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Community structure and succession of brackishwater rotifers in relation to ecological parameters

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Abstract

The rotifer community structure and succession in relation to ecological parameters was investigated at three brackish water habitats of Kerala – a low saline habitat (Veli Lake), a medium saline habitat (Kadinamkulam Lake) and a high saline habitat (Ashtamudi Lake). The ecological parameters of the waters studied in relation to rotifer community were surface water temperature, salinity, dissolved oxygen, *p*H, phosphate, nitrite, nitrate, silicate and chlorophyll *a*. The main factors determining the community typology of rotifers in these habitats were temperature, salinity and trophic status of waters. The general abundance of rotifers during pre-monsoon season when the temperature was comparatively high, indicated the high temperature preference of rotifers. The key factor for the poor species diversity of rotifers in brackishwater habitats was the wide variation in salinity due to the opening and closure of barmouths. At Kadinamkulam and Ashtamudi lakes, the major species of rotifers recorded were *Brachionus plicatilis* and *B. rotundiformis*. In contrast, the low saline habitat of Veli Lake harbours the maximum species diversity of rotifers. The eutrophic nature of Veli Lake as revealed by high algal densities and elevated concentration of nutrients resulted in rotifer blooms of different species almost throughout the year. Blooms were recorded mainly for the brachionids namely *B. calyciflorus, B. caudatus, B. angularis, B. falcatus, B. plicatilis* and *B. rotundiformis*. Dramatic succession of different species was also recorded at Veli Lake.

Introduction

Rotifers are of paramount significance in aquatic eco-systems due to their fastest reproductive rates and rapid development. They can populate vacant niches with extreme rapidity, convert primary production into a form usable for secondary consumers and achieve this transformation with remarkable efficiency (Nogrady *et al.*, 1993). The utility of rotifer populations for understanding the trophic status of lakes adds a new dimension to the study of the ecology of rotifers. Recently it has been found that the changes in the rotifer assemblages are indicators of water quality parameters and hence they are also important in the field of aquatic toxicology.

Physico-chemical parameters impart a profound influence on the rotifer population. Galkovskaja (1987) studied planktonic rotifers in relation to temperature and opined that temperature influences other ecological parameters of the lakes, which in turn affect rotifers. Berzins and Pejler

(1989) stated that most rotifers have a very wide tolerance range of temperature and difference in temperature dependence exists between separate species. Mikschi (1993) investigated rotifer distribution in relation to temperature and oxygen content. Miracle and Serra (1989) opined that the main factors determining the community typology of rotifers are temperature, salinity and trophic status of waters. The seasonal succession of rotifers was investigated by Herzig (1987), who stated that there is a predictable seasonal succession of rotifer species from year to year. Recently much attention was focussed in India on the synecological investigations of rotifers (Rao and Mohan (1977), Mukhopadhyay *et al.*, (1981), Laal (1984), Sharma and Pant (1985), Khan *et al.*, (1986), Deb *et al.*, (1987), Konnur and Azariah (1987), Haque *et al.*, (1988), Sharma (1986), Saksena (1987) and Sharma (1992). The ecological studies on rotifers from brackishwater bodies of Kerala are confined to limited observations on their availability and abundance while investigating the general plankton ecology of these habitats by Shibu (1991), Bijoy Nandan (1991), Harikrishnan (1993), Bijoy Nandan and Abdul Aziz (1994), George Thomas (1996) and Anuradha (1996).

As can be expected, the major ecological factor which influences the community structure and succession of rotifers in a brackishwater system is the fluctuation in salinity. The annual fluctuation in the salinity varies in the different brackishwater bodies of Kerala and a comparative investigation on the rotifer ecology of the different backwater systems with varying salinity patterns can yield a comprehensive picture of the community structure and population dynamics of these organisms. With this in view, three brackishwater lakes which exhibited varying salinity pattern in South Kerala were selected for the study.

Material and methods

Zooplankton samples were collected at fortnightly intervals from February 1996 – January 1997 from three brackishwater habitats of South Kerala – Veli Lake, Kadinamkulam Lake and Ashtamudi Lake. The collection sites were fixed near to barmouth areas so as to get the maximum influence of salinity variations. The samples were collected between 0500 hrs. and 0600 hrs. by five minute surface hauls with uniform speed using a conical plankton net of mesh size of 7μm and a mouth area of 0.066m^2. The distance covered during the haul was measured in meters. The samples were preserved in 4% formaldehyde and they were diluted to a fixed volume and 1ml of each sub-sample was counted for species-wise number of rotifers by drop counting method and raised to species-wise abundance per m^3 of the collection area. The hydrographical parameters and chlorophyll *a* were estimated by standard methods (Martin 1968; Strickland and Parsons 1968; Mullin and Riley 1955). The data of two collections made during each month were combined and the average for each month was taken. Correlation matrices between various water quality parameters and number of rotifers were worked out.

Results

Veli Lake–a low saline brackishwater habitat

The monthly variations of physico-chemical parameters of surface waters at Veli backwater is given in Table1. The species-wise number of rotifer per m^3 is given in Table 2. The maximum rotifer abundance was during July, followed by that in May. October-December showed the least abundance of rotifers. Twenty species of rotifers were fairly common at Veli backwaters. Brachionids dominated the rotifer fauna by contributing 12 species, followed by Lecinadae (2 species).

B. calyciflorus was very common and occurred during most part of the year. Its abundance was during pre-monsoon and monsoon periods. Occasionally blooms appeared in the area as were seen during August and February.

B. caudatus was also very common and contributed to the rotifer fauna during most part of the year. Occasional blooms appeared as were seen during July and January.

B. angularis also occurred throughout the year in the habitat. Pre-monsoon period contributed the maximum abundance of the species. Occasional blooms appeared as was noted during May.

B. falcatus also a very common species which was available almost throughout the year. The species was also characterised by its blooming nature as was observed during July.

B. plicatilis and *B.rotundiformis* appeared almost throughout the year. Blooms were recorded during March and August.

Other Brachionids: *B. rubens, B. budapestinensis* and *Keratella tropica* were the most abundant among other brachionids. *B. rubens* showed a peak in March, *B. budapestinensis* in July and *K. tropica* in February. The less abundant species of brachionids in the habitat were *B. bidentata, B. patulus, B. urceolaris* and *B. quadridentatus.*

Table 1. *Monthly variation of ecological parameters in Veli backwater station (February'96 to January'97)*

Parameter/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Surface water temp. (0°C)	29.70	31.00	30.15	32.60	29.20	28.90	29.05	28.75	29.40	29.05	27.90	29.75
Salinity ($x10^{-3}$)	1.80	1.95	1.25	1.55	1.30	1.95	3.40	5.05	0.90	1.90	1.95	1.70
Dissolved Oxygen (ml $litre^{-1}$)	3.68	6.79	5.37	5.37	3.68	6.78	4.25	3.68	4.52	5.66	6.22	5.66
*p*H	7.50	7.55	7.55	7.95	7.60	7.85	7.13	7.70	8.20	8.25	8.25	8.10
Phosphate (μ mol $litre^{-1}$)	6.54	5.87	1.67	2.87	1.36	0.56	1.33	6.65	1.58	0.56	0.92	1.32
Nitrite (μ mol $litre^{-1}$)	2.11	11.64	1.52	1.78	8.77	3.87	0.93	2.79	1.80	1.03	0.95	0.26
Nitrate (μ mol $litre^{-1}$)	18.40	38.55	13.60	8.76	17.43	8.21	17.17	38.12	21.47	56.53	26.68	3.47
Silicate (μ mol $litre^{-1}$)	57.03	26.55	17.34	15.72	9.34	21.82	62.99	45.10	20.40	17.43	16.95	21.70
Chlorophyll *a* (mg m^{-3})	7.16	7.88	8.28	4.39	2.32	6.40	1.63	1.06	1.97	1.95	1.81	2.68

Table 2. *Species-wise number of Rotifers/m³ at Veli*

Species/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B. calyciflorus	9646	-	770	2864	-	1788	14960	24	81	5	-	2750
B. caudatus	1018	-	466	983	762	4579	130	-	6	-	-	5629
B. angularis	7113	8032	485	30879	743	3585	2349	60	18	1	18	1656
B. falcatus	227	-	65	339	70	22559	148	3	1	-	-	898
B. plicatilis & B. rotundiformis	24	4012	44	13	262	74	7191	354	19	46	53	76
B. urceolaris	11	-	-	-	-	-	-	-	-	-	-	-
B. rubens	-	3204	93	-	-	152	110	-	-	-	2	-
B. budapestinensis	-	-	44	113	57	338	21	1	5	-	-	-
B. bidentata	-	-	-	-	572	-	-	-	1	-	-	
B. patulus	-	-	-	-	11	-	-	-	42	1	-	-
B. quadridentatus	-	-	-	-	18	-	-	-	3	-	-	-
Filinia longiseta	912	-	47	613	195	4980	1253	5	129	-	-	909
Epiphanes macrourus	33	-	-	537	156	59	65	-	11	2	1	260
Asplanchna brightwelli	119	-	-	-	5	693	-	11	2	-	-	130
Keratella tropica	6769	55	44	-	-	109	217	-	6	-	-	6593
Monostyla bulla	-	3	-	-	22	-	-	1	19	2	1	-
Testudinella patina	-	-	163	24	-	14	671	-	5	-	-	303
Polyarthra vulgaris	-	-	130	89	13	1364	76	34	116	1	2	325
Hexarthra intermedia	-	-	-	554	9	866	44	5	6	-	-	3356
Lecane luna	-	-	-	-	6	-	-	1	12	2	1	-
Others	-	-	-	-	-	-	-	-	30	-	-	-
Total Rotifers	25872	15306	2351	37008	2901	41160	27235	498	512	60	84	22885

Other rotifers: The Lecanids, *Monostyla bulla* and *Lecane luna* were available mainly during the monsoon and post-monsoon months. They were present in sparse numbers and blooming of these two species was not noted. *Filinia longiseta* was the most abundant non-brachionid rotifer which was available almost throughout the year. The peak abundance was during July-August. *Epiphanes macrourus* was commonly available from May to August with the peak in May. *Asplanchna brightwelli, Testudinella patina, Polyarthra vulgaris* and *Hexarthra intermedia* recorded one peak each during the monsoon months.

Succession: Seasonal succession of the major species of rotifers was noted during different months. In February, *K. tropica, B. angularis* and *B. calyciflorus* dominated the rotifer fauna. In March also *B. angularis* continued its dominance but *K. tropica* and *B. calyciflorus* were entirely absent. Instead, *B. rubens, B. plicatilis* and *B.rotundiformis* became abundant. In April, *B. calyciflorus* dominated again, followed by *B. caudatus*

and *B. angularis*. In May, *B. angularis* suppressed all the other species. In June, *B. caudatus*, *B. angularis* and *B. bidentata* were present in moderate numbers. In July, *B. falcatus* became the dominant species. Again *B. calyciflorus* became the major species in August. In September, *B. plicatilis* and *B.rotundiformis* were the dominant species. In October and November, the fauna was generally poor and no domination of species was noted. Again in January, *B. caudatus* and *K. tropica* were the dominant species, followed by *B. calyciflorus*, *H. intermedia* and *B. angularis*.

Correlation with ecological parameters: The correlation coefficient relating ecological parameters with abundance of total rotifers showed a negative correlation with nitrate. *B. plicatilis* and *B.rotundiformis* abundance was positively correlated with silicate and negatively correlated with *p*H (Table 3).

Kadinamkulam Lake – a medium saline brackish water habitat

The monthly variations of physico-chemical parameters of surface waters is presented in Table 4. The species-wise number of rotifers per m^3 is presented in Table 5. The rotifer abundance was clearly confined to the pre-monsoon period with peak in May. The least abundance of rotifers was noted during the post-monsoon period. Eventhough nine species of rotifers were recorded from the habitat, *B. plicatilis* and *B.rotundiformis* were the only species which were abundantly available. The other species were available in stray numbers during certain months.

B.plicatilis and B.rotundiformis were available throughout the year. The pre-monsoon period was noted for the blooms of these species. They were scanty during

Table 3 *Correlation coefficient (r) relating ecological parameters with abundance of* B. plicatilis *and* B.rotundiformis *and total Rotifers at Veli, Kadinamkulam and Ashtamudi*

	Surface water	Salinity	Dissolved Oxygen	*p*H	Phosphate	Nitrite	Nitrate	Silicate	Chloro phyll *a*
VELI									
B. plicatilis &									
B.rotundiformis	0.0307	0.3583	-0.0155	-0.6670**	0.0805	0.2227	0.0808	0.5762*	-0.0348
Total Rotifers	0.4332	-0.0326	0.2369	-0.2733	0.0227	-0.0485	-0.5846*	0.2708	0.3614
KADINAMKULAM									
B. plicatilis &									
B.rotundiformis	0.8535**	0.1671	-0.4143	-0.2251	0.1350	-0.1332	-0.4486	0.0788	0.6529**
Total Rotifers	0.8522**	0.1529	-0.3965	-0.2224	0.1263	-0.1345	-0.4379	0.0949	0.6472**
ASHTAMUDI									
B. plicatilis &									
B.rotundiformis	-0.5949*	-0.5289*	-0.2451	0.1757	0.2637	0.6917**	0.1261	0.2406	-0.0161
Total Rotifers	-0.6028*	-0.5246*	-0.2511	0.1774	0-2753	0.6911**	0.1243	0.2365	0.0179

Table 4. *Monthly variation of ecological parameters in Kadinamkulam backwater station (February'96 to January'96)*

Parameter/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Surface water temp. (0°C)	29.95	30.70	31.75	32.55	30.35	28.20	29.05	28.45	29.20	28.90	28.05	27.1
Salinity ($x10^{-3}$)	14.15	11.60	5.90	5.75	5.15	9.55	8.70	7.45	4.30	4.15	4.00	6.40
Dissolved Oxygen (ml litre^{-1})	4.24	2.83	2.83	5.37	3.13	4.81	5.37	6.22	5.66	5.94	6.22	6.22
*p*H	7.8	8.1	7.55	7.85	8.05	7.85	7.64	7.34	8.15	8.20	8.60	8.60
Phosphate (μ mol litre^{-1})	1.88	1.10	7.17	0.34	0.34	0.56	0.63	0.32	1.92	4.98	1.34	0.29
Nitrite (μ mol litre^{-1})	1.08	0.48	2.60	0.17	0.68	9.04	0.42	0.35	0.35	0.67	0.48	0.44
Nitrate (μ mol litre^{-1})	2.40	9.42	2.19	10.15	8.84	14.22	7.68	12.09	17.25	21.73	16.38	18.59
Silicate (μ mol litre^{-1})	11.11	20.76	52.70	67.86	48.58	31.45	53.19	68.12	55.57	50.63	30.56	47.26
Chlorophyll *a* (mg m^{-3})	1.33	1.37	2.48	1.88	1.74	0.11	1.24	1.12	0.11	0.42	0.54	0.39

the post-monsoon period. The correlation coefficient relating ecological parameters with abundance of *B.plicatilis and B.rotundiformis* showed a positive correlation with surface water temperature and chlorophyll *a* (Table 3).

Ashtamudi Lake – a high saline brackish water habitat

The monthly variation of physico-chemical parameters of surface waters is given in Table 6. The species-wise number of rotifers per m^3 is given in Table 7. The rotifer abundance was mainly restricted to June – October period with a peak in June. The pre-monsoon period showed least abundance of rotifers. Eventhough stray availability of *K. tropica* was recorded in February, the rotifer fauna of the habitat was almost exclusively dominated by *B.plicatilis* and *B.rotundiformis*. The correlation coefficient relating to ecological parameters with abundance of these species showed a negative correlation with surface water temperature and salinity and positive correlation with nitrite nitrogen (Table 3).

Discussion

The main factors determining the community typology of rotifers are temperature, salinity and trophic status of water bodies. The other ecological factors are only indirectly correlated through their influence on these primary parameters (Miracle *et al.*, 1987; Nogrady, 1988).

Salinity is the most important variable affecting the distribution of plankton in estuaries and backwaters of Kerala (Abdul Aziz and Nair, 1986; Bijoy Nandan *et al.*, 1989; Anuradha, 1996). The opening and closure of barmouth separating the backwater from the sea in many lakes play the crucial role in the variation of salinity. In the present study, the barmouth at Veli Lake remains closed for most part of the year and at Kadinamkulam it remains closed mostly during pre-monsoon months. On the other hand, the barmouth

Table 5. *Species-wise number of rotifers/m³ at Kadinamkulam*

Species/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Brachionus plicatilis & *B. rotundiformis*	6120	16420	14270	27166	150	74	160	22	2	13	6	24
B. bidentata	-	-	-	-	2	-	-	-	-	-	-	-
B. quadridentatus	-	-	-	-	1	-	-	-	-	-	-	-
B. angularis	-	-	-	1353	-	-	-	-	-	-	-	-
B. falcatus	-	-	-	-	-	-	-	-	-	1	-	-
Lecane luna	-	-	-	-	1	-	-	-	-	3	-	-
Hexarthra intermedia	-	-	120	130	-	-	-	-	-	-	-	-
Keratella tropica	40	2	-	-	-	-	-	-	-	1	-	-
Monostyla bulla	-	-	-	-	1	-	-	-	1	-	-	-
Total Rotifers	6160	16422	14390	28649	155	74	160	22	2	13	6	24

of Ashtamudi lake remains open throughout the year. The impact of salinity on rotifer species composition was evidenced by the availability and abundance of different species from these habitats. At Kadinamkulam and Ashtamudi lakes, the major species of rotifers were *B.plicatilis* and *B.rotundiformis*. In contrast, the low saline habitat of Veli lake harboured maximum species diversity of rotifers.

The abundance and species composition of rotifers often reflect the trophic status of lakes. Lakes subjected to intense eutrophication often have changes in the maximum total population density (Walz *et al.*, 1987). Individual species can also

Table 6. *Monthly variation of ecological parameters in Ashtamudi backwater station (February'96 to January'97)*

Parameter/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Surface water temp. (0°C)	27.3	30.9	31.9	31.9	26.7	27.6	29.1	28.4	28.7	29.0	29.1	28.8
Salinity ($x10^{-3}$)	28.0	30.0	25.0	22.5	13.8	13.0	11.3	11.0	14.4	15.1	14.3	24.5
Dissolved Oxygen (ml litre^{-1})	4.52	4.52	5.66	5.66	4.52	4.52	5.09	6.79	5.66	6.22	6.79	6.22
*p*H	8.2	8.2	8.0	8.0	8.3	7.3	7.7	8.4	8.8	8.1	8.2	8.4
Phosphate (μ mol litre^{-1})	2.39	0.29	0.06	0.06	1.11	0.62	0.6	1.37	1.84	0.74	0.52	1.01
Nitrite (μ mol litre^{-1})	0.13	0.03	0.09	0.09	0.56	0.15	0.05	0.37	0.47	0.44	0.29	0.27
Nitrate (μ mol litre^{-1})	2.65	6.67	1.19	0.85	5.20	2.30	4.54	5.67	9.94	5.65	0.45	12.76
Silicate (μ mol litre^{-1})	8.28	5.62	19.76	5.62	13.67	9.90	10.69	11.39	19.70	17.34	12.64	9.32
Chlorophyll *a* (mg m^{-3})	0.98	1.23	1.22	1.76	0.69	1.57	1.91	1.96	1.35	1.04	0.42	0.27

Table 7. *Species-wise number of rotifers/m³ at Ashtamudi*

Species/Months	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B. plicatilis & *B.rotundiformis*	-	-	13	19	1342	381	149	502	465	89	57	4
Keratella tropica	22	-	-	-	-	-	-	-	-	-	-	-
Total Rotifers	22	-	13	19	1342	381	149	502	465	89	57	4

undergo dramatic population changes during periods of eutrophication. The high algal density noted and the elevated concentration of nutrients inVeli Lake indicated the eutrophic nature of the habitat. The rotifer blooms of different species noted almost throughout the year corroborate the above. The dramatic changes noted in the species succession also lend support to this conclusion.

The changes in the structure of rotifer assemblages can be taken as an indicator of water quality (Green, 1993; Pontin and Langley, 1993). The Kadinamkulam Lake is subjected to intense coconut husk retting resulting in sulphide pollution (Bijoy Nandan and Abdul Aziz, 1994). The abundance of *B. plicatilis* and *B.rotundiformis* almost to the exclusion of other zooplankters during certain months point out that these species are indicators of pollution, which is supported by the observation of Rao and Chandramohan (1984), who noted the occurrence of *B. plicatilis* in highly polluted industrial areas of Visakhapatnam and harbour backwaters of east coast of India.

Most species of planktonic rotifers are characterised by wide temperature tolerances. They are able to reproduce over a wide range of temperature, provided that other factors are not limiting (Galkovskaja, 1987). Often temperature is considered to be the most important factor determining the population dynamics of rotifers. The general abundance of rotifers noted in the present study during the pre-monsoon period may be related with the comparatively high temperature during the period. The population of rotifers is limited by the combined effect of oxygen concentration and temperature (Herzig, 1987). Although most rotifers require oxygen concentration significantly above 1.5mg/litre, some can tolerate anaerobic or near anaerobic conditions for short periods (Esparcia *et al.*, 1989). Hence, it is felt that the dissolved oxygen fluctuation in the different habitats during the current study may not have acted as a limiting factor in determining the availability and abundance of different rotifer species. However, it is probable that it could have influenced other vital parameters such as temperature and salinity and would have exerted an indirect influence.

It has long been established that rotifer species can be classified into a few broad groups based on *p*H alone – alkaline species, acid species and those with a broad range. Hence, studies on rotifer occurrence as a function of *p*H alone is of limited value. Berzins and Pegler (1987) demonstrated that the species found in oligotrophic waters had *p*H optima at or below neutrality and those species common

to eutrophic waters at are above neutrality. The brackishwater habitats investigated in the present study were always alkaline and the species recorded are generally recognized as alkaline species. Hence, *p*H could not be taken as a limiting factor in determining the availability and abundance of the species encountered in the current study.

From the foregoing facts it is evident that the differences in community structure and succession of rotifers might be attributed to temporal changes in the ecological parameters and trophic status of the lakes. The succession of the different species with one or two major modes annually was clearly noted in the Veli brackishwater habitat. The community structure and succession of rotifers was investigated in detail by Herzig (1987) and Berner-Frankhauser (1987). According to Herzig (1987), there is a predictable seasonal succession of rotifer species with some variations from year to year. Species abundance may vary markedly from year to year, but the seasonality of occurrence and growth remains constant over decades. Well defined short term succession can partly be explained by physical and chemical limitations, food availability and exploitative competition, mechanical interference competition, predation and parasitism. All these parameters act in a combined manner and hence a single factor cannot be isolated for interpreting its relation with the community structure and succession of rotifers. This explains the absence of direct correlation of many of the ecological parameters in determining the rotifer assemblage of the habitat in the current study. The sampling frequency and long term investigations may give a better picture of community structure and succession of rotifers in a habitat. Since the generation time of most rotifers is about a week, low sampling frequency provides only the general trend of rotifer abundance and species composition in the course of the year. High frequency sampling may give much better estimates of population of individual species. Hence it can be inferred that since the present study was carried out in the course of an year, it gives only a short term picture of the community structure and succession of the rotifer assemblages. It is suggested that long term qualitative and quantitative investigations in the brackishwater habitats of Kerala may be worth attempting in future to get a comprehensive picture of the community structure and succession of rotifers.

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