Research Article

Current Status and Seasonal Distribution of Malacofaunal Assemblage in Poba Reserve Forest in Relation to Certain Physico-chemical Parameters

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ABSTRACT

A field survey was conducted for two consecutive years in the aquatic bodies of Poba reserve forest (PRF) to assess the diversity, distribution and status of freshwater mollusc's species in relation to physico-chemical parameters of habitat water. Sample collection was carried out in 12 randomly selected sampling stations of the reserve forest using quadrate method (1m2 size) for four consecutive seasons viz. pre-monsoon, monsoon, post-monsoon and winter. Physico-chemical analysis of the habitat waters were carried out with standard methods. Altogether 16 species under class Gastropoda and Bivalvia contributing 45.95% and 54.04% to the total population of recorded molluscs were found during the study period. Highest number of species was encountered in the winter season and an overall decline in species count was registered in the monsoon season. Brotia costula was the most abundant species followed by *Tarebia lineata*. As per the IUCN 3.1 population trends for most of the recorded species were Unknown (UN) except for *Bellamya bengalensis, Parreysia corrugata, Parreysia favidens*, and *Corbicula striatella*. Which were found to be stable (ST). Except *Parreysia pachysoma* and *Corbicula striatella* rest of the mollusc's species were found to be frequent in the studied area. *Pila globosa* was the only rare species in the local context. Analysis of physico-chemistry of habitat water revealed a profound effect on the distribution and abundance of the mollusc's population of the studied area. Various anthropogenic activities have been affecting the reserve forest during the last few years. Recognition of the region as a potential site for freshwater mollusc species and conservation strategies are urgently required.

Key words: Diversity, Molluscs, Overexploitation, Physico-chemical parameters, Poba reserve forest, Threatened species.

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INTRODUCTION

Molluscs are one of the important benthic suspension feeder ecological communities widely distributed in different types of habitats around the world except for Antarctica.[1] It constitutes the second-largest invertebrate assemblage and the most successful group next to class Insecta.[2] Among the phylum Mollusca, Gastropoda is the largest and most successful class with 75,000 living species and found in a wide range of habitats.[3] They are the efficient assemblages in extracting and processing organic matter and it's recycling in aquatic ecosystems. At the same time, many species of the malacofaunal community are highly sensitive to certain pollutants and anthropogenic impacts such as nutrient enrichment, availability of oxygen and changes in habitat structure.[4] Due to the inheritance of this character they are becoming well-suited sentinel organisms for studying the health of an aquatic ecosystem.[5] Many molluscs species are consumed as food by coastal communities in the southern part of India.[6] In the north-eastern region of India generally, gastropods are preferred.[6,7] Besides,

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molluscs are also proved to be beneficial as medicinally and as household decorative items and jewellery in the recent past.[8]

The Brahmaputra basin of the north-east India is one of the Eastern Himalayan Biodiversity hot spot regions. Adequate comprehensive studies on the status, taxonomy and distribution of malacofaunal assemblage in this region are scanty.[9] Few studies were carried out on the diversity of freshwater molluscs in the region[9,10] but there are no any works on the diversity of the malacofaunal community with relation to the physico-chemical structure of the region. The ecology of molluscs are considered to be affected by various biotic and abiotic factors like physico-chemical parameters.[11] competition, availability of food, predator-prey interactions,[12] the architecture of the bottom substrate[13] and prevalence of macrophytes in their habitats.[14]

Poba reserve forest (PRF) (Figure 1) is the only natural reserve forest situated towards the eastern part of Assam, India, is a treasure trove of the region with the numerous streams flowing from the foothills of Arunachal Pradesh (Figure 1). Presence of rich aquatic faunal assemblage manifests the heterogeneity in the wetlands of the reserve forest. Despite their apparent vulnerability, there is no published information on the general ecology, status, taxonomy, diversity and distribution of freshwater molluscs in the freshwater systems of the reserve forest. Due to the practical importance of imperilled status worldwide and realizing the paucity of scientific information on freshwater molluscs diversity of the region and PRF in particular, we undertook the present study in the aquatic bodies of the reserve forest to explore the diversity and present status of freshwater molluscs assemblages across the reserve forest. To identify prevailing environmental and spatial correlations of its assemblage in the area, we have studied seasonal variations in richness and abundance, along with the cumulative influence of physico-chemical parameters on recorded molluscs species.

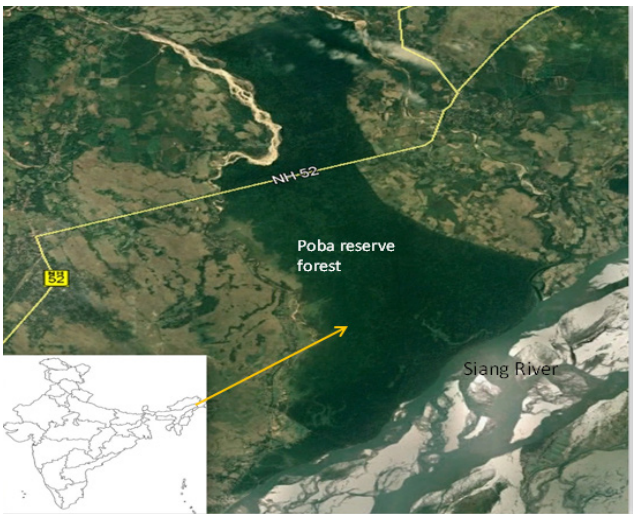

Figure 1: Map of study area (Poba reserve forest).

MATERIALS AND METHODS

The study area comprises of the aquatic bodies of PRF (latitude 27°50'11"N and Longitude 95°17'45"E) Assam, India; covering an area of about 10,221 hectares of land which includes a large portion of Ruksin forest range of East Siang forest division, Arunachal Pradesh. Sample collection was carried out in 12 randomly selected sampling stations of the reserve forest from Mars 2018 to February 2020, using quadrate method (1m^2 size) for four consecutive seasons viz. pre-monsoon, monsoon, post-monsoon and winter. Larger mollusc specimens were handpicked and the smaller ones were collected from the bottom substrate by using a metal sieve of mesh size 1 mm^2. Specimens from each quadrate were washed, counted and collected in separate poly packs. The representatives were brought to the laboratory and preserved in 80% ethanol for future references. The identification of the samples were done according to standard identifying keys,[15,16] Zoological survey of India (ZSI) Kolkata along with the available updated literature from IUCN.

For the study of Physico-chemical parameters, water samples were collected and analysed monthly from each sampling points. Water temperature was determined by Mercury thermometer, Transparency by Secchi Disc, For pH digital pH meter (Henna model) and other abiotic factors namely, free carbon dioxide (FCO_2), dissolved oxygen (DO), calcium, magnesium, chloride, total dissolved solids (TDS), phosphate and nitrate were analysed following standard methods.[17]

Diversity analysis

For evaluation of the state of diversity in the studied area, abundance (*N*), Species richness (*S*), Shannon-Wiener diversity index (*H*) (in log10), Simpson index (*1-D*), Evenness index ($E^{H/S}$) were calculated using the program PAST 3 (Paleontological Statistics Version 3.08). Pearson correlation coefficients (r) were calculated between molluscs of the study area with Physico-chemical parameters to ascertain if there any correlation persists with the habitat water quality.

RESULTS

Malacofaunal samples examined from aquatic bodies of the PRF revealed sixteen species with five orders and

seven families under two major classes of Gastropoda and Bivalvia. Some of the photographs of mollusc samples recorded from the study area are given in Figure 2. With five families Gastropoda dominated the molluscs population over Bivalvia with two families of Unionidae and Cyrenidae (Table 1). But on the basis of abundance, Bivalvia contributed 54.04% and gastropods only 45.95% to the total counts of molluscs for the entire studied seasons (Table 2). Gastropoda was represented by six species viz. *Bellamya bengalensis, Pila globosa, Pila virens, Tarebia lineata, Brotia costula* and *Indoplanoris exustus*. While Bivalvia was represented by *Parreysia corrugata, Parreysia lima, Lamellidens corrianus, Lamellidens marginalis, Parreysia corbis, Parreysia smaragdites, Parreysia favidens, Parreysia pachysoma, Corbicula striatella*

Figure 2: Molluscan fauna of Poba reserve forest: *A-Parreysia favidens, B-Lamellidens corrianus, C-Pila globosa, D-Tarebia granifera, E-Bellamya bengalensis, F-Brotia costula G-Corbicula striatella, H-Tarebia lineata.*

Table 1: Systematic position and Status of recorded freshwater mollusc species based on the assessment of the IUCN Red List of Threatened Species. Version 3.1.

Class	Order	Family	Genus/Species	IUCN Red List Category and Criteria (3.1)	Population Trend (IUCN,3.1)	Current status in the studied area
Gastropoda	Architaenioglossa	Viviparidae	*Bellamya bengalensis* (Lamarck,1822)	LC	ST	F
		Ampullariidae	*Pila globosa* (Swainson, 1822)	LC	UN	R
			Pila virens (Lamarck, 1822)	LC	UN	F
	Sorbeoconcha	Thiaridae	*Tarebia lineata* (Gray, 1828)	LC	UN	F
		Pachychilidae	*Brotia costula* (Brandt, 1974)	LC	UN	F
	Hygrophila	Planorbidae	*Indoplanorbis exustus* (Deshayes, 1834)	LC	UN	F
Bivalvia	Unionoida	Unionidae	*Parreysia corrugata* (Muller, 1774)	LC	ST	F
			Parreysia lima (Simpson, 1900)	LC	UN	F
			Lamellidens corrianus (Lea, 1834)	LC	UN	F
			Lamellidens marginalis (Lamarck, 1819)	LC	UN	F
			Parreysia corbis (Hanley, 1856)	DD	UN	F
			Parreysia smaragdites (Benson,1862)	LC	UN	F
			Parreysia favidens (Benson, 1862)	LC	ST	F
			Parreysia pachysoma (Benson, 1862)	LC	UN	IF
	Venerida	Cyrenidae	*Corbicula striatella* (Deshayes, 1854)	LC	ST	IF
			Corbicula assamensis (Prashad, 1928)	LC	UN	F

Table 2: Seasonal abundance of molluscs in the study area.

Taxa	Species	Pre-monsoon	Monsoon	Post-monsoon	Winter	Total Species	% Contribution
Gastropoda	*Bellamya bengalensis*	76	35	65	28	204	9.17
	Pila globosa	12	0	13	11	36	1.61
	Pila virens	43	27	54	15	139	6.25
	Tarebia lineata	87	16	53	74	230	10.34
	Brotia costula	75	44	84	68	271	12.18
	Indoplanoris exustus	42	12	50	38	142	6.38
Total Gastropoda		335	134	319	234	1022	45.95
Bivalvia	*Parreysia corrugata*	27	18	28	36	109	4.9
	Parreysia lima	22	13	43	33	111	4.99
	Lamellidens corrianus	48	31	53	61	193	8.67
	Lamellidens marginalis	28	22	33	48	131	5.89
	Parreysia corbis	26	19	32	28	105	4.72
	Parreysia smaragdites	31	0	39	46	116	5.21
	Parreysia favidens	19	27	62	55	163	7.32
	Parreysia pachysoma	19	10	22	14	65	2.92
	Corbicula striatella	18	9	25	38	90	4.04
	Corbicula assamensis	47	16	25	31	119	5.35
Total Bivalvia		285	165	362	390	1202	54.04
Total Mollusca		620	299	681	624	2224	

Table 3: Physico-chemical parameters recorded from the sampling stations.

Parameters	Minima	Maxima	Mean± SD
Water temperature (°C)	18	30.22	22.5± 4.20
Transparency (cm)	15.42	35.18	21.65± 5.30
Water current (m/s)	0.10	0.18	0.14± 0.05
Dissolved oxygen (mg/l)	4.74	10.38	6.25± 1.80
pH	6.0	7.52	6.84±0.82
Total dissolve solids (mg/l)	0.09	0.39	0.23± 0.13
Free Carbon dioxide (mg/l)	13.67	22.08	18.63±2.47
Calcium (mg/l)	16.20	22.64	19.64±3.74
Magnesium (mg/l)	7.46	15.24	10.11±2.50
Chloride (mg/l)	11.31	20.65	16.87±3.75
Phosphate (mg/l)	0.08	0.32	0.15±0.09
Nitrate(mg/l)	0.61	1.77	0.97±0.43

Table 4: Correlation coefficient (r) between molluscs of PRF with physico-chemical Parameters.

Parameters	Gastropoda	Bivalve
Water temperature (°C)	-0.43	-0.967*
Transparency (cm)	0.656	0.813
Water current (m/s)	-0.966*	-0.794
Dissolved oxygen (mg/l)	0.820	0.744
pH	-0.870	-0.607
Total dissolve solids	-0.854	-0.698
Free Carbon dioxide (mg/l)	-0.877	-0.257
Calcium (mg/l)	0.827	0.547
Magnesium (mg/l)	0.635	0.795
Chloride (mg/l)	0.536	-0.253
Phosphate	-0.871	-0.240
Nitrate	-0.316	-0.84

*Marked correlation was significant ($p < 0.05$).

and *Corbicula assamensis* respectively. The highest number of species was encountered in the post-monsoon season (N=681) followed by in winter season (N=624). On individual species count basis the highest number of recorded species was *Brotia costula* (N=271 species), followed by *Tarebia lineata* (N=230 species). Highest in the population of gastropods were observed during the pre-monsoon whereas lowest was observed during monsoon season. On the contrary, an increase in the population of bivalves was observed in winter and post-

monsoon seasons. During the study period overall a total of 1022 species of gastropods and 1202 species of bivalve were recorded (Table 2). *Bellamya bengalensis*, *Tarebia lineata, Brotia costula, Indoplanorbis exustus* were the single species from the family Viviparidae, Thiaridae, Pachychilidae, and Planorbidae respectively. The calculated diversity indices of the study area are shown in Figure 3. Shannon-Wiener diversity index (*H*) value ranges from 2.536 to 2.680 and Simpson index (*1-D*) ranges from 0.913 to 0.926. Whereas, Evenness index ($E^{H/S}$) value ranges from 0.858 to 0.911.

The IUCN 3.1 population trends for most of the recorded species were Unknown (UN) except for the *Bellamya bengalensis, Parreysia corrugata, Parreysia favidens,* and *Corbicula striatella* which were found to be stable (ST). For most of the species the current status in the studied area was frequent (F). *Pila globosa* was the only species found to be rare (R) during the entire study period. Two species viz. *Parreysia pachysoma* and *Corbicula striatella* were found to be infrequent (IF) (Table1).

The results of the analysis of Physico-chemical parameters are shown in Table 3. Table 4 shows the correlation coefficient (r) values between the Physico-chemical parameters and the population of recorded molluscs species with the habitat water quality of the study area.

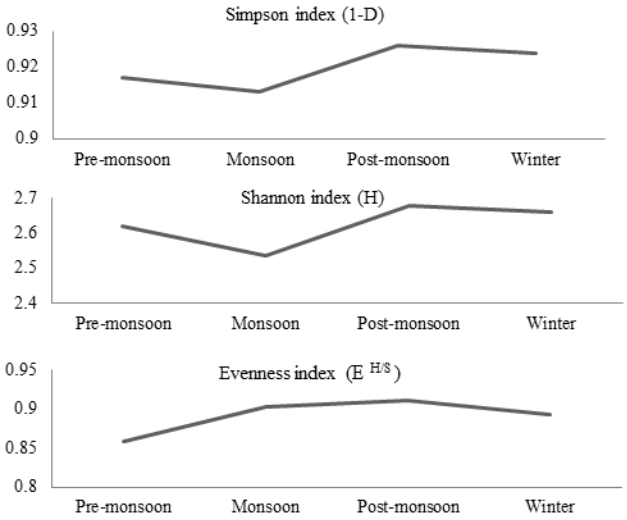

Figure 3: Values of different diversity indices of mollusc's population in the studied area.

DISCUSSION

Most of the recorded species during the studied seasons were found to be common in all the 12 sampling stations. But an unequal distribution of species count was observed (Table 2). In the present study predominance of gastropods with five families contributing 71.42% to the total families were registered. Bivalvia with two families contributing only 28.57% to the total recorded families. The present findings of the gastropods predominance are corroborated with the previous study[13] of gastropods in Jammu division of Jammu and Kashmir and Maguri beel of Assam.[10] In the present findings, the gastropods *Brotia costula* and *Terebia lineata* were the highest abundant and the most ubiquitous species being present in all the sampling stations. An overall decline in species count with complete absent of *Pila globosa* and *Parreysia smaragdites* was observed during the monsoon season (Table 2). The reason might be the high water current of runoff water and flooding of the adjacent area from the Siang River. Human activities like cultivation, grazing and overexploitation of aquatic resources also observed frequently during the season which might exert a profound effect on the molluscs population of the study area. Ethnic communities of the study area use different types of molluscs species as a non-conventional food resource. *Pila globosa* is one of the most preferred one, so this overexploitation may be the reason for the least abundant species during the whole study period.

Effects of Physico-chemical parameters and differences in habitat structural complexity with the influence of biotic interactions results in distinct habitat types that support various forms of faunal assemblages.[18] Regional processes such as colonization or extinction dynamics and dispersal also influence species distribution and compositions.[19] The sustainability and productivity of aquatic fauna depend on optimum physico-chemical attributes. Many Gastropod species are tolerant to a wide range of physico-chemical parameters and their occurrence is influenced by the nature of bottom substrata and vegetations. Generally, the most suitable substrate for gastropods (snails) in the ecosystem of a river is a sandy bottom with a thin layer of organic silt.[20] In the present study, the bottom substrata of the sampling sites were composed of mainly mud and sandy layers, favouring the gastropods population of the area. Observation of the Table 2 reflects that there was a variation in the abundance of molluscs species during the studied seasons. Comparing with the other seasons, monsoon season registered low species count. A similar result was reported earlier in Beheira Province where the snail abundance was high in spring and low in monsoon.[21] Temperature is one of the most seasonal conspicuous changes which to a greater extend effects the population pattern of species in a particular region. It influences the growth rates, body size, emergence patterns, metabolism and also reproduction.[22,23] The recorded temperature of the present study ranges from

18.0 to 30.22°C (Table 3). Both Gastropoda and Bivalvia exhibit a negative correlation with the temperature that corresponds with the earlier reports[24] Transparency of the present study ranged from 15.42 to 35.18 cm with a mean value of 21.65 cm. The positive correlation of molluscs species with transparency corroborated with the findings reported earlier.[25] Only in the monsoon season a low clarity of the water in most of the sampling stations was observed, due to the mixing of runoff water with mud and sandy particles from the adjacent cultivated areas. Water velocity has a wide influential effect on the distribution of molluscs population. Both gastropods and bivalves showed a negative correlation with the water current (Table 4). In the present study, high water velocity of waters in the monsoon season in all the sampling stations was observed which may be one of the reasons for least species count in the monsoon season. The studies on the distribution of *Physa marmorata* and *M. tuberculata* support our present findings.[26] pH value of an aquatic body is a significant indicator of water quality. Usually, pH values between 6.5 and 8.5 indicate good water quality and suitable for a major portion of aquatic faunal assembles.[27] According to a report, acidic pH value is generally unfavourable to the molluscs population which affects its abundance and distribution.[28] The pH value of the present study ranges from 6.0 to 7.52 suggesting that the malacofaunal assemblage in the study area can tolerate slightly acidic to alkaline water (Table 4). Correlation analysis of the present recorded molluscs species furnishes a negative correlation with pH which corroborated with the results of the earlier study.[11] DO is one of the important parameters for evaluating aquatic body's degree of freshness. It also has a determinant role in the abundance and distribution of aquatic fauna. The mean value of DO was recorded as 6.25 mg/l with a strong positive correlation with the molluscs species. Some authors reported that particular molluscs species can survive in very low oxygen conditions and have noted an inverse relationship with DO.[29,30] The molluscs species recorded during the survey were found to exhibit a negative correlation with FCO_2. A similar relationship between molluscs and FCO_2 was reported earlier[11] for the malacofaunal community of Ramsagar Reservior (M.P).

Analysis of calcium concentration in the water bodies of the sampling station revealed that the mean value was 19.64 mg/l. Present findings of positive correlation by both the classes of molluscs corroborated with the findings of earlier study[31] where the authors described that concentration of calcium is an important factor for controlling the abundance and distribution of freshwater molluscs population. Mollusca generally obtain calcium for shell formation by absorbing from the external medium. However, calcium contents in food materials are also utilized for the growth and development of the organism.[32,33] The chloride concentration in the studied water samples ranged from 11.31 to 20.65 mg/l. Gastropods show a positive correlation however bivalves exhibit a weak negative correlation with chloride concentration suggesting a favouring influence of chloride over gastropods population. Generally, a high concentration of chloride is an indicator of sewage outfall. The present value of the chloride analysis was mainly from surface run-off water and defecation activities. In aquatic habitats, nitrate enhances the growth of plankton and primary production. A high content of nitrate in an aquatic body indicates towards polluted water due to mixing of organic waste and domestic sewage. In the present study, nitrate concentration of 0.61 to 1.77 mg/l suggesting no major source of nitrate pollution in the study sites. Correlation coefficient value of gastropods and bivalves with nitrate shows a negative relationship (Table 4). Similarly, Phosphate shows a strong negative correlation (-0.871) with gastropods and a weak correlation (-0.24) with bivalve indicating the influential nature on molluscs population.

According to The IUCN Red List of Threatened Species, about 32.3% of freshwater molluscs of the eastern Himalaya region fall under Data Deficient (DD).[9] Similarly, 49.76% and 32.55% of molluscs population of Indo-Burma region falls under Least Concern (LC) and Data Deficient (DD) respectively.[34] The current status of the recorded molluscs species as per IUCN Red List of threatened species (Version 3.1) shows that except *Parreysia corbis* which is categorised as Data Deficient (DD) all the other recorded molluscs species (93.75%) were categorised as least concern (LC) (Table 1). The population trends for most of the recorded species (75%) was unknown (UN) except for the species *Bellamya bengalensis, Parreysia corrugata, Parreysia favidens,* and *Corbicula striatella* which were categorised as stable (ST). At the local context, it was observed that out of a total of 16 species recorded, 81.25 % were frequent (F), 12% infrequent (IF) and 6.25% were rare (R). Out of total species (N=2224), only 36 specimens of *Pila globosa* were encountered during the entire seasons hence categorized as rare (R) in the local context. Similar distribution pattern was reported in the Maguri beel of Assam, India.[10]

CONCLUSION

Freshwater molluscs play an important role in aquatic habitats. Studies on the ecology and distribution have become imperative. The present study revealed aquatic bodies of PRF has potential wetland with 16 freshwater molluscs species distributed heterogeneously and intimately correlated with prevailing physico-chemical parameters. The species can also be assigned as bio-indicator of aquatic habitats as they were found to respond to various environmental attributes. PRF being the single natural forest of the region provides fundamental cultural and supporting services to local communities. The scenario has become complicated owing to the overharvesting of aquatic faunal resources from the wetland during the last few years. Moreover, due to reduction of catchment area, ethnic communities of the region solely dependent on the wetland of PRF are shifting the secondary source of supplements for their livelihood towards edible molluscs population. Various anthropogenic activities have been affecting the reserve forest during the last few years. Therefore urgently the conservationists and the scientific community have to recognize the reserve forest as a potential site for freshwater mollusc to ensure the conservation of molluscs and other aquatic faunal of the region.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

LC: Least concern; **DD:** Data deficient; **UN:** Unidentified; **ST:** Stable; **F:** Frequent; **IF:** Infrequent; **R:** Rare.

REFERENCES

1. Graf DL, Cummings KS. Review of the systematics and global diversity of fresh water mussel species (Bivalvia: Unionoida). Journal of Molluscan Studies. 2007;73(4):291-314.
2. Bouchet P. Extinction and preservation of species in the tropical world: What future for Molluscs. American Conchologist. 1992;20(1):20-4.
3. Mavinkurve RG, Shanbhag SP, Madhyastha NA. Non-marine molluscs of Western Ghats: A status review. Zoos' Print Journal. 2004;19(12):1708-11.
4. Mereta ST, Boets P, Meester LD, Goethals PL. Development of a multimetric index based on benthic macroinvertebrates for the assessment of natural wetlands in Southwest Ethiopia. Ecological Indicators. 2013;29:510-21.
5. Bogan AE, Roe KJ. Freshwater bivalve (Unioniformes) diversity, systematics, and evolution: status and future directions. Journal of the North American Benthological Society. 2008;27(2):349-69.
6. Hornell J. The edible molluscs of the Madras Presidency. Government Press. 1918.
7. Dey A. Handbook on Indian freshwater molluscs. AICOPTAX-Mollusca, Zoological Survey of India; 2007.
8. Wosu LO. Commercial snail farming in West-Africa-A guide. Nsukka: AP Express Publishers Ltd; 2003.
9. Budha PB, Aravind NA, Daniel BA. The status and distribution of freshwater molluscs of the eastern Himalayas. The status and distribution of freshwater biodiversity in the Eastern Himalaya. IUCN. 2010;42-52.
10. Kardong D, Puzari M, Sonowal J. Diversity of freshwater Mollusc in Maguri beel: A floodplain Wetland of Tinsukia District in Assam, India. International Journal of Current Research. 2016;8(4):29169-76.
11. Garg RK, Rao RJ, Saksena DN. Correlation of molluscan diversity with physico-chemical characteristics of water of Ramsagar reservoir, India. International Journal of Biodiversity and Conservation. 2009;1(6):202-7.
12. Harman WN. Benthic substrates: Their effect on fresh-water mollusca. Ecology. 1972;53(2):271-7.
13. Kershner MW, Lodge DM. Effect of substrate architecture on aquatic gastropod-substrate associations. Journal of the North American Benthological Society. 1990;9(4):319-26.
14. Costil K, Clement B. Relationship between freshwater gastropods and plant communities reflecting various trophic levels. Hydrobiologia. 1996;321(1):7-16.
15. Rao SNV. Handbook of freshwater molluscs of India. Zoological Survey of India. 1989;1-289.
16. Dey RA. Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata. 2007;1-399.
17. American Public Health Association (APHA). Standard methods for the examination of water and waste water. (18th Ed.). American public health association (APHA). 1992.
18. Meester DL, Declerck S, Stoks R, Louette G, Meutter VDF, Bie DT, *et al*. Ponds and pools as model systems in conservation biology, ecology and evolutionary biology. Aquatic Conservation: Marine and Freshwater Ecosystems. 2005;15(6):715-25.
19. Cornell HV, Lawton JH. Species interactions, local and regional processes, and limits to the richness of ecological communities: A theoretical perspective. Journal of Animal Ecology. 1992;61:1-12.
20. Strzelec LM, Królczyk A. Factors affecting snail (Gastropoda) community structure in the upper course of the Warta river (Poland). Biologia, Bratislava. 2004;59(2):159-63.
21. Diab MR. Biological studies on Trematode larvae and freshwater snails. MVSc thesis, Faculty of Veterinary Medicine, Alexandria University. 1993.
22. Sweeney BW, Schnack JA. Egg development, growth, and metabolism of *Sigara alternata* (Say) (Hemiptera: Corixidae) in fluctuating thermal environments. Ecology. 1977;58(2):265-77.
23. Vannote RL, Sweeney BW. Geographic analysis of thermal equilibria: A conceptual model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. The American Naturalist. 1980;115(5):667-95.
24. Ricker WE. The benthos of Cultus lake. Journal of the Fisheries Board of Canada. 1952;9(4):204-12.
25. Sharma KK, Bangotra K, Saini M. Diversity and distribution of Mollusca in relation to the physico-chemical profile of Gho-Manhasan stream, Jammu (JK). International Journal of Biodiversity and Conservation. 2013;5(4):240-9.
26. Giovanelli A, Silva CL, Leal GB, Baptista DF. Habitat preference of freshwater snails in relation to environmental factors and the presence of the competitor snail *Melanoides tuberculatus* (Müller, 1774). Memórias do Instituto Oswaldo Cruz. 2005;100(2):169-76.
27. Schell VA, Kerekes JJ. Distribution, abundance and biomass of benthic macroinvertebrates relative to pH and nutrients in eight lakes of Nova Scotia, Canada. Water, Air, and Soil Pollution. 1989;46(1-4):359-74.

28. Júlia MMS, Barros M. Occurrence and distribution of fresh-water molluscs in the Riacho Fundo Creek Basin, Brasilia, Brazil. Revista de Biologia Tropical. 2001;49(3-4):865-70.
29. Cheatum EP. Limnological investigations on respiration, annual migratory cycle, and other related phenomena in fresh-water pulmonate snails. Transactions of the American Microscopical Society. 1934;53(4):348-407.
30. Sharma RC. Effect of physico-chemical factors on benthic fauna of Bhagirathi River, Garhwal Himalaya. Indian Journal of Ecology.1986;13(1):133-7.
31. Supian Z, Ikhwanuddin AM. Population dynamics of freshwater molluscs (Gastropod: *Melanoides tuberculata*) in Crocker Range Park, Sabah. ASEAN Review of Biodiversity and Environmental Conservation. 2002;1(1):1-9.
32. Kado Y. Studies on shell formation in molluscs. Journal of science of the Hiroshima University Ser. B-1 Zoology. 1960;19:163-210.
33. Borght VDO, Puymbroeck VS. Active transport of alkaline earth ions as physiological base of the accumulation of some radionuclides in freshwater molluscs. Nature. 1964;204(4958):533-4.
34. Köhler F, Seddon M, Bogan AE, VanTu D, Sri-Aroon P, Allen D. The status and distribution of freshwater molluscs of the Indo-Burma region. The status and distribution of freshwater biodiversity in Indo-Burma. IUCN, Cambridge, UK and Gland, Switzerland; Zoo Outreach Organization, Coimbatore, India. 2012;67-85.

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