertilized pond O both in 1982 and 1983. The lowest values of production in 1982 were found in pond G and in 1983 in pond M (Szumiec unpubl. results). This may suggest that in pond G (and also in pond M) the organic fertilization contributed to the stronger development of bacterial flora at the beginning of the season. In consequence, a rapid development of bacteriophagous fauna, especially of large *Chironomus* sp. I (? *Ch. plumosus* L.) larvae was noted, at the time when it was not yet accessible to the youngest developmental stages of the carp. In ponds O and NP the mean annual numbers and biomass of zoobenthos were smaller, but there were larger numbers of tiny larvae, more accessible in the second half of the season, hence they were more intensively consumed by the fingerlings. In the nutrition and growth of carp fingerlings the most important role is played by benthos communities, chiefly Chironomidae larvae. Their taxonomic composition, and also the seasonal variation observed in the ponds, were in agreement with the data in the literature (Ljachov 1954, Borodicova 1962). Besides Chironomidae, also Oligochaeta, chiefly *Limnodrilus hoffmeisteri* Clap., *Nais* sp., and *Tubifex tubifex* (Müll.), play an important role there. They are common in the complex of zoobenthos of the Gołysz ponds (Zięba 1963, Siemińska A., J. Siemińska 1967) and also in other water bodies of southern Poland (Zięba 1967, Krzyżanek 1970, 1987). An important role in the nutrition of carp fingerlings is also played by plankton, as well as phytophilous communities, which might have brought about such a pattern of fish growth as was observed in the investigated ponds in 1982 and 1983.

The production results obtained in the ponds selected for zoobenthos investigation do not agree with the mean results achieved in the different variants of the experiment (Szumiec 1987). The probable differentiation in trophic conditions between the individual ponds within the experimental variants suggests that it is essential to carry out investigations of the zoobenthos in a larger number of ponds for each variant.

5. Polish summary

Badania nad intensyfikacją chowu narybku karpi

8. Liczebność i biomasa zoobentosu

W latach 1981—1983 prowadzono badania zoobentosu w Zakładzie Doświadczalnym PAN w Gołyszu. Były one częścią zespołowych badań nad optymalizacją intensywnego chowu narybku karpi, prowadzonych w 24 stawach doświadczalnych.

W 1981 r. terenem badań były 4 stawy, w których w latach 1976—1980 prowadzono chów karpia na różnych poziomach intensyfikacji: porównawczym (I-30 i I-40), (K), intensywnym (I-30 i I-40) i wysokointensywnym (SI). Celem badań było określenie następczego działania tych zróżnicowanych poziomów intensyfikacji na zoobentos.

Celem badań w latach 1982—1983 było określenie wpływu zróżnicowanego nawożenia na rozwój zoobentosu. Badania prowadzono w stawie z nawożeniem mineralnym (NP), organicznym (G), mieszanym (M) oraz w stawie nie nawożonym (O).

Najwyższą liczebność oraz biomasę we wszystkich stawach posiadały larwy Chironomidae (ryc. 1, 3, 4). W rodzinie tej dominowały *Chironomus* sp. I (? *Ch. plumosus* L.), *Polypedilum* sp. I (? *P. nubeculosum* Mg.) oraz *Glyptotendipes* spp. (tabela I).

Znacznie mniejszą liczebność i biomasę uzyskiwały Oligochaeta (ryc. 2, 5), głównie: *Limnodrilus hoffmeisteri* Clap., *Nais* sp. i *Tubifex tubifex* Müll.

W 1981 r. największą liczebność i biomasę osiągnął zoobentos w stawach I-40 i I-30 (tabela II). Intensywny chów karpia prowadzony w tych stawach w latach 1976—1980 stworzył lepsze warunki dla rozwoju zoobentosu, co w efekcie dało wyższą produkcję narybku.

W 1982 r. najwyższe wartości zoobentosu notowano w stawach G i M, najniższe w stawach NP i O (tabela II).

W 1983 r. zoobentosu było dwukrotnie mniej niż w r. 1982, a najwyższe wartości stwierdzono w stawach G i NP (tabela II).

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