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Cyclomorphosis of fresh water rotifers from wetlands of contrasting ecological feature – seasonal analysis

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Abstract

Cyclomorphosis, an interesting biological phenomenon involves the alteration of different ~~of~~ morphs in time. Various eco-biological parameters including temperature, Dissolved Oxygen, pH, alkalinity, turbidity and nutrients (total phosphate phosphorus and total nitrogen) along with meteorological changes may have a role in inducing this survival strategy of phylum Rotifera. The primary aim of this study is to test the hypothesis that the morphological variations of various species of Rotifers occur due to environmental oscillations pertaining to different seasons of a year in different contrasting ecoregions. This manifestation of phenotypic plasticity in two different species of rotifers (*Brachionus* sp. *and Keratella* sp.) was studied from three wetlands having contrasting ecological features over a period of one year. Simultaneous recording of physico-chemical parameters and computing their relationships with the density of cyclomorphic forms were also done. Cyclomorphic forms of *Brachionus* sp. were found mostly during summer season while that of *Keratella* sp. species occurred during late monsoon and winter season. Rooted aquatic macrophytes were observed to display inverse relationship with the abundance of cyclomorphic forms of *Brachionus* sp. Recording of proportion of body length and posterior spine length in *Keratella* sp. revealed the appearance of longest posterior spine length during winter and the development of posterior spines tended to become smaller in eutrophicated water body. We concluded that high temperature, availability of nutrients and turbulence of water triggered the cyclomorphic or polymorphic development of various species of Rotifers.

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Introduction

The phenomenon Cyclomorphosis involves the alteration of different morphs in time. This interesting phenomenon is thought to be an interesting survival strategy of several species of phylum Rotifera, the smallest pseudocoelomate form of metazoan reducing mortality due to size-selective predation.

Although, the proximal causes inducing cyclomorphosis are still remain unanswered, impact of a number of eco-biological parameters might have had their roles. A relatively warm, or warming, temperature is often contributory.

Turbulence in the presence of light is also required. Exuberant forms of rotifers have been correlated with starvation for *Brachionus* sp. or with dense food or cold water. In the case of *Brachionus* sp., concentrations of specific organic substances influence cyclomorphosis (Dodson, 1974).

The importance of seasonal oscillation of physico-chemical parameters coupled with meteorological changes lead to changes in water buoyancy which bears great adaptive significance of cyclomorphosis in all groups (Gallagher, 1957). Since warm water is less dense and less viscous than cold water, the exuberances were interpreted as brakes to slow in the summer (Dodson, 1974).

Phenotypically plastic defenses are strategies to reduce predation risk in variable environments. Predator-induced formations of protective devices in rotifers are prominent examples of phenotypically plastic defenses. Small brachionids such as *Brachionus* sp. are prey items for many aquatic invertebrate predators and thus comprise a useful model system to investigate defenses and their effects. The spines of rotifers are inducible with chemical cues from different kinds of predators and that they act as a generalized defense offering protection against several predators, each using a different hunting strategy.

In contrast to the usual pattern of rotifer cyclomorphosis, *Keratella* sp. has its longest spine in August. Carlin (1943) suggested that the selective mechanism involved was the decrease in buoyancy due to a decrease in turbulence with decreasing temperature.

Results from the induction experiment shows that chemical cues released from *Asplanchna* sp. induce significantly longer tail spines and thus act as proximate factors for cyclomorphosis in *Brachionus* (Gilbert, 1999). The induced morphological changes offers protection against each of the predators tested. Interestingly, the protective mechanisms and the prey size classes which were protected differed between predator systems.

In our study we have tried to find the impact of various eco-biological parameters in inducing Cyclomorphosis in two different species of rotifers (*Brachionus* sp. *and Keratella* sp.) by collecting data from three wetlands having contrasting ecological features over a period of one year.

Material and methods

Study area:

Monthly collections were made from three different types of contrasting wetlands of West Midnapore district - one well maintained large pond used for pisciculture (Site- I), the second one – a backwater impoundment of the river Shilabati (Site- II) and third one - an eutrophicated wetland having dense macrophytes (Site- III) throughout a year (March,2010 – February, 2011). The low-lying areas (Site- II and III) get inundated during rainy season (June-September) due to heavy discharge from the river. Site- III supported luxuriant growth of floating macrophytes, viz. *Eichhornia crassipes* and *Salvinia* sp. and also one submerged macrophyte viz. *Hydrilla* sp. throughout the year (Fig.1).

Samplings

Samples were collected by means of a net of mesh size 50µm made of nylon cloth which was dragged through a constant distance. Collections were always made between 10 and 10:30 am.

Analyses

Plankton analysis

The qualitative analysis of rotifers was done under light microscope (Zeiss, using 10X * 25X) and then measurements (micrometer) of spine length were made. For quantitative analysis, 50L of water was filtered through the plankton net. Immediately after the collection, the concentrated material was preserved in 4-5% formaldehyde adding strong formalin. The preserved material was centrifuged and decanted in the laboratory. Rotifers were enumerated using Sedgewick-Rafter cell.

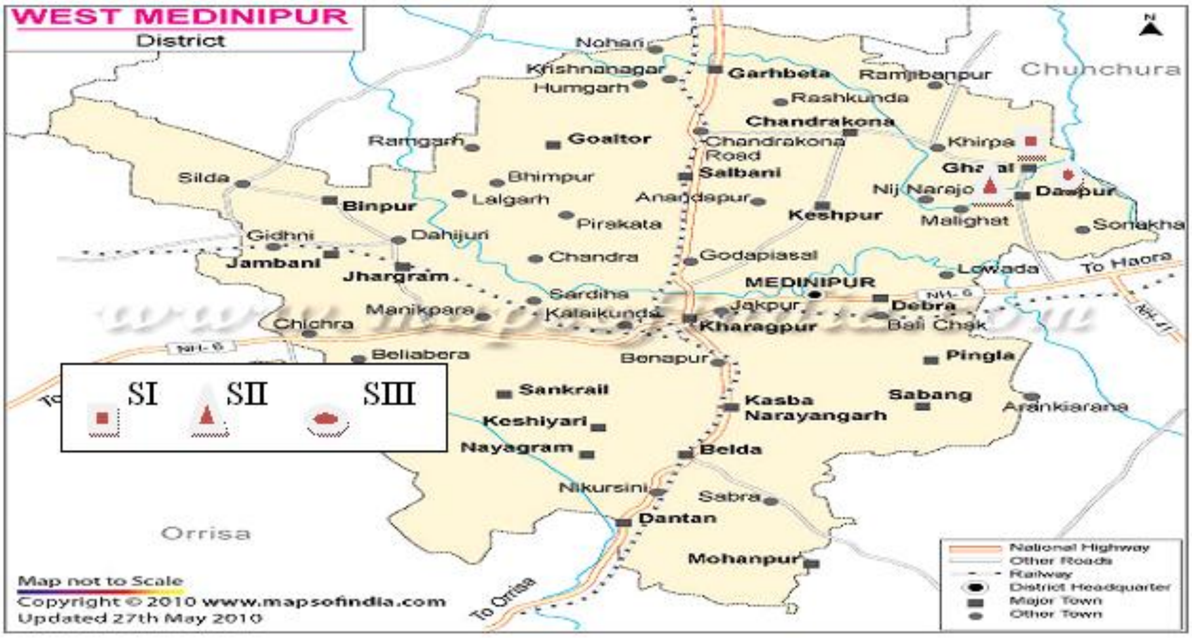

Fig. 1. Map showing three study sites (Site-I, Site-II & Site-III).

Physico-chemical analysis

The physico-chemical factors like temperature of the water were recorded at the time of collection. Hydrogen ion concentration and conductivity were recorded using pH meter and conductivity meter, respectively. Analyses of other factors were done according to the 'Standard Methods for the examination of Water and Wastewater' (APHA, 2005).

Results

Diversity of rotifers

All total 38 species of Rotifera belonging to 9 genera and 8 families were recorded (Table-1). Most of the recorded species are cosmopolitan in nature. The density of some genera like *Lecane* and *Brachionus* was closely associated with the trophic status of the habitat. Rotifer diversity was highest in eutrophicated water body except brachionids. Rooted aquatic macrophytes were supposed to have repellent effect on the presence of brachionids.

Rotifer density

High densities of rotifers were observed during early summer and low during winter at three sites. The most prevalent rotifer species was *Brachionus* spp. The density of family Brachionidae was high mainly in summer (Fig. 2).

In the study of cyclomorphosis among 38 species of rotifers, only 2 genera *viz. Brachionus* spp. and *Keratella* spp. were highlighted for detailed analyses in respect to morphological changes.

Morphological variations

Detailed morphological study revealed that a wide range of variations in size of different species of rotifers *viz. Brachionus* spp. and *Keratella* spp. occurs seasonally. The striking morphological manifestation was the development of different spines.

Usually, the contribution of the Brachioids of the total rotifer density was high except during winter. Other species reactions seem to differ considerably e.g. *Keratella* sp. Appendages appear to become smaller as the temperature rises. (Fig.-3).

In eutrophic water bodies, *Keratella* tends to be smaller and have smaller posterior spines than those living in oligotrophic conditions. The course of seasonal variation produces shorter spines, and eventually posterior spine (tecta), during the summer months.

Table 1. Occurrence of rotifers in various study sites study sites.

Sl.no.	Name of Species	Total No. of Species	Species found in Pisciculture pond	Species found in Backwater Pond	Species found in Eutrophicated Water body
1	*Brachionus* sp.	14	14	12	7
2	*Keratella* sp.	3	3	3	2
3	*Euchlanis* sp.	1	1	-	1
4	*Mytilina* sp.	2	1	1	2
5	*Lepadella* sp.	5	4	3	4
6	*Lecane* sp.	7	4	7	6
7	*Cephalodella* sp.	2	1	1	1
8	*Asplanchna* sp.	2	1	2	2
9	*Filinia* sp.	2	2	1	1

Table 2. The range of total length of body, Maximum body-width and Posterior Spine Length in various *Brachionus* sp. and *Keratella* sp. from the study sites.

Sl. no.	Species Name	Range of Total Body Length (µm)	Range of Maximum Body Width (µm)	Range of Posterior Spine Length (µm)
1	*Brachionus angularis*	90-100	70-85	_
2	*B. bidentata jirovci*	155-175	115-120	15-22
3	*B. bidentatus bidentatus*	185-200	100-110	_
4	*B. bidentata crassispineus*	175-195	160-175	60-65
5	*B. forficula minor*	135-150	80-90	40-45
6	*B. patulus patulus*	220-250	160-175	28-30
7	*B. rubens*	190-225	140-165	_
8	*B. quadridentatus brevispinus*	230-235	190-195	35-45
9	*B. quadridentatus rhenanus*	200-215	185-190	_
10	*B. sessils*	100-105	90-95	_
11	*B. caudatus personatus*	150-170	105-110	65-70
12	*B. falcatus*	220-350	120-135	150-155
13	*B. calyciflorus*	410-450	250-270	60-65 (lateral Occipital)
14	*B. budapestinensis*	120-125	80-85	18-20 (lateral Occipital)
15	*Keratella cochlearis*	15-190	65-75	40-55
16	*K. tropica*	190-220	75-85	Upto 105 (Right) Upto 35 (Left)
17	*K. quadrata*	200-215	85-90	65-72

In a deep region of water body the individuals of *Keratella* in the cool meta- and hypo limnion are larger and have longer spines than those in the warm epilimnion (Table-2).

Physico-chemical analyses:

Water temperature of different study sites was measured at the coolest time of the year (December – February), and was mostly between 16-19°C and in the summer season (March – May) the temperature was between 30-35° C and in the monsoon season (June – September) it was between 27-31° C.

Table 3. Range of variations in various physico-chemical parameters at three study sites. Numbers in body are mean±standard error of mean and ranges are enclosed in parentheses.

Sl. No.	Parameter	Site- I	Site- II	Site- III
1	Surface water temperature (◦C)	25.25±1.2 (19-35)	23.5±1.26 (16-33)	24.5±1.23 (16-33)
2	pH	6.63±0.16 (5.9-7.5)	6.72±0.19 (5.7-7.8)	6.58±0.19 (5.4-7.5)
3	Conductivity (μ mho/cm)	325.83±9.15 (275-380)	324.58±11.88 (275-400)	328.75±11.11 (275-390)
4	TDS (mg/l)	195.83±10.54 (135-260)	203.33±11.32 (145-280)	199.17±9.93 (145-260)
5	DO (mg/l)	7.01±0.22 (5.8-8.14)	6.95±0.23 (5.8-8.14)	6.51±0.21 (5.2-7.9)
6	Chloride (mg/l)	34.88±1.73 (25.1-44.02)	35.02±1.69 (25.1-45.02)	34.96±1.69 (25.1-45.02)

Table 4. Correlations between rotifer densities (individuals/L) and physico-chemical parameters.

Sl. No.	Parameter	Site- I	Site- II	Site- III
1	Surface water temperature (◦C)	0.549*	0.537*	0.536*
2	pH	-0.022	0.251	0.215
3	Conductivity (μ mho/cm)	0.081	-0.033	0.001
4	TDS (mg/l)	0.001	0.003	0.009
5	DO (mg/l)	-0.15	-0.16	0.265
6	Chloride (mg/l)	0.073	0.166	0.108

Correlations are Pearson Product Moment type ($p<0.05$).

A measurement of pH was 5.9-7.5 in the fresh water pond, 5.7-7.8 in the backwater of river and 5.4-7.5 in the eutrophicated pond (Table-3). But no relationship between pH and spine length was found.

Temperature, Total Dissolved Solid (TDS), conductivity showed upward peak and pH, Dissolved Oxygen (DO), nutrient (chloride) content displayed downward peak in pre-monsoon and the parameters displayed the opposite peaks in the post-monsoon. In monsoon, TDS and DO were increasing in nature.

Statistical assessment: correlations between rotifer densities and physico-chemical parameters

At the three sites, rotifer abundance displayed strong positive correlation ($p<0.05$) with surface water temperature. There was a high degree of site-specific variability with rotifer abundance.(Table-4)

Discussion

Cyclomorphosis is a biological phenomenon for a number of faunal components. They depict an adaptive strategy to overcome adverse ecological conditions. The present paper has highlighted the morphological variations as a part of cyclomorphological phenomenon in different environmental changes pertaining to different seasons of a year in different contrasting ecoregions.

The previous study of Wetzel (2001) described that high degree of diversity of freshwater ecosystems occurred where these are coupled to any open waters of lakes or river channels. Site- II also supported this and represented diverse rotifer communities. In addition, site- III supported the highest degree of rotifer diversity. During the study period, the rotifer density raise to maximum level during early summer and minimum level during winter. The availability of nutrient and presence of favourable physico-chemical environment were responsible for greater abundance during early summer season.

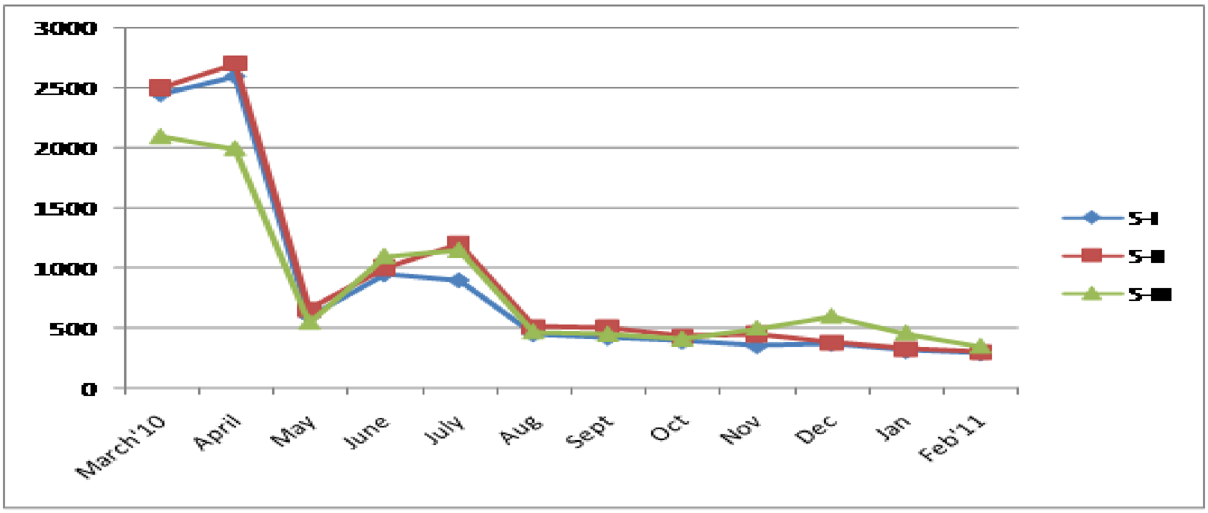

Fig. 2. Seasonal variations of rotifera density (individuals/L).

In early investigation, it was reported that the rapid increase of rotifer abundance may be attributed to their intrinsic high fecundity supported by favourable food and environmental conditions (Dumont, 1977; Gulati, 1999). However, during study period rotifer abundance displayed strong positive correlation ($p<0.05$) with surface water temperature. Though Holland *et al.* (1983) explained that the influence of temperature and oxygen on rotifer abundances is less in warmer climates. The present study showed that rotifer abundance was positively correlated with TDS and chloride content of water and negatively associated with DO especially at site-I and site-II. Chloride content of water partially determined the relation between trophic status and rotifer density. All total 38 species of rotifers were recorded, mainly represented by the genus *Brachionus* (14 species); *Keratella* (3 species); *Euchlanis* (1 species); *Mytilina* (2 species); *Lepadella*(5 species); *Lecane* (7 species); *Cephalodella* (2 species) ; *Asplanchna* (2 species); *Filinia* (2 species). The appearance of cyclomorphic forms of *Brachionus* during summer months may be attributed by higher evaporation coupled with temperature, low oxygen stress, more turbidity with elevated TDS, chloride content of water etc. All those changed ecological parameters triggered higher predation pressure (decrease of water volume, restricted scope of dispersal and elevation of the habitat fragmentation and decrease of connectivity) as well as the problem of desiccation, reduced food availability, releasing of chemical messenger like kairomones (Gilbert,1999).

Moreover, differential population density of rotfers in different study sites was supposed to indicate the non-preferability of *Brachionus* species for macrophyte infested wetlands (site-III) rather than the wetlands having backwater influence (site-II) and clean fresh water wetlands (site-I).

Similarly, the *Keratella* sp. displayed not only seasonality in the occurrence of variation in cyclomorphic forms but also showed a preference for the development of such morphological feature in wetlands having more macrophytes.

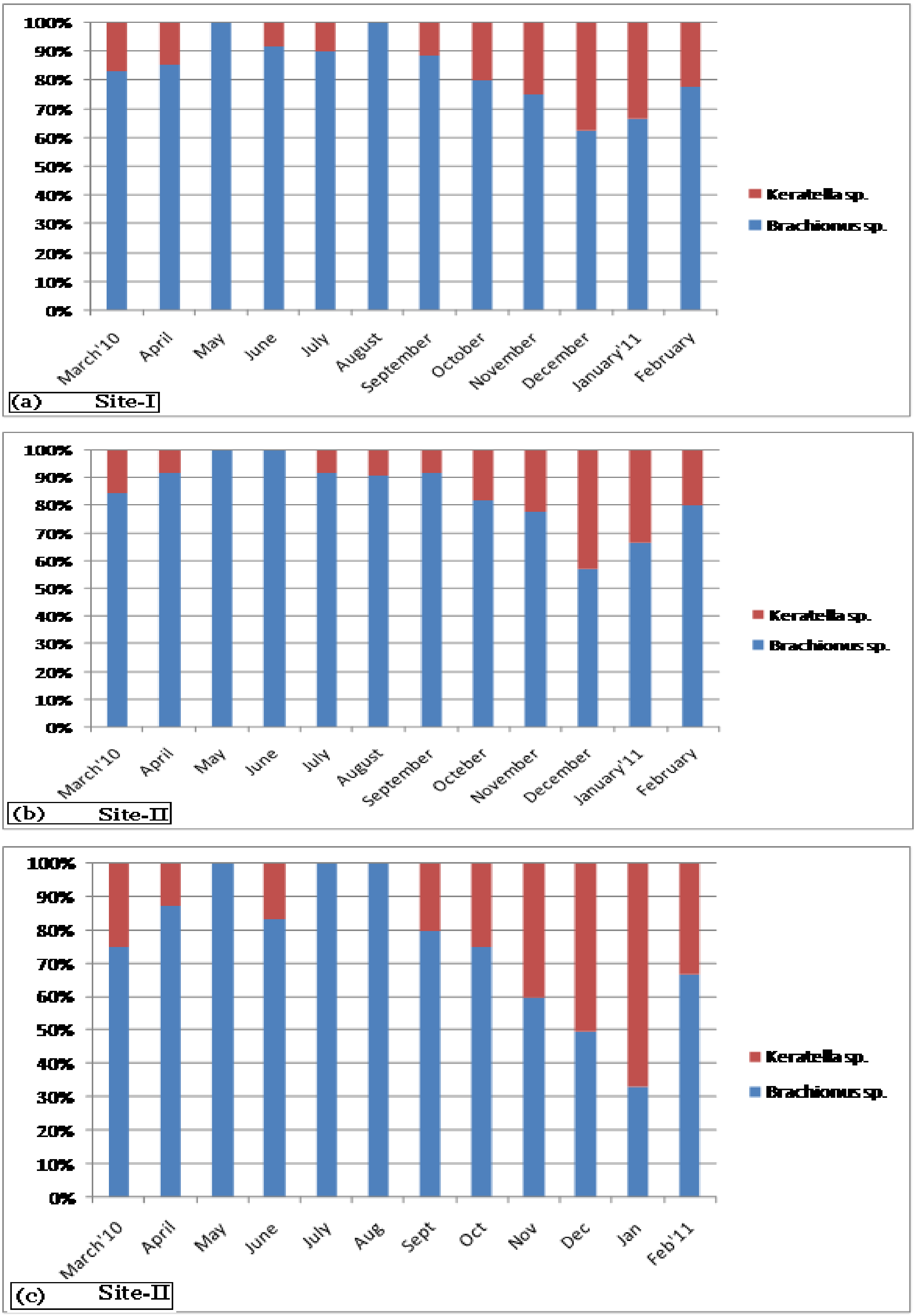

Fig. 3. The seasonal variations of cyclomorphic forms in the relative percentage of densities of two rotifer species at site-I, site-II & site-III respectively.

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References

Dhanapathi MV. 2000. Taxonomic notes on the rotifers from India (from 1889-2000). Publication of Indian Association of Aquatic Biologists, Hyderabad-500095, Andra Pradesh,India,1-178.

Declerck S, Vandekerckhove J, Johannson L, Muylaert K, Conde-Porcuna JM, Gucht KV, 2005. Multi-group biodiversity in shallow lakes along gradients of phosphorus and water plant cover. Ecology **86,** 1905–1915.

Dodson SI. 1974. Adaptive change in plankton morphology in response to size-selective predation: A new hypothesis of cyclomorphosis. Limnology And Oceanography **19(5)**, 721-729.

Dumont HJ. 1977. Biotic factors in the population dynamics of rotifers. Archiv fur Hydrobiologie. Beih **8,** 98-122.

Dumont HJ. 1983. Biogeography of Rotifers. Hydrobiologia **104**, 19-30.

Dumont HJ, Segers H. 1996. Estimating lacustrine zooplankton species richness and complementarity. Hydrobiologia **341,** 125-132.

Gallagher JJ. 1957. Cyclomorphosis in the rotifer Keratella cochlearis (Gosse). Transactions of the American Microscopical Society **76**, 197-203.

Ganesan L, Khan RA. 2008. Studies on the Ecology of Zooplankton in a Floodplain Wetland of West Bengal, India. In Sengupta, M. and R. Dalwani (Eds) Proceedings of Taal2007, The 12th World Lake Conference, p. 67-73.

Gilbert JJ. 1966. Rotifer ecology and embryological induction. Science **151,** 1234-1237.

Gilbert JJ. 1973. Induction and ecological significance of gigantism in the rotifer *Asplanchna sieboldi*. Science **181,** 63-66.

Green J. 1994. The temperate –tropical gradient of planktonic Protozoa and Rotifera. Hydrobiologia **272,** 13-26.

Gulati RD. 1990. Zooplankton structure in the Loosdrecht lakes in relation to trophic status and recent restoration measures. Hydrobiologia **191,** 173-188.

Gulati RD. 1999. Population dynamics of planktonic rotifers in Lake Loosdrecht, the Netherlands, in relation to their potential food and predators. Freshwater Biology **42,** 77-97.

Holland LE, Bryan CF, Newman JP. 1983. Water quality and the rotifer populations in the Atchafalaya river Basin, Louisiana. Hydrobiologia **98,** 55-69.

Hofmann W. 2003. The long-term succession of high-altitude cladoceran assemblages: a 9000-year record from Sa¨gistalsee (Swiss Alps). Journal of Paleolimnology **30,** 291–296.

Jafari N, Nabavi SM, Akhavan M. 2011. Ecological investigation of zooplankton abundance in the river Haraz, Northeast Iran: Impact of environmental variables. Archives of Biological Sciences, Belgrade **63(3),** 785-798.

Korhola A, Rautio M. 2001. Cladocera and other branchiopod crustaceans. In Smol JP, Birks HJB, Last WM, Eds. Tracking Environmental Change Using Lake Sediments 4. Zoological Indicators. Kluwer Academic Publishers, Dordrecht, The Netherlands, p. 5–41.

Mehra NK, Arora J. 2003. Seasonal dynamics of rotifers in relation to physical and chemical conditions of the river Yamuna (Delhi), India. Hydrobiologia, **491,** 101-109.

Mukhopadhyay SK, Chatterjee A, Gupta R, Chattopadhyay B. 2000. Rotiferan community structure of a tannery effluent stabilisation pond in east Calcutta wetland ecosystem. *Chemical* and *Environmental* Research **9(1&2)**, 85-91.

Pradhan P, Chakraborty SK. 2006. Diversity of zooplanktonic rotifers of river Shilabati, West Midnapore District, West Bengal, India. Aquaculture **7(1),** 1-19.

Reddy YR. 2001. Zooplankton diversity:fresh water planktonic copepod with key to common calanoid and cyclopoid genera in India. In: water quality assessment, biomonitoring and zooplankton diversity, Sharma BK, Ed. Department of Zoology, North Eastern Hill University, Shilong, 83-95.

Sharma BK. 1992. Systematics, distribution and ecology of fresh water rotifer of West Bengal. In: Mishra SR, Saksena DN, Eds. Aquatic Ecology, Asish Publishing House, Delhi: 231-237.

Sharma BK. 1998. Fresh water Rotifer (Rotifera:Eurotatoria). Zoological Survey India, Calcutta. State Fauna Series 3: Fauna of West Bengal, Part 11, p. 341-461.

Sharma BK, Sharma S. 1999. Fresh water Rotifera. In: Fauna of MeghalayaState Fauna series 4. Zoological Survey of India. Calcutta **(4),** 11-161.

Sharma BK, Sharma S. 2000. Freshwater Rotifers (Rotifera: Eurotatoria). In: Fauna of Tripura: – State Fauna Series 7. Zoological Survey of India, Calcutta **(4),** 163–224.

Sharma BK. 2000. Rotifers from some tropical flood-plain lakes of Assam (N.E. India). Tropical Ecology **41(2),** 175-181.

Sharma S, Sharma BK. 2008. Zooplankton diversity in floodplain lakes of Assam. Records of the Zoological Survey of India, Occasional Paper No. **290,** 1–307.