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SEASONAL DYNAMICS OF PELAGIC ROTIFERS OF LAKES PEIPSI-PIHKVA AND VÕRTSJÄRV

The area of L. Võrtsjärv is 270 sq. km, the area of L. Peipsi-Pihkva 3,550 sq. km. The latter consists of three different parts: the northern part L. Peipsi (2,670 sq. km in area), the southern part L. Pihkva (710 sq. km) and narrow L. Lämmijärv (170 sq. km), connecting the two larger parts.

Hydrobiologically, the investigated lakes belong to moderately eutrophic water bodies. The most eutrophic one is L. Võrtsjärv, being followed by L. Pihkva, L. Lämmijärv and L. Peipsi in this sense. L. Peipsi has preserved some characteristics of mesotrophic lakes.

The article is based on 1,003 quantitative samples of zooplankton taken from the pelagic part of Lakes Peipsi-Pihkva and Võrtsjärv in 1965 and 1966, the whole year round.

70 taxons of rotifers were found in pelagic regions of the investigated lakes: of them 60 taxons in L. Peipsi-Pihkva (43 in L. Peipsi, 33 in L. Lämmijärv, 40 in L. Pihkva) and 34 in L. Võrtsjärv (Table 1). No species of *Synchaeta* were identified in L. Võrtsjärv. *Ploesoma* sp. is a new taxon, preparations for the description of which are in progress.

The greatest number of species of rotifers occurs in July (37), followed by September (34), May (34) and October (31), while January comes last (9). The maximum number of species per month forms 55.8 per cent of the total number of species found in L. Peipsi. The corresponding figure for L. Lämmijärv is 57.5, 55.0 for L. Pihkva and 58.8 for L. Võrtsjärv. In the case of rotifers, differences in this index between lakes are much less than in other groups of zooplankton. The ratio of the minimum and maximum number of species is as follows: 1 : 4 for L. Peipsi, 1 : 3 for L. Lämmijärv, 1 : 4 for L. Pihkva and 1 : 3 for L. Võrtsjärv. In L. Pihkva and L. Võrtsjärv the number of species is maximal not in July (as in L. Peipsi and L. Lämmijärv) but in May and September. The reason lies in the small depth of these lakes and, perhaps, in their higher trophy, which causes the disappearance of some thermophobe rotifers (e. g., *Synchaeta*) from plankton in midsummer.

As for the frequency of occurrence, it is 100 per cent in the case of *Keratella cochlearis* and *Kellicottia longispina*, i. e., they have been found in all the lakes every month. Almost the same can be said of *Keratella guadrata* which is absent only in the samples taken from L. Lämmijärv in March. *Asplanchna priodonta, Bipalpus hudsoni, Conochilus unicornis* and *Synchaeta* sp. may be considered as very frequent (frequency of occurrence over 50%) in all the four lakes. *Polyarthra dolichoptera* is very frequent in L. Peipsi-Pihkva only, *Filinia limnetica, Filinia longiseta,*

Table 1

List of species

Species	L. Peipsi	L. Lämmijärv	L. Pihkva	L. Võrtsjärv
1	2	3	4	5
Rotatoria				
Asplanchna herricki (Guerne)				×
Asplanchna priodonta Gosse	×	×	×	×
Bipalpus hudsoni (Imhof)	×	×	×	×
Brachionus angularis Gosse			×	×
Brachionus angularis bidens Plate			×	
Brachionus calyciflorus Pallas			×	
Brachionus calyciflorus anuraeiformis Brehm			×	
Brachionus calyciflorus calyciflorus Pallas			×	
Brachionus diversicornis Daday	×			
Cephalodella sp.				×
Conochilus hippocrepis (Schrank)	×	×	×	
Conochilus unicornis Rousselet	×	×	×	×
Encentrum sp.	×	×	×	
Euchlanis dilatata lucksiana Hauer	×	×	×	×
Euchlanis dilatata uniceta Leydig		×		
Euchlanis incisa Carlin		×		
Euchlanis proxima Myers				×
Filinia limnetica (Zacharias)	×	×	×	×
Filinia longiseta (Ehrenberg)	×	×	×	×
Filinia terminalis (Plate)	×	×		×
Gastropus stylifer Imhof	×			×
Kellicottia longispina Kellicott	×	×	×	×
Keratella cochlearis Gosse	×	×	×	×
Keratella cochlearis macracantha (Lauterborn)		×		
Keratella hiemalis Carlin	×	×	×	×
Keratella quadrata O. F. Müller	×	×	×	×
Keratella quadrata frenzeli (Eckstein)	×			
Keratella quadrata quadrata O. F. Müller	×			
Lecane closterocerca (Schmarda)				×
Lecane luna (O. F. Müller)		×		×
Lophocharis sp.				×
Mytilina mucronata (O. F. Müller)				×
Notholca acuminata (Ehrenberg)				×
Notholca caudata Carlin			×	×
Notholca cinetura Skorikov	×	×	×	
Notholca foliacea (Ehrenberg)	×		×	×
Notholca labis Gosse			×	
Notholca squamula (O. F. Müller)	×		×	×
Notholca squamula frigida Jaschnov		×		
Notholca striata (O. F. Müller)				×
Ploesoma truncatum (Levander)	×	×	×	
Ploesoma sp.	×		×	
Polyarthra dissimulans (Nipkow)	×	×	×	×
Poluarthra dolichoptera Idelson	×	×	×	×
Polyarthra euryptera Wierzejski	×			
Polyarthra longiremis Carlin	×			
Polyarthra luminosa Kutikova	×	×	×	×
Polyarthra major Burckhardt	×	×	×	
Polyarthra minor Voigt				×
Polyarthra remata Skorikov				×
Polyarthra vulgaris Carlin	×	×	×	×
Pompholyx sulcata Hudson			×	
Synchaeta grandis Zacharias			×	
Synchaeta kitina Rousselet	×			
Synchaeta pectinata Ehrenberg			×	
Synchaeta tremula (O. F. Müller)	×			

Table 1 (continued)

1	2	3	4	5
Synchaeta sp.	×	×	×	×
Trichocerca bicristata (Gosse)	×			
Trichocerca capucina (Wierzejski et Zacharias)	×	×	×	×
Trichocerca cylindrica (Imhof)	×	×	×	
Trichocerca porcellus (Gosse)	×	×	×	
Trichocerca porcellus major Hauer	×			
Trichocerca pusilla (Lauterborn)		×		
Trichocerca rattus (O. F. Müller)	×	×	×	
Trichocerca similis (Wierzejski)	×		×	
Trichocerca stenroosi Wulfert	×			
Trichocerca tenuior (Gosse)	×			
Trichocerca weberi (Jennings)	×	×		
Trichotria pocillum (O. F. Müller)	×	×	×	
Trichotria tetractis (Ehrenberg)			×	×

Gastropus stylifer, Notholca squamula, Polyarthra dissimulans, Trichocerca capucina — only in L. Võrtsjärv.

A. Mäemets (1966) identified 22 taxons of rotifers in L. Peipsi-Pihkva (pelagic + littoral zone). R. Levander (Mühlen, Schneider, 1920) found 24 species of rotifers in L. Võrtsjärv.

In the Byelorussian Chervonnoye lake, 23 species of rotifers were found in 1954 and 20 in 1955 (Черемисова, 1958). The biggest number of rotifers in Estonian lakes has been stated in L. Tamula (27), L. Verevi (25), L. Vagula (23) and L. Pühajärv (24) (Eesti järved, 1968). In L. Ladoga as many as 200 taxons of rotifers have been found (Деньгина, Соколова, 1968), while the maximal number for L. Onega has been but 36 (Смирнова, 1972).

The regularity of the seasonal dynamics of groups depends on the seasonal dynamics of the main species in the group. If thermophilic species are dominating, as in the case of cladocerans, the seasonal dynamics of the group is regular and the yearly differences are small. Among rotifers, the thermophobe and biseasonal species are also of great importance. Due to that, the seasonal dynamics of the group as a whole is rather irregular and yearly different.

The dynamics of the number is considerably more distinct than that of the biomass. The maximum of the number, obviously depending on the

Table 2

Number of rotifers, ind./m³

Month	L. Peipsi		L. Lämmijärv		L. Pihkva		L. Võrtsjärv	
	1965	1966	1965	1966	1965	1966	1965	1966
I	—	2 200	—	14 700	—	24 700	17 000	6 100
II	9 700	4 300	34 600	17 300	35 200	31 200	11 900	2 300
III	6 900	7 600	8 500	11 700	6 900	9 600	7 600	1 700
IV	7 000	9 300	21 000	—	9 300	—	25 100	109 600
V	14 000	28 600	43 100	66 100	42 600	69 200	144 400	552 800
VI	42 600	65 800	80 700	43 100	206 700	153 300	230 100	143 900
VII	86 400	81 600	113 000	73 100	132 900	120 200	36 800	92 400
VIII	—	—	—	—	—	—	14 100	22 200
IX	30 900	—	8 600	—	33 800	—	14 800	13 100
X	9 000	11 400	4 900	1 100	10 900	2 900	20 700	5 300
XI	—	—	—	—	—	—	16 800	8 100
XII	—	—	—	—	—	—	9 900	5 300

rate of the warming-up of water in spring, occurs in L. Peipsi and L. Lämmijärv in July, in L. Pihkva — in June, and in L. Võrtsjärv either in May or June. The minimal number of rotifers occurs in autumn or winter months, mostly in March and October (Table 2). The maximum of biomass in all the lakes in 1966 was observed in May, while in 1965 it was July for L. Peipsi, February for L. Lämmijärv, October for L. Pihkva and November for L. Võrtsjärv (Table 3). The irregularity of the occurrence of the maximum is obviously caused by the temporary abundant occurrence of species of big size (genus *Asplanchna*). Similarly to the number, the minimum of biomass also occurs in autumn or winter months. In comparison with other groups of zooplankton, rotifers prove to stand winter best of all. Their number and biomass in winter are, as a rule, the biggest.

Rotifers are most numerous in L. Võrtsjärv; L. Pihkva follows, while L. Lämmijärv and L. Peipsi are more or less equal in this respect. As regards biomass, the order is the same, but here L. Peipsi is clearly the last. It seems that the biggest numbers and biomasses reflect rather distinctly the trophy of the lake.

In the years when temperature conditions are usual, the maximum biomass of rotifers in the investigated lakes occurs in May. After May it decreases, increasing again in July, towards the autumn. In such years the maximum of the number either coincides with that of the biomass (L. Võrtsjärv) or it occurs a month or two later (L. Peipsi-Pihkva).

The maximal occurrence of rotifers in early summer is a well known phenomenon (Carlin, 1943; Michael, 1968). Then there begins a decrease in the number and biomass towards the autumn or winter minimum (Печюлене, 1968, Смирнова, 1969). In some water bodies there is a slight increase in biomass in autumn (Щербаков, 1957). Naturally, the maxima of rotifers in different bodies of water occur at different times. It is not excluded that the time of the maximum of the number and that of the biomass do not coincide in one and the same body of water, since biomass often depends on the species of big weight which do not predominate in the number (Волков, 1965). The temporary abundant occurrence of such species, esp. *Asplanchna priodonta*, brings about irregular changes in the biomass of rotifers in Estonia (Table 3, 1965; Haberman, Mäemets, 1973) as well as elsewhere (Herbst, 1961; Nauwerck, 1963).

A sharp rise to the spring-summer maximum and the following fall to

Table 3

Biomass of rotifers, g/m^2

Month	L. Peipsi		L. Lämmijärv		L. Pihkva		L. Võrtsjärv	
	1965	1966	1965	1966	1965	1966	1965	1966
I	—	0.010	—	0.069	—	0.131	0.070	0.043
II	0.043	0.018	0.148	0.075	0.122	0.136	0.045	0.014
III	0.027	0.032	0.026	0.015	0.021	0.036	0.016	0.003
IV	0.018	0.031	0.057	—	0.009	—	0.059	0.763
V	0.040	0.082	0.063	0.304	0.184	0.275	0.153	1.914
VI	0.052	0.063	0.076	0.026	0.188	0.091	0.183	0.150
VII	0.075	0.062	0.094	0.053	0.149	0.210	0.037	0.289
VIII	—	—	—	—	—	—	0.054	0.096
IX	0.033	—	0.006	—	0.095	—	0.181	0.035
X	0.019	0.029	0.037	0.001	0.282	0.001	0.156	0.015
XI	—	—	—	—	—	—	0.204	0.032
XII	—	—	—	—	—	—	0.084	0.013

the autumn-winter minimum seems to be a general rule. Such a dynamics of rotifers is due to their biological qualities. 1. In comparison with other groups, rotifers reach sexual maturity most quickly (Elgmork, 1959), thus being able to reach the maximum before the others, as well. 2. The rise of temperature in spring is sufficient for the intensive reproduction of many species of rotifers, while it is too low for cladocerans. 3. For rotifers, cladocerans are rivals for food and at the time of their mass occurrence, the latter, as a rule, suppress rotifers (Мануйлова, 1964). During the maximal occurrence of rotifers, the thermophilic cladocerans are not numerous. Thus, the dynamics of rotifers may be regarded as an adaptation of the group to the dynamics of the zooplankton as a whole, by forming a sort of a "seasonal niche". 4. In the spring, in the case of several mass species of rotifers, the number of eggs per specimen as well as the percentage of females with eggs in the population are higher than during the other seasons (Wiktor, 1968). A higher fecundity of the first generations, as compared with the following ones, is a feature characteristic of the whole zooplankton.

Nevertheless, a few species of rotifers have gained a somewhat greater autonomy in respect to the rest of the biocoenosis in comparison with the whole group. For example, *Asplanchna priodonta* does not fully participate in the competition for food due to its predatory way of life. On the other hand, by means of certain adaptations (e. g., transparency) it has decreased the elimination of fishes (Hillbricht-Ilkowska, 1963). Rises of such independent species are difficult to prognosticate, and they seem to be irregular. According to data from literature, periods of mass development of *Asplanchna* cannot be foreseen very exactly, and they may occur at different times during a year (Пидгайко, 1957). The biomass of *Asplanchna* may also have great yearly differences (Петрович, 1969).

Comparing the studied years on the basis of the amplitudes of fluctuations in the number and biomass, it turns out that in the warm summer of 1966 the maximum number of rotifers in L. Peipsi-Pihkva was lower, in L. Võrtsjärv higher than that of 1965, while the maximum biomass in the warm 1966 was higher in all the lakes. The minima in 1966 were clearly lower than those of 1965 (Table 4). The amplitude of fluctuation of both the number and biomass was considerably greater in 1966, especially in L. Võrtsjärv. Comparing the amplitude of fluctuation of the number with that of biomass, we can state that in 1965 the number fluctuates more than the biomass, while in 1966 the situation was a contrary one.

The rate of the variability of the number of rotifers is clearly highest in L. Võrtsjärv. L. Pihkva-L. Peipsi and L. Lämmijärv follow. As regards biomass, the rate is highest in L. Võrtsjärv again. L. Pihkva and L. Lämmijärv follow, being more or less equal in this respect. The variability of the biomass of rotifers in L. Peipsi is so small that it does not even reach the rate of 1 mg/full day. The highest increases in the number of rotifers occur in April and May in L. Võrtsjärv, May and June in L. Peipsi-Pihkva while in L. Lämmijärv and L. Peipsi they may sometimes occur in June and July. As for the highest increase in biomass, the time coincides with that of the number in L. Võrtsjärv, while in the other lakes the time is rather accidental (Tables 5—10). Unlike cladocerans, the rate of the decrease in the number and biomass of rotifers often exceeds that of their increase. The reason obviously lies in the fast rise in the number and, consequently, in the rivalry of the other groups of zooplankton.

Unlike the other groups whose instability is indirectly proportional to the depth of the lake, rotifers are rather stable even in the shallowest

Table 4

Maximal and minimal numbers and biomasses of rotifers

Data	Year	L. Peipsi Absolute numbers	L. Peipsi Max/Min	L. Lämmijärv Absolute numbers	L. Lämmijärv Max/Min	L. Pihkva Absolute numbers	L. Pihkva Max/Min	L. Võrtsjärv Absolute numbers	L. Võrtsjärv Max/Min
Number, ind./m³	1965	6 900—86 400	12.5	4 900—113 000	23.0	6 900—206 700	30.0	7 600—230 100	30.2
	1966	2 200—81 600	37.1	1 100— 73 100	66.4	2 900—153 300	52.9	1 700—552 800	325.2
Biomass, g/m³	1965	0.018—0.075	4.2	0.006—0.148	24.7	0.009—0.282	31.3	0.016—0.204	12.7
	1966	0.010—0.082	8.2	0.001—0.304	304.0	0.001—0.275	275.0	0.003—1.914	638.0

Ratio of maximum and minimum — Max/Min.

Table 5

Rate of variability of number of rotifers, ind./day

Lake	Year	I	II	III	IV	V	VI	VII	IX	X
Peipsi	1965	—	−93	+3		+233	+953	+1460	−925	−730
	1966	+70	+110		+350		+1240	+527	−780	
Lämmijärv	1965	—	−870	+417		+737	+1253	+1077	−1740	−123
	1966	+87	−187		+907		−767	+1000	−900	
Pihkva	1965	—	−943	+80		+1110	+5470	−2460	−1652	−763
	1966	+217	−720		+993		+2803	−1103	−1303	
Võrtsjärv	1965	—	−143	+583		+3977	+2857	−6443	−367	+197
	1966	−127	−20		+9185		−13 630	−1717	−968	

Table 6

Rate of variability of number of rotifers, % of biggest growth

Lake	Year	I	II	III	IV	V	VI	VII	IX	X
Peipsi	1965		−6.4	+0.2	+15.9	+65.3	+100.0	−63.4		−50.0
	1966	+5.6	+8.9		+28.2	+100.0	−42.6		−62.9	
Lämmijärv	1965		−50.0	+23.9	+42.4	+72.0	+61.9	−100.0		−7.1
	1966	+8.7	−18.7		+90.7	−76.7	+100.0		−90.0	
Pihkva	1965		−17.2	+1.5	+20.3	+100.0	−45.0	−30.2		−13.9
	1966	+7.7	−25.7		+35.4	+100.0	−39.3		−46.5	
Võrtsjärv	1965		−2.1	+9.0	+61.7	+44.4	−100.0	−5.7		+3.1
	1966	−0.9	−0.1		+67.3	−100.0	−12.6		−7.1	

Table 7

Degree of fluctuation of number of rotifers, % of biggest growth in comparison with previous month

Lake	Year	II	III	IV	V	VI	VII	IX	X
Peipsi	1965		6.6	15.7	49.4	34.7	163.4		13.4
	1966	3.3		19.3	71.8	142.6		20.3	
Lämmijärv	1965		73.9	18.5	29.6	10.1	161.9		92.9
	1966	27.4		108.4	167.4	176.7		190.0	
Pihkva	1965		18.7	21.8	78.7	145.0	14.8		16.3
	1966	33.4		61.1	64.6	139.3		7.2	
Võrtsjärv	1965		11.1	52.7	17.3	144.4	94.3		8.8
	1966	0.8		67.4	167.3	87.4		5.6	

Table 8

Rate of variability of biomass of rotifers, mg/day

Lake	Year	I		II		III		IV		V		VI		VII		IX		X
Peipsi	1965		—		−0.5		−0.3		+0.7		+0.4		+0.8		−0.7		−0.5	
	1966		+0.3		+0.5			+0.8			−0.6		0			−0.4		
Lämmijärv	1965		—		−4.1		+1.0		+0.2		+0.4		+0.6		−1.5		+0.5	
	1966		+0.2		−2.0			+4.8			−9.3		+0.9			−0.6		
Pihkva	1965		—		−3.4		−0.4		+5.8		+0.1		−1.3		−0.9		+6.2	
	1966		+0.2		−3.3			+4.0			−6.1		+4.0			−2.3		
Võrtsjärv	1965		—		−1.0		+1.4		+3.1		+1.0		−4.9		+2.4		−0.8	
	1966		−1.0		−0.4			+31.9			−58.8		+4.6			−3.0		

Table 9

Rate of variability of biomass of rotifers, % of biggest growth

Lake	Year	I		II		III		IV		V		VI		VII		IX		X
Peipsi	1965		—		−62.5		−37.5		+87.5		+50.0		+100.0		−87.5		−62.5	
	1966		+37.5		+62.5			+100.0			−75.0		0			−50.0		
Lämmijärv	1965				−100.0		+24.3		+4.9		+9.8		+14.6		−36.5		+12.2	
	1966		+2.2		−21.5			+51.6			−100.0		+9.7			−6.4		
Pihkva	1965				−54.8		−6.5		+93.5		+1.6		−21.0		−14.5		+100.0	
	1966		+3.3		−54.1			+65.6			−100.0		+65.6			−37.7		
Võrtsjärv	1965				−20.4		+28.6		+63.2		+20.4		−100.0		+49.0		−16.3	
	1966		−1.7		−0.7			+54.2			−100.0		+7.8			−5.1		

Table 10

Degree of fluctuation of biomass of rotifers, % of biggest growth in comparison with previous month

Lake	Year	II	III	IV	V	VI	VII		IX	X
Peipsi	1965	—	25.0		125.0	37.5	50.0	187.0		25.0
	1966	25.0		37.5		175.0	75.0		50.0	
Lämmijärv	1965	—	124.3		19.4	4.9	4.8	51.1		48.7
	1966	23.7		73.1		151.6	109.7		16.1	
Pihkva	1965	—	48.3		100.0	91.9	22.6	6.5		114.5
	1966	57.4		119.7		165.6	165.6		103.3	
Võrtsjärv	1965	—	49.0		34.6	42.8	120.4	149.0		65.3
	1966	1.0		54.9		154.2	107.8		12.9	

Table 11

Indices of instability of rotifers

Lake	Number			Biomass		
	1965	1966	Average	1965	1966	Average
Peipsi	47.1	51.4	49.2	75.0	72.5	73.8
Lämmijärv	64.5	134.2	99.4	43.2	74.9	59.0
Pihkva	49.4	61.1	55.2	64.0	122.3	93.2
Võrtsjärv	54.6	65.6	60.1	76.8	66.1	71.4

Table 12

Ratio of average biomass (g/m³) of rotifers during the ice-free and ice-cover period

Lake	1965			1966			Average		
	ice-free period	ice-cover period	Ratio	ice-free period	ice-cover period	Ratio	ice-free period	ice-cover period	Ratio
Peipsi	0.044	0.029	1.5	0.059	0.023	2.6	0.051	0.026	2.0
Lämmijärv	0.055	0.077	0.7	0.096	0.053	1.8	0.076	0.065	1.2
Pihkva	0.080	0.051	3.5	0.144	0.101	1.4	0.162	0.076	2.1
Võrtsjärv	0.128	0.054	2.4	0.412	0.018	22.6	0.270	0.036	7.5

Table 13

Average weight of rotifers, mg

Lake	Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Peipsi	1965	—	0.0044	0.0039	0.0026	0.0029	0.0012	0.0009	—	0.0011	0.0021	—	—
	1966	0.0045	0.0042	0.0042	0.0033	0.0029	0.0010	0.0008	—	—	0.0025	—	—
Lämmijärv	1965	—	0.0043	0.0031	0.0027	0.0015	0.0009	0.0008	—	0.0007	0.0076	—	—
	1966	0.0047	0.0043	0.0013	—	0.0046	0.0006	0.0007	—	—	0.0009	—	—
Pihkva	1965	—	0.0035	0.0030	0.0010	0.0043	0.0009	0.0011	—	0.0028	0.0259	—	—
	1966	0.0053	0.0044	0.0038	—	0.0040	0.0006	0.0017	—	—	0.0003	—	—
Võrtsjärv	1965	0.0041	0.0038	0.0021	0.0024	0.0011	0.0008	0.0010	0.0038	0.0122	0.0075	0.0121	0.0085
	1966	0.0070	0.0061	0.0018	0.0070	0.0035	0.0010	0.0031	0.0043	0.0027	0.0028	0.0040	0.0025

Table 14

The role of rotifers (%) in the total number of zooplankton

Lake	Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Peipsi	1965	—	90.7	90.2	83.6	65.4	59.8	24.6	—	24.0	26.2	—	—
	1966	80.8	90.1	92.2	90.4	95.5	65.6	27.2	—	—	22.0	—	—
Lämmijärv	1965	—	84.8	63.8	82.9	80.7	46.4	38.7	—	10.3	5.6	—	—
	1966	83.1	80.6	78.6	—	76.5	29.2	31.6	—	—	1.4	—	—
Pihkva	1965	—	97.3	92.5	100.0	62.8	57.3	23.6	—	13.6	7.4	—	—
	1966	92.5	96.4	85.2	—	70.5	40.4	23.9	—	—	2.0	—	—
Võrtsjärv	1965	85.2	75.5	60.4	51.3	72.0	59.9	12.6	3.9	15.6	19.9	30.1	63.3
	1966	73.4	42.3	47.2	75.5	87.9	44.9	34.3	10.4	9.6	8.7	19.8	48.9

Table 15

The role of rotifers (%) in the total biomass of zooplankton

Lake	Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Peipsi	1965	—	78.2	75.0	60.0	40.8	20.6	2.6	—	3.5	6.6	—	—
	1966	71.4	75.0	84.2	83.8	89.0	23.2	3.8	—	—	5.0	—	—
Lämmijärv	1965	—	84.7	35.1	59.8	50.8	10.0	5.1	—	1.1	5.2	—	—
	1966	77.6	71.0	44.1	—	64.6	3.0	1.9	—	—	0.2	—	—
Pihkva	1965	—	93.8	84.0	100.0	54.8	6.3	5.8	—	5.2	14.4	—	—
	1966	78.2	92.5	72.0	—	57.1	2.0	5.7	—	—	0.1	—	—
Võrtsjärv	1965	85.4	57.7	22.5	28.8	24.1	15.3	2.5	4.0	28.2	22.8	37.0	73.0
	1966	70.5	26.9	12.0	79.5	75.1	13.0	25.2	10.0	4.5	2.8	8.4	15.7

lake under observation — L. Võrtsjärv (Table 11). It seems to be a proof of the suitability of the lake as a habitat for rotifers.

The ratio $\frac{\text{ice-free period biomass}}{\text{ice-cover period biomass}}$ in the case of rotifers (Table 12) is, on the average, higher in L. Võrtsjärv than elsewhere. It was especially obvious in May of 1966. Characteristic of rotifers only is the smallness of the ratio. This means that the difference between the vegetation period and the winter biomass of rotifers is quite small. It happens only among rotifers that the average biomass under ice-cover is higher than that during the ice-free period as was the case in L. Lämmijärv in 1965.

The average weight of rotifers (Table 13) in the investigated lakes is comparatively uniform, with a slight growth tendency towards the increase of trophy (we should consider that the yearly average of L. Pihkva is higher due to the rise of *Asplanchna* in October of 1965). It is conspicuous that yearly differences in the average weight of rotifers in L. Peipsi are much smaller than in the other lakes. The average weight of rotifers is always the smallest in June or July (small *Conochilus unicornis* and *Keratella cochlearis* dominate), and the highest in autumn or winter (species of *Asplanchna* and *Synchaeta* prevail). In the autumn of 1965 rotifers were, as a rule, bigger than in 1966, while the situation in winter and spring was opposite. Probably the above differences were partially caused by differences in the temperature of water.

The role of rotifers in the number of zooplankton as a whole is maximal in the winter and spring. Although in June their role decreases, they are still the dominating group (Table 14). The decrease of the role of rotifers follows, reaching its minimum in the period from August to October. In October-November a new increase begins. Approximately similar is the dynamics of the role of the biomass of rotifers (Table 15), the main difference lying in the fact that the last month of the domination of rotifers as regards biomass is May (it was June in the case of the number), since June coincides with the appearance of big cladocerans whose biomass exceeds that of rotifers considerably. Differences between the lakes as regards the role of rotifers are rather small. One could mention that in winter the role of rotifers in L. Võrtsjärv is smaller than in L. Peipsi-Pihkva. The reason lies in the abundant occurrence of the genus *Synchaeta* (which prefers water with a lower trophy) in the latter. Due to the bigger depth and slower warming-up of L. Peipsi, the role of rotifers in spring is big for a long time. One could suppose an opposite situation in autumn, but it is not so, due to the relative scantiness of cladocerans here (in the other lakes cladocerans are represented abundantly in the autumn); the role of rotifers is big already in early autumn.

Although in winter zooplankton is investigated to a smaller extent, data on the domination of rotifers in winter are sufficient (Arnemo, 1965; Straškraba, 1965). The spring domination has also often been mentioned (Michael, 1968; Almquist, 1970).

Often situations different from ours have been described. In some lakes rotifers dominate all the year round (Щербаков, 1957; Черемисова, 1958). In Georgia the role of rotifers in spring is not big (Мачарашвили, 1963). In L. Seliger rotifers are absent in summer (Ефимова, 1963), which can hardly be true.

In spite of several possible exceptions, the dynamics of the role of rotifers described in L. Peipsi-Pihkva and L. Võrtsjärv seems to be rather typical of lakes in the temperate zone. In spring the role of rotifers is big due to their quick reproduction. The rise of cladocerans and copepods occurs later. When it happens, it causes a decrease in the role of rotifers by summer. The role of rotifers is low as long as the deterioration of conditions of life in autumn causes a decrease of crustaceans. Rotifers and crustaceans, and especially rotifers and cladocerans, are considered as antagonists: the role of rotifers from spring to autumn decreases while that of cladocerans increases. Comparing the absolute indices (Tables 2, 3), we may assume that actual fluctuations in the number and biomass of rotifers are, especially in contrast to cladocerans, much smaller. We could even say that the dynamics of the role of rotifers is caused by changes in the number and biomass of crustaceans.

Data on the factors limiting rotifers are less in number than those about other groups of zooplankton. V. Rylov (1935) has pointed out that rotifers do not stand an elevated sulphate content of water. Some investigators are of the opinion that turbid water constipates their stomachs, obstructs filtration and is thus another limiting factor (Мордухай-Болтовская, 1965). There are also data asserting that in lakes with a very thick mud layer the number of rotifers decreases (Klimowicz, 1967). Rather unfavourable a factor is the oxygen deficit (Nayar, 1965). Still, one should take into consideration that we are comparing rotifers with other groups of zooplankton, not with bacteria. Of zooplankters rotifers are least sensitive to chemical compounds. In water bodies rich in seston they parry other filters feeders (Волков, 1965). Rotifers dominate in rivers where crustaceans never gain any significant role, in various extreme conditions, such as mountain lakes (Ertl, Vranovsky, 1964) and cut-off lakes (Ruse, 1969). In the latter, according to K. Ruse, after amelioration cladocerans will dominate instead of rotifers. B. Pejler (1965) underlines that the euryforms of rotifers are able to adapt themselves much more widely than those of crustaceans. A comparatively high durability enables us to assume that the dynamics of rotifers depends first of all on the abundance of food objects, and not on abiotic factors.

Judging by N. Schönberg's (1958) data, the role of rotifers in L. Võrtsjärv during the recent decades has increased. The reason lies in the increased influence of fish on zooplankton and lower water-levels, which both favour the increase of the role of rotifers.

In the Byelorussian mesotrophic lake Naroch the average biomass of rotifers during 10 years equalled 0.097 while in the eutrophic lake Myastro the corresponding figure was 0.252 g/m^3 (Петрович, 1968). In L. Peipsi the average biomass of rotifers is 0.040, in L. Lämmijärv 0.070, in L. Pihkva 0.129 and in L. Võrtsjärv 0.192 g/m^3.

Different attitudes exist as to the role of rotifers in fishery. One summer old (0+) carps do not use rotifers from the genera *Asplanchna*, *Conochilus*, *Synchaeta* for food (Hillbricht-Ilkowska, 1963). In the Azov Sea, fishes feeding on plankton almost do not use rotifers for this purpose at all and avoid *Asplanchna priodonta* even when fasting (Марковский, 1954). On the basis of analogical facts, a conclusion is drawn that the predominance of rotifers in zooplankton decreases the latter's nutritive value (Комарова, 1969), while the high role of crustaceans increases it. In Estonia rotifers have not proved to be of great value as food for fishes, either (Haberman, 1964, Eesti järved, 1968; Kangur, 1971). Still, it seems that at the initial stage of the feeding of young fishes the importance of rotifers is invaluably great (Кутикова, 1965). These stages in the feeding of fish have simply seldom been studied. We may assume that during the hatching period of the majority of fishes the big role of rotifers is a positive phenomenon, and in summer a negative one.

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PEIPSI-PIHKVA JÄRVE JA VÕRTSJÄRVE PELAGIAALI ROTATOORIDE SESOONNE DÜNAAMIKA

Resümee

Artikkel põhineb 1003 kvantitatiivsel zooplanktoniproovil, mis on kogutud Peipsi-Pihkva järve ja Võrtsjärve pelagiaalist 1965. ja 1966. aastal.

Antakse ülevaade rotatooride liigilisest koostisest (tab, 1), arvukusest (tab. 2), biomassist (tab. 3), miinimumidest ja maksimumidest (tab. 4), arvukuse (tab. 5, 6, 7) ja biomassi (tab. 8, 9, 10) muutlikkuse tempost ja määrast ning labiilsusindeksitest (tab. 11), vegetatsiooniperioodi ja talvise biomassi suhtest (tab. 12), keskmisest kaalust (tab. 13) ja osatähtsusest planktonis (tab. 14, 15).

Eesti NSV Teaduste Akadeemia
Zooloogia ja Botaanika Instituut

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Юта ХАБЕРМАН

СЕЗОННАЯ ДИНАМИКА КОЛОВРАТОК ПЕЛАГИАЛИ ЧУДСКО-ПСКОВСКОГО ОЗЕРА И ОЗЕРА ВЫРТСЪЯРВ

Резюме

Материалом статьи являются 1003 количественные пробы зоопланктона, собранные из пелагиали Чудско-Псковского озера и озера Выртсъярв в 1965 и 1966 гг.

В статье дается обзор: видового состава (табл. 1), численности (табл. 2) и биомассы (табл. 3), минимумов и максимумов (табл. 4), темпа и степени изменчивости численности (табл. 5, 6, 7) и биомассы (табл. 8, 9, 10) и индексов лабильности (табл. 11), соотношения биомассы в вегетационный и зимний периоды (табл. 12), среднего (табл. 13) и удельного веса коловраток в зоопланктоне (табл. 14, 15).

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