

The diversity of Indian Brachionidae (Rotifera: Eurotatoria: Monogononta) and their distribution

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Abstract. We evaluate diversity status of the Brachionidae of India and present an annotated checklist of 46 species excluding dubious and unconfirmed reports. These merit biodiversity value as ~27% of the global diversity of the taxon and ~81% of its Oriental species. We observed two Australasian elements, two Oriental endemics, one Indian endemic, one paleotropical and one cosmo (sub) tropical species. The cold-water *Keratella serrulata* and *Notholca squamula* are new records from eastern Himalayas. Maximum brachionid diversity (32 species) from Assam state of northeast India (NEI) is followed by the reports of 27 and 26 species from Tamil Nadu and West Bengal, respectively; 25 species each from Tripura and Maharashtra; and 24 species from Jammu & Kashmir. *Brachionus*, the most diverse brachionid genus, is widely distributed in India with low richness in hill states of NEI and coastal waters in particular. The Indian brachionid taxonomy is confounded with unconfirmed reports, misidentifications, invalid taxa, and inconsistent treatment of morphological variants, while analysis of cryptic diversity in *Brachionus calyciflorus*, *B. caudatus*, *B. forficula*, *B. plicatilis*, *B. quadridentatus*, *B. urceolaris*, *Keratella cochlearis* and *K. quadrata* species-groups awaits attention.

Keywords. Brachionids, biodiversity, dubious report, interesting taxa, misidentification, taxonomic status.

INTRODUCTION

Brachionidae, an important family of monogonont Rotifera and of the rotifer fauna of India (Sharma 1996, 1998a, Sharma & Sharma 2008) has received relatively more attention of the Indian workers relying on limnetic collections. The *rotiferologist effect* (Fontaneto *et al.* 2012) resulted in reasonably good number of regional reports including those primarily on the family (Sharma 1979, 1981, Sharma & Sharma 1990) while Sharma (1983, 1987) dealt with the diversity of *Brachionus* and the Brachionidae of the country, respectively. A resurgence of interest on the family, during more than last two and half decades, added interesting brachionids to the Indian Rotifera but indiscriminate listing of unconfirmed reports of dubious and ambiguous taxa, and misidentifications nevertheless confounded brachionid taxonomy necessitating its critical evaluation.

We assess diversity status of the Indian Brachionidae and provide an annotated checklist of

valid species with comments on their richness and composition known till date from different states / union territories (UT) of India, biogeographically important elements, distribution of interesting taxa and on anomalous reports.

MATERIALS AND METHODS

This review is based on analysis of our extensive samples collected, during the last two and half decades, from Northeast India (NEI) and collections from scattered localities from different states of Northern, Eastern, and Southern India; our earlier reports; and evaluation of various published Indian reports. The plankton and littoral periphytic samples were collected from the littoral, semi-limnetic and limnetic regions of diverse aquatic ecosystems by towing a plankton net (# 50 µm) and were preserved in 5% formalin. All of the collections were screened, different brachionids were isolated and mounted in Polyvinyl alcohol-lactophenol mixture, and were observed with Leica (DM 1000) stereoscopic phase

contrast microscope fitted with an image analyzer. The different taxa were identified following Koste (1978), Sharma (1983, 1998b), Koste & Shiel (1987), and Sharma & Sharma (1999, 2000, 2008, 2013). The remarks on biogeography were made following Segers (2007). The community similarities between the rotifer assemblages of different states and union territories (UT) of India were calculated *vide* Sørensen's index and SPSS (version 20) was used for the hierarchical cluster analysis.

RESULTS

We present, hereunder, an annotated checklist of 46 valid species of the Brachionidae of India:

Phylum: **Rotifera Cuvier, 1817**

Class: **Eurotatoria De Ridder, 1957**

Subclass: **Monogononta Plate, 1889**

Order: **Ploima Hudson & Gosse, 1886**

Family: **Brachionidae Ehrenberg, 1838**

1. *Anuraeopsis coelata* De Beauchamp, 1932
2. *A. fissa* Gosse, 1851
3. *A. navicula* Rousset, 1911
4. *Brachionus ahlstromi* Lindeman, 1939
Syn. *B. caudatus* var. *personatus* Ahlstrom, 1940
B. caudatus var. *indica* Novotóná-Dvořáková, 1963
5. *B. angularis* Gosse, 1851
B. angularis bidens Plate, 1886
6. *B. bennini* Leissling, 1924
7. *B. bidentatus* Anderson, 1889
B. bidentatus f. *adornus* Wulfert, 1966
B. bidentatus f. *crassispineus* Hauer, 1963
B. bidentatus f. *inermis* Rousset, 1906
B. bidentatus f. *jirovci* Bartoš, 1946
B. bidentatus f. *testudinarius* Jakubski, 1912
8. *B. budapestinensis* Daday, 1885
9. *B. calyciflorus* Pallas, 1766
B. calyciflorus f. *anuraeiformis* Brehm, 1909
B. calyciflorus f. *amphiceros* Ehrenberg, 1838
B. calyciflorus f. *dorcas* Gosse, 1851
B. calyciflorus borgerti Apstein, 1907
10. *B. caudatus* Barrois & Daday, 1894
B. caudatus var. *aculeatus* Hauer, 1937 (including f. *lateralis* Hauer, 1937)
B. caudatus f. *apsteini* Fadeev, 1925
B. caudatus f. *majusculus* Ahlstrom, 1940
B. caudatus f. *vulgatus* Ahlstrom, 1940
11. *B. dichotomus reductus* Koste & Shiel, 1980
12. *B. dimidiatus* Bryce, 1931
13. *B. diversicornis* (Daday, 1883)
14. *B. donneri* Brehm, 1951
15. *B. durgae* Dhanapathi, 1974
16. *B. falcatus* Zacharias, 1898
17. *B. forficula* Wierzejski, 1891
Syn. *B. forficula* var. *keralensis* Nayar & Nair, 1969
B. forficula f. *minor* (Voronkov, 1913)
18. *B. kostei* Shiel, 1983
19. *B. leydigii* Cohn, 1862
20. *B. mirabilis* Daday, 1897
21. *B. plicatilis* O.F. Müller, 1786 *s. lato*
B. plicatilis murrayi Fadeev, 1925
22. *B. pterodinooides* Rousset, 1913
23. *B. quadridentatus* Hermann, 1783
B. quadridentatus f. *melhemi* Barrois & Daday, 1894
B. quadridentatus f. *brevispinus* Ehrenberg, 1832
B. quadridentatus f. *cluniorbicularis* Skorikov, 1894
B. quadridentatus f. *rhenanus* Lauterborn, 1893
24. *B. rotundiformis* Tschugunoff, 1921
25. *B. rubens* Ehrenberg, 1838
26. *B. sessilis* Varga, 1951
27. *B. urceolaris* O. F. Müller, 1773
28. *Kellicottia longispina* (Kellicott, 1879)
29. *Keratella cochlearis* (Gosse, 1851)
30. *K. edmondsoni* Ahlstrom, 1943
31. *K. javana* Hauer, 1937
32. *K. hiemalis* Carlin, 1943
33. *K. lenzi* Hauer, 1953
34. *K. procurva* (Thorpe, 1891)
35. *K. quadrata* (O. F. Müller, 1786)
36. *K. serrulata* (Ehrenberg, 1838)

37. *K. tecta* (Gosse, 1851)
38. *K. ticinensis* (Callerio, 1921)
39. *K. tropica* (Apstein, 1907)
40. *Notholca acuminata* (Ehrenberg, 1832)
41. *N. labis* Gosse, 1887
42. *N. squamula* (O.F. Müller, 1786)*
43. *N. striata* (O. F. Müller, 1786)
44. *Platyonus patulus* (O.F. Müller, 1786)
P. patulus macracanthus (Daday, 1905)
45. *Platyias leloupi* (Gillard, 1967)
Syn. *P. longispinosus* Arora, 1966
46. *P. quadricornis* (Ehrenberg, 1832)
P. quadricornis andhraensis Dhanapathi, 1974

* New record from NEI.

Infrasubspecific categories indicated above have no nomenclatural validity as per ICZN; these are invariably cited in the Indian literature and, hence, require cautious use by amateur workers.

Brachionus includes 24 species; 11 species belong to *Keratella*; *Notholca*, *Anuraeopsis* and *Platyias* are represented by four, three and two species respectively, and *Platyonus* and *Kellicottia* include one species each. Our collections particularly from NEI indicate several interesting taxa namely *Brachionus dichotomus reductus* (Fig. 1), *B. donneri* (Fig. 2), *B. durgae* (Fig. 3), *B. kostei* (Fig. 4), *Keratella edmondsoni* (Fig. 5) and *K. javana* (Fig. 6). *Notholca squamula* (Fig. 7) and *Keratella serrulata* (Fig. 8), observed in our recent samples from Arunachal Pradesh, are new records from NEI. *Platyias quadricornis andhraensis* is the sole Indian endemic.

The richness of Brachionidae and *Brachionus* from different parts of India varies between 7–32 (19±6) species and 5–18 (11±4) species, respectively. The community similarities (vide Sørensen's index) and dendrogram depicting the hierarchical cluster analysis of the Brachionidae occurring in different states / Union territories of this country are indicated in Table 1 and Figure 9, respectively. Their community similarities range between 22.2–96.7%. We observed 32, 27, 26 species from Assam, Tamil Nadu and West Bengal, respectively; Tripura and Maharashtra

recorded 25 species each; Jammu & Kashmir showed 24 species; 23 species each are observed from Delhi and Kerala, and 22 species each are listed from Andhra Pradesh, Meghalaya, Orissa and Punjab. On the other hand, only seven species are known from Andaman and 11 species each are documented from the states of Arunachal Pradesh, Himachal Pradesh, Mizoram and Nagaland.

DISCUSSION

Richness and composition

We recognize a total of 46 valid species (53 taxa, including subspecies) of Brachionidae from India. These are of biodiversity value as ~27% of the global diversity and ~81% of Oriental species (Segers 2008) of the taxon. *Notholca squamula* and *Keratella serrulata*, from Arunachal Pradesh, are new records from NEI. The former is known from Kashmir Himalayas (Shah *et al.* 2014) while the latter is known by its un-validated reports from Kashmir and elsewhere from India (BKS unpublished). This report is the first validation of *K. serrulata* from India and extends the distribution of both species to eastern Himalayas; it is incidentally the first report of genus *Notholca* from NEI. Our inventory provides a notable update (~48.0%) to earlier Indian reports of 31 species of the Brachionidae (Sharma & Michael 1980, Sharma 1987). All seven genera of the family (Segers 2007, 2008) are represented in the rotifer fauna of India.

The richness of the Indian Brachionidae is higher than 41 species known from Thailand (Sardrit *et al.* 2013); their composition compares well with the latter (~73.0% similarity *vide* Sørensen's index) but differs in the absence of *Notholca* and *Kellicottia* in Thai fauna in particular. The cosmopolitan species form main component (~48.0%) of the brachionids known from India while the pantropical (~24.0%) and the biogeographically important (~15.5%) species form important fractions. Five species (~11.0%) are characterized by restricted distribution and *Brachionus mirabilis* and *Platyias leloupi* are tropicopolitan elements.



Figure 1. *Brachionus dichotomus reductus*
Koste & Shiel, after Sharma (2014)

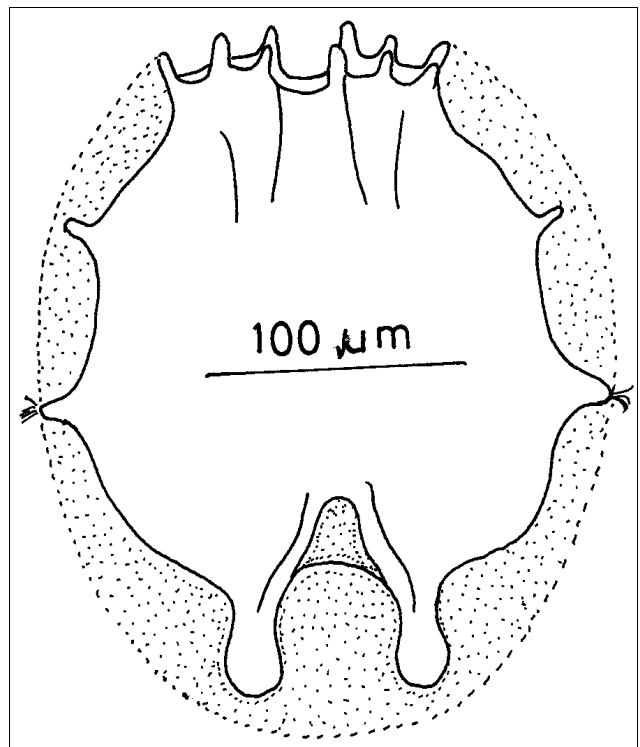


Figure 2. *Brachionus donneri* Brehm,
after Sharma & Sharma (2008)



Figure 3. *Brachionus durgae* Dhanapathi
(from Mizoram state, NEI)



Figure 4. *Brachionus kostei* Shiel
after Sharma (2014)



Figure 5. *Keratella edmondsoni* Ahlstrom ,
after Sharma (2014)



Figure 6. *Keratella javana* Hauer
(from Mizoran state, NEI)



Figure 7. *Notholca squamula* (O.F. Müller)
(from Arunachal Pradesh, NEI)



Figure 8. *Keratella serrulata* (Ehrenberg)
(from Arunachal Pradesh, NEI)

Our analysis of distinct variations in composition of the Brachionidae of different States / UT of India (7–32, 19±6 species) is supported by wide range of community similarities (22.2–96.7% *vide* Sørensen's index). The lowest similarity between species occurring in Andaman and Meghalaya is hypothesized to contrasting ecological conditions. The geographical proximity, however, explains maximum affinity between Delhi vs. Haryana and again between Delhi vs. Jammu & Kashmir, and is followed by 93.3% similarity between Haryana vs. Jammu & Kashmir. Ten more instances in the matrix register higher values of ~ or < 90.0% similarity. The cluster analysis reiterates distinctness of brachionids of Andaman followed by certain degrees of distinctness in their composition from Assam, Jammu & Kashmir, Nagaland and Manipur as well as Meghalaya, Himachal Pradesh and Sikkim in particular. The affinities in their composition, result in main cluster groupings between Haryana, Jharkhand, Chandigarh, Rajasthan, Karnataka, Uttarakhand; Tamil Nadu, West Bengal, Orissa, Kerala, Tripura; and Madhya Pradesh, Uttar Pradesh, Bihar, Goa, Andhra Pradesh, Maharashtra, Delhi while homology is indicated between species known from Gujarat and Punjab; Assam and Meghalaya; and Nagaland, Himachal Pradesh and Sikkim.

Our collections from Assam record the richest diversity (~71.0% of the Indian Brachionidae) and represent total richness of the taxon known from NEI. This salient feature is hypothesized to environmental heterogeneity of sampled aquatic ecosystems as well as to our intensive sampling. Our reports of 30 species from the floodplains of the Brahmaputra basin (BKS unpublished) and 26 species (Sharma & Sharma 2013) from Deepor Beel (a Ramsar site) in particular support the former hypothesis. In addition, the reports of 27 and 26 species from Tamil Nadu (Sharma & Sharma 2009) and West Bengal (Sharma 1998b) respectively, 25 species each Tripura (Sharma & Sharma 2000) and Maharashtra (BKS unpublished); 24 species from Jammu & Kashmir, and 23 species (BKS unpublished) from Delhi and Kerala exhibit rich diversity in these states of India.

The brachionid paucity from the greater Andaman (George *et al.* 2011) and from certain coastal ecosystems and backwaters of India (Varghese 2006, 2011, Varghese & Krishnan 2008, Manikannan *et al.* 2011, Prabhahar *et al.* 2011, Janakiraman *et al.*, 2012, Mohapatra & Patra 2012, 2013) is attributed to influence of salinity on the rotifers in general (Sladeczek 1983, Attayde and Bozelli 1998) and Brachionidae in particular (Athibai *et al.*, 2013). Low richness in Arunachal Pradesh, Mizoram and Nagaland of NEI (Sharma & Sharma 2014a) and Sikkim (BKS, unpublished) is attributed to slightly acidic waters of hilly areas of NEI (Sharma & Sharma 2005, 2014a) and is also hypothesized to lack of permanent limnetic habitats (BKS, unpublished).

The predominantly 'tropic-centered' and most diverse genus *Brachionus* (Segers 2007, 2008) registers rich diversity in India (24 species) representing ~37.0% and ~72.0% of its global and Oriental species, respectively. It shows considerable richness variations in different states / UT (5–18, 11±4 species) with the reports of 18 and 17 species from Assam and Tripura, respectively; 16 species each from Maharashtra, Tamil Nadu and West Bengal, and 15 species each from Andhra Pradesh, Delhi and Kerala. Low *Brachionus* richness in brackish waters of Andaman (George *et al.* 2011) and coastal ecosystems (Varghese & Krishnan 2008, Manikannan *et al.* 2011, Prabhahar *et al.* 2011, Varghese 2011, Janakiraman *et al.* 2012) is attributed to influence of salinity. A paucity of *Brachionus* spp. in several hill states of India namely Arunachal Pradesh, Himachal Pradesh, Manipur, Mizoram, Nagaland, Uttarakhand and Sikkim is hypothesized to lack of permanent limnetic habitats as well as to slightly acidic waters of certain states of NEI.

The 'temperate centered' *Keratella* (11 species) ranks second with ~22.0% its global diversity and ~92.0% of the Oriental richness. Its richness in India is to be considered with caution as we observed more richness only from Assam, and Tamil Nadu. *Notholca*, *Anuraeopsis* and *Platyias* include four, three, and two species, respectively.

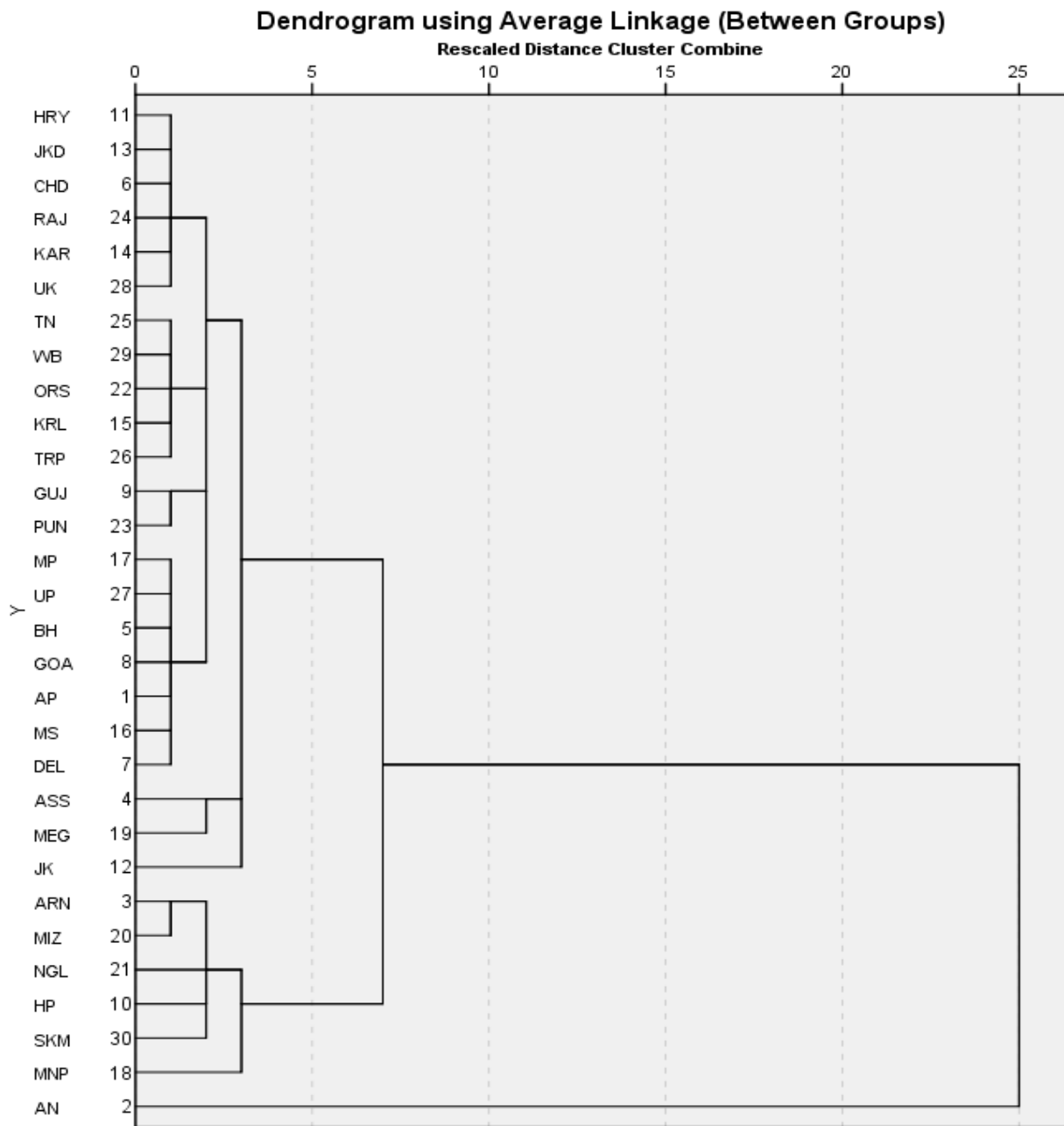


Figure 9: The hierarchical cluster analysis of Brachionidae known from different states/Union territories of India

Abbreviations. 1. AP-Andhra Pradesh; 2. AN-Andamans (UT); 3. ARN-Arunachal Pradesh; 4. ASS-Assam; 5. BH-Bihar; 6. CHD-Chandigarh (UT); 7. DEL-Delhi; 8. GOA-Goa(UT); 9. GUJ-Gujarat; 10. HP-Himachal Pradesh; 11. HRY- Haryana; 12. JK-Jammu & Kashmir; 13. JKD-Jharkhand; 14. KAR-Karnataka; 15. KRL-Kerala; 16. MS-Maharashtra; 17. MP-Madhya Pradesh; 18. MNP-Manipur; 19. MEG-Meghalaya; 20. MIZ-Mizoram; 21. NGL-Nagaland; 22. ORS-Orissa; 23. PUN-Punjab; 24. RAJ-Rajasthan; 25. TN-Tamil Nadu; 26. TRP-Tripura; 27. UP-Uttar Pradesh; 28. UK-Uttarakhand; 29. WB-West Bengal; 30. SKM-Sikkim (not included Chhattisgarh-insufficient information)

Table 1: Percentage similarities (vide Sorensen's index) between Brachionidae assemblage in different states / union territories of India

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1	-	41.3	54.5	77.7	85.7	78.9	80.8	90.4	82.0	66.7	75.7	78.2	75.7	80.0	89.4	85.7	81.6	54.6	54.6	81.8	77.3	80.9	81.6	76.6	90.5	72.2	79.2	62.9			
2	-	-	33.3	45.6	44.4	45.5	40.0	44.4	41.7	44.4	45.5	32.2	36.4	48.0	46.7	37.5	37.0	36.4	27.6	21.2	33.3	35.7	42.9	37.0	35.3	43.8	37.0	36.1	40.0		
3	-	-	-	46.5	64.5	66.6	58.8	64.5	64.2	81.8	69.2	57.1	69.2	68.9	58.8	55.5	64.5	75.9	60.6	81.8	81.8	54.5	60.6	64.5	52.6	55.5	64.5	71.0	54.0	66.6	
4	-	-	-	-	69.2	66.7	69.1	90.5	65.3	51.1	63.8	64.2	63.8	64.0	76.4	73.7	73.1	63.3	77.8	46.5	52.4	81.5	70.4	73.1	84.8	80.7	73.1	60.9	82.8	57.7	
5	-	-	-	-	-	83.3	83.7	90.0	86.5	70.9	85.7	72.7	80.0	89.5	88.4	84.4	85.0	80.0	76.2	53.1	64.5	85.7	85.7	85.0	85.1	80.0	90.0	81.4	86.9	60.6	
6	-	-	-	-	-	-	78.9	83.3	78.7	74.0	96.7	75.0	96.7	82.3	76.9	73.1	88.8	70.9	63.1	59.2	59.2	84.2	84.2	88.8	85.1	88.8	80.0	76.1	62.0		
7	-	-	-	-	-	-	-	88.3	80.0	64.7	73.6	68.0	73.6	82.9	73.9	79.1	74.4	68.4	71.1	52.9	52.9	71.1	80.0	83.7	76.0	75.0	83.7	75.6	77.5	55.5	
8	-	-	-	-	-	-	-	-	81.0	70.9	80.0	72.7	80.0	89.4	83.7	88.8	85.0	74.2	76.1	58.0	58.0	85.0	80.9	85.0	85.1	80.0	90.0	82.3	83.6	66.6	
9	-	-	-	-	-	-	-	-	-	80.0	80.0	68.2	81.2	80.0	80.0	76.1	75.6	75.0	71.7	64.2	71.4	76.9	82.0	75.6	77.2	76.1	81.0	77.4	79.0	73.3	
10	-	-	-	-	-	-	-	-	-	-	76.9	62.8	76.9	75.6	64.7	61.1	70.9	60.6	81.8	81.8	60.6	66.6	70.9	57.8	61.1	70.9	80.0	59.4	83.3		
11	-	-	-	-	-	-	-	-	-	-	-	71.7	93.3	84.8	78.9	75.0	85.7	73.3	70.2	61.5	61.5	81.0	81.0	85.7	71.4	70.0	85.7	82.7	73.1	64.2	
12	-	-	-	-	-	-	-	-	-	-	-	-	-	71.4	63.8	77.5	81.8	56.4	65.2	51.4	51.4	69.5	73.9	77.2	70.5	61.2	77.2	68.4	60.0	54.0	
13	-	-	-	-	-	-	-	-	-	-	-	-	*	78.7	73.6	75.0	85.7	73.3	70.2	61.5	61.5	81.0	81.0	85.7	71.4	70.0	85.7	82.7	73.1	64.2	
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	78.0	83.7	84.2	72.7	60.6	68.9	62.0	75.0	80.0	84.2	71.1	74.4	84.2	87.5	77.2	64.5	
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79.1	74.4	73.6	71.1	52.9	50.3	80.0	80.0	74.4	84.0	83.3	79.0	70.2	81.6	61.1	
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	84.4	65.0	68.0	50.0	50.0	80.0	85.1	80.0	84.6	72.0	84.4	71.7	78.4	57.8	
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68.5	76.1	58.0	58.0	80.9	80.9	90.0	76.5	71.1	90.0	82.3	82.6	66.6	
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69.2	76.9	75.6	70.2	74.2	71.4	70.0	74.2	75.8	68.2	64.2		
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80.6	65.6	72.2	72.7	71.4	77.5	85.1	75.1	79.1	57.1		
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	81.3	48.4	54.5	58.0	47.3	55.5	58.0	64.0	49.6	66.6	
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations: 1.AP-Andhra Pradesh; 2.AN-Andamans (UT); 3.AR-Andhra Pradesh; 4.ASS-Assam; 5.BH-Bihar; 6.CHD-Chandigarh (UT); 7.DEL-Delhi; 8.GOA-Goa(UT); 9.GUJ-Gujarat; 10.HP-Himachal Pradesh; 11.HRY-Haryana; 12.JK-Jammu & Kashmir; 13.JKD-Jharkhand; 14.KAR-Karnataka; 15.KRL-Kerala; 16.MS-Maharashtra; 17.MP-Madhya Pradesh; 18.MNP-Mizoram; 19.MEG-Meghalaya; 20.MIZ-Mizoram; 21.NGL-Nagaland; 22.ORS-Orissa; 23.PUN-Punjab; 24.RAJ-Rajasthan; 25.TN-Tamil Nadu; 26.TR-P-Tripura; 27.UP-Uttar Pradesh; 28.UK-Uttarakhand; 29.WB-West Bengal; 30.SKM-Sikkim

Kellicottia and *Plationus* are known by one species; the latter is invariably identified as *Platyias* or *Brachionus* from this country indicating a casual approach on its nomenclatural change. We are yet to confirm the reports of *Kellicottia longispina* and *Notholca striata* from Kashmir Himalayas in particular notwithstanding their 'dubious records' elsewhere from India. The Indian literature shows notorious reports of *Notholca* species. We seek re-examination of *Plationus patulus macracanthus* as earlier reports indicate specimens with longer posterior species but not confirming to this taxon *sensu stricto*.

Morphological plasticity inherent in certain Brachionidae infrequently resulted in designation of infra-subspecific categories from India as already commented earlier by Sharma (1983). This trend has continued unabated in recent reports, by amateur workers, without recourse even to standard taxonomic works (Segers 2007, Jersabek *et al.* 2012, Jersabek & Leitner 2013) thus confounding the Indian literature with records without any nomenclatural validity.

Analysis of cryptic diversity in the Indian populations of *Brachionus calyciflorus*, *B. caudatus*, *B. forficula*, *B. plicatilis*, *B. quadridentatus*, *B. urceolaris*, *Keratella cochlearis* and *K. quadrata* species-groups awaits attention concurrent with such global initiatives particularly on the *B. plicatilis* complex (Ciros-Perez *et al.* 2001, Suatoni *et al.* 2006). Anitha & George (2008) analyzed the latter complex and classified its variants into *B. plicatilis*, *B. rotundiformis* and *B. murrayi* describing new infrasubspecific variants with no taxonomic validity *i.e.*, *B. plicatilis* f. *ovalis* f. nov. and *B. murrayi* f. *divergispinus* f. nov. Of these, *B. murrayi* itself is a junior synonym of *B. plicatilis murrayi* and *B. rotundiformis* is a distinct taxon. A global rotifer community initiative on "Cryptic speciation in *B. plicatilis*" launched at Rotifera XIII held at Shillong in 2012 is likely to resolve status of this species-complex. We allocated *Brachionus caudatus* var. *personatus* to *B. ahlstromi* following Giri & Jose De Paggi (2006).

Interesting taxa

Brachionidae contains taxa with well-documented ranges (Pejler 1977, Dumont 1983). Likewise, various interesting taxa known from India including the Australasian *Brachionus dichotomus reductus* and *B. kostei*, two Oriental endemics *B. donneri* and *Keratella edmondsoni*, and the sole known Indian endemic: *Platyias quadricornis andhraensis*. The paucity of endemics from this country concurs with low endemicity model of the Oriental Brachionidae (Segers 2008) in particular and also with their paucity in well studied Thai Rotifera (Sa-Ardrit *et al.* 2013).

We support the hypothesis of Segers (2001) on possible Australian origin of *Brachionus dichotomus reductus* by its relation with the Australian *B. dichotomus dichotomus* with recent expansions of populations of the former to the Indian sub-region (Sharma 2004, Sharma & Sharma 2005, 2014a). Contrastingly, Sa-Ardrit *et al.* (2013) indicated occurrence of names of both taxa in literature on Thai Rotifera with comments on need for confirmation of the latter.

Brachionus kostei, the second Australasian species, is known elsewhere from Australia, Papua Guinea and Thailand while its unpublished report from northeast China is a possible example of introduction (Sa-Ardrit *et al.* 2013). Jersabek & Leitner (2013) indicated verification of conspecificity of the forms of *B. kostei* known from SE Asia and northeast India with the 'typical form' from Australia.

The Oriental *Keratella edmondsoni*, described from Tamil Nadu (Ahlstrom 1943) as *K. quadrata* var. *edmondsoni*, was raised to the status of a distinct species by Nayar (1965). It is reported elsewhere from Northeast Thailand (Sanoamuang *et al.* 1995, Sa-Ardrit *et al.* 2013). *Brachionus donneri*, another Oriental species described by Brehm (1951), was erroneously listed as pantropical species (Sharma & Sharma 2001, 2005). Its unconfirmed report from Panama Canal *i.e.* be-

yond the classical distribution limit is a possible example of its introduction (Segers 2007).

The sole Indian endemic *Platyias quadricornis andhraensis*, described by Dhanapathi (1974a) from Hussain Sagar reservoir, Hyderabad, Andhra Pradesh, is known only from its 'type-locality'. The other interesting brachionids include *Keratella javana* and *Brachionus durgae*. The latter was described from Andhra Pradesh (Dhanapathi 1974b) and its distribution now extends to the African, Neotropical, Oriental and Palearctic regions (Segers 2007).

Distribution

The distribution of Brachionidae merits interest for its relative paucity in various hill states of India and in coastal waters. We allocate brachionids known from this country into three categories:

(a) **Species with restricted distribution:** *Keratella javana*, *Brachionus dichotomus reductus* and *B. kostei* are examples with distribution restricted to NEI. The occurrence of the Australasian *B. dichotomus reductus* and *B. kostei* impart special affinity of Rotifera of NEI with those of the Oriental region and Australia (Sharma & Sharma 2005, 2008, 2012, 2014a, Sharma 2014). We also assign *Keratella hiemalis*, *K. ticinensis*, *Kellicottia longispina* and *Notholca striata* to this category because of restricted distribution to Kashmir Himalayas notwithstanding their unconfirmed reports elsewhere from India. The halobiont *Brachionus rotundiformis* is restricted to coastal brackish-waters of South India extending up to Andaman.

(b) **Species with disjunct distribution:** Eighteen species *i.e.* *Anuraeopsis coelata*, *A. navicula*, *Brachionus bennini*, *B. dimidiatus*, *B. donneri*, *B. durgae*, *B. pterodinoides*, *B. urceolaris*, *Keratella edmondsoni*, *K. lenzi*, *K. procurva*, *K. quadrata*, *K. serrulata*, *K. tecta*, *Notholca acuminata*, *N. squamula*, *N. labis* and *Platyias leloupi* show disjunct populations in India.

(c) **Widely distributed:** Fourteen species namely *Anuraeopsis fissa*, *Brachionus angularis*, *B. bidentatus*, *B. budapestinensis*, *B. caudatus*, *B. calyciflorus*, *B. falcatus*, *B. forficula*, *B. plicatilis*, *B. quadridentata*, *Keratella cochlearis*, *K. tropica*, *Plationus patulus* and *Platyias quadricornis* are widely or nearly widely distributed in India.

Indeterminate species: Segers & Babu (1999, Figs 1–2) examined single specimen of *Keratella* species which appeared close to *K. tropica*. It is differentiated by peculiar antero-median facet. Insufficient material did not allow for a description of this taxon (Segers & Babu 1999).

Anomalous reports: Various recent publications spurted from amateur workers without adequate taxonomic expertise, in several online journals / even regular journals without expert peer-review, are an alarming impediment to Rotifera biodiversity in India (Sharma & Sharma 2014b, 2014c). This generalization holds true to anomalous Brachionidae reports categorized as follows:

Misidentifications

1. *Brachionus havanaensis* Rousselet, 1911: It is known from Nearctic and Neotropical regions with possible introduction to Oriental and Palearctic regions (Segers 2008). Its notorious Indian reports from Tamil Nadu (Francis *et al.* 2003), Maharashtra (Ekhande *et al.* 2013), Rajasthan (Paulose & Maheshwari 2008) and Uttar Pradesh (Khan *et al.* 1986, Haque *et al.* 1988, Ali *et al.* 1990) are considered as examples of misidentifications of its vicariant – *B. diversicornis*.
2. *Keratella valga* (Ehrenberg, 1834): We agree with Sa-Ardrit *et al.* (2013) considering that the distinction between the cold-water, acidophilic *K. valga* and the warm-water, euryoecious *K. tropica* has long remained problematic. *K. valga* is indiscriminately listed, without any validation from India, from Bihar (Pandey *et al.* 2013), Jammu & Kashmir (Sharma J.P. & Srivastava 1986, Ahangar *et al.* 2012), Gujarat (Nirmal Kumar *et al.* 2011), Madhya Pradesh (Adohlia 1979), Maharashtra

(Tayade & Dabhade 2011), Punjab (Bath & Kaur 1998, Kaur *et al.* 1999), Rajasthan (Saxena 2001, Sharma V. *et al.* 2008, Sharma R. *et al.* 2011), Tamil Nadu (Raghunathan & Suresh Kumar 2006, Sonia & Ramanibai 2012). We consider all of the stated records as misidentifications apparently of *K. tropica* unless authenticated otherwise.

3. *Brachionus urceus* Linneaus, 1758: Ahlstrom (1940) indicated the early descriptions of the taxon as being inadequate. Jersabek & Leitner (2013) considered *B. urceus* as a 'doubtful species' and "recommended the name *urceolaris*, associated for many years with the species under consideration." The sole unvalidated report of this brachionid from Madhya Pradesh (Bhat *et al.* 2012) lacking 'author citation' refers to misidentified *B. urceolaris*.
4. *Keratella canadensis* Berzins, 1954: Un-validated reports of this Nearctic species from Uttar Pradesh (Khan *et al.* 1986, Ali *et al.* 1990) and without 'author citation' are misidentifications.
5. *Keratella earlinae* Ahlstrom, 1943: An unvalidated report from Tripura (Banik & Chakraborty 1998) represents misidentification.
6. *Notholca caudata* Carlin, 1943: The sole unvalidated report from Wular Lake, Kashmir (Mir *et al.* 2008) perhaps refers to misidentified *N. acuminata* (BKS unpublished).
7. *Kellicottia* sp.: The report from Andaman (George *et al.* 2011, Fig. 2H) does not show this taxon.

Reports warranting confirmations

Un-validated reports of the following taxa warrant confirmations to ascertain their validity:

1. *Keratella serrulata* (Ehrenberg, 1838): Jammu & Kashmir (Balkhi *et al.* 1987, Ticku & Zutshi 1993, Mir *et al.* (2008), Punjab (Bath & Kaur, 1998) and Uttar Pradesh (Tare 2012).
2. *Kellicottia* sp.: Punjab (Bath & Kaur 1998).
3. *Notholca laurentiae* Stemberger, 1976: Kashmir (Raina & Vass 1993).

4. *Platyonus polyacanthus* (Ehrenberg, 1834): Kashmir (Balkhi *et al.* 1987, Pandit & Yousuf 2003; Shah *et al.* 2014) and Punjab (Bath & Kaur 1998).

Dubious reports

Sharma and Sharma (2014b) commented on dubious reports lacking validation without voucher specimens – a recurrent problem with rotifer records from India. We categorize the following brachionid taxa, reported in *ad hoc* ecological studies, as 'dubious':

- a. The most notorious report (Adholia 1979) is of five *Notholca* spp. from Madhya Pradesh: *Notholca acuminata*, *N. squamula*, *N. striata*, *N. carinata* and *N. foliaacea* (misspelled!).
- b. *Keratella ticinensis* (Callerio, 1921): Madhya Pradesh (Chourasia & Adoni 1986), Maharashtra (Tayade & Dabhade 2011) and Tamil Nadu (Raghunathan & Suresh Kumar 2006). Misspelled as '*K. ticinensis* (Carlin)' from Tamil Nadu.
- c. *Keratella hiemalis* Carlin, 1943: Maharashtra (Tayade & Dabhade 2011) and Rajasthan (Sharma V. *et al.* 2008).
- d. *Kellicottia longispina* (Kellicott, 1879): Madhya Pradesh (Adholia 1979).
- e. *Notholca acuminata* (Ehrenberg, 1832): Bihar (Ahmed & Singh, 1988, Kumar *et al.* 2011), Madhya Pradesh (Chourasia & Adoni 1986), Orissa (Mohapatra & Patra 2012), Punjab (Bath & Kaur 1998, Kaur *et al.* 1999) and West Bengal (Moharana *et al.* 2012).
- f. *Notholca labis* Gosse, 1887: Tamil Nadu (Dheenadayalamoorthy & Sultana 2011) and West Bengal (Chattopadhyay & Barik 2009).
- g. *Notholca priodonta*: Uttar Pradesh (Haque *et al.* 1988).
- h. *Notholca* sp.: Bihar (Ahmed & Singh 1988, Kumar *et al.* (2011).
- i. *Notholca accuminata* Gosse (Misspelled!): Puri coast, Orissa (Mohapatra & Patra (2012).
- j. *Notholca accuminata* Gosse (Misspelled!): Digha coast, West Bengal (Moharana *et al.* 2012, Moharana & Patra 2013).

Invalid reports

The followings are categorized as 'invalid reports' from India:

- Anuraeopsis* sp.: (Lauterborn 1990). Haryana (Chopra *et al.* 2014).
Brachionus longiceps: Rajasthan (Sharma V. *et al.* 2008).
Brachionus terminalis: Bihar (Kumar *et al.* 2011).
Brachionus tropica Apstein: Orissa (Patra *et al.* 2011).
Brachionus sp. (Pallas, 1776): Haryana (Chopra *et al.* 2014).
Brachionus patulus (Attwood, 1881): Haryana (Chopra *et al.* 2014).
Platyias trgonellus: West Bengal (Datta 2011).

To sum up, Indian Brachionidae is speciose by its relation to the Oriental diversity of the taxon. In spite of its low endemicity model in India, it reveals certain globally interesting elements and species of regional biogeography interest. The *rotiferologist effect* resulted in its documentation from certain parts of India but casual approach by several amateur workers invariably culminated in *ad hoc* inventories riddled with misidentifications, unconfirmed dubious and invalid reports. The diversity of Brachionidae of India is likely to increase following studies from biodiversity hotspots namely the Himalayan region and Western Ghats in particular; analysis of cryptic diversity in certain species groups; and validation / confirmation of questionable reports.

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