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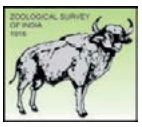

Faunal diversity of zooplankton in the selected wetlands of Nagaland, North-East India

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Abstract

The study aims to assess the faunal diversity of zooplankton importance base on our plankton collections from three selected wetland of Nagaland (North East-India). Our collection from Madladijam, Bolfangdisa and Noune wetlands revealed biodiverse zooplankton assemblage with a report of 181 species spread over 79 genera and 34 families, belonging to five groups of zooplankton. Rotifera followed by Cladocera largely contribute to zooplankton richness while Rhizopoda, Copepoda and Ostracoda are other components. Our study reveals 32 species new records from Nagaland State and 2 species from North East-India, besides, 50 species of rotifers has been recently added as new records from the State. Total zooplankton richness ranged between 109-160 (138±22) species and percentage similarity between wetlands shows high similarities, Noune and Madladijam is 71.1%; Noune and Bolfangdisa is 73.6% and similarity between Madladijam and Bolfangdisa wetland is 83.4%. The study revealed several biogeographically interesting elements. The biodiversity and biogeographically importance as recorded is attributed to ecological heterogeneity of the sampled wetlands.

Keywords: Zooplankton, Diversity, Wetlands, Nagaland, North-East India.

Introduction

Zooplankton is an essential constituent of aquatic ecosystems and plays a significant role in the transfer of energy and nutrients through the food web (Steinberg & Robert, 2009). Zooplankton invariably forms an integral component of freshwater communities and contributes significantly to biological productivity. These fish-food organisms have been studied from various inland ecosystems of this country but information on their ecology in the Indian floodplain lakes in particular is yet limited (Sharma & Sharma, 2008). Floodplain lakes are important features of landscapes in major river systems all around the world. These shallow wetlands are considered ecotones, as they have diverse environmental conditions due to changes in water levels and the presence of macrophytes and are well-known for their rich biodiversity and ecological significance (Funk et al. 2009, Górski et al. 2013, Dembowska & Napiórkowski 2015, Napiórkowski et al. 2019). The floodplain lakes, an important component of inland aquatic resources of India, are hypothesized to be rich habitats for zooplankton diversity (Sharma & Sharma 2008). The small water bodies (ponds and wetlands) are considered as keystone systems for analyses of biodiversity (Vad et. al. 2017; Oertli 2018). The present study is the continuation of our earlier reports on biodiversity of rotifers in Nagaland (Sharma and Kensibo, 2017; Sharma et. al., 2017).

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Material and Methods

Plankton samples were collected from Bolfangdisa, Madladijam and Noune wetlands at regular monthly intervals during the study period i.e., from December 2014-November 2016 at three sampling station each. The monthly qualitative plankton samples were collected by towing nylobolt plankton net (#50 µm) from the littoral and limnetic regions of three wetlands and were preserved in 5% formalin. All plankton samples were screened with Wild Stereoscopic Binocular Microscope for isolation of various taxa which in turn were observed with Leica (DM 1000) stereoscopic phase contrast microscope fitted with an image analyser. A polyvinyl alcohol-lactophenol mixture was used to mount zooplankton. Micro-photographs were taken with a Leica DM 1000 image analyser. The measurements were given in micrometres (µm). Different groups of zooplankton, Rotifera were identified following Kutikova (1970), Koste (1978), Koste and Shiel (1987, 1989, 1990), Shiel and Koste (1992, 1993), Segers (1995), De Smet (1997), Sharma (1983, 1987a, 1987b, 1998), Nogrady and Pourriot (1995), Sharma and Sharma (1997, 1999a, 1999b, 2000, 2008) and, Nogrady and Segers (2002). Cladocera were identified following Smirnov (1971, 1974, 1996), Michael and Sharma (1988), Korovchinsky (1992), Sharma and Sharma (2008, 2013), Orlova-Bienkowskaja (2001) and Korinek (2002). Rhizopoda were identified following the works of Deflandre (1959), Chattopadhyay and Das (2003) and, Sharma and Sharma (2008). Copepoda were identified following Ranga (1994, 2001), Alekseev (2002) and, Ueda and Reid (2004). Ostracoda were identified following Victor and Fernando (1982) and Victor (2002).

Various macrophytes were recorded from the sampled wetlands. In Bolfangdisa wetland it comprises of *Alternanthera* sp., *Azolla* sp., *Centella* sp., *Ceratophyllum* sp., *Chara* sp., *Commelina bengalensis, Elodea* sp., *Hydrilla verticillata, Juncus* sp., *Nelumbo* sp., *Nymphaea* sp. *and Scirpus* sp. The different macrophytes of Madladijam wetland were *Alternanthera* sp., *Azolla* sp., *Centella* sp., *Ceratophyllum* sp., *Chara* sp., *Commelina bengalensis, Elodea* sp., *Hydrilla verticillata, Juncus* sp., *Nymphaea* sp. and *Scirpus* sp. *Nymphaea* sp. is the main macrophyte in Noune wetland.

Systematic Accounts

Systematic list of zooplankton recorded of Nagaland wetlands

(In the Tables and figures file)

Results and Discussion

The present report of 181 species belonging to 81 genera, 33 families and five groups from the three wetlands of Nagaland state of NEI affirms species-rich and diverse zooplankton. The reported taxa deserve biodiversity importance as the highest richness of fish-food organisms and one of the richest zooplankton diversity known till date from small lentic environs of any state of northeast India (NEI) and from India (BKS, unpublished), respectively. The results endorse the hypothesis (Sharma and Kensibo, 2017) on small lentic ecosystems to be one of the rich habitats for metazoan diversity. The documented zooplankton heterogeneity is hypothesized to habitat diversity and ecological heterogeneity of the sampled wetlands and it is also attributed (Sharma and Sharma, 2004, 2008) to biodiverse nature of 'slightly acidic-circum neutral-slightly alkaline' and 'soft-moderately hard' waters characterized by 'low ionic concentrations'.

A total of 34 species (18.78% of S) of zooplankton are new records with 32 new records from Nagaland and 2 species are new records from northeast India (NEI); the former includes 13, 4, 11 and 4 species of new records of Cladocera, Copepoda, Rhizopoda and Ostracoda, respectively while two of Copepoda are new records from NEI. This study marks an important contribution to faunal diversity and biogeography of zooplankton in NEI in general and Nagaland in particular in light of limited earlier works on the rotifer species (Sharma and Sharma, 2014a; Sharma and Kensibo, 2017; Sharma et. al. 2017).

Total zooplankton of Nagaland wetlands reported richness outnumbered distinctly the reports of 148 species from sub-tropical small urban wetland of Meghalaya (Sharma & Sharma, 2021); 141 species from three Floodplain Lakes (Beels) of the Majuli River Island, Assam (Sharma & Hatimuria, 2017); 121 species from two floodplain lakes of Manipur (Sharma, 2011); 76 species (Khan, 2002) and 89 species (Khan, 2003) from the floodplains lakes of Southeastern West Bengal; 76 species from two floodplain wetlands (Datta, 2011) of north Bengal; and 51 species from two Himalayan wetlands (Khan, 1987). The stated comparisons asserted biodiversity importance of the present study *vis-à-vis* ecosystem diversity of the small lentic ecosystems of Nagaland.

The present study indicated higher rotifer richness of 109-160 (139±22) species of individual wetlands. Bolfangdisa wetland recorded a total of 160 species with richness of 149 and 111 species during two years, respectively. Madladijam wetland recorded 147 species with 133 and 109 species

during two years of the study, respectively. Noune wetlands recorded a total 109 species and it indicated 96 and 83 species during first and second year, respectively. Community similarities of 71.1-83.4% (*vide Sørenson index*) during this study as well as 62.9-77.6% and 62.5-82.2% during two years, respectively, the present results characterized overall homogeneity in zooplankton species composition amongst the wetlands. Maximum similarity is observed between Bolfangdisa and Madladijam while Noune and Madladijam recorded the lowest similarity both during the study as well as during two years individually. The Maximum community similarity observed between Bolfangdisa and Madladijam while Noune and Madladijam recorded the lowest similarity maybe attributed to diversity in aquatic macrophytes (Ahmad & Parveen, 2013).

Rotifera, the most species-richness group of zooplankton, recorded a total of (S) of 110 species (S) belonging to 31 genera and 17 families; the results thus indicate rich and diverse Rotifera assemblage (Sharma and Kensibo, 2017) which merit biodiversity interest as ~39.0 and ~26.0% of species known from NEI and India, respectively (Sharma and Sharma, 2017a). The rotifer richness provides a significant update to 66 species, 23 genera and 14 families of the rotifers reported earlier from Nagaland (Sharma and Sharma, 2014a) while it is higher than a recent high report of 90 species from a small urban sub-tropical wetland of Meghalaya state of NEI (Sharma *et al*., 2016). Rotifera recorded reasonable richness variations (82±12 species) amongst three Nagaland wetlands with higher richness in Bolfangdisa (95 species) > Madladijam (84 species) wetlands while Noune wetlands with the semi-limnetic habitat is characterized by relatively lower richness (66 species). Besides, high rotifer richness in the three wetlands individually is hypothesized to their habitat diversity and environmental heterogeneity.

The globally interesting elements formed a notable fraction (11.0% of S) of Rotifer diversity of the Nagaland wetlands (Sharma and Kensibo, 2017). These are represented by the Australasian *Brachionus dichotomus reductus*; three Oriental endemics *i.e.*, *Lecane blachei*, *Lecane bulla diabolica*, *Lecane latissima*; and eight palaeotropical species *viz., Lepadella discoidea, Lepadella vandenbrandei*, *Lecane lateralis, Lecane simonneae, Lecane unguitata*, *Testudinella brevicaudata*, *Testudinella greeni* and *Trichocerca hollaerti*. Besides, *Lecane doryssa, Lecane elegans, Lecane haliclysta, Lecane hastata, Lecane rhenana, Lecane thienemanni, Lecane undulata, Lepadella benjamini, Lepadella costatoides, Lepadella dactyliseta, Testudinella amphora, Testudinella dendradena*, *Testudinella tridentata, Trichocerca insignis* and *Trichocerca maior* are species of regional distribution interest in the Indian-sub region. Amongst these, 12 species *viz., Lepadella benjamini, Lepadella vandenbrandei*, *Lecane elegans, Lecane latissima, Lecane rhenana, Lecane undulata, Testudinella amphora, Testudinella brevicaudata*, *Testudinella dendradena*, *Testudinella greeni*, *Trichocerca hollaerti* and *Trichocerca maior* are characterized by their distribution in India till date exclusively restricted to NEI (Sharma and Sharma, 2015, 2017a). *Lecane latissima,* an interesting lecanid noticed in Nagaland collections, deserved attention. It was originally reported from India from Meghalaya state of NEI (Sharma, 2004) as *Lecane thailandensis* which was subsequently assigned (Sharma and Sharma, 2014b) to *Lecane latissima* following its recent synonymy (Segers and Savatenalinton, 2010).

Lecanidae > Lepadellidae together comprise major component (~49.0% of S) of the rotifer diversity. In addition, Brachionidae > Trichocercidae > Testudinellidae deserved attention (~29.0% of S). *Lecane* > *Lepadella* (45.4% of S) are more diverse genera and *Trichocerca* > *Brachionus* > *Testudinella* together form a notable fraction (~23% of S). The richness importance of the stated taxa endorsed the littoral-periphytic character of the rotifer assemblages concurrent with general habitat of the two wetlands. This generalization endorsed the remarks the wetlands of Manipur (Sharma *et al*., 2016) of the Brahmaputra river basin floodplains of NEI (Sharma and Sharma, 2014a, 2014c). Nevertheless, the richness of Brachionidae (14 species) and *Brachionus* (8 species) is attributed to certain semi-limnetic conditions in these water bodies. This in contrast to the relative paucity of these taxa known from Meghalaya wetland (Sharma *et al*., 2016) in spite of open water conditions. The speciose nature of the `tropic-centred' *Lecane* and *Brachionus* to certain extent; high richness of cosmopolitan species (~62.0% of S); and the reports of several tropicopolitan and pantropical species (~25% of S) impart a 'tropical character' to the rotifer fauna in conformity with the composition of the tropical faunas from different parts of the globe (Green, 1972; Pejler, 1977; Fernando, 1980; Dussart *et al*., 1984; Segers, 1996, 2001; Sharma and Sharma, 2014a, 2017a).

Forty-four species (S), belonging to 34 genera and seven families, recorded from the sampled Nagaland wetlands reveal a fairly rich and diverse **Cladocera** assemblage; these comprise ~37.0% of the species of this group known from India (Sharma and Sharma, 2017b). Total cladoceran

richness (S) assumes particular biodiversity value *vis-à-vis* a conservative estimate of up to 60–65 cladoceran species from tropical and subtropical parts of the Indian subcontinent (Fernando and Kanduru, 1984; Sharma and Michael, 1987; Sharma and Sharma, 2017b). Thirteen species are new records to Nagaland; these include *Alona kotovi, Anthalona harti, Chydorus angustirostris, Chydorus eurynotus, Disparalona caudata, Graptoleberis testudinaria, Grimaldina brazzai, Guernella raphaelis, Kurzia latissima, Leydigiopsis pulchera, Macrothrix odiosa, Ovalona cambouei* and *Picripleuroxus quasidenticulatus.* In general, the present study marked a significant contribution to the ecosystem diversity of Cladocera of the small lentic ecosystems of India in general and Nagaland wetlands in particular.

The biogeographically interesting **Cladocera** include the Australasian *Disparalona caudata*; the Indo-Chinese *Alona cheni, Alona kotovi* and *Picripleuroxus quasidenticulatus*; the Oriental *Celsinotum macronyx*; and the Palaearctic *Kurzia latissima*. Of these, *Disparalona caudata* is an important link between the Cladocera faunas of northeast India, Southeast Asia and Australia (Sharma and Sharma, 2007, 2017b). The Indo-Chinese *Alona cheni* was originally described by Sinev (1999); it is known elsewhere in India from Kerala while Sharma and Sharma (2013) extended its distribution to NEI. *Alona kotovi,* another member of this category, is recent addition (Sharma and Sharma, 2014d) to the cladoceran faunas of India from the wetlands of the Majuli River Island. This conger of the old world *Alona quadrangularis* is considered as a notable example of connection between South American and Australasian faunas of Chydoridae (Sinev, 2012). The Oriental *Celsinotum macronyx* reported from NEI from Meghalaya (Sharma, 2008) and Assam (Sharma and Sharma, 2012, 2015). The Palaearctic *Kurzia latissima* deserved attention: this species is reported from India from the Brahmaputra basin, Assam (Sharma and Sharma, 2012, 2014d).

Total **Cladocera** richness (S) reported from Nagaland (40 species) is higher than the reports of 11 species from two floodplain lakes (Khan, 1987) of Kashmir; 9 species from 65 wetlands of 24-Parganas district (Nandi *et al.*, 1993) of West Bengal; 4 species (Sinha *et al.*, 1994) and 12 species (Sanjer and Sharma, 1995) from the floodplains of Bihar; 36 species from 20 wetlands from the floodplains of south-eastern West Bengal (Khan, 2003) and 30 species from 30 wetlands of Keoladeo National Park (Venkataraman, 1992).

Cladocera exhibited richness variations in this study (33±8 species) in conformity with habitats variations of the three wetlands; Bolfangdisa and Madladijam indicated high diversity of 40 and 36 species, respectively while the semi-limnetic waters of Noune wetland recorded only 22 species. The results also indicated inter-annual richness variations in individual wetlands. The richness reports during the study and annually coupled with community similarities asserted habitat variations amongst three wetlands but with high homogeneity of Cladocera species composition. Cladocera are also more biodiverse than the reports of 13 species (Sharma and Bhattarai, 2005) from peat bog in Bumdeling wildlife sanctuary of Bhutan; 7 species (Sharma and Lyngskor, 2003) from a subtropical reservoir of Meghalaya; 6 species (Sharma and Wanswett, 2006) from fish pond of high rainfall region of Meghalaya.

Chydoridae, the most diverse family, formed a dominant component (59.1% of S) of the richness of Cladocera with Aloninae and Chydorinae represented by 7 and 19 species, respectively. In general, the chydorid importance concurred with the reports of Khan (2003), Sharma and Sharma, (2008, 2014d). This generalization highlighted the littoral-periphytic character of Cladocera which, in turn, is supported by certain semi-planktonic taxa *viz., Chydorus sphaericus, Disparalona caudata, Ephemeroporus barroisi, Graptoleberis testudinaria, Karualona karua* and *Notoalona globulosa*; and paucity of planktonic *elements*. The lack of any species of *Daphnia* as well as *Acroperus harpae* and *Dadaya macrops* in the sampled water bodies is notable and required analysis of factors limiting the distribution of these taxa. In general, Cladocera assemblages of Nagaland wetlands are characterized by their 'tropical character' following the generalizations of Sharma and Sharma (2008, 2014d, 2017b); Sharma and Sharma (2013).

Rhizopoda included 14 species belonging to seven genera and five families in the sampled Nagaland wetlands with Lobosea: Filosea ratio = 2.5. High richness in individual wetlands (12±1 species) affirmed high homogeneity of the testate amoebae composition amongst the wetlands. The richness is higher than the report of 8 species (Sharma and Bhattarai, 2005) from peat bog of Bhutan, 4 species (Sharma and Lyngskor, 2003) from a reservoir of Meghalaya and 3 species (Sharma and Wanswett, 2006) from fish pond of Meghalaya. Eleven species of Rhizopods are new records from Nagaland state. *Arcella hemispherica, Centropyxis aculeata, Centropyxis ecornis, Difflugia corona, Difflugia oblonga, Difflugia pyriformis, Difflugia urceolata, Euglypha*

acanthophora, Trinema lineare, Lesquereusia spiralis and *Nebela caudata* are new records of rhizopods from Nagaland.

Copepoda is represented by 8 species spread over four genera and two families; cyclopoid and calanoid Copepoda included four species each. *Mesocyclops isabellae* and *Mesocyclops parentium* are new records from northeast India (NEI) while *Heliodiaptomus cinctus, Heliodiaptomus contortus, Neodiaptomus schmackeri* and *Thermocyclops crassus* are new records from Nagaland. Of these, the palaeotropical *Mesocyclops isabellae* is known from India (Madhya Pradesh) and Sri Lanka (Holynska, 1997) and *Mesocyclops parentium* originally reported from Kerala and from swamps of Sri Lanka (Holynska, 1997; Ueda and Reid, 2003), is a rare cyclopoid species (Resmi and Jayachandran, 2014). *Heliodiaptomus contortus,* described by Gurney (1907) from the Indian Museum tank, Calcutta, is an Indian endemic and *Heliodiaptomus viduus* is reported to be most common in South India and decreased gradually in North (Hossain, 1985). *Heliodiaptomus cinctus*, described by Gurney (1907) from Chakradharpur (Bihar), is a eurytopic species which is fairly widely distributed in India except subtropical Kashmir. It is a Southeast Asian element with reports from India, Sri Lanka and Myanmar while *Neodiaptomus schmackeri* is an Oriental element. Copepoda richness in individual ponds varied 8±1 species; it is lower than the reports of 12 species (Kumar *et al.,* 2011) from a pond of Bihar but higher than 3 species (Sharma and Bhattarai, 2005) from peat bog of Bhutan; 5 species (Devi *et al*., 2013) from temple pond of Jammu and Kashmir; and 4 species (Sharma *et al*., 2015) from two ponds of Jammu region.

Ostracoda is represented by five species belonging to five genera and two families; all the recorded species *viz., Cypris subglobulosa, Hemicypris anomala, Stenocypris major* and *Pseudocypretta maculata* are new records from Nagaland except *Cypretta* sp. Of these, *Cypris subglobulosa* is a widely distributed in the Oriental region and *Hemicypris anomala* distributional range is recently extended to northeast India (Sharma and Sharma, 2013).

Table-1: The sampled wetlands of Nagaland

SAMPLED WETLANDS	LATITUDE	LONGITUDE	ALTITUDE	AREA (ha)
Noune wetland	25°50'54.6" N	093°50'05.6" E	172 m ASL	7.2
Madladijam wetland	25°46'36.39" N;	093°38'07.58" E	175 m ASL	4.7
Bolfangdisa wetland	25°46'23.86" N	093°38'03.49" E	178 m ASL	5.2

Table-2: Species richness of zooplankton of three wetlands of Nagaland (Study Period)

Group↓ Wetland→	Noune	Madladijam	Bolfangdisa
Rotifera	66	84	95
Cladocera	22	36	40
Rhizopoda	11	14	12
Copepoda	7	8	8
Ostracoda	3	5	5
Total species	**109**	**147**	**160**

Table-3: Species composition of zooplankton of three wetlands of Nagaland

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
Family BRACHIONIDAE			
1. *Anuraeopsis fissa* Gosse	+	-	+
2. *Brachionus angularis* Gosse	+	-	-
3. *Brachionus caudatus* Barrois & Daday	+	+	-
4. *Brachionus dichotomus reductus* Koste & Shiel	-	+	+
5. *Brachionus diversicornis* (Daday)	+	-	-
6. *Brachionus falcatus* Zacharias	+	+	+
7. *Brachionus forficula* Wierzejski	+	+	-
8. *Brachionus mirabilis* Daday	-	+	+
9. *Brachionus quadridentatus* Hermann	+	+	+
10. *Keratella cochlearis* (Gosse)	+	+	+
11. *Keratella lenzi* Hauer	+	-	+
12. *Keratella tropica* (Apstein)	+	-	+
13. *Plationus patulus* (O.F. Müller)	+	+	+
14. *Platyias quadricornis* (Ehrenberg)	+	+	+
Family EUCHLANIDAE			
15. *Beauchampiella eudactylota* (Gosse)	-	+	+
16. *Dipleuchlanis propatula* (Gosse)	+	+	+
17. *Euchlanis dilatata* Ehrenberg	+	+	+
18. *Euchlanis incisa* Carlin	+	-	+
19. *Tripleuchlanis plicata* (Levander)	-	-	+
Family MYTILINIDAE			
20. *Mytilina acanthophora* Hauer	+	-	+
21. *Mytilina bisulcata* (Lucks)	+	-	+
22. *Mytilina ventralis* (Ehrenberg)	+	+	+
Family TRICHOTRIIDAE			
23. *Macrochaetus sericus* (Thorpe)	-	+	+
24. *Trichotria tetractis* (Ehrenberg)	+	+	+
Family LEPADELLIDAE			
25. *Colurella obtusa* (Gosse)	+	+	+

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
26. Colurella sulcata (Stenroos)	+	+	-
27. Colurella uncinata (O.F. Müller)	+	+	+
28. Lepadella acuminata(Ehrenberg)	+	+	+
29. Lepadella apsida Harring	+	-	+
30. Lepadella benjamini Harring	-	+	+
31. Lepadella biloba Hauer	+	+	-
32. Lepadella costatoides Segers	-	+	+
33. Lepadella dactyliseta (Stenroos)	-	+	+
34. Lepadella discoidea Segers	+	+	+
35. Lepadella ovalis (O.F. Müller)	+	+	+
36. Lepadella patella (O.F. Müller)	+	+	+
37. Lepadella rhomboides (Gosse)	-	+	+
38. Lepadella triba Myers	+	-	+
39. Lepadella triptera Ehrenberg	-	+	-
40. Lepadella vandenbrandei Gillard	-	+	+
41. Lepadella (H.) apsicora Myers	+	-	+
42. Lepadella (H.) ehrenbergi Perty	+	+	+
43. Lepadella (H.) heterostyla (Murray)	-	-	+
44. Squatinella lamellaris (O.F. Müller)	-	+	-
Family LECANIDAE			
45. Lecane aculeata (Jakubski)	+	+	+
46. Lecane blachei Berzins	-	-	+
47. Lecane bulla (Gosse)	+	+	+
Lecane bulla diabolica (Hauer)	-	-	+
48. Lecane closterocerca (Schmarda)	+	+	+
49. Lecane crepida Harring	+	+	+
50. Lecane curvicornis (Murray)	-	+	+
51. Lecane doryssa Harring	-	+	+
52. Lecane elegans Harring	-	+	+
53. Lecane furcata (Murray)	+	+	+
54. Lecane haliclysta Harring & Myers	+	+	+
55. Lecane hamata (Stokes)	+	+	+

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
56. Lecane hastata (Murray)	-	+	-
57. Lecane hornemanni (Ehrenberg)	+	+	+
58. Lecane lateralis Sharma	+	+	+
59. Lecane latissima Yamamoto	-	+	+
60. Lecane leontina (Turner)	+	+	+
61. Lecane ludwigii (Eckstein)	-	+	+
62. Lecane luna (O.F. Müller)	+	+	+
63. Lecane lunaris (Ehrenberg)	+	+	+
64. Lecane monostyla (Daday)	-	-	+
65. Lecane nitida (Murray)	-	+	+
66. Lecane obtusa (Murray)	-	+	+
67. Lecane papuana (Murray)	+	+	+
68. Lecane ploenensis (Voigt)	-	+	-
69. Lecane pyriformis (Daday)	+	+	+
70. Lecane quadridentata (Ehrenberg)	+	+	+
71. Lecane rhenana Hauer	-	+	+
72. Lecane signifera (Jennings)	+	+	+
73. Lecane simonneae Segers	-	-	+
74. Lecane stenroosi (Meissner)	+	+	+
75. Lecane thienemanni (Hauer)	-	-	+
76. Lecane undulata Hauer	+	+	+
77. Lecane unguitata (Fadeev)	+	+	+
78. Lecane ungulata (Gosse)	+	+	+
Family NOTOMMATIDAE			
79. Cephalodella gibba (Ehrenberg)	+	+	+
80. Monommata longiseta (O.F. Müller)	-	+	+
81. Monommata maculata Harring & Myers	+	-	+
82. Notommata copeus Ehrenberg	-	+	+
Family SCARIDIIDAE			
83. Scaridium longicaudum (Müller)	-	+	+
Family GASTROPODIDAE			
84. Ascomorpha ovalis (Bergendal)	+	+	+

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
Family TRICHOCERCIDAE			
85. Trichocerca bicristata (Gosse)	-	-	+
86. Trichocerca bidens (Lucks)	-	+	+
87. Trichocerca flagellata Hauer	+	+	+
88. Trichocerca hollaerti De Smet	-	+	-
89. Trichocerca insignis (Herrick)	+	-	+
90. Trichocerca maior (Hauer)	-	-	+
91. Trichocerca pusilla (Jennings)	-	+	-
92. Trichocerca rattus (O.F. Müller)	-	+	+
93. Trichocerca similis (Wierzejski)	+	+	+
94. Trichocerca tigris (O.F. Müller)	-	-	+
Family ASPLANCHNIDAE			
95. Asplanchna priodonta Gosse	+	+	-
Family SYNCHAETIDAE			
96. Polyarthra vulgaris Carlin	+	+	+
97. Synchaeta sp.	-	-	+
Family DICRANOPHORIDAE			
98. Dicranophorus epicharis Harring & Myers	-	+	+
Family FILINIIDAE			
99. Filinia longiseta (Ehrenberg)	+	+	-
Family FLOSCULARIIDAE			
100. Sinantherina spinosa (Thorpe)	+	-	+
Family TESTUDINELLIDAE			
101. Pompholyx sulcata Hudson	+	-	-
102. Testudinella amphora Hauer	-	+	+
103. Testudinella brevicaudata Yamamoto	-	+	+
104. Testudinella dendradena de Beauchamp	-	-	+
105. Testudinella emarginula Stenroos	-	+	+
106. Testudinella greeni Koste	-	+	+
107. Testudinella patina (Hermann)	+	+	+
108. Testudinella tridentata Smirnov	+	+	-
Family PHILODINIDAE			

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
109. Dissotrocha aculeata (Ehrenberg)	+	+	+
110. Rotaria neptunia (Ehrenberg)	+	+	+
CLADOCERA			
Family SIDIDAE			
111. Diaphanosoma excisum Sars	-	-	+
112. Diaphanosoma sarsi Richard	+	+	+
113. Pseudosida szalayi (Daday)	-	+	+
114. Sida crystallina (O. F. Muller)	+	+	+
Family DAPHNIIDAE			
115. Ceriodaphnia cornuta Sars	-	+	+
116. Scapholeberis kingi Sars	+	+	+
117. Simocephalus acutirostratus (King)	-	+	+
118. Simocephalus mixtus Sars	+	+	+
119. Simocephalus serrulatus (Koch)	+	+	+
Family BOSMINIDAE			
120. Bosmina longirostris (O. F. Muller) s.lat.	+	+	+
Family MOINIDAE			
121. Moina micrura Kurz	-	+	-
122. Moinodaphnia macleayi (King)	-	+	+
Family MACROTHRICIDAE			
123. Grimaldina brazzai Richard*	+	+	+
124. Guernella raphaelis Richard*	+	-	+
125. Macrothrix odiosa Gurney*	-	-	+
126. Macrothrix spinosa King	-	-	+
127. Macrothrix triserialis (Brady)	+	+	+
Family ILYOCRYPTIDAE			
128. Ilyocryptus spinifer Herrick	-	+	+
Family CHYDORIDAE			
Subfamily ALONINAE			
129. Alona affinis (Leydig) s.lat	+	+	+
130. Alona cheni Sinev*	+	+	+
131. Alona kotovi Sinev*	+	+	+

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
132. Anthalona harti Van Damme et al.	-	+	+
133. Camptocercus uncinatus Smirnov*	+	+	+
134. Celsinotum macronyx (Daday)	-	-	+
135. Coronatella rectangula (Sars)	+	+	+
136. Euryalona orientalis (Daday)*	-	-	+
137. Karualona karua (King)*	-	+	+
138. Kurzia latissima (Kurz)	-	+	-
139. Kurzia longirostris (Daday)	-	+	+
140. Leberis diaphanus (King)*	-	+	+
141. Leydigia ciliata (Gauthier)*	-	+	-
142. Leydigiopsis pulchera	+	-	+
143. Notoalona globulosa (Daday)	+	+	+
144. Ovalona cambouei (Guerne & Richard)	-	+	+
145. Oxyurella singalensis (Daday)	+	+	+
Subfamily CHYDORINAE			
146. Alonella excisa (Fischer)	+	+	+
147. Chydorus angustirostris Frey	-	+	+
148. Chydorus eurynotus Sars*	-	+	+
149. Chydorus sphaericus (O. F. Muller)	+	+	+
150. Disperalona caudata Smirnov	+	+	+
151. Dunhevedia crassa King*	+	-	+
152. Ephemeroporus barroisi (Richard)	-	+	+
153. Graptoleberis testudinaria (Fischer)*	-	+	-
154. Pleuroxus quasidenticulatus (Smirnov)	+	+	+
RHIZOPODA			
Family ARCELLIDAE			
155. Arcella discoides Ehrenberg	+	+	+
156. Arcella hemispherica Perty*	+	+	+
157. Arcella vulgaris Ehrenberg	+	+	+
Family CENTROPYXIDAE			
158. Centropyxis aculeata (Ehrenberg)*	+	+	+
159. Centropyxis ecornis (Ehrenberg)*	+	+	+

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
Family DIFFLUGIDAE			
160. Difflugia acuminata Ehrenberg	+	+	+
161. Difflugia corona Wallich*	+	+	+
162. Difflugia oblonga Ehrenberg*	+	+	+
163. Difflugia pyriformis Perty*	-	+	-
164. Difflugia urceolata Carter*	-	+	+
Family NEBELIDAE			
165. Lesquereusia spiralis (Ehrenberg)*	+	+	+
166. Nebela caudata Leidy*	+	+	+
Family EUGLYPHIDAE			
167. Euglypha acanthophora Dujardin*	+	+	+
168. Trinema lineare Penard*	-	+	-
COPEPODA			
Family DIAPTOMIDAE			
169. Heliodiaptomus cinctus (Gurney)*	+	+	+
170. Heliodiaptomus contortus (Gurney)*	+	+	+
171. Heliodiaptomus viduus (Gurney)	-	+	+
172. Neodiaptomus schmackeri (Poppe & Richard)*	+	+	+
Family CYCLOPIDAE			
173. Mesocyclops hyalinus (Rehberg)**	+	+	+
174. Mesocyclops isabellae Dussart & Fernando**	+	+	+
175. Mesocyclops parentium Holynska*	+	+	+
176. Thermocyclops crassus (Fischer)	+	+	+
OSTRACODA			
Family CYPRIDIDAE			
Subfamily CYPRIDINAE			
177. Cypris subglobulosa Sowerby*	+	+	+
Subfamily CYPRINOTINAE			
178. Hemicypris anomala (Klie)*	+	+	+
Subfamily HERPETOCYPRIDINAE			
179. Stenocypris major (Baird)*	-	+	+
Family CYPRIDOPSIDAE			

Taxa↓ Wetland→	Noune	Madladijam	Bolfangdisa
Subfamily CYPRIDOPSINAE			
180. Pseudocypretta maculata Klie*	-	+	+
Subfamily CYPRETTINAE			
181. Cypretta sp.	+	+	+
Total Number of Species	**109**	**147**	**160**

** New records from northeast India; * New record from Nagaland

Table-4: Zooplankton similarities (study period)

Wetland	Noune	Madladijam	Bolfangdisa
Noune	-	**71.1**	73.6
Madladijam	-	-	**83.4**
Bolfangdisa	-	-	-

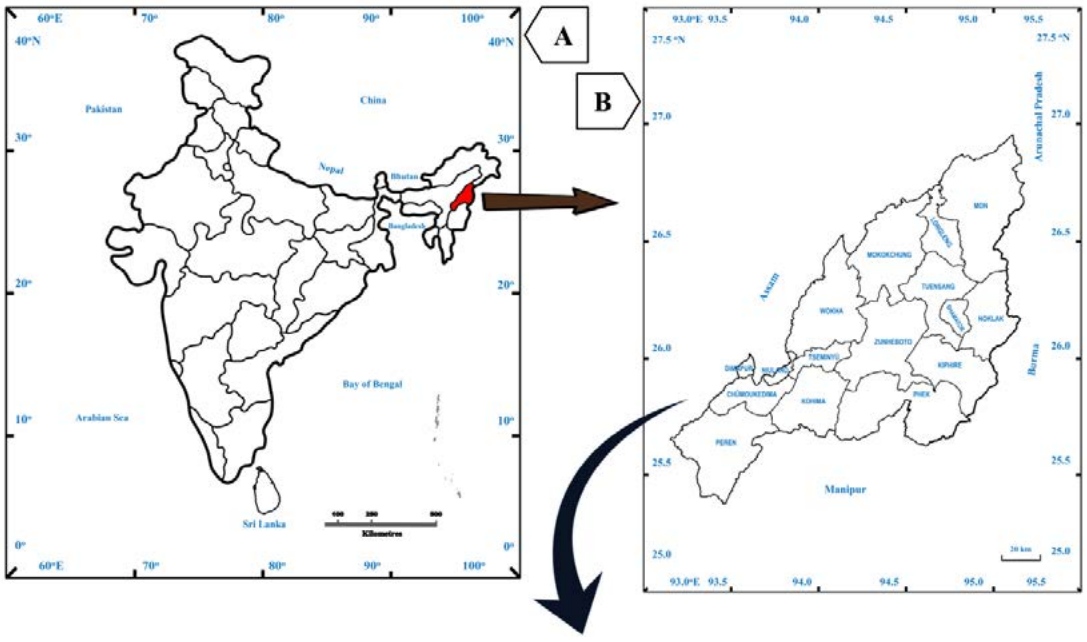

Figure-1: (A) Map of India indicating Nagaland state; (B) Map of Nagaland indicating different districts; (C) Noune wetland (Google image); (D) Madladijam wetland (Google image); (E) Bolfangdisa wetland (Google image)

Figure-2: View of Noune wetland from sampling site

Figure-3: View of Madladijam wetland from sampling site

Figure-4: View of Bolfangdisa wetland from sampling site

Conclusion

The species-rich and diverse assemblage, hypothesized to result from the micro-habitat diversity and environmental heterogeneity of wetlands. The rich and diverse zooplankton of the 'slightly acidic-circum neutral-slightly alkaline' and 'soft-moderately hard' waters characterized by 'low ionic concentrations' Nagaland wetlands reveal sizeable fractions of species of global and regional biogeography interest (Sharma and Sharma, 2021). Total richness variations and heterogeneity of species composition are attributed to habitat heterogeneity amongst the wetlands. This study provides the first baseline data on the faunal diversity of zooplankton in the small wetlands of Nagaland, North-East India. The findings reveal that these wetlands have a relatively high diversity of zooplankton, with rotifers being the dominant group. More research is needed to understand the factors affecting zooplankton diversity and abundance in these wetlands, as well as their role in the food web and ecosystem functioning. The findings of this study have important implications for the conservation and management of these wetlands, which are facing increasing threats from anthropogenic activities.

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