KOMITET EKOLOGICZNY - POLSKA AKADEMIA NAUK

EKOLOGIA POLSKA - SERIA A

Tom XIV Warszawa 1966 Nr 5

Anna HILLBRICHT-ILKOWSKA

THE EFFECT OF DIFFERENT PERIODS OF UTILIZATION OF FISH PONDS ON THE OCCURRENCE AND ABUNDANCE OF PLANKTON *ROTATORIA**

The longer fish remain in a pond and the denser the fish stock, the stronger their influence on plankton *Rotatoria*. This influence is expressed by an increase in the abundance of euplankton rotifers and reduction in littoral rotifers. In addition it was found that when the pond was kept filled during the winter it caused a significant shift in the time of occurrence of many species.

Contents

I. Study area and methods
II. Abundance of rotifers in continuously and periodically filled ponds with different fish stocks
III. Variations in the character of occurrence of different species of plankton rotifers in continuously and periodically filled ponds
IV. Domination relations of euplankton rotifers in continuously and periodically filled ponds with different fish stocks
V. Interpretation of results

In an earlier study (Hillbricht-Ilkowska 1964) is was found that a fish population causes significant changes in a plankton rotifer community, and that the greater the number of fish, the more intensive the changes. The present study was aimed at finding the answer to the question as to what degree this influence also depends on the length of time the fish were kept in the pond. Investigations were made of ponds used by the fish for a period of several summer months and of ponds in which the fish lived uninterruptedly over a long period.

* From the Institute of Ecology, Polish Academy of Sciences, Warszawa.

Attention was also paid in these investigations to the degree to which possible changes in rotifer plankton are due to lengthy occupation of the pond by fish and to what degree they are independent of the fish stock, and are conditioned only by the length of time during which the pond is in use.

I. STUDY AREA AND METHODS

Investigations were made in a large group of ponds (Tab. I) of uniform area (0.20 ha), depth (approximately 1 m) and construction, belonging to the Experimental Fishery Station of the Institute of Inland Fishery at Żabieniec near Warsaw. Some of the ponds were kept filled over the period from June 17th, 1960 to October 2nd, 1961 (these are the continuously filled ponds, with around 16 months uninterrupted filling period) – while others were emptied for the winter period of 1960–1961 and refilled in June 1961, and thus had two 4-month growing periods in 1960 and 1961, from mid-June to mid-October, these two periods being separated by an 8-month interval when they were left empty. Different variants of fish stocking were used for both groups of ponds (Tab. I).

Number of periodically and continuously filled ponds examined, containing different fish stocks

Tab. I

Fish stock (specimens/ha)	Periodically filled ponds	Continuously filled ponds
0*	1	1
2,500	–	1
7,500	2	4
15,000	2	1
22,500	1	–
30,000	1	–

* Control ponds.

The continuously filled ponds were stocked in June, 1960, with 1 g carp fry, which grew to weights of 150–600 g, depending on the stock during 16-month period. The ponds emptied in winter were stocked in both investigation years with fry weighing 1 g, which reached weights of 40–70 g[1] during the 4-month filling periods.

Quantitative material was taken from several ponds every 4–7 days, and every 14 days during the winter Samples were taken at intervals of not more than 10–14 days in the remainder of the ponds. A sample consisted of 20 litres

[1] The data on stocking apply to the number of fish released in the ponds. The fish were fed with rough-ground barley during the second year of use of the continuously filled ponds.

of water taken with a 1-litre Fatalas type plankton-sampler in different places in the pond, and then strained through a net with approximately 50 μ mesh.

II. ABUNDANCE OF ROTIFERS IN CONTINUOUSLY AND PERIODICALLY FILLED PONDS WITH DIFFERENT FISH STOCKS

The basic differences in the quantitative occurrence of rotifers during the summer growing period (June-October) between the two groups of ponds

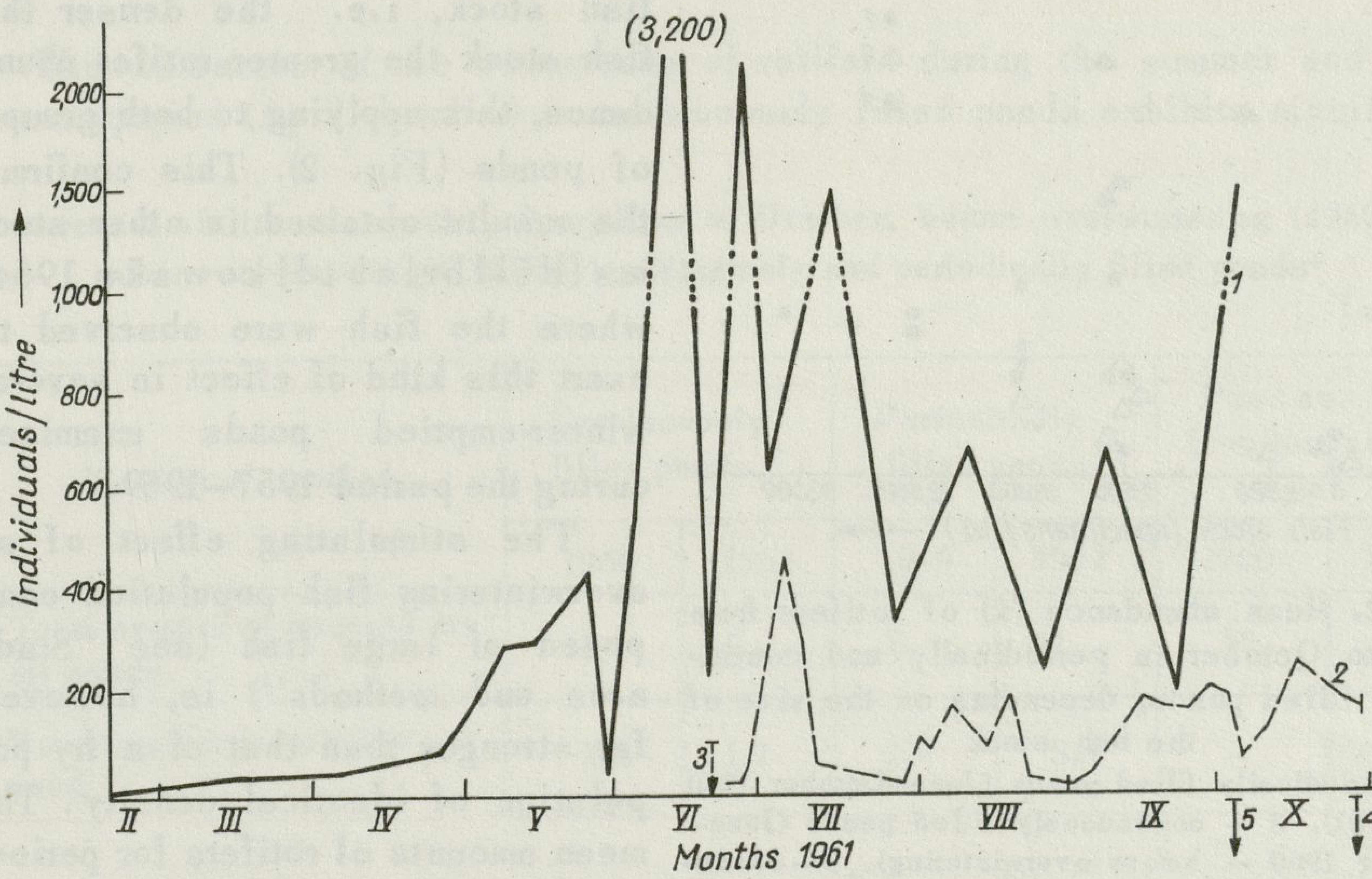

Fig. 1. Variations in abundance of rotifers in a periodically and a continuously filled pond, containing fish stocks of 15,000 fish/ha

1 – continuously filled pond, *2* – periodically filled pond, *3* – refilling of periodical pond, *4* – draining of periodical pond, *5* – draining of continuous pond

consisted in the greater abundance of rotifers in ponds continuously used by fish (continuously-filled ponds). In these ponds – in comparison with periodically emptied ponds, in which the fish lived for a period four times shorter – rotifers occurred more numerously and longer, and attained higher maximum abundance (Fig. 1). As a result the mean abundance of rotifers in ponds in which fish remain in the winter was higher than in the ponds emptied for the winter (Fig. 2).

The above differences are undoubtedly connected with the duration of the period the fish remained in the pond, since during the summer-time of 1960, that is, during the period when all the ponds were emptied for the preceding winter, the mean abundance of rotifers was similar in both groups of ponds (Fig. 2). In addition the increase in the abundance of rotifers in the ponds with the overwintering fish population is due only to the continuous use of the pond by the fish, and not to the continuous filling, since the control pond, which was neither emptied in winter nor stocked, does not exhibit, in comparison with the unstocked pond, which was emptied in winter – an increase in rotifer abundance in summer (Fig. 2).

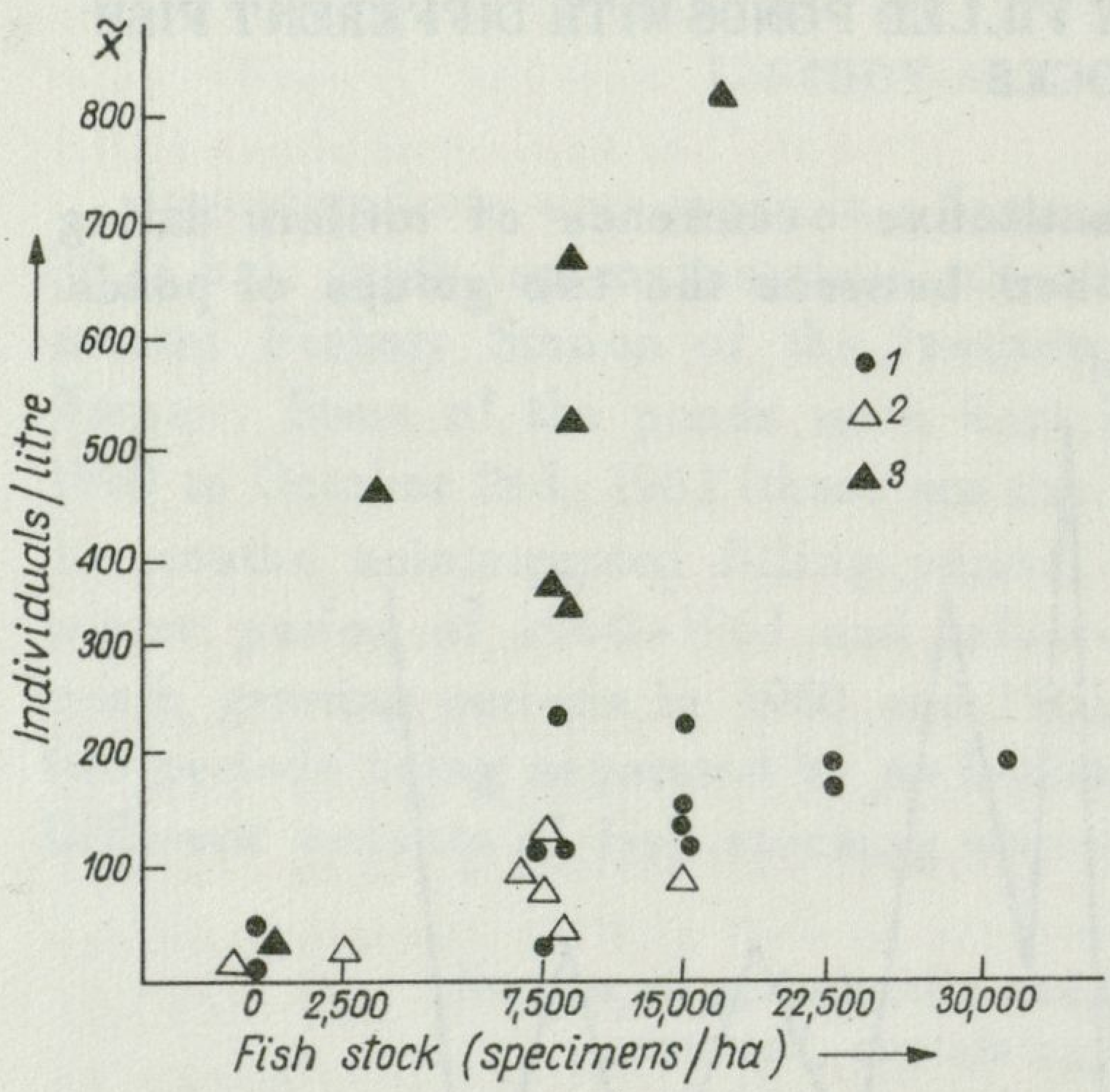

Fig. 2. Mean abundance (x̄) of rotifers from June to October in periodically and continuously filled ponds, depending on the size of the fish stock

1 – periodically filled ponds (June–October 1960 and 1961), *2* – continuously filled ponds (June–October 1960 – before overwintering), *3* – continuously filled ponds (June–October 1961 – after overwintering)

The mean amount of rotifers during the summer also exhibits correlation with the size of the fish stock, i.e. the denser the fish stock the greater rotifer abundance, this applying to both groups of ponds (Fig. 2). This confirms the results obtained in other studies (Hillbricht-Ilkowska 1964) where the fish were observed to exert this kind of effect in several winter-emptied ponds examined during the period 1957–1959.

The stimulating effect of an overwintering fish population composed of large fish (see "Study area and methods") is, however, far stronger than that of a fry population of identical density. The mean amounts of rotifers for periodically emptied ponds and ponds stocked with the densest fry stocks (22,500–30,000 fish/hectare) are several times smaller than the mean amounts of rotifers in continuously filled ponds in which the overwintering fish stock had been released in numbers from 7,500–15,000 fish/hectare the previous summer (Fig. 2).

Mean abundance of rotifers (x̄) and time of their numerous appearance from March to mid-June 1961, in continuously filled ponds with different fish stocks

Tab. II

Fish stock (specimens/ha)	x̄ (specimens/litre)	Time of numerous appearance
0	13	end of April
2,500	87	mid-April
7,500–15,000	423 (range 288–497)	first half of March

The effect of the fish can be observed in the continuously filled ponds as early as the spring, i. e. during the period directly preceding the filling of the winter-emptied ponds (mid-June). The greater the density of the overwintering fish during this period, the greater the abundance and the earlier the numerous occurrence of rotifers (Tab. II).

III. VARIATIONS IN THE CHARACTER OF OCCURRENCE OF DIFFERENT SPECIES OF PLANKTON ROTIFERS IN CONTINUOUSLY AND PERIODICALLY FILLED PONDS

The character of the occurrence of rotifers during the summer and early autumn period (April-October) in continuously filled ponds exhibits significant

Occurrence of littoral species from June to October, before overwintering (1960) and after overwintering (1961) in continuously and periodically filled ponds*

Tab. III

Number of species	Continuously filled ponds		Periodically filled ponds		Pond no. 18 (continuously filled)	
	1960	1961	1960	1961	1960	1961
Total number of species for all ponds	12	8	8	17	12	4
Mean number of species per pond	3.5	1.7	2.8	5.4	–	–

* The above comparison was made between 6 continuously filled and 5 periodically filled ponds examined both years (1960 and 1961), using samples taken every 14 days as a basis in order to compensate for the possibility of finding species in ponds examined with different frequency (every 3–5 days and every 14 days). Pond no. 18 which was examined with uniform frequency in both years (every 3–5 days) was treated separately.

differences in comparison with their occurrence in ponds kept filled during this period only (Tab. III, Fig. 3).

These changes would seem to be the result both of continuous use of the pond by the fish and the longer period of existence of the pond itself.

In the case of littoral[2] species continuity of filling and use of the ponds by fish during the winter creates conditions unfavourable to their occurrence

[2] Species, more or less indirectly connected with water plants and usually occurring in either the littoral zone or in shallow bodies of water filled with plants were taken as littoral species (Voigt 1957, Bartoš 1959). There was a total number of 25 species of the following genera: *Colurella, Lecane, Lepadella, Lophocharis, Trichocerca, Testudinella, Mytilina, Trichotria, Euchlanis, Cephalodella*.

during the summer growing period. This results in a decrease in the total and mean number of species in the continuously filled ponds after their overwintering (Tab. III), whereas in the case of winter-emptied ponds and then refilled not only is there no decrease in the number of species, but even some increase takes place (Tab. III).

Contrary to the littoral species – continuous filling favours the development of euplankton species, i.e. those connected with the "pelagic" zone of the water, free of plants (Fig. 3).

During the period June-October these species occur more constantly and abundantly in the continuously filled ponds than is those periodically filled

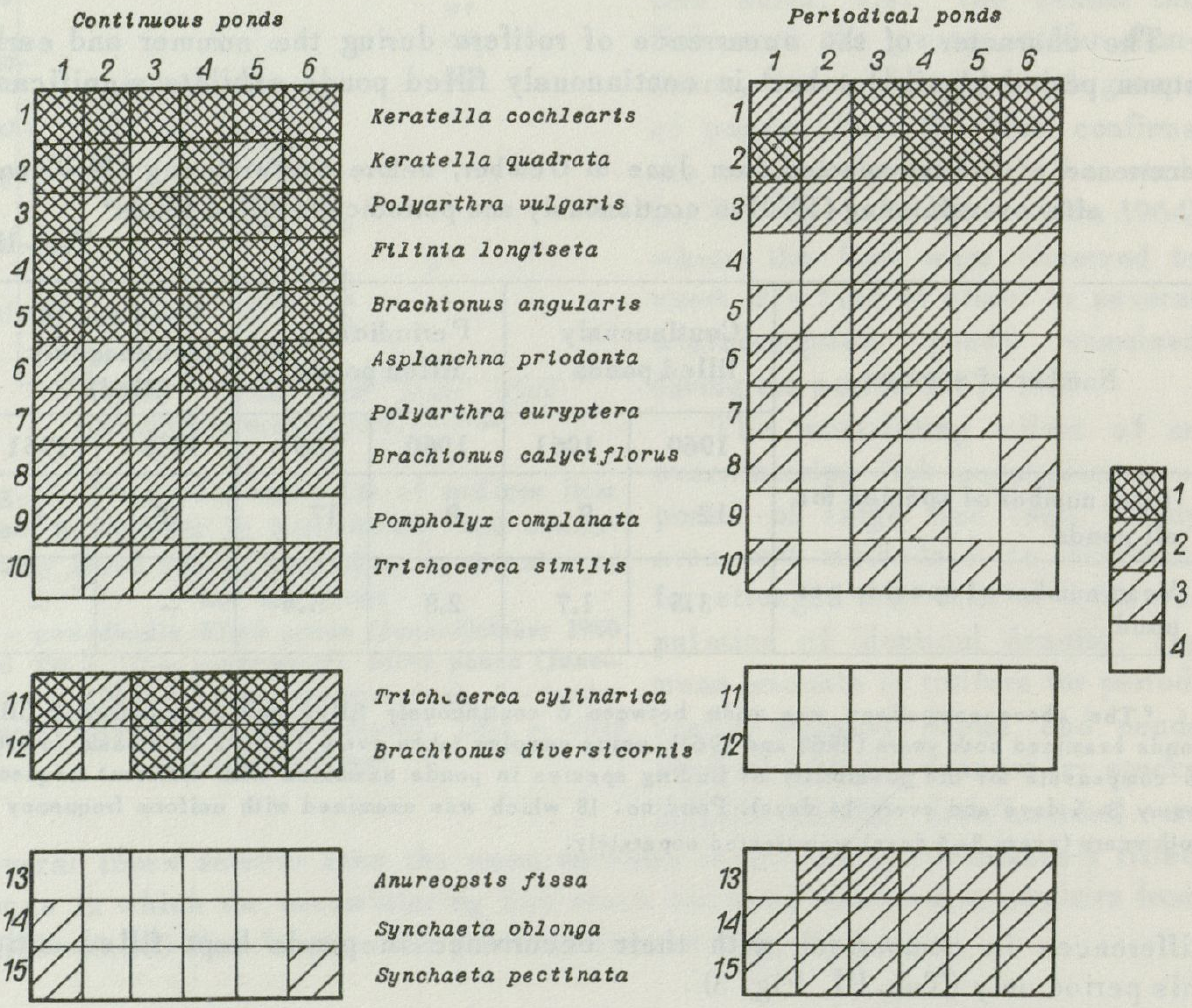

Fig. 3. Occurrence of euplankton species from June to October 1961 in six stocked ponds, either continuously or periodically filled

1 – species occurs numerously over the whole of, or at least for half of the study period, *2* – species occurs numerously over short periods, or in small numbers but frequently, *3* – species occurs in small numbers, *4* – species not found

(Fig. 3). This applies particularly to such species as *Brachionus angularis*[3],

[3] A list of species together with the names of their authors was given in the study by Hillbricht-Ilkowska (1964).

Occurrence of selected rotifer species in different months in 1961 in six continuously filled ponds (o)* and six periodically filled ponds** (x) *

Tab. IV

No.	Species	Months							
		III	IV	V	VI	VII	VIII	IX	X
1	*Synchaeta oblonga*	o o o o o o	o o o o	o o	o x x x	 x x x			 x x x x
2	*Synchaeta pectinata*	o		o o o o	o x	o x	 x x	 x x x	 x x x x x x
3	*Brachionus urceolaris*		o	o o o	 x	 x x x x x	 x	 x	
4	*Conochilus hippocrepis*		o o o o o o	o o o o o o	o	o o o x	 x x x x x x	o o o x x x x x x	o o x x x
5	*Keratella quadrata*	o o o o	o o o o o o	o o o o o o	o o o o x	o o o o o x x x x x x	o o o o o o x x x x x x	o o o o o o x x x x x x	o o o o o o x x x x x x
6	*Filinia longiseta*	o o	o o	o o o o o o	o o o o o o x	o o o o o o x x x	o o o o o x	o o o o o x x	o o o o o o x x
7	*Asplanchna priodonta*	o	o o	o o o o o	o o o o o o x x	o o o o x	o o o o o	o o o o o o x x x x	o o o o o o x x x x x x
8	*Brachionus calyciflorus*	o o o o		o o o o o o	o x x x x	o o o o o x x x x x	o o o o o o	o o o o o o	o o
9	*Brachionus angularis*			o o o o	o o o o o o	o o o o o o x x x x	o o o o o o x x x	o o o o o x x x x	 x
10	*Polyarthra euryptera*				o o o	o o o o o	o o o x x	o o x x x	
11	*Hexarthra mira*				o	 x x x x	o o x x x x	o o o	
12	*Pompholyx complanata*					o o o o o x	o o o o x	o o o x	o x

* Single recording indicates occurrence of given species in one pond and one month.

** Periodically filled ponds were kept filled from June to October.

Filinia longiseta, *Polyarthra vulgaris* and *Asplanchna priodonta*, which occur in far greater amounts and more constantly in the continuously filled ponds, and *Trichocerca cylindrica* and *Brachionus diversicornis*, which hardly occurred at all in the periodically filled ponds, whereas they occur frequently and abundantly in the continuously filled ponds. Of the 15 species compared only three (Fig. 3, species 13–15) occur almost exclusively in the periodically filled ponds from June to October[4].

Continuous filling of the pond during the winter and spring also significantly affects the change to the time of occurrence of different species (Tab. IV). In certain species (species 1–4, Tab. IV) this change consists in a shift in the time of their occurrence in continuously filled ponds to the spring and early summer, i. e. before the winter-emptied ponds are refilled, whereas they occur in summer and autumn in the latter. In the case of other species the time and continuity of occurrence are prolonged for several months in the continuously filled ponds (frequently throughout the year), while in the winter-emptied ponds they either occur over their whole filling-period (species 5–6, Tab. IV) or for a shorter time (species 7–9, Tab. IV). Species 10–11 (Tab. IV) exhibit a distinct shift in time of occurrence within the summer months. Species 12 (Tab. IV), given for the sake of comparison with the former species, forms an example of similarity in time of occurrence in ponds in both groups, that is, no change in occurrence takes place as the result of continuous filling.

IV. DOMINATION RELATIONS OF EUPLANKTON ROTIFERS IN CONTINUOUSLY AND PERIODICALLY FILLED PONDS WITH DIFFERENT FISH STOCKS

The abundance of certain species, particularly species occurring frequently and in considerable numbers in the ponds examined, clearly depends on the fish stock. Together with an increase in the density of the fish stock the abundance of these species alters in a definite direction, and in consequence their participation in the total numbers of rotifers (Tab. V, VI, VII). Percentages were calculated on the basis of mean abundance for the period March-May for continuously filled ponds (Tab. V) and June-October for continuously filled (Tab. VI) and periodically filled (Tab. VII) ponds. In addition to species, the changes in abundance and percentage of which are clearly correlated with the fish stock, some other species have also been given for purposes of comparison, the numbers of which do not exhibit correlation with the fish stock but which

[4]It must be added that comparison was made, analogically to that presented in Figure 3, of the two groups of ponds in 1960, that is, before the overwintering period of the continuously filled ponds. This was done to obtain confirmation of any possible differences between the two groups of ponds which might affect differences between them in 1961, that is, after the overwintering period of the continuously filled ponds. Analysis revealed relative similarity of occurrence of euplankton species in the two groups of ponds in 1960, which indicates that their differing from each other the following year was due to the different overwintering conditions.

Mean abundance ($\bar{x}$, specimens/litre) and percentages of selected euplankton species* in continuously filled, stocked** ponds from March to May 1961

Tab. V

No.	Species		Fish stock (specimens/ha) 2,500	7,500	15,000
1	*Keratella cochlearis*	$\bar{x}$	5	67	194
		%	9	23	41
2	*Keratella quadrata*	$\bar{x}$	5	52	60
		%	9	16	13
3	*Filinia longiseta*	$\bar{x}$	1	46	54
		%	1	13	11
4	*Polyarthra dolichoptera*	$\bar{x}$	–***	33	122
		%	–	9	26
5	*Asplanchna priodonta*	$\bar{x}$	2	24	12
		%	3	8	3
6	*Conochilus hippocrepis*	$\bar{x}$	26	22	1
		%	50	11	0
7	*Synchaeta oblonga*	$\bar{x}$	14	23	22
		%	26	15	5

* Comparison includes species, the abundance of which is distinctly correlated with the fish stock, and species, the abundance of which is great enough to qualify the given species as dominating (i.e. forming at least over 10% of the total numbers). Species occurring scantily and not exhibiting correlation with the fish stock have been omitted.

** Control pond, unstocked, has been omitted from this comparison on account of the small total numbers (several specimens/litre) of rotifers.

*** Do not occur.

are large enough for these species to be included, in certain fish stocking variants, among dominating species.

It was decided to consider species, the numbers of which formed at least over 10% of the total numbers of rotifers in a given period, as dominating species.

It was found, on the basis of comparison of variations in numbers and percentages of different species, depending on the fish stock (Tab. V, VI, VII) that:

1. *Keratella cochlearis* (G o s s e) 1851 is a species numerous in both periods (Tab. V, VI) and in both groups of ponds (Tab. V, VI, VII), the numbers and percentage of domination of which increase together with increased density of the fish stock. In ponds with the maximum density of fish stock this species forms about half of the total numbers of rotifers.

Mean abundance ($\bar{x}$, specimens/litre) and percentages of selected euplankton species* in continuously filled, stocked ponds from June to October 1961**

Tab. VI

No.	Species		Fish stock (specimens/ha)		
			2,500	7,500	15,000
1	*Keratella cochlearis*	$\bar{x}$	113	186	388
		%	26	33	34
2	*Filinia longiseta*	$\bar{x}$	5	106	86
		%	1	20	13
3	*Polyarthra vulgaris*	$\bar{x}$	25	61	56
		%	6	10	8
4	*Brachionus angularis*	$\bar{x}$	12	43	56
		%	3	12	8
5	*Trichocerca cylindrica*	$\bar{x}$	19	30	42
		%	3	5	6
6	*Asplanchna priodonta*	$\bar{x}$	9	16	33
		%	2	4	5
7	*Trichocerca similis*	$\bar{x}$	–***	2	11
		%	–	0	1
8	*Pompholyx complanata*	$\bar{x}$	142	16	64
		%	32	6	9
9	*Keratella quadrata*	$\bar{x}$	100	16	19
		%	23	4	3
10	*Brachionus calyciflorus*	$\bar{x}$	16	21	4
		%	3	3	0

*, **, *** Explanations as for Tab. V.

2. Certain other species exhibit either dependence on the fish stock similar to that of *K. cochlearis*, or their abundance in ponds with larger fish stocks is generally greater than in ponds with smaller stocking (species 2–5, Tab. V, and species 2–7, tab. VI). The majority of these species exhibit abundance often qualifying them as species co-dominating with *K. cochlearis*.

3. Several species, e. g. species 6 (Tab. V) and species 8–10 (Tab. VI) seem to exhibit negative correlation with the fish stock, i. e. their abundance is greater in ponds with small fish stocks than in the more densely stocked ponds. There species are even among the dominating species in ponds with minimum density of fish stock (2,500 fish/hectare). Their scanty occurrence

in ponds with larger stocks cannot, however, be explained by their being eaten by the dense fish population since they do not constitute food for carp at this stage of the development of the fish.

The above analysis of domination relations in the two groups of ponds justifies the statement that the abundance of many euplankton species, par-

Mean abundance ($\bar{x}$, specimens/litre) and percentages of selected euplankton species* in periodically filled, stocked** ponds from June to October 1961

Tab. VII

Species		Fish stock (specimens/ha)			
		7,500	15,000	25,000	30,000
Keratella cochlearis	$\bar{x}$	20	41	69	96
	%	31	38	51	57
Keratella quadrata	$\bar{x}$	9	21	13	20
	%	20	20	10	12
Polyarthra vulgaris	$\bar{x}$	12	9	24	17
	%	2	8	18	10

*,** Explanations as for Tab. V.

ticularly *Keratella cochlearis*, increases with increased density of fish stock in both groups of ponds, and this results in sharply-defined domination structure of rotifer communities in the most densely stocked ponds.

V. INTERPRETATION OF RESULTS

The results of the study consist of further data, proving that the fish population affects the habitat and biocenosis of ponds to a degree depending not only on the density of the stock, but also on the duration of their stay in the pond.

It is primarily lengthy and continuous use of a pond by fish which, proportionately to stock density, exerts a strong "fertilizing" effect on the pond habitat and therefore accelerates its eutrophisation. This is manifested by the increase of the abundance of rotifers and prolongation of the time of their numerous occurrence to almost the whole of the year, such as takes place in ponds in which fish live for periods of 16 months. This influence is stronger than the effect exercised by fish living for a period four times shorter, even though density of stock in such case was several times greater. This result confirms the results obtained by Spodniewska (1965) for phytoplankton and by Grygierek (1964) for crustaceans, in which abundance of occurrence was also found to increase in ponds in which the fish population overwintered, in comparison with seasonal ponds. Thus all three basic components of plankton react similarly to prolonged stay of fish in the pond.

The considerable abundance of rotifers and their high percentage in the zooplankton is generally considered as a feature of fertile, eutrophic bodies of water rich in organic material foming the food of these organisms, that is, detritus, bacteria and nannoplankton. Particularly fertile and productive ponds are usually characterized by great total abundance of rotifers (Kulamowicz 1956, Pidgajko 1957, Ljachnovič 1958, Krzeczkowska 1963). They also form an element reacting most strongly to fertilization, particularly to organic fertilization (Akatova 1957, Bombówna, Krzeczkowska and Klimczyk 1962, Klimczyk 1964).

Another indicator of increase in fertility in ponds with overwintering fish populations in comparison with seasonal ponds is the occurrence of certain species of rotifers. Species such as *Brachionus urceolaris*, *B. calyciflours*, *B. diversicornis* and *Filinia longiseta*, in which abundance of occurrence was found to increase in ponds with an overwintering fish population, are often considered as indicators of productive ponds, and in general intensely eutrophic or organically polluted bodies of water (Ljachnovič 1958, Krzeczkowska 1961). The species *Keratella cochlearis* and *Brachionus angularis* exhibited a strong reaction to organic fertilization (Edmondson 1959, Klimczyk 1964).

In general it can therefore be stated that ponds kept filled during the winter together with their fish population exhibit a greater degree of fertility in comparison with seasonal ponds in which the duration of the fishes' stay is four times shorter, and even in comparison with seasonal ponds which have a fish stock several times greater. On the other hand, continuous filling for many months, that is, lengthier functioning of a pond irrespective of its use by fish does not have a "fertilizing" effect, as is shown by the very low numbers of rotifers in a pond kept filled during the winter, but without fish. Continuous filling of a pond in winter only causes changes in the time of occurrence of certain species in the summer season following the winter.

It must, however, be added that supplementary feeding of the growing fish undoubtedly influences an increase in fertility in ponds with overwintering fish stocks, since it forms a kind of organic fertilization introduced both directly into the pond and also indirectly through the alimentary tract of the fish.

Elimination of littoral species – which is the more intense, the longer the period the pond is kept filled and the longer the period the fish stay in the pond – points to yet another way in which fish exert an influence – an influence which reduces the pond habitat to uniformity by destroying plants. As the result of this kind of influence being exerted by fish, typically plankton species, connected with the open body of water, dominate in the plankton. Continued simplification of relations, expressed by the increasingly powerful domination of one species – *Keratella cochlearis* – takes place among these species together with increasingly strong influence of the fish.

I should like to express my thanks to the Head of the Experimental Pond Fischeries Station of the Institute of Inland Fishery at Żabieniec for making it possible for me to carry out the investigations discussed above.

REFERENCES

1. Akatova, I. 1957 – Vlijanie udobrenija na razvitie zooplanktona v prudach Rybcogo-Semajnogo pitomnika – Trudy probl. Sovešč. 1.
2. Bartoš, E. 1959 – Viŕnici (Fauna ČSR, vol. XV) – Praha, 970 pp.
3. Bombówna, H., Krzeczkowska, L. Klimczyk, M. 1962 – Czynniki chemiczne, fito- i zooplankton przesadkowych stawów karpiowych rozmaicie nawożonych – Acta Hydrobiol. 4: 345–384.
4. Edmondson, W. T. 1957 – Trophic relations of the zooplankton – Trans. Amer. micr. Soc. 76: 225–246.
5. Grygierek, E. 1964 – Wpływ ryb na faunę skorupiaków planktonowych – Rocz. Nauk. roln. B, 83.
6. Hillbricht-Ilkowska, A. 1964 – The influence of the fish population on the biocenosis of a pond, using *Rotifera* fauna as an illustration – Ekol. Pol. A, 12: 453–503.
7. Klimczyk, M. 1964 – Plankton zwierzęcy i jego biomasa w stawach nawożonych – Acta Hydrobiol. 6: 187–205.
8. Krzeczkowska, L. 1961 – Materiały do znajomości planktonu stawów rybnych – Acta Hydrobiol. 3: 69–90.
9. Krzeczkowska, L. 1963 – Charakterystyka planktonu stawów woj. kieleckiego – Acta Hydrobiol. 5: 189–213.
10. Kulamowicz, A. 1956 – Badania nad wrotkami planktonowymi stawów rybnych w Żerominie pod Łodzią – Prace ŁTN, 42: 1–47.
11. Ljachnovič, V. L. 1958 – O biologičeskich pokazateljach ryboproduktivnosti prudov – Trudy Biol. Stancii „Naroč", 1: 197–208.
12. Pidgajko, M. L. 1957 – Zooplankton prudov stepnoj zony Ukrainy – Vopr. Ichtiol. 8: 129–142.
13. Spodniewska, I. 1965 – Development of phytoplankton in ponds with different periods of filling and different fish stocks – Ekol. Pol. A, 13: 45–55.
14. Voigt, M. 1957 – Die Rädertiere Mitteleuropas – Berlin, 510 pp.

WPŁYW RÓŻNEGO OKRESU RYBACKIEGO UŻYTKOWANIA STAWÓW NA WYSTĘPOWANIE I LICZEBNOŚĆ WROTKÓW PLANKTONOWYCH

Streszczenie

Praca przedstawia wyniki badań przeprowadzonych na kilkunastu stawach (tab. I) o jednakowej powierzchni (0,20 ha), głębokości (około 1 m) i jednakowej konstrukcji, z których część pozostawiona była pod zalewem na okres około 16 miesięcy (stawy

nieosuszane na zimę), część zaś na okres 4 miesięcy (stawy osuszane na zimę). W obu grupach stawów zastosowano różne obsady rybne: od 0 (kontrolne) do 30 000 sztuk narybku (o wadze 1 g) na hektar. Narybek ten dorastał w stawach osuszanych do kilkudziesięciu, a w stawach nieosuszanych — do kilkuset gramów.

Nieprzerywane w okresie zimowym użytkowanie stawu przez populację ryb zwiększa kilkakrotnie obfitość wrotków planktonowych w okresie wegetacji letniej (czerwiec—październik) (fig. 1, 2) oraz umożliwia wczesne i obfite ich występowanie w okresie wiosennym (marzec—maj) (tab. II). Czas wiosennego pojawu wrotków jest tym wcześniejszy, a ich obfitość w okresie wiosennym i letnim tym większa, im większe jest zagęszczenie zimującej populacji ryb (tab. II, fig. 2).

Ciągłość zalewu stawu i jego użytkowania przez ryby w okresie zimowym stwarza w okresie letnim niesprzyjające warunki dla występowania gatunków litoralowych (tab. III), natomiast stymuluje częstość i obfitość występowania gatunków euplanktonowych (fig. 3). Ciągłość ta powoduje ponadto istotne przesunięcia w czasie występowania wielu gatunków (tab. IV).

Liczebność i procentowe udziały wielu gatunków euplanktonowych są uzależnione od wielkości obsady rybnej. Im większa jest obsada rybna, tym większe są również ich odpowiednie wartości liczbowe. Dotyczy to zarówno stawów z dłuższym, jak i z krótszym okresem użytkowania przez ryby (tab. V, VI, VII). Gatunkiem najliczniejszym i najsilniej reagującym na wielkość obsady rybnej jest *Keratella cochlearis* (tab. V, VI, VII). Zwiększanie się dominacji tego gatunku, w miarę wzrostu obsady rybnej, w obu grupach stawów i w ciągu całego roku wegetacji, powoduje silne zmiany struktury dominacyjnej zgrupowania wrotków planktonowych.

Opisane wyniki pozwalają na scharakteryzowanie wpływu ryb na siedlisko stawu. Jest to wpływ ,,użyźniający", powodujący tym silniejszą eutrofizację im dłuższy jest czas przebywania ryb w stawie i im większa jest obsada rybna. Wskaźnikiem tego procesu jest zarówno zwiększanie się liczebności całego planktonu wrotkowego, jak i poszczególnych gatunków, wskaźnikowych dla eutrofizacji.

Obecność ryb wpływa ponadto ujednolicająco na strukturę zgrupowania wrotków, czego dowodem jest ustępowanie gatunków litoralowych przy dłuższym przebywaniu ryb w stawie oraz potęgująca się dominacja jednego gatunku — *Keratella cochlearis* — wśród wrotków euplanktonowych.

Uzyskane wyniki są zgodne z wynikami badań Spodniewskiej (1965) nad fitoplanktonem i wynikami badań Grygierek (1964) nad skorupiakami, co dowodzi podobnego reagowania wszystkich podstawowych składników planktonu na wpływ obecności ryb w stawach.

AUTHOR'S ADDRESS:
Dr. Anna Hillbricht-Ilkowska,
Institute of Ecology, Polish
Academy of Sciences, Warszawa,
ul. Nowy Świat 72, Poland.