

## Original Article

# Biodiversity of freshwater rotifers (Rotifera: Eurotatoria) of Mizoram, Northeast India: composition, new records and interesting features

Bhushan Kumar Sharma\*, Sumita Sharma

Freshwater Biology Laboratory, Department of Zoology, North-Eastern Hill University, Shillong - 793 022, Meghalaya, India.

**Abstract:** The plankton and semi-plankton samples examined from Mizoram state of northeast India (NEI) revealed speciose and diverse Rotifera assemblage including a total richness (S) of 162 species belonging to 19 families and 35 genera. The reports of six species new to India, four species new to NEI and 76 new records to Mizoram merit biodiversity interest. The occurrence of one Australasian, one Oriental, seven Palearctic, one Holarctic, one cosmo (sub) tropical and five other interesting species imparts biogeographical value while several species indicate regional distribution importance. Lecanidae > Lepadellidae > Brachionidae > Trichocercidae collectively comprised 69.7% of total richness (S). *Lecane* > *Lepadella* > *Trichocerca* are diverse genera (~52.0% of S) while *Brachionus* spp. (~8.0%) deserve cautious mention. The rotifer diversity pattern is predominantly 'tropical' with a large component of cosmopolitans (~71.0% of S) while tropicopolitan and pantropical species contributed ~16.0%. This study indicated high richness of the littoral-periphytonic and relative paucity of planktonic taxa. Analysis of periphytic, sessile, colonial and benthic taxa, and of cryptic diversity in certain species-groups merit attention for further biodiversity update and we estimate occurrence of 250+ rotifer species in Mizoram.

### Article history:

Received 1 September 2015

Accepted 5 October 2015

Available online 25 October 2015

### Keywords:

Composition  
Biogeography  
Interesting taxa  
Richness  
Sub-tropical waters

## Introduction

Mizoram, one of the hill-states of NEI, has received little attention on aquatic metazoans diversity in general and on Rotifera, an important group of fish-food organisms and an integral component of aquatic food-webs, in particular. Initial reports of Sharma (1987), Sharma and Sharma (1987a, 1987b), and Sharma and Sharma (1990) on the latter dealt with eleven species of Lecanidae, three species of *Lepadella*, one species of Notommatidae and 10 species of Brachionidae, respectively. Recently, Sharma and Sharma (2014a) reported occurrence of 76 species and remarked on yet partially studied diversity of the taxon from this state while Sharma and Sharma (2014b, 2015) highlighted inadequately documented Brachionidae and Lepadellidae in particular, respectively. The present study, hence, attempts to provide a more exhaustive account of

Rotifera biodiversity of Mizoram based on the recent sampling surveys. Remarks are made on composition and richness of the observed diversity, various interesting elements and distribution of different taxa.

## Materials and Methods

The present observations are based on water and plankton and semi-plankton samples collected, during four field surveys (January, March, July and October) in 2012 and one in March 2013, from all eight districts of Mizoram (21°58'-24°35' N and 92°15'-93°29' E). A total of 330 samples were collected from varied aquatic ecosystems. Water samples were examined for water temperature, specific conductivity and pH by the field probes; dissolved oxygen was estimated by Winkler's method while free CO<sub>2</sub>, alkalinity, hardness and

\* Corresponding author: Bhushan Kumar Sharma  
E-mail address: profbksharma@gmail.com

Table 1. Variations in some basic abiotic parameters.

Parameters ↓		Range	Mean	SD
Water temperature	°C	12.0 - 28.0	17.4	4.2
Specific conductivity	µS cm <sup>-1</sup>	20.0 - 65.2	42.5	12.0
pH		5.60 - 6.98	6.70	0.24
Dissolved Oxygen	mg l <sup>-1</sup>	4.0 - 10.2	6.7	2.1
Free Carbon dioxide	mg l <sup>-1</sup>	5.0 - 17.6	12.1	3.2
Alkalinity	mg l <sup>-1</sup>	21.0 - 40.0	29.6	4.3
Hardness	mg l <sup>-1</sup>	19.0 - 38.6	31.2	6.8
Chloride	mg l <sup>-1</sup>	4.0 - 10.9	6.5	3.1

chloride were analyzed following APHA (1992). The qualitative plankton samples were collected by towing a nylobolt plankton net (No. 25) and were preserved in 5% formalin. Individual collections were screened with a Wild stereoscopic binocular microscope; the rotifer taxa were isolated and mounted in Polyvinyl alcohol–lactophenol, and observed with Leica (DM 1000) stereoscopic phase contrast microscope fitted with an image analyzer. The measurements were given in micrometers (µm). Various Rotifera taxa were identified following the works of Koste (1978), Koste and Shiel (1987, 1989, 1990), Shiel and Koste (1992, 1993), Segers (1995), Sharma (1983, 1987, 1998), Sharma and Sharma (1997, 1999, 2000, 2008, 2013). Segers (2002) was followed for the system of Rotifera classification and the remarks on distribution of various taxa were made following Segers (2007) and Jersabek and Leitner (2013). The reference materials are in the holdings of Freshwater Biology laboratory, Department of Zoology, North-Eastern Hill University, Shillong.

## Results

The variations (ranges, mean±SD) in the recorded abiotic parameters of the sampled water bodies are indicated in Table 1.

The collections from Mizoram revealed 162 species of Rotifera belonging to 19 families and 35 genera of Eurotatoria (Appendix I). Of these, *Lecane aeganea* (Fig. 1A), *Testudinella walkeri* (Fig. 1B), *Trichocerca hollaerti* (Fig. 1C), *T. maior* (Fig. 1D), *T. siamensis* (Fig. 1E) and *T. taurocephala* (Fig. 1F) are new records to India. *Brachionus leydigii* (Fig.

1G), *Lecane syngenes* (Fig. 1H), *Macrochaetus subquadratus* (Fig. 1I) and *Trichocerca edmondsoni* (Fig. 1J) are new records to northeast India (NEI). In addition, 76 species are new additions to the rotifer fauna of Mizoram.

*Testudinella walkeri* is an interesting Australasian species; *Filinia camasecla* (Fig. 2A) is an Oriental endemic. Our collections included seven paleotropical species namely *Keratella javana* (Fig. 2B), *Lepadella discoidea* (Fig. 2C), *L. vandenbrandei* (Fig. 2D), *Lecane lateralis* (Fig. 2E), *L. unguitata* (Fig. 2F), *Testudinella greeni* (Fig. 2G), and *Trichocerca hollaerti*; *T. taurocephala* is the Holarctic species; and *Brachionus durgae* (Fig. 2H) is a cosmo (sub) tropical element. Besides, *Lepadella elongata* (Fig. 2I) and *Testudinella amphora* (Fig. 2J) are other interesting species.

## Discussion

Water temperature affirmed sub-tropical nature of the sampled ecosystems concurrent with their geographical location. The slightly acidic-circum neutral and 'soft' waters of Mizoram are characterized by low ionic concentration as indicated by specific conductivity values; the latter warranted their inclusion under 'Class I' category of trophic classification vide Talling and Talling (1965). The results exhibited well-oxygenated waters, low free CO<sub>2</sub> and low chloride content. Various abiotic parameters concurred broadly with the report of Sharma and Pachuau (2013).

One hundred and sixty-two species of Rotifera, belonging to 35 genera and 19 families of Eurotatoria, observed from Mizoram revealed rich

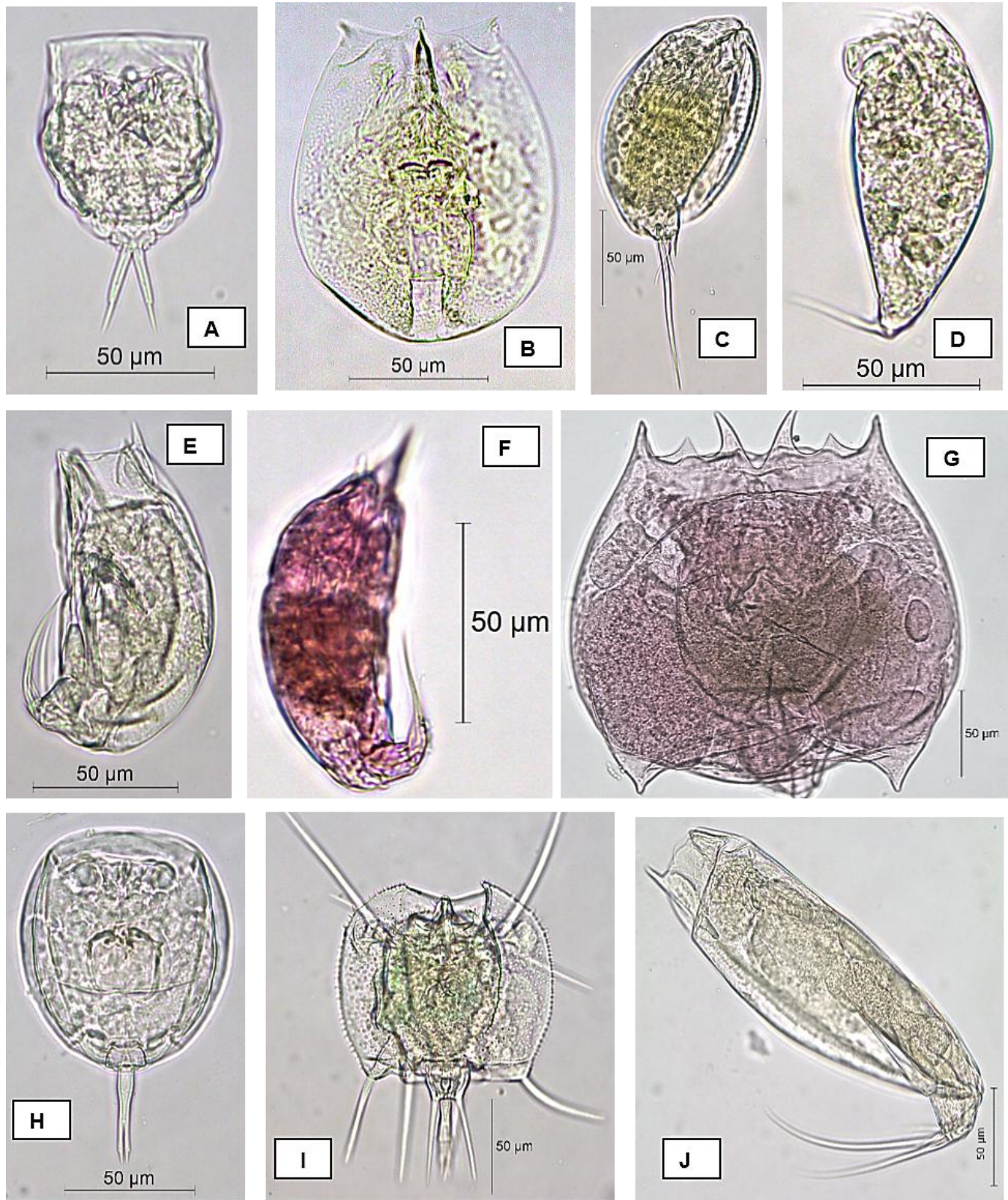


Figure 1. A, *Lecane aeganea* Haring (ventral view); B, *Testudinella walkeri* Koste & Shiel (ventral view); C, *Trichocerca hollaerti* De Smet (lateral view); D, *Trichocerca siamensis* Segers & Pholpunthin (lateral view); E, *Trichocerca maior* Hauer (lateral view); F, *Trichocerca taurocephala* (Hauer) (lateral view); G, *Brachionus leydigii* Cohn (ventral view); H, *Lecane syngenes* (Hauer) (ventral view); I, *Macrochaetus subquadratus* (Perty) (dorsal view); J, *Trichocerca edmondsoni* (Myers) (lateral view).

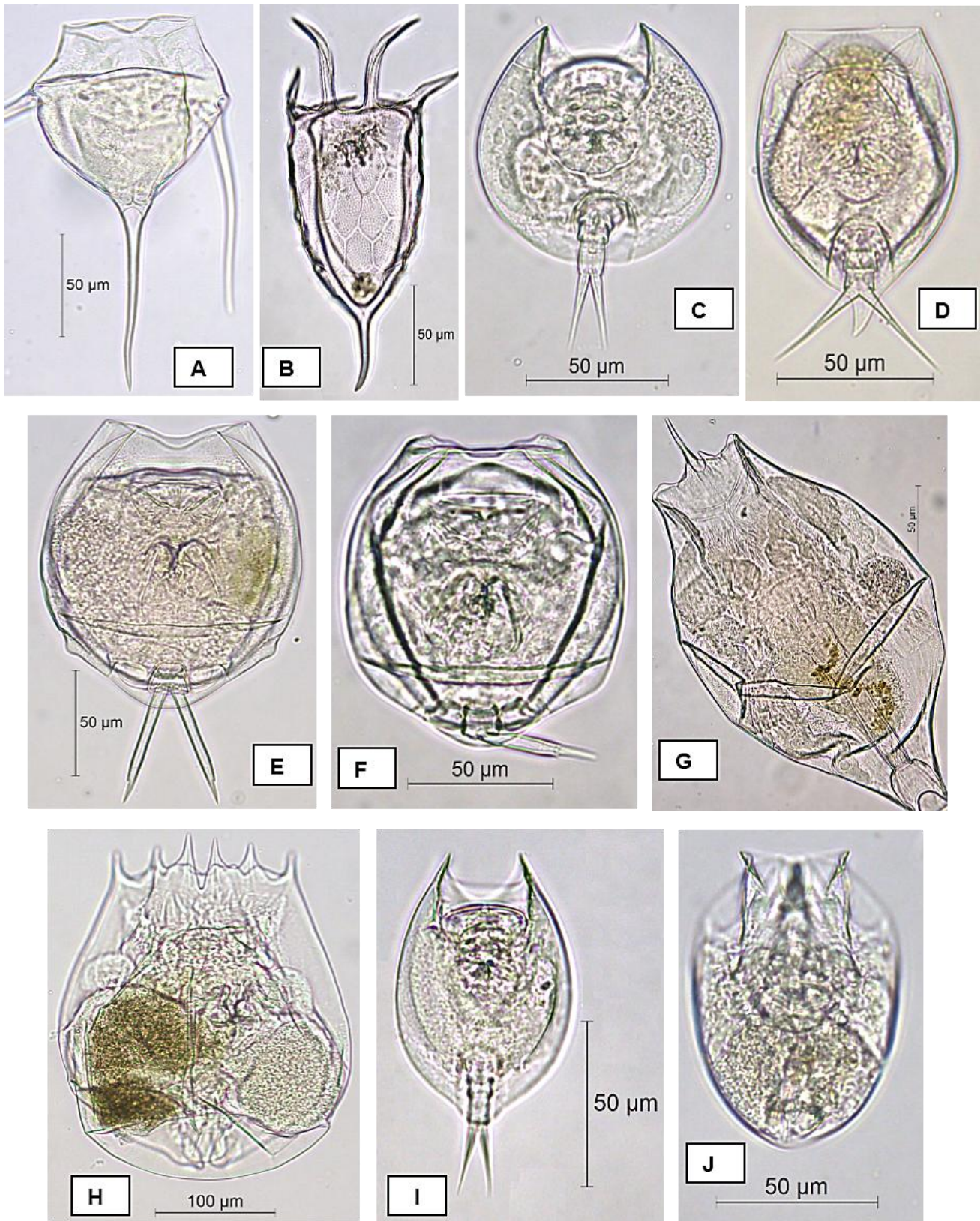


Figure 2. A, *Filinia camasecla* Myers (ventral view); B, *Keratella javana* Hauer (ventral view); C, *Lepadella discoidea* Segers (ventral view); D, *Lepadella vandenbrandei* Gillard (ventral view); E, *Lecane lateralis* Sharma (ventral view); F, *Lecane unguitata* (Fadeev) (ventral view); G, *Testudinella greeni* Koste (dorsal view); H, *Brachionus durgae* Dhanapathi (dorsal view); I, *Lepadella elongata* Koste (ventral view); J, *Testudinella amphora* Hauer (ventral view).

and diverse assemblage of the phylum. This salient feature is hypothesized to habitat diversity and environmental heterogeneity of the sampled aquatic ecosystems and merits biodiversity interest particularly in light of the scarcity of perennial lentic biotopes in sub-tropical environs of this hill-state of NEI. Six species namely *Lecane aeganea*, *Testudinella walkeri*, *Trichocerca hollaerti*, *T. maior*, *T. siamensis* and *T. taurocephala* are new records to the Indian Rotifera. *Brachionus leydigii*, *Lecane syngenes*, *Macrochaetus subquadratus* and *Trichocerca edmondsoni* are new to NEI and 76 species are new to the rotifer fauna of Mizoram. Interestingly, the documented species comprised ~22.0% and ~66.0% of the rotifer richness known from India (BKS, unpublished) and NEI (Sharma and Sharma, 2014a), respectively. This study marked more than two-fold increase in the species reported from Mizoram (Sharma and Sharma, 2014a) and incidentally it represented the third richest rotifer diversity known till date from any state of India following the reports of 220 and 177 species from Assam (Sharma and Sharma, 2014c) and Tamil Nadu (Sharma and Sharma, 2009), respectively. The stated features imparted special biodiversity value to the present study.

The globally important species (~10% of S) included the Australasian *Testudinella walkeri*; the Oriental endemic *Filinia camasecla*; seven paleotropical species namely *Keratella javana*, *Lepadella discoidea*, *L. vandenbrandei*, *Lecane lateralis*, *L. unguitata*, *Testudinella greeni* and *Trichocerca hollaerti*; the Holarctic *Trichocerca taurocephala*; cosmo (sub) tropical *Brachionus durgae* and five other interesting species i.e., *Lepadella elongata*, *Trichocerca edmondsoni*, *T. maior*, *T. siamensis* and *Testudinella amphora*; these assigned biogeographic importance to Mizoram Rotifera. Of these, *Testudinella walkeri* is an interesting addition of the first category to the fauna of NEI (Sharma and Sharma, 2014a) and thus affirmed affinity of Rotifera assemblage of this region as well as of Mizoram with Southeast Asia and Australia. This generalization supported earlier remarks of Sharma

(2005) and Sharma and Sharma (2005, 2008, 2013, 2014a, 2014c).

*Lecane aeganea*, a new record from India, is often confused with *L. tensuisseta* but differed from the latter in having shorter lorica and shorter toes. It is known from the Oriental region from Cambodia (Meas and Sanoamuang, 2010) and Thailand (Sa-Ardrit et al., 2013). *Testudinella walkeri* is another addition to the Indian Rotifera. Described from Australia (Koste and Shiel, 1980), it is enlisted in several reports from Thailand (Sa-Ardrit et al., 2013). The specimens from Mizoram, however, agreed with those reported by Segers and Pholpunthin (1997). The present report thus extended the distribution of these two species to the Indian sub-region.

Of the other new records to India, *Trichocerca hollaerti* is characterized by a lateral keel over the entire body, by a head aperture with longitudinal folds and by having a single elongate right, and a S-shaped, short left toe. This species resembled *T. lophoessa* f. *carinata* Koste; the identity of latter cannot be ascertained (Segers, 2003). We assign our specimens to *T. hollaerti* following Segers and Sarma (1993) and Segers (2003). This paleotropical species is known (Segers, 2007) from African, Neotropical, Pacific and Oriental regions; the present report further extended its distribution within the last region.

*Trichocerca maior* (Hauer), often considered *T. porcellus* f. *maior*, is characterized by distinct shape of its lorica and trophi, and was hence assigned the status of a distinct species by Segers (2003); the latter treatment is followed in this account. This species is distributed in Nearctic and Palearctic regions (Segers, 2007) while it is known from the Oriental region by a number of workers from Thailand (Sa-Ardrit et al., 2013); the present report extended distribution range of *T. maior* to the Indian sub-continent.

*Trichocerca siamensis*, new addition to the Indian Rotifera, was described from Thailand (Segers and Pholpunthin, 1997). Considering the almost identical external morphology of the two species, it is likely

to be confused with the Holarctic *T. uncinata* while the tropical records are referred (Segers, 2003) to belong to *T. siamensis*. Sharma et al. (2015) recently reported *T. uncinata* from the floodplains of the Majuli river island of the Brahmaputra river basin; this report yet required examination in view of the stated distributional limits of the two species.

*Trichocerca taurocephala* (Hauer), an interesting species new to India, deserved attention. Koste and Zhuge (1996) compared the specimens from China considered this species and identified the same as *Trichocerca pygocera* (Wiszniewski) while considering the former as its synonym. Segers (2003) commented *T. taurocephala* after Koste and Zhuge (1996) to be possibly an unnamed taxon endemic to Hainan, China (Segers, 1998). The specimens from Mizoram differed from *Trichocerca pygocera* and the Chinese material in shorter anterior spines and in the absence of characteristic posterior or caudal spike of lorica and are thus identified as *T. taurocephala*.

The present study extended distribution ranges of *Brachionus leydigii*, *Lecane syngenes*, *Macrochaetus subquadratus* and *Trichocerca edmondsoni* to NEI. The first species is validly known from Delhi (Arora and Mehra, 2003) and Panjab (Sharma, 1980) while the reports from Jammu and Kashmir, Maharashtra, Tamil Nadu and Uttarakhand are unverifiable. *Lecane syngenes* is reported till date from West Bengal (Sharma, 1979). *Macrochaetus subquadratus* is known from Kerala (Kakkassery, 2003) while the report from Andhra Pradesh warranted validation. *Trichocerca edmondsoni* is documented from Kashmir (Edmondson, 1938) as *T. compressa* (a synonym of the former) while Segers (2003) remarked on the confirmation of this sole report outside the Americas. The present report confirmed occurrence of this new world species in the Indian sub-region and extended its distribution to eastern Himalayas.

The occurrence of Eastern hemisphere species namely *Brachionus diversicornis*, *B. forficula*, *Lecane lateralis*, *L. simonneae*, *L. unguitata*, *Lepadella discoidea*, *L. vandenbrandei*, and

*Testudinella greeni* is a noteworthy feature of Mizoram Rotifera. In addition, *Brachionus bennini*, *Colurella adriatica*, *Euchlanis meneta*, *Lecane bifurca*, *L. doryssa*, *L. haliclysta*, *L. pusilla*, *L. tenuiseta*, *L. thienemanni*, *Lepadella benjamini*, *L. costatoides*, *L. dactyliseta*, *L. elongata*, *L. quadricarinata*, *L. quinquecostata*, *Macrochaetus longipes*, *Mytilina acanthophora*, *Platyias leloupi*, *Testudinella amphora*, *T. tridentata*, *Trichocerca bidens*, *T. scipio*, *T. tigris*, *T. weberi* and *Wolga spinifera* indicated regional distributional interest. Of these, *B. bennini*, *Lepadella benjamini*, *L. elongata*, *L. vandenbrandei*, *Trichocerca bidens*, *T. scipio*, *Testudinella amphora* and *T. greeni* are restricted till date to NEI. *Testudinella amphora* is reported from India from Assam (Sharma et al., 2015) while *E. meneta* and *W. spinifera* are recent additions to NEI from the Brahmaputra basin of Assam state (Sharma and Sharma, 2014b).

Our collections are characterized by the stated order of importance of Lecanidae > Lepadellidae ≥ Brachionidae > Trichocercidae; these families comprised 69.7% of total rotifer richness (S) known from the state. Their biodiversity importance concurred with the reports from the floodplains of Thailand (Sanoamuang, 1998), Indian Rotifera (Sharma, 1996) and the Oriental fauna (Segers, 2008). Their richness pattern primarily concurred with the rotifer fauna of NEI (Sharma and Sharma, 2014a) but it differed in particular from Assam Rotifera (Sharma and Sharma, 2014b). Euchlanidae = Testudinellidae ≥ Trichotriidae ≥ Notommatidae are other notable families (15.5% of S). Interestingly, the stated families, except Brachionidae, included predominantly the littoral-periphytic taxa (Segers, 2001). On the other hand, the general paucity of planktonic rotifers in Mizoram collections is hypothesized to the scarcity of perennial lentic ecosystems in sub-tropical environs of this hill-state of NEI, their usually shallow nature and to the lack of definite pelagic habitats (De Manuel, 1994). Incidentally, this study doubled richness of Brachionidae than an earlier report of Sharma and Sharma (2014a); this feature as well as

*Brachionus* spp. (~8.0%) desired cautious attention because of fewer planktonic species occurring in limnetic environs of certain fish ponds.

*Lecane* > *Lepadella* > *Trichocerca* are diverse genera (~52.7% of S) of Mizoram Rotifera. The relative importance of richness of these periphytic genera concurred with the report by Sharma (2014) and endorsed the possibility of assemblage rules for the periphytic rotifer assemblages as hypothesized by Green (2003). The importance of 'tropic-centered' *Lecane* is distinct (24.8% of S), the richness of *Trichocerca* (21 species, 13.0% of S) marked a significant increase than only eight species reported by Sharma and Sharma (2014a) while 'tropic-centered' *Brachionus* (~8.0%) is rather limited. Nevertheless, significance of *Lecane* and to a lesser degree of *Brachionus* affirmed the role of thermophiles in our collections concurrent with the rotifer fauna of Southeast Asia (Segers, 2001). The said features along with occurrence of a large component of cosmopolitans (~71.0% of S) and of various tropicopolitan and pantropical species (~16.0%) impart a general 'tropical character' to the rotifer fauna of Mizoram. These remarks are supported by low richness of 'temperate-centered' *Keratella* and scarcity of 'cold-water' genera *Cephalodella* and *Synchaeta*. These generalizations are in conformity with the composition of the tropical faunas from different parts of the globe (Green, 1972; Pejler, 1977; Fernando, 1980; De Ridder, 1981; Dussart et al., 1984; Segers, 2001, 2008).

To sum up, the rich and diverse Mizoram Rotifera is hypothesized to habitat diversity and environmental heterogeneity of the sampled ecosystems of this hill-state of NEI which are characterized by the scarcity of perennial lentic biotopes and the lack of definite pelagic habitats in particular. Various new records, globally interesting elements and Eastern hemisphere species impart biodiversity and biogeographic value to this study. The rotifer fauna is predominantly of 'tropical nature' and is characterized by notable richness of the littoral-periphytic taxa and general paucity of planktonic

rotifers. Our collections are biased towards planktonic and semi-planktonic taxa and specific analysis of the periphytic, sessile, colonial and benthic taxa, and of cryptic diversity in certain species-groups merit interest for future biodiversity update. We estimate occurrence of 250<sup>+</sup> rotifer species in Mizoram state.

### Acknowledgements

The senior author (BKS) is thankful to the Ministry of Environment and Forests (Govt. of India) for a research project No. 22018-09/2010-CS (Tax) under its AICOPTAX program which facilitated the present sampling. Thanks are due to the Head, Department of Zoology, NEHU, Shillong for laboratory facilities and to Mr. N Noroh for the field collections.

### References

- A.P.H.A. (1992). Standard Methods for the Examination of Water and Wastewater (18th Ed.). American Public Health Association, Washington D. C. pp. 1198.
- Arora J., Mehra N.K. (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.
- 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.
- De Ridder M. (1981). Some considerations on the geographical distribution of Rotifera. *Hydrobiologia*, 85: 209-235.
- Dussart B.H., Fernando C.H., Matsumura-Tundisi J., Shiel R.J. (1984). A review of systematics, distribution and ecology of tropical freshwater zooplankton. *Hydrobiologia*, 113: 77-91.
- Edmondson W.T. (1938). Three new species of Rotatoria. *Transactions of American Microscopic Society*, 57: 153-157.
- 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.
- Green J. (2003). Associations of planktonic and periphytic rotifers in a tropical swamp, the Okavango Delta, Southern Africa. *Hydrobiologia*, 490: 197-209.
- Kakkassery F.K. (2003). Studies on freshwater rotifers of Kerala. Ph.D. thesis. University of Calicut, Calicut. 246 p.
- Koste W. (1978). Rotatoria. Die Rädertiere Mitteleuropas, begründet von Max Voigt. Überordnung Monogononta. Gebrüder Borntraeger, Berlin, Stuttgart. I. 673 pp. U. II. Tafelbd. (T. 234).
- Koste W., Shiel R.J. (1987). Rotifera from Australian inland waters. II. Epiphanidae and Brachionidae (Rotifera: Monogononta). *Invertebrate Taxonomy*, 7: 949-1021.
- Koste W., Shiel R.J. (1989). Rotifera from Australian inland waters. IV. Colurellidae (Rotifera: Monogononta). *Transactions of the Royal Society of South Australia*, 113: 119-143.
- Koste W., Shiel R.J. (1990). Rotifera from Australian inland waters V. Lecanidae (Rotifera: Monogononta). *Transactions of the Royal Society of South Australia*, 114(1): 1-36.
- Koste W., Zhuge Y. (1996). A preliminary report on the occurrence of Rotifera in Hainan. *The Quekett journal of Microscopy*, 37: 666-883.
- Jersabek C.D., Leitner M.F. (2013). The Rotifer world catalog. World Wide Web electronic publication. <http://www.rotifera.hausdernatur.at/>, accessed {03.12.2013}.
- Meas S., Sanoamuang L. (2010). New records of rotifer fauna in the Cambodia Mekong River Basin. *Cambodian Journal of Natural History*, 1: 48-62.
- Sa-Ardrit P., Pholpunthin P., Segers H. (2013). A checklist of the freshwater rotifer fauna of Thailand (Rotifera, Monogononta, Bdelloidea). *Journal of Limnology*, 72(2): 361-375.
- Sanoamuang L. (1998). Rotifera of some freshwater habitats in the floodplains of the River Nan, northern Thailand. *Hydrobiologia*, 387/ 88: 27-33.
- Segers H. (1995). Rotifera 2: Lecanidae. In: H.J. Dumont, T. Nogrady (Eds.). *Guides to identification of the Microinvertebrates of the Continental waters of the world*. SPB Academic Publishing bv. Amsterdam, the Netherlands. 6: 1-226.
- Segers H. (1998). Notes on the taxonomy and distribution of the interstitial Rotifera from a dune pool. *Belgian Journal of Zoology*, 128: 35-47.
- Segers H. (2001). Zoogeography of the Southeast Asian Rotifera. *Hydrobiologia*, 446/447: 233-246.
- 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. (2003). A biogeographical analysis of rotifers of the genus *Trichocerca* Lamarck, 1801 (Trichocercidae, Monogononta, Rotifera), with notes on taxonomy. *Hydrobiologia*, 500: 103-114.
- Segers H. (2007). Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution. *Zootaxa*, 1564: 1-104.
- Segers H. (2008). Global diversity of rotifers (Rotifera) in freshwater. *Hydrobiologia*, 595: 49-59.
- Segers H., Pholpunthin P. (1997). New and rare Rotifera from Thale Noi Lake, Pattalang Province, Thailand, with a note on the taxonomy of Cephalodella (Notommatidae). *Annals Limnologie*, 33(1): 13-21.
- Segers H., Sarma S.S.S. (1993). Notes on some new or little known Rotifera from Brazil. *Revue Hydrobiologie Tropicale*, 26: 175-185.
- Sharma B.K. (1979). Further contributions to the lecanid fauna (Rotifera: Lecanidae) of West Bengal. *Acta Hydrobiologia Krakow*, 21(1): 53-59.
- Sharma B.K. (1980). Contributions to the rotifer fauna of Panjab State, India. I. Family Brachionidae. *Hydrobiologia*, 76: 249-253.
- Sharma B.K. (1983). The Indian species of the genus *Brachionus* (Eurotatoria: Monogononta: Brachionidae). *Hydrobiologia*, 104: 31-39.
- Sharma B.K. (1987). Indian Brachionidae (Eurotatoria: Monogononta) and their distribution. *Hydrobiologia*, 144: 269-275.
- Sharma B.K. (1996). Biodiversity of freshwater Rotifera in India - a status report. *Proceedings of the Zoological Society, Calcutta* 49: 73-85.
- Sharma B.K. (1998). Freshwater Rotifers (Rotifera: Eurotatoria). In: *Fauna of West Bengal. State Fauna Series*, 3(11): 341-461. Zoological Survey of India, Calcutta.
- Sharma B.K. (2005). Rotifer communities of floodplain lakes of the Brahmaputra basin of lower Assam (N. E. India): biodiversity, distribution and ecology. *Hydrobiologia*, 533: 209-221.
- Sharma B.K. (2014). Rotifers (Rotifera: Eurotatoria) from wetlands of Majuli - the largest river island, the



- Brahmaputra river basin of upper Assam, northeast India. *Check List*, 10(2): 292-298.
- Sharma B.K., Pachau, L. (2013). Zooplankton diversity of a sub-tropical reservoir of Mizoram, Northeast India. *Opuscula Zoologica*, Budapest, 44(1): 47-60.
- Sharma B.K., Sharma S. (1987a). On species of the genus *Lepadella* (Eurotatoria: Monogononta: Colurellidae) from North Eastern India, with remarks on Indian taxa. *Hydrobiologia*, 147: 15-22.
- Sharma B.K., Sharma S. (1987b). On some species of the family Notommatidae (Eurotatoria: Monogononta) from North Eastern India. *Bulletin of the Zoological Survey of India*, 8(1-3): 177-183.
- Sharma B.K., Sharma S. (1990). On the distribution of brachionid rotifers (Eurotatoria: Brachionidae) in North-Eastern India. In: R.R. Mishra, K. Chatterjee (Eds.). *Current Trends in Environmental biology*. Wiley Eastern Limited: 189-196.
- Sharma B.K., Sharma S. (1997). Lecanid rotifers (Rotifera: Monogononta: Lecanidae) from North Eastern India. *Hydrobiologia*, 356: 159-163.
- Sharma B.K., Sharma S. (1999). Freshwater Rotifers (Rotifera: Eurotatoria). In: *Fauna of Meghalaya*. State Fauna Series, 4(9): 11-161. Zoological Survey of India, Calcutta.
- Sharma B.K., Sharma S. (2000). Freshwater Rotifers (Rotifera: Eurotatoria). In: *Fauna of Tripura*: State Fauna Series, 7 (4): 163-224. Zoological Survey of India, Calcutta.
- Sharma B.K., Sharma S. (2005). Biodiversity of freshwater rotifers (Rotifera: Eurotatoria) from North-Eastern India. *Mitteilungen aus dem Museum für Naturkunde Berlin, Zoologische Reihe*, 81: 81-88.
- Sharma B.K., Sharma S. (2009). Biodiversity and distribution of freshwater rotifers (Rotifera, Eurotatoria) of Tamil Nadu. *Records of the Zoological Survey of India*, 109(3): 41-60.
- Sharma B.K., Sharma S. (2014a). Northeast India – An important region with a rich biodiversity of Rotifera. In: B.K. Sharma, H.J. Dumont, R.L. Wallace (Eds.). *Rotifera XIII: Rotifer Biology - A structural and functional Approach*. *International Review of Hydrobiology*, 99(1-2): 20-37.
- Sharma B.K., Sharma S. (2014b). The diversity of Indian Brachionidae (Rotifera: Eurotatoria: Monogononta) and their distribution *Opuscula Zoologica*, Budapest, 45(2):165-180.
- Sharma B.K., Sharma S. (2014c). Floodplains of the Brahmaputra river basin-globally interesting ecotones with rich Rotifer (Rotifera: Eurotatoria) biodiversity. In: R.K. Sinha, B. Ahmed (Eds.). *Rivers for Life - Proceedings of the International Symposium on River Biodiversity: Ganges–Brahmaputra–Meghna River System, Ecosystems for Life*, A Bangladesh – India Initiative, IUCN, International Union for Conservation of Nature, 258-270.
- Sharma B.K., Sharma S. (2015). The diversity and distribution of Lepadellidae (Rotifera: Eurotatoria: Monogononta) of India. *International Review of Hydrobiology* 100(1): 34-42.
- Sharma B.K., Sharma S., Hatimuria M.K. (2015). Rotifer assemblages (Rotifera: Eurotatoria) of the floodplain lakes of Majuli River Island, the Brahmaputra river basin, northeast India. *International Journal of Aquatic Biology*, 3(1): 1-13.
- Sharma S., Sharma B.K. (2008). Zooplankton diversity in floodplain lakes of Assam. *Records of the Zoological Survey of India*, Occasional Paper No. 290: 1-307.
- Sharma S., Sharma B.K. (2013). Faunal Diversity of Aquatic Invertebrates of Deepor Beel (a Ramsar site), Assam, northeast India. *Wetland Ecosystem Series*, 17: 1-226. Zoological Survey of India, Kolkata.
- Shiel R.J., Koste W. (1992). Rotifera from Australian inland waters VIII. Trichocercidae (Monogononta). *Transactions of the Royal Society of South Australia*, 116 (1): 1-27.
- Shiel R.J., Koste W. (1993). Rotifera from Australian inland waters. IX. Gastropodidae, Synchaetidae, Asplanchnidae (Rotifera: Monogononta). *Transactions of the Royal Society of South Australia*, 117 (1): 111-139.
- Talling J.F., Talling I.B. (1965). The chemical composition of African lake waters. *Internationale Revue der gesamten Hydrobiologie*, 50: 421-463.

**Appendix I:** A detailed systematic list of the rotifer species examined from Mizoram**Phylum: Rotifera****Class: Eurotatoria****Subclass: Monogononta****Order: Ploima****Family: Brachionidae**

1. *Anuraeopsis coelata* De Beauchamp, 1932 \*\*\*
2. *A. fissa* (Gosse, 1851)
3. *Brachionus ahlstromi* Lindeman, 1939 \*\*\*
4. *B. angularis* Gosse, 1851
5. *B. bennini* Leissling, 1924
6. *B. bidentatus* Anderson, 1889 \*\*\*
7. *B. calyciflorus* Pallas, 1766
8. *B. caudatus* Barrois & Daday, 1894 *s. lato*
9. *B. diversicornis* (Daday, 1883) \*\*\*
10. *B. durgae* Dhanapathi, 1974 \*\*\*
11. *B. falcatus* Zacharias, 1898
12. *B. forficula* Wierzejski, 1891 \*\*\*
13. *B. leydigii* Cohn, 1862\*\*
14. *B. rubens* Ehrenberg, 1838 \*\*\*
15. *B. quadridentatus* Hermann, 1783
16. *Keratella cochlearis* (Gosse, 1851)
17. *K. javana* Hauer, 1937 \*\*\*
18. *K. tecta* (Gosse, 1851) \*\*\*
19. *K. tropica* (Apstein, 1907)
20. *Platyias leloupi* (Gillard, 1967) \*\*\*
21. *P. quadricornis* (Ehrenberg, 1832)
22. *Platyonus patulus* (O.F. Muller, 1786)

**Family: Euchlanidae**

23. *Beauchampiella eudactylota* (Gosse, 1886)
24. *Euchlanis dilatata* Ehrenberg, 1832
25. *E. incisa* Carlin, 1939 \*\*\*
26. *E. meneta* Myers, 1930 \*\*\*
27. *E. triquetra* Ehrenberg, 1838
28. *Dipleuchlanis propatula* (Gosse, 1886)
29. *Tripleuchlanis plicata* (Levander, 1894) \*\*\*

**Family: Mytilinidae**

30. *Lophocharis salpina* (Ehrenberg, 1834)
31. *Mytilina acanthophora* Hauer, 1938 \*\*\*
32. *M. bisulcata* (Lucks, 1912) \*\*\*
33. *M. ventralis* (Ehrenberg, 1830)

**Family: Trichotriidae**

34. *Macrochaetus collinsi* (Gosse, 1867)
35. *M. subquadratus* (Perty, 1850) \*\*
36. *M. longipes* Myers, 1934 \*\*\*
37. *M. sericus* (Thorpe, 1893)
38. *Trichotria tetractis* (Ehrenberg, 1830)
39. *Volga spinifera* (Western, 1894) \*\*\*

**Family: Lepadellidae**

40. *Colurella adriatica* Ehrenberg, 1831 \*\*\*
41. *C. colurus* (Ehrenberg, 1830) \*\*\*
42. *C. obtusa* (Gosse, 1886)
43. *C. sulcata* (Stenroos, 1898)
44. *C. uncinata* (O.F. Muller, 1773) *s. lato*
45. *Lepadella acuminata* (Ehrenberg, 1834)
46. *L. apsidea* Haring, 1916 \*\*\*
47. *L. benjamini* Haring, 1916 \*\*\*
48. *L. biloba* Hauer, 1958 \*\*\*
49. *L. costatoides* Segers, 1992
50. *L. cristata* (Rousselet, 1893) \*\*\*
51. *L. dactyliseta* (Stenroos, 1898) \*\*\*
52. *L. discoidea* Segers, 1993
53. *L. elongata* Koste, 1992 \*\*\*
54. *L. eurysterna* Myers, 1942 \*\*\*
55. *L. latusinus* (Hilgendorf, 1889) \*\*\*
56. *L. lindau* Koste, 1981\*\*\*
57. *L. minuta* (Weber & Montet, 1918) \*\*\*
58. *L. ovalis* (O.F. Muller, 1786) *s. lato*
59. *L. patella* (O.F. Muller, 1773) *s. lato*
60. *L. quadricarinata* (Stenroos, 1898) \*\*\*
61. *L. quinquecostata* (Lucks, 1912) \*\*\*
62. *L. rhomboides* (Gosse, 1886) *s. lato*
63. *L. triba* Myers, 1934 \*\*\*
64. *L. triptera* Ehrenberg 1832 \*\*\*
65. *L. vandenbrandei* Gillard, 1952 \*\*\*
66. *L. (Heterolepadella) apsicora* Myers, 1934
67. *L. (H.) ehrenbergi* (Perty, 1850)
68. *L. (H.) heterostyla* (Murray, 1913)
69. *Squatinella lamellaris* (O. F. Müller, 1786) \*\*\*

**Family: Lecanidae**

70. *Lecane aculeata* (Jakubski, 1912)

71. *L. arcula* Haring, 1914
72. *L. aeganea* Haring, 1914 \*
73. *L. bifurca* (Bryce, 1892) \*\*\*
74. *L. bulla* (Gosse, 1851) *s. lato*
75. *L. closteroerca* (Schmarda, 1859)
76. *L. crepida* Haring, 1914
77. *L. curvicornis* (Murray, 1913) *s. lato*
78. *L. decipiens* (Murray, 1913) \*\*\*
79. *L. doryssa* Haring, 1914 \*\*\*
80. *L. elegans* Haring, 1914 \*\*\*
81. *L. flexilis* (Gosse, 1886) \*\*\*
82. *L. furcata* (Murray, 1913)\*\*\*
83. *L. haliclysta* Haring & Myers, 1926 \*\*\*
84. *L. hamata* (Stokes, 1896) *s. lato*
85. *L. hornemanni* (Ehrenberg, 1834) \*\*\*
86. *L. inermis* (Bryce, 1892)
87. *L. inopinata* Haring & Myers, 1926
88. *L. lateralis* Sharma, 1978 \*\*\*
89. *L. leontina* (Turner, 1892) *s.lato*
90. *L. ludwigii* (Eckstein, 1883)
91. *L. luna* (Müller, 1776)
92. *L. lunaris* (Ehrenberg, 1832) *s. lato* \*\*\*
93. *L. monostyla* (Daday, 1897) \*\*\*
94. *L. nana* (Murray, 1913) \*\*\*
95. *L. obtusa* (Murray, 1913)
96. *L. ohioensis* (Herrick, 1885)
97. *L. papuana* (Murray, 1913)
98. *L. ploenensis* (Voigt, 1902)
99. *L. pusilla* Haring, 1914 \*\*\*
100. *L. pyriformis* (Daday, 1905)
101. *L. quadridentata* (Ehrenberg, 1830) *s. lato*
102. *L. stenroosi* (Meissner, 1908) \*\*\*
103. *L. styra* (Haring & Myers, 1926)
104. *L. syngenes* (Hauer, 1938) \*\*
105. *L. tenuiseta* Haring, 1914 \*\*\*
106. *L. thienemanni* (Hauer, 1938) \*\*\*
107. *L. undulata* Hauer, 1938 \*\*\*
108. *L. unguitata* (Fadeev, 1925)
109. *L. ungulata* (Gosse, 1887)

**Family : Notommatidae**

110. *Cephalodella forficula* (Ehrenberg, 1830)
111. *C. gibba* (Ehrenberg, 1830)
112. *C. mucronata* Myers, 1924 \*\*\*
113. *Monommata longiseta* (O.F. Müller, 1786)
114. *Monommata* sp.

**Family: Scaridiidae**

115. *Scaridium longicaudum* (O.F. Müller, 1786)

**Family: Trichocercidae**

116. *Trichocerca bicristata* (Gosse, 1887)
117. *T. cylindrica* (Imhof, 1891) \*\*\*
118. *T. bidens* (Lucks, 1912) \*\*\*
119. *T. edmondsoni* (Myers, 1936) \*\*
120. *T. elongata* (Gosse, 1886)
121. *T. hollaerti* De Smet, 1990 \*
122. *T. iernis* (Gosse, 1887) \*\*\*
123. *T. insignis* (Herrick, 1885) \*\*\*
124. *T. insulana* (Hauer, 1937) \*\*\*
125. *T. maior* Hauer, 1936 \*
126. *T. pusilla* (Jennings, 1903)
127. *T. rattus* (O.F. Müller, 1776)
128. *T. scipio* (Gosse, 1886) \*\*\*
129. *T. siamensis* Segers & Pholpunthin, 1997 \*
130. *T. similis* (Wierzejski, 1893)
131. *T. stylata* (Gosse, 1851) \*\*\*
132. *T. taurocephala* (Hauer, 1931) \*
133. *T. tigris* (O.F. Müller, 1786) \*\*\*
134. *T. vernalis* (Hauer, 1936) \*\*\*
135. *T. voluta* (Murray, 1913) \*\*\*
136. *T. weberi* (Jennings, 1903) \*\*\*

**Family: Asplanchnidae**

137. *Asplanchna priodonta* Gosse, 1850

**Family: Synchaetidae**

138. *Polyarthra euryptera* Wierzejski, 1891 \*\*\*
139. *P. vulgaris* Carlin, 1943
140. *Ploesoma lenticulare* Herrick, 1885 \*\*\*
141. *Synchaeta pectinata* Ehrenberg, 1832 \*\*\*

**Family: Dicranophoridae**

142. *Dicranophoroides caudatus* (Ehrenberg, 1834) \*\*\*
143. *Dicranophorus forcipatus* (O.F. Müller, 1786)

**Order: Flosculariaceae****Family: Floscularidae**

144. *Floscularia ringens* (Linnaeus, 1758) \*\*\*
145. *Sinantharina socialis* (Linne, 1758)
146. *S. spinosa* (Thorpe, 1893)

**Family: Hexarthridae**

147. *Hexarthra mira* (Hudson, 1871)

**Family: Testudinellidae**

148. *Testudinella amphora* Hauer, 1938 \*\*\*  
 149. *T. emarginula* (Stenroos, 1898) *s. lato*  
 150. *T. greeni* Koste, 1981 \*\*\*  
 151. *T. parva* (Ternetz, 1892) \*\*\*  
 152. *T. patina* (Hermann, 1783) *s. lato*  
 153. *T. tridentata* Smirnov, 1931 \*\*\*  
 154. *T. walkeri* Koste & Shiel, 1980\*  
 155. *Pompholyx sulcata* Hudson, 1885 \*\*\*

**Family: Trochosphaeridae**

156. *Filinia camasecla* Myers, 1938

157. *F. longiseta* (Ehrenberg, 1834) *s. lato*  
 158. *F. opoliensis* (Zacharias, 1898)  
 159. *F. terminalis* (Plate, 1886) *s. lato* \*\*\*

**Family: Collothecidae**

160. *Collotheca ornata* (Ehrenberg, 1832) \*\*\*

**Sub-class: Bdelloidea**

**Family: Philodinidae**

161. *Philodina roseola* Ehrenberg, 1832 \*\*\*  
 162. *Rotaria neptunia* (Ehrenberg, 1830)

---

\* New record from India, \*\* new record from northeast India, \*\*\* new record from Mizoram

## چکیده فارسی

### تنوع روتفرهای (Rotifera: Eurotatoria) آب شیرین میزورما، شمال شرقی هندوستان: ترکیب گونه‌ای، ثبت جدید و ویژگی‌های جالب

بوشان کومار شارما\*، سومیت شارما

آزمایشگاه زیست‌شناسی آب‌های شیرین، گروه جانورشناسی، دانشگاه هیل شمال شرقی، شیلونگ ۷۹۳۰۲۲، مقلالایا، هندوستان.

#### چکیده:

بررسی نمونه‌های پلانکتون و نیمه‌پلانکتون ایالت میزورما در شمال شرقی هندوستان اجتماعی پرگونه و متنوع از روتیفرها شامل غنایی با ۱۶۲ گونه متعلق به ۱۹ خانواده و ۳۳ جنس را آشکار کرد. این مطالعه ۶ گونه جدید برای هندوستان، ۴ گونه جدید برای شمال شرقی هند و ۷۶ گونه جدید برای ایالت میزورما که از نظر تنوع زیستی جالب هستند را ثبت می‌کند. وقوع یک گونه استرالیایی، یک گونه شرقی، ۷ گونه پالئوتروپیکال، یک گونه هولوآرکتیک، یک گونه جهانی (زیر) استوایی و ۵ گونه جالب دیگر ارزش جغرافیای زیستی را آشکار می‌سازد، در حالی که چندین گونه اهمیت پراکنش منطقه‌ای را نشان می‌دهند. خانواده‌های *Trichocercidae* < *Brachionidae* < *Lepadellidae* < *Lecanidae* در مجموع ۶۹/۷ درصد از غنای گونه‌ای را دربرمی‌گیرند. *Trichocerca* < *Lepadella* < *Lecane* متنوع‌ترین جنس‌ها هستند (با حدود ۵۲ درصد از غنای گونه‌ای) در حالی که گونه‌های *Tropicopolitan* و *Pantropical* حدود ۱۶ درصد را تشکیل می‌دهند. این مطالعه غنای بالایی از آرایه‌های ساحلی-پریفیتونی و غنای کمتر از آرایه‌های پلانکتونی را نشان داد. آنالیز آرایه‌های پریفیتیک، ساکن، کلونی و بنتیک و تنوع نهفته برخی گروه‌های گونه‌ای معین نیاز به توجه بیشتر به بروز رسانی تنوع گونه‌ای را بیان می‌کند و حضور بیش از ۲۵۰ گونه روتیفر در میزورما تخمین زده می‌شود.

**کلمات کلیدی:** ترکیب، جغرافیای زیستی، آرایه‌های جالب، غنای گونه‌ای، آب‌های زیراستوایی.