INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 9, No. 6, p. 69-77, 2016
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Evaluation of pearl mussels diversity in Terai region of Eastern Himalaya, India

Arpita Dey[1], Ruksa Nur[1], Uday Kumar Udit[*2], Shailesh Saurabh[2], Sudip Barat[1]

[1]*Aquaculture and Limnology Research Unit, Department of Zoology, University of North Bengal, Darjeeling, Siliguri, West Bengal, India.*

[2]*Central Institute of Freshwater Aquaculture, Indian Council of Agricultural Research, Kausalyaganga, Bhubaneswar, Odisha, India.*

Article published on December 30, 2016

Key words: Terai region, Eastern Himalaya, Bivalve, Pearl mussels diversity

Abstract

The present study was conducted to evaluate and generate a primary database on bivalve diversity found in the water bodies of Terai region of Eastern Himalaya, West Bengal, India. A total of 20 species belonging to two genus *Lamellidens* and *Parreysia* were recorded. The availability of maximum molluscs was observed during the summer months of April to June. The most dominant species among genus *Lamellidens* and *Parreysia* were *L. Marginalis* and *P. triembolus,* respectively. Among the above observed bivalves species, *Lamellidens consobrinus* (L=11.2cm, D=5.6cm) was the largest in size and *Parreysia lima* (L=2.8cm, D=1.5cm) the smallest. The evaluation of conservation status of the bivalves and the results of the present study revealed that 14 species were considered as Lower Risk Least Concern and 6 species were Data Deficient. Also, the study revealed that 6 species were of relative abundance (+++) such as *Lamellidens marginalis, Lamellidens jenkinsianus obesus, Lamellidens corrianus, Parreysia triembolus, Parreysia favidens, Parreysia favidens assamensis* and 5 species were of very less abundance (+) in the study areas and these included *Lamellidens jenkinsianus daceaensis, Lamellidens jenkinsianus, Parreysia bonneaudi, Parreysia pachysoma* and *Lamellidens phenchoganjensis.* Ten species have more food value than the rest of the species. Despite its abundant food value, several wild populations of bivalves have been suffering drastic reduction. So, awareness programmes amongst the fishermen and local people and strict ban of illegal monsoon collection of bivalves from rivers and water bodies should be promulgated. It is concluded, that anthropogenic pressure has posed threat to the bivalve diversity.

***Corresponding Author:** Uday Kumar Udit ✉ uday4cife@gmail.com

Introduction

The Eastern Himalaya comprises Bhutan, Northern part of West Bengal, Sikkim North- Eastern India and Southern, Central and Eastern Nepal. Strictly speaking, the Eastern Himalayan region comprises of two large hotspots: the Indo-Burma and the Himalaya Hotspots (CEPF, 2005). The Eastern Himalaya with rich biodiversity is under immediate threat of species extinction and habitat destruction due to tremendous pressure from demo technic growth and natural environmental changes. The Molluscs are soft bodied invertebrates with a shell, in which the soft parts are enclosed. It is the second largest phylum in the invertebrates comprising more than 100,000 species worldwide of which, 5070 species are present in India (Venkataraman and Wafar, 2005). The first Mollusc appeared at the end of the Pre-Cambrian period, approximately 550 million years ago (Sturm *et al.,* 2006). Gastropods and bivalves constitute 98% of the total population of mollusc (Anandaraj *et al.*, 2012).

According to Araujo and de Jong (2015) Bivalves (8,000 species) are the second richest mollusc class after the Gastropoda (60,000 species). Freshwater bivalves live in rivers and lakes around the world except Antarctica. They represent three subclasses, 19 families, 206 genera and about one thousand species (Bogan, 2008). European freshwater bivalves belong to the orders Unionoida and Cardiida (Carter *et al.,* 2011). Freshwater bivalves Unionidae is the largest family of freshwater bivalves in the world (Sicuro, 2015). Unionids have a world-wide distribution with very high species diversity in North America, China and South East Asia (Karatayev *et al.,* 2007; Bogan, 2008; Bogan and Roe, 2008). The bivalves shell consists of two calcified halves or valves and a typically wedge-shaped foot (Subba Rao, 1989). The shell is bilaterally symmetrical and valves are closed and opened by two adductor muscles. Bivalves inhabit usually water bodies, marine, estuarine, as well as fresh water; many are also terrestrial, often associated with moist shaded lands. They filter water continuously and feed on phytoplankton. During the inhalant siphons and exhalent siphon process the suspended soil particles, excess algal blooms and metal ions (Cu, Zn, Ni etc.) are removed from the water.

Bivalves, which include clams and oysters, contribute to the livelihoods of many people in India. Bivalves are used for edible purpose, source of lime, as decorative shells for industrial purpose (Mohanty and Saurabh, 2015).

Freshwater bivalves play an important role in lotic and lentic ecosystems and their presence or absence in stream has manifold implications for aquatic ecosystems. The mussels are ecologically important because of their widespread distribution and biological filtration activity (Lewandowski and Stanczykowska, 1975; Kasprzak, 1986) and also economically, used as food and production of freshwater pearls (Subba Rao and Dey, 1989). Molluscs have been exploited worldwide for food, ornamentation, pearls, lime, and medicine (Nayar and Rao, 1985; Saurabh *et al.,* 2014). Subba Rao (1989) made a conservative estimate of 66,535 species, out of which 5070 (7.62%) species were recorded from India.

Cooch Behar district of West °Bengal, India lying between 25°57′47″ to 26°36′2″ North latitude and between 89°54′35″ to 88°47′44″ East longitude, is very unique in its topography and climatic characteristics bearing Terai agro-climatic characteristics and a total water stretch of more than 6121 ha including hill stream rivers, wetlands and others aquaculture resources.

The total riverine network includes some major rivers like Torsa, Ghargharia, Kaljani, Gadadhar and so on which are the potential sources of huge aquatic biodiversity. Cooch Behar district is situated on the foothills of Eastern Himalaya.

The Eastern Himalaya having rich biodiversity is under immediate threat of species extinction. The Eastern Himalayan region also comprises of two large hotspots: the Indo-Burma and the Himalaya Hotspots (CEPF 2005). This means that the region contains exceptional levels of plant endemism (at least 1,500 endemic species) and has lost 70% or more of its original habitat (Myers *et al.,* 2000).

Limited information or report exists on biodiversity of freshwater Mollusca in India. Patil and Talmale (2005) reported 142 species of molluscs with all forms and varieties belonging to 48 genera and 23 families from the Maharashtra state; Anandaraj *et al*., (2012) reported 40 species of mollusc from Tamil Nadu; Souji and Radhakrishnan (2013) reported 6 species from Southern Coast of India; Rao *et al*., (2013) recorded a total of 14 species of bivalves in 10 families and 10 species of gastropods in 15 families; Bhuiyan *et al*., (2013) reported 6 species from Bangladesh, 5 bivalve species were reported by Souji *et al*., (2014) from South East coast of India;10 species of molluscs were identified by Sarwade *et al*., (2015) from Maharashtra, having seven families, that is, *Physidae, Lymnaeidae, Viviparidae, Corbiculidae, Thiaridae, Planorbidae* and *Littorinidae* included in class Gastropods and Bivalve. The existing literature does not give any distribution of bivalve in different water bodies of the Cooch Behar district, West Bengal, India. The present study, therefore, is aimed at to generate a database of the bivalve diversity, relative abundance, economic importance, conservation status and distributional pattern in the water bodies of Cooch Behar district of West Bengal, India.

Materials and methods

Study areas

The work was surveyed over a period of one year (June 2015 to July 2016). Live specimens and dead shells were collected from local ponds, Gadadhar river, Ghargharia river, Kaljani river, Loknath beel, Chandi beel, Gumai beel and Aludhuya Chhara of Cooch Behar district of West Bengal, India.

The sampling areas were divided into 7 sites namely, Chandi beel (26°19' N latitude and 89°33' E longitude), Gumai beel (26°19' N latitude and 89°34' E longitude), Aludhuya Chhara (26°20' N latitude and 89°33' E longitude), Loknath beel (26°21' N latitude and 89°33' E longitude), Ghargharia river (26°26' N latitude and 89°32' E longitude), Kaljani river (26°18' N latitude and 89°35' E longitude) and Gadadhar river (26°18' N latitude and 89°38' E longitude).

Experimental procedure

Freshwater mussels were collected from different sites with the help of fishermen using different types of nets, hand dredge and other locally designed fishing gears. In ponds, the collection was made by scooping the bottom mud and then sieving and washing with water. Sometimes, in rivers, samples were collected by Ekman dredge. Mussels shells after collection were washed and cleaned. After washing the shells were dried in sunlight. Dried shells were separated on the basis of similarities and dissimilarities of morphometric characters like umbo shape, growth lines, ligament, cardinal teeth, lateral teeth, hinge line, pallial line, colour and shape of valves. Similar types of samples were marked and put in a container. Photographs were taken from fresh samples by camera (Nikon, Coolpix L24) and were identified following their general body form and morphometric characteristics using standard taxonomic keys of Subba Rao (1989) and Ramakrishna and Dey (2007). Conservation status of mollusc was given as per International Union for Conservation of Nature (IUCN, 2016).

Result and discussion

In the present study, about 20 species of Class Bivalves were recorded from June 2015 to July 2016 (Table 1). Twenty freshwater mussel species belonging to the Order-Unionida, Family-Unionidae, Class Bivalvia under two genus *Lemellidens* and *Parreysia* were recorded for the first time from Cooch Behar, West Bengal, India. Of the genus *Lamellidens,* 8species namely *Lamellidens marginalis, Lamellidens phenchoganjensis, Lamellidens jenkinsianus, Lamelliden jenkinsianus obesus, Lamellidens jenkinsianus daceaensis, Lamellidens generosus, Lamellidens consobrinus* and *Lamellidens corrianus* were identified. Twelve *Parreysia* species, *Parreysia andersoniana, Parreysia bonneaudi, Parreysia favidens, Parreysia favidens deltae, Parreysia favidens plagiosoma, Parreysia favidens assamensis, Parreysia occata, Parreysia caerulea, Parreysia lima, Parreysia caerulea goudichaudi, Parreysia triembolus* and *Parreysia pachysoma* were also identified.

The availability of maximum number of molluscs were observed during the summer months April to June. The most dominant species among genus *Lamellidens* contributing to the study was *Lamellidens marginalis.* In genus *Parreysia*, dominant species was *Parreysia triembolus.* Among above bivalves species, *Lamellidens consobrinus* was the largest species and *Parreysia lima* the smallest. The evaluation of conservation status of the Bivalves and the results of the present study revealed that 14 species were Lower Risk Least Concern and 6 species were Data Deficient. Ten species had more food value from the rest of the species. Present study revealed, that 6 species were of relative abundance (+++) such as *Lamellidens marginalis, Lamellidens jenkinsianus obesus, Lamellidens corrianus, Parreysia triembolus, Parreysia favidens, Parreysia favidens assamensis* and 5 species of very less abundance (+) in the study areas. Very less abundance species were to *Lamellidens jenkinsianus daceaensis, Lamellidens jenkinsianus, Parreysia bonneaudi, Parreysia pachysoma* and *Lamellidens phenchoganjensis.*

The abundance of Molluscan populations are good indicators of localized condition of water means indicating less pollution of water quality. They also play important role in the ecosystem structure and biodiversity. Amongst the seasons the molluscan species showed lower diversity in monsoon compared to summer.

From the present study, 20 species of bivalves were reported which belonged to two genera *Lamellidens* and *Parreysia* .Some new species were found but not identified till now. Patil and Talmale (2005) reported 142 species belonging to 48 genera and 23 families whereas, Sarwade *et al.,* (2015) reported 10 species of molluscs from the Maharashtra state; Anandaraj *et al.*, (2012) reported 40 species of mollusc from Tamil Nadu; Souji and Radhakrishnan (2013) reported 6 species and Souji *et al.*, (2014) reported 5 bivalve species from Southern Eastern Coast of India; Rao *et al.*, (2013) a total of 14 species of bivalves in 10 families and 10 species of gastropods in 15 families ;Bhuiyan *et al.*, (2013) reported 6 species from Bangladesh of which there was of seven families, that is, *Physidae, Lymnaeidae, Viviparidae, Corbiculidae, Thiaridae, Planorbidae* and *Littorinidae* included in class Gastropoda and Bivalvia. Despite its abundant food value, several wild populations of bivalve have been suffering drastic reduction. The reduction in population may due to the anthropogenic pressure being created by local people who use its for food.

There were many diverse bivalve population in the past, but due to indiscriminate fishing of molluses by local people for making delicious traditional food items has resulted in the study declaim of the population. Bivalve flesh has nutritional as well as medicinal value for arthritis (Chakraborty *et al.,* 2012).

Table 1. Bivalve diversity along with their size, relative abundance, distribution, economic value and conservation status in water bodies of Cooch behar district, W.B., India.

Sl.No.	Species name	Average sample size	Relative abundance	Distribution	Economic value	Conservation Status
1	*Lamellidens marginalis*	L=10.2cm,D= 5cm	+++	Ind, Bur, Bag, Sri	Fd+	LC
2	*Lamellidens phenchoganjensis*	L=10.3cm,D=4.6cm	+	Ind.Ban	Fd+	LC
3	*Lamellidens jenkinsianus obesus*	L=10.1cm,D= 4.8cm	+++	Ind,Bur,Ban	Fd+	DD
4	*Lamellidens generosus*	L=9.9cm,D= 5.2cm	++	Ind,Bur	Fd+	LC
5	*Lamellidens jenkinsianus daceaensis*	L=9.3cm, D=5.1cm	+	Ind,Ban	Fd+	DD
6	*Lamellidens jenkinsianus*	L=9.2cm, D=.6cm	+	Ind,Bur,Ban	Fd+	LC
7	*Lamellidens consobrinus*	L=11.2cm, D=5.6cm	++	Ind, Sri	Fd+	LC
8	*Lamellidens corrianus*	L=7.9cm, D=3.7cm	+++	Ind, Ban, Bur	Fd+	LC
9	*Parreysia bonneaudi*	L=4.1cm, D=2.1 cm	+	Ind,Bur	Fd	LC
10	*Parreysia triembolus*	L=4.6cm, D=2.8cm	+++	Ind	Fd+	LC
11	*Parreysia favidens deltae*	L=3.6cm, D=2.4cm	++	Ind	Fd	DD
12	*Parreysia andersoniana*	L=4.2cm, D=2.1cm	++	Ind	Fd	LC
13	*Parreysia caerulea goudichaudi*	L=4.9cm, D=2.4cm	++	Ind, Ban	Fd	DD

Sl.No.	Species name	Average sample size	Relative abundance	Distribution	Economic value	Conservation Status
14	*Parreysia favidens plagiosoma*	L=4.5cm, D=2.7cm	++	Ind	Fd	DD
15	*Parreysia lima*	L=2.8cm, D=1.5cm	++	Ind	Fd	LC
16	*Parreysia caerulea*	L=5.4cm, D=2.7cm	++	Ind,Bur	Fd+	LC
17	*Parreysia favidens assamensis*	L=3.8cm, D=2.4cm	+++	Ind	Fd	DD
18	*Parreysia occata*	L=3.8cm, D=2cm	++	Ind,Ban	Fd	LC
19	*Parreysia favidens*	L=3.5cm, D=2.2cm	+++	Ind,Ban	Fd	LC
20	*Parreysia pachysoma*	L=3.8cm, D=1.9cm	+	Ind,Ban,Bur	Fd	LC

Note: Fd+ = Food value more and Fd= less food value. Abundance category: +++ = relatively abundant, ++ = relatively less abundant and + = very less abundant. According to IUCN (2016) DD= Data deficient and LC =lower risk least concern. Distribution: Ind= India, Bur =Burma, Ban =Bangladesh, Sri=Sri Lanka. L=Length, D= Depth of valves.

Fig. 1. Physical map of the sampling sites of Terai region of West Bengal, India.

Fig. 2 & 3. Inner and outer views of *Lamellidens marginalis*

Fig. 6 & 7. Inner and outer views of *Lamellidens jenkinsianus obesus*

Fig. 4 & 5. Inner and outer views of *Lamellidens phenchoganjensis*

Fig. 8 & 9. Inner and outer views of *Lamellidens generosus*

Fig. 10 & 11. Inner and outer views of *Lamellidens jenkinsianus daceaensis*

Fig. 12 & 13. Inner and outer views of *Lamellidens jenkinsianus*

Fig. 14 & 15. Inner and outer views of *Lamellidens consobrinus*

Fig. 16 & 17. Inner and outer views of *Lamellidens corrianus*

Fig. 18 & 19. Inner and outer views of *Parreysia bonneaudi*

Fig. 20 & 21. Inner and outer views of *Parreysia triembolus*

Fig. 22 & 23. Inner and outer views of *Parreysia favidens deltae*

Fig. 24 & 25. Inner and outer views of *Parreysia andersoniana*

Fig. 26 & 27. Inner and outer views of *Parreysia caerulea goudichaudi*

Fig. 28 & 29. Inner and outer views of *Parreysia favidens plagiosoma*

Fig. 30 & 31. Inner and outer views of *Parreysia lima*

Fig. 32 & 33. Inner and outer views of *Parreysia caerulea*

Fig. 34 & 35. Inner and outer views of *Parreysia favidens assamensis*

Fig. 36 & 37. Inner and outer views of *Parreysia occata*

Fig. 38 & 39. Inner and outer views of *Parreysia favidens*

Fig. 40 & 41. Inner and outer views of *Parreysia pachysoma*

Conclusion

Bivalves are among the most fascinating, most widespread, and most endangered animals in fresh waters. They play important roles in freshwater ecosystems and are economically valuable for their shells and pearls. Recent research, fuelled by concern over widespread extinctions and population declines, has produced valuable and even astonishing insights into the ecology, biology, and conservation needs of these animals. Bivalve transfer nutrients and energy from the water column to the sediments through their filtering activity and stimulate production across trophic levels (Howard and Cuffey 2006, Spooner and Vaughn 2006, Vaughn *et al.,* 2007). The present investigation can be regarded as a valuable contribution in generating information towards the database on the Bivalve diversity in different reaches of water bodies of Cooch Behar district, West Bengal, India. Damming, deforestation, diversion and withdrawal of water for irrigation, urban and industrial consumption have caused large scale changes in the channel bed and hydrology of the river in terms of flow, flow-rate, flood-rhythm and regime. The consumption of these species will definitely give an opportunity to the local people to get their livelihood. However, it can be considered as a good raw material used for the enrichment of handicraft cottage industry in our country. Spawning of bivalve occurs during the monsoon season of the bivalves therefore, creating awareness programmes amongst the fisher man and local people and strict ban of illegal monsoon collection of bivalves from rivers and water bodies should be encouraged. The protection of breeding grounds from agricultural run-offs and indiscriminate collection of commercially important species should be initiated which would ultimately protect and conserve the Bivalve species diversity of the rivers and reservoirs of Cooch Behar district, West Bengal, India.

This study is useful for Molluscan researchers as it will help to know the basic idea about Bivalve diversity and also helps in future use and alteration of their habitat must carefully planned with this knowledge in mind to prevent any further irrevocable loss of biodiversity.

Acknowledgements
The first author is grateful to the Associates, Mr. Amar Chandra Dey and Mr. Sunil Barman for their valuable help and suggestions.

References

Anandaraj T, Balasubramanian U, Murugesan P, Muthuvelu S. 2012. Biodiversity of Marine Mollusks in East Coastal Area of Thanjavur District, Ttamil Nadu, India. International Journal Pharma Biological Sciences **3(1),** 131-133.

Araujo R, De Jong Y. 2015. Fauna Europaea: Mollusca-Bivalvia. Biodiversity Data Journal **3,** e5 211.
DOI: 10.3897/BDJ.3.e5211.

Bhuiyan SM, Rahman R, Jahan S, Haque M. 2013. New Record Of Some Freshwater Mussels (Bivalvia: Unionidae) From North-East Bangladesh. Bangladesh Journal of Zoology **41(1),** 29-42.

Bogan AE, Roe KJ. 2008. Freshwater bivalve (Union formes) diversity, systematics, and evolution: status and future directions. Journal of North American Benthology Society **27(2),** 349-369.

Bogan AE. 2008. Global diversity of freshwater mussels (Mollusca, Bivalvia) in freshwater. Hydrobiologia **595,**139-147.

Carter J, Altaba C, Anderson L, Araujo R, Biakov A, Bogan A, Campbell D, Campbell M, Chen J, Cope JW, Delvene G, Dijkstra H, Fang Z, Gardner R, Gavrilova V, Goncharova I, Harries P, Hartman J, Hautmann M, Hoeh W, Hylleberg J, Jiang B, Johnston P, Kirkendale L, Kleemann K, Koppka J, Kriz J, Machado D, Malchus N, Márquez-Aliaga A, Masse J, Mcroberts C, Middelfart P, Mitchell S, Nevesskaja L, Ozer S, Pojeta J, Polubotko I, Pons JM, Popov S, Sanchez T, Sartori A, Scott R, Sey I, Signorelli J, Silantiev V, Skelton P, Steuber T, Waterhouse JB, Wingard GL, Yancey T. 2011. A Synoptical classification of the Bivalvia (Mollusca). Paleontological Contributions 4, 47 p.

Critical Ecosystem Partnership Fund. 2005. Ecosystem Profile: Eastern Himalayas Region. Critical Ecosystem partnership fund available: www.cepf.net/Documents/final.ehimalayas.ep.pdf.

Chakraborty M, Bhattacharya S, Mishra R, Mukherjee D, Mishra R. 2012. Antioxidant content and activity of the Indian fresh-water pearl mussel in the prevention of arthritis in an experimental animal model. British Journal of Nutrition **108,**1346-1350.

Howard JK, Cuffey KM, 2006. The functional role of native freshwater mussels in the fluvial benthic environment. Freshwater Biology **51,** 460-474.

International Union for Conservation of Nature. 2016. Red List of Threatened Species www.iucnredlist.org/apps/redlist/search

Karatayev AY, Padilla DK, Minchin D, Boltovskoy D, Burlakova LE. 2007. Changes in global economies and trade: the potential spread of exotic freshwater bivalves. Biological Invasion **9,**16-180.

Kasprzak K. 1986. Role of Unionidae and Sphaeriidae (Mollusca, Bivalvia) in the Eutrophic lake Zbechy and its outflow, International Revue Gesamten Hydrobiol **71,** 315-334.

Lewandowski K, Stanczykowska A. 1975. The occurrence and role of bivalves of the family Unionidae in Mikolajskie Lake, Polish journal of Ecology **23,** 317-334.

Mohanty UL, Saurabh S. 2015. Multi-faceted role of mussels. In: Fish Habitat and Aquaculture. Discovery Publishing House Pvt. Ltd. New Delhi-110002, 26-37.

Myers N, Mittermeie RA, Fonseca CG, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature **403,** 853-0858.

Nayar K N, SatyanarayanaRao K. 1985. Molluscan Fisheries of India. Marine Fisheries Information Service, Technical and Extension Series **61,** 1-7.

Patil SG, Talmale SS. 2005. A Checklist of Land and Freshwater mollusca of Maharashtra state. Zoo's Print Journal **20(6),** 1912-1913.

Ramkrishna, Dey A. 2007. Hand book on Indian Fresh water Molluscs, Zoological Survey of India, Calcutta.

Rao YP, Murthy LN, Kishore S. 2013. Diversity of Molluscs in Chittoor district of Andhra Pradesh with Special Reference to Tirumala Hills, India. International Journal of Advance Scientific and Technical Research **3(2),** 573-581.

Sarwade AB, Pati SK, Kamble NA. 2015. Diversity of Molluscan Fauna from Freshwater Bodies of Sangli District: A Comprehensive Study In Relation To Environmental Variables. International Journal of Pharmaceutical sciences review and research **6(8),** 3563-3570.

Sicuro B. 2015. Freshwater bivalves rearing: a brief overview. International Aquatic Research **7,** 93-100.

Souji S, Vardhanan YS, Radhakrishnan T. 2014. New Records Of Five Barbatia Species From Arcidae Family (Mollusca: Bivalvia) From South East Coast Of India. Indian Journal of Scientific Research **9 (1),** 001-007.

Souji S, Radhakrishnan T. 2013. New Report and Taxonomic Comparison of Anadara and Tegillarca Species of Arcidae (Bivalvia: Arcoidea) from Southern Coast of India International Journal Scientific Research 2319-7064.

Spooner DE, Vaughn CC. 2006. Context-dependent effects of fresh water mussels on the benthic community. Freshwater Biology **51,**1016-1024.

Sturm CF, Pearce TA, Valdes A. 2006. The Mollusks: Introductory Comments. In The Mollusks: a Guide to Their Study, Collection, and Preservation. American Malacological Society, Pittsburgh, PA., U.S.A 1-7.

SubbaRao NV, Dey A. 1989. Fresh water Molluscs in Aquaculture. Zoological Survey of India Calcutta 225-232.

Subba Rao NV. 1989. Handbook-freshwater molluscs of India. Zoological Survey of India. Calcutta 289.

Vaughn CC, Spooner DE, Galbraith HS. 2007. Context-dependent species identity effects within a functional group of filter-feeding bivalves. Ecology **88,**1664-1662.

Venkataraman K, Wafar MVM. 2005. Coastal and Marine Biodiversity of India. Indian Journal Marine Science **34(1),** 57-75.