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Rotifer communities of floodplain lakes of the Brahmaputra basin of lower Assam (N.E. India): biodiversity, distribution and ecology

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Abstract

The rotifer communities of 15 acidic – alkaline and soft – marginally hard water floodplain lakes of the lower Assam valley of the Brahmaputra river basin, characterized by low ionic concentrations, reveal 164 species (178 taxa) belonging to 39 genera and 20 families and represent the richest biodiversity known to date in these ecotones of the Indian subcontinent. Nine species are new to the Indian Rotifera. Cosmopolitan (59.7%) > pantropical (15.2%) > cosmotropical (12.2%) species dominate the taxocoenosis. Biogeographically interesting elements constitute a notable component (13.4%); important members of this category include six Oriental, two Australasian and seven Palaeotropical species. The examined fauna depicts a tropical character with predominance of *Lecane* spp. (28.0%). Littoral or periphytic rotifers (76.2%) dominate the planktonic species. Rotifers comprise a dominant qualitative (67–103, 79.1 ± 11.0 species) and an important quantitative (mean: 41.1–65.9%) component of zooplankton in all floodplain lakes, register a moderate diversity (mean: 2.036–2.642), low dominance (mean: 0.019–0.216) and high evenness (mean: 0.840–0.893). The examined material indicates several interesting acidophilous elements. Richness depicts significant inverse correlation with pH. Water temperature, conductivity, dissolved oxygen and alkalinity record significant direct relationships with the rotifer abundance. Diversity is influenced by abundance and is also directly correlated with water temperature and conductivity. Canonical analysis shows a notable cumulative impact of six abiotic factors on richness, density and diversity.

Introduction

The floodplain lakes, an integral component of different riverine systems, harbor the richest aquatic biodiversity and are one of the most productive ecosystems of the world. These important inland aquatic resources of India (area: 0.20 million ha) deserve special mentioning in N.E. India (0.12 million ha) in general and Assam in particular (0.10 million ha); they comprise about 93% of the total fish-prone area of the latter state and play a vital role in the socio-economic development of the region. Little is known to date about the micro-fauna and zooplankton diversity in these ecotones of India; routine limnological surveys from this country include poor species inventories due to the general lack of taxonomic expertise. The Rotifera, one of the most diversified group of littoral and limnetic micro-invertebrates of the floodplains, has thus been largely ignored by the Indian workers (Sharma, 1998) except for the detailed investigations by Sharma (2000a, b) and Sharma & Sharma (2001). The present study, an attempt to corroborate this information, deals with the species composition, distribution and ecology of the rotifer communities of 15 floodplain lakes (locally called *beels*) of the lower Assam region of the Brahmaputra basin of N.E. India. The results obtained are discussed with remarks on species richness, general nature and composition of the taxocoenosis, percentage similarities, biogeographically interesting elements and on their abundance, diversity, dominance and evenness.

Materials and methods

Observations were undertaken in 15 floodplain lakes of the lower Assam valley (longitude: 90°–93° E and latitude: 26°–27°N) of the Brahmaputra basin (Fig. 1A–C). The sampled lakes belonged to six districts, namely: Dhubri (Bhoispuri, Barundanga and Dhir), Barpeta (Fingua and Sagmara), Nalbari (Kamakhya and Rowmari), Kamrup (Deepor, Dighali, Borbila and Siligurijan), Marigaon (Mori, Kujibalipatty and Thekera) and Nagaon (Bandha) of Assam state (N.E. India). Water samples were collected from different beels during summer, monsoon, autumn and winter seasons (2002–2003) and were analyzed for water temperature, specific conductivity, pH, dissolved oxygen, alkalinity and hardness. Qualitative and quantitative plankton samples were obtained seasonally by a nylobolt plankton net (no. 25), preserved in 5% formalin and were screened for identification and quantitative enumeration of the Rotifera. Various rotifer taxa were identified following Kutikova (1970), Koste (1978), Koste & Shiel (1990), Segers (1995) and Sharma & Sharma (1999, 2000). Segers (2002) was followed for the recent nomenclature of the Rotifera. Percentage similarities (Sorensen index), diversity (Shannon index), dominance (Berger–Parker index) and evenness (Pielou index) were calculated following Ludwig & Reynolds (1988) and Magurran (1988). The significance of temporal variations of the rotifers was ascertained by ANOVA. Canonical analysis (STATISTICA version 5.0) was undertaken for simple and multivariate correlations.

Results and discussion

The sampled floodplain lakes (Table 1) are characterized by low ionic concentrations. Barundanga records the lowest conductivity (28.2 ± 3.0 μS/

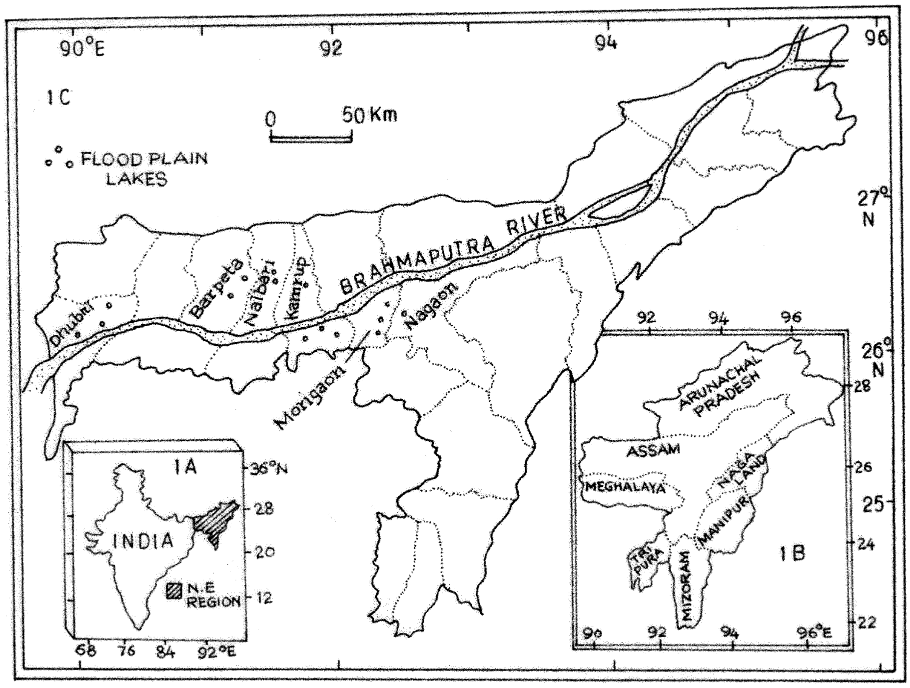

Figure 1. (A) Map of India indicating N.E. region; (B) different states of north-eastern India; (C) map of Assam showing sampled (15) floodplain lakes of six districts.

Table 1. Abiotic factors of floodplain lakes of lower Assam

Abiotic factors	Water temp. (°C)	Specific conductivity (μS/cm)	pH	Dissolved oxygen (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)
Floodplain lakes						
Bhoispuri	21.0–30.5	39.0–86.5	6.3–7.2	4.4–10.8	18.0–32.0	12.8–24.0
	25.6 ± 3.1	60.2 ± 20.3	6.4 ± 0.4	6.9 ± 2.7	22.4 ± 2.8	14.2 ± 4.5
Barundanga	17.0–32.4	24.0–37.0	5.5–6.6	4.8–9.8	12.0–26.0	10.0–18.0
	27.2 ± 5.6	28.2 ± 3.0	6.2 ± 0.4	6.8 ± 2.1	14.2 ± 7.3	12.0 ± 4.5
Dhir	17.5–30.0	68.0–130.0	6.5–7.2	5.0–10.6	28.6–56.8	20.4–48.0
	25.6 ± 4.5	106.0 ± 17.6	6.8 ± 0.3	7.8 ± 2.1	36.7 ± 5.1	34.1 ± 3.8
Fingua	23.2–33.5	89.0–173.0	6.9–9.4	4.2–12.	62.0–84.0	57.0–76.0
	29.4 ± 5.5	137.3 ± 43.4	7.9 ± 1.3	7.9 ± 4.1	73.7 ± 11.1	67.0 ± 9.5
Sagmara	21.0–32.6	76.0–98.0	6.8–8.9	5.8–9.0	28.2–46.0	25.0–42.8
	28.0 ± 4.0	86.0 ± 6.1	7.8 ± 0.4	7.6 ± 1.8	34.0 ± 5.2	32.1 ± 4.3
Kamakhya	18.4–33.6	114.0–182.0	6.8–7.2	3.4–12.4	58.0–78.0	53.0–69.0
	26.8 ± 7.7	158.0 ± 38.2	7.05 ± 0.3	8.5 ± 4.6	69.3 ± 10.3	61.7 ± 8.1
Rowmari	19.5–31.9	72.0–148.0	6.8–7.9	4.2–10.4	83.0–124.0	67.0–82.0
	27.1 ± 4.4	111.0 ± 28.6	7.3 ± 0.4	7.5 ± 2.6	106.2 ± 16.7	74.0 ± 5.6
Deepor	20.9–32.8	106.0–199.0	6.5–9.5	3.2–12.8	32.0–94.0	46.0–82.0
	28.7 ± 3.7	164.8 ± 32.9	7.4 ± 0.7	6.4 ± 2.3	69.7 ± 17.9	63.3 ± 14.5
Dighali	18.0–31.2	46.0–89.0	6.4–7.2	4.6–7.8	28.0–48.0	26.2–45.4
	26.2 ± 4.6	60.8 ± 7.8	6.7 ± 0.7	6.4 ± 2.2	38.4 ± 3.2	32.8 ± 5.7
Borbila	17.8–32.0	50.0–98.0	6.8–8.0	5.2–10.6	26.0–40.0	20.8–38.0
	27.0 ± 4.0	68.0 ± 8.0	7.3 ± 0.5	7.8 ± 2.0	32.8 ± 4.0	26.0 ± 6.5
Siligurijan	17.9–31.7	130.0–189.0	6.8–7.4	4.4–9.8	45.0–84.0	40.0–76.0
	27.1 ± 5.5	157.0 ± 25.1	7.2 ± 0.2	6.5 ± 2.0	61.4 ± 14.1	60.0 ± 14.1
Mori	18.5–30.0	80.6–132.0	6.8–8.2	4.2–12.0	55.0–85.0	50.5–76.0
	26.5 ± 4.2	98.0 ± 18.7	7.6 ± 0.4	6.2 ± 3.8	65.4 ± 10.2	62.1 ± 7.1
Kujibalipatty	18.0–30.0	76.9–102.0	6.2–8.2	5.7–12.5	50.2–84.5	36.8–82.0
	26.2 ± 3.8	86.0 ± 12.5	7.6 ± 0.6	6.8 ± 3.2	60.8 ± 10.7	59.6 ± 10.1
Thekera	18.0–29.5	130.0–178.0	7.2–8.1	5.7–8.2	32.0–57.0	26.0–38.0
	24.0 ± 4.2	152.4 ± 20.8	7.6 ± 0.3	6.8 ± 1.3	38.4 ± 7.6	32.6 ± 2.5
Bandha	16.8–30.0	66.0–82.2	6.4–7.2	4.8–7.8	32.0–68.4	30.6–62.0
	25.6 ± 3.1	68.0 ± 7.5	6.8 ± 0.2	6.2 ± 0.8	40.5 ± 10.2	38.9 ± 7.8

cm), seven beels show mean conductivity <100 μS/cm while the mean conductance ranges between 106.0 and 164.8 μS/cm in the rest; these biotopes, hence, can be assigned to 'Class I' category *vide* Talling & Talling (1965). The mean water temperature (25.6–29.4 °C) affirms a tropical range. Dissolved oxygen (mean: 6.2–8.5 mg/l) indicates a well-oxygenated nature of these waters and also corresponds with earlier results from upper Assam (Sharma, 2000a; Sharma & Sharma, 2001). The mean pH indicates acidic nature of five lakes, one shows circum-neutral character while nine are alkaline. In addition, eight lakes show soft-waters, six indicate slightly hard-waters and one lake exhibits hard-water character.

One hundred and 64 species (178 taxa) identified presently (Table 2) indicate the highest diversity of Eurotatoria in the floodplain lakes of the Indian subcontinent to date. This salient feature, in turn, certainly reflects a greater environmental heterogeneity of the sampled beels as suggested by Jose de Paggi (1993), Bonecker et al. (1998) and

Table 2. Rotifera in Floodplain lakes of Lower Assam

Reported taxa	Localities
Family: Brachionidae	
Anuraeopsis fissa (Gosse)	1,3–9, 11, 12, 14, 15
A. navicula Rousselet	5, 8, 10, 11, 13, 15
Brachionus angularis Gosse	1–15
B. bidentatus Anderson	1–10, 12–14
B. budapestinensis Daday	1, 2, 15
B. calyciflorus Pallas	1–4, 6–12, 15
B. caudatus Barrois & Daday	1, 4, 5, 8, 11–13
B. dichotomus reductus Koste & Shiel	1, 10, 14
B. diversicornis (Daday)	2–11, 13–15
B. donneri Brehm	2, 9, 13
B. falcatus Zacharias	1–15
B. forficula Wierzejski	1–3, 5, 7–10, 12, 14, 15
B. mirabilis Daday	3, 8, 9
B. quadridentatus (Hermann)	1–15
B. rubens Ehrenberg	4, 6–9, 11, 12
Keratella cochlearis Gosse	1–15
K. edmondsoni Ahlstrom	3
K. javana Hauer	1
K. tropica (Apstein)	1–5
K. lenzi Hauer	2, 3, 5–11, 15
K. procurva (Thorpe)	2, 3, 5, 8, 9, 10, 14
K. quadrata (Müller)	1, 3, 8, 11
Platyias quadricornis (Ehrenberg)	1, 3–12, 14
P. leloupi (Gillard)	2, 15
Plationus patulus (Müller)	1–15
P. patulus macracanthus (Daday)	3, 5–10, 12, 13, 15
Family: Euchlanidae	
Euchlanis dilatata Ehrenberg	1–15
E. incisa Carlin	3, 6, 8, 14
E. oropha Gosse	2, 11, 13
E. triquetra Ehrenberg	3, 8, 9, 12
Dipleuchlanis ornata Segers	1,14
D. propatula (Gosse)	2, 3, 6–13, 15
Manfredium eudactylotum (Gosse)	1–4, 6–10, 13–15
Family: Mytilinidae	
Lophocharis salpina (Ehrenberg)	2, 3, 12
Mytilina acanthophora Hauer	1, 9, 13, 14
M. bisulcata (Lucks)	3, 5–10, 13
M. ventralis (Ehrenberg)	1–15
Family: Trichotriidae	
Macrochaetus collinsi (Gosse)	3, 15
Macrochaetus longiges (Myers)	1, 13, 9, 13

Table 2. (Continued)

Reported taxa	Localities
M. sericus (Thorpe)	2–14
Trichotria tetractis (Ehrenberg)	1–15
Family: Ephiphanidae	
Ephiphanes brachionus (Ehrenberg)	1, 3, 6, 8, 9, 13–15
Family: Lepadellidae	
Colurella adriatica (Ehrenberg)	2, 10, 14
C. obtusa (Gosse)	1–15
C. sulcata (Stenroos)	1, 8
C. sanoamuangae Chittapun et al.	3
C. uncinata (Müller)	1, 2, 4–15
Lepadella acuminata (Ehrenberg)	1, 3, 5, 8,9–13,15
L. apsida Harring	1, 2, 5–12
L. biloba Hauer	3, 4, 6, 7, 14
L. cristata (Rousselet)	2, 7, 10
L. costatoides Segers	3, 8
L. discoidea Segers	1
L. ehrenbergi (Perty)	1–12, 14
L. heterodactyla Fadeev	2, 12
L. heterostyla (Murray)	1–10, 12, 15
L. lindaui Koste	2, 13
L. minuta (Montet)	3, 8, 9, 14, 15
L. ovails (Müller)	1–15
L. patella (Müller)	1–15
L. rhomboides (Gosse)	1, 3–6, 8–12, 14
L. triba Myers	2
L triptera Ehrenberg	3, 8, 9, 11, 13, 14
Squatinella mutica (Ehrenberg)	1, 2, 6, 7, 8–11
Family: Lecanidae	
Lecane acanthinula (Hauer)	7
L. aculeata (Jakubski)	1–13, 15
L. arcula Harring	3
L. batillifer (Murray)	2, 9
L. bifurca (Bryce)	1, 4, 8, 9
L. blachei Berzins	1, 10
L. bulla (Gosse)	1–15
L closterocerca (Schmarda)	1–15
L. crepida Harring	1–3, 6, 8, 13–15
L. curviconis (Murray)	1–15
L. decipiens (Murray)	1, 7, 10
L. doryssa Harring	2, 8
L. flexilis (Gosse)	1, 3, 9, 13–15
L. glypta Harring & Myers	12
L. hastata (Murray)	2–6, 9–15
L. haliclysta Harring & Myers	2
L. hamata (Stokes)	8, 9, 15

Continued on p. 213

Table 2. (Continued)

Reported taxa	Localities
L. hornemanni (Ehrenberg)	1, 3–12, 15
L. inermis (Bryce)	1–3, 7–9, 12–14
L. inopinata Harring & Myers	1, 2, 4, 6, 10–14
L. lateralis Sharma	4, 11
L. leontina (Turner)	1–15
L. ludwigii (Eckstein)	1, 3–10, 12, 13, 15
L. luna (Müller)	1–15
L. lunaris (Ehrenberg)	1–15
L. monostyla (Daday)	2, 12
L. nana (Murray)	1, 2, 6, 9, 13–15
L. ohioensis (Herrick)	2, 3, 6, 8, 12
L. papuana (Murray)	1–5
L. ploenensis (Voigt)	1–6, 8–12, 14
L. pertica Harring & Myers	1, 3, 4, 6–9, 11, 12
L. pusilla Harring	2
L. pyriformis (Daday)	1–11, 13–14
L. quadridentata (Ehrenberg)	1–15
L. rugosa (Harring)	8
L. ruttneri Hauer	11
L. scutata (Harring & Myers)	1, 2, 7–9, 12
L. signifera (Jennings)	1, 2, 4, 8, 9, 13–15
L. sola Hauer	3,7
L. solfatara (Hauer)	10
L. stenroosi (Meissner)	3, 13–15
L. superaculeata Segers & Sanoamuang	3
L. sympoda Hauer	3, 8, 9, 14, 15
L. thienemanni (Hauer)	2, 3, 6–12
L. unguitata (Fadeev)	1–15
L. ungulata (Gosse)	1–15
Family: Notommatidae	
Cephalodella forficula (Ehrenberg)	1, 3–11, 14, 15
C. gibba (Ehrenberg)	2–5, 7–12
C. mucronata Harring & Myers	13, 14
Monommata longiseta (Müller)	1, 3, 4, 6–10, 12, 13, 15
M. maculata Myers	4
Notommata pachyura (Harring & Myers)	5
N. spinata Koste & Shiel	1
Taphrocampa selenura Gosse	10
Family: Scarididae	
Scaridium longicaudum (Müller)	1, 2, 4–12, 14
Family: Gastropodidae	
Ascomorpha saltans Bartsch	1, 13
A. ovalis (Bergendal)	3, 4, 9, 13, 14
Family: Trichocercidae	
Trichocerca bicristata (Gosse)	2, 13, 15
T. capucina (Wierzejski & Zacharias)	1, 3–13
T. cylindrica (*Imhof*)	1–6, 8–10, 12, 15
T. elongata (*Gosse*)	1, 3–5, 7–11 ,13 ,14
T. flagellata Hauer	4, 14
T. jenningsi Voigt	3, 12
T. iernis (Gosse)	7
T. longiseta (Schrank)	1–6, 9
T. porcellus (Gosse)	1–3, 5–12, 14, 15
T. rattus (Müller)	1, 13, 14
T. similis (Wierzejski)	1–3, 5–12, 14, 15
T. voluta (Murray)	13
T. weberi (Jennings)	2, 14, 15
Family: Asplanchnidae	
Asplanchna brightwelli Gosse	3, 13, 14
A. priodonta Gosse	1–12, 15
Family: Synchaetidae	
Synchaeta oblonga Ehrenberg	12
Pleosoma lenticulare Herrick	3, 9, 15
Polyarthra vulgaris Carlin	1–15
Family: Dicranophoridae	
Dicranophorides caudatus (Ehrb.)	1, 3, 5–10, 12, 15
D. forcipatus (Müller)	3–11
Family: Flosculariidae	
Sinantherina spinosa (Thorpe)	1, 3, 5–9, 12, 15
S. socialis (Linne)	2–9, 11, 13, 14
Family: Conochilidae	
Conochilus unicornis Rousselet	1, 3, 4, 6–10, 12, 15
Family: Hexarthridae	
Hexarthra intermedia Wiszniewski	4, 14
H. mira (Hudson)	1, 3, 5–9, 14, 15
Family: Filiniidae	
Filinia brachiata (Rousselet)	3
F. camasecla Myers	1–4, 7–10, 12
F. longiseta (Ehrenberg)	1–15
F. terminalis (Plate)	3, 6, 8, 9, 15
F. opoliensis (Zacharias)	1, 3–11, 14, 15
F. pejleri Hutchinson	1, 2, 4, 5, 10, 13, 15
F. saltator (Gosse)	2, 13, 15

Continued on p. 214

Table 2. (Continued)

Reported taxa	Localities
Family: Testudinellidae	
Testudinella brevicaudata Yamamoto	4, 8
T. emarginula (Stenroos)	1–3, 9, 14, 15
T. greeni Koste	1, 3–5, 7–9, 11, 12, 15
T. parva (Ternetz)	2, 13
T. patina (Hermann)	1–15
T. tridentata Smirnov	3, 11, 14
Pompholyx sulcata Hudson	3, 9, 10, 15
Family: Trochosphaeridae	
Horaella brehmi Donner	13, 14
Trochosphaera aequatorialis Semper	1, 3, 7–10
Family: Philodinidae	
Philodina citrina (Ehrenberg)	3, 4, 8, 12, 14
Rotaria neptunia (Ehrenberg)	1, 3, 4, 5, 8–12, 14
R. rotatoria (Pallas)	2, 13, 15

1. Bhoispuri; 2. Barundanga; 3. Dhir; 4. Finguna; 5. Sagmara; 6. Kamakhya; 7. Rowmari; 8. Deepor; 9. Dighali; 10. Borbila; 11. Siligurijan; 12. Mori; 13. Kujibalipatty; 14. Thekera; 15. Bandha.

Shiel et al. (1998) and also supports the statement of Segers et al. (1993) indicating (sub)tropical floodplains to be the world's richest habitats for rotifers. The documented species comprise a significant fraction of the Indian Rotifera (46.4%) and of the fauna of North-Eastern India (87.2%). This study indicates the highest rotifer generic (39 genera) and family diversity (20 families) known from any region of this country. Besides, nine species, namely: *Dipleuchlanis ornata* (Figs. 2 and 3), *Macrochaetus longipes* (4), *Colurella sanoamuangae* (5), *Lepadella heterodactyla* (6), *Lecane glypta* (7), *L. rugosa* (8, 9), *L. solfatara* (10), *Monommata maculata* (11, 12) and *Notommata spinata* (13) are new to India.

The overall richness (164 species) noticed presently is reasonably lower than previous highest records of 207 (Segers et al., 1993), 252 (Shiel et al., 1998) and 218 (Bonecker et al., 1998) species from Africa, Australia and South America respectively. The richness of 67–103 (79.1 ± 11.0) species recorded in individual beels is, however, the highest known so far from India but is yet distinctly lower than the reports of 136 species (Iyi-Efi lake) and 124 species (Oguta lake) in the Niger delta (Segers et al., loc cit), 130 species from Lake Guarana, Brazil (Bonecker et al., 1994). The peak richness of 103 species nearly corresponds with 104 species from Laguana Bufeos, Bolivia (Segers et al., 1998) and is reasonably comparable with 111 species and 114 taxa examined from floodplains of Argentina by Jose de Paggi (1993, 2001), respectively. On the other hand, it presents a remarkable coincidence with 102+ rotifer species recorded in a sampling campaign in a Brazilian reservoir (Segers & Dumont, 1996).

The documented richness is distinctly greater than an earlier highest record of 116 species (Sharma & Sharma, 2001) from seven floodplain lakes of Assam and registers 80.0% of similarity (*vide* Sorensen index) with the same. This notable enhancement is due to the more extensive nature of the currently examined collections as well as relatively larger number of sampled beels while higher similarity between these studies is due to common occurrence of several cosmopolitan, pantropical and cosmotropical elements. On the other hand, a comparison of the present list from the floodplains of the Brahmaputra basin with the report of 89 species (Arora & Mehra, 2002) and subsequently 110 species (Arora & Mehra, 2003) based on monthly collections from the backwaters of the river Yamuna at Delhi indicates only 41.8 and 48.2% similarities respectively. These differences in rotifer composition are, however, attributed to the unique ecotone nature of the sampled beels rather than the basic wetland character of the river Yamuna backwaters and to the lesser diversity of macrophytes in the latter.

The rotifers depict a qualitative predominance in all floodplain lakes and thus concur with the previous findings of Sarma (2000), Sharma (2000a, b), Sharma & Sharma (2001) and Khan (2002). The richness (67–103 species) in different lakes (Table 3) is significantly higher than 54–65 species (Sharma & Sharma, 2001) recorded from beels of upper and lower Assam. On the other hand, a comparison with the other Indian literature is handicapped due to an inadequate sampling, and insufficient analysis of the rotifer communities due to general lack of taxonomic expertise and ignoring of smaller taxa. These salient lacunae are clearly endorsed by incomplete inventories reporting merely 29 species from four beels (Goswami, 1997), 48 species from 33 beels (Sarma,

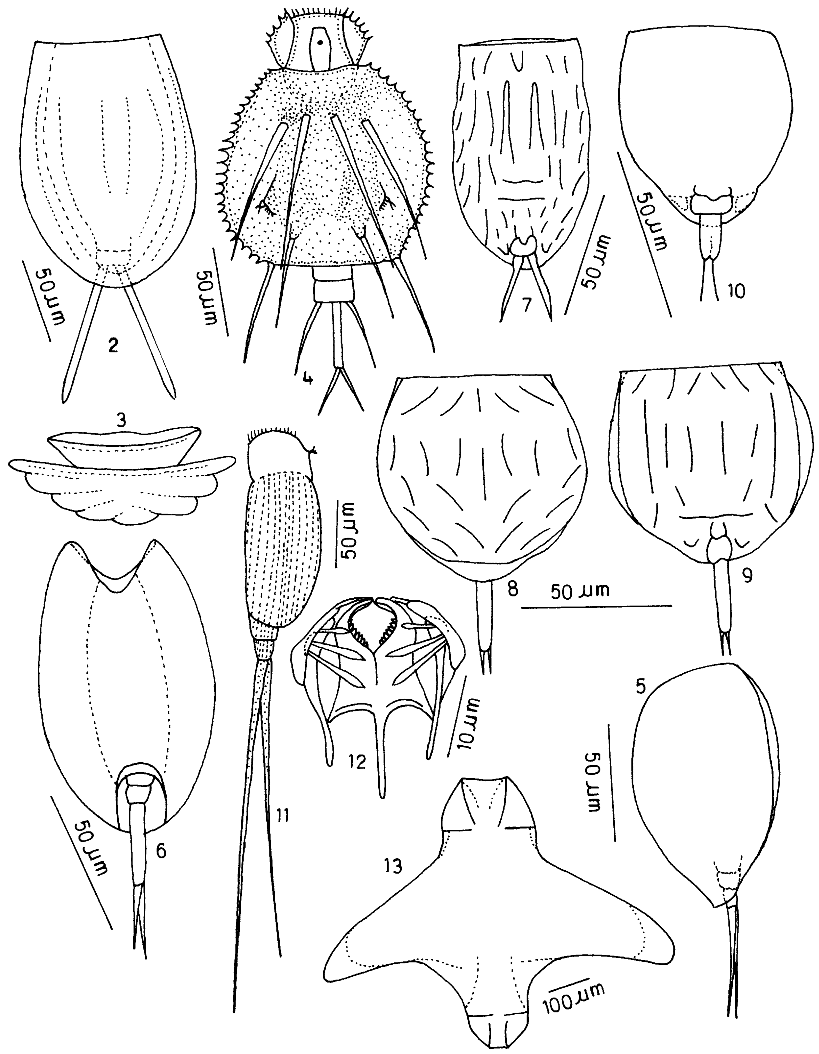

Figure 2. Dipleuchlanis ornata Segers: 2, dorsal view, 3, cross-section; *Macrochaetus longipes* (Myers): 4, dorsal view; *Colurella sanoamuangae* Chittapun et al.: 5, lateral view; *Lepadella heterodactyla* Fadeev: 6, ventral view; *Lecane glypta* Harring & Myers: 7, ventral view; *L. rugosa* (Hauer): 8, dorsal view, 9, ventral view; *L. solfatara* (Hauer): 10, ventral view; *Monommata maculata* Myers: 11, lateral view, 12, trophi; *Notommata spinata* Koste & Shiel: 13, dorsal view (contracted).

2000), 54 species from five beels (Sharma, 2000b) and 9 species from one beel (Goswami & Goswami, 2001) of Assam state. Besides, this disparity is again affirmed by the reports of only 11 species from two floodplain lakes of Kashmir (Khan, 1987), as well as 37 species from two Ox-bow lakes (Khan, 2002) and 38 species from 9 floodplain lakes (Khan, 2003) of South-eastern West Bengal while the lists by Sanjer & Sharma (1995) and Baruah & Das (2001) are incomplete to ascertain correct extent of the examined taxa.

Lecanidae (46 species) > Brachionidae (25 species) > Lepadellidae (22 species) > Trichocercidae (13 species) comprise a dominant fraction (64.5%) of overall diversity and that of the communities of individual beels (63.1–72.8, 67.0 ± 2.8%). The occurrence of a number of taxa of these families concurs with the reports from floodplains of South America (Jose de Paggi, 1993, 2001; Bonecker et al., 1994, 1998; Lansac-Toha et al., 1997; Rossa, 1997; Serafim, 1997; Segers et al., 1998), Africa (Segers et al., 1993), Thailand

Table 3. Seasonal variations in Rotifer species richness

Lakes	Autumn	Winter	Summer	Monsoon	Range	Mean ± SD	Total richness
Bhoispuri	48	60	63	55	48–55	56.5 ± 5.7	89
Barundanga	42	58	61	46	42–61	51.5 ± 7.9	81
Dhir	58	65	68	52	52–68	60.7 ± 6.2	103
Fingua	38	45	57	44	38–57	46.0 ± 6.0	73
Sagmara	38	42	48	50	38–50	44.5 ± 4.8	67
Kamakhya	45	56	45	41	41–56	46.7 ± 5.6	72
Rowmari	41	45	48	54	41–54	47.3 ± 4.4	75
Deepor	59	68	67	45	45–68	59.7 ± 9.2	97
Dighali	46	59	65	42	42–65	53.0 ± 9.3	95
Borbila	40	46	54	49	40–54	46.7 ± 5.7	77
Siligurijan	34	52	45	42	34–52	43.2 ± 6.5	67
Mori	40	48	44	38	38–51	42.5 ± 3.8	71
Kujibalipatty	49	54	42	30	30–54	43.7 ± 9.0	71
Thekera	34	35	48	32	32–48	37.2 ± 6.3	74
Bandha	37	39	50	35	35–50	40.1 ± 5.8	75

(Sanoamuang, 1998) and India (Sharma & Sharma, 2001). In addition, this generalization agrees with general composition of the Indian Rotifera (Sharma, 1998) and the rotifer fauna of the Oriental region. Besides, Notommatidae > Euchlanidae = Filiniidae = Testudinellidae, together, form a valuable component in the beels of the lower Assam.

The present observations register a predominance of cosmopolitan species (59.7%). Pantropical (25 species) > cosmotropical (20 species) elements, together, constitute an important component (27.4%). *Lecane* and *Brachionus*, two 'tropic-centered' genera, exhibit significance. In fact, *Lecane* spp. alone comprise 28.0% of total richness and that of the faunas of individual beels (23.9–32.4, 29.2 ± 1.8%). The lecanid dominance compares well with floodplain rotifer communities studied by Segers et al. (1993, 1998), Sanoamuang (1998), Jose de Paggi (2001) and Sharma & Sharma (2001). The stated features impart a general tropical character to the examined taxocoenosis and also concur with the composition of tropical rotifer faunas from different parts of the globe (Green, 1972; Pejler, 1977; Fernando, 1980; Dussart et al., 1984; Segers, 1996; Sharma, 1998). This conclusion is also supported by the occurrence of fewer species of 'temperate-centered' *Keratella* (7 species) and *Synchaeta* (1 species). The lack of any member of *Notholca* in these floodplains is interesting though species of this temperate genus are reported to drift with the Himalayan rivers to lower latitudes of N.W. India (Arora & Mehra, 2003). In addition, 23 species (14%) are observed in all the beels while an equal number of species (14%) exhibit rare occurrence.

The examined collections reveal an important fraction (13.4%) of biogeographically interesting elements. Notable among these are six Oriental species namely *Keratella edmondsoni*, *Colurella sanoamuangae*, *Lecane acanthinula*, *L. blachei, L. solfatara* and *L. superaculeata*. Of these, *C. sanoamuangae* and *L. superaculeata* are described from Thailand by Chittapun et al. (1999) and Sanoamuang & Segers (1997), respectively and *L. solfatara* has been described from Sumatra (Hauer, 1938). The lecanid *L. superaculeata* is reported recently from N.E. India (Sharma, 2004), the distributional ranges of *C. sanoamuangae* and *L. solfatara* are presently extended to the Indian subcontinent, while comments on the distribution of other Oriental elements are made earlier by Sharma & Sharma (2001). Two Australasian elements i.e., *Brachionus dichotomus reductus* and *Lecane batillifer* have also been recorded earlier from N.E. region (Sharma & Sharma, loc cit). Besides, this study indicates seven paleotropical species, namely *Keratella javana*, *Lepadella discoidea*, *Lecane braumi*, *L. lateralis*, *L. unguitata*, *Testudinella greeni* and *T. brevicaudata*; all these except *L. discoidea* were examined earlier (Sharma & Sharma, loc cit). The report of the erstwhile Afrotropical *Dipleuchlanis ornata*, described from the floodplain of the river Niger (Segers, 1993), deserves special attention. A few specimens of this euchlanid collected earlier (Sharma, unpublished) from Tripura could not be described due to insufficient material. This species has been reported earlier from Papua New Guinea by Segers & De Meester (1994) who believed it to occur in the tropical and subtropical regions of the Old World. As of now, the present study, however, represents its second report from the Oriental region.

Interestingly, the analyzed rotifer communities are characterized by the occurrence of a high number of small taxa although species up to the size class of about 600 μm are also frequently noticed. The former feature may be assigned to conditions of low concentrations of food, and predation by fish and invertebrates as suggested by Papinski (1990) and Baumgartner et al. (1997) respectively. However, the detailed observations are required to confirm these findings. The predominance of periphytic or littoral elements (76.2%) and fewer planktonic rotifers noticed presently may be attributed to the lack of definite pelagic habitats (De Manuel, 1994) in floodplain lakes, their shallow nature and the growth of aquatic macrophytes. Further, this study demonstrates a frequent occurrence of non-planktonic taxa in open waters of many beels. The establishment of both planktonic and non-planktonic taxa in beels with marginal vegetation suggests the occupation of different niches (Bonecker et al., 1998).

The present study indicates an acidophilic nature of *Colurella sanoamuangae*, *Lecane glypta* and, *Monommata maculata* which, in turn, concurs with the remarks of Chittapun et al. (1999), Koste & Shiel (1990) and Koste & Shiel (1991) respectively. In addition, several other examined acidophilous elements namely *Plationus patulus* f. *macracanthus*, *Dipleuchlanis propatula*, *Euchlanis triquetra*, *Mytilina bisulcata*, *Colurella sulcata*, *Lepadella acuminata*, *L. cristata*, *Lecane pertica*, *Monommata longiseta*, *Testudinella emarginula*, *T. parva* and *T. tridentata* are in broad conformity with the earlier results of Sharma & Sharma (2001). Among about 22 species of the genus *Brachionus* known to occur in the Indian waters (Sharma, 1998), only 13 species are included in this account. The relative paucity of these species in general is assigned to the acidic nature of a number of beels. However, the present report of 13 *Brachionus* spp., as against an earlier report of only eight species (Sharma & Sharma, loc cit), is attributed to the fact that nine beels sampled presently exhibit an alkaline nature.

The rotifer richness shows significant variations in different seasons ($F_{3.59} = 12.827$, $p < 0.001$) and in different beels ($F_{14.59} = 5.863$, $p < 0.001$). The number of species varies between 30 and 68 in individual beels (Table 3) in different seasons, shows indefinite seasonal periodicity and depicts nearly identical mean values between autumn (43.3 ± 7.4) and monsoon (43.2 ± 7.5) and again between winter (51.5 ± 9.3) and summer (51.9 ± 9.4). The maximum richness is noted during summer and winter in eight and five beels, respectively. Canonical analysis registers a significant inverse relationship between richness and pH ($r = -0.542$), thereby suggesting a higher rotifer diversity in acidic waters than in alkaline conditions. The rotifer communities of different beels register 54.4–86.5% similarity (*vide* Sorensen index). The peak similarity is observed between Deepor and Dighali while lowest similarity is observed between Rowmari and Kujibalipatty. Only 12.4 and 8.6% instances (Table 4) indicate a similarity <60 and >80% respectively while in majority of instances (79%), the similarity varies between 60 and 70%. Further, Thekera beel records the lowest similarity range (55.2–67.6%). In general, the rotifer similarity noted presently is higher than 42.9–80.4% (Sharma & Sharma, 2001) and 37.3–68.8% (Sharma, 2000b) reported earlier from the beels of the upper Assam.

This study depicts significant differences (Table 5) of rotifer densities (68–329 n/l) between beels ($F_{14.59} = 10.601$, $p < 0.001$) and between seasons ($F_{3.59} = 2.345$, $p < 0.08$). Bhoispuri (74–132 n/l), Barundanga (81–102 n/l), Mori (79–123 n/l) and Kujibalipatty (73–121 n/l) record a lower abundance while, Sagmara (191–318 n/l) and Kamakhya (210–329 n/l) beels indicate a relatively

Table 4. Percentage similarities between Rotifer communities (Sorensen's index)

Floodplain lakes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bhoispuri	–	60.0	62.5	71.7	70.5	70.8	69.5	74.2	77.2	73.5	64.1	68.7	65.0	65.0	65.8
Barundanga		–	56.5	62.3	66.2	67.8	64.1	62.9	64.8	67.1	60.8	65.8	64.5	58.1	61.5
Dhir			–	65.9	68.2	70.9	71.9	83.0	63.6	71.1	67.0	66.7	57.5	62.1	69.7
Fingua				–	75.7	78.6	74.3	77.6	73.8	73.3	74.3	75.0	59.7	61.2	69.7
Sagmara					–	80.6	76.1	76.8	74.1	80.6	79.1	72.5	57.9	65.2	61.9
Kamakhya						–	80.2	60.4	82.6	80.5	77.7	75.5	60.1	67.1	72.1
Rowmari							–	81.4	76.5	81.6	77.5	74.9	53.4	60.4	64.0
Deepor								–	86.5	77.0	74.4	75.0	57.1	65.5	69.8
Dighali									–	76.7	71.6	69.9	71.1	66.3	74.1
Borbila										–	73.6	74.3	59.4	63.6	61.8
Siligurijan											–	71.0	58.0	61.0	59.1
Mori												–	53.5	55.2	63.2
Kujibalipatty													–	67.6	61.4
Thekera														–	60.4
Bandha															–

1. Bhoispuri; 2. Barundanga; 3. Dhir; 4. Fingua; 5. Sagmara; 6. Kamakhya; 7. Rowmari; 8. Deepor; 9. Dighali; 10. Borbila; 11. Siligurijan; 12. Mori; 13. Kujibalipatty; 14. Thekera; 15. Bandha.

higher abundance. In general, the recorded ranges concur with the earlier report of Sharma (2000b). The rotifers, however, comprise a dominant quantitative component (mean: 41.1–65.9%) of zooplankton of the sampled beels; the lowest component (34.2–44.7%) is noticed in Mori while Kamakhya depicts peak range (60.3–71.2%). In addition, percentage contributions depict marginal variations in their ranges and mean values in all beels during different seasons i.e., autumn (34.2–70.0; 52.2 ± 10.2%), winter (41.4–69.5; 53.7 ± 8.7%), summer (34.2–67.6; 52.2 ± 11.6%) and monsoon (36.9–71.2; 51.6 ± 10.7%). Our results indicate a higher

Table 5. Seasonal variations in Rotifer abundance (n/l) and percentage composition

Lakes	Autumn	Winter	Summer	Monsoon	Mean ± SD	Percentage
Bhoispuri	94	132	74	109	102 ± 21	49.0 ± 7.6
Barundanga	115	99	81	102	99 ± 12	51.8 ± 6.8
Dhir	187	129	158	122	149 ± 26	55.9 ± 12.7
Fingua	161	195	182	250	197 ± 33	64.1 ± 4.5
Sagmara	191	210	242	318	240 ± 48	65.9 ± 5.4
Kamakhya	210	235	252	329	256 ± 44	63.7 ± 4.4
Rowmari	272	182	153	210	192 ± 29	57.3 ± 6.6
Deepor	210	239	175	224	212 ± 24	52.1 ± 5.9
Dighali	131	145	120	192	147 ± 27	47.1 ± 6.5
Borbila	142	163	105	138	137 ± 21	49.4 ± 4.0
Siligurijan	109	87	158	172	132 ± 35	55.9 ± 9.9
Mori	89	123	79	108	100 ± 17	41.9 ± 4.5
Kujibalipatty	121	73	69	85	87 ± 20	42.4 ± 7.0
Thekera	81	68	137	110	99 ± 27	41.4 ± 3.2
Bandha	108	122	198	135	141 ± 34	48.3 ± 8.7

Table 6. Seasonal variations in Rotifer Species diversity

Lakes	Autumn	Winter	Summer	Monsoon	Mean ± SD
Bhoispuri	1.910	2.238	1.817	2.249	2.053 ± 0.193
Barundanga	2.506	3.001	1.992	2.102	2.250 ± 0.254
Dhir	2.622	2.314	2.280	2.018	2.309 ± 0.214
Fingua	2.110	1.994	1.987	2.547	2.159 ± 0.229
Sagmara	2.585	2.008	2.672	2.876	2.535 ± 0.322
Kamakhya	2.851	2.972	2.030	2.087	2.485 ± 0.429
Rowmari	2.194	2.647	2.857	1.914	2.403 ± 0.370
Deepor	2.885	2.989	2.653	2.040	2.642 ± 0.368
Dighali	2.242	2.018	2.110	2.145	2.151 ± 0.054
Borbila	1.982	2.110	1.998	2.015	2.036 ± 0.049
Siligurijan	2.128	2.543	2.672	2.782	2.531 ± 0.495
Mori	2.082	2.432	1.987	2.102	2.152 ± 0.168
Kujibalipatty	1.987	2.114	2.257	1.990	2.087 ± 0.110
Thekera	2.010	1.989	2.153	2.432	2.146 ± 0.177
Bandha	2.414	2.567	1.981	2.015	2.244 ± 0.252

rotifer abundance in warmer months with the peak density during summer in five beels and during monsoon in two beels. This trend is supported by a significant correlation with water temperature ($r = 0.589$). In addition, the rotifer density shows significant direct relationships with specific conductivity ($r = 0.449$), dissolved oxygen ($r = 0.584$) and alkalinity ($r = 0.420$).

The mean rotifer diversity (Table 6) ranges between 2.036 and 2.642 and thus concurs with the earlier reports of Sharma (2000a) and Sharma & Lyngskor (2003). The diversity is significantly influenced by density ($r = 0.697$) but registers insignificant variations between the sampled lakes ($F_{14.59} = 1.666$) and during different seasons ($F_{3.59} = 1.002$). The later aspect is supported by indefinite seasonal periodicity with the peak diversity during winter and summer in six and five floodplain lakes, respectively. The rotifers are characterized by a low dominance (mean: 0.109–0.216) that signifies a quantitative influence of fewer species. The dominance shows insignificant variations between lakes ($F_{14.59} = 0.879$) and seasons ($F_{3.59} = 0.176$). This study reflects a higher evenness (mean: 0.840–0.925) with significant variations only between lakes ($F_{14.59} = 4.807$, $p < 0.001$) and affirms an equitable abundance of a majority of species. The dominance exhibits insignificant direct and inverse correlations with diversity and evenness, respectively. Canonical analysis records notable cumulative influence of six abiotic factors (water temperature, conductivity, pH, dissolved oxygen, alkalinity, hardness) on abundance ($r = 0.798$), richness ($r = 0.579$) and diversity ($r = 0.723$). On the other hand, the first three factors alone show important influence on abundance ($r = 0.685$), richness (0.553) and diversity ($r = 0.717$).

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References

Arora, J. & N. K. Mehra, 2002. Seasonal dynamics of rotifers in relation to physical and chemical conditions of the river Yamuna (Delhi), India. Hydrobiologia 491: 101–109.

Arora, J. & N. K. Mehra, 2003. Species diversity of planktonic and epiphytic rotifers in the backwaters of the Delhi segment of the Yamuna River, with remarks on new records from India. Zoological Studies 42(2): 239–247.

Baruah, B. K. & M. Das, 2001. Study of plankton as indicator and index of pollution in aquatic ecosystem receiving paper mill effluent. Indian Journal of Environmental Sciences 5: 41–46.

Baumgartner, G., K. Nakataki, M. Cavicchiolo & M. S. Baugartner, 1997. Some aspects of the ecology of fish larvae in the floodplain of the high Parana river, Brazil. Revue of Brasilian Zoology 14: 551–563.

Bonecker, C. C., F. A. Lansac-Tôha & A. Staub, 1994. Qualitative study of Rotifers in different environments of the high Parana river floodplain (Ms), Brazil. Revista UNIMAR 16: 1–16.

Bonecker, C. C., F. A. Lansac-Tôha & D. C. Rossa, 1998. Planktonic and non-planktonic rotifers in two environments of the upper Parana river floodplain, state of Mato Grosso do Sul, Brazil. Brazilian Archives of Biology & Technology 41: 447–456.

Chittapun, S., P. Pholpunthin & H. Segers, 1999. Rotifera from peat-swamps in Phuket province, Thailand, with the description of a new *Colurella* Bory de St. Vincent. Internationale Revue Hydrobiologie 587–583.

De Manuel, J., 1994. Taxonomic and zoogeographic considerations on Lecanidae (Rotifera: Monogononta) of the Balearic archipelago, with description of a new species, *Lecane margalefi* n. sp. Hydrobiologia 288: 97–105.

Dussart, B. H., C. H. Fernando, J. Matsumura-Tundisi & R. J. Shiel, 1984. A review of systematics, distribution and ecology of tropical freshwater zooplankton. Hydrobiologia 113 : 77–91.

Fernando, C. H., 1980. The freshwater zooplankton of Sri Lanka, with a discussion of tropical freshwater zooplankton composition. Internationale Revue Hydrobiologie 65: 411–426.

Green, J., 1972. Latitudinal variation in associations of planktonic Rotifera. Journal of Zoology, London 167: 31–39.

Goswami, N., 1997. Studies on the productivity indicators in three different types of wetlands of Assam, India. Ph.D thesis. Gauhati University, Assam.

Goswami, M. M. & N. Goswami, 2001. Studies on productivity indicators in Mori beel of Assam. Tropical Zoology 2&3 : 1–9.

José de Paggi, S., 1993. Composition and seasonality of planktonic rotifers in limnetic and littoral region of a floodplain lake (Parana River System). Revue Hydrobiologie tropicale 26: 53–64.

José de Paggi, S., 2001. Diversity of Rotifera (Monogononta) in wetlands of Rio Pilcomayo national park, Ramsar site (Formosa, Argentina). Hydrobiologia 462: 25–34.

Hauer, J., 1938. Die Rotatorien von Sumatra, Java und Bali nach den Ergebnissen der Deutschen Limnologischen Sunda Expedition. Zweiter Teil. Archiv für Hydrobiology, supplement 15: 507–602.

Khan, M. A., 1987. Observations on zooplankton composition, abundance and periodicity in two flood-plain lakes of the Kashmir Himalayan valley. Acta hydrochemica Hydrobiologica 15: 167–174.

Khan, R. A. 2002. The ecology and faunal diversity of two floodplain Ox-bow lakes of South-Eastern West Bengal. Records of the Zoological Survey of India, Occasional Paper No. 195: 1–57.

Khan, R. A. 2003. Faunal diversity of zooplankton in freshwater wetlands of Southeastern West Bengal. Records of the Zoological Survey of India, Occasional Paper No. 204: 1–107.

Koste, W., 1978. *ROTATORIA*. Die Rädertiere Mitteleuropas, begründet von Max Voigt. Überordnung Monogononta. Gebrüder Borntaeger, Berlin, Stuttgart. I. Text (673 pp), U. II. Tafelbd (T. 234).

Koste, W. & R. J. Shiel, 1990. Rotifera from Australian inland waters. V. Lecanidae (Rotifera: Monogononta). Transactions of the Royal Society of South Australia 114(1): 1–36.

Koste, W. & R. J. Shiel, 1991. Rotifera from Australian inland waters. VII. Notommatidae (Rotifera: Monogononta). Transactions of the Royal Society of South Australia 115(3): 111–159.

Kutikova, L. A., 1970. The rotifer fauna of the USSR. Fauna SSSR 104, Academia Nauk, 744 pp (in Russian).

Lansac-Tôha, F. A., C. C. Bonecker, L. F. M. Velho & A. F. Lima, 1997. Comunidade zooplanctônica. In Vazzoler, A. E. A.M., A. A. Agostinho & N. S. Hahn (eds)., A Planície de Inundacâo do Alto Rio Paraná Editora da Universidade Estadual de Maringná, Maringná: 117–155.

Ludwig, J. A. & J. F. Reynolds, 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley & Sons, New York, 337 pp.

Magurran, A. E., 1988. Ecological Diversity and its Measurement. Croom Helm Limited, London, 179 pp.

Papinski, K., 1990. Abundance and composition of rotifers in the Vistula river. Polski Archiwum Hydrobiologii 37: 449–459.

Pejler, B., 1977. On the global distribution of the family Brachionidae (Rotatoria). Archiv für Hydrobiology, supplement 53: 255–306.

Rossa, D. C., 1997. Cosmpoicão e abundância do zooplâcton da região de uma lagoa de várzea e um rio da planície de inundacão do alto rio Paraná- MS. Monograph, State University of Maringná, Maringná, Paraná.

Sarma, P. K., 2000. Systematics, distribution and ecology of zooplankton of some floodplain wetlands of Assam, India. Ph.D. thesis. Gauhati University, Assam.

Sanjar, L. R. & U. P. Sharma, 1995. Community structure of plankton in Kawar lake wetland, Begusarai, Bihar: II. Zooplankton. Journal of Freshwater Biology 7: 165–167.

Sanoamuang, L., 1998. Rotifera of some freshwater habitats in the floodplains of the River Nan, northern Thailand. Hydrobiologia 387/388: 27–33.

Sanoamuang, L. & H. Segers, 1997. Additions to the *Lecane* fauna (Rotifera: Monogononta) of Thailand. Internationale Revue Hydrobiologie 82: 525–530.

Sanoamuang, L., H. Segers & H. J. Dumont, 1995. Additions to the rotifer fauna of south-east Asia: new and rare species from north-east Thailand. Hydrobiologia 313/314: 35–45.

Segers, H., 1993. Rotifera of some lakes in the floodplain of the river Niger (Imo State, Nigeria). I. New species and other taxonomic considerations. Hydrobiologia 250: 39–61.

Segers, H., 1995. In Dumont, H. J. & T. Nogrady (eds.). Rotifera 2: Lecanidae. Guides to identification of the Microinvertebrates of the Continental Waters of the World. SPB Academic Publishing bv. Amsterdam, the Netherlands, 1–226.

Segers, H., 1996.The biogeography of littoral *Lecane* Rotifera. Hydrobiologia 323: 169–197.

Segers, H., 2002. The nomenclature of the Rotifera: annotated checklist of valid family- and genus-group names. Journal of Natural History 36: 621–640.

Segers, H. & H. J. Dumont, 1996. 102+ rotifer species (Rotifera: Monogononta) in Broa reservoir (SP., Brazil) on 26 August 1994, with the description of three new species. Hydrobiologia 316: 183–197.

Segers, H. & L. De Meester, 1994. Rotifera from Papua New Guinea, with the description of new *Scaridium* Ehrenberg, 1830. Archiv für Hydrobiology 131(1): 111–125.

Segers, H., N. L. Ferrufino & L. De Meester, 1998. Diversity and zoogeography of Rotifera (Monogononta) in a flood plain lake of the Ichilo river, Bolivia, with notes on little known species. Internationale Revue Hydrobiologie 83: 439–448.

Segers, H., C. S. Nwadiaro & H. J. Dumont, 1993. Rotifera of some lakes in the floodplain of the river Niger (Imo State, Nigeria). II. Faunal composition and diversity. Hydrobiologia 250: 63–71.

Serafim, M. Jr., 1997. Heteroheneidade espacia e temporal da comunidade zooplanktônica do sistema rio Ivinhema-lagoa dos Patos, Planície de inundacão do alto rio Paraná MS Dissertation. State University of Maringná, Maringná, Paraná.

Shiel, R. J., J. D. Green & D. L. Nielsen, 1998. Floodplain biodiversity: why are there so many species? Hydrobiologia 387/388: 39–46.

Sharma, B. K., 1998. Faunal Diversity in India: Rotifera. In Alfred, J. R. B., A. K. Das & A. K. Sanyal (eds), Faunal Diversity of India. ENVIS Centre, Zoological Survey of India, Calcutta, 57–70.

Sharma, B. K., 2000a Synecology of Rotifers in a tropical floodplain lake of Upper Assam (N. E. India). Indian Journal of Animal Sciences 70: 880–885.

Sharma, B. K. 2000b. Rotifers from some tropical flood-plain lakes of Assam (N. E. India). Tropical Ecology 41(2): 175–181.

Sharma, B. K., 2004. Rare and interesting monogonont rotifers (Rotifera: Eurotatoria) from North-Eastern India. Mitteilungen aus dem Museum für Naturkunde Berlin, Zoologische Reihe 80: 33–40.

Sharma, B. K. & C. Lyngskor, 2003. Plankton communities of a subtropical reservoir of Meghalaya (N. E. India). Indian Journal of Animal Sciences 73(2): 209–215.

Sharma, B. K. & S. Sharma, 1999. Freshwater Rotifers (Rotifera: Eurotatoria). In Fauna of Meghalaya. State Fauna Series, Zoological Survey of India, Calcutta, 4(9): 11–161.

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

Sharma, B. K. & S. Sharma, 2001. Biodiversity of Rotifera in some tropical floodplain lakes of the Brahmaputra river basin, Assam (N. E. India). Hydrobiologia 446/447: 305–313.

Talling, J. F. & I. B. Talling, 1965. The chemical composition of African lake waters. Internationale Revue gesammten Hydrobiologie 50: 421–463.