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COMMUNICATION

Diversity of freshwater molluscs from the upper Brahmaputra Basin, Assam, India

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Abstract: A field survey was conducted for three consecutive years, 2015–17 to assess the diversity of freshwater molluscs (Gastropoda and Bivalvia) of the upper Brahmaputra Basin in Assam, India. Altogether, 18 gastropods and 27 bivalve species representing nine families were recorded from 17 sampling stations comprising small to large tributaries and wetlands in the flood-plains covering a total geographical area of approximately 3,500km^2. A large fraction (15.55%) of the collected mollusc species are new records from the upper Brahmaputra Basin of Assam. Rarity in the occurrence of freshwater mollusc was confirmed with singleton and doubleton species accounting for 6.66% and unique species accounting for 35.55% of the total species recorded. It was observed that most of the mollusc species of the upper Brahmaputra Basin are either in the 'Least Concern' or 'Data Deficient' category of the IUCN Red List; except for *Lymnaea ovalior* (Annandale & Prashad, 1921) and *Sphaerium austeni* Prashad, 1921 assessed as 'Vulnerable' and 'Near Threatened', respectively. A significant trend in the diversity in terms of species richness and composition was observed across the sampling stations of the northern basin and southern basin of the river Brahmaputra.

Keywords: Burhi-Dihing, Data Deficient, habitat heterogeneity, species richness, unique.

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INTRODUCTION

Freshwater molluscs are one of the most widely distributed groups of aquatic macroinvertebrates, considered an emerging wealth of the freshwater bodies (Elder & Collins 1991; Maltchik et al. 2010), and play a pivotal role in the health of the aquatic ecosystems (Fenchel & Kofoed 1976; Bertness 1984; Peterson & Black 1987; Kay 1995; Stewart et al. 1998; Strayer et al. 1999; Gutierrez et al. 2003; Vaughan et al. 2004; Lydeard et al. 2004; Budha et al. 2010). Freshwater molluscs (Gastropoda and Bivalvia) are distributed in the freshwater bodies throughout the globe except Antarctica (Schiaparelli et al. 2014). Apart from their role in the ecosystem, people across the globe exploit several species of freshwater molluscs as food, medicine, ornament, and in the craft industry (Wood & Wells 1995; Sonowal & Kardong 2020). Freshwater molluscs are also used as bio-monitoring agents in the aquatic ecosystem and in integrated fish farming (Sicuro 2015). Most of the information on the status and distribution of Indo-tropical freshwater molluscs is based on the studies in the eastern Himalaya (Budha et al. 2010); the Western Ghats (Aravind et al. 2011), and the Indo-Burma region (Köhler et al. 2012) especially in the Mekong River basin covering the nations comprising Vietnam, Laos, Cambodia, Thailand, Burma, and China. In India, pioneering work on the diversity, distribution and taxonomy of freshwater molluscs were carried out by Benson (1836, 1850, 1865), Blanford (1863, 1870, 1880), Blanford & Godwin-Austen (1908), Preston (1915), Annandale (1918), Prashad (1920, 1928), and later reviewed by Rao (1989) and Ramakrishna & Dey (2007). Research on molluscs in India is basically limited to the Western Ghats in southern India and some parts of the eastern Himalayan region. Reports on richness and diversity of freshwater molluscs from various parts of mainland India and Indo-Burma region are available (Rao 1989; Ramakrishna & Dey 2007; Budha et al. 2010; Köhler et al. 2012). A good number of research studies are going on in the southwestern parts of the Indian peninsula (Aravind et al. 2010; Ramesha et al. 2013). Ironically, no significant studies on the status and distribution of freshwater molluscs have been carried out in the Brahmaputra River basin of Assam. As a result, studies on the distribution, taxonomy and biology of mollusc population of the region remains obscure and also that of several reported species seem to be doubtful (Budha et al. 2010). Therefore, the present study is aimed to assess the diversity of the freshwater mollusc community across the upper Brahmaputra Basin (UBB), their distribution pattern and also for identification of important sites for future conservation planning of freshwater molluscs in the region.

MATERIALS AND METHODS

Study area

The Upper Brahmaputra basin (UBB) is a part of the Himalayan biodiversity hotspot and lies between the hill ranges of the eastern and northeastern Himalayan ranges. The river Brahmaputra enters Assam through the easternmost corner of Arunachal Pradesh and divides the eastern valley of Assam into two banks across the river—the northern bank and southern bank—with prominent physiographic differences. The present study area covers a total geographical area of approximately 3,500km^2 between 27.273–27.809 ^{0}N and 94.591–95.378 ^{0}E (Image 1). The area was selected because of the large-scale habitat loss during the last few decades due to recurring floods which is reported to have begun after the devastating earthquake of the 1950s and anthropogenic activities like the discharge of chemicals from oil fields and tea gardens (CPCB 2005; Baruah 2007) and urbanization.

Sampling

The survey was conducted in 17 sampling stations (Table 1) using the random sampling method for a period of three consecutive years (2015–2017) from December to February. Among the selected survey sites there were nine small and large tributaries of the Brahmaputra (site B, C, D, E, F, G, H, I, J, K, L, N, P) and four wetlands (site A, M, O, Q). Geocordinates of the sampling sites were recorded using GARMIN GPS (Model No. GPSMAP 60CSx). Ten random sampling points were selected in each sampling station and samples were collected using quadrat of 1m^2 size. The large specimens were handpicked and the smaller ones were collected from the bottom substrata by using a metal sieve of mesh size 2mm^2. Specimens were then washed, sorted into morpho-species, and representatives were brought to the laboratory for reference. Identification of the specimens was done according to Rao (1989), Ramakrishnan & Dey (2007), and by comparing with authentic voucher specimens deposited at the Zoological Survey of India (ZSI), Kolkata.

Data analysis

Abundance (N), species richness (S), the Shannon-Wiener diversity index (H) (in $\log_{10}$), Simpson index (1-D), evenness index ($E^{H/S}$), and equitability index (E_H=H/H_{max}; H_{max} = lnS) of all the sites were calculated using PAST (Paleontological Statistics, Version 3.08) programme

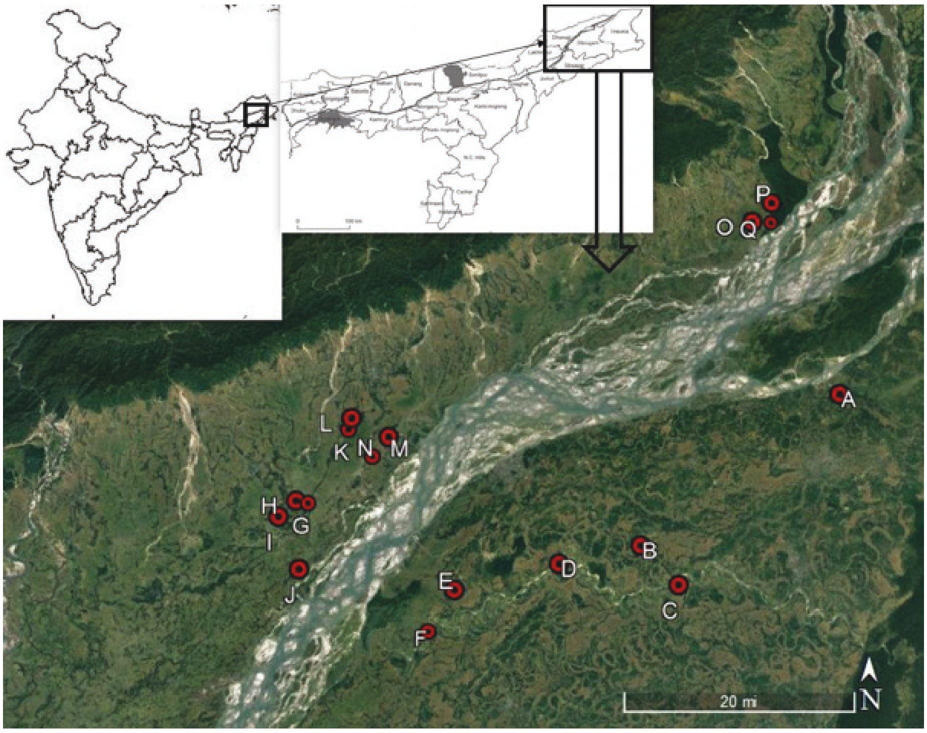

Image 1. Satellite image of the upper Brahmaputra Basin of Assam, India. Red coloured markings are different sampling stations of the study area.

Table 1. Name, assigned code and the co-ordinate of the sampling stations.

Name	Code	Latitude (^{0}N)	Longitude (^{0}E)
Maguri beel (Wetland)	A	27.571	95.378
Diharang river (Tributary)	B	27.381	95.101
Kulagora, Burhi-Dihing River (Tributary)	C	27.333	95.153
Hareghat, Burhi-Dihing river (Tributary)	D	27.356	94.983
Sesa river (Tributary)	E	27.325	94.839
Janzi, Burhi-Dihing River (Tributary)	F	27.273	94.802
Aamguri River (Tributary)	G	27.432	94.632
Laipulia river (Tributary) (Dusutimukh)	H	27.435	94.616
Kopahtoli (Tributary) (Bhomura guri)	I	27.415	94.591
Sisi River (Tributary)	J	27.350	94.621
Gelua river (Tributary)	K	27.524	94.688
Mesu River (Tributary)	L	27.538	94.693
Tongani Beel (Wetland) (Tongani majgaon)	M	27.515	94.745
Tongani River (Tributary)	N	27.490	94.722
Nahor Village (Wetland) (Bahir Jonai)	O	27.785	95.255
Sile river (bahir chilai) (Tributary)	P	27.809	95.282
Aagrung beel (Wetland)	Q	27.784	95.280

to evaluate the state of diversity in the studied area. Sample-based rarefaction (interpolation-extrapolation) curves for all the stations sampled were compared based on incidence data using the method proposed by Colwell et al. (2012). The non-overlap of 95% confidence intervals was used as the indication of statistical difference (Colwell et al. 2012; Gotelli & Ellison 2013). Rarefaction and extrapolation analyses were conducted using the PAST and EstimateS programme.

RESULTS

Species Abundance and Composition

From the survey conducted in the 17 sampling stations during the three years, 7,881 (all live) specimens belonging to 45 species of nine freshwater mollusc families from two classes, Gastropoda and Bivalvia, were recorded (Table 2). These comprised Viviparidae (N= 526, six species), Ampullaridae (N= 16, one species), Thiaridae (N= 1,928, five species), Pachychilidae (N= 539, one species), Lymnaeidae (N= 154, two species), and Planorbidae (N= 136, three species) from the class Gastropoda. The class Bivalvia was represented by three families, viz., Unionidae (N= 3,516, 22 species), Cyrenidae (N= 938, two species), and Sphaeriidae (N= 128, three species). *Indonaia* under the family Unionidae was recorded as the dominant genus comprising nine (20% of the total species richness) species. Among the total population recorded, *Parreysia favidens* (Benson, 1862) and *Melanoides tuberculata* (Müller, 1774) emerged as the most abundant species. Three (6.66% of the total) species were recorded as rare species, i.e., singleton species (with only one individual throughout the survey), viz., *Lymnaea ovalior* (Annandale & Prashad, 1921) (station G) & *Trapezidens exolescens* (Gould, 1843) (Station B) and doubleton species (with only two individuals throughout the survey), *Filopaludina micron* (Annandale, 1921) (Station A) from the study area. Further, 16 (35.55% of the total) species were observed to be unique, i.e., they were confined to a particular/ single sampling station and seven (15.55%) species were recorded as new reports from UBB (Table 3).

Species richness and diversity assessment

The species richness and diversity indices are listed in Table 4. As for the species richness and abundance, sampling station A with 27 (60% of the total recorded) species emerged as the richest sampling station in the study area, whereas sampling station Q corresponds to only 17.77% of the total richness (Table 4). The Simpson index (1-D) and Shannon diversity index (H*)* showed a general constancy across the sampling stations (Table 4), with values 0.86±0.03 and 2.28±0.24, respectively. Evenness ($E^{H/S}$) index showed variations across the sampling stations, with values ranging between 0.47 and 0.86 (Table 4). It was observed that the southern basin (stations A–F) of UBB showed an uneven species distribution pattern ($E^{H/S}$= 0.47–0.71) than the rest of the sampling stations of the northern basin.

Species richness was evaluated through sample-based and individual-based rarefaction curves which are presented in Figures 2, 3, 4(a), and 4(b). Differences in species richness and composition were observed in both the northern and southern basins of UBB (Figure 2). On the northern basin of the river, the cluster formation of curves between sampling stations was noted due to a large overlapping (at 95% unconditional confidence intervals) at sampling stations G, H, I, J, K, L, M, and N (Figure 3(a)). In contrast to this observation, the sampling stations of the southern basin showed remarkably different values and patterns in which the sampling stations C, D, and F showed clusters of non-overlapping curves at 95% unconditional confidence intervals (Figure 3(b)).

Differences in species composition were also observed among the mollusc populations in tributaries and wetlands. Species like *Filopaludina bengalensis* (Lamarck, 1822), *M. tuberculata*, *Tarebia granifera* (Lamarck, 1822), *T. lineata* (Gray, 1828), *Brotia costula* (Rafinesque, 1833), *Lamellidens corrianus* (Lea, 1834); *L. marginalis* (Lamarck, 1819), *P. corbis* (Benson, 1856), *P. corrugata* (Müller, 1774), and *P. favidens* are common to both tributaries and wetlands; while species like *Thiara aspera* (Lesson, 1831), *L. ovalior*, *Scabies crispata* (Gould, 1843), *Balwantia soleniformis* (Benson, 1836), *Indonaia olivaria* (Lea, 1831), *I. nuttaliana* (Lea, 1856), *I. shurtleffiana* (Lea, 1856), *I. theobaldi* (Preston, 1912), *and T. exolescens* are confined to the tributaries only. Unique species like *Mekongia crassa* (Benson, 1836), *Idiopoma dissimilis* (Müller, 1774), *F. micron*, *Angulyagra microchaetophora* (Annandale, 1921), *Pila olea* (Reeve, 1856), *Gyraulus convexiusculus* (Hutton, 1849), *Sphaerium austeni* Prashad, 1921, and *Musculium indicum* (Deshayes, 1854) were recorded only from the wetlands.

DISCUSSION

Approximately, 186 species of freshwater molluscs have been estimated to inhabit freshwater rivers, streams, and lakes in the eastern Himalayan region (Budha et al. 2010) which is approximately 3% of the total global estimate (Vinarski et al. 2020). During the present survey, we recorded 45 species of freshwater molluscs from the UBB. This figure accounts for 24.19% of total freshwater mollusc species from the eastern Himalaya (Table 2). As regards the species richness, there is the possibility of encountering even more native species from the region as is indicated by the sample-based rarefaction curve (Figure 1).

Biogeographically, most families of freshwater molluscs from the eastern Himalayan and Indo-Burma hotspot region are cosmopolitan in nature (Budha et al. 2010; Köhler et al. 2012). The Unionidae and Cyrenidae,

Table 2. List of freshwater molluscs recorded across the sampling stations of upper Brahmaputra Basin of Assam.

Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Angulyagra microchaetophora	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Angulyagra oxytropis	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Balwantia soleniformis	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Brotia costula	-	-	-	+	+	+	+	+	-	+	+	+	+	-	+	+	+
Corbicula assamensis	+	+	+	+	-	+	+	+	-	+	-	-	-	-	-	+	-
Corbicula striatella	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	+	-
Filopaludina bengalensis	+	+	+	-	+	-	+	+	+	+	+	+	+	-	+	+	+
Filopaludina micron	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gyraulus convexiusculus	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helicorbis cantori	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idiopoma dissimilis	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia andersoniana	-	+	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-
Indonaia caerulea	-	+	-	-	+	-	-	+	-	-	+	+	+	+	+	+	+
Indonaia lima	+	+	-	-	+	-	-	-	-	-	+	-	+	-	+	+	-
Indonaia nuttalliana	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Indonaia occata	-	+	-	-	-	-	-	-	-	-	+	-	+	-	+	+	+
Indonaia olivaria	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Indonaia pachysoma	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia shurtleffiana	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia theobaldi	-	+	-	-	+	-	+	-	-	-	+	+	-	-	-	-	-
Indoplanorbis exustus	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-
Lamellidens phenchooganjensis	+	+	-	-	+	-	-	-	-	-	+	+	+	-	-	-	+
Lamellidens corrianus	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
Lamellidens jenkinsianus	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-
Lamellidens marginalis	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
Lymnaea ovalior	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Mekongia crassa	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Melanoides tuberculata	+	-	-	-	-	+	+	+	+	+	+	+	+	+	-	-	-
Mieniplotia scabra	+	-	-	-	-	+	+	-	+	+	+	+	-	+	-	+	-
Musculium indicum	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parreysia corbis	+	+	+	+	+	-	+	+	+	+	-	-	-	-	+	-	-
Parreysia corrugata	-	-	-	-	+	-	+	+	+	+	+	+	-	+	+	+	+
Parreysia favidens	-	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	-
Parreysia gowhattensis	-	-	+	+	+	-	+	-	-	-	+	-	-	+		+	-
Parreysia sikkimensis	-	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-
Parreysia smaragdites	+	+	+	+	-	-	+	-	-	-	+	-	-	+	-	-	-
Pila olea	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radix rufescens	+	+	+	-	-	-	+	-	+	+	-	+	+	-	-	-	+
Scabies crispata	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerium austeni	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarebia granifera	+	+	+	-	-	+	+	-	+	-	-	+	-	+	-	+	-
Tarebia lineata	+	+	+	-	-	+	+	+	+	+	-	+	-	-		+	-
Thiara aspera	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Trapezidens exolescens	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	27	19	15	10	17	11	20	11	10	11	17	15	14	10	11	16	8

+—species present | -—species absent

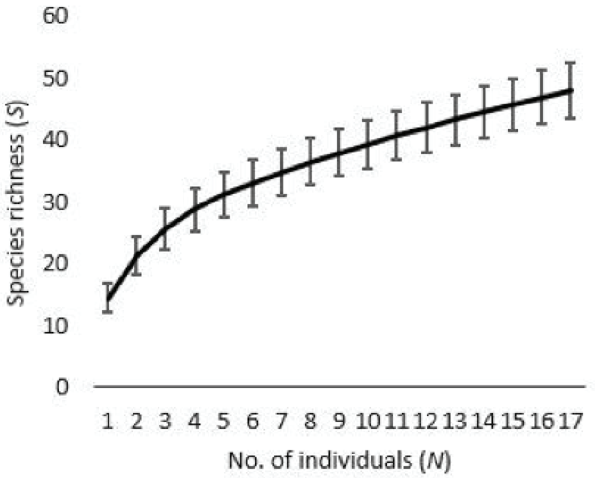

Figure 1. Sample-based rarefaction (interpolation-extrapolation) curves for incidence data from reference samples corresponding to Upper Brahmaputra basin. Error bars represent upper and lower limits of each sampling station at 95% unconditional confidence intervals.

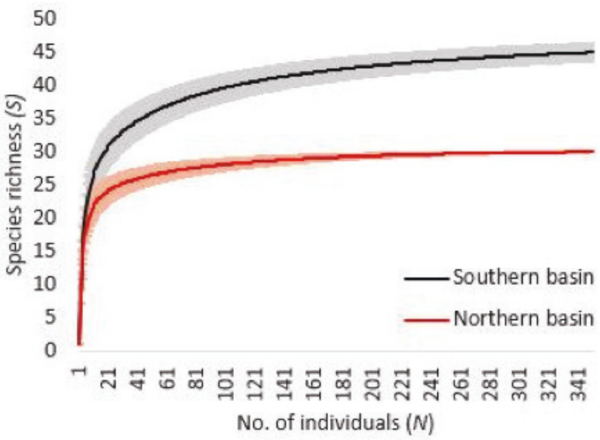

Figure 2. Individual-based rarefaction curves of northern and southern basins of river Brahmaputra. Shaded areas represent 95% unconditional confidence intervals.

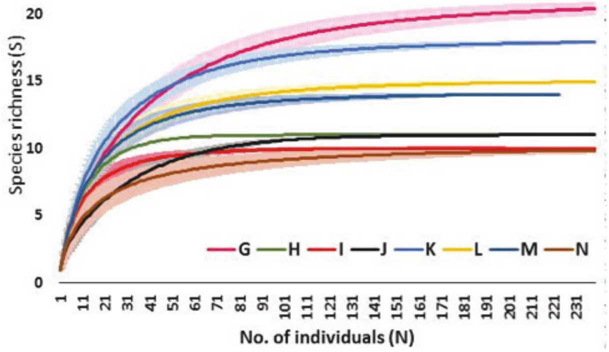

Figure 3(a). Individual-based rarefaction (interpolation-extrapolation) curves for incidence data from reference samples corresponding to sampling stations ('G', 'H', 'I', 'J', 'K', 'L', 'M' and 'N') of northern basin of river Brahmaputra. Shaded areas represent 95% unconditional confidence intervals.

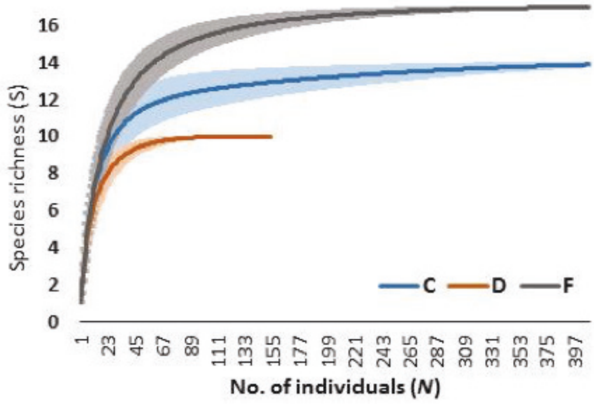

Figure 3(b). Individual-based rarefaction (interpolation-extrapolation) curves for three sampling stations of Burhi-Dihing River on the southern basin of river Brahmaputra showing non-overlapping cluster of curves at 95% unconditional confidence intervals.

for instance, are globally distributed. The scenario at the species level, however, is quite different as observed in the present investigation. We recorded 16 (35.55% of the total recorded species) unique species (Table 3) which were found confined to particular sampling station indicating the role of certain abiotic and biotic factors that might influence the habitat specificity for their survival. There are some ubiquitous species like *L. corrianus*, *L. marginalis*, *Corbicula assamensis*, *C. striatella*, *B. costula*, *F. bengalensis*, *T. lineata*, and some species of the genera *Parreysia* and *Indonaia* found in almost all sampling stations. In contrast, the presence of more than one-third unique species reflects many aspects like changes in habitat conditions across the sampling stations or narrow range of habitat adaptability of species which might have been eliminated from other sampling stations due to the factors related to habitat parameters. A more detailed study, however, will be needed to explain the issue. The species *B. soleniformis* is exclusively recorded from a short stretch of about 300m along the river Burhi-Dihing (Sampling station F). Likewise, *T. exolescens* and *S. crispata* were found only from the sampling station B and E, respectively (Image 2). Similarly, most of the unique gastropod species were exclusively found from the sampling station A (Table 2), which may be indicative of habitat heterogeneity in the region (Figure 3(b)). Further study, however, is needed to explain the causes of an allopatric pattern of distribution of these species. Reports suggest that the abundance of the malacofauna is linked to the cumulative effect of abiotic and biotic components such as alkaline nature of water, chlorine content (Ndifon

Table 3. Status of recorded freshwater molllusc of upper Brahmaputra Basin of Assam.

Unique species	Rare species	New reports
Idiopoma dissimilis	*Filopaludina micron*	*Filopaludina micron*
Filopaludina micron	*Lymnaea ovalior*	*Angulyagra oxytropis*
Angulyagra microchaetophora	*Trapezidens exolescens*	*Lymnaea ovalior*
Pila olea		*Lamellidens phenchooganjensis*
Thiara aspera		*Indonaia shurtleffiana*
Lymnaea ovalior		*Pisidium* sp.
Gyraulus convexiusculus		*Sphaerium austeni*
Helicorbis cantori		
Scabies crispata		
Balwantia soleniformis		
Indonaia pachysoma		
Indonaia shurtleffiana		
Trapezidens exolescens		
Pisidium sp.		
Sphaerium austeni		
Musculium indicum		

Table 4. Richness, abundance, and diversity indices of different sampling stations along the upper Brahmaputra Basin of Assam.

Sampling stations	Richness S	N	Simpson 1- D	Shannon H	Evenness $E^{H/S}$	Equitability E_H
A	27	1131	0.89	2.55	0.47	0.77
B	19	776	0.88	2.36	0.56	0.80
C	15	617	0.89	2.34	0.69	0.86
D	10	153	0.85	2.06	0.71	0.89
E	17	367	0.86	2.28	0.58	0.81
F	11	851	0.75	1.85	0.58	0.77
G	20	799	0.92	2.76	0.75	0.90
H	11	208	0.87	2.25	0.86	0.94
I	10	239	0.86	2.10	0.81	0.91
J	11	304	0.85	2.18	0.80	0.91
K	17	437	0.90	2.52	0.73	0.89
L	15	485	0.87	2.35	0.70	0.87
M	14	223	0.87	2.34	0.74	0.88
N	10	527	0.87	2.13	0.84	0.92
O	11	203	0.86	2.17	0.80	0.90
P	16	266	0.92	2.64	0.88	0.95
Q	8	295	0.83	1.92	0.85	0.92

& Ukoli 1989; Giovanelli et al. 2005), calcium content (Hussein et al. 2011), the presence of macrophytic vegetation, water flow (Appleton 1978), water depth and sediment (Lacoursière et al. 1975; Vincent et al. 1982), recurring flood (Thomaz et al. 2007), and so on.

Large differences in species richness and abundance were observed in different sampling stations on the southern basin and northern basin of river Brahmaputra (Figure 2). For instance, sampling stations C, D, and F showed markedly different values, with non-overlapping cluster of curves at 95% unconditional confidence intervals (Figure 3(b)), though species collected were

Image 2. Some recorded freshwater molluscs of upper Brahmaputra Basin: 1—*P. favidens mercens* (Benson, 1862) | 2—*P. f. assamensis* Preston, 1912 | 3—*P. corbis* Hanley, 1856 | 4—*B. soleniformis* (Benson, 1836) | 5—*P. gowhattensis* (Theobald, 1874) | 6—*I. nuttalliana* (Lea, 1856) | 7—*S. crispata* Gould, 1843 | 8—*L. jenkinsianus* (Benson, 1862) | 9—*T. exolescens* Gould, 1843 | 10—*C. assamensis* Prashad, 1928 | 11—*P. sikkimensis* (Lea, 1859) | 12—*I. caerulea* (Lea, 1831) | 13—*Pisidium* sp. | 14—*G. convexiusculus* (Hutton, 1849) | 15—*A. oxytropis* (Benson, 1836) | 16—*L. ovalior* (Annandale & Prashad, 1921) | 17—*R. rufescens* (J.E. Gray in Sowerby, 1822) | ©—Jyotish Sonowal.

from the same river (Burhi-Dihing, a tributary of river Brahmaputra), but from different localities. For instance, the species abundance and composition of sampling stations O, P, and Q is markedly different from that of sampling station A (Table 2) though these sites are geographically close to each other (Image 1). The most plausible explanation for this unparalleled distribution pattern may be due to differential local driving forces in river floodplain systems (RFS). According to available literature, the floodplain aquatic habitats are isolated from each other and subject to local driving forces during low water periods (Camargo & Esteves 1995; Tockner et al. 1999; Lewis et al. 2000; Thomaz et al. 2007). The influence of local driving forces induces heterogeneity leading to localized physical and chemical characteristics (that are basin-specific) like induced sediment resuspension, which affects water bodies in their morphometry and ecology. These local forces act with different intensities in the floodplain landscape, thus creating habitats with different characteristics (Thomaz et al. 2007). Thus, our present observation has corroborated the findings of previous workers.

The homogeneous distribution of species observed in various sampling stations (G, H, I, J, K, L, M, and N) along the northern basin of the river Brahmaputra (Figure 3(a)) may largely be attributed to the 'homogenization effect of flood'. It may be noted that the northern bank of the river Brahmaputra is largely affected by recurring floods every year and this has influenced not only the distribution but also the overall diversity of aquatic fauna (Furch & Junk 1985; Hamilton & Lewis Jr. 1990; Bozelli 1992; Thomaz et al. 2007). According to some other reports, however, the limnological characteristics, the composition of phytoplankton, zooplankton, fish, and macrophytes of rivers & wetlands are similar in the RFS (Thomaz et al. 2007).

The study on freshwater molluscs of the eastern Himalayan region recorded 32.3% species which falls under Data Deficient (DD) category of the IUCN Red List (Budha et al. 2010). On the other hand, the study conducted in the Indo-Burma region assessed 49.76% and 32.55% of the total recorded species under the category of Least Concern (LC) and DD, respectively (Köhler et al. 2012). Ironically, most of these DD species are known only from descriptions of the 19th or 20th century. It is noteworthy that the majority of the mollusc species recorded during the present study belonged to the LC category (39 species) and four species belonged to the DD category of the IUCN Red List, except *L. ovalior* and *Sphaerium austeni* which are assessed as Vulnerable (VU) and Near Threatened (NT) category of Red List (IUCN 2010). The presence of DD species is mainly due to lack of information on the distribution, population trends and threats (IUCN 2010) from this region.

During the present investigation, we recorded seven freshwater mollusc species which were not reported in earlier literature from this region indicating the scope for a thorough field survey in the region covering a much larger area (Table 3). For example, *L. phenchooganjensis* Preston, 1912 which was previously reported only from Phenchooganj (Bangladesh) and from Mizoram (Ramakrishna & Dey 2007) have no earlier reports from this area. There is certain information for freshwater mollusc species of eastern Himalaya, Indo-Burma as well as for the Western Ghats, however, such information is not enough to describe all the aspects of species in the present scenario. So, it may be suggested to give enough emphasis on the review of many taxonomic issues persisting in the available literature and resolve them in the light of regional context through further work (Budha et al. 2010). The inconsistencies in available data clearly indicate that determination of taxonomic status is still a major problem in establishing a local checklist and implementation of species conservation plans in the region.

CONCLUSION

The present work is based on firsthand information on the diversity, distribution, and status of freshwater mollusc population of this region. The UBB is found to be rich in freshwater mollusc diversity with 45 species from Gastropoda and Bivalvia. Records of a few unique species and new reports highlight the scope and possibility of encountering newer species from the region. More crucial aspects like the effect of environmental and ecological conditions, habitat heterogeneity, and its impact trends, however, need to be addressed with further studies. The presence of unique and rare species indicates the significance of the region as a suitable habitat for the malacofaunal population.

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