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LIMNOLOGICAL INVESTIGATIONS OF A FISH-POND SUPPLIED WITH SEWAGE-WATER IN THE VICINITY OF LAKE BALATON. I.

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The method of sewage purification in fish-ponds is of old standing. Since the beginning of this century this type of fish-ponds has been maintained in Germany (FALCK, 1935; KISSKALT and ILZHÖFER, 1937; KAUFMANN, 1958; LIEBMANN, 1960). The main point of the procedure is that the organic substances of the sewage-water getting in to the fish-pond after a suitable dilution and distribution, are aerobically destructed by means of bacteria and the biogenic elements formed this way are utilized by the algae. The bacteria and algae propagated during the decomposition of organic substances as well as the organic fragments are incorporated by planktonic animals and other invertebrate organisms, which are in turn consumed by other invertebrates or directly by fish.

In spite of the fact that these fish-ponds supplied with sewage-water function with a good efficiency according to the experience of Germany (IMHOFF, 1956; LIEBMANN, 1960), the results and observations can only be utilize with some difficulties owing to the different conditions in Hungary (CSANÁDY and GREGÁCS, 1965 a). Upon the influence of the advantageous observations obtained in Czechoslovakia (PYTLIK, 1957) several papers have been published in our country which, on the one hand, urged the operating experimental introduction of the postpurification of sewage-water in fish-ponds (WOYNAROVICH, 1959 a, b), and on the other hand, described the principal problems together with home possibilities (DONÁSZY, 1965; CSANÁDY and GREGÁCS, 1965 a). In spite of that, attention was rather focused on the so-called waste stabilization ponds ("Abwasserteich") (UHLMANN, 1962; BRINCK, 1961; CSANÁDY and GREGÁCS, 1965 b), since as against to the fish-pond purification, there is no need of dilution-water in this case, offering a possibility for wider application. According to certain data,the waste stabilization ponds and the fish-ponds supplied with sewage-water cannot be sharply distinguished (PYTLIK, 1957), since in a closed system the culture of carp and tench can be realized even without diluting the water, and what is more, for this purpose even the strongly contaminated waste waters of the food industry can be used.

Neither sewage fish-ponds nor waste stabilization ponds were established in Hungary until 1970 for direct purposes of purification of sewage-waters. Nevertheless, the home literature (CSANÁDY and GREGÁCS, 1965 a, b) reported on the bacteriological, chemical and parasitological relationships of some fish-ponds loaded with sewage-water and waste stabilization ponds, indicating that these methods could be applied in a useful way even in our country. The authors cited above suggest the establishment of these types of pond especially on the southern shore of Lake Balaton, since "by means of them the sewage-water can practically be kept out of the lake" (CSANÁDY and GREGÁCS, 1965 a, p. 185), and hold as necessary to perform experiments in operational sizes in order to estimate the possibilities. The idea of establishing sewage fish-ponds has arisen even formerly, however, recently some apprehensiveness came to light both abroad and home as regards this method of sewage purification especially in connection with the ponds along the Lake Balaton, containing peat and a huge amount of organic substances (HOLÉNYI, 1962).

The OVH (National Buro for Water Conservancy) agreed to establish experimental ponds in 1970, which is to be built in the region of Fonyód for the utilization of sewage-waters and to start to function in 1973. Until putting this fish-pond into operation, we have investigated the so-called pond of Zardavár No. 1 since 1971, which is a sewage fish-pond not studied before from hydrobiological point of view. The long-term aim of our investigations was to obtain scientific material on the basis of which the research work can be planned with suitable certainty on the experimental ponds starting in 1973.

The investigations were intended to study directly

a) the biomass of bacterio-, phyto- and zooplankton as well as their changes;

b) the biomass of fauna at the bottom of the pond;

c) the growth of fishes;

d) the most important chemical components.

Description of the place of investigations

A fish-pond system of 370 cadastral acre consisting of 3 units serves for the postpurification of the sewage-water of the Fonyód resort centre. The water is conducted here by a main collecting pipe. After lifting over and sedimentation, the water reaches pond No. 1 at one point, which is of 85 cadastral acre. The other two ponds can be filled in with water through the first one, thus, the accidentally remaining contamination can further be destructed.

During the emptying of the ponds, the water gets in a canal called Keleti-Bozót then into Lake Balaton. During this period, the sewage-water is collected in a reserve pond *(Fig. 1)* acting for waste stabilization. The refilling of the ponds takes place from the canal mentioned above containing plentiful clean water.

According to the aims of investigations, the work was concentrated on pond No. 1. The standard places of sampling, except one, fall on the transversal section of the pond. The place of sampling No. 1 was near the inflow of the sewage-water, that of No. 5 near the outflow of the pond, and further 3 places were selected at about identical distances from each other between the two marginal places mentioned above.

Using these places of sampling, the changes can be followed from the inflow up to the outlet of the pond. Samples were taken occassionally from another point of the pond for comparisons *(Fig. 1,* place of sampling No. 6). Thus, 3 samples were at our disposal each from the marginal and open water areas.

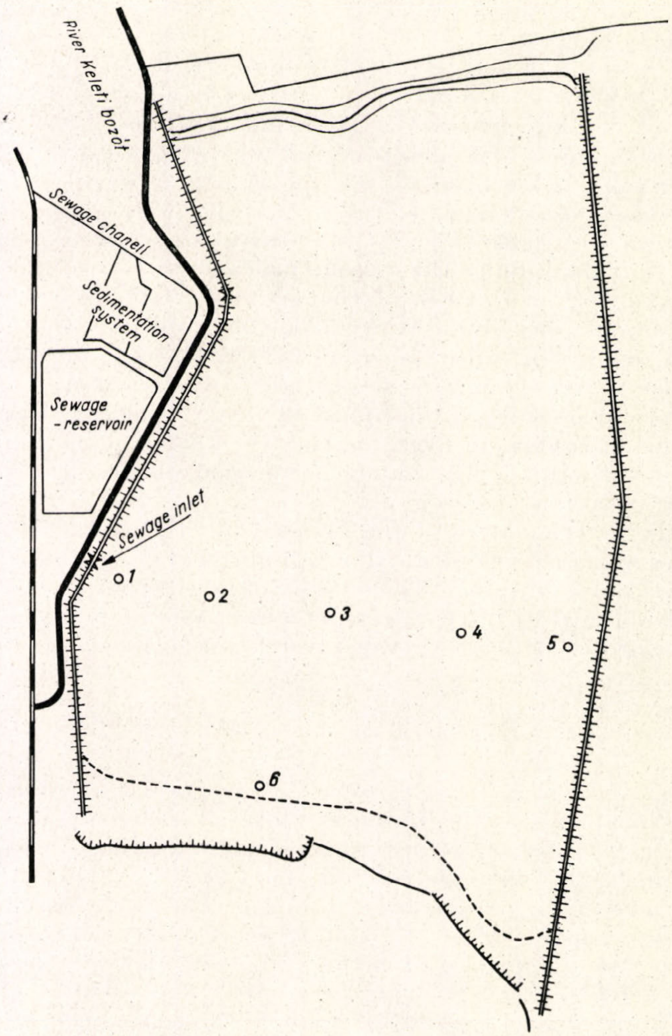

Fig. 1. Places of sampling on pond No. 1 of Zardavár

Methods

1. *The biomass of the planktonic members*

The amount of the total microbial plankton was determined by means of the method of Razumov (1932), whereas the biomass was calculated according to Rodina (1965). For measurements of the phytoplankton biomass, the chlorophyll-method of Strickland and Parsons (1969) was applied. For the determination of alga species as well as for the evaluation of their percentual distribution, samples filtered through a mesh No. 25 were used. The counting was carried out in a microscope type Uthermöl.

The determination of the zooplankton biomass was performed in light of the works of SEBESTYÉN (1958), NAUWERCK (1963), SCHNESE and SCHWARZ (1970). For qualitative and quantitative analyses of the Rotatoria plankton, the filtrate obtained on a mesh No. 25 from 4.5 l of water was used. At the evaluation of the biomass of the predominant species, the volume values calculated on the basis of models of SEBESTYÉN (1958) concerning the periods of "warm water", as well as the values of length, width and thickness of different species measured under the microscope, were applied. The product of multiplication of those values is considered as a volume given in μ^3 units of a given individual. Since the measurements were carried out on formalin-fixed material, the morphological changes of certain species could not be taken into account (e.g. the retracted foot of Epiphanes, the head-region of Asplanchna, etc.). The chitin-processes and the spines were also neglected (e.g. *Brachionus diversicornis*, or *B. calicyflorus)*. The volume values obtained this way were averaged and multiplied by 1.025 resulting in the wet weight of one rotifer individual in average. The dry weight amounts to 10 percent of that (WINBERG, 1971). The number of individuals per litre was multiplied by this average weight.

For the determination of the biomass of Crustacean plankton, 15 l of drawn water was used concentrated on a bronze-net of 90 μ mesh. The biomass was calculated by multiplying the number of individuals per litre by the value of dry weight measured separately for every species (e.g. the weight of a *Bosmina longirostris* is 2 μg, that of juvenile *Cyclops vicinus* is 5 μg).

2. *The me hods of investigation of the benthos*

The macrobenthos was investigated by using the Eckmann—Birge dredge, the mud was passed through riddles of different mesh (the smallest one of 500 μ). Organisms of this order of magnitude occurred so rarely that the determination of biomass was omitted.

The collecting of meiobenthic samples was also carried out by using the Eckmann—Birge dredge. A mud layer of 1 cm thickness and 40 cm^2 surface area was taken away from the untouched surface of the sample. The material was fixed in 4 percent formalin. The mud sample was put into a measure cylinder of 200 ml and filled up to the sign, then after mixing by shaking the animals were selected and investigated in portions of $25 \times 2-4$ ml in counting dishes. The biomass of Nematoda was estimated in dry weight according to the work of WARWICK and BUCHANAN (1971) by calculations. The biomass of the other groups of organisms was not calculated because of their low number of individuals.

3. *Methods of measurements on the fish-production and growth of fishes*

The investigations were mainly carried out on fishes collected during sampling fisheries. The total and standard body length as well as the body weight were measured and conclusions were drawn for the absolute growth from the average values. The allometric growth was calculated from those values (HUXLEY, 1924; cit. BEVERTON and HOLT, 1957). The rate of growth of body length and weight was characterized by the so-called growth coefficients on the basis of the equations given below (CHAPMAN, 1968; TESCH, 1968):

$$G_w = \frac{\log_e \overline{w}_1 - \log_e \overline{w}_0}{\Delta t}; \quad \text{and} \quad G_1 = \frac{\log_e \overline{L}_1 - \log_e \overline{L}_0}{\Delta t}$$

where G_w = growth coefficient of the body weight, G_1 = growth coefficient of the body length; w = body weight; L = body length; Δt = time between 0 and 1 (in our case it is 6 months).

The condition of the fishes was determined by using the method of HILE (1936) and LE CREN (1951) on the basis of the following equations:

$$CF = \frac{W}{L^3}; \quad \text{and} \quad CF = \frac{10^6 \times W}{L^3}.$$

At the seasonal changes of the condition the average and the limit values were considered.

The calculation of the actual total mortality was carried out according to RICKER (1958):

$$Z = \frac{-(\log_e N_1 - \log_e N_0)}{\Delta t},$$

where Z = coefficient of the actual total mortality; N = number of individuals at the beginning and at the end; Δt = time (= 0.5 year). From that equation one can determine the coefficient of survival, i.e. the rate of that:

$$S = e^{-Z};$$

as well as the total yearly mortality: A = 1 — S; this applies in this case only to half a year. The "losts" at economical level are given simply as percentages without time-dependence on the basis of the results of fisheries.

The production parameters of Zardavár ponds No. 1, 2 and 3 were evaluated separately between 1964 and 1971, and the net fish-production of each pond was investigated by using the parameters determined above as well as statictical data according to necessity (RICKER, 1958; BACKIEL, 1963; NAGIĘĆ, 1964).

4. The water analyses were carried out according to the Hungarian National Standards. The mud-analyses were performed by the Department of waterphysiology of OMMI.

Results

1. *Qualitative characterization of the water in the sewage fish-pond as well as in the in- and out-flow canals*

Several data summarized in *Table I* and *Table II* on water quality indicate that the fish-pond shows an efficiency of purification of about 40—74 percent. The recipient Keleti-Bozót contains water of good quality 1 km before Lake Balaton. This manifests itself especially in the low O_2-consumption and low ammonium-values.

TABLE I

Some chemical characteristics of the water flowing in and out of the sewage-water fish-pond

Substances investigated (mg/l)	The shaft of the rough screen before the cleaner				The outflow after the sedimentator 1969				The outflow of the pond			
	June	August	Sept.	Oct.	June	August	Sept.	Oct.	June	August	Sept.	Oct.
O_2 consumption (original)	195	245	140	192	90	205	106	152	42	155	71	99
BOI [5]	91	187	99	193	60	136	94	140	25	112	54	108
Dissolved O_2	—	—	—	—	—	1.5	—	—	8.8	7.8	6.3	—
pH	8.0	7.3	7.3	7.5	7.5	7.35	7.35	7.5	8.1	8.1	8.5	7.5
NH_4^+	41	49	54	64.8	51	44	46	54	20	3.0	3.4	48.6
Total dry substance	1438	1260	1545	1097	1234	805	1447	1194	531	577	619	959
Total organic substance	570	747	550	623	382	268	517	519	257	196	338	333
Total mineral substance	868	515	995	728	852	537	830	675	274	381	281	626

TABLE II

Some chemical characteristics of the water of Keleti-Bozót canal reaching Lake Balaton

Substances investigated (mg/l)	1969 June	1969 Sept.	Vehicular bridge of Fonyód 1970 April	1970 Nov.	1971 March
O_2 consumption	9.1	5.2	8.0	7.4	2.6
BOI_5	4.1	5.0	5.0	3.0	2.3
Dissolved O_3	6.7	12	7.3	10.4	8.9
pH	8.4	8.0	8.2	8.0	8.1
NH_4^+	0.15	0.2	0.1	0.6	0.1
Total dry substance	456	628	452	606	539

2. *The biomass of bacterioplankton*

The bacterial biomass was of high value during May due to the increasing temperature *(Tables III* and *IV)*. The high spring values were characteristic for the whole pond; no increase in values was noted near the inflow. During nearly one month, by the 9th June, the biomass of the bacterioplankton decreased. The highest value was found at the place farthest from the inflow on the 9th June, together with a low content of bacteria.

TABLE III

Biomass values of the bacterioplankton (g wet weight/m³) in 1971

	13th May	9th June	23rd June	6th July	10th Aug.	29th Aug.	14th Sept.	12th Oct.	21st Oct.
1.	11	4	21	0.25	4.4	2.8	13.8	20.6	24.1
2.	10.6	3.4	18	0.38	1.4	2.3	12.5	19.7	23.9
3.	9	4.2	14	0.46	1.3	1.8	10.8	21.0	23.3
4.	12	3.8	11	0.51	1.2	1.8	9.2	21.6	25.2
5.	11.8	5.9	12.2	0.55	1.4	3.0	14.9	20.6	21.4
Keleti Bozót	2.6	1.9	2.1	—	—	—	—	—	—

TABLE IV

Biomass values of the bacterioplankton (g dry weight/m³) in 1971

	13th May	9th June	23rd June	6th July	10th Aug.	29th Aug.	14th Sept.	12th Oct.	21st Oct.
1.	2.2	0.8	4.2	0.05	0.8	0.5	2.7	4.1	4.8
2.	2.1	0.6	3.6	0.07	0.2	0.4	2.5	3.9	4.7
3.	1.8	0.8	2.8	0.09	0.2	0.3	2.1	4.2	4.6
4.	2.4	0.7	2.2	0.10	0.2	0.3	1.8	4.3	5.0
5.	2.3	1.1	2.4	0.10	0.2	0.6	2.9	4.1	4.2
Keleti Bozót	0.5	0.3	0.4	—	—	—	—	—	—

The restarted inflow of sewage-water increased again the biomass of the microbial plankton in the whole pond according to the investigations of the 23rd June. The biomass values surpassed those in high spring. The highest values were obtained near the inflow. Proceeding toward the outlet, the biomass of the bacterioplankton decreased nearly to its half.

Parallel with the blue-green algal bloom, the biomass of the bacterioplankton decreased to an extremely low value (6th July). The bacterioplankton was formed mainly by a single coccoid form of 2—3 μ size (with food-inclusion and often in the state of division).

The biomass of the bacterioplankton remained low even on the 10th August beside the abundant biomass of Anabaena-Microcystis-Oscillatoria-Aphanizomenon species. However, the cocci of 2—3 μ size were changed replaced by filamentous forms. The biomass of bacterioplankton was very low even on the 29th August and the filamentous forms predominated.

The biomass of bacterioplankton was high on the 14th September. The initiated mineralization of Anabaena filaments was indicated by the fact that after the cocci of 2—3 μ size and the filamentous forms, a significant proportion of the bacterioplankton consisted of a form of less than 1 μ of a coccus-streptococcus type. The more or less colonized bacteria were always localized around the destructed Anabaena cells. The terminal cells of the destructed Anabaena filaments were surrounded almost always by the microcolonies of this microorganism.

The biomass of the bacterioplankton remained high on the 12th and 21st October. The decrease of blue-green algae was accompanied by the appearance of diatoms. Parallel to this phenomenon, a thin (less than 1 μ thick) filamentous organism became predominant in the bacterioplankton.

The biomass of bacterioplankton in the Keleti-Bozót was very low during the period of investigations as compared to that of the pond.

In the seasonal change of the biomass of bacterioplankton the very low number of bacteria is the most conspicuous phenomenon observed parallel with the bluegreen algal bloom. The decrease in the number of bacteria accompanying the blue-green algal bloom has also been described during our previous investigations in Lake Balaton and Lake Belső (OLÁH, 1971). It seems to be regular that the destruction and mineralization of the large blue-green algal biomass leads to an extreme increase in the bacterial biomass following the minimum value of it. The complex causal relationships between the blue-green algae and the bacteria described even here will be elucidated in more detail in the future.

On the basis of literary data and considering the bacterial biomass, the waste stabilization pond of Fonyód can be classified as a pond of high productivity and of medium loading.

3. *The changes of biomass of phytoplankton and the percentual composition of the algal groups*

a) Chlorophyll content and phytoplanktonic biomass. Similarly to the biomass of bacterioplankton, the amount of chlorophyll-a decreased after a high spring value *(Table V)*. By the end of June, after the restarting of the sewage-water inflow, the chlorophyll-a content increased again. During July, August and September, the amount of chlorophyll-a extremely increases in

TABLE V

Chlorophyll-a content in μg/litre in 1971

	13th May	9th June	23rd June	6th July	10th Aug.	29th Aug.	14th Sept.	12th Oct.	21st Oct.
1.	95.6	28.2	63	456	464	672	313	150	34
2.	58.4	32.4	114.1	589	603	545	823	150	104
3.	75.2	41.6	92	614	603	522	788	23	58
4.	84	26.9	106	536	487	661	730	11	174
5.	40	21.6	98	519	556	742	812	46	139
Keleti Bozót	16	14	11	—	—	—	—	—	—

consequence of the mass production of blue-green algae. Parallel with the decrease of blue-green algae during October the chlorophyll-a content also significantly decreased.

The chlorophyll-a content is usually lower at the points near the inflow than at the other places of the pond. This decrease in the chlorophyll-a content at the inflow is especially conspicuous in the results of September.

The chlorophyll-a content of the Keleti-Bozót is low as compared to that of the pond.

Apart from the measurements of chlorophyll-a, in some investigations the amounts of chlorophyll-b and c were also measured. At some points the amount of chlorophyll-c reached the value of 200 μg/l indicating an important role of diatoms in the photosynthetic organic production as well as indirectly in the production of oxygen necessary for the aerobic bacteria to decompose organic substances.

The quantitative estimation of phytoplanktonic biomass on the basis of the pigment content is widely known. For this purpose the following formula was used:

$$\text{mg C} = 25 \times \text{mg chlorophyll-a.}$$

The phytoplanktonic biomass and the pigment contents indicate *(Table VI)* an important role of photosynthetic oxygen production in the decrease of organic content of the sewage-water as well as in the processes of decomposition and mineralization. The bacterioplanktonic biomass is somewhat lower in natural, non-contaminated waters or even identical with the phytoplank-

TABLE VI

The biomass values of the phytoplankton in gC/m³ in 1971

	13th May	9th June	23rd June	6th July	10th Aug.	29th Aug.	14th Sept.	12th Oct.	21st Oct.
1.	4.7	1.4	3.1	22.8	23.2	33.6	15.6	7.5	1.7
2.	2.9	1.6	5.7	29.4	30.1	27.2	41.1	7.5	5.2
3.	3.7	2.0	4.6	30.7	30.1	26.1	39.4	1.1	2.9
4.	4.2	1.3	5.3	26.8	24.3	33.0	36.5	0.5	8.7
5.	2.0	1.6	4.9	25.9	27.8	37.1	40.6	2.3	6.9
Keleti Bozót	0.8	0.7	0.5	—	—	—	—	—	—

tonic one. The phytoplanktonic biomass of the waste stabilization pond of Fonyód significantly surpassed that of the bacterioplankton especially during the blue-green algal bloom.

b) Qualitative relationships of algal species *(Table VII)*. The number of algal species determined in the drawn-filtered samples collected at 5 points of the pond No. 1 between the 13th May and 21st October, 1971 as well as in the water of Keleti-Bozót, amounted to 114. They showed the following phylal distribution:

Cyanophyta	14
Euglenophyta	6
Pyrrophyta	3
Chrysophyta	34
Chlorophyta	56
Mycophyta	1
	114

Among the four systematic groups, the species were distributed as follows:

Occurrence of Cynophyta species in the places of sampling of the pond No. 1 during 1971.

	Points of sampling					
	1	2	3	4	5	Keleti-Bozót
13th May		2				
25th May	3	3	3	2	1	1
9th June	5	5	3	5	6	
23rd June	10	4	2	6	5	1
6th July	7	6	9	9	8	1
10th August	6	8	4	8	7	
29th August	5	6	4	9	9	
14th September	6	7	8	7	7	
12th October	10	8	8	5	4	
21st October	6	5	6	6	7	

The number of individuals of the following 4 species gradually increased from July:

Anabaena scheremetievi Elenkin
Aphanocapsa delicatissima W. et G. S. West
Microcystis flos-aquae (Wittrock) Kirchner
Spirulina laxissima G. S. West.

All four species prefer the strongly contaminated waters, i.e. they are mesosaprobic organisms. The *Anabaena scheremetievi* reached the total bloom by the end of August and beginning of September. Its exact taxonomical place could be determined on the basis of the persisting cells. Several variants and forms of it also occurred, but, they have not been identified. *Aphanizomenon flos aquae* var. *klebahnii* Elenkin and *Anabaena spiroides* Kleb. are also characteristic beta-mesosaprobic species. Both occurred rather frequently in the samples.

Euglenophyta

1971	1	2	3	4	5	Keleti-Bozót
25th May		2		1	1	
9th June		1	1			
23rd June	2	2	3		3	
6th July		2	3	1	2	
10th August	1		1	1		
14th September		1	1	1	1	
12th October	2		1	1	1	
21st October	2	1	2	3	2	

Euglena klebsii (LEMM.)MAINX and *Phacus pyrum* (EHR.) STEIN were present in the majority of samples, during the blue-green algal bloom only the *Euglena klebsii* appeared, their number decreased to only a few individuals by August—September.

Pyrrophyta

1971	1	2	3	4	5	Keleti-Bozót
9th June	1					
6th July			1	1		
10th August				1		
29th August				2	1	
14th September	1	1	1	1	1	
12th October	2	3	1	1	1	
21st October	1		2		2	

The Mallomonas species appeared in the samples from July, whereas none of them were found during the bloom of Anabaena during September. They reappeared in October.

Larger numbers of *Peridinium sp.* are significant at the end of August, September and October. The highest number of individuals was found just during the Anabaena bloom.

Chrysophyta

1971	1	2	3	4	5	Keleti-Bozót
13th May			11			
25th May	12	8	4	2	8	4
9th June	14	10	8	10	10	5
23rd June	12	12	10	15	13	
6th July	11	12	11	13	13	8
10th August	6	5	4	4	7	1
29th August	2	6	3	3	9	
14th September		3	4	1	6	
12th October	8	6	7	4	4	
21st October	7	5	8	5	5	

The majority of species are beta-mesosaprobic. Among the 3 classes of this phylum, 2 species of Xantophyceae *(Botryococcus braunii* and *Tetrakentron*

TABLE VII

The phytoplankton data of fish-pond No. 1 of Fonyódliget between 13th May, 1971 and 21st October, 1971

Symbols: 1—5 places of sampling in the pond; KB = Keleti-Bozót; e = appears; k = low number of individuals; g = frequently occurs; s = numerous; t = mass, algal bloom; β-m = beta-mesosaprobionts; ehl = euryhaline.

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
CYANOPHYTA								
1. *Anabaena scheremetievi*	9th June					e		
ELENKIN	6th July	k	k	k	k	k		
	10th Aug	s	s	s	s	s		
	29th Aug	s	s	s	s	s		β—m
	14th Sept	t	t	t	t	t		
	12th Oct	g	k	k	k	k		
	21st Oct	k	k	k	k	k		
2. *A. spiroides* KLEB.	13th May			e				
	9th June			e		e		
	23rd June	k			k	k		
	6th July				k	k		
	10th Aug		k	k	k	k		β—m
	29th Aug				k			
	12th Oct	k						
3. *Aphanizomenon flos-*	9th June	k	k	k	k			
-aquae var. *klebahnii*	23rd June	k	k	k	k			
ELENKIN	6th July	k	k	k	k	k		β—m
	10th Aug		k					ehl
	29th Aug				k	k		
	14th Sept			k		k		
	12th Oct	g	k	k				
	21st Oct	k	k		k	k		
4. *Aphanocapsa delica-*	25th May	k	k	k				
tissima W. et G. S.	9th June	k	k		k	k		
WEST	23rd June	s	k	k	k	k		
	6th July	s	k	k	s	k		
	10th Aug	k	k		s	s		
	29th Aug	s	k	k	s	s		
	14th Sept	g	s	s	g	s		
	12th Oct	k	k	k	k	g		
	21st Oct	k	k	k	k	k		
5. *A. elachista* W. et	25th May				k			
G. S. WEST	23rd June	k					k	
	29th Aug				k	s		
6. *Chroococcus*	25th May	k						
limneticus LEMM.	9th June	k	k	k	k	k		
	23rd June	g	k		k	k		
	6th July	k	k	k	k	k		
	10th Aug	k	k	k	k	k		
	29th Aug		k	k	k	k		
	14th Sept	k	k	k		k		
	12th Oct	k	k	k	k			
	21st Oct		k			k		

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
7. *Gomphosphaeria*	9th June	k				k		
lacustris CHOD.	23rd June	k	k		k			
	6th July	k	k	k	k	k		β—m
	10th Aug	k						
8. *Lyngbya limnetica*	25th May	k	k	k	k	g	k	
LEMM.	9th June	k	k		k	k		
	23rd June	k			k	k		
	6th July	k	k	k	k	k		
	10th Aug	k	k		g	k		
	29th Aug	k	k	k	k	k		
	14th Sept	g	k	k	k	k		
	12th Oct	k	k	k				
	21st Oct	k		k		g		
9. *L. martensiana*	13th May			k				
MENEGH.	25th May		k					
	23rd June	k						
	6th July			k				
	10th Aug					k		β—m
	14th Sept	k						
10. *Merismopedia glauca*	6th July				k		k	
(EHR.) NAEG.	10th Aug		k		k			
	29th Aug		k		k	k		ehl
	14th Sept		k	k	k			
	12th Oct	k				k		
11. *Microcystis flos-aquae*	25th May			k				
(WITTROCK)	9th June		k		k			
KIRCHNER	23rd June	k				k		
	6th July	k		k	k	s		β—m
	10th Aug	k	k	s	k	s		ehl
	29th Aug	k	k			s		
	14th Sept	k	g	g	s	g		
	12th Oct	k	k	k	k	k		
12. *Oscillatoria princeps*	23rd June	k						
VAUCHER	12th Oct	k	k	k				
	21st Oct			k	k	k		α—m
13. *Romeria elegans*	6th July			k		k		
(WOLOSZ.) KOCZW.	10th Aug				k			
	29th Aug					k		
	14th Sept				k			
14. *Spirulina laxissima*	29th Aug	k	g		k			
G. S. WEST	14th Sept		k	k	k	k		
	12th Oct	k	k	k	k	k		
Euglenophyta	21st Oct	k		k	k	k		
15. *Euglena ehrenbergii*								
KLEBS	23rd June			e				

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
16. *E. klebsii* (LEMM.) MAINX	23rd June			k		k		
	6th July		k	k	k	k		
	10th Aug			k	k			
	14th Sept		k	k	k	k		
	12th Oct	k		k	k	k		
	21st Oct	k	k	k	k	k		
17. *E. oxyuris* SCHMARDA	23rd June		k					
	6th July		k	k				
18. *Phacus acuminatus* STOKES	25th May		k		k			
	6th July			k				
	21st Oct				k			
19. *P. pseudonordstedtii* POCHM.	25th May		e					
	23rd June	e				e		
	6th July					e		
20. *P. pyrum* (EHR). STEIN.	25th May					k		
	9th June		k	k				
	23rd June	k	k	k		k		
	10th Aug	k						
	12th Oct	k				k		
	21st Oct	k		k	k	k		
PYRROPHYTA Cryptophyceae								
21. *Mallomonas acaroides* PERTY	6th July			k	k			
	10th Aug				k			
	12th Oct		k					
	21st Oct				k	k		
22. *M. tonsurata* TEIL.	29th Aug				k	k		
	12th Oct	k	k					
	21st Oct			k		k		
Dinophyceae								
23. *Peridinium* sp.	9th June	k						
	29th Aug				k			
	14th Sept	k	k	g	k	k		
	12th Oct	k	k	k	k	k		
	21st Oct	k		k		k		
CHRYSOPHYTA Xantophyceae								
24. *Botryococcus braunii* KÜTZ.	9th June	k						
	23rd June				k			
	6th July		k	k	k	k		
	10th Aug			k		k		
25. *Tetrakentron tribulus* GEITLER	9th June					k		
	23rd June	k	k		k			
	6th July		k	k	k	k		
	10th Aug					k		
Chrysophyceae								

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
26. *Amphichrysis compressa* KORCSH.	29th Aug		k			k		
	12th Oct	k	k	k				
	21st Oct	k	k	k		k		
27. *Chromulina* sp.	9th June	e						
	12th Oct			e				
28. *Rhizochrysis limnetica* G. M. SMITH	9th June	k	k	k		k		
	23rd June			k		k		
	6th July	k		k	k	k		
	10th Aug			k	k			
Bacillariophyceae								
29. *Amphora ovalis* KÜTZ.	25th May		e				e	
	9th June	k	k	k				
	23rd June	k	k	k	k	k		
	6th July	k			k	k	k	
	10th Aug	e						
	14th Sept		e					
30. *Anomoeoneis sphaerophora* (KÜTZ) PFITZNER	9th June				e			
	23rd June					e		
	10th Aug					e		
31. *Cocconeis diminuta* PANT.	9th June				e			
32. *C. placentula* EHR.	13th May				k			
	25th May	k					k	
	9th June	k	k	k		k	k	
	23rd June			k	k			
	6th July		k				s	
	21st Oct	k						
33. *Cyclotella meneghiniana* KÜTZ.	25th May	k	k	k		k		
	9th June	k	k	k	k			
	23rd June	k	k	k		k		
	6th July	k	k	k	k	k	k	β—m
	10th Aug	k	k		k			
	29th Aug	k	k	k		k		
	14th Sept					k		
	12th Oct	k	k	k	k			
	21st Oct	k	k	k	k			
34. *C. ocellata* PANT.	9th June						e	
	23rd June				e			
	6th July					e		
35. *Cymatopleura solea* (BRÉB.) W. SMITH	25th May			e				
	23rd June	k	k	k		k		
	6th July	k		k				
	29th Aug	k				k		
	14th Sept		k	k				
	21st Oct	e						

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
36. *C. prostata* (Berk.) Cleve	9th June					k		
	23rd June	k	k	k	k			
	6th July			k			s	
	10th Aug	k	k					
37. *Cymbella cymbiformis* (Kütz.) V. Heurck	9th June				e	e		
	23rd June				e			
	10th Aug		e					
38. *Epithemia sorex* Kütz.	25th May					k		
	23rd June					k		
	6th July				k	k		
	10th Aug	k						
	14th Sept		k		k			
39. *Fragilaria construens* (Ehr.) Grun.	13th May				k			
	25th May	g	g					
	9th June	k	k		k	k	k	
	23rd June	g	k	k	k	k		
	10th Aug	k	k	k	k			
	29th Aug		k		k	k		
	21st Oct			k				
40. *Gomphonema lanceolatum* Ehr.	9th June				e			
41. *Gyrosigma kützingii* (Grun.) Cleve	25th May	k	k	k		k		
	9th June	k	k	k	k			
	23rd June		k		k	k		
	6th July	k	k		k	k		
	10th Aug					k		
	29th Aug				k			
42. *Melosira granulata* (Ehr.) Ralfs	25th May	k						
	9th June	k			k	k		
	23rd June	k	k		k			
	6th July		k	k	k			
	10th Aug	k			k		k	
	29th Aug		k	k		k		
	14th Sept					k		
	21st Oct	k		k		k		
43. *M. granulata* var. *angustissima* Müll.	13th May				k			
	25th May	k						
	9th June							
	14th Sept					k		
	12th Oct	k		k		k		
	21st Oct		k	k	k			
44. *M. granulata* var. *angustissima* f. *spiralis* Müll.	13th May				g			
	9th June	k	k	k		k		
	23rd June	k	k			k		
	6th July	k	k	k	k	k		
	10th Aug		k	k				
	29th Aug		k		k	k		
	14th Sept			k				
	12th Oct	k	k	k		k		
	21st Oct	k		k	k			

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
45. *M. varians* C. A. AG.	13th May				k			
	25th May	k	k			k		
	9th June		k			k		
	23rd June				k			β—m
	6th July				k		k	
	14th Sept		k	k				
46. *Navicula cryptocephala* KÜTZ.	13th May				e			
	25th May						e	
	6th July						e	β—m
	29th Aug					e		
	14th Sept			e				
47. *N. hungarica* var. *capitata* (EHR.) CLEVE	13th May				k			
	25th May		k					
	9th June						k	
	23rd June	k				k		
	14th Sept					k		
48. *Nitzschia acicularis* W. SMITH	13th May				k			
	25th May	k	k	k	k	g		
	9th June	k			k	k		
	23rd June	k	k	k	k	k		β—m
	6th July	k	k	k	k	k	k	
	12th Oct	s	s	s	s	s		
	21st Oct	s	s	s	s	s		
49. *N. sigmoidea* W. SMITH	13th May				k			
	25th May	k						
	9th June	k		k				
	23rd June	k			k	k		
	6th July		k			k		
	29th Aug			k				
	14th Sept					k		
50. *Pinnularia maior* KÜTZ.	25th May	k						
	23rd June				k			
	6th July		k					
	12th Oct	k						
51. *Rhizosolenia longiseta* ZACH.	25th May				k	k		
	9th June	k	k		k	k		
	23rd June			k				
	6th July	k		k	k	k		
	10th Aug					k		
52. *Strauoneis alabamae* HEIDEN	13th May				e			
	25th May	e				e		
	6th July	e						
53. *Stephanodiscus hantzschii* GRUN.	29th Aug					k		
	12th Oct	k	k	k				β—m
	21st Oct					k		

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
54. *Surirella robusta*	25th May						k	
var. *splendida*	9th June	k	k	k				
(EHR.) V. HEURCK	23rd June	k	k		k	k		
	6th July		k			k		
	10th Aug					k		
	29th Aug					k		
55. *S. tenera* GREG.	25th May		k					
	23rd June		k					
	6th July	k						
	10th Aug					k		
56. *Syndera acus* KÜTZ.	6th July		k					
57. *S. acus* var.	13th May					k		
angustissima GRUN.	25th May				k			
	23rd June			k				
	14th Sept					k		
	12th Oct	s	s	s	s	s		
	21th Oct	s	s	s	s	s		
CHLOROPHYTA								
Volvocales								
58. *Chlamydomonas* sp.	9th June					k		
59. *Pandorina morum*	9th.June						k	β—m
BORY								
Chlorococcales								
60. *Actinastrum*	13th May				k			
hantzschii LAGERH.	25th May	k	k	k	k			
	9th June					k		
	29th Aug		k					β—m
	12th Oct	k	k	k		k		
	21st Oct	k		k	k	k		
61 *Ankistrodesmus*	13th May				k			
falcatus (CORDA)	25th May	k	k		k	k	k	
RALFS	9th June		k					
	23rd June		k					
	6th July	k	k				k	β—m
	10th Aug			k	k			
	29th Aug		k			k		
	14th Sept					k		
	12th Oct	g	k		k	k		
	21st Oct		k	g	g	k		
62. *A. falcatus* var.	25th May					e		
acicularis (A.	13th May				e			
BRAUN) G. S. WEST	12th Oct			e				
63. *A. falcatus* var.	9th July					e		
mirabile W. et G. S.								
WEST .								

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
64. *A. lacustris* (Chod.)	25th May		k	k	k	k		
Ostenf.	9th June	k	k	k	k	k		
	23rd June	k		k	k	k		
	6th July	k	k	k	k	k	k	
	12th Oct	k	k					
65. *A. longissimus*	9th June					k		
(Lemm.) Wille	23rd June				k			
	12th Oct	k	k					
66. *Chodatella balatonica* Scherffel	9th June					k		
67. *C. ciliata* (Lagerh.)	9th June	k	k	k	k	k		
Lemm.	23rd June	k		k	k	k		β—m
	6th July			k	k			
	10th Aug		k					
	29th Aug					k		
68. *C. quadriseta* Lemm.	25th May		k		k			
	21st Oct	k						
69. *Coelastrum*	25th May		k	k				
microporum Naeg.	9th June		k	k	k	k		
	23rd June				k			
	6th July			k	k		k	β—m
	10th Aug	k	k		k	k		
	29th Aug	k	k	k	k	k		
	14th Sept	k	k		k	k		
	12th Oct	k		k		k		
	21st Oct	k	k	k	k			
70. *C. sphaericum* Naeg.	9th June	e						
	10th Aug				e			
	29th Aug					e		
71. *Crucigenia*	9th June	k	k		k			
tetrapedia (Kirchn.)	23rd June		k		k	k		
W. et G. S. West	6th July			k		k		β—m
	12th Oct	k				k		
	21st Oct	k	k	k				
72. *Dictyosphaerium*	13th May				k			
pulchellum Wood	9th June	k	k					
	23th June		k		k	k		
	6th July				k	k		β—m
	10th Aug			k				
	12th Oct			k				
	21st Oct			k				
73. *Golenkinia radiata*	9th June	e						
Chod.	23rd June		k					
	6th July			k				
	10th Aug	k	k			k		
	29th Aug	k	k	k	k	k		
	14th Sept				k	k		
	12th Oct		k	k	k	k		
	21st Oct	k	k	k	k	k		

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
74. *Micractinium pusillum* FRESENIUS	10th Aug	k				k		
	10th Aug	k				k		
	14th Sept		k	k	k	k		
	12th Oct		k	k	k	k		
	21st Oct			k	k	k		
75. *Oocystis solitaria* WITTR.	25th May			k				
	9th June		k	k	k	k	k	
	23rd June	k		k	k	k		
	6th July	k	k	k	k	k		
	10th Aug	k						
	29th Aug			k				
	14th Sept						k	
76. *Pediastrum boryanum* (TURPH.) MENEGH.	25th May	k	k					
	9th June	k	k					
	23rd June			k			k	
	6th July	k						β—m
	10th Aug	k	k	k				
	29th Aug		k		k			
	12th Oct	k		k		k		
	21st Oct			k	k	k		
77. *P. boryanum* var. *granulatum* (KÜTZ.) A. BRAUN	13th May				k			
	25th May	k	k	k	k	k	k	
	9th June	k		k	g	g	k	
	23th June	k	k		k	k		
	6th July	k	k	k	k	k		
	10th Aug		k	k	k	k		
	29th Aug			k		k		
	14th Sept	k	k	k	k	k		
	12th Oct		k					
	21st Oct	k	k	k				
78. *Pediastrum simplex*	25th May	k		k	k	k		
	9th June	k	k	k	k	s		
	23rd June	k	k	k	k	k	k	
	6th July	k	k	k	k	k		
	10th Aug	k	k	k	k	k	k	
	29th Aug	k	k	k	k	k		
	14th Sept	k	k	k	k	k		
	12th Oct	k	k	k	k	k		
	21st Oct	k	k	k	k	k		
79. *P. tetras* (EHR.) RALFS	13th May				k			
	9th June	k	k	k	g	k		
	23rd June	k		k	k	k		
	6th July	k	k	k	k	k	k	
	10th Aug	k			k			
	29th Aug	k	k	k	k			
	14th Sept	k				k		
	12th Oct	k	k	k	k	k		
	21st Oct		k	k		k		

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
80. *Scenedesmus acuminatus* (LAGERH.) CHOD.	13th May				g			
	25th May	g	k	k	k	k	k	
	9th June	k	k	k	k	k		
	23rd June	k	k	k	k	k	k	
	6th July			k	k	k	k	
	10th Aug	k				k		
	12th Oct	k	k	k	k	k		
	21st Oct	k	k	k	k	k		
81. *S. carinatus* var. *polycostatus* HORTOB. et NÉMETH	9th June	k	k	g	g			
	23rd June	k	k	g	g	k		
	6th July	k	k	k	k	s		
	10th Aug	k	k	k	k	k		
	29th Aug	k	k	k	k	k		
	14th Sept	k	k	k	k	k		
	12th Oct	s	g	k	k	k		
	21st Oct	k		k	k	k		
82. *S. denticulatus* LAG.	6th July		k					
83. *S. dispar* BRÉB.	9th June			k				
	12th Oct					k		
84. *S. ecornis* (RALFS) CHOD.	23rd June		k		k			
	6th July		k		k	k		
85. *S. ecornis* var. *disciformis* CHOD.	23rd June		k					
	21st Oct		k					
86. *S. ellipsoideus* CHOD.	23rd June			k		k		
87. *S. intermedius* CHOD.	9th June	k	k	k	k			
	23rd June	k		k	k	k		
	6th July			k	k	k	k	
	10th Aug		k		k	k		β—m
	29th Aug					k		
	14th Sept		k	k				
	12th Oct	k	k	k		k		
	21st Oct	k		k				
88. *S. quadricauda* (TURP.) BRÉB.	13th May				s			
	25th May	s	k	k		s	k	
	9th June	s	k	s	s	s	k	
	23rd June	s	s	s	s	s	k	
	6th July	s	s	s	s	s	k	β—m
	10th Aug	s	k	k	s	s		
	29th Aug	s	s	s	k	s		
	14th Sept	s	s	s	k	s		
	12th Oct	s	s	s	s	s		
	21th Oct	s	s	s	s	s		
89. *S. quadricauda* var. *biornata* KISS	25th May	k						
	9th June		s	k		s		
	23rd June		k					
	6th July		k		k	k		
	10th Aug	k	k	k	k			
	29th Aug	k	k		k	k		
	14th Sept					k		
	12th Oct	k			k	g		
	21st Oct	g			g			

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
90. *Scenedesmus quadricauda* var. *biornata* f. *gigantica* UHERKOV.	9th June	g	s	g	g	s		
	23rd June	g	g	g	g	g		
	6th July	k	k	k	k	s	k	
	10th Aug	k	k	k		k		
	29th Aug	k	k	k	k	k		
	14th Sept	k	k	k	k	k		
	12th Oct	k	k	k	k	g		
	21st Oct	g	k	k				
91. *S. quadricauda* var. *longispina* (CHOD.) G. M. SMITH	13th May				s			
	25th May	s	k	k	s	g		
	9th June	s	k	s	s	s	k	
	23th June	s	s	s	s	s	k	
	6th July	s	s	s	s	s	k	
	10th Aug	k	k	k	s	s		
	29th Aug	ss	s	k		s		
	14th Sept	s	k	g	k	k		
	12th Oct	s	s	g	k	k		
	21st Oct	k	k	k		k		
92. *S. pannonicus* HORTOB.	9th June	k	k					
	23rd June	k	k			k		
	26th July			k	k	k		
	29th Aug		k			k		
93. *S. spinosus* CHOD.	13th May				s			
	25th May	k	g		k	s		
	9th June	k	s	k	k	g	k	
	23rd June	g		g	s	k		
	6th July	k	k	g		k		β—m
	10th Aug	k				k		
	29th Aug				k			
	14th Sept	k						
	12th Oct			k	k	k		
	21st Oct	k		k	k	k		
94. *Selenastrum gracile* REINSCH	9th June					k		
	6th July				k		k	
	29th Aug	k						
	14th Sept	k	k	k				
95. *Tetraedron caudatum* var. *incisum.* LAGERH.	13th May				k			
	25th May	k	k	k	k	g		
	9th June	k	g	k	g	k		
	23rd June	g	k	k	k	g		
	6th July	k	k	k	g	k		
	10th Aug		k	k	k	k		
	29th Aug	k	k		k	k		
	14th Sept	k		k				
	12th Oct	k		k	k	k		
	21st Oct	k	k	k		k		
96. *T. cruciatum* (WALLICH) W. et G. S. WEST	9th May	k	k					
	10th Aug			k				

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
97. *T. hastatum* var. *palatinum* LEMM.	9th June		k	k	k			
	23rd June	k	k					
	6th July	k	k	k				
	10th Aug	k	k	k				
	29th Aug	k	k					
	14th Sept			k				
	21st Oct		k					
98. *T. minimum* (A. BRAUN) HANSG.	13th May				g			
	25th May	k	k	k		k		
	9th June	k	g	k	s	k	k	
	23rd June	g	k	k	k	g		
	6th July	k	k	k	g	g	k	
	10th Aug	k	k	k	k	k		
	29th Aug	k	k	k	k	k		
	14th Sept	k	k	k	k	k		
	12th Oct	k	k	k	k	k		
	21st Oct	k	k	k	k			
99. *T. muticum* (A. BRAUN) HANSG.	9th June	k	k			k		
	23rd June	k	k	k	k	k		
	6th July	k		k	k	k		
	10th Aug		k		k			
	12th Oct					k		
	21st Oct	k		k	k			
100. *Tetraedron proteiforme* (TURNER) BRUNNTH.	9th June					e		
101. *T. regulare* KÜTZ.	13th May				k			
	9th June	k		k	k	k		
	23rd June	k	k	k		k		
	10th Aug	k	k					
	29th Aug		k		k	k		
	14th Sept				k	k		
	12th Oct	k	k	k		k		
	21st Oct		k		k	k		
102. *Tetrastrum heteracanthum* (NORDST.) CHOD.	25th May		k			k		
103. *T. staurogeniaeforme* (SCHROED.) LEMM.	13th May				k			
	9th June	k	k	g	k	k	k	
	23rd June	k		k		k		
	6th July	k	k	k	k	k		β-m
	29th Aug					k		
	12th Oct	k	k	k	k			
	21st Oct	k	k	k	k	k		
104. *Treubaria triappendiculata* BERN.	9th June	k	k	k	k	k		
	23rd June	k		k	k	k		
	6th July	k		k	k	k		
	10th Aug	k				k		
	29th Aug			k				
	12th Oct		k	k				
Zygnematales	13th May				k			

TABLE VII *(continued)*

Species	Date of sampling	1.	2.	3.	4.	5.	KB	Note
105. *Closterium acerosum* var. *elongatum* Bréb.	12th Oct	k		k				
106. *Cosmarium* sp. (I.)	25th May					k		
	9th June	k			k	k		
	23rd June	k	k		k	k		
	6th July	k	k		k	k		
107. *Cosmarium* sp. (II.)	9th June	k		k	k	k		
	23rd June				k			
	6th July				k	k		
108. *Cosmarium* sp. (III.)	6th July					k		
	10th Aug	k						
	29th Aug	k	k					
109. *Staurastrum furcigerum* Bréb.	25th May					k		
	9th June					k		
	23rd June			k		k		
	6th July	k	k	k	k	k		
	10th July		k					
110. *S. gracile* Ralfs	9th June					k		
	29th Aug				k			
	14th Sept	k				k		
	12th Oct					k		
	21st Oct		k					
111. *S. paradoxum* Meyen	25th May		k		k			
	9th June	k	k	k		k		
	23rd June	k	k	k	k	k		
	6th July	k	k	k	k			
	10th Aug.					k		
	29th Aug					k		
112. *Spirogyra* sp. (I.)	13th May				g			
	9th June		k		k	k		
113. *Spirogyra* sp. (II.)	13th May				k			
	9th June		k			k	k	
	25th June						k	
Mycophyta								
114. *Planktomyces békefii* Gimesi	13th May				k			
	10th Aug	k						
	12th Oct				k			
	21st Oct		k			k		

tribulus) occurred and reached a higher number of individuals during July—August. None of them were found before and after the end of August.

Among the 3 representatives of Chrysophyceae, *Rhizochrysis limnetica* was very frequent during June beginning of August. During the blue-green algal bloom it disappeared from the samples. *Amphychrysis compressa* occurred in the samples of August. It be came rare during the intense Anabaena bloom in September and was again frequent in the samples of places No. 1, 2 and 3 in October.

Pelagic, benthic and epiphytic species appeared among the species of Bacillariophyceae. The pelagic *Melosira granulata* and its variant as well as its spirale form were present from May till the end of October, their number significantly decreased during the Anabaena bloom, whereas later on many empty shells were found. In the October samples the variant and the spiral form reached a higher number of individuals. The *Cyclotella meneghiniana* was very frequent in all samples except the period of algal bloom in September. The individuals of *Fragilaria construens* floating in forms of ribbon and the fragile *Rhizosolenia longiseta* reached their highest frequency from May till the beginning of August, during the algal bloom they occurred only sporadically. After the mass appearance of blue-green algae none of them were found again.

The *Nitzschia acicularis* and *Synedra acus* var. *angustissima* were of rather high frequency from May till June. None of them were found during July and August, whereas their number abruptly increased by October at all 5 places of sampling.

Stephanodiscus hantzschii preferring strongly eutrophic waters appeared in masses after the Anabaena bloom in October.

Chlorophyta

1971	1	2	3	4	5	Keleti-Bozót
13th May			17			
25th May	12	15	11	12	14	4
9th June	28	29	24	23	34	10
23rd June	23	22	22	25	25	6
6th July	21	22	25	27	27	11
10th August	19	18	13	15	14	
29th August	15	19	12	14	18	
14th September	13	11	12	11	15	
12th October	21	19	22	15	23	
21st Oct.	19	18	22	16	15	

The 56 species of green algae found in the samples can be divided into 3 groups according to their frequency, similarly as the diatoms:

1. Those occurring in all samples and showing often a high number of individuals, e.g. *Coelastrum microporum*, *Pediastrum* species, *Scenedesmus quadricauda* and its variants and forms, *Tetraedron* species. These were not influenced by the Anabaena bloom.

2. Those influenced strongly by the blue algal bloom, their number of individuals decreased to be sporadic during August—September. Their number is higher before and after the algal bloom, e.g. *Scenedesmus spinosus*, *Tetrastrum staurogeniaeforme*, *Treubaria triappendiculata*.

3. Two subgroups can be distinguished: *a)* Significant number of individuals during May—June—July, i.e. before the Anabaena bloom, e.g. *Ankistrodesmus lacustris*, *Chodatella ciliata*, *Oocystis solitaria*, *Staurastrum*

furcigerum and *S. paradoxum*. *b)* Higher number of individuals appear just during and after the Anabaena bloom, e.g. *Golenkinia radiata*, *Micractinium pusillum*.

Mycophyta

1971	1	2	3	4	5	Keleti-Bozót
10th August	1					
29th August		1				
14th September				1		
21st October	1				1	

The *Planctomyces békefii* was of higher frequency before and after the Anabaena bloom in the plankton of the pond.

The total number of algal species in the pond and the canal shows the following distribution:

1971	1	2	3	4	5	Keleti-Bozót
13th May			30			
25th May	27	28	18	17	24	9
9th June	48	45	36	38	50	15
23rd June	47	40	37	46	46	7
6th July	39	42	49	51	50	20
10th August	33	31	22	29	28	1
29th August	22	32	19	28	37	
14th Sept.	20	23	26	22	30	
12th Oct.	43	36	39	26	33	
21st Oct.	35	30	40	30	32	

The percentual distribution of the algal phyla according to their number of individuals in the pond No. 1 on the basis of the samples of May—October, was as follows:

13th May

Cyanophyta	5%
Chrysophyta	15%
Chlorophyta	80%
	100%

25th May

Cyanophyta	10%
Euglenophyta	4%
Chrysophyta	26%
Chlorophyta	60%
	100%

9th June

Cyanophyta	15%
Euglenophyta	5%
Pyrrophyta	1%
Chrysophyta	19%
Chlorophyta	60%
	100%

23rd June

Cyanophyta	12%
Euglenophyta	8%
Chrysophyta	20%
Chlorophyta	60%
	100%

9th July

Cyanophyta	12%
Euglenophyta	5%
Pyrrophyta	3%
Chrysophyta	20%
Chlorophyta	60%
	100%

10th August	
Cyanophyta	30%
Euglenophyta	2%
Pyrrophyta	2%
Chrysophyta	25%
Chlorophyta	40%
Mycophyta	1%
	100%

29th August	
Cyanophyta	50%
Pyrrophyta	5%
Chrysophyta	14%
Chlorophyta	30%
Mycophyta	1%
	100%

14th September	
Cyanophyta	60%
Euglenophyta	3%
Pyrrophyta	3%
Chrysophyta	10%
Chlorophyta	23%
Mycophyta	1%
	100%

12th October	
Cyanophyta	20%
Euglenophyta	5%
Pyrrophyta	5%
Chrysophyta	35%
Chlorophyta	35%
	100%

21st October	
Cyanophyta	20%
Euglenophyta	5%
Pyrrophyta	4%
Chrysophyta	30%
Chlorophyta	40%
Mycophyta	1%
	100%

4. *The change of biomass and percentual composition of the zooplankton during the periods of investigations*

a) Rotatoria plankton

The average volume of 9 predominating Rotatoria species was calculated by multiplication of measures of length, width and thickness.

Brachionus calyciflorus	10 688 986 μ^3
Brachionus diversicornis	3 696 491 μ^3
Anuraeopsis fissa	138 727 μ^3
Epiphanes macrourus	2 153 005 μ^3
Brachionus angularis	1 213 946 μ^3
B. calyciflorus amphiceros	2 997 164 μ^3
Proalides tentaculatus	131 604 μ^3
Pedalia mira	943 622 μ^3
Asplanchna sieboldi	100 737 294 μ^3

Considering the volume values determined by SEBESTYÉN, the average value of the volume of one Rotatoria individual (except Asplanchna) amounts to 1 622 444 μ^3. Including the Asplanchna, this value would be above 7 millions which is wholly unreal. Therefore, we used the former value for the calculations of the biomass.

The Rotatoria biomass shows various distribution within the transversal section both in space and time *(Tables VIII* and *IX)*. The lowest value were always obtained at the inflow except in a few cases (6th July, 29th August and 12th October).

13th May: The predominant species are identical both qualitatively and in quantitative rates at the places of sampling No. 2–5. At point No. 1, *Conochilus unicornis* was substituted by *Brachionus quadridentatus*. Predominant species: *Keratella cochlearis*, *Pompholyx sulcata*, *Keratella tecta*, *Conochilus unicornis*, *Brachionus angularis*, *Brachionus quadridentatus*.

TABLE VIII

The distribution of the Rotatoria biomass (g/m³) in pond No. 1 in 1971

Date of sampling	Points of sampling				
	1	2	3	4	5
13th May	0.400	1.019	1.173	1.055	0.832
25th May	1.537	3.682	3.169	3.432	3.179
9th June	0.270	0.295	0.410	0.280	0.338
23th June	0.165	0.166	0.253	0.209	0.231
6th July	0.534	0.469	0.491	0.342	0.317
10th Aug	0.372	0.507	0.460	0.303	0.776
29th Aug	1.598	0.928	1.112	0.837	0.741
14th Sept	0.830	1.025	0.886	1.046	1.120
12th Oct	0.393	0.407	0.417	0.350	0.196
21st Oct	0.165	0.233	0.183	0.170	0.194

TABLE IX

Changes of the quantitative section of pond No. 1 during in 1971
(individuals per litre)

Points of sampling	Date of sampling									
	13. V.	25. V.	9. VI.	23. VI.	6. VII.	10. VIII.	29. VIII.	14. IX.	12. X.	21. X.
1.	2408	9 241	1624	991	3209	2237	9610	4991	2361	990
2.	6127	22 143	1776	998	2818	3050	5580	6167	2450	1403
3.	7055	19 115	2464	1524	2953	2767	6685	5331	2508	1099
4.	6344	20 638	1684	1260	2056	1823	5031	6288	2106	1022
5.	5004	19 119	2034	1392	1908	4664	4457	6737	1181	1167

25th May: The predominant species are identical on all the 5 places of sampling. Their quantitative distribution shows identical rates on points No. 2—5 and differs only on No. 1. Predominant species: *Pompholyx sulcata, Brachionus diversicornis, Keratella tecta, Brachionus calyciflorus dorcas, Keratella quadrata.*

The horizontal distribution of the predominant species was roughly uniform on the whole area of the pond in those two times of sampling.

19th June: Only two predominant species are common in all places of sampling *(Keratella tecta, Pompholyx sulcata)*. Further predominant species: *Filina longiseta, Brachionus angularis, Brachionus quadridentatus, Brachionus diversicornis, Keratella quadrata.*

23rd June: Four of the 5 predominant species appeared at all 5 points of sampling. The quantitative rates of the predominant species, however, strongly varied. Predominant species: *Keratella tecta, Pompholyx sulcata, Brachionus angularis, Polyarthra vulgaris, Filina longiseta, Keratella cochlearis, Brachionus calyciflorus dorcas, Trichocerca pusilla.*

6th July: Polyarthra vulgaris and *Pompholyx sulcata* occurred in the highest rates at points No. 1, 2 and 3, whereas at No. 4 and 5, *Keratella tecta* and *Brachionus angularis* represented the largest mass. The predominant species were qualitatively identical on places No. 3, 4 and 5, however, their rates were different to each other. Predominant species: *Pompholyx sulcata, Polyarthra vulgaris, Keratella tecta, Brachionus angularis, Filinia longiseta, Keratella cochlearis.* The last one was represented by its subspecies, *K. c. macracantha* on places No. 1 and 2. Apart from the predominant species listed above, the *Brachionus budapestinensis* also appeared. At point No. 2, *Keratella quadrata* predominated instead of *K. cochlearis.*

10th August: Among the predominating species, the first place was occupied by *Filina longiseta* at all sampling points, its number of individuals varied between 1073—1846 per litre. Apart from it, 5 species were found occurring at least at 4 points in predominant quantities: *Brachionus calyciflorus amphiceros, Keratella tecta, Anuraeopsis fissa, Proalides tentaculatus, Polyarthra vulgaris.* From the last two the former and latter were absent at points No. 2 and 1, respectively. Other predominant species: *Trichocerca pusilla* in places No. 1, 2, 4 and 5; *Brachionus calyciflorus anuraeiformis* at points No. 2, 4 and 5; *Brachionus angularis* at points No. 4 and 5; *Brachionus budapestinensis* at point No. 2; *Pedalia mira* at No. 3; a *Bdelloidea sp.* and *Asplanchna sieboldi* at No. 5.

29th August: The highest number of individuals was yielded by *Epiphanes macrourus* (2034—2599 per litre) at points No. 2—5. The number of predominant species amounts to 8 *(Epiphanes macrourus, Polyarthra vulgaris, Anuraeopsis fissa, Keratella tecta, Filinia longiseta, Keratella cochlearis, Pedalia mira, Proalides tentaculatus).* Five of them occurred at all 5 points of sampling, two of them *(Keratella cochlearis* and *Proalides tentaculatus)* were absent from points No. 4, and 1, and so was *Pedalia mira* from No. 1 and 2. On this basis the pond can be regarded as uniform in the period of investigation. Wide quantitative differences occurred, however, just in this period (the total number of individuals per litre was almost twice as high at point No. 1 than at the others).

14th September: Among the predominant species, the quantitative rates of *Anuraeopsis fissa* and *Keratella tecta* were nearly identical at the sampling point of the transversal section. The number of predominant species was 10 *(Anuraeopsis fissa, Keratella tecta, Polyarthra vulgaris, Filinia longiseta, Epiphanes macrourus, Keratella cochlearis, Brachionus calyciflorus amphiceros, Brachionus angularis, Chromogaster ovalis, Proalides tentaculatus);* 6 were common at all points of sampling, *Brachionus calyciflorus amphiceros* was absent at point No. 2, and so was *Brachionus angularis* at No. 1 and 3. Chromogaster and Proalides were present in a dominant quantity only at point No. 5.

12th October: The number of predominating species decreased to 5, and to 3 at point No. 1. The transversal section can be regarded as uniform from the view point of the composition of the qualitative Rotatoria plankton. Predominant species: *Polyarthra vulgaris, Brachionus angularis, Brachionus calyciflorus amphiceros, Keratella tecta, Keratella cochlearis.*

21st October: The number of predominating species was 3 and 2 at point No. 1. As regards the qualitative composition of Rotatoria plankton, the 5 sampling point were identical. The quantitative relationships were balanced. Predominant species: *Brachionus angularis, Brachionus calyciflorus amphiceros, Polyarthra vulgaris.*

The number of species encountered during the whole investigation was 62.

1. *Asplanchna amphora* WESTERN
2. *Asplanchna brightwelli* GOSSE
3. *Asplanchna girodi* DE GUERNE
4. *Asplanchna sieboldi* (LEYDIG)
5. *Anuraeopsis fissa* (GOSSE)
6. *Bdelloidea* sp.
7. *Brachionus angularis* GOSSE
8. *Brachionus budapestinensis* DADAY
9. *Brachionus calyciflorus calyciflorus* PALLAS
10. *Brachionus calyciflorus anuraeiformis* BREHM
11. *Brachionus calyciflorus amphiceros* (EHRBG)
12. *Brachionus calyciflorus dorcas* BREHM
13. *Brachionus calyciflorus dorcas spinosa* (WIERZEJSKI)
14. *Brachionus diversicornis diversicornis* (DADAY)
15. *Brachionus leydigi* COHN
16. *Brachionus plicatilis* MÜLLER
17. *Brachionus rubens* EHRENBERG
18. *Brachionus quadridentatus* HERMANN
19. *Brachionus quadridentatus ancylognathus* SCHMARDA
20. *Brachionus quadridentatus brevispinus* EHRENBERG
21. *Brachionus quadridentatus cluniorbicularis* SKORIKOV
22. *Brachionus quadridentatus rectangularis* (LUCKS)
23. *Brachionus quadridentatus rhenanus* (LAUTERBORN)
24. *Cephalodella gibba* (EHRBG)
25. *Chromogaster ovalis* (BERGENDAL)
26. *Colurella adriatica* (EHRBG)
27. *Colurella colurus* (EHRBG)
28. *Colurella obtusa* (GOSSE)
29. *Colurella obtusa aperta* HANER
30. *Collotheca* sp.
31. *Conochilus unicornis* ROUSSELET
32. *Euchlanis deflexa* (GOSSE)
33. *Euchlanis dilatata lucksiana* HAUER
34. *Epiphanes macrourus* BARROIS & DADAY
35. *Filinia longiseta* (EHRENBERG)
36. *Keratella cochlearis* GOSSE
37. *Keratella cochlearis macracantha* LAUTERBORN
38. *Keratella cochlearis macracantha micracantha* LAUTERBORN
39. *Keratella tecta* GOSSE
40. *Keratella quadrata* MÜLLER
41. *Lecane bulla* GOSSE
42. *Lecane closterocerca* SCHMERDA
43. *Lecane hamata* STOKES
44. *Lecane lunaris* (EHRBG)
45. *Lecane stenroosi* MEISSNER
46. *Lepadella ovalis* MÜLLER
47. *Lepadella patella* MÜLLER
48. *Lophocaris salpina* (EHRBG)
49. *Monommata longiseta* MÜLLER
50. *Mytilina mucronata* MÜLLER
51. *Pedalia mira* HUDSON
52. *Platyias quadricornis* (EHRENBERG)
53. *Philodina* sp.
54. *Polyarthra vulgaris* CARLIN
55. *Pompholyx sulcata* HUDSON
56. *Proalides tentaculatus* DE BEAUCHAMP
57. *Proales* sp.
58. *Rotatoria* sp.
59. *Trichocerca dixon-nuttalli* JENNINGS
60. *Trichocerca pusilla* JENNINGS
61. *Trichocerca stylata* GOSSE
62. *Trichotria pocillum* MÜLLER

Considering the whole period of investigations, we may state the following.

1. The characteristic species of the open water plankton such as *Keratella cochlearis*, *Pompholyx sulcata*, *Keratella tecta*, *Keratella quadrata* predominating at the beginning of May, completely disappear by August, and are not found in significant quantities even later.

2. The appearance of *Pompholyx sulcata* in the water indicates a temperature of about 20° C and contamination. Its disappearance by August cannot be explained by the change in temperature but can be connected only with the increase of pollution. This is also proved by the occurrence of this species in Lake Balaton (it is absent in the Keszthely Bay, Zánkai and Ponyi, 1970; 1972).

3. *Filinia longiseta* is of a cold stenothermic character in Lake Balaton, whereas in the pond investigated it grows better at higher temperatures.

b) Crustacean plankton

The changes of the Crustacean biomass show a uniform pattern in the pond. The development of Cladocera mass results in a maximum at the early

TABLE X

Quantitative changes of biomass of the Crustacea-plankton in the transversal section of pond No. 1 (the values are in g/m³) in 1971

Date of sampling	Groups of crabs	Points of sampling					
		1.	2.	3.	4.	5.	KB
	Cladocera	0.092	0.060	0.140	0.088	0.098	—
13th May	Copepoda	0.129	0.220	0.494	0.215	0.179	—
	Total Crustacea	0.221	0.280	0.634	0.303	0.277	—
	Cladocera	0.252	1.266	0.870	0.630	0.860	—
25th May	Copepoda	0.320	0.340	0.423	0.562	0.354	—
	Total Crustacea	0.572	1.606	1.293	1.192	1.214	—
	Cladocera	4.466	4.450	5.066	3.140	1.910	0.674
9th June	Copepoda	0.579	0.453	0.497	0.845	0.293	0.229
	Total Crustacea	5.045	4.903	5.563	3.985	2.203	0.903
	Cladocera	2.130	1.684	3.526	4.244	3.956	0.164
23rd June	Copepoda	0.212	0.439	0.442	0.577	0.599	0.041
	Total Crustacea	2.342	2.123	3.968	4.821	4.545	0.205
	Cladocera	0.400	4.110	1.730	2.097	1.140	0.166
6th July	Copepoda	0.221	0.472	0.437	0.105	0.343	0.021
	Total Crustacea	0.621	4.582	2.167	2.202	1.483	0.187
	Cladocera	0.060	0.064	0.036	0.054	0.010	—
10th Aug	Copepoda	0.189	0.283	0.323	0.291	0.314	—
	Total Crustacea	0.249	0.347	0.359	0.345	0.324	—
	Cladocera	0.024	0.030	0.026	0.001	0.010	—
29th Aug	Copepoda	0.280	0.184	0.164	0.098	0.084	—
	Total Crustacea	0.304	0.214	0.190	0.099	0.094	—
	Cladocera	0.006	0.006	0.016	0.010	0.004	—
14th Sept	Copepoda	0.121	0.116	0.112	0.117	0.040	—
	Total Crustacea	0.127	0.122	0.128	0.127	0.044	—
	Cladocera	0.006	0.002	—	—	—	—
12th Oct	Copepoda	0.026	0.045	0.065	0.036	0.045	—
	Total Crustacea	0.032	0.047	0.065	0.036	0.045	—
	Cladocera	0.014	0.004	0.006	0.002	0.008	—
21st Oct	Copepoda	0.094	0.043	0.079	0.090	0.058	—
	Total Crustacea	0.108	0.047	0.085	0.092	0.066	—

summer (about 4 g per m^3) and abruptly decreases by August. Later on its amount is minimal *(Fig. 2, Table X)*. The Copepoda biomass is much lower (0.2—0.5 g per m^3) during spring and early summer seasons than that of Cladocera, however, from August when the biomass of Cladocera is insignificant, that of Copepoda is considerable.

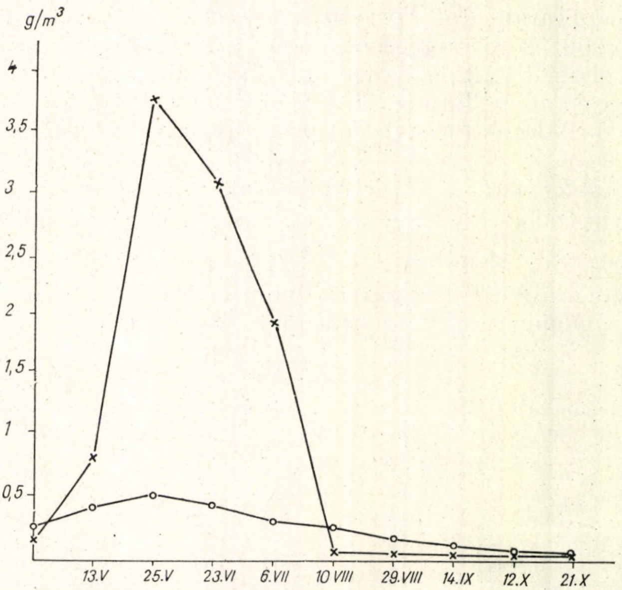

Fig. 2. The change of biomass of Cladocera and Copepoda in the whole section of investigation. x—x—x Cladocera; o—o—o Copepoda

The Cladocera biomass consists practically of *Bosmina longirostris* and *Chydorus sphaericus (Table IX)*. The rare occurrence of *Daphnia hyalina* (and generally the species of *Daphnia)* is connected with the fact that these animals possessing a fine filtering apparatus hardly at all, or can not live in waters rich in corpuscular organic substances (moorish waters). Their filtering apparatus becomes clogged and consequently they die.

The biomass of Copepoda is composed essentially of *Acanthocyclops vernalis* and *Cyclops vicinus (Table XI)*. Both species possess a high ecological tolerance. The former is expressis verbis carnivorous (feeds on small larvae of water insects and worms), whereas the latter lives on the smaller members of the plankton (algae, Rotatoria) as well as on other plant fragments.

During the investigations 18 Cladocera, 6 Ostracoda and 7 Copepoda species, varieties and forms were identified *(Table XII)*.

TABLE XI

The seasonal occurrence of the planktonic Crustacea species in pond No. 1

Species	13. V.	25. V.	9. VI.	23. VI.	6. VII.	10. VIII.	29. VIII.	14. IX.	12. X.	21. X.
Cladocera										
Daphnia hyalina var. *lacustris* SARS	+	+	+++	++						
Simocephalus vetulus (O. F. MÜLLER)										
Ceriodaphnia pulchella SARS			+	+		++				
Moina rectirostris (LEYDIG)							+			
Scapholeberis kingi SARS	+	+								
Macrothrix laticornis (JURINE)										
Ilyocryptus sordidus LIÉVIN										
Ilyocryptus agilis KURZ			+							
Leydigia leydigii (LEYDIG)										+
Leydigia acanthocercoides (FISCHER)									+	
Chydorus sphaericus (O. F. MÜLLER)	+++	++++	++++	++	+			+	+	
Pleuroxus trigonellus (O. F. MÜLLER)										
Alona affinis LEYDIG										
Alona quadrangularis (O. F. MÜLLER)										
Alona guttata SARS		+								
Alona rectangula rectangula SARS		+	+							
Bosmina longirostris f. *cornuta* JURINE	+++	++++	++++	++++	++++	++	+	+	+	+
Bosmina longirostris f. *curvirostris* FISCHER										+
Copepoda										
Macrocyclops albidus (JURINE)								+		
Paracyclops fimbriatus (FISCHER)										
Cyclops vicinus ULJANIN	++++	++	++		+		+	+	+	++
Acanthocyclops vernalis (FISCHER)	+	++	++	++	+	++	+	+	+	
Thermocyclops crassus (FISCHER)	+	++		+			+			
Cyclops sp. copepodid stadium	++	+++	+++	+++	+++	++	++	++	+	
Cyclops nauplius	++++	++	++++	+++	++	++	+	+	++	+++

Explanation: Mass ++++; Numerous +++; Little ++; Sporadic +

TABLE XII

The occurrence of Crustacea species in pond No. 1 and in the canal Keleti-Bozót in 1971

Species	Pond No. 1		Keleti-Bozót
	plankton	mud	
Cladocera			
Bosmina longirostris f. *cornuta*	+	+	+
Bosmina longirostris f. *curvirostris*	+		
Chydorus sphaericus	+	+	+
Pleuroxus trigonellus			+
Macrotrix laticornis		+	
Ilyocryptus sordidus		+	
Ilyocryptus agilis	+	+	
Scapholeberis kingi	+		
Cladocera			
Ceriodaphnia pulchella	+		
Daphnia hyalina var. *lacustris*	+		
Simocephalus vetulus	+		+
Moina rectirostris	+		
Alona guttata	+		
Alona rectangula	+	+	
Alona affinis	+	+	+
Alona quadrangularis	+	+	+
Leydigia leydigii	+	+	+
Leydigia acanthocercoides	+	+	
Ostracoda			
Lymnocythere inopinata		+	
Cyclocypris laevis	+	+	+
Cypridopsis vidua		+	
Cyclocypris ovum		+	
Cypria ophtalmica	+	+	
Darwinula stevensoni		+	
Copepoda			
Macrocyclops albidus	+		
Cyclops vicinus	+		
Acanthocyclops vernalis	+		
Thermocyclops crassus	+		
Paracyclops fimbriatus		+	+
Eucyclops serrulatus			+
Nitocra hibernica			+

5. *Changes of the dissolved* O_2 *in the transversal section of pond No. 1*

The measurements of oxygen concentrations carried out 10 times *(Fig. 3)* revealed that the values were more or less different at the points of sampling at the same time. As a rule, higher values were obtained in the central regions while near the shore they were lower. The oxygen concentration of point No. 1 (at the inflow) showed significant differences 3 times (23rd June, 29th August and 15th September) as compared to the other place near the shore, i.e. No. 5.

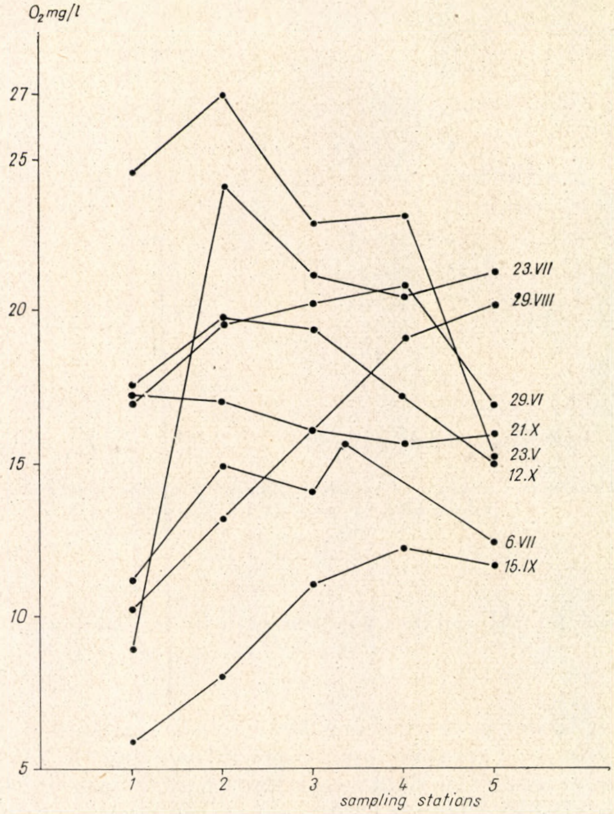

Fig. 3. The quantities of the oxygen dissolved in the water at the places of sampling of pond No. 1

The values were 9, 10 and 6 at point No. 1, respectively, whereas at the other place 21, 20 and 12 mg/litre, i.e. just twice as high. The difference is presumably due to the effect of the inflowing sewage-water.

The data of *Fig. 3* indicate that the oxygen concentration of the water is of decreasing tendency from May till September and it increases again only from October. At the beginning of May, the average O_2 concentration was 36 mg/litre, whereas at the end of May and in June it amounted to 19—22 mg/l. During July, August and September, the average value varied between 10—15 mg/l. It increased again to reach the early summer value during October.

On the 6th July and 29th August the oxygen content analyzed throughout a day (24 hr). It was found that in the middle of the pond (point No. 3) the oxygen supply was sufficient for the fishes even in the "critical" period of early morning, however, at the point of inflow it is so low in August (1 mg/l) to be insufficient for them *(Fig. 4)*. Furthermore, the oxygen supply is better generally in the middle of the pond than near the shore. Similar observations were made in other fish-ponds by HANNAN and ANDERSON (1971).

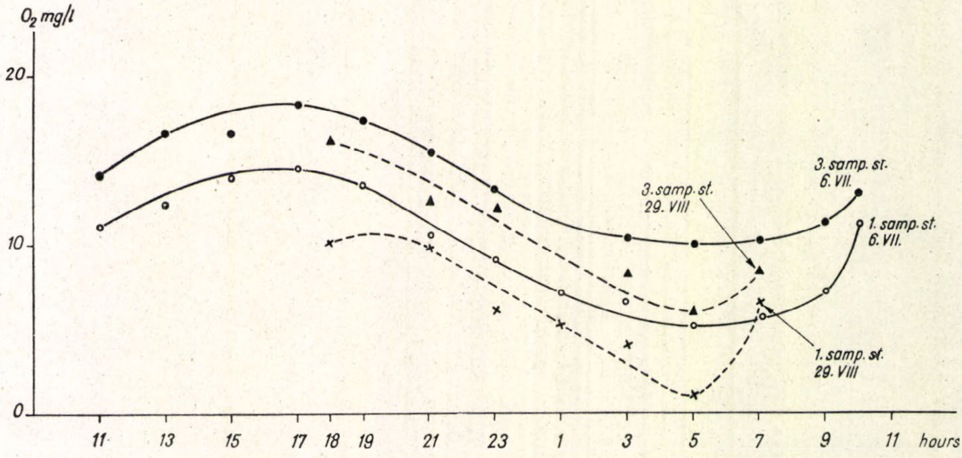

Fig. 4. The quantitative change of oxygen dissolved in the water during 24 hr at two points (No. 1 and 3) of pond No. 1

6. *Some reasons for the changes in biomasses of the more important groups of plankton*

According to our investigations, the bacteria, algae, Rotatoria, Crustacea represent the groups of greatest importance influencing the planktonic biomass to the highest extent. The data regarding the biomass of those groups are summarized in *Table XIII*.

In the beginning of May, the biomass is composed in a nearly identical proportion of the algae (3.5 g per m^3) and bacteria (2.2 g per m^3), followed by Rotatoria (0.89) and last comes the Crustacea plankton (0.32). Upon the influence of the relatively high algal and bacterial biomasses, mainly the Rotatoria showing a quick propagation increase among the members of the zooplankton, then it is followed by a large increase of Crustacea (Bosmina) plankton. Presumably, the algal and bacterial biomasses further decrease on the effect of zooplanktonic biomasses.

The organic substances arriving with the sewage-water in an increasing quantity from the beginning of July, induced an extensive Anabaena bloom. On its effect the bacterioplankton as well as the Rotatoria and Crustacea biomasses were reduced *(Fig. 5, Table XIII)*. The Anabaena biomass reached its maximum in the middle of September. Between July and September, only the Rotatoria biomass is considerable, apart from the algal mass, the former displayed a maximum at the end of August (1 g per m^3). The bacterial mass becomes significant only after the decrease of algae. The Crustacea biomass completely lost its significance from August owing to the algal bloom. Significant differences appeared between the points of sampling as regards the biomass of the total plankton (bacteria, algae, Rotatoria and Crustacea) from July when the loading with sewage-water increased *(Table XIII, Fig. 6)*. The relatively lowest biomass value was found during the whole period of

TABLE XIII

Quantitative changes of the total planktonic biomass in pond No. 1 during 1971 (g dry weight/m³)

Date	Groups of organism	Points of sampling					Average
		1.	2.	3.	4.	5.	
13. V.	Bacteria	2.20	2.10	1.80	2.40	2.30	2.16
	Algae	4.70	2.90	3.70	4.20	2.00	3.50
	Rotatoria	0.40	1.02	1.17	1.05	0.83	0.89
	Crustacea	0.22	0.28	0.63	0.30	0.28	0.34
25. V.	Bacteria	—	—	—	—	—	—
	Algae	—	—	—	—	—	—
	Rotatoria	1.54	3.68	3.17	3.43	3.18	3.00
	Crustacea	0.57	1.61	1.29	1.19	1.21	1.17
9. VI.	Bacteria	0.80	0.60	0.80	0.70	1.10	0.80
	Algae	1.40	1.60	2.00	1.30	1.60	1.58
	Rotatoria	0.27	0.29	0.41	0.28	0.34	0.32
	Crustacea	5.04	4.90	5.56	3.98	2.20	4.33
23. VI.	Bacteria	4.20	3.60	2.80	2.20	2.40	3.04
	Algae	3.10	5.70	4.60	5.30	4.90	4.92
	Rotatoria	0.16	0.17	0.25	0.21	0.23	0.20
	Crustacea	2.34	2.12	3.97	4.82	4.54	3.55
6. VII.	Bacteria	0.05	0.07	0.09	0.10	0.10	0.08
	Algae	22.80	29.40	30.70	26.80	25.90	27.12
	Rotatoria	0.53	0.47	0.49	0.34	0.32	0.43
	Crustacea	0.62	4.58	2.17	2.20	1.48	2.21
10. VIII.	Bacteria	0.80	0.20	0.20	0.20	0.20	0.32
	Algae	23.20	30.10	30.10	24.30	27.80	27.10
	Rotatoria	0.37	0.51	0.46	0.30	0.78	0.48
	Crustacea	0.25	0.35	0.36	0.34	0.32	0.32
29. VIII.	Bacteria	0.50	0.40	0.30	0.30	0.60	0.42
	Algae	33.60	27.20	26.10	33.00	37.10	31.40
	Rotatoria	1.60	0.93	1.11	0.84	0.74	1.04
	Crustacea	0.30	0.21	0.19	0.10	0.09	0.17
14. IX.	Bacteria	2.70	2.50	2.10	1.80	2.90	2.40
	Algae	15.60	41.10	39.40	36.50	40.60	34.64
	Rotatoria	0.83	1.02	0.89	1.05	1.12	0.98
	Crustacea	0.13	0.12	0.13	0.13	0.04	0.11
12. X.	Bacteria	4.10	3.90	4.20	4.30	4.10	4.12
	Algae	7.50	7.50	1.10	0.50	2.30	3.78
	Rotatoria	0.39	0.41	0.42	0.35	0.20	0.35
	Crustacea	0.03	0.05	0.06	0.04	0.04	0.04
21. X.	Bacteria	4.80	4.70	4.60	5.00	4.20	4.66
	Algae	1.70	5.20	2.90	8.70	6.90	5.08
	Rotatoria	0.16	0.23	0.18	0.17	0.19	0.19
	Crustacea	0.11	0.05	0.08	0.09	0.07	0.08

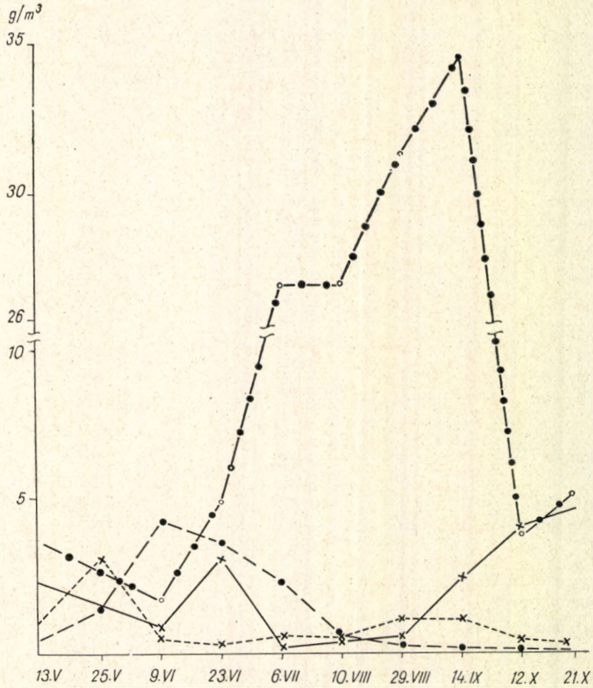

Fig. 5. The changes in the biomass of the most important planktonic groups at all the points of the pond No. 1. o— Bacteria; o—.—.—o Algae; o———o Rotatoria; o — — o Crustacea

investigations at point No. 1 (at the inflow) and the highest at point No. 2. The averages are as follows:

Point No. 1	14.96 g/m³
Point No. 2	19.18 g/m³
Point No. 3	18.05 g/m³
Point No. 4	17.82 g/m³
Point No. 5	18.52 g/m³

The differences in planktonic composition as well as of biomass values must be looked for in the quantity and quality of the sewage-water. The insignificant role of Crustacea plankton during summer and the lower biomass value near the inflow may indicate the inlet of a considerable amount of detergents into the system. The practically complete absence of Daphnia species as well as the secondary role of Cladocera during the summer season involves a limited transportation of the increased algal biomass along the food chain. These questions will be discussed later in connection with fish production.

7. *Investigations on the benthos in the transversal section of pond No. 1*

a) Detailed chemical analyses of an average sample. The mud sample taken between points No. 1 and 2, i.e. near the shore is be classified to be an

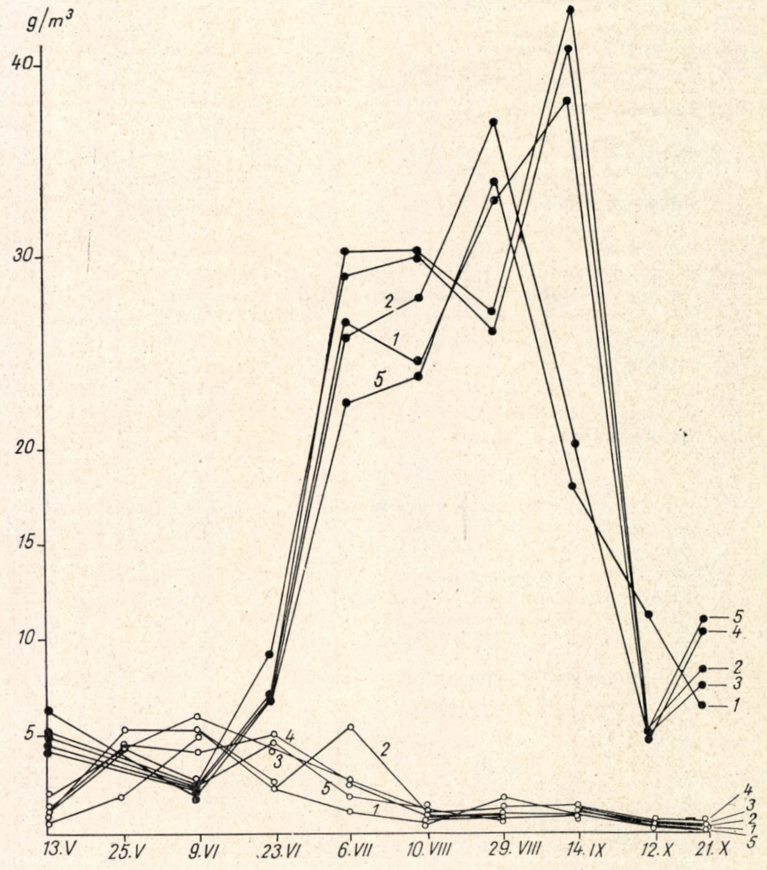

Fig. 6. The upper curves 1—5 show the biomass changes of algae and bacteria, the lower ones those of the total zooplankton at the five points during the whole period of investigations

organic mud *(Tables XIV* and *XV)*. It proved to be of rather inhomogeneous composition during the analyses.

Its reaction was neutral, although contained 22,4 percent $CaCO_3$. This originates mainly in fragmented shells of mussels and snails.

In the mud saturated up to the level of flow (K_A number: 170), 0.11 percent water-soluble salts were measured, indicating a tendency to salt-accumulation.

The compact fractions contained more Fe^{3+}, SO_4^{2+} and SiO_2 than the disintegrated one.

The fraction of the mud sedimentable by boiling (percentage of the particles of less than 0.02 mm) was low, 16.03 percent, indicating a relatively high amount of non-humificated organic matter in the mud, contradicting the results obtained by humid decomposition and burning.

Among the interchangeable cations of the mud, Ca^{2+} predominated, however, the amount of Mg^{2+} was almost the same, while that of Na^+ and K^+ was relatively low.

TABLE XIV

The results of investigations of the mud-samples taken near the shore (between the points of sampling Nos. 1—2) of the pond of Fonyód (1971)

Reaction: 7.10 pH	
K_A (H_2O)	170
Total amount of water-soluble salts	0.11%
$CaCO_3$	22.40%
Sluiceable fraction	16.03%
Fe^{3+} in the disintegrated fraction	41.94 mg/100 g
Fe^{3+} in the compact fraction	1358.90 mg/100 g
Humus by humid decomposition	23.20%
Organic substance by burning	56.42%
P_2O_5 soluble in aqua regia	192.00 mg/100 g
K_2O soluble in aqua regia	235.00 mg/100 g
Total N	900.00 mg/100 g
Easily soluble P_2O_5-(Al-P)	52.00 mg/100 g
Moderately soluble P_2O_5-(Al-P)	39.10 mg/100 g
Hardly soluble P_2O_5-(Al-P)	13.00 mg/100 g
Binding of phosphorous	90.00%
Easily soluble K_2O-(Al-K)	21.00 mg/100 g
SO_4^{2-} in the disintegrated fraction	134.43 mg/100 g
SO_4^{2-} in the compact fraction	3696.79 mg/100 g
SiO_2 in the disintegrated fraction	12.50 mg/100 g
SiO_2 in the compact fraction	104.06 mg/100 g
P_2O_5 in the disintegrated fraction	180.00 mg/100 g
P_2O_5 in the compact fraction	150.00 mg/100 g

The exchangeable cations of the mud:

	mg/100 g
Ca^{2+}	1010.00
Mg^{2+}	541.04
Na^+	34.75
K^+	26.50

The water-extract analyses of the mud are only informative results, since they give preliminary prognosis to a certain extent to the secondary quality of the water, and allows us to calculate the order of magnitude of dissolution of the mud components during the refilling of the fish-pond.

The large O_2-consumption of the water-extract is considerable in this respect. The amounts of inorganic nitrogen, PO_4^{3-} and Fe^{3+} are remarkable in the aqueous extracts. In a mud-water of 1 : 5 extract 455.6 mg/l salts were dissolved.

The chemical type of the aqueous extract is characterized by Ca-hydrocarbonate.

The mud is rich in N and phosphorous and contains small amounts of K_2O soluble in aqua regia, as the morassy soils do in general. As compared to the soluble P_2O_5, even the soluble K_2O is inconsiderable. The amount of P_2O_5 soluble only in aqua regia is nearly identical with the P_2O_5 content of the compact and humificated fractions (even the disintegrated fraction contains a considerable amount of P_2O_5). Twenty-seven percent of the P_2O_5 soluble in aqua regia is easy to dissolve. Using a continuous dissolution, the second results in 39.10, the third in 13.00 mg P_2O_5 per 100 g. Therefore, more than a half of the P_2O_5 soluble in aqua regia can be dissolved to different degrees (easily, moderately and hardly).

TABLE XV

The data of analysis of the water extract of the mud prepared using a water : mud rate of 5 : 1 (1971)

Reaction: 7.30 pH

	mg/l/200 g mud
O_2-consumption (0.01 n $KMnO_4$)	56.98
Total degree of hardness	12.01
Soluble sulphide	4.87
Calculated H_2S	0.98
Alkalinity L°	2.73
Na^+	40.09
K^+	6.3
Ca^{2+}	37.5
Mg^{2+}	29.5
Fe^{3+}	1.7
NH_4^+	3.0
HCO_3^-	166.6
Cl^-	11.3
SO_4^{2-}	128.3
PO_4^{3-}	0.8
SiO^{2-}	17.8
NO_2^-	6.6
NO_3^-	5.3
Sum of cations	118.9
Sum of anions	336.7
Cations and anions together	455.6

During the laboratory experiments of dunging the applied amount of P_2O_5 (10 mg/100 g) was bound to 90 percent, the binding, however, was weak, it was easy to liberate, observed during the continuous dissolution of the dunged mud. The bound P_2O_5 was given back during the second or third dissolution. Therefore, the mud samples of Fonyód contain considerable amounts of N, P_2O_5, Fe^{3+} and SO_4^{2-}. Large O_2 consumption and P_2O_5 as well as N amounts can be precalculated during refilling.

b) Quantity and quality of the benthic organisms. According to their sites they can be divided into 3 groups: macro-, micro- and meiobenthos. The term macrobenthos involves the Chironomida-Tubifex, the meiobenthos the Nematoda-Cladocera-Copepoda, while the microbenthos includes the algae and unicellular animals. We call the macrobenthos above 2 mm, the meiobenthos between 2 and 0.1 mm.

Macrobenthos

The points of transversal section investigated proved to be very poor in macrobenthic organisms. Only near the inflow (No. 1) have we found a few Tubifex samples. The almost complete absence of the macrobenthos can be explained by the activity of carps searching for these organisms.

Meiobenthos

Only the Nematoda showed a higher frequency in this group, whereas the other organisms occurred only sporadically *(Table XVI)*.

It deserves special interest that the Nematoda were almost without exception juvenile forms. This obviously indicates that the fish have optimal

TABLE XVI

The occurrence of the members of meiobenthos in the transversal section of the pond

	Place of sampling No. 1.					Place of sampling No. 2.				
	13. V.	9. VI.	6. VII.	29. VIII.	12. X.	13. V.	9. VI.	6. VII.	29. VIII.	12. X.
Nematoda	367	17	114	17	47	17	—	19	28	64
Oligochaeta	—	—	—	—	—	33	—	3	—	—
Cladocera	—	—	—	—	—	—	—	8	3	3
Ostracoda	17	17	3	—	—	17	—	—	3	—
Copepoda	50	33	14	17	8	—	—	5	—	—
Diptera	—	—	—	—	—	—	—	—	—	—
Total	434	67	131	34	55	67	—	35	34	67

accers to the benthic organisms. On this basis one can clearly explain the sporadic occurrence of the organisms larger in size than the Nematoda (Cladocera, Copepoda, Oligochaeta, Diptera). This peculiar phenomenon can only be explained by the fact that the toxic substances (e.g. detergents) of the inflow are fixed by the mud surface of point No. 1. Therefore, Cladocera being relatively sensitive to environmental effects, immediately die.

One can point out the interesting occurrence of the mud-living Cladocera. Whereas these animals are absent in the mud near the inflow, their number increases towards the other side of the pond.

Hydracarina and Tardigrada organisms occur sporadically in the benthos.

Biomass values were only calculated for the more frequent Nematoda *(Table XVII)*. The data indicate that the largest biomass value was yielded by point No. 1, i.e. the inflow region during the whole period of investigation.

TABLE XVII

Changes of Nematoda biomass in pond No. 1 (mg/m^2) during 1971

Points of sampling	Dates of sampling					Average
	13. V.	9. VI.	6. VII.	29. VIII.	12. X.	
1.	6.0	0.3	2.0	0.3	0.8	1.8
2.	0.3	—	0.3	0.5	1.1	0.5
3.	0.5	0.3	0.1	0.5	0.1	0.3
4.	0.3	0.8	0.1	0.3	0.1	0.3
5.	2.2	0.5	0.3	0.1	0.5	0.7

The reason is that this group is less sensitive to environmental changes than the Cladocera, and there are many species among them preferring the medium of high organic content. Considering the fact that apart from the spring and early summer seasons, the zooplanktonic biomass plays only a secondary role beside the phytoplankton, the members of the meiobenthos may be of higher importance in the nutrition of fish than it had been assumed before the investigations.

investigated in 1971. (Values are given in individuals/dm², rounded of figures)

Place of sampling No. 3.					Place of sampling No. 4.					Place of sampling No. 5.				
13. V.	9. VI.	6. VII.	29. VIII.	12. X.	13. V.	9. VI.	6. VII.	29. VIII.	12. X.	13. V.	9. VI.	6. VII.	29. VIII.	12. X.
33	17	5	30	3	17	50	8	17	5	133	33	19	5	36
—	—	3	—	3	33	—	11	—	—	33	—	3	5	—
—	17	5	—	—	—	33	8	—	—	—	117	150	3	—
17	33	—	—	—	—	—	—	—	—	—	—	5	—	—
50	83	5	3	—	17	—	19	8	11	17	50	5	—	—
17	—	—	—	—	—	—	—	—	—	—	17	3	—	3
117	150	18	33	6	67	83	46	25	16	183	217	185	13	39

It should be noted that the mud of the pond is inclined to form hydrogen sulphide affecting the quantitative relations of certain benthic organisms. This question will be treated in more detail later in connection with the destruction of fish.

8. *Investigations on the growth of the fish population*

a) Evaluation of the productivity of ponds on the basis of parameters of production.

Only the data of highest significance will be treated from the voluminous *tables (XVIII* and *XIX*, *a + b)* in order to characterize the ponds.

Pond No. 1 *(Table XX, Fig. 7):*

The production of the pond showed significant differences depending on the amount of fish recovered as well as on the mortality during 1964—1971.

Considering the total amount of fish recovered (106—286 q), the production forms a variable part of the average biomass, namely 8.59—67.42 percent, related to the natural loss. During 1971, this rate much surpassed the results of the earlier years, amounting to 204.6 percent. The fishes introduced were mainly carp and tench, whereas in May 1971 sheat-fish as well as fry of white and spotty grass-carps were also introduced. The natural loss of carp was significant at the first-summer individuals, 37—61 percent, while in the case of older ones, it amounted to only 15—20.4 percent. The natural production of the pond varied between 36—150.2 kg/cadastral acre (in 1971 107.7 kg) achieved by consuming 1.4—2.6 kg food per 1 kg fish flesh. Considering the number of introduced fishes, this seems to be a better efficiency of the food than in the other ponds (see *Tables XVIII* and *XIX b)*. The pre-sedimented sewage-water diluted with that of the Keleti-Bozót gets in directly into pond No. 1. The quality and daily amount is not yet known, however, it may significantly affect the natural production and the parameters seem to indicate even higher productions. The carp and other fishes cultured in that pond tolerate the loading with sewage-water, as far as we are informed, mass destruction of fishes has not been observed because of the sewage-water inflow. Considering that the pond has a bottom of boggy character and is rich in phytoplankton, the introduction of grass-eating species during 1971 was a fair bid for the future.

TABLE XIX/b

Recovery statistics of fish during 1964—1971 from

	A	B	Planted material			
			Carp	Other fishes	Total	Total
			kg			
1964	1	88	2 537	1122	3 659	10 632
	2	132	6 330	274	6 604	20 430
	3	142	10 559	479	11 038	15 456
total:		366	19 426	1875	21 301	46 518
1965	1	88	2 860	—	2 860	22 214
	2	132	9 364	839	10 203	6 027
	3	142	6 660	533	7 193	5 234
total:		366	18 884	1372	20 256	33 475
1966	1	88	10 600	—	10 600	28 556
	2	132	19 915	613	20 528	39 323
	3	142	16 480	—	16 480	22 149
total:		366	46 995	613	47 608	90 028
1967	1	88	9 200	1123	10 323	24 397
	2	132	14 000	997	14 997	18 703
	3	142	13 680	2100	15 780	29 720
total:		366	36 880	4220	41 100	72 820
1968	1	88	9 693	1036	10 729	16 971
	2	132	13 467	3057	16 524	19 343
	3	142	16 581	1506	18 087	18 852
total:		366	39 741	5599	45 340	55 166
1969	1	75	10 400	—	10 400	16 853
	2	84	8 594	348	8 942	22 912
	3	90	2 958	—	2 958	1 241
total:		249	21 952	348	22 300	41 006
1970	1	75	7 794	—	7 794	11 561
	2	84	13 060	305	13 365	29 647
	3	90	9 013	675	9 688	12 280
total:		249	29 867	980	30 847	53 488
1971	1	75	10 006			10 827

w = White grass-carp; sp = Spotty grass-carp; sh = Sheat-fish; * = 1-summer-old

Pond No. 2 *(Table XXI)*

This pond had had an area of 132 cadastral acres between 1964 and 1969, then it was restricted to 84 cad. acres. The number of introduced fishes as well as the amounts recovered were higher excepting the years of 1965 and 1967, than in the previous pond. The percentual value of the loss amounted to 4.1—44.2 at the first-summer fishes, whereas at the older ones it was much higher, 6.5—64.9 percent. The pond offered an outstanding production in 1965, when the introduced amount of fishes was 60 q and in spite of the high mortality, it increased to 120 q by the end of the year involving a production of 169.3 percent achieved by a food consumption of 3.51 kg/1 kg fish flesh. The natural *the fish-ponds of Zardavár*

Increase of the pond per cad. acre		Number of missing carps from the initial stock in percentage		Consumed food in maize value kg	Amount of food per 1 kg fish flesh, kg	Natural production of the pond per cad. acre in kg
From carp	Total	At 1-summer-old ones	At older ones			
kg		kg				
—	120	57	—	26 011	2.44	36
—	155	—	45	50 355	2.46	46
—	106	—	77	16 107	1.04	74
—	127	57	63	92 473	1.90	55
228	222	37	—	31 475	1.41	150.2
41	44	—	64.9	21 292	3.51	—
29	37	97.3	—	9 453	1.60	17.8
66	91	86.8	64.9	62 220	1.86	42.9
318	324	60	8.9	60 046	2.10	129.5
286	290	4.1	—	74 790	1.90	132
153	159	71.8	60.5	49 304	2.22	56.7
242	246	59.9	37.8	184 140	2.04	102.2
282	277	56.2	—	55 425	2.27	82.8
132	137	—	30	41 939	2.24	42
203	209	45.9	—	61 294	2.06	76
195	199	49	30	158 658	2.18	67.7
191	192	60.9	20.4	39 789	2.34	63
135	142	—	40.5	50 461	2.61	36.2
141	133	—	—	66 096	3.65	—
151	151	60.9	24.5	156 346	2.83	28.7
—	224	50.9	—	31 176	1.8	—
—	272	—	6.5	42 044	1.8	—
13	13	—	7.9	12 228	9.9	—
—	—	—	—	85 448		—
147	154	—	15	30 034	2.6	39
332	353	44.2	—	57 862	1.9	156
125	136	—	29.2	40 878	3.3	—
202	215	44.2	23.5	128 774	2.4	66.7
	295	44.7*		49 253	2.22	107.7
		5,3 w				
		26,4 sp.				
		40,3 sh.				

production of the pond was 36.2—156 percent, its average biomass production varied between 32.33—169.3 percent.

Pond No. 3 *(Table XXII)*

It is of lower planting than that of No. 2. (except 1967), having an area of 142 cadastral acres between 1964—1969 and 90 cad. acres from 1969. The values of mortality were high, nevertheless the amounts of produced fish widely varied: 42—455 q. The production, accordingly, amounted to 53.1—238.4 percent. The amount of food consumed fluctuated between 1.04—9.9 kg

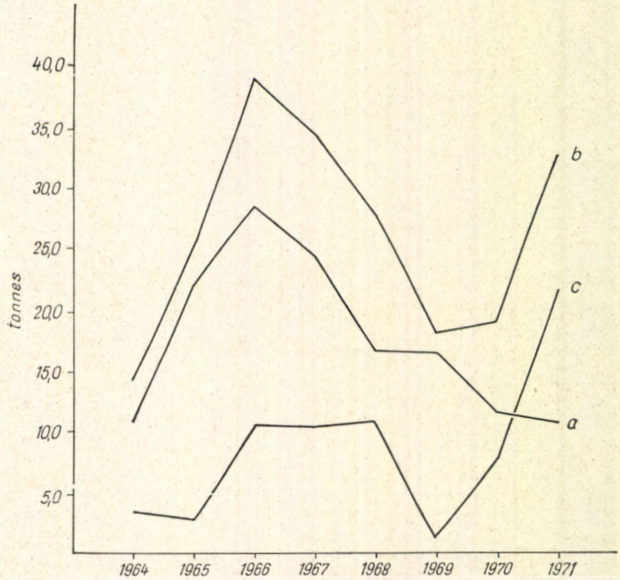

Fig. 7. The data of fish production in pond No. 1 of Zardavár during 1964—71. a = material planted; b = recovered material; c = production

TABLE XX

The productivity of pond No. 1 of Zardavár (Fonyód) during 1964—71 (without wild fish)

Year	Area of the pond cad. acre	The amount of planted matter kg	Total increase per 1 cad. acre kg	Rate of missing fish from the initial stock in percentage		Total recovery kg	Production of the biomass	
				A	B		kg	%
1964	88	10 632	120	57	—	14 291	3 659	34.4
1965	88	22 214	222	37	—	25 074	2 860	12.87
1966	88	28 556	324	60	8.9	39 156	10 600	37.12
1967	88	24 397	277	56.2	—	34 720	10 323	42.31
1968	88	16 971	192	60.9	20.4	27 700	10 729	63.22
1969	75	16 853	224	50.9	—	18 300	1 447	8.59
1970	75	11 561	154	—	15	19 355	7 794	67.42
1971	75	10 827	295	44.7	—	32 978	22 151	204.59

Note: Rate of missing fish from the initial stock in percentage, A = one-summer-old, B = at older ones

per 1 kg fish flesh representing a high value. During the years of 1965—66 and 1969 this pond was of the lowest level of planting among the three, however, it offered the highest relative production in 1965 and 1969, corresponding to an increase of weight of 30—72 q. Nevertheless, the production depends on the intense feeding. During seven years between 1964—70, the survived portion of the introduced fish-mass produced an increase in weight of about 30—181 q.

TABLE XXI

The productivity of pond No. 2 of Zardavár (Fonyód) during 1964—71 (without wild fish)

Year	Area of the pond cad. acre	The amount of planted matter kg	Total increase per 1 cad. acre kg	Rate of missing fish from the initial stock in percentage		Total recovery kg	Production of the biomass	
				A	B		kg	%
1964	136	20 430	155	—	45	27 034	6 604	**32.33**
1965	136	6 027	44	—	64.9	16 230	10 203	169.29
1966	136	39 323	290	4.1	—	59 851	20 528	52.20
1967	136	18 703	137	—	30	33 700	14 997	80.18
1968	136	19 343	142	—	40.5	35 867	16 524	85.43
1969	84	22 912	272	—	6.5	31 854	8 942	39.05
1970	84	29 647	353	44.2	—	43 012	13 365	45.08

TABLE XXII

The productivity of pond No. 3 of Zardavár (Fonyód) during 1964—71 (without wild fish)

Year	Area of the pond cad. acre	The amount of planted matter kg	Total increase per 1 cad. acre kg	Rate of missing fish from the initial stock in percentage		Total recovery kg	Production of the biomass	
				A	B		kg	%
1964	142	15 456	106	—	77	26 494	11 038	71.42
1965	142	5 234	37	97.3	—	12 427	7 193	137.43
1966	142	22 149	159	71.8	60.5	38 629	16 480	74.41
1967	142	29 720	209	45.9	—	45 500	15 780	53.10
1968	142	18 852	133	—	—	36 939	18 087	95.94
1969	90	1 241	13	—	7.9	4 199	2 958	238.36
1970	90	12 280	136	—	29.2	21 968	9 688	**78.79**

TABLE XXIII

The productivity of ponds Nos. 1—3 of Zardavár (Fonyód) during 1964—71 (without wild fish)

Year	Area of the pond cad. acre	The amount of planted matter kg	Total increase per 1 cad. acre kg	Rate of missing fish from the initial stock in percentage		Total recovery kg	Production of the biomass	
				A	B		kg	%
1964	366	46 518	127	57	63	67 819	21 301	45.79
1965	366	33 475	91	86.8	64.9	53 731	20 256	60.51
1966	366	90 028	246	59.9	37.8	137 636	47 608	52.88
1967	366	72 820	199	49	30	113 920	41 100	56.44
1968	366	55 166	151	60.9	24.5	100 506	45 340	82.19
1969	249	41 006	—	—	—	63 306	22 300	54.38
1970	249	53 488	215	44.2	23.5	84 335	30 847	57.67

General evaluation of ponds Nos. 1—3 *(Table XXIII)*

The summarized area of the ponds was 366 cad. acres until 1968, then 249 fròm 1969. The amounts planted varied between 335—900 q. The increase of weight was 91—246 kg per cad. acre. Except 1964, the mortality was higher at the first-summer carp (44.2—86.8 percent) than at the older ones (23.5—64.9 percent). The total amount of fish caught was between 633—1376 q including a total biomass production of 202—467 q, i.e. 52.9—60.5 percent showing extreme values of 45.8—82.2 percent. It can be regarded in general that the ponds taken either collectively or even individually are of medium fish-production as compared to other ponds. However, it seems to be likely that perhaps by an increased sewage-water consumption and by mass plantation of lower number of species mainly of grass-carps, the production can be increased up to 80—100 percent in each pond or even above that. For this reason one has to know more about the connections between sewage-water loadings and fish-production, since only a few data are known at present concerning this problem. The joint effect of duck-cultivation and sewage-water consumption should also be cleared up in pond No. 1, first of all, in order to increase the production of the grass-eating species.

b) Investigations on the growth of carp in pond No. 1.

During 1971 altogether 679 two-summer-old and 263 fry-carps were investigated in order to estabilsh the rate of growth *(Table XXIV)*. Although the performance of samplings could not always be carried out, sufficient amount of data have been obtained during June, September and November in pond No. 1 regarding the growth of carps *(Table XXIV)*. The results prove that in

TABLE XXIV

The fish-material studied in pond No. 1 of Zardavár with a view to the rate of growth (1971)

	June	Sept.	Nov.	Total (pc)
Carp 2-summer-old	103	280	296	679
Carp 1-summer-old	42	107	114	263
White grass-carp	—	26	37	63
Tench	—	35	35	70
Crucian carp	—	48	31	79
Total:	145	496	513	1154

spite of the large amount of food consumed in this pond, carps grow relatively slowly and rather unevenly. This concerns both the body length and weight and the slow growth is reflected by the low or medium results of production mentioned above. The growth of length of the second-summer carps remains far below the attainable values and even the rate of growth of the fry is unsatisfactory *(Fig. 8)*. A similar conclusion is gained when investigating the coefficients of equations calculated for the allometric connections of the body weight and length. The value of regression coefficient b changes seasonaly (2.4—2.6), it has never reached the value of 3.0, i.e. the body mass (the so-called specific weight) of the fish is significantly lower than the average achieved in other fish-ponds *(Fig. 9)*.

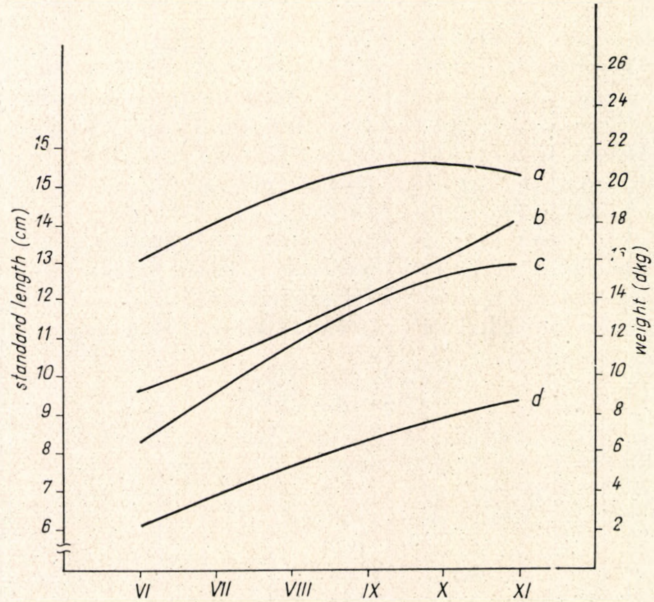

Fig. 8. The increase of body length and weight of carp in pond No. 1 of Zardavár. a = increase of standard length of two-summer-old carp; b = increase of body weight of two-summer-old carp; c = increase of standard length of carp fry; d = increase of body weight of carp fry

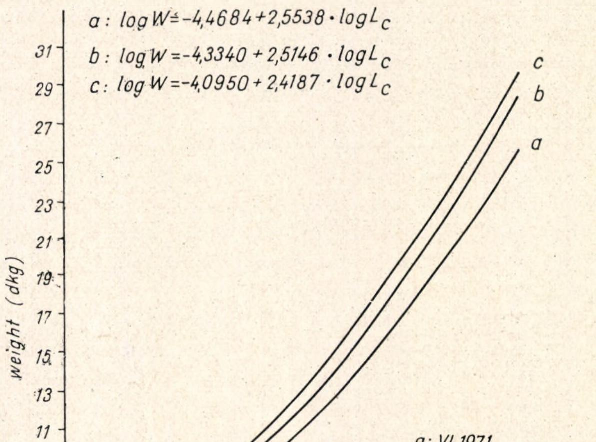

Fig. 9. The ratio of body weight and length of carp during the period of investigation (pond No. 1). W = body weight in dkg; L_c = standard length in mm

The coefficient of body-weight increase varied between $G_w = 1.39-2.46$ at the second-summer carps during the period of investigations, whereas the same regarding body length was $G_l = 0.26$ showing a much slower increase *(Table XXV)*. The rate of growth of the fry significantly surpasses the above values ($G_w = 2.58$; $G_l = 0.91$).

The condition of the carps changes according to season, it seems to decline by the end of the year. The values of CF were 3.2367—4.6654 in June (average 4.2010), 3.0440—4.9202 in September (average 3.814) and 2.666—5.370 in November (average 3.956). The extreme values display great differences among the fishes of the same age. Beside those numerical values, the population cannot be regarded as uniform attributable to nutritional and ecological connections.

TABLE XXV

The rates of mortality and survival of fish-species as well as the growth coefficients of body weight and length in pond No. 1 (1971)

	Z	G_w	G_l	S	A
Carp 2-summer-old	−1.1912	2.4642	0.2652	30.42	69.58
fry	—	2.5756	0.9062	—	—
Tench	−3.7002	1.3054	—	2.47	97.53
White grass-carp	−0.1069	5.9994	—	89.58	10.42
Spotty grass-carp	−0.9082	3.2325	—	40.25	59.75
Sheat-fish	−1.0780	4.6614	—	33.96	66.04

Z = instantaneous total coefficient of mortality (RICKER, 1958), G_w and G_l = coefficients of growth of weight and length, respectively, (CHAPMAN, 1968; TESCH, 1968), S = survival rate in percentage, A = total annual mortality in percentage (in our case, involves 0.5 year).

The value of the actual total mortality is high at the two-summer-old carps ($Z = -1.1912$), the loss was 69.6 percent during a period of 6 months accordingly the survival rate was only 30.4 percent. The calculated values of mortality and survival differ more or less from the real values, since they describe mathematically a change between an initial (t_0) and a final (t_1) point of time, i.e. they express the time dependence of a logarithmic decrease in the number of individuals. The seasonal variations of the values cannot be followed, since the exact determination of the number of individuals is possible only on the basis of data of planting and recovery because of the large area of the ponds and the insufficient technical facilities.

Data regarding the growth of carps allow us to draw the conclusion that this species may play only a secondary role in the waste stabilization ponds of Fonyód, if the increase of fish production is intended at a higher consumption of sewage-water.

c) Observations on the growth of other fishes

Apart from the carps, white and spotty grass-carps as well as sheat fish were introduced into pond No. 1 in 1971. At the same time, mainly tench, a smaller number of pike-perch and pike were fished representing the natural production of the pond. The crucian carp was the most significant among the wild fishes, nevertheless, it plays no role in the statistic. Apart from the carps, observations were carried out to study the growth of tench, the crucian carp, the white and spotty grass-carps and partly of sheat fish. The results are summarized briefly as follows:

Tench: Both the body and length increased more intensely than in the case of carps *(Fig. 10)* according to the relationships calculated for the allometric growth at first- and second-summer as well as fry individuals. The allometric exponent significantly differs from 3.0. As against the carp, this species is of continuous growth during the whole period of investigations, thus at the end of autumn, from September till November, the body length increased about 2—2.5 cm and the body weight about with one third. The actual coefficient of the increase of body weight is of relatively low value ($G_w = 1.3054$). The mortality is high (97 percent), accordingly, the survival rate is only 2.47 percent.

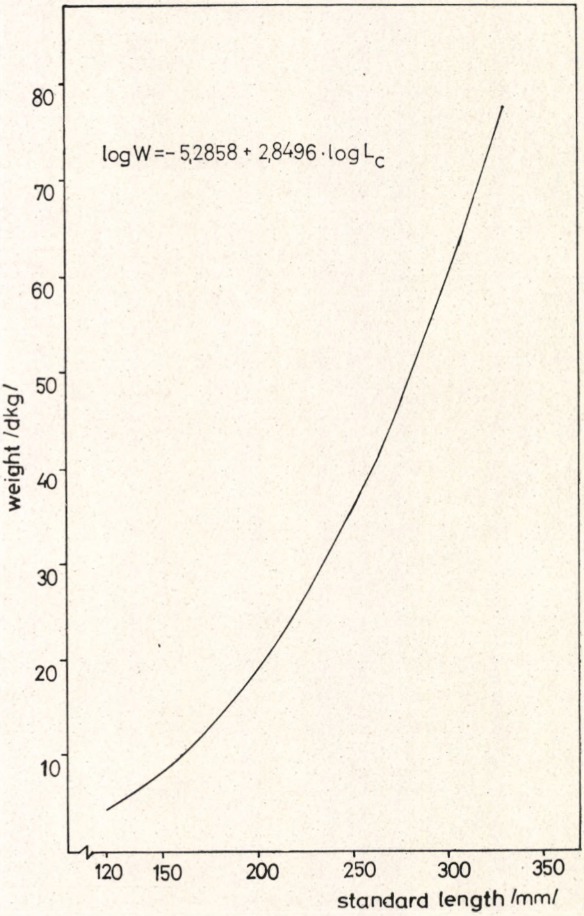

Fig. 10. The allometric relationship of body weight and length of tench (see for other explanations *Fig. 9)*

Crucian carp: It is considered to be a junk-fish in fish-ponds, since it is a food-competitor of carps and other useful fishes. It gets into the pond with the filling-water and because of its extraordinary prolification and intense food-consumption it may have a considerable effect on the growth of carps. Two groups of size occurred in pond No. 1 (first-summer-old and fry) with a size-difference of 6—7 cm *(Table XXVI)*. The equation calculated for the connection of body-weight and length indicates that the increase in body size compared to the other species, best approaches the isometric value (b = = 2.954) *(Fig. 11)*.

TABLE XXVI

The average values of body sizes of fish investigated during the period of investigation in 1971

	June			September			November		
	L_c	L_t	W	L_c	L_t	W	L_c	L_t	W
Carp 2-summer-old	130	161	9.3	154	189	14.2	153	190	14.0
fry	82	103	2.4	118	144	6.2	145	180	12.5
							129	161	8.7
White grass-carp	—	—	—	253	305	31.9	—	—	—
Tench	—	—	—	175	210	13.0	149	180	9.3
							199	235	20.3
							293	348	53.3
Crucian carp	—	—	—	115	142	5.0	163	203	15.4
							109	136	5.2

L_c = standard length in mm; L_t = total body length in mm; W = body weight in dkg.

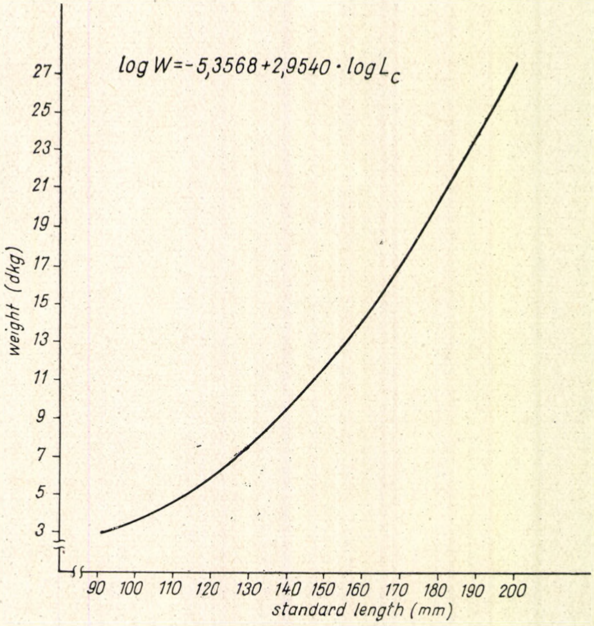

Fig. 11. The allometric relationship of body weight and length of crucian carp (see for other explanations *Fig. 9)*

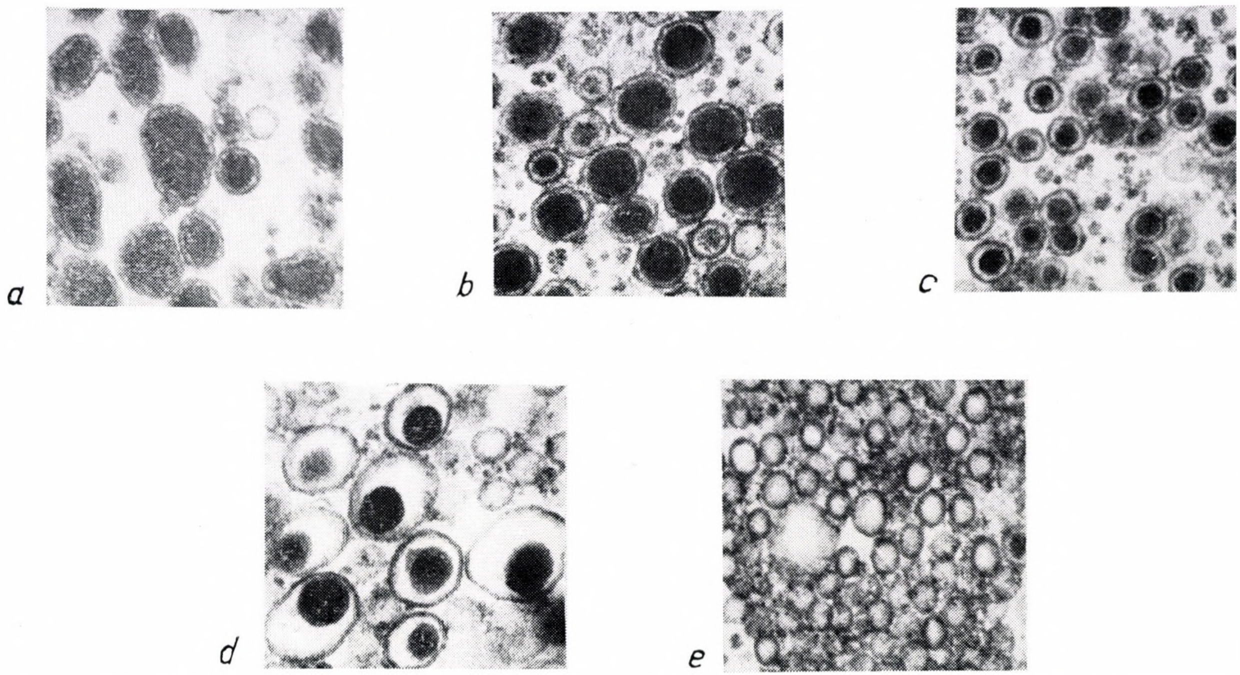

Fig. 1. Different vesicle types in the axons of the neuropile. *a)* Peptidergic neurosecretory — PNV; *b)* large dense-core — LDCV; *c)* small dense-core — SDCV; *d)* eccentric dense-core — EDCV; *e)* clear — CV. GA-Os fixation, ×58.500

TABLE XVIII

Planting statistics of fish into the ponds of Fonyód-Zardavár (1964—1971)

	A	B	C	D	Carp						Tench		Sheat-fish				Pike-perch				White amur		White grass-carp		Spotty grass-carp		Planted together kg
					Mature female		2-summer-old		1-summer-old		Fry		Breeding		Fry		Breeding		Fry		Breeding		Fry		Fry		
					pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	
1964	1	88	250	8.0	71	354	176 000	1 408	74 000	2 183	—	1122	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5 067
			840	2.9																							
	2	136	496	11.0	—	—	66 100	7 111	—	—	—	180	—	—	1760	274	—	—	—	—	—	—	—	—	—	—	7 565
	3	142	500	7.4	234	762	94 200	7 608	—	—	—	—	—	—	1900	299	—	—	—	—	—	—	—	—	—	—	8 669
total:		366			305	1116	336 300	16 127	74 000	2 183	—	1302	—	—	3660	573	—	—	—	—	—	—	—	—	—	—	21 301
1965	1	88	795	4.0	—	—	—	—	70 000	2 860	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2 860
	2	136	316	20.0	350	960	41 750	8 404	—	—	—	—	1272	747	—	—	430	92	—	—	—	—	—	—	—	—	10 203
	3	142	2250	2	63	533	—	—	330 000	6 600	—	—	—	—	2500	60	—	—	—	—	—	—	—	—	—	—	7 193
total:		366			413	1493	41 750	8 404	400 000	9 460	—	—	1272	747	2500	60	430	92	—	—	—	—	—	—	—	—	20 256
1966	1	88	2270	2.8																							
			114	50.0	—	—	10 000	5 000	200 000	5 600	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10 600
	2	136	154	11.4																							
			255	54.0	—	—	34 750	17 537	20 920	2 378	—	96	531	249	480	40	280	200	570	28	—	—	—	—	—	—	20 528
	3	142	535	2.8																							
			500	20.6	—	—	70 300	14 480	76 000	2 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16 480
total:		366					115 050	37 017	296 920	9 978	—	96	531	249	480	40	280	200	570	28	—	—	—	—	—	—	47 608
1967	1	88	2270	2.8	1500	3600	—	—	200 000	5 600	—	1123	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10 323
	2	136	316	32.0	—	—	43 000	14 000	—	—	—	590	265	177	—	—	425	230	—	—	—	—	—	—	—	—	14 997
	3	142	3500	2.0	1500	4100	—	—	498 940	9 580	—	2100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15 780
total:		366			3000	7700	43 000	14 000	698 940	15 180	—	3813	265	177	—	—	425	230	—	—	—	—	—	—	—	—	41 100
1968	1	88	3200	2.8																							
			100	13.0	105	443	8 800	1 150	281 600	8 100	—	1036	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10 729
	2	136	880	10.0	500	2400	119 900	11 067	—	—	—	1481	—	—	1100	230	—	—	—	—	802	1346	—	—	—	—	16 524
	3	142	535	15.0	1305	5423	75 950	11 158	—	—	—	1278	—	—	1100	228	—	—	—	—	—	—	—	—	—	—	18 087
total:		366			1910	8266	204 650	23 375	281 600	8 100	—	3795	—	—	2200	458	—	—	—	—	802	1346	—	—	—	—	45 340
1969	1	75	2893	4.6	—	—	—	—	217 030	10 070	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10 070
	2	84	431	24.0	—	—	36 200	8 594	—	—	—	124	277	166	—	—	66	34	—	—	—	—	—	—	—	—	8 942
	3	90	9		829	3288	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3 288
total:		249			829	3288	36 200	8 594	217 030	10 070	—	124	277	166	—	—	66	34	—	—	—	—	—	—	—	—	22 300
1970	1	75			—	—	32 795	7 794	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7 794
	2	84			—	—	441	215	353 600	12 845	—	242	—	—	1045	63	—	—	—	—	—	—	—	—	—	—	13 365
	3	90			—	—	43 254	9 013	—	—	—	675	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9 688
total:		249			—	—	76 490	17 022	353 600	12 845	—	917	—	—	1045	63	—	—	—	—	—	—	—	—	—	—	30 847
1971	1	75	4500	3.5	—	—	—	—	288 500	10 006	—	—	1800	120	—	—	—	—	—	—	—	—	30 000	380	20 000	321	10 827
	2	84	550	21.0	—	—	46 110	9 779	—	—	—	—	1650	990	—	—	—	—	—	—	—	—	—	—	—	—	10 769
	3	90	4500	1.5	—	—	9 000	1 041	342 300	4 335	50 000	2080	—	—	—	—	—	—	—	—	3000	28	—	—	—	—	8 084
total:		249			—	—	55 100	10 820	630 800	14 941	50 000	2080	3450	1110	—	—	—	—	—	—	3000	28	30 000	380	20 000	321	29 680

A = number of ponds; B = area of the pond in cad. acres; C = planted per cad. acre; D = average weight in dkg.

TABLE XIX/a

Recovery statistics of fish during 1964—1971 from the fish-ponds of Zardavár

	A	B	Carp								Recovered material						Tench			Sheat-fish				Pike-perch		White amur		Pike		Crucian carp	Others	Total (without wild fish)
			Class I/b 1.5—2 kg		Class II 1—1.5 kg		Class III 0.6—1 kg		Class IV below 0.6 kg		Mature female		Breeding of 2-summer-old		Fry		Total	above 10 dkg	below 10 dkg	Mat. fem. and for selling		Breeding mature f. and fry		mat. fem. and fry				Above and below 1 kg				
			pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	kg	kg	kg	pc	kg	pc	kg	pc	kg	pc	kg	pc	kg	kg	kg	kg
1964	1	88	—	—	284	349	—	—	—	—	150	602	30 556	10 735	—	—	11 731	643	803	—	—	—	—	90	21	—	—	4050	1093	—	—	14 291
	2	132	—	—	8 223	8 799	14 289	11 044	9 943	5129	—	—	—	—	—	—	24 972	—	108	—	—	1232	1196	—	—	—	—	1410	758	—	—	27 034
	3	142	1 538	2 925	8 225	9 965	7 101	6 126	137	67	72	333	9 460	3 471	6 650	1194	24 081	—	338	—	—	909	672	—	—	—	—	4370	1403	—	—	26 494
total:		366	1 538	2 925	16 732	19 158	21 390	17 170	10 080	5196	222	935	40 016	14 206	6 650	1194	60 784	643	1249	—	—	2141	1868	90	21	—	—	9830	3254	—	—	67 819
1965	1	88	—	—	730	930	1 450	1 070	510	310	—	—	44 090	22 160	6 550	750	24 910	—	96	—	—	500	48	210	20	—	—	—	—	100	350	25 074
	2	132	249	302	7 452	8 759	6 960	5 074	—	—	197	643	660	377	—	—	14 778	210	—	500	824	315	141	280	200	—	—	—	200	—	—	16 230
	3	142	—	—	5 354	6 232	2 170	1 640	—	—	129	747	—	—	14 370	1618	10 994	430	—	121	139	—	—	360	8	—	—	—	775	—	—	12 427
total:		366	249	302	13 536	15 921	10 580	7 784	510	310	326	1390	44 750	22 537	20 920	2378	50 622	640	96	621	981	815	189	850	228	—	—	—	975	100	350	53 731
1966	1	88	5 482	10 387	2 315	3 233	1 310	1 036	—	—	—	—	80 000	24 000	—	—	38 656	300	200	—	—	—	—	—	—	—	—	—	—	—	—	39 156
	2	132	6 060	11 925	21 300	31 059	9 450	8 520	—	—	—	—	18 000	7 398	—	—	58 902	120	—	300	424	400	252	250	137	—	—	—	16	100	50	59 851
	3	142	2 193	3 439	13 188	15 592	10 782	8 593	1 550	734	—	—	21 392	9 828	—	—	38 186	—	—	—	—	—	—	—	—	—	—	—	443	13	—	38 629
total:		366	13 735	25 751	36 803	59 884	21 542	18 149	1 550	734	—	—	119 392	41 226	—	—	135 784	420	200	300	424	400	252	250	137	—	—	—	459	113	50	137 636
1967	1	88	490	784	1 771	2 245	755	755	88	46	1300	3350	84 440	26 830	—	—	34 010	—	710	—	—	—	—	—	—	—	—	—	—	—	889	34 720
	2	132	1 000	1 800	10 000	14 000	15 000	14 400	—	—	—	—	4 000	1 800	—	—	32 000	992	200	200	300	—	—	220	200	—	—	10	8	—	—	33 700
	3	142	—	—	—	—	—	—	—	—	1200	3500	27 000	39 000	—	—	42 500	1500	1500	—	—	—	—	—	—	—	—	—	—	—	—	45 500
total:		366	1 490	2 584	11 771	16 245	15 755	15 155	88	46	2500	6850	358 440	67 630	—	—	108 510	2492	2410	200	300	—	—	220	200	—	—	10	8	—	889	113 920
1968**	1	88	—	—	7 000	5 000	—	—	—	—	80	500	11 000	21 000	—	—	26 500	400	800	—	—	—	—	—	—	—	—	—	—	—	—	27 700
	2	132	235	268	8 620	5 831	—	—	—	—	366	1565	62 460	23 144	100 000	1006	31 814	—	1030	11	27	288	135	20	25	733	2821	38	15	—	—	35 867
	3	142	—	—	—	—	—	—	—	—	668	1583	103 140	35 135	—	—	36 718	—	—	—	—	340	212	10	9	—	—	—	—	—	516	36 939
total:		366	235	268	15 620	10 831	—	—	—	—	1114	3648	275 600	79 279	100 000	1006	95 032	400	1830	11	27	628	347	30	34	733	2821	38	15	—	516	100 506
1969			—	—	—	—	—	—	—	—	—	—	73 200	18 300	—	—	18 300	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18 300
	1	75	359	382	320	251	—	—	—	—	89	298	32 800	7 883	—	—	8 814	—	—	120	87	—	—	—	—	—	—	100	52	—	760	8 953
	2	84	14 204	18 677	10 090	8 317	—	—	—	—	—	—	9 536	3 783	—	—	30 777	—	—	250	401	—	—	150	63	—	—	348	613	229	—	31 854
	3	90	127	576	—	—					554	2074	441	215	22 700	706	3 571	—	152	—	—	—	—	—	—	—	—	1070	476	—	12	4 199
total:		249	14 690	19 635	10 410	8 568	—	—	—	—	643	2342	115 977	30 181	22 700	706	61 462	—	152	370	488	—	—	150	63	—	—	1518	1141	229	772	63 306
1970	1	75	3 016	3531	15 697	10 786	9 170	3 962	—	—	—	—	—	—	23 100	549	18 828	—	180	1	6	—	—	629	290	—	—	60	51	—	—	19 355
	2	84	—	—	—	—	—	—	—	—	—	—	197 240	41 014	—	—	41 014	—	802	—	—	806	635	100m	124m	—	—	540	437	1012	—	43 012
	3	90	490	578	11 524	8 663	18 610	7 745	—	—	—	—	—	—	167 200	3328	20 314	—	1407	—	—	17	32	1379	207	—	—	8	8	—	—	21 968
total:		249	3 506	4 109	27 221	19 449	27 780	11 707	—	—	—	—	197 240	41 014	190 300	3877	80 156	—	2389	1	6	823	667	2108	621	—	—	608	496	1012	—	84 335
1971	1	75											159 400	19 053			19 053	7860	628	24	9	1050	720	730	70	28 420w 12 720Sp	7254 5148	350	60			32 978

Notes: ** = estimated values; w = white grass-carp; Sp. = spotty grass-carp, breeding; m = mature female for selling (see pike-perch in 1970)

White and spotty grass-carp: their growth could not be followed by means of samplings because of their motility, only the data of planting and recovery could be used. Grass-eating fishes were first introduced in pond No. 1 in 1971 and this action proved to be of surprisingly successful result. Considering the very high value of the coefficient of the body-weight increase ($G_w = 5.9994$) of the grass-carp, surpassing by far all other fish species, it can be regarded as the most suitable for the given circumstances. Apart from its quick growth, even the low rate of mortality (10.4 percent) is advantageous, the survival is 89.6 percent. It reached a body weight of about 8—10-times higher than the average weight at planting by the end of the first year, and the body length of 4—5 cm increased to 27—32 cm. There was no observation at our disposal regarding the behaviour of this species in sewage-water ponds, thus, further investigation is needed to determine the number of individuals of maximal planting.

The spotty grass-carp proved to be also of successfully plantable and quickly increasing species, although it does not the former in any respect. The coefficient of increase in body weight was $G_w = 3.2325$, the rate of mortality was about 60 percent, accordingly the survival was only 40 percent.

Sheat fish: The coefficient indicating the growth of body weight ($G_w = 4.6614$) was between those of the two grass-eating species, however, its mortality was higher (66 percent). From the flesh-production point of view in waste-stabilization ponds this species is insignificant.

d) The reasons for the high mortality of fishes in the pond of Zardavár

Among the data of pond No. 1 investigated in more details, the high, yearly changing rates of mortality of planted carps, first of all of fry are especially conspicuous. Because of its importance, this problem should be more thoroughly analyzed.

On the basis of home literary data (VÁMOS et al., 1963) it is known that the mass destruction of fish was observed in the ponds having an acidic, boggy bottom extremely rich in organic substances. Hydrogensulphide can easily be formed in those waters during the summer season. This compound is not formed from the protein decomposition but as a result of activity of sulphate-reducing bacteria in the mud. The initial point of the process is the fermentation of the plant residues (cellulose) in the mud, offering the hydrogen and the organic substances for the reduction processes transforming the sulphate ion into hydrogensulphide.

The H_2S in the water forms ferrous-sulphide (FeS) as long as the water contains dissolved iron, and in the form of a black deposit it is sedimented at the bottom. If the water layer above the mud contains O_2, the FeS will be oxidized (rost-brown colour). What is more, under oxidative circumstances there exist the possibility that the H_2S could be transformed into untoxic elementary sulphur.

If anaerobic conditions prevail at the bottom, the redox-level increases from the mud into the water. In such cases the amount of molecular hydrogen represents one of the main factors of the intense activity of the sulphate-reducing bacteria.

If the prolonged warm weather is followed abruptly by a cool period, the oxygen content of the cool water increases in pressing down the redox-level. As a consequence, the reductive layer having been so far anaerobic, abruptly becomes aerobic and quick processes of oxidation will start resulting in the formation of sulphuric acid which liberates H_2S.

The formation of H_2S is usually accompanied by algal bloom, mainly by a blue-green alga due to increased respiration induced by H_2S, as a consequence of which their specific weight decreases and they will rize to the surface.

The chemical analyses of mud and water of pond No. 1 prove (the extremely high organic substance-, iron- and sulphate-content of the mud, the periodically occurring oxygen-shortage at the mud-surface) that the mud and water of that pond are inclined to form H_2S, since all the factors of sulphate-reduction are present together. These facts can explain even the high mortality of fishes.

General discussion

When evaluating the results, it should be borne in mind that they were obtained only during one year. The relations and phenomena observed cannot be applied without any further restrictions to other seemingly identical aqueous biotopes.

Pond No. 1 analyzed in details represents a biotope rich in organic substances, nitrogen and phosphorous, having a boggy bottom. The investigation of the planktonic biomass indicates that during the summer season when the loading with sewage-water is of the highest rate, the biomass of blue-green algae predominates (Anabaena bloom). In spite of the good N and P supplies, the water of the pond is poor in natural fish-food (Chironomida, Tubifex, Crustacea plankton, etc.) because of the reductive processes taking place at the water-mud interface and the boggy mud of disadvantageous structure.

On the basis of parameters of production of several years, the growth and production of carps in pond No. 1 was lower than even the values obtained in the fish-ponds of medium production. The rate of mortality of carps especially of the fry was very high, although it varied annually. That rate was much lower in case of second-summer carps, however, nevertheless the value of 15—20 percent represents a considerably loss. The high mortality can probably be explained by the locally formed hydrogensulphide. Namely, H_2S induced a mass destruction of fish in that pond during the early sixties. Certain amount of detergents may also get in into the pond and cause destruction. The reasons of the slow development of carps can be searched mainly in the poor bottom-fauna and zooplankton.

The grass-carp first planted in 1971 showed the highest productivity on the basis of both the rate of growth and the low mortality. The quick growth can be explained not only by the large amount of phytoplankton and its consumption but also by the utilization of the boggy bottom and its fauna (meiobenthos) being useless or inaccessible for the other fish species (carp, tench). The observations of soviet researchers prove that the grass-carp develops extremely well in ponds of boggy bottom where there is no firm flora. The intestinal content of fish included peat occasionally up to 80 percent. Using a mixed plantation, the rate of feeding of the carp indicates no considerable consumption of carp-feed by the grass-carps. On the basis of that observation, it seems to be likely that the grass-carps planted into pond No. 1 were feeding to a considerable extent on peat and its fauna apart from the phytoplankton. Home experiences proved that in the ponds where a nearly optimal plantation of grass-eating fishes was applied, the increase of production could be reached without any essential increase of dunging and feeding, i.e. first of all the natural production increased. The natural production of carps based mainly on the protein of zooplankton does not limit the plantation with grass-eating fishes even when considering economical points of views. Apart from the poorness of the pond investigated in proteins of animal origin, the condition is of special significance that the mass-production of phytoplankton representing the main food for the grass-eating fishes is greatly enchanced by the duck-cultivation and post-purification of sewage-waters carried out in the pond. Considering that under such conditions the carp produces flesh only according to the rate of feeding, it is in a disadvantageous position as against to the grass-eating fish, therefore, its maintenance in that pond is uneconomic. One of the aims of our investigations was even the selection of the suitable species of fish. On the basis of our observations and the data of production we are convinced that for the utilization of sewage-waters in fish-ponds, the white grass-carp are the most suitable. Beside the disadvantageous morphometric and soil-characters of the pond, the role of the grass-eating fishes is underlined by the fact that they need no animal proteins except in the first several months of their life and even during that period hardy or not at all, therefore, they do not load the natural ability of the pond for carp-production. In the case of the white grass-carp, the ability of the pond to produce algal plankton can be intensified almost without limitation even beside duck-cultivation and supply with sewage-water of suitable mixture, as long as it does lead not to the worsening of the water quality and to the lowering of the oxygen-supply. The relationships of the optimal density of population and the load with sewage-water, representing the keyproblems of the post-purification of sewage-waters by fish-ponds, will be studied in experimental waste-stabilization ponds during the following years (and a final evaluation will be given only on the basis of those future experiments).

Summary

1. The distribution of the total planktonic biomass is uneven in the transversal section of pond No. 1, namely it is about 4—7 percent lower in the vicinity of the inflow of sewage-water than at other places.

2. The zooplankton plays a secondary role in the planktonic community during the warm-water period as compared to the algal biomass.

3. The almost complete absence of Daphnia species as well as the se condary role of the other Cladocera during the summer season indicate a limited transfer of the algal biomass increased by the sewage-water along the food-chain.

4. On the basis of the bacterial biomass, pond No. 1 can be classified to be of high productivity and medium loading.

5. The boggy soil of the pond is rich in organic substances (N, P_2O_5) iron and sulphate ions. There exist a danger of the formation of H_2S because of the O_2-shortage at the mud-surface during summer.

6. The data of production of the ponds testify that carp-production is generally high and apart from the varying mortality, it depends on the quantity and quality of the fishes planted as well as on the feeding. Pond No. 1 but the other two also are qualified to be of medium or low productivity.

7. The rate of growth of different fishes varied in pond No. 1; the increase of body weight and length of carp lagged that of other fishes. Its mortality was high, survival rate was low.

8. The slow growth of carp can be explained by the poorness of the natural food of animal origin.

9. The white and spotty grass-carps consuming algae and small benthic animals displayed intense growth, showed a lower mortality and the best adaptation to the given circumstances.

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LIMNOLÓGIAI VIZSGÁLATOK EGY BALATON MELLETTI SZENNYVIZES HALASTÓBAN I.

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Összefoglalás

1. A teljes plankton biomassza megoszlása az 1. sz. tó keresztmetszetében egyenetlen, a szennyvízbeömlését körülvevő vízterületen 4—7%-kal kisebb, mint egyéb helyeken.

2. A plankton társulásban meleg víz idején a zooplankton alárendelt szerepet játszik az alga-biomasszához képest.

3. *Daphnia* fajok szinte teljes hiánya, valamint a többi Cladocera alárendelt szerepe a nyári időszakban, azt jelenti, hogy a szennyvíz által megemelt alga-biomasszának a továbbjutása a tápláléklánc mentén korlátozott.

4. A bakterioplankton biomasszája alapján az 1. sz. tó nagy produktívitású, közepesen terhelt tavak közé sorolható.

5. A tó tőzeg talaja szerves anyagban (N, P_2O_5), vas- és szulfátionban gazdag. Nyáron az iszap felszínén fellépő O_2 hiány miatt a kénhidrogén képződésének veszélye fennáll.

6. A halastavak termelési adatai arról tanúskodnak, hogy a ponty-produkció általában magas és változó mortalitás mellett mindenkor a telepített halanyag mennyiségétől, minőségétől, valamint a takarmányozástól függ. Az 1. sz. — de a két másik tó is — közepes vagy alacsony produktívitású tónak minősül.

7. Az 1. sz. szennyvízoxidációs tóban az egyes halfajok növekedési sebessége eltérő, a ponty testhossz és testsúlygyarapodása egyaránt elmarad egyéb halastavi adatoktól. Mortalitása magas, életben maradási százaléka alacsony.

8. A ponty lassú növekedésének oka a természetes, állati eredetű táplálék szegénysége.

9. A fehér és pettyes busa mint az algák és apró iszaplakó állatok fogyasztói intenzív növésű, alacsonyabb mortalitású, az adott körülményekhez legjobban alkalmazkodó fajok.