



A preliminary report on freshwater mollusca of Arunachal Pradesh, Northeast India and first report of an exotic invasive species *Physella acuta* (Draparnaud, 1805) from the state

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Abstract

A total of 32 freshwater molluscs has been reported from the state of Arunachal Pradesh which belongs to 2 classes, 7 orders, 12 families and 20 genera including two invasive freshwater species, *Physella acuta* and our own native species *Melanoides tuberculata* which is widely invasive in the tropics outside its native. Unionidae under class Bivalvia has the maximum number species followed by Paludomidae under the class Gastropoda. Thirty species of the freshwater molluscs reported from the state belongs to least concerned category of IUCN Red List of Threatened Species. Version 2021-1 (n.d.). Conservation status of two indigenous species under family Paludomidae, viz., *Paludomus aborensis* Godwin-Austen, 1918 and *Paludomus rotungensis* Preston, 1915 were not evaluated. *Physella acuta* which is an exotic species is reported for the first time from the state.

Keywords: Arunachal Pradesh, Bivalvia, Conservation Status, Freshwater Mollusca, Gastropoda

Introduction

Arunachal Pradesh is included in one of the five highest forest cover an area of the country with more than 79% of its geographical area under forest cover. The state is located between 26.28° N and 29.30° N latitude and 91.20° E and 97.30° E longitude on the northeastern side of India and has an 83,743 square km area. The land is mostly mountainous with the Himalayan ranges running north-south traversed throughout by a number of rivers and rivulets. Rainfall in the state varies from 1000 mm in higher reaches to 5750 mm in the foot-hill areas and spread over 8-9 months except the drier days in winter. The entire territory forms a complex hill system with varying elevations ranging from 50 m in the foot-hills and gradually ascending to about 7000 m. Three Himalayan zones, viz. (i) The sub-Himalayan zone (ii) The lesser or Lower Himalayas (iii) The Greater or Higher Himalayas with heights greater than 6000 m having precipitous slopes and deep gorges represented (Kumar, 2015) This diversity of topographical and climatic conditions has made the state rich with various flora and fauna and

included in eastern Himalayan biodiversity hot spot of the world.

In numbers of living animal species, though far behind the Arthropoda, Mollusca is the second biggest phylum. However, a great majority of Mollusca species are marine and only about 11% belong to freshwater represented by a fraction under two classes Gastropoda and Bivalvia (Nicol, 1969). From India, Ramakrishna and Dey, 2007 listed 199 freshwater mollusca species that to belong to 59 genera and 29 subgenera under 26 families after examining the large number of named, unnamed and type collections present in the National Zoological Collection of Zoological Survey of India and consulting the literature of freshwater molluscs. A perusal of literature on the study of freshwater Mollusca of India reveals that Preston (1915) gave a comprehensive account of freshwater molluscs in the Fauna of British India (Freshwater Gastropoda and Pelecypoda). Rao (1989) gave a consolidated account of freshwater molluscs of India in “Handbook on Freshwater Molluscs of India”. Work on the mollusca taxonomy in India is in inception,

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some commendable works on the mollusca of western ghats have been done by researchers (Tonapi, 1971; Madhyastha, 2001; Pati and Talmale, 2005; Madhyastha, 2006). Recently 77 freshwater Mollusca species were listed from the western ghats by Madhyastha *et al.*, 2011 and 57 species by Tripathy and Sajan in 2020. Few works on the freshwater Mollusca of eastern Himalaya and Assam were done by some researchers like Reid *et al.*, 2013; Tripathy *et al.*, 2018; Budha *et al.*, 2010; Kardong *et al.*, 2020; Sonowal *et al.*, 2021; Chutia, *et al.*, 2021. However, very few works on mollusca taxonomy have been taken up in a north eastern state of India specially in Arunachal Pradesh. No consolidated list of freshwater Mollusca has been compiled for the state except the reports included in the Handbook on Indian Freshwater molluscs by Ramakrishna and Dey (2007). The present study includes all the species reported by earlier workers and collection made by myself during the various faunal survey carried out in various parts of the state.

Materials and Methods

Based on the collection during an extensive filed survey taken from 2014 to 2020 and a review of published literature, an inclusive list of freshwater Mollusca reported from the states is presented here. Freshwater Mollusca samples were randomly handpicked from rivers, streams and lakes. Molluscan specimens were identified following Rao (1989), Mitra *et al.*, (2005), Ramakrishna and Dey (2007) and Reid *et al.*, (2013). The systematic arrangement used in this study broadly follows the work of Vaught (1989) and Bouchet *et al.* (2017) system of classification. The conservation status of the species was worked out following the IUCN Red List of Threatened Species. Version 2021-1 (n.d.).

Results and Discussion

A total of 32 freshwater Mollusca has been reported from the state of Arunachal Pradesh which belongs to 2 classes, 7 orders, 12 families and 20 genera including one new record from the state. Number of species wise, Gastropoda (19 species) outnumbered Bivalvia (13 species). Familywise, Unionidae under class Bivalvia has the maximum number of species (11 species) followed by Paludomidae (four species) under the class Gastropoda. Viviparidae, Lymnaeidae and Planorbidae were represented by three taxa each. Thiaridae was represented by two taxa whereas

the remaining families viz., Bithyniidae, Pachychilidae, Bulinidae, Physidae, Sphaeriidae and Cyrenidae were represented by single species each. Two species under the family Paludomidae, viz., *Paludomus aborensis* Godwin-Austen, 1918 and *Paludomus rotungensis* Preston, 1915 were described as new to science from the state for the first time although the latter species is marked as *taxon inquirendum* by MolluscaBase. *Paludomus aborensis* collected from a stream near Rotung during the Abor expedition was described from a single individual but there is no further mention of this species and record of collection by any researcher. However, taxonomically the species is validated by MolluscaBase (2021) by including it in their database. But this species is not cited in the handbooks of Ramakrishna and Dey (2007) and Rao (1989). Some taxonomist synonymized *Paludomus rotungensis* with *Paludomus blanfordiana* G. Nevill, 1877 which was first discovered in Ava, Myanmar, however, MolluscaBase (2021) keep the species under *taxon inquirendum*. Designated Syntypes of *Paludomus blanfordiana* housed in the National Zoological Collection of Zoological Survey of India, Kolkata under registration number NZSI M.18896/3 need to be examined further.

Remarks

From the literature review, it is found that two species *viz.*, *Physella acuta* (Figure 1) and *Melanoides tuberculata* under Physidae and Thiaridae are placed under invasive category. Though *Melanoides tuberculata* was described from the Indian Coromandel coast, the species is categorized as an invasive species outside its native range of Asia and Africa because of its high adaptive capacity and plasticity, by Invasive Species Compendium (n.d.) and Invasive and Exotic Species of North America (www.invasive.org). The exotic *Physella acuta* which is native to North America, reported for the first time from the state is listed under the invasive category by the Invasive Species Compendium (n.d.). This species preferred polluted stagnant waters and was also reported from other parts of the country *viz.* Delhi, Kolkata, Assam, Himachal Pradesh, Andhra Pradesh and Chandigarh are both from lentic and lotic freshwater ecosystems (Tripathy and Sajan, 2018.). Some other freshwater exotic species like *Gyraulus convexiusculus*, *Radix andersoniana* and *Thiara aspera* are also reported from the state but they are not recognized as invasive. Conservation status

of the 32 species was studied by referring IUCN Red List of Threatened Species. Version 2021-1 (n.d.). Fortunately, not a single species is listed under the threatened category. Thirty species of the freshwater Mollusca reported from the state belong to the least concerned category. However, two species viz., *Paludomus rotungensis* and *P. aborensis* discovered from the state are not evaluated under this system indicating the need for a thorough study of these two species.

The classification of molluscs underwent several changes in recent years. The history of the classification of species in the class Gastropoda has been volatile, undergoing constant change since Cuvier's time. Thiele Johannes (1929-1935), put together earlier classifications and proposed Thiele's system of classifications basing his classification on the respiratory organs, which was used by malacologists for most of the century. Bouchet and Rocroi (2005) have given a new system for the scientific classification of gastropods which was mainly based on the concept of clades and was taken from research on

molecular studies. Following this system of classification, many taxon have been renamed and rearranged and a lot more taxon have been Synonymised based on new studies and findings (Bouchet *et al.*, 2017). After a thorough study, a systematic list of 32 freshwater Mollusca under 2 classes, 7 orders, 12 families and 20 genera along with old scientific names are listed in Table 1.



Figure 1. *Physella acuta* (Draparnaud, 1805).

Table 1. Systematic list of freshwater mollusca species of Arunachal Pradesh along with material referred

	Systematic list	Material referred
1	Class GASTROPODA Order Architaenioglossa Family Viviparidae Genus <i>Filopaludina</i> <i>Filopaludina bengalensis</i> (Lamarck, 1822)	ZSI/IV/APRC/M-324; Pillumukh, Pashighat; 18.ii.2020 (3 exs)
2	Genus <i>Idiopoma</i> <i>Idiopoma dissimilis</i> (O. F. Müller, 1774)	ZSI/IV/APRC/M-50; Moing, Poma basti; 27.v.2016 (302xs)
3	Genus <i>Pila</i> <i>Pila globosa</i> (Swainson, 1822)	ZSI/IV/APRC/M-69; Ranibheel, East Siang; 12.ii.92 (6 exs)
4	Order Littorinimorpha Family Bithyniidae Genus <i>Bithynia</i> <i>Bithynia pulchella</i> (Benson, 1836)	ZSI/IV/APRC/M-328; Poma basti, 11.ix.2015 (27 exs)
5	Order Caenogastropoda Family Pachychilidae Genus <i>Brotia</i> <i>Brotia costula</i> (Rafinesque, 1833)	ZSI/IV/APRC/M-51; Moing, Poma basti; 27.v.2017 (2 exs)
6	Family Paludomidae Genus <i>Paludomus</i> <i>Paludomus aborensis</i> Godwin-Austen, 1918	Records of the Indian Museum. 8 (12): 620; Rotung, East Siang
7	<i>Paludomus blanfordiana</i> G. Nevill, 1877	ZSI/IV/APRC/M-107; Koronu village, Lower Dibhang village; 22.i.2017 (19 exs)
8	<i>Paludomus crassa</i> (von dem Busch, 1842) Synonymised name <i>Paludomus conica</i> (Gray, 1833)	ZSI/IV/APRC/M-350; Kamle Mite Village Hill stream and bank 18.ix.2018 (4 exs)

9	<i>Paludomus rotungensis</i> Preston, 1915	Records of the Indian Museum, 8 (8): 539; Abor hills.
10	Family Thiaridae Genus <i>Thiara</i> <i>Thiara aspera</i> (Lesson, 1831)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; 152.
11	Genus <i>Melanoides</i> <i>Melanoides tuberculata</i> (O. F. Müller, 1774)	ZSI/IV/APRC/M-96; Injino village, Lower Dibang Valley; 29.viii.2016 (1 ex)
12	Superorder Hygrophila Family Bulinidae Genus <i>Indoplanorbis</i> <i>Indoplanorbis exustus</i> (Deshayes, 1833)	ZSI/IV/APRC/M-261; Koronu village, Lower Dibang Valley; 22.1.2017 (20 exs)
13	Family Lymnaeidae Genus <i>Racesina</i> <i>Racesina luteola</i> (Lamarck, 1822)	ZSI/IV/APRC/M-347; Holongi, Papumpare; 17.x.2020 (53 exs)
14	Genus <i>Radix</i> <i>Radix andersoniana</i> (G. Nevill, 1877)	ZSI/IV/APRC/M-146; Ethun river bank, Dibang Valley; 7.v.2015 (1 ex)
15	<i>Radix rufescens</i> (J. E. Gray in G. B. Sowerby I, 1822)	ZSI/IV/APRC/M-348, Holongi, Papumpare; 17.x.2020 (12 exs)
16	Family Physidae Genus <i>Physa</i> <i>Physella acuta</i> (Draparnaud, 1805)	ZSI/IV/APRC/M-166, Roing, Lower Dibang Valley; 1.iv.2016 (7 exs)
17	Family Planorbidae Genus <i>Gyraulus</i> <i>Gyraulus convexiusculus</i> (T. Hutton, 1849)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 234, Figures 172 A and B and 173 A and B.
18	Genus <i>Pettacylus</i> <i>Pettacylus verruca</i> (Benson, 1855)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 258, Figures 192 A, B and C.
19	Genus <i>Polypylis</i> <i>Polypylis calathus</i> (Benson, 1850)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 246; Figures 182A, B and 183A,B and C.
20	Class Bivalvia Order Sphaeriida Family Sphaeriidae Genus <i>Musculium</i> <i>Musculium indicum</i> (Deshayes, 1854)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 360; Figures 276A,B and 277A and B.
21	Order Venerida Family Cyrenidae Genus <i>Corbicula</i> <i>Corbicula striatella</i> Deshayes, 1855	Rao, 1989. Handbook on Freshwater Molluscs of India and adjacent countries. pp. 204, Figures 575, 576.
22	Order Unionida Family Unionidae Genus <i>Indonaia</i> <i>Indonaia andersoniana</i> (G. Nevill, 1877)	ZSI/IV/APRC/M-326; Pillungmukh, Pasighat, 18.ii.2020 (45 exs)
23	<i>Indonaia involuta</i> (Hanley, 1856)	ZSI/IV/APRC/M-327; Pillungmukh, Pasighat, 18.ii.2020 (9 exs)
24	<i>Indonaia lima</i> (Simpson, 1900)	ZSI/IV/APRC/M-235; Sally Lake, Roing; 15.x.2015 (1 ex)
25	<i>Indonaia occata</i> (I. Lea, 1860)	ZSI/IV/APRC/M-123; Sally Lake, Roing; 15.x.2015 (1 ex)
26	Genus <i>Lamellidens</i> <i>Lamellidens corrianus</i> (I. Lea, 1834)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 283; Figs . 205A and B.
27	<i>Lamellidens generosus</i> (Gould, 1847)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 284; Figures 207A and B.
28	<i>Lamellidens marginalis</i> (Lamarck, 1819)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 288; Figures 211 A and B.

29	Genus <i>Parreysia</i> <i>Parreysia corrugata</i> (O. F. Müller, 1774)	ZSI/IV/APRC/M-73; Ranibheel, Pasighat; 12.ii.1992 (1 ex)
30	<i>Parreysia favidens</i> (Benson, 1862)	ZSI/IV/APRC/M-325; Pllungmukh, Pasighat; 18.ii.2020 (3exs)
31	<i>Parreysia sikkimensis</i> (I. Lea, 1859)	Ramakrishna and Day, A. 2007; Handbook on Indian Freshwater Molluscs. Zoological Survey of India, Kolkata, India; pp 309; Figures 131 A and B.
32	<i>Parreysia smaragdites</i> (Benson, 1862)	ZSI/IV/APRC/M-339; Pllungmukh, Pasighat; 18.ii.2020 (14 exs)

Taxonomic account of *Physella acuta* (Draparnaud, 1805)

Class **Gastropoda**

Superorder **Hygrophila**

Family **Physidae**

Genus ***Physella*** Haldeman, 1842

Physella acuta (Draparnaud, 1805)

1805. *Physa acuta* Draparnaud, *Histoire naturelle des mollusques terrestres et fluviatiles de la France*, Paris: 55.

2007. *Physa acuta* Ramakrishna and Dey, *Handbook on Indian Freshwater Molluscs*: 227.

2009. *Physa acuta* Wethington, Wise and Dillon, Jr., *The Nautilus*, **123**(4): 285.

Material Examined: ZSI/IV/APRC/M-166, Roing, MWLS, 05.04.2016, (5 exs)

IUCN Status: Least Concern (LC)

Diagnosis: This snail is commonly referred to as a tadpole snail or pouch snail. The shell is medium to small, sinistral, and transparent with a thick and sharply pointed spire. The outer surface of the body is smooth, the body whorl large and around; the tentacles are long and slender. Externally *Physella* is closely resemblance to *Bullinus*, but it is distinguished from it by its lack of haemoglobin, pseudo branch, the presence of mantle processes and the different copulatory organs.

Distribution: India: Arunachal Pradesh, Andhra Pradesh, Delhi, Maharashtra, Bihar, West Bengal, Jammu and Kashmir. **Elsewhere:** Åland Islands, Albania, Algeria, Andorra, Angola, Austria, Belgium, Benin, Bosnia and Herzegovina, Botswana, Bulgaria, Burkina Faso, Cameroon, Canada, Cape Verde, Chad, China, Comoros, Côte d'Ivoire, Croatia, Czech Republic, Denmark, Djibouti, Egypt, Eritrea, Estonia, Ethiopia, Faroe Islands, Finland, France, French Polynesia, Gabon, Gambia, Germany, Ghana, Gibraltar, Greece, Greenland, Guernsey, Guinea, Guinea-Bissau, Holy See (Vatican City State), Hong Kong, Hungary, Iceland, Iran, Ireland, Isle of

Man, Italy, Japan, Jersey, Kenya, Latvia, Lesotho, Liberia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Madagascar, Malta, Mayotte, Monaco, Montenegro, Morocco, Namibia, Netherlands, New England, Niger, Norway, Pakistan, Poland, Portugal, Romania, Russian Federation Saint Helena, Ascension and Tristan da Cunha, Saint Pierre and Miquelon, San Marino, São Tomé and Príncipe, Senegal, Serbia, Seychelles, Slovakia, Slovenia, Somalia, South Africa, Spain, Sudan, Svalbard and Jan Mayen, Sweden, Switzerland, Tanzania, Tunisia, Uganda, United Kingdom, United Republic of Togo, U.S.A, Western Sahara, Zambia and Zimbabwe (Ramakrishna and Dey 2007; Van Damme *et al.* 2012).

Remark: Five individuals of this species were collected from a stagnant water body from Roing near the district fishery office fish farm. Physidae in India is represented by two genera *Physella* and *Aplexa*, and *Physella* by one species *P. acuta*. The key characteristics of this family is the lack of blood haemoglobin and the pseudobranch, the presence of mantle processes, and the different copulatory organ. The taxonomy of this species was uncertain for a long time. Most of these species are not easy to identify on shell character alone. Earlier it was known as *Physa acuta* and many of the modern taxonomists still use this name. This species was recorded from India (Pune, Maharashtra) by Rao *et al.* (1994) for the first time. The species was earlier confined to Western countries but now occurs in all continents except Antarctica and becoming a globally invasive species (Wethington *et al.*, 2007; Jarne *et al.* 2014). A characteristic that might contribute to the invasion success of *P. acuta* is the remarkable reproductive plasticity within the species (Clampitt, 1970; Monsutti *et al.*, 1999). A report of IUCN red list Data says that the population of this species is growing rapidly thus increasing its range extension as the species is highly pollution tolerant and also resists heavy metal and organic pollution.

Conclusion

Inventorisation and taxonomic studies of Mollusca fauna of the state are sketchy and still in infancy. Considering the vastness and richness of the biodiversity of the state, more new findings are expected from this region if thorough research is done in this field. Most of the work in Mollusca taxonomy was done during the British India period. A total of 32 freshwater molluscs have been reported from the state of Arunachal Pradesh which belongs to 2 classes, 7 orders, 12 families and 20 genera including two invasive freshwater species, *P. cuta* and our own native species *M. tuberculata*. Thirty species of the freshwater molluscs reported from the state belong

to the least concerned category of IUCN Red List of Threatened Species. However, the conservation status of two indigenous species whose type locality is contained in Arunachal Pradesh viz., *Paludomus aborensis* and *Paludomus rotungensis* were not evaluated. *Physella acuta* which is an exotic species is reported for the first time from the state.

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