



## Freshwater molluscan diversity of India-Threats and conservation

Sandhya Leeda D'Souza

Department of Zoology, St. Joseph's University, Bangalore, Karnataka, India

### Abstract

In this paper, the diversity and regional patterns on distribution of freshwater molluscs in India, their existing threats, and habitat-based approaches to their conservation are reviewed. About 212 molluscan species are known from the freshwater habitats of India. Highest number of molluscs species are confined to Western Ghats and to Eastern Himalayan hotspots. Molluscs are facing threat due to overharvesting, construction of dams, mining and urban developments in the freshwater habitats. Future studies on molluscs need to concentrate on data collection by extensive sampling to understand of species distribution. Conservation of freshwater molluscs should be prioritised based on threat status at species specific sites.

**Keywords:** Rivers, paddy fields, anthropogenic activities, environment

### Introduction

India has various freshwater habitats namely ponds, streams, rivers springs, lakes, groundwater, flood plains, bogs, marshes and swamps, as well as semi-natural manmade habitats like paddy fields, fish-ponds, reservoirs and tanks. Lentic ecosystems are standing water bodies includes lakes and ponds whereas lotic ecosystems are rivers and streams (Ramesha *et al.*, 2013) <sup>[44]</sup>. They are the constantly changing habitats wherein the species adapt to the fluctuations in the environmental conditions, pollution and climate change. These ecosystems are among the most threatened on the planet facing unprecedented pressures due to anthropogenic disturbances (Aravind *et al.*, 2016) <sup>[5]</sup>. The species associated with these habitats render ecosystem services such as regulating water quality, food web and nutrient cycling.

Molluscs are found in a wide range of freshwater habitats, have different life-history strategies and exhibit complex ecological interactions, due to which they can be used in environmental assessment (Seddon *et al.*, 2010). Further, they maintain wetland ecosystems, by the control of water quality and nutrient balance through filter-feeding, algal-grazing, as a prey for other species. They are the prominent links in the trophic levels and play significant roles in biogeochemical cycles (Sarwade *et al.*, 2015) <sup>[52]</sup>.

Freshwater molluscs are known for their ecological and economic importance. Freshwater snails such as *Pila* sp. are consumed by people for their taste and nutritive value. Due to the good quality meat and protein contents freshwater mussels are suitable for human consumption. Mother of pearl is found inside freshwater mussels which can be used to make pearls, buttons and ornaments (Ozkahya *et al.*, 2012) <sup>[32]</sup>. As vectors, freshwater molluscs are the intermediate host of many trematodes, of which schistosomiasis is recognised need as a potential threat to human population (Ramakrishna and Dey, 2007). Because of their significance, the review focusses on species inventories from freshwater ecosystems of India.

Indo-Burma region comprises 325 currently known freshwater gastropod species belonging to 20 families (Allen *et al.*, 2008). The inventories on freshwater molluscs of India began in 20<sup>th</sup> century. The first contribution to explore the diversity of molluscs from freshwater habitats of

India is Subba Rao (1989) <sup>[58]</sup> wherein detailed account on 285 species of molluscs can be found. Later studies from different regions of India came up. Molluscan diversity has been documented from freshwater habitats of Kerala (Rakhi Gopalan *et al.*, 2014; Vineetha, 2016) <sup>[41]</sup> Western Ghats (Madhyastha, 2001; Aravind *et al.*, 2011; Ramesha *et al.*, 2013) <sup>[6, 27, 44]</sup>.

There are 212 freshwater molluscan species living in the wild in India which placed under 21 genera (Ramakrishna and Mitra, 2002) <sup>[43]</sup>. Subramanian and Jaiswal (2012) <sup>[59]</sup> worked on freshwater fauna of India and observed that the snail *Sulcospira hugely*, common to streams of peninsular India. They also inferred that rivers and streams consist of higher proportion (77%) of molluscan species.

Peter and Ulrich (2013) <sup>[40]</sup> reported described 20 freshwater gastropod species from North India, of which seven are new records to northeast India (Jadhav *et al.*, 2020). Tripathy and Mukhopadhyay (2014) gave a detailed information on taxonomy of Indian freshwater gastropods and bivalves and highlighted their status, conservation and management. Highest freshwater snail endemicity is found in Western Ghats and North-Eastern parts of India (Tripathy and Mukhopadhyay 2014). About 77 freshwater molluscan species are endemic to Western Ghats. Western Ghats being the biodiversity hotspots have been studied for molluscan diversity (Ried *et al.*, 2012; Pati *et al.*, 2014) <sup>[37]</sup>. Although most of the molluscs of family Littorinidae of India are marine, nine species of genus *Cremnochoncus* known to inhabit streams of Western Ghats. Reid *et al* (2012) <sup>[47]</sup> described six new species freshwater snails of genus *Cremnochoncus* from the central Western Ghats in addition to previously existing three species (*C. syhadrensis*, *C. canaliculatus*, *C. conicus*). Aravind *et al* (2016) <sup>[5]</sup> discussed that *Cremnochoncus* spp are point endemics, showing limited distribution and vulnerable to environmental changes. They assessed the conservation status using IUCN Red list criteria and suggested conservation measures. Pati *et al* (2014) <sup>[37]</sup> gave a systematic account of 30 freshwater molluscs from the collections of Western Ghat regional centre. Recently, D'Souza and Shenoy (2023) <sup>[14]</sup> recorded 14 species of molluscs from Western Ghat rivers of Karnataka, showing the impact of seasonal variations on molluscan diversity.

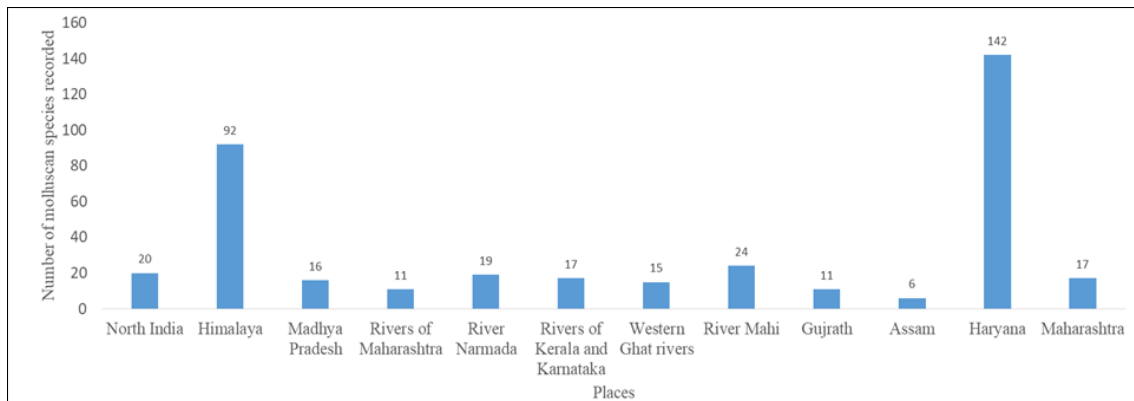
Dey and Mitra (2000) [18] presented a list of 92 species of freshwater molluscs from Himalayan region. Their study indicated that Jammu-Kashmir, is the only region in India which has species of freshwater molluscs similar to those of Central Asia, Europe, and Africa. Bahaar and Bhat (2011) [7] studied the aquatic biodiversity of Jammu and Kashmir and reported five molluscan taxa. Sharma *et al.*, (2013) [55] studied the diversity and distribution of molluscs in the Gho-Manhasan stream of Jammu-Kashmir and reported 11 species. Jadhav *et al.*, (2023) [20] found 18 species of edible molluscs from northeast India.

Molluscan diversity of Maharashtra state has been assessed in detail. The pioneer work on molluscs of Maharashtra Subba Rao (1989) [58], Surya Rao *et al.*, (2002) [60], Annandale and Prasad (1919) [4], Patil and Talmale (2005) [38]. Amrutsagar and Lohar (2011) [3] reported the presence of 17 species of molluscs from Gondoor and Nakane lake of Maharashtra.

Shaikh *et al.*, (2011) [54] identified 11 species from Hotagi tank of Maharashtra and noted the abundance of *Lamellidens marginalis* and *Bellamyia bengalensis*. Waghmare *et al.*, (2012) [63] studied the freshwater molluscs from Bhima river and reported 15 species. They correlated

the diversity to the river pollution. Dahegaonkar *et al.* (2012) [15] studied the freshwater gastropods from river Wardha and opined that water quality affects species composition, abundance, productivity and physiological condition of aquatic communities. Suryawanshi *et al.* (2012) recorded 24 species of molluscs from Nanded region. Bimbisar *et al.*, (2014) [10] nine species of molluscs from Lendi river and Sarwade *et al.* (2015) [52] recorded 10 species of molluscs from Sangli district. About 20 species of molluscs are known from Ujjani wetland (Markad and Pillai, 2021) [28].

Investigations have been carried out on molluscan diversity in other states of India as well (Figure 1). Satyamurthy (1960) gave an account of freshwater molluscs from the collection of Madras government museum. Kumar and Vyas (2012) [23] river Narmada was found to have 19 species of molluscs including 13 species of gastropods and six species of bivalves. The need for attention on exploration of bio-monitoring abilities of molluscan community in the river has been suggested by Kumar and Vyas (2012) [23]. Dey (2008) [17] gave a comprehensive account on six commercial and medicinally important molluscs from freshwater habitats of Sunderbans.



**Fig 1:** Freshwater molluscan inventories from India.

Number of molluscs are reported from Madhya Pradesh (Bhalodia *et al.*, 2001) [9], 9 species from Bardha Wildlife Sanctuary (Patil, 2013) [39], 11 species from Vadodara city (Parikh and Mankodi, 2009) [36], 24 species from Mahi river of Gujarat (Pandya and Vachhrajani, 2012) [35]. Pal and Day (2011) [34] documented 21 species of molluscs from West Bengal, Karuthapandi (2013) [22] showed the freshwater snail *Physa acuta* as new species to Andhra Pradesh and gave a detail on its distribution. Altogether, 23 species of molluscs representing 13 families were recorded from Subarnarekha river of Jharkhand (Pakhira and Chakraborty, 2016) [33] and 18 gastropods and 27 bivalve species have been known from Brahmaputra river basin of Assam (Sonowal *et al.*, 2021) [56], Das and Biswas (2018) [16] identified six species of molluscs from Assam. About 31 snail species were recorded from northeastern hilly regions and agro-climatic zones of Tamil Nadu (Soundararajan *et al.*, 2018) [57] and 5 gastropods from Teekar Taal Haryana (Kumar *et al.*, 2019) [24].

About 16% of the freshwater molluscs assessed for the IUCN Red List are threatened with extinction (Molur *et al.* 2011) [30]. Among these seven are threatened species and 51 species as least concerned and 19 species listed as data deficient. Freshwater molluscs (36%) of Western Ghats are least endemic than terrestrial snails (76%) (Aravind *et al.*,

2005). Studies on molluscs emphasize research on ecology, distribution and population change in the freshwater molluscs. Research on freshwater molluscs has increased gradually in the last decade. The molluscan inventories have been carried out from Western Ghats, rivers of Karnataka and confined to wetlands/specific sites (Aravind *et al.* 2005; Shafakatullah 2012; D'Souza and Shenoy 2023) [14, 53]. Although freshwater molluscan taxonomy is known from the Western Ghats, many species are yet to be discovered (Aravind *et al.*, 2011) [6].

Dorlikar *et al.*, (2014) [19] studied the molluscan diversity of Gorewada reservoir, Nagpur and correlated species diversity with physico-chemical characteristics of water. The molluscs of family Unionidae were more in number. Rayate and Patil (2019) [46] studied molluscs of Godavari, Mula and Pravara rivers of Ahmednagar district and noted the occurrence of 11 species of gastropods. They stressed on the ban on anthropogenic disturbances and conservation of these habitats and associated species.

Bivalves are source of food and used in preparing medicinal products, monitoring water quality and past environments products the filtration, sequestration, storage and/or transformation of biological and physico-chemical water properties (Zeiritz *et al.*, 2022). Few studies have focussed on freshwater bivalve diversity and their ecology. Benson

(1862)<sup>[8]</sup> was the pioneer to work on Unionidae. Blandford (1867)<sup>[11]</sup> contributed to the malacology by listing the species of *Unio* and *Anodonta* from India, Burma and Sri-Lanka. Rao (2001)<sup>[45]</sup> listed 17 species of molluscs and Neemann *et al.*, (2005)<sup>[31]</sup> reported 28 species of bivalves from river Ganga. They described the distribution and habitats of molluscs and suggested that these taxa can be used for assessment of water quality.

Molluscan diversity from freshwater habitats of Karnataka has been explored from rivers of Western Ghats. Madhyastha (2001)<sup>[27]</sup> conducted survey on freshwater snails of Western Ghat rivers and found rare species of bivalve *Pseudomulleria* from Tunga and Bhadra rivers. This bivalve species is believed to show discontinuous distribution and is an examples for living fossil. About 19 species of freshwater bivalves have been reported from the rivers of Western Ghats (Ramesha *et al.* 2013)<sup>[44]</sup>. In total, 60 species of freshwater molluscs are known from Western Ghats (Aravind *et al.* 2011)<sup>[6]</sup>. Recent inventories recorded 15 species of molluscs from river Souparnika, Netravathi and Sharavathi rivers of Western Ghats (D'Souza and Shenoy, 2023)<sup>[14]</sup>. Shafakatullah (2012)<sup>[53]</sup> working on rivers of Karnataka and Kerala, and identified 14 species of freshwater bivalves. Amanullah and Hameed (1996)<sup>[2]</sup> studied molluscan diversity of Kaveri river system with special reference to vector snails of trematode species. They recorded 13 species of molluscans which consisted of eight gastropod and five bivalve species. Amidst these, five gastropods were carrying disease causing cercarial larvae.

The freshwater molluscs of Guntur district are represented by 24 species (Janaki Ram and Radhakrishna, 1984)<sup>[21]</sup>. Karekal *et al.*, (2010) studied diversity and abundance of molluscs in Bhutnal reservoir of Bijapur district of Karnataka. Eleven species of molluscs have been identified of which eight were gastropods and three were bivalves. Dsouza *et al.*, (2024) listed five species of molluscs from paddy fields of coastal Karnataka and elucidated the factors governing the diversity of snails in these wetlands.

## Threat to Molluscs

### 1. Mining

Illegal mining of sand is prevalent in Western Ghats and Government policies on sand mining are lacking leading to degradation of riverbed and harming the aquatic species. Sand mining and dredging disturbs habitat through changing the physical structure of the river bed, impacting water quality, reducing habitat heterogeneity and therefore leading to a change in the community composition and to the local extirpation of species.

Bivalves being burrowers and filter feeders, are susceptible to change in the soil porosity and turbidity that will cause negative impact on populations. The studies addressing impact of sand mining on molluscs are lacking, prioritising the research on effect of sand mining on mollusc population. Frequent dredging and dumping of organic waste from slaughter have led to the closure of Thaneermukham Barrage near Vembanad Lake, threatening the freshwater molluscs (Laxmilatha and Appukuttan, 2002)<sup>[25]</sup>. In the Western Ghats bivalve *Pseudomulleria dalyii* is found only in five locations and has a limited extent of occurrence. The construction of dams on Tunga and Bhadra rivers and water pollution in the Tunga River are causing major habitat degradation affecting their specialised habitat, rocky river bottoms (Aravind *et al.*, 2011)<sup>[6]</sup>.

Mining causes direct and indirect effects on ecosystem. Removal of floodplains habitat involves extraction of sand particles impacts directly on the ecosystem whereas physical changes in the rivers have indirect impact on the ecosystem. Direct impacts are those in which the extraction of materials directly responsible for the ecosystem impact. Indirect impacts are related to ecosystem changes that are propagated through the system due to physical changes in the river system resulting from sand extraction (Aravind *et al.*, 2011)<sup>[6]</sup>. Sand mining removes the sand bed from the river, its flow and hydraulics, sediment modifies the habitats and functioning of ecosystems. The removal of sand takes place at slower rate, and only few changes may be observed for an extended period.

### 2. Pollution

Pollution of waterbodies and unsustainable harvesting of freshwater molluscs in the Western Ghats region lead to their extinction or decreases the survival rates. Agriculture, sewage and urban runoff, industrial effluents from shrimp and fish processing industries are major sources of pollution in freshwater habitats of India in general and in Western Ghats (Laxmilatha and Appukuttan, 2002)<sup>[25]</sup>, Mining, industries *viz.* iron ore, paper and textile mills, and washing and bathing are prevalent along Western Ghat hotspot. Continuous deforestation, runoff and sedimentation, heavy monsoons in the Western Ghats deteriorated the freshwater habitats. Moreover unsustainable land use practices are detrimental to the survival of molluscs. The bivalves get affected due to loss of sedimentation of rivers. Besides excessive sedimentation reduces habitat heterogeneous habitats needed for the survival bivalve population. However, some highly tolerant gastropod species such as *I. exutus*, *L. luteola*, *L. acuminata*, and *G. convexiusculus* will remain in such habitats.

Freshwater bivalves accumulate toxins faster indicates that bivalves are extremely sensitive to water pollution (Salanki *et al.*, 2003) and have been adversely affected in polluted habitats. Another major source of pollution, usage of more than 5,000 house boats in operation, human activities (washing and bathing), agricultural pollution and fishing using chemicals are all major threats as well. The subpopulation of *Pseudomulleria dalyii* in the Tunga river is restricted (Madhyastha, 2001)<sup>[27]</sup>. More research is needed on the impact of pollution upon the molluscs of the Western Ghats, Many species have been destroyed because of pollution and some remain unnoticed.

### 3. Overharvesting Molluscs

Bivalve species belonging to *Parreysia*, *Corbicula*, *Lamellidens* are harvested for human consumption especially in the coastal regions of Karnataka and Kerala. The size and impact of this harvest on the population is not known, however for most of these species it is not thought to be so significant as to cause them to be threatened. *Villorita cornucopia* and *V. cyprinoides* are commercially important molluscs harvested extensively from the wild population in Kerala. These species are facing threat from continuous harvesting of molluscs from their native habitat. Capture of species needs to be monitored and population check is recommended. *P. dalyi* is the only threatened molluscan species impacted by harvesting. Fishes are hosts to *P. dalyi* till they complete the life cycle. Overharvesting fishes that are hosts of *P. dalyi* in Tunga river has led to the

decline in population of the host and this bivalve (Aravind *et al.*, 2011)<sup>[6]</sup>.

#### 4. Water Abstraction and Dams

Freshwater molluscs are facing threat due to water abstraction, water diversion and construction of dams. In the Western Ghats there are large dams and reservoirs constructed. Further few dams have been proposed for hydro-electric projects in the region. The upcoming Gundia hydel project in Hassan District would cut down 1,900 acres of primary evergreen forest and harming the riverine habitats. This project has is expected to cause biodiversity loss in general and Unionid population in particular.

Unionid population is likely to be affected if such projects are implemented, would seriously affect the aquatic mollusc fauna across the region (Salmon and Green 1983)<sup>[49]</sup>. There is ample evidence to show that dams contribute to the overall depletion of unionoid populations by restricting their distributions and isolating populations from each other (Watters, 1999)<sup>[64]</sup>.

*Pseudomulleria dalyi*, inhabits the freshwater habitats of Western Ghats, is facing high level of threat. Bhadra Project undertaken by Karnataka state government involves the construction of a dam on the Bhadra River. *P. dalyi* population has drastically declined at this location because of flooding (Madhyastha, 2001)<sup>[27]</sup>. The Tunga dam located near Shimoga has impacted the population of *P. dalyi*. The idakkal dam that is built at Ghattaprabha River, gets dried up the river during the summer months. Hence the threatened mollusc *Arcidopsis footei* cannot survive because of lack of water (Aravind *et al.*, 2011)<sup>[6]</sup>. It is now feared that the species is extirpated from this area (Madhyastha and Mumbrekar, 2006)<sup>[26]</sup>. The same species is also likely impacted by a dam that has been constructed across the Tunga River at Gajanur, Shimoga in Karnataka and recently another dam project is taking place in the upper Tunga River, to increase the height of the existing dam (Madhyastha and Mumbrekar, 2006)<sup>[26]</sup>. Removal of water withdrawal, siltation and changes in the hydrological regime are occurring throughout its range and resulting in localized declines.

Construction of dams leads to variation of river flow, increased sedimentation, loss of fish-hosts, and habitat degradation. These impacts are applicable to the freshwater habitats of India in general and to Western Ghats. However, data on impact of dams on freshwater ecosystem is not known completely (McAllister *et al.*, 2001)<sup>[29]</sup>

Although Western Ghats are pristine ecosystems, invasive molluscan species not documented. However, other invasives, particularly plants, are very numerous in the freshwater ecosystems especially in lentic habitats. The plant species such as *Eichhornia crassipes*, *Ipomea* sp., *Pistia* sp. and *Salvinia* sp. are found in standing waters of this region. These plant species favour the growth of gastropods such as *Lymnaea luteola*, *L. acuminata*, *Indoplanorbis exutus* and *Gyraulus convexiusculus*. The death and decomposition of invasive plants increase turbidity levels and decrease the dissolved oxygen (Aravind *et al.*, 2011)<sup>[6]</sup>.

#### 5. Developments Along the Rivers

Road widening and construction of bridges across rivers, dredging to erect pillars, and consequent pollution from oil spills from heavy machinery has led to the decline in

diversity of aquatic biota in the Western Ghats. Road widening work of NH 17 from Karnataka border to Kundapura that was completed recently in on the western coast of India has altered the structure of eight west flowing rivers that are originating from Western Ghats. The real estate industries and developmental activities along the banks of the rivers and waste disposal have narrowed down the width of the rivers. A comprehensive studies on the impact of these activities on the freshwater molluscs are lacking and to be carried out as a priority (Aravind *et al.*, 2011)<sup>[6]</sup>.

#### Conservation recommendations

##### Species-specific conservation programmes

The gap in the knowledge of species distributions, ecology, population trends and threats has hampered the conservation planning of molluscs. The species-specific conservation programmes are not implemented for freshwater regions of Western Ghats (Budha *et al.*, 2011)<sup>[13]</sup>. Threatened molluscs needs to be protected by conserving their wild habitats, minimising construction of dams, preventing forest loss and afforestation, reducing pollution, and establishment of protected areas by restricting the human activities. The molluscs require correct flow regimes with suitable water quality. Thus the aquatic habitats their watersheds regenerated and further loss of biodiversity can be anticipated (Aravind, 2014).

Environmental Impact Assessments consider the molluscan species and variation in their habitats effecting the freshwater ecosystems. The data pertaining to the freshwater molluscs and their habitats and the species distribution information from the IUCN Red List is expected to provide an initial information source for EIAs. However, field surveys are needed to add more on the distribution of species (Aravind, 2014).

**1. Conservation education and awareness:** Unlike the higher taxa molluscs have not gained the conservation importance. Because the standard literature on molluscan identification was lacking. Nevertheless, Aravind and Jadhav (2003) highlighted the ecology, threat status of edible non-marine molluscs of India. More data on molluscs needs to be collected on a broader scale. However, creating awareness on the importance of molluscs to ecosystems and to people is required. Awareness about the freshwater molluscs should be created among the public, forest managers and policy makers about their conservation. Involvement of local communities and stakeholders is necessary to implement conservation measures (Aravind *et al.*, 2011)<sup>[6]</sup>.

Studies on ecology of each species and their conservation are emerging in snail's pace. In the last decade, three species of *Cremnoconchus* are known to be threatened, are assessed placed in IUCN Red List. These species show limited distribution and vulnerable to environmental changes, conservation status has been assessed 'Red List' criteria and conservation measures are recommended (Aravind *et al.*, 2016)<sup>[5]</sup>. In general habitat and catchment-based conservation methods should be planned to save the population than a species-based approach. Conservation of freshwater molluscs requires long-term monitoring of the population and their habitat risk assessment. Besides, snail

farming is recommended for molluscan conservation (Jadhav *et al.*, 2023)<sup>[20]</sup>.

## 2. Research Actions

In India, diversity of freshwater molluscs is known from Western Ghats region and north eastern Himalayas than the other states (Aravind *et al.*, 2011; Aravind and Jadhav, 2023; Budha *et al.* 2011)<sup>[6, 13, 20]</sup>. Future research should concentrate on ecosystem services provided by freshwater molluscs, the distribution patterns, population status and dynamics of molluscs, the impact of aquatic invasive plants, and their species-specific threats. Studies needs to be carried on data deficient molluscs, studying the ecology or natural history of molluscs by revisiting type specimens to know their taxonomic status (Budha *et al.*, 2011)<sup>[12]</sup>.

## 3. Conservation for livelihood of people

Many freshwater molluscs are used as food *viz.* *Parreysia* sp., *Lamellidens* sp., *Corbicula* sp., *Villorita spp.* *Villorita cornucopia* and *Villorita cyprinoides* are harvested for black clam fishery. *V. cyprinoides* found in Aghanashini estuary (west coast of India) is consumed as food. *Pila globosa* is used for treating sore eyes in Southern India and in treatment of wounds in poultry (Boominathan *et al.*, 2008)<sup>[12]</sup>. Rearing these species separately and minimising their collection would help to protect their population.

## Conclusion

India constitutes 4% of the global freshwater ecosystems. A number of studies have been carried out on freshwater molluscs of India. However, the molluscan inventories are limited to Western Ghats and north eastern parts of India because of their endemism. Few studies have focussed on major Indian rivers and others limited to the states. Threatened molluscs needs to be protected by conserving their wild habitats, minimising construction of dams, preventing forest loss and afforestation, reducing pollution, and establishment of protected areas by restricting the human activities. Status of some molluscs has been assessed are placed in IUCN Red list and conservation measures are recommended. Data deficient species can be identified by using type specimens to know their taxonomy.

## Acknowledgements

Author is thankful to SJU, India for the support.

**Competing Interests:** Author does not have any competing interests.

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