Environment and Ecology 44 (4A) : 1101—1108, October—December 2026
Article DOI: https://doi.org/10.60151/envec/HTRY7455
ISSN: 0970-0420 (Print), ISSN: 3049-3625 (Online)

Proximate Composition, Mineral Content and Heavy Metal Assessment in *Pila globosa* and *Filopaludina bengalensis* from Deepor Beel of Assam, India

Pooja Das, Devajit Basumatari

Received 4 August 2026, Accepted 2 November 2026, Published on 26 November 2026

ABSTRACT

Freshwater gastropods are increasingly recognized as potential alternative sources of animal protein and essential nutrients. The present study evaluates the proximate composition, mineral content and heavy metal levels of two edible freshwater snail species, *Pila globosa* and *Filopaludina bengalensis*, collected from Deepor Beel. The results revealed significant interspecific variation in proximate composition, with higher moisture content in *P. globosa* (78.57%) compared to *F. bengalensis* (74.65%), whereas protein (18.64%) and carbohydrate (3.59%) contents were higher in *F. bengalensis* than in *P. globosa* (16.35% and 1.55%, respectively). Both species exhibited low lipid levels (~1%). Mineral analysis indicated calcium as the most abundant element in both species, recorded at 151.38 mg/100 g in *P. globosa* and 143.30 mg/100 g in *F. bengalensis*, followed by notable levels of iron (75.16 and 66.11 mg/100 g, respectively) and potassium, which was markedly higher in *F. bengalensis* (111.10 mg/100 g) than in *P. globosa* (47.11 mg/100 g). Other trace minerals including magnesium, manganese, and copper were present in moderate amounts. Heavy metals such as lead, molybdenum, and mercury were not detected in either species. These findings highlight the nutritional potential of these freshwater gastropods as valuable sources of protein and essential minerals, supporting their potential role in improving dietary diversity and nutritional security in the region.

Keywords Freshwater gastropods, Nutritional composition, Trace minerals, Heavy metals, *Pila globosa*, *Filopaludina bengalensis*.

INTRODUCTION

Aquatic macroinvertebrates are small organisms lacking an internal skeletal system that inhabit freshwater ecosystems for part or all of their life cycle. This group is highly diverse and includes insects, molluscs, annelids, and crustaceans (Chutia and Kardong 2022). Among them, molluscs represent the second largest and most successful group of invertebrates after insects, and several freshwater molluscs, particularly clams and snails, serve as important food resources for human populations (Khalua *et al.*

Pooja Das[1], Devajit Basumatari[2]*

[1]PhD Research Scholar, [2]Associate Professor
Department of Zoology, Cotton University, Panbazar, Guwahati 781001, Assam, India

Email: devajitbasumatari@cottonuniversity.ac.in
*Corresponding author

2014). Freshwater snails constitute one of the major invertebrate groups in Indian aquatic habitats (Gupta *et al.* 2014). At the same time, high incidences of protein–energy malnutrition resulting from inadequate protein intake remain widespread among children in developing and underdeveloped economies (Haldar *et al.* 2014). In the face of rapid population growth and the challenges posed by climate change, there is an increasing need to explore alternative, sustainable, and nutritionally adequate food resources for the future (Baghele *et al.* 2022).

Snail meat has been recognized as a high-quality food source due to its high protein content, low fat levels, and appreciable amounts of essential minerals such as iron (USDA 2006). Conventional animal protein sources including poultry, pork, beef, lamb, and fish are increasingly under pressure owing to factors such as recurrent droughts, disease outbreaks, natural disasters, rising feed costs, and the low productivity of indigenous breeds (Haldar *et al.* 2014). Consequently, the search for unconventional and low-cost animal protein sources has gained considerable attention. Among these alternatives, snails are particularly valuable as they contain significant levels of polyunsaturated fatty acids (PUFAs), especially essential fatty acids that cannot be synthesized by humans and must be obtained through diet (Rout *et al.* 2022). Moreover, Çağıltay *et al.* (2011) reported that the consumption of 100 g of snail meat can fulfil approximately 30% of the daily essential amino acid requirements of an adult weighing 75 kg.

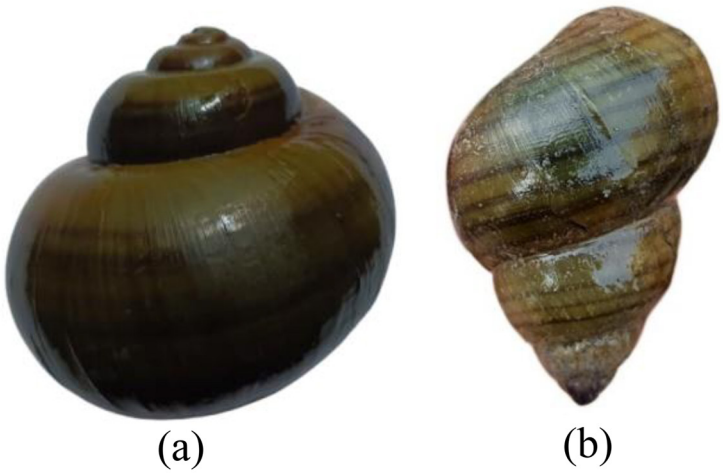
Northeast India, home to approximately 145 tribal communities, harbors a rich diversity of freshwater molluscs including snails that have long been integrated into local diets as staple or seasonal food resources (Bhattacharyya *et al.* 2024). Jadhav *et al.* 2020 documented 12 edible species from the region, representing 5 families and 7 genera that include ten species of snails–*Pila globosa*, *Pila olea*, *Bellamya* (*Filopaludina*) *bengalensis*, *Angulyagra sp*., *Cipangopaludina lecythis*, *Brotia costula* and three *Paludomus* species. Despite this notable diversity and cultural significance, nutritional profiling of freshwater snails in India remains underexplored, with existing studies largely restricted to West Bengal (Chakraborty *et al.* 2015; Khalua *et al.* 2014), Odisha (Rout *et al.* 2023), and Bhopal (Gupta *et al.* 2014). Only a few reports from Northeast India have addressed nutritional aspects (Chutia *et al.* 2020; Lourembam and Singh 2023; Bhattacharyya *et al.* 2024; Rout *et al.* 2022), underscoring the need for comprehensive assessments to both preserve indigenous knowledge and evaluate their potential role in enhancing dietary diversity and nutritional security. Comprehensive information on the nutritional status of snail species is therefore essential to assess their potential contribution to human health and animal nutrition. In this context, the present study, conducted in Deepor Beel – a Ramsar-designated wetland of Assam, aims to evaluate the nutritional quality of two edible freshwater snail species (Photo Plate 1) commonly found in the beel.

MATERIALS AND METHODS

Study area: The present study was carried out in Deepor Beel (26°05′–26°11′ N, 91°35′–91°43′ E), a freshwater wetland situated on the Southern periphery of Guwahati city in the state of Assam, Northeastern India (Saikia 2005). The geographical location of the study area is shown in Fig.1. The wetland functions as a residual channel of the Brahmaputra River and represents one of the largest beels (oxbow lakes) in the Brahmaputra floodplain. Historically, Deepor Beel covered an area of approximately 40 km² ; however, rapid urban expansion and inadequate watershed management have led to a drastic reduction in its spatial extent to about 4.1 km² of water–land interface (Dash *et al.* 2021). In recognition of its ecological significance, the wetland was designated as a Ramsar Site in 2002 under the Ramsar Convention on Wetlands of International Importance, particularly for its critical role in supporting regional biodiversity and migratory waterfowl populations.

Sample collection and preparation

Live specimens (n = 26 per species) were collected using a cast net with the assistance of a local fisherman. Sample size was determined prior to collection using G*Power 3.1 based on a two-sample t-test (α= 0.05, power = 0.80, Cohen's d= 0.5). The specimens were transported to the laboratory, washed with distilled water and the edible soft tissues were separated after



Photoplate 1: (a) *Pila globosa.* (b) *Filopaludina. bengalensis.*

shell removal. The tissues were lyophilized for 24 h, ground into a fine powder and used for proximate and mineral analysis.

Proximate analysis

Proximate analysis was conducted following standard methods prescribed by the Association of Official Analytical Chemists (AOAC 2015). All analyses were performed in six replicates to minimize experimental error and to ensure the accuracy and reliability of the results.

Moisture Content

Moisture content was estimated by weighing a pre-determined quantity (g) of the tissue sample placed in a 12.5 cm glass Petri dish. The sample was then oven-dried at 100–105°C until a constant weight was obtained. Moisture percentage was calculated from the loss in weight observed after drying, using the formula given below (Louberman and Singh 2023).

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight of sample taken}} \times 100$$

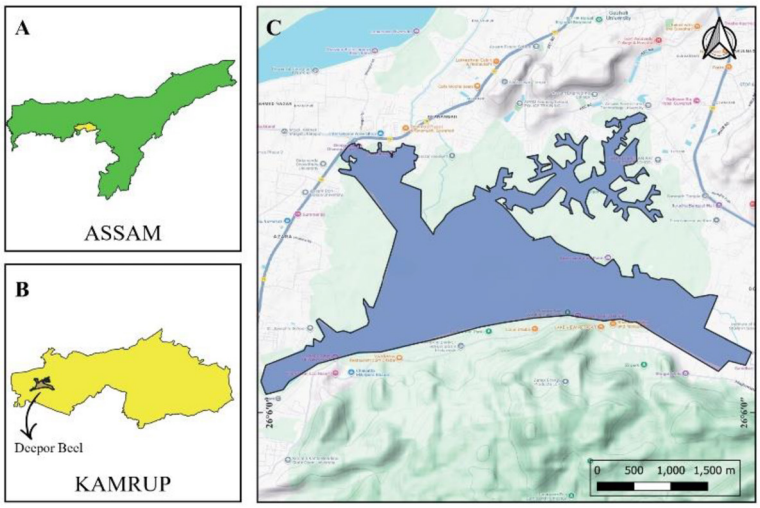


Fig. 1. Map of the study area. A- Map of Assam; B- Map of Kamrup; C- Map of Deepor beel.

Ash

For ash determination, 4 g of the sample was transferred into a clean, pre-weighed crucible and incinerated in a muffle furnace at 550°C until a white or light grey residue was obtained. After completion of ashing, the furnace was allowed to cool, and the crucible was reweighed. The ash content was then calculated using the formula given below (Khatun *et al.* 2024).

$$\%\text{Ash} = \frac{\text{Weight of crucible plus sample after ashing} - \text{Empty weight of crucible}}{\text{Weight of the sample before adding}} \times 100$$

Crude fat

Crude fat content was determined using the Soxhlet extraction method. The oven-dried samples obtained after moisture analysis were finely powdered, and approximately 2 g of the sample was transferred into an extraction thimble. The thimble was placed in the Soxhlet apparatus, and lipid extraction was carried out using diethyl ether as a non-polar solvent (Kalita *et al.* 2024). The percentage of crude fat was subsequently calculated using the standard formula:

$$\%\ \text{Crude fat} = \frac{\text{Weight of the residue}}{\text{Sample weight}} \times 100$$

Carbohydrate

Carbohydrate content was estimated by the difference method, in which the combined percentages of moisture, protein, fat, and ash were subtracted from 100 (Debnath *et al.* 2016). The carbohydrate percentage was calculated using the following equation.

$$\text{Carbohydrate (\%)} = 100 - (\%\ \text{moisture} + \%\ \text{protein} + \%\ \text{fat} + \%\ \text{ash})$$

Crude protein content

Protein content was quantified using the micro-Kjeldahl method. Approximately 2 g of the sample was digested with concentrated sulfuric acid (H_2SO_4) in a digestion mixture unit (Copper and Potassium Sulphate in the ratio of 1:8) for 45 minutes. The resulting digest was subsequently subjected to distillation, followed by titration with 0.1 N hydrochloric acid (HCl). The nitrogen content obtained was converted to crude protein by applying a conversion factor of 6.25 (Jones' factor) (Kalita *et al.* 2024).

$$\text{N \%} = \frac{(\text{Titration reading - blank reading}) \times \text{strength of acid} \times 14 \times 100}{\text{Weight of the sample}} \times 100$$

$$\text{Crude protein content (\%)} = \text{N (\%)} \times 6.25$$

Minerals and heavy metals

Mineral and heavy metal contents were determined using Atomic Absorption Spectrometry (AAS). Approximately 4 g of tissue sample was digested with a mixed acid solution containing 3 ml $HClO_4$, 21 ml HNO_3 and 1.5 ml H_2SO_4 and left overnight at room temperature. The digest was filtered through Whatman No. 42 filter paper and diluted to 100 ml with 2% HNO_3 (Gokoglu *et al.* 2004). Essential minerals (Ca, K, Fe, Mg, Mn and Cu) and heavy metals (Pb, Mo and Hg) were quantified using an Atomic Absorption Spectrophotometer (Varian Spectra-220 AA, Australia) and the concentrations were expressed as mg/100g dry weight. Calibration was performed using 1000 mg L^{-1} standard stock solutions (Sigma-Aldrich) serially diluted with Milli-Q water with calibration curves showing regression coefficients (R^2) of ≥ 0.995.

Statistical analysis

Data are presented as mean ± SD. An independent samples t-test was performed to determine significant differences between the two gastropod species. Effect size was calculated using Cohen's d, where values of 0.2, 0.5, and 0.8 indicate small, medium, and large effect sizes, respectively. Statistical significance was considered at $p < 0.05$ with a 95% confidence interval.

RESULTS AND DISCUSSION

The present study evaluated the proximate composition, minerals, and heavy metals of *Pila globosa* and *Filopaludina bengalensis* to assess their nutritional significance. It represents the first comprehensive

Table 1. Proximate composition of the two species (g/100 g of dry tissue).

	Pila globosa	Filopaludina. bengalensis	P value	Efffect Size (Cohen's D)
Moisture	78.57 ± 0.65	74.65 ± 0.76	P < 0.01	5.289
Ash	2.35 ± 0.27	2.07 ± 0.23	P = 0.094	1.067
Carbohydrate	1.55 ± 0.98	3.59 ± 1.7	P = 0.029	1.47
Fat	1.16 ± 0.28	1.03 ± 0.12	P = 0.2961	0.6364
Protein	16.35 ± 0.91	18.64 ± 1.37	P = 0.0068	1.961

Values are expressed as Mean±SD, n=6

nutritional evaluation of these edible freshwater gastropods from Deepor Beel, a Ramsar designated wetland of international importance. Given the ecological and socioeconomic importance of Deepor Beel, this assessment provides valuable baseline information on its edible molluscan resources. Comparative analysis with previous studies also highlights interspecific variation and the influence of environmental and biological factors on nutrient composition.

The comparative proximate composition of the two gastropod species is summarized in Table 1, highlighting variations in their moisture, ash, protein, fat, and carbohydrate contents. Moisture content was significantly higher in *Pila globosa* (78.57 ± 0.65%) than in *Filopaludina bengalensis* (74.65 ± 0.76%) (P < 0.01; d = 5.289). In *P. globosa*, the present value was lower than those reported by Baby *et al.* 2010 (85.5 ± 0.02%) and Moniruzzaman *et al.* 2021 (83.4 ± 0.6%) but comparable to Debnath *et al.* 2016 (73.80 ± 4.87%). Similarly, the moisture content of *F. bengalensis* was lower than that reported by Baby *et al.* 2010 (82.1 ± 0.04%) but higher than the values reported by Debnath *et al.* 2016 (65.80 ± 9.49%) and Bhattacharyya *et al.* 2024 (59.57 ± 1.43%).

Ash content did not differ significantly between *P. globosa* (2.35 ± 0.27%) and *F. bengalensis* (2.07 ± 0.23%) (P > 0.05; d = 1.067). In *P. globosa* the ash content was lower than that reported by Gupta *et al.* 2014 (4.53±0.05), Chutia *et al.* 2020 (8.28±0.24) and Moniruzzaman *et al.* 2021 (16.8±0.6). Similarly, the ash content of *F. bengalensis* was lower than the values reported by Baby *et al.* 2010 (3.64±0.04), Chutia *et al.* 2020 (10.52±0.32) and Bhattacharyya *et al.* 2024 (14.25±0.40). The relatively lower ash content observed in the present study may reflect reduced mineral deposition likely influenced by differences in water chemistry, feeding ecology and environmental conditions.

Protein content was significantly higher in *F. bengalensis* (18.64 ± 1.37) than in *P. globosa* (16.35±0.91) (p<0.05; d=1.961). The protein content of *P. globosa* exceeded the values reported by Baby *et al.* 2010 (8.272±0.05) and Debnath *et al.* 2016(15.59±1.40) but remained considerably lower than those documented by Chutia *et al.* 2020 (33.31±1.01) and Moniruzzaman *et al.* 2021 (49.6±0.6). Likewise, the protein content of *F. bengalensis* was intermediate, being higher than the values reported by Baby *et al.* 2010 (8.966 ± 0.26) and Debnath *et al.* 2016 (13.14 ± 1.82) yet lower than those recorded by Chutia *et al.* 2020 (35.67 ± 1.03) and Bhattacharyya *et al.* 2024 (22.83 ± 1.27). Such variations among studies are likely associated with differences in analytical methodology, habitat condition and the physiological status of the specimens.

Fat content did not differ significantly between *P. globosa* (1.16 ± 0.28%) and *F. bengalensis* (1.03 ± 0.12%) (P > 0.05; d = 0.6364) although *P. globosa* exhibited a slightly higher value. The fat content of *P. globosa* was comparable to that reported by Debnath *et al.* 2016 (1.15±0.17) but lower than the values reported by Chutia *et al.* 2020 (3.12±0.29). Similarly, the fat content of *F. bengalensis* was comparable to Baby *et al.* 2010 (0.98±0.02) but lower than the values reported by Bhattacharyya *et al.* 2024 (2.70±0.23). These variations may be attributed to seasonal changes, reproductive status and species-specific metabolic characteristics.

Table 2. Mineral content of the two species (mg/100g of dry tissue).

Minerals	Pila globosa	Filopaludina. bengalensis	P value	Effect Size (Cohen's D)
Ca	151.38 ± 6.72	143.30 ± 3.31	0.0246	1.526
K	47.11 ± 2.94	111.10 ± 3.23	< 0.01	20.73
Cu	0.65 ± 0.22	0.20 ± 0.08	0.0008	2.727
Fe	75.16 ± 4.32	66.11 ± 3.76	0.0031	2.236
Mg	15.27 ± 1.91	10.09 ± 2.07	0.0011	2.601
Mn	4.09 ± 0.92	1.51± 0.40	0.0001	3.618
Pb	ND	ND	NA	NA
Mo	ND	ND	NA	NA
Hg	ND	ND	NA	NA

Values are expressed as Mean±SD; n=6

Carbohydrate content was significantly higher in *F. bengalensis* (3.59 ± 1.70%) than in *P. globosa* (1.55 ± 0.98%) (P < 0.05; d = 1.47). In *P. globosa,* the carbohydrate content was lower than the values reported by Gupta *et al*. 2014 (7.58±0.40), Chutia *et al.* 2020 (12.11±0.32) and Moniruzzaman *et al.* 2021 (30.2±0.9). For *F. bengalensis*, the carbohydrate content was lower than that reported by Baby *et al*. 2010 (4.31±0.17) and Chutia *et al.* 2020 (22.54±0.60) but higher than Bhattacharyya *et al.* 2024 (0.65±0.65). These variations may reflect differences in glycogen storage associated with habitat productivity, feeding intensity and physiological condition.

The mineral composition of *Pila globosa* and *Filopaludina bengalensis* exhibited significant interspecific differences (Table 2). Calcium was the most abundant mineral in both species and was significantly higher in *P. globosa* (151.38±6.72 mg/100 g) than in *F. bengalensis* (143.30±3.31mg/100g) (p=0.0246; d=1.526). The calcium content of *P. globosa* was lower than the values reported by Gupta *et al.* 2014 (302.327 mg/100g) and Moniruzzaman *et al.* 2021(1739.0±8.3 mg/100g) but higher than that reported by Chutia *et al.* 2020 (19.87±1.82 mg/100 g). For *F. bengalensis*, calcium content was lower than the values reported by Baby *et al.* 2010 (166.404 mg/100 g) and Bhattacharyya *et al*. 2024 (435.11±1.2 mg/100g).

Potassium was significantly higher in *F. bengalensis* (111.10±3.23 mg/100 g) than in *P. globosa* (47.11±2.94 mg/100 g) (p<0.01; d= 20.73). The potassium content of *P. globosa* was lower than that reported by Debnath *et al*. 2016 (182.28 ± 8.02 mg/100 g) and Moniruzzaman *et al*. 2021 (202.0±3.0 mg/100 g) whereas the values for *F. bengalensis* was comparable to Baby *et al.* 2010 (128.849 mg/100 g) and higher than Debnath *et al.* 2016 (93.53 ± 1.65 mg / 100 g).

Copper, iron, magnesium and manganese were all significantly higher in *P. globosa* than in *F. bengalensis* (p<0.01, d>2). Copper concentrations (0.65±0.22 and 0.20 ± 0.08 mg/100 g, respectively) were lower than those reported by Moniruzzaman *et al.* 2021 and Bhattacharyya *et al.* 2024. Iron content 75.16±4.32 mg/100 g in *P. globosa* and 66.11±3.76 mg/100 g in *F. bengalensis* was lower than the values reported by Baby *et al*. 2010 but considerably higher than those documented by Debnath *et al.* 2016. Likewise, magnesium (15.27±1.91 mg/100 g in *P. globosa*) and manganese (4.09 ± 0.92 mg/100g in *P. globosa* and 1.51±0.40 mg/100g in *F. bengalensis*) were generally lower than or comparable to previous reports.

Heavy metal analysis showed that lead, molybdenum and mercury were not detected in either species indicating the absence of detectable contamination by these toxic metals. Overall variations in mineral composition between the present study and earlier reports are likely associated with differences in geographical location, water and sediment characteristics, feeding ecology, seasonal variation and analytical methodology.

CONCLUSION

The present study provides the first comprehensive assessment of the proximate composition, mineral profile and heavy metal status of *Pila globosa* and *Filopaludina bengalensis* from Deepor beel, a Ramsar designated wetland of international importance. Both species exhibited high moisture and protein content, low lipid levels and appreciable concentrations of essential minerals particularly calcium indicating their nutritional value as potential sources of protein and minerals. Comparative analysis with previous studies revealed variations in nutrient composition which are likely influenced by differences in habitat characteristics, environmental conditions, water and sediment chemistry, seasonal variation, physiological status, geographic location and analytical methodology. Overall this study establishes a baseline nutritional data for edible freshwater gastropods from Deepor beel and provides a foundation for future investigations on their nutritional potential, seasonal variation and contribution to regional food security.

ACKNOWLEDGMENT

The Authors thank Prof. Arup Kumar Hazarika, HOD, Department of Zoology, Cotton University, Guwahati-01, Assam, for allowing the smooth conductance of the research with good laboratory facilities. The authors would also like to thank Guwahati Biotech Park and Khanapara Veterinary College for providing laboratory facilities for carrying out some of the research objectives.

REFERENCES

AOAC. (2015). Official Methods of Analysis. Association of Official Analytical Chemists. 18th Edition, Published by AOAC International. Suite 300,2275 Research BLV, Rock ville, Marryland, 20850-3250, USA, pp, 806—814.

Baby, R. L., Hasan, I., Kabir, K. A., & Naser, M. N. (2010). Nutrient analysis of some commercially important molluscs of Bangladesh. *Journal of Scientific Research*, 2 (2), 390—396.

Baghele, M., Mishra, S., Meyer-Rochow, V. B., Jung, C., & Ghosh, S. (2022). A review of the nutritional potential of edible snails: A sustainable underutilized food resource. *Indian Journal of Natural Products and Resources*, 13 (4), 419—433.

Bhattacharyya, B., Das, P. P. G., Borkataki, S., & Bhairavi, K. S. (2024). Molluscophagy in North East India: Assessment of nutritive value of four edible freshwater molluscs. *Journal of Aquatic Food Product Technology*, 33 (6), 455—468.

Çağıltay, F., Erkan, N., Tosun, D., & Selçuk, A. (2011). Amino acid, fatty acid, vitamin and mineral contents of the edible garden snail (Helix aspersa). *Journal of Fisheries Sciences. com*, 5 (4), 354—363.

Chakraborty, D., Mukherjee, M., & Maity, J. (2015). Ethno-medicinal importance of viviparous gastropod, *Bellamya bengalensis* (Lamarck 1822) in terms of estimation of its proximate protein and amino acid composition. *International Journal of Scientific Research*, 4(1), 178—180.

Chutia, J., & Kardong, D. (2022). Diversity and Spatial Distribution of Freshwater Macro-Invertebrates in Poba Reserve Forest of Assam, India. *Asian Journal of Biological and Life Sciences*, 11(1), 117—126.

Chutia, J., Sonowal, J., Pegu, B. K., & Kardong, D. (2020). Evaluation of proximate and heavy metals in twelve edible freshwater macroinvertebrates of Poba Reserve Forest Assam, India. *Biosciences Biotechnology Research Asia*, 17(4), 819—829.

Dash, S., Borah, S. S., & Kalamdhad, A. S. (2021). Heavy metal pollution and potential ecological risk assessment for surficial sediments of Deepor Beel, India. Ecological Indicators, 122, 107265.

Debnath, C., Sahoo, L., Haldar, A., Datta, M., Yadav, G. S., Singha, A., & Bhattacharjee, J. (2016). Proximate and mineral composition of freshwater snails of Tripura, North-East India. *Fishery Technology*, 53, 307—312.

Gokoglu, N., Yerlikaya, P., & Cengiz, E. (2004). Effects of cooking methods on the proximate composition and mineral contents of rainbow trout (*Oncorhynchus mykiss*). *Food chemistry*, 84 (1), 19—22.

Gupta, A., Singh, R., & Dixit, S. (2014). Nutrient content of some fresh water snails from wetlands of Bhopal. *Bioscience Biotechnology Research Communications*, 7 (2), 142—146.

Haldar, A., Dey, T. K., Dhar, P., & Chakrabarti, J. (2014). Exploring the nutritive values of the fresh water mussel Lamellidens marginalis as potential functional food. *Journal of Environmental Science, Toxicology and Food Technology*, 8 (8), 01—07.

Jadhav, A., Das, N. K., & Aravind, N. A. (2020). Edible freshwater molluscs from Northeast India. *Tentacle*, 28 (3), 3—4.

Kalita, K., Ghosh, S. S., Basumatari, D. (2024). Sun-Dried Fish: Bridging Food Science and Cultural Significance of Traditional Knowledge. *Egyptian Journal of Aquatic Biology and Fisheries*, 28(4), 2051— 2072.

Khalua, R., Tripathy, S., Paul, B. & Bairy, D. (2014). Seasonal variation of carbohydrate, protein and lipid of common freshwater edible gastropod (*Bellamya bengalensis*) of Medinipur district, West Bengal. *Research Journal of Biology*, 2, 49—52.

Khatun, N., Basumatari, D., Sharma, P. (2024). Comparative evaluation of change in organoleptic, proximate and vitamin content of freshwa ter fish species, heteropneustes fossilis at various duration of low temperature preservation. *Environment and Ecology*, 42(3B), 1449—1457.

Lourembam, J., & Singh, K. B. (2023). Essential elements profile in the freshwater snails commonly consumed by the living population of Manipur, a North Eastern state of India: An insight to use snails as nutraceutical food. *Journal of Survey in Fisheries Sciences*, 10(3S), 904—919.

Moniruzzaman, M., Sku, S., Chowdhury, P., Tanu, M. B., Yeasmine, S., Hossen, M. N., ... & Mahmud, Y. (2021). Nutritional evaluation of some economically important marine and freshwater mollusc species of Bangladesh. *Heliyon*, 7 (5).

Rout, B., Mehta, N. K., Tripathi, H. H., Sharma, S., Majumdar, R. K., & Priyadarshini, M. B. (2022). Preliminary investigations on antimicrobial, antioxidant and nutritional properties of freshwater snail *Brotia costula* (Rafinesque, 1833). *Indian Journal Fisheries*, 69 (2), 100—110.

Rout, S., Rath, S. K., & Kumar, S. (2023). Food and medicinal aspects of freshwater snail *Filopaludina bengalensis* (Lamarck, 1822). *Asian Journal of Biology*, 18 (2), 11—14.

Saikia, P. K. (2005). Qualitative and quantitative study of lower and higher organisms and their functional role in the Deepor Beel ecosystem. Project report submitted to North Eastern Space Applications Centre (NESAC), Department of Space, Government of India, Umium, Meghalaya, Shillong, 97pp.

United States Department of Agriculture. (2006). USDA national nutrient database for standard reference (Release 19). U.S. Department of Agriculture, Agricultural Research Service.