Opusc. Zool. Budapest, 2002, 34: 85-94

Seasonal changes in Rotifera assemblages of a shallow lake in the Fertő-Hanság National Park, Hungary

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Abstract. In the framework of hydrobiological studies of an extremely shallow lake, we sampled planktonic Rotifera from five characteristic sites in the lake. Besides the collection of rotifers several abiotic parameters were also recorded at every site on every occasion. We have examined the structure and the seasonal changes of the rotifer assemblages. SYN-TAX 5.1 Multivariate Statistical Program Package also was used to analyse our data. We searched relationships between the parallel measured abiotic parameters and the rotifer community with multivariate analysis. We have found, that the conductivity and the temperature have some effects on the qualitative and quantitative composition of the planktonic rotifer community.

Lake Fehér (Fehér-tó), located in the Hanság region, is a protected wetland habitat of high natural value in the Fertő-Hanság National Park. It is situated in the northwestern part of Hungary (47° 41' N, 17° 21' E) at an altitude of 110 m above sea level, covering 2.69 km², with an average depth of 50 cm. The lake had been intensively used for fish breeding and had been starting to become heavily eutrophic until 1987, when it was placed under legal protection mainly due to its valuable avifauna.

In 1998, the basic hydrobiological survey of the lake was starzted by the Hungarian Danube Research Station of the HAS, including water chemistry, zoological, and botanical investigations (Kiss, 2002). Studying planktonic rotifers, I joined this research project in 1999.

Today, only few researchers work on Rotifera in Hungary, but the previously published literature contains several valuable data. Since the abiotic alterations of shallow (or even temporal) waters are promptly followed by the qualitative and quantitative changes of rotifer assemblages, our results may be applied for the description of similarly unstable standing waters. The aim of our research was to describe the rotifer community of the lake and its seasonal variations by the analysis of rotifer samples and the most significant abiotic parameters at several sites for two years.

MATERIALS AND METHODS

Samples were taken between August 1999 and July 2001 at monthly intervals from 5 (occasionally 7) characteristic sites in the lake, by filtering 20-20 litres of water through a 50 µm-mesh plankton net. The sampling sites represented characteristically different parts of the lake:

No. 102. Border of open water, reed bed and *Typha* bed.

No. 103. Border of open water and reed bed in the northern part of lake.

No. 104. Open water in the middle of lake.

No. 107. Shore end of an artificial channel opening southeast from lake.

No. 304. Thin reed bed in the south-western part of lake.

Samplings always took place in the morning hours. Sampling sites were visited by boat. Two 20-litre samples were collected from the depths of 15-25 cm. One sample was taken to the laboratory; the other was instantly preserved in a 4 % formaldehyde solution. Live specimens were collected to be able to make accurate identification (Varga, 1943).

Live specimens were identified within 4-5 hours (Bancsi, 1986; Koste, 1978). Specimens in

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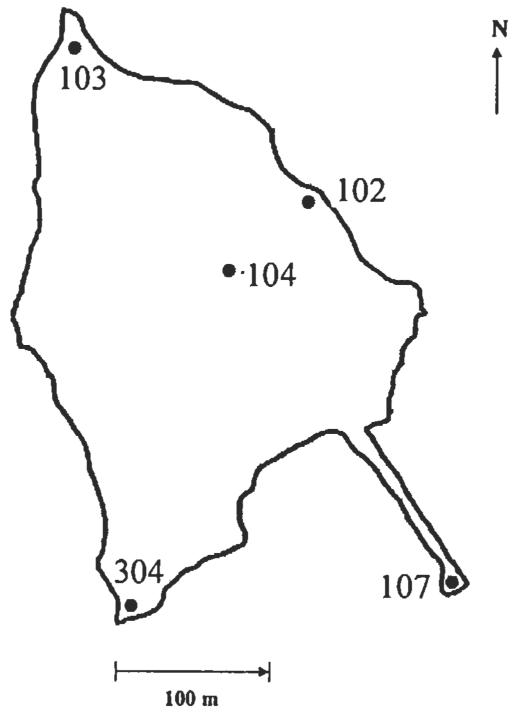

Figure 1. Lake Fehér and the sampling sites

the preserved samples were counted in a Sedgewick-Rafter Chamber, data were expressed as individual per 10 litres and stored in an EXCEL database.

Besides the collections of rotifers, the following abiotic parameters were also recorded with a Multiline-P field device at every site on every occasion: water temperature, pH, conductivity, dissolved oxygen content and oxygen saturation. Air pressure was also measured and weather conditions were noted. Detailed water chemical analyses were carried out on several occasions with a Dionex 120 ion analyser, by Gábor Horváth at the laboratory of the Hungarian Danube Research Station of the HAS. The concentrations of the following ions were examined: F^-, Cl^-, NO_2^-, NO_3^-, PO_4^{2-}, SO_4^{2-}, HCO_3^-, CO_3^{2-} (anions), Li^+, Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+} (kations). Besides these parameters, the amount of suspended solids, total dissolved material, and total dry material were measured, together with alkalinity, hardness, and chemical oxygen demand (analysed by Mónika Gánti, Table 1).

Data analysis

A species list of Rotifera found in Lake Fehér in the study period was compiled, and was compared with literature data from the lake. SYN-TAX 5.1 Multivariate Statistical Program Package was used to analyse our data. Several analyses were run and evaluated with SYN-TAX on the database, to form the final conclusions. However, only few are presented here to demonstrate the processes. Every analysis was run both for objects and variables (Hufnagel, Bakonyi & Vásárhelyi, 1999).

The temporal and spatial comparison of samples was based on both presence–absence and quantitative data. Distance matrix was created using Euclidean Distance. Qualitative data were analysed with and without standard deviation, as well. Ordination was carried out through non-metric multi-dimensional scaling (NMDS). Hierarchic classification was done using unweighted pair group method (UPGMA) within distance optimisation.

***Table 1**. Hydrochemical parameters in Lake Fehér*

Parameters	Sampling dates							
	08.24. 1999	10.25. 1999	02.22. 2000	04.26. 2000	05.30. 2000	06.27. 2000	07.26. 2000	08.28. 2000
Suspended solids (mg/l)	0,012		7,3	1,2	30,0	5,5	4,0	23,0
Total diss. material (mg/l)	0,200			17,0	23,0	31,0	8,0	7,0
Total dry material (mg/l)	0,242							
Alkalinity (W°)	2,61		6,51	7,33	6,7	2,5	1,0	1,3
HCO_3^- (mg/l)	0	300,1	370,9	442,2	408,7	54,9		30,6
CO_3^{2-} (mg/l)	36,78	0	0	0	0	48	24,0	24,1
Total hardness (nk°)	6,94		18,43	20,16	200,1	274,7	57,5	65,4
Ca hardness (nk°)	3,27		10,63	10,2				
Mg hardness (nk°)	3,67		7,80	9,96				
Ca^{2+} content (mg/l)	23,39	44,06	75,94	72,91	87,26	153,1	21,14	29,1
Mg^{2+} content (mg/l)	15,96	24,83	33,90	43,27	33,43	25,9	13,6	10,7
KOI_{sMn} total (mg O_2/l)	19,12		15,81	18,38	15,95	16,6	9,2	5,65
KOI_{sMn} diss (mg O_2/l)	14,28		12,83	15,7	13,95	15,5	8,7	5,13
KOI_{sMn} formed (mg O_2/l)	4,84		2,98	2,68	2	1,12	0,5	0,52
F^- content (mg/l)	0,144	0,191				0,135	0,133	0,145
Cl^- content (mg/l)	15,62	35,52				46,94	38,57	35,75
NO_2^- content (mg/l)		0				0		0
NO_3^- content (mg/l)	0	0		0	0	0	0	0,11
PO_4^{3-} content (mg/l)	0,59	0			0,12	0	0	0
SO_4^{2-} content (mg/l)	11,99	22,50		14	21	51,80	40,88	46,31
Li^+ content (mg/l)	0	0				0	0	0
Na^+ content (mg/l)	21,71	39,10				32,55	42,16	30,20
NH_4^+ content (mg/l)	0	0				0	0	0
K^+ content (mg/l)	1,333	14,79				4,24	2,08	5,18

The measured chemical and physical parameters and the qualitative data of rotifers were also correlated using the ordinations [Hufnagel, Bakonyi & Vásárhelyi, 1999; Podani, 1993, 1997).

RESULTS

Hydrology and water chemistry

Water chemistry measurements were carried out in the field with the assistance of Anita Kiss. Both field and laboratory data reflected the high instability of the chemical state of the lake, originating from its shallowness and the strong fluctuation of the water level.

The direct effects of certain chemical parameters are known only for few species [Dumont, 1977; Hofmann, 1977]. Water chemistry measurements could serve as basic background information on the environment. They also help to determine the ecological tolerance values of a given species, or to make already existing data more accurate.

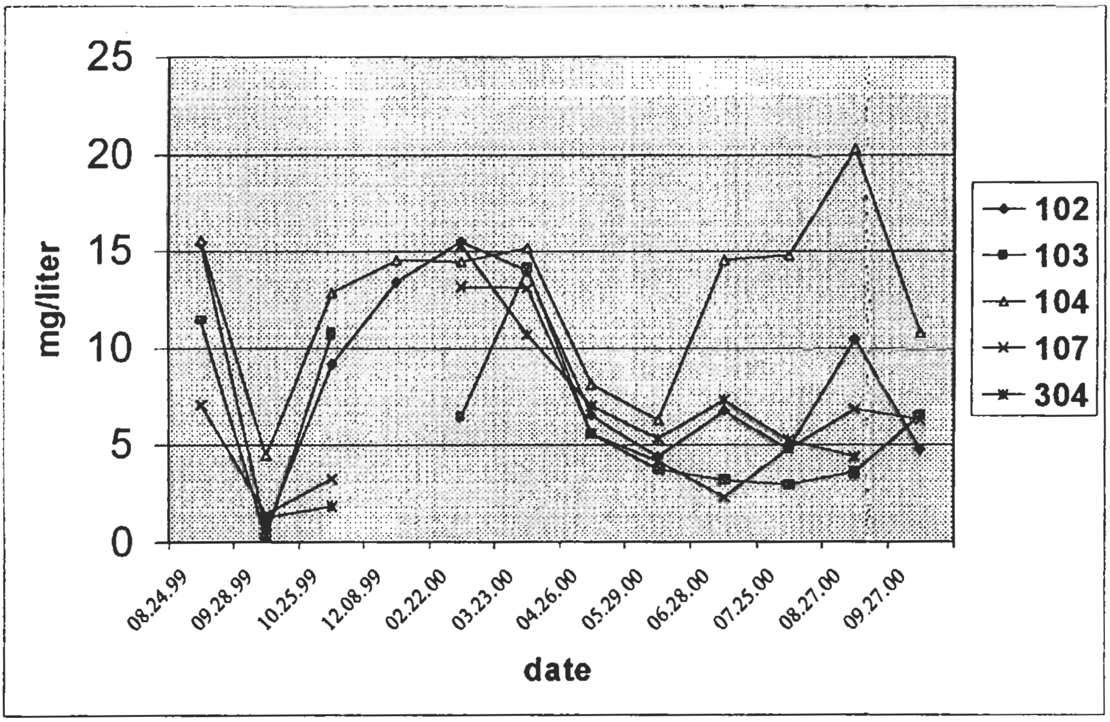

Figure 2. The amount of dissolved oxygen at the sampling sites

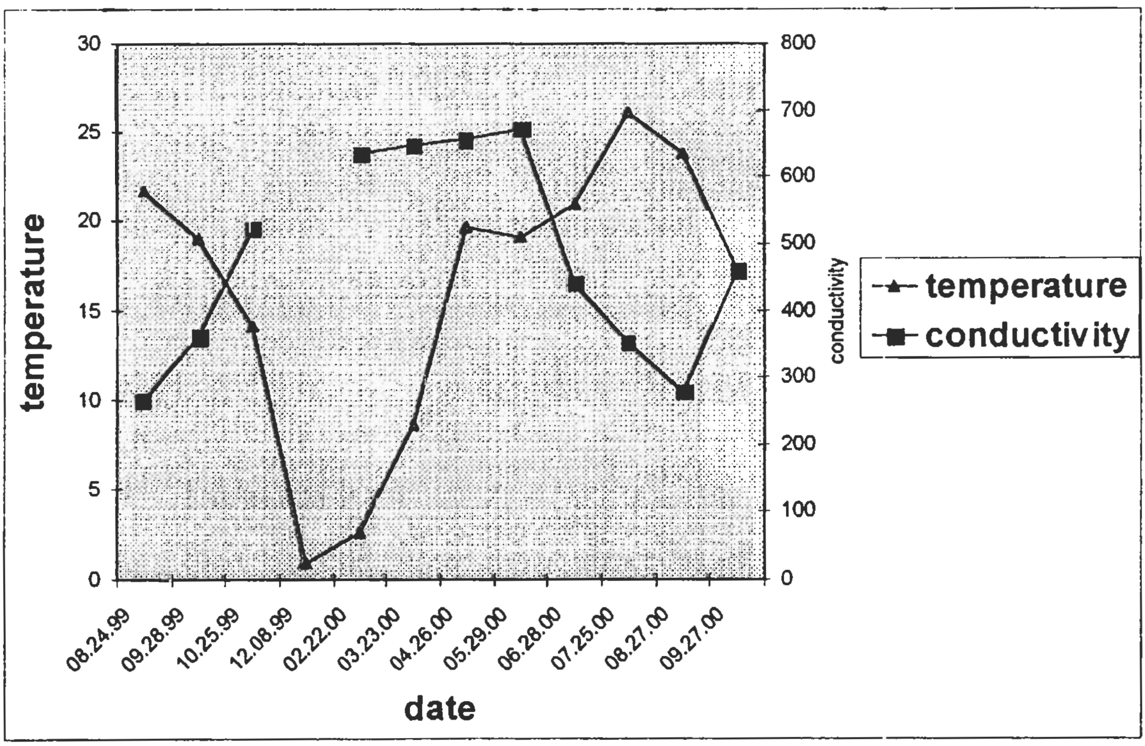

Figure 3. Water temperature and conductivity at the sampling site 104

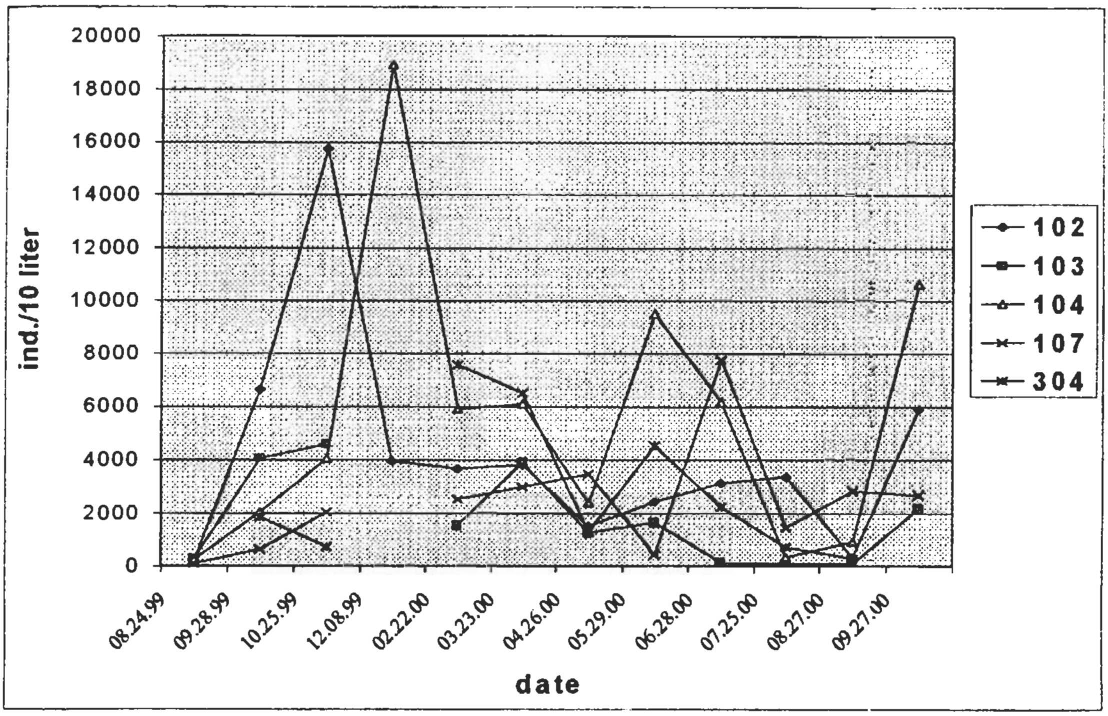

Figure 4. The abundance of rotifers in all sampling sites

The following aberrations had to be taken into consideration when analysing physical/chemical parameters:

1. During summer droughts water was supplied from a small brook (Rábca-Keszeg Brook), which may explain low conductivity values measured in summer.

2. Weather conditions (e.g. the mixing effect of moderate wind) strongly influenced the measured values.

3. In May 2000, buffaloes were introduced to the lake, which stirred and polluted the water, biasing the measured parameters.

From among the parameters measured, even water depth clearly reflected high instability and water volume fluctuations. Water depth changed from 81 to 14 centimetres within four months at sampling site 304. Water temperature also fluctuated in a wide range. Conductivity was lowest in summer (Fig. 3), probably for the reasons mentioned above.

Increasing values in winter were likely caused by the absence of affluent waters (frost), and ions dissolving from the lake bed and mud. Besides continuous spatial differences, the value of pH changed seasonally, as well. It was always higher at site 104 than at sampling sites 107 and 304. This was probably due to the greater production of the open water, as the amount of dissolved oxygen was also the highest here (Fig. 2).

List of Rotifera found in Lake Fehér

The following 35 species of Rotifera were found in the lake during the study period:

Bdelloidea

Fam. Philodinidae

Rotaria citrina Ehrenberg
R. sordida Western

Monogononta

Fam. Asplanchnidae

Asplanchna brightwelli Gosse *
A. girodi de Guerne
A. sieboldi Leydig
Asplanchnopus multicerps Schrank *

Fam. Brachionidae

Brachionus angularis Gosse *
B. budapestiensis Daday
B. calyciflorus Pallas *
B. diversicornis Daday
B. leydigi Cohn *
B. plicatilis O. F. Müller
B. quadridentatus Hermann
Keratella cochlearis Gosse *
K. quadrata O. F. Müller *
Notholca acuminata Ehrenberg
Platyias quadricornis Ehrenberg

Fam. Collurellidae

Lepadella acuminata Ehrenberg *
L. patella O. F. Müller *

Fam. Conochilidae

Conochilus hippocrepis Schrank

Fam. Euchlanidae

Euchlanis dilatata Ehrenberg *

Fam. Lecanidae

Lecane quadridentata Ehrenberg

Fam. Synchaetidae

Polyarthra longiremis Carlin
P. minor Voigt
Synchaeta pectinata Ehrenberg *
S. tremula O. F. Müller *

Fam. Notommatidae

Scaridium longicaudum O. F. Müller *

Fam. Filiniidae

Filinia cornuta Weisse
F. longiseta Ehrenberg
F. terminalis Plate

Fam. Hexarthridae

Hexarthra mira Hudson

Fam. Trichocercidae

Trichocerca intermedia Stenroos
T. pusilla Lauterborn
T. weberi Jennings *

Fam. Trichotriidae

Trichotria pocillum O. F. Müller *

The species marked by asterisks (*) had already been recorded in the surroundings of the lake by Varga [1935].

All but two of the species listed above belong to the class Monogononta. This emerges from the fact that planktonic rotifers were collected, and therefore sessile bdelloids were not or only sporadically sampled (nevertheless, the samples contained several tychoplanktonic species).

Oligotrophic lakes in the temperate zone are characterised by *Keratella cochlearis, Conochilus hippocrepis, Polyarthra longiremis, P. minor, Synchaeta pectinata, S. tremula, Filinia terminalis.* However, when *Euchlanis dilatata, Trichocerca intermedia, T. pusilla, T. weberi* also appear, it indicates eutrophy.

Members of the genera *Brachionus* (*angularis, budapestiensis, calyciflorus, diversicornis, leydigi, plicatilis, quadridentatus*), *Keratella* (*cochlearis, quadrata*) and *Polyarthra* (*longiremis, minor*), and the species *Euchlanis dilatata* clearly indicate extreme shallowness [Bancsi, 1986; Koste, 1978; Varga, 1966].

Conochilus hippocrepis exists both in brackish and saltwater, forming colonies, which are kept together by a round, jelly-like mantle [Bancsi, 1986]. In April 2000, colonies consisting of 20–30 indivuals were found. They fell apart within hours, and the animals shrank because of the formaldehyde, making identification impossible. The same phenomenon could be observed in the case of *Hexarthra mira, Rotaria sordida* and *R. citrina*, therefore we do not have reliable qualitative data for these species.

In late May 2000, buffaloes were introduced to the lake. This fact might correlate with the mass appearance of *Brachionus leydigi* in June, a species that had not been detected from the lake before, and which is described in the literature as characteristic to waters used by cattle [Bancsi, 1986; Koste, 1978]. Nevertheless, the amount of *B. leydigi* decreased and finally disappeared during summer, although buffaloes stayed by the lake. A remarkably high number of rotifer species have been recorded from the lake, which also exist in brackish or saltwater. However, they are not strictly confined to saltwater, only their tolerance is wide towards salinity. Their presence in the lake

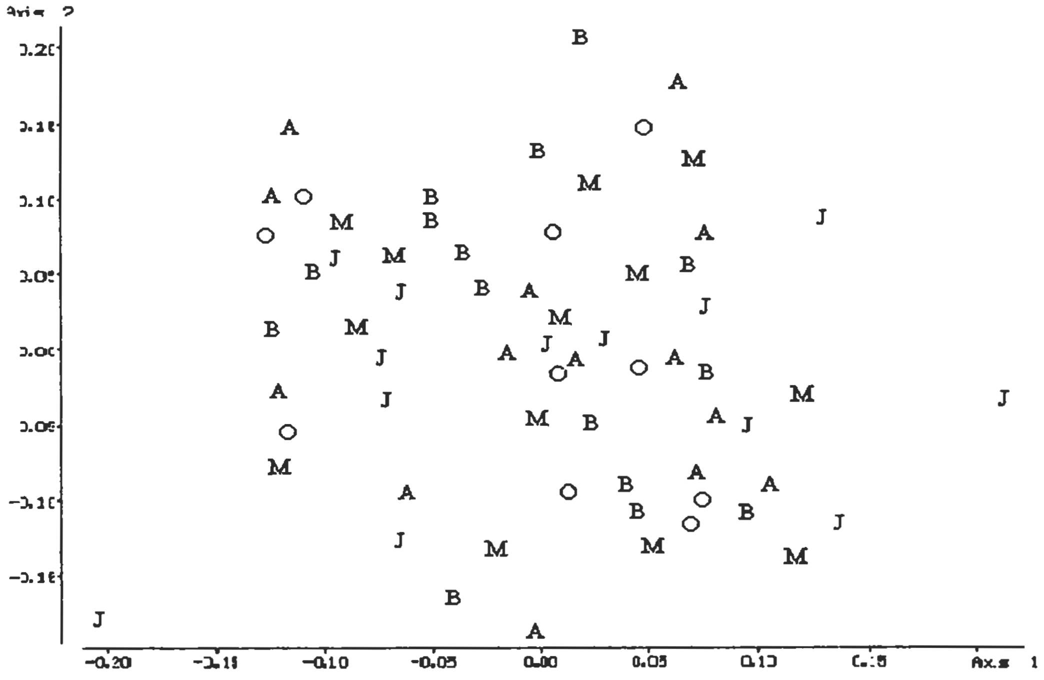

Figure 5. Ordination plot of NMDS analysis. (The different letters denote the samples, which was collected at the same sampling site)

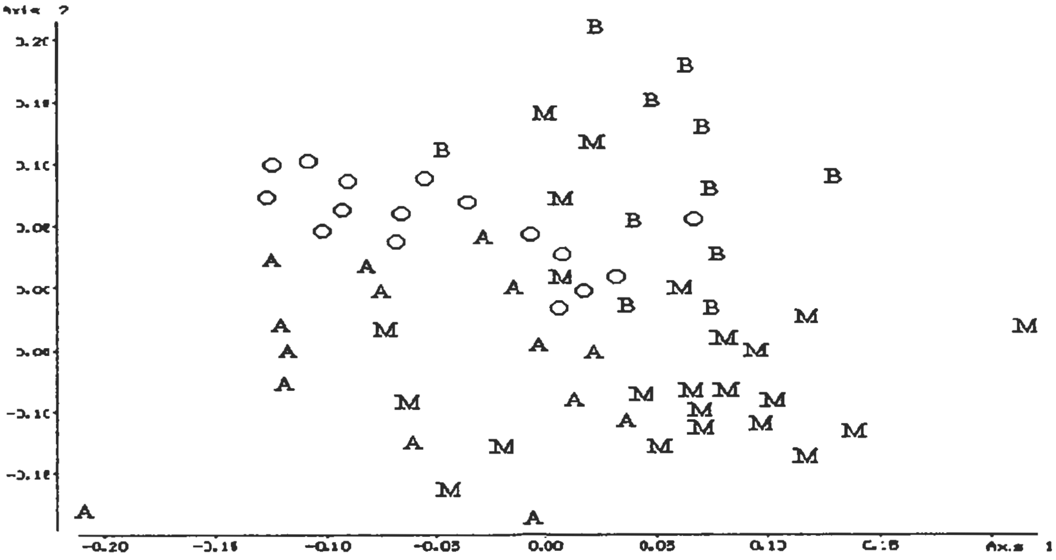

Figure 6. Ordination plot of NMDS analysis. (The different letters denote the samples, which was collected at the same
same
sampling time)

can be explained by its extreme shallowness and water level fluctuations.

Qualitative data clearly show that both the species number and the abundance of rotifers strongly decreased by the middle or end of summer in 1999 and 2000. In July 2001, however, high abundance of rotifers could be observed. During that summer there was a heavy algal bloom in the lake, and the formerly clear water – „clear state" – dominated by *Najas marina* was replaced by the „turbid state". The abundance of rotifers reached its highest value in late autumn (November, December) and late spring (end of May) in the years examined (Fig. 4).

The abundance of one or occasionally two species was much higher than that of the other component species in each sampling occasion. The dominant species were not the same throughout the year, but four or five taxa played this role in turns. In summary, this pattern clearly reflects the diversity in environmental conditions, which the assemblage dynamics of rotifers flexibly follows.

Based on the dominance and constancy values, Rotifera found in the species list could be put in three characteristic groups:

1. Species with high constancy and dominance: *Keratella cochlearis*, *Polyarthra longiremis*, *Brachionus angularis*, *Filinia terminalis*.

2. Species with high constancy but low dominance: *Brachionus quadridentatus*, *Lepadella patella*.

3. Species with the lowest constancy but great dominance: *Synchaeta tremula*, *Brachionus leydigi*, *Trichocerca weberi*.

The multivariate analysis of both presence/absence and quantitative data, based on both ordination (NMDS) and classification (cluster analysis - UPGMA) methods, showed that the composition of rotifer assemblages depended rather on the date of sampling than the sampling site. The species composition of samples collected at the same date was much more similar to each other than that collected at the same sampling site at different times (Figs. 5, 6).

Among the chemical and physical environmental parameters (temperature, pH, conductivity, oxygen content, oxygen saturation) measured simultaneously with rotifer samplings, temperature and conductivity were found to have strong influence on both the species composition and the quantitative composition of planktonic rotifer assemblages in Lake Fehér. On the other hand, multivariate methods failed to show explicit relationship between the assemblage structure of rotifers and the other abiotic factors (Figs. 7, 8).

CONCLUSIONS

Extreme shallowness and fluctuating water volume cause high chemical variability in Lake Fehér. Rapid changes in the species composition and the quantitative composition of planktonic rotifer assemblages reflect these changes well. The majority of the thirty-five detected species are cosmopolitan, well adapted to such unstable habitats with their wide ecological tolerance. In spite of this, the species composition changed cyclically. Among the species detected in the lake, fifteen had been formerly found in its vicinity by Varga (1933, 1935).

Exploring the relationships between samples by multivariate methods, it turned out that species composition – in case of planktonic samples – depended mainly on the sampling date, i.e. on environmental parameters changing cyclically throughout the year. The place of sampling is not a determining factor in this respect (Figs. 5, 6). Among the physico-chemical parameters measured directly at the sampling site (temperature, pH, conductivity, oxygen content, oxygen saturation), temperature and conductivity proved to be the most important factors to determine the assemblage dynamics of Rotifera (Figs. 7, 8).

Acknowledgements. This survey was supported by the KVM-MTA/F-H Program and the Danubius Project of the Hungarian Academy of Sciences.

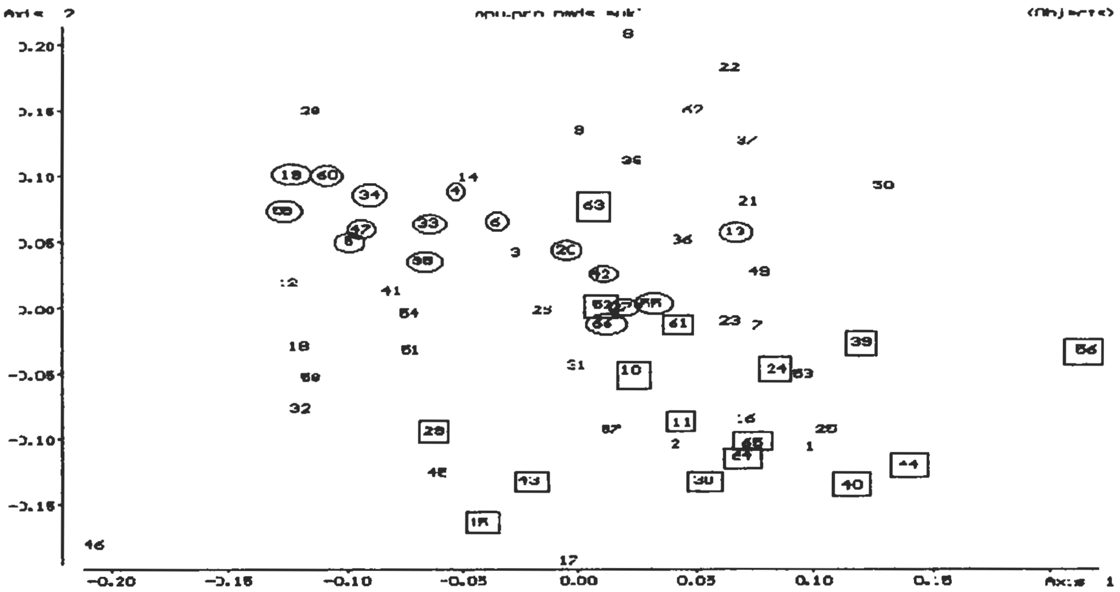

Figure 7. Ordination plot of NMDS analysis. (The different objects denote the samples, wich was sampled by under 10°C and over 20°C water temperature)

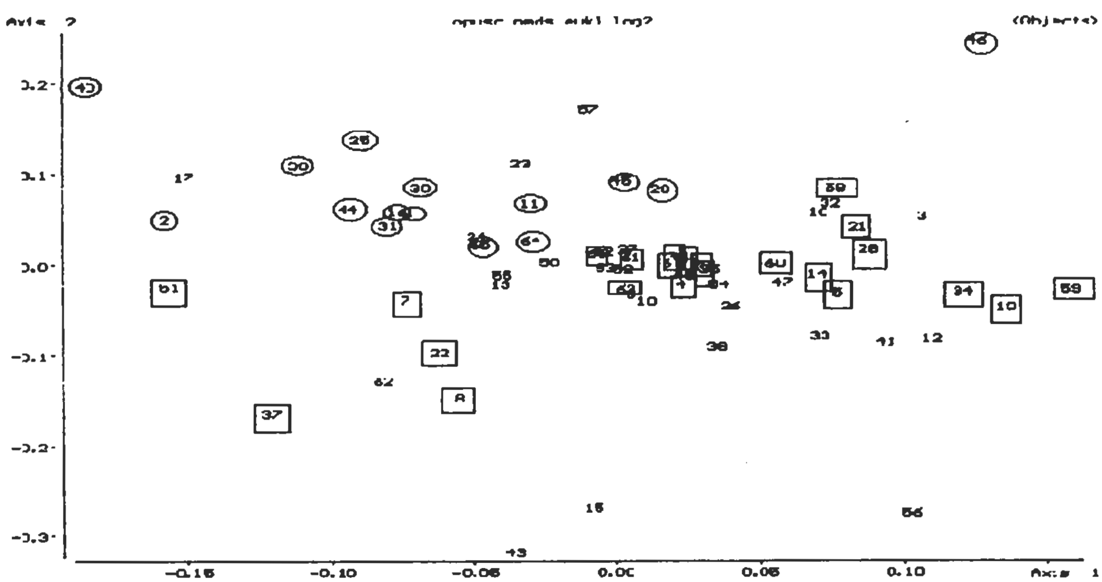

Figure 8. Ordination plot of NMDS analysis. (The different objects denote the samples, wich was sampled by under 450 µS/cm and over 600µS/cm conductivity)

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