

**Two New Invasive Species of Marine Bivalves from the Coastal
Waters of Bangladesh**

UNDER PEER REVIEW

ABSTRACT

Benthic suspension feeders, such as many marine bivalve molluscs, influence the nutrient and organic cycles of benthic and pelagic systems through their ability to filter a wide size range of particles and deposit organic matters that sink to the bottom. They also play important roles in coastal and marine ecosystems by filtering the water, and serving as habitat and prey for a variety of sea life. Due to the increasing trends of environmental contaminations in recent years, many bivalves have been using as a potential biomarker for assessing the worse environment. Moreover, the shell of a bivalve is comprised of calcium carbonate, which may support thousands of calciferous organisms into the water body. Mostly, bivalves inhabit the tropics, as well as temperate and boreal waters, and they can survive and even flourish in extreme environmental conditions like Bangladesh. Nowadays, many bivalve molluscs have been identified as superior source of bioactive compounds and are using for pharmaceutical and nutraceutical purposes as well as other applications. However, until now, few systematic studies on marine bivalve molluscs have been conducted through which a total of 437 marine and brackish water species were identified and recorded in Bangladesh. But still, our knowledge of taxonomy and systematic on marine molluscs are primitive in the context of the country. Here we report two new species of bivalve molluscs, *Parvicardium exigum* and *Trachycardium procerum* belonging to the family Cardiidae, from the Kutubdia Island of Bangladesh. The study added these two bivalve species, which has not been recorded from the coastal zone of Kutubdia Island during the previous studies. To sum up, studies and survey on taxonomy and systematics in marine bivalves will provide new dimensions for further research about these important marine invertebrates.

Keywords: Molluscs; Bivalve; Heterodonta; Veneroida; Cardiidae; new records; Kutubdia Island.

1. INTRODUCTION

Bivalve molluscs (oysters, scallops, clams, and mussels) form a significant part of the world's fisheries production that show a diverse array of life history characteristics and perform

important ecological functions [1]. Bivalves not only have epifaunal characteristics but also have infaunal lifestyles. Infaunal bivalves attached to the benthic substrate have close relation to increase the fertility of barren environment. On the other hand, epifaunal bivalves use byssal threads to attach themselves to hard surface or one another that almost assist to clean water. Bivalves are largely filter feeders, although some species, especially infaunal organisms, feed on detritus (i.e., deposit or pedal feeding). Most taxa are largely sedentary as adults, with movement documented for foraging, reproduction, and predator escape. Juvenile stages of some fauna are more likely to show mobility that is critical for dispersal [2]. Finally, bivalve assemblages can occur in high densities with ecological impacts at large spatial scales. Moreover, Bivalves tolerate and accumulate contaminations and, because they are sessile and widely distributed, can be used for monitoring water turbidity and removal of contaminants [3]. The dense mussel aggregations can act as nutrients transformation hot spot in many pelagic areas, supporting the rest of food web and altering nutrient cycling. As mussels feed, they remove phytoplankton and bacterioplankton and also detrital organic matter from the water column, metabolize the labile fractions, excrete dissolved nutrients back to the water, and deposit organic nutrients to the sediment as feces and pseudo feces. Collectively, the benefits that humans derive from healthy ecosystems are considered ecosystem services. Currently, human cultures derive benefits from bivalves via direct as well as indirect use. Direct benefits include food production and commercial products such as road building material, concrete production, fertilizer, and cultured pearls. Indirect benefits of healthy bivalve communities include shoreline stabilization and nutrient mitigation.

Fisheries and aquacultures production of bivalves is a billion-dollar global industry. Although estuarine bivalves make up the vast majority of bivalves consumed by humans, fresh water mussels and clams (*Corbicula* sp.) are an important food resource in Southeast Asia [4]. In addition to food values, nowadays, many bivalve species have been found to produce a number of important bioactive peptides, proteins and metabolites. Among them, the numerous families of antimicrobial peptides identified in the mussels likely contribute to vigor and could assist with the identification of molecular scaffolds for innovative pharmaceuticals, nutraceuticals and constructs suitable products for other applications [5]. It has been estimated that global harvest (capture fisheries and aquaculture) of marine bivalves in 2015 was more than 16 million metric

ton comprising of oysters (24%), mussels (18%), scallops (25%), and clams (33%) [6]. Estuaries around the world are in a state of decline following decades or more of overfishing, pollution, and climate change [7], and commercial bivalve capture has decreased. Future bivalve aquaculture is threatened by ocean acidification from climate change, which affects carbonate mineral saturation and thus impacts shell formation [1].

The southeastern coastal region, more specifically referred to as coastal islands of Kutubdia, Maheskhali and Sonadia of Bangladesh, supports diverse molluscs assemblage consisting sandy, sandy-muddy and muddy beaches, mangroves, sea grass beds, sand dunes and considerable profundity of the Bay of Bengal. These islands have been tended to more attention by researchers, specializing in a wide range of disciplines. In recent years, the molluscs of these islands have received clod application of the mind than other invertebrates. In these regions, it was Commans [8] who first reported some species of molluscs from the St. Martin Islands, and a subsequent study [9] described 33 species under three different classes from the same area. Later Ahmed [10] provided an extended list and taxonomic description of marine and brackish water molluscan fauna in Bangladesh, composed of 301 species belonging to 151 genera, 79 families and 16 orders in 4 classes. After that Siddique et al. [11] compiled so far 20 land, 22 fresh water and 437 marine and brackish water molluscs species belonging to 210 genera, 105 families and 23 orders under 4 classes from Bangladesh, and are included in the volume of the Encyclopedia. But still, our knowledge of taxonomy and systematic of marine molluscs are basic in the context of Bangladesh. This is not only due to short-skilled people and tools to study them, but also owing to the problems in morphological analysis and identification of molluscs as a result of their complex larval stages, phenotypic plasticity and substantial cryptic species diversity. While deciding to prepare a monograph of the marine gastropods and bivalves of the Kutubdia, Maheskhali and Sonadia Island with a view to comprehend the status and diversity of molluscs assemblage, we incarnated two species belonging to the family Cardiidae that are new not only in this region but also in Bangladesh. After examining the associated specimens at the laboratory of Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, we ascertained the species *Parvicardium exigum* [12] and *Trachycardium procerum* [13] as new records to Bangladesh. The habitat of proposed specimens in the intertidal area was also assured.

2. MATERIALS AND METHODS

Mollusc samples were collected from the intertidal and subtidal habitats at locations across the southeastern coastal region namely Kutubdia Island of Bangladesh, during January 2013 to December 2013. The exact location of the study area is shown in Figure 1. One sample from each specimen was kept in the laboratory catalogue of Institute of Marine Sciences and Fisheries, University of Chittagong (Code Numbers: MSC/IMSF C0248 and MSC/IMSF C0181). Systematic information was based on the descriptions of Van Aartsen and Goud [14] ; EV Coan and Paul Valentich-Scott P [15] and WoRMS (World Register of Marine Species database). An updated checklist of species under the family Cardiidae from the coastal zone of Bangladesh was compiled based on the published reports of Ahmed [10] and Siddique et al. [11].

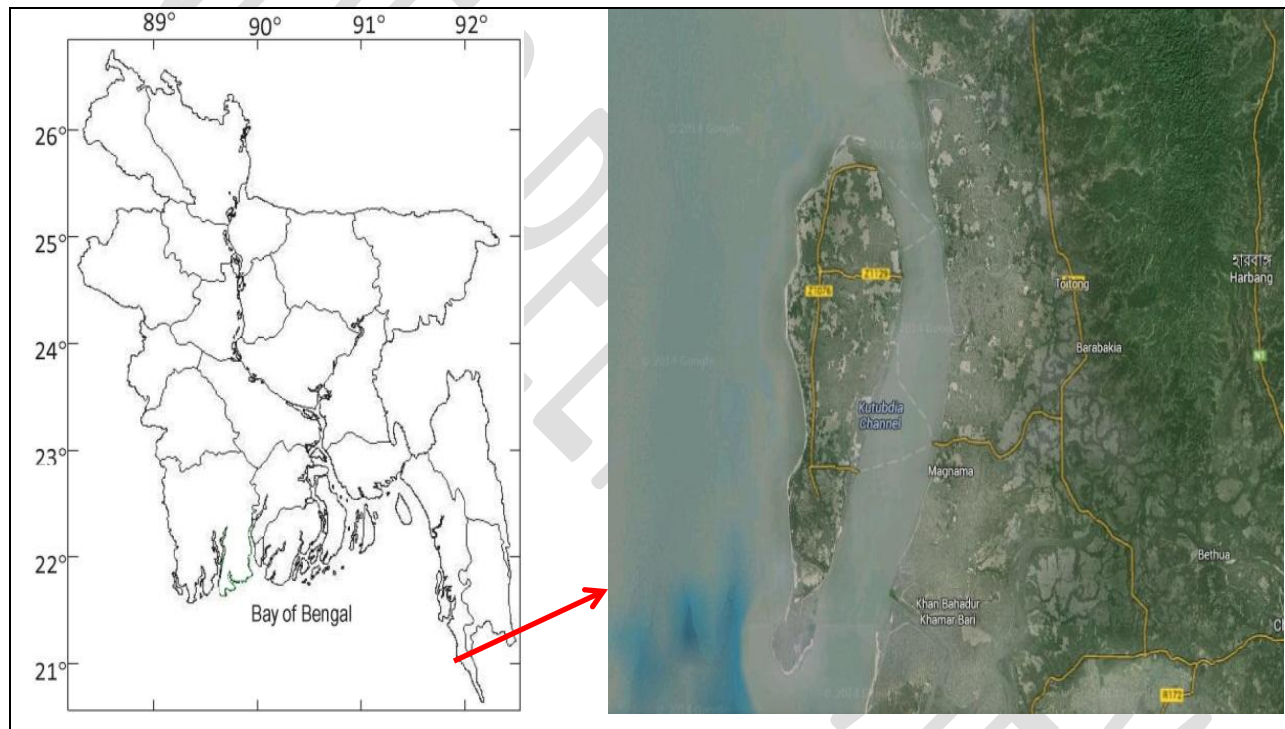


Figure 1. Map of the study area at Kutubdia Island, Bangladesh (taken from Google)

3. RESULTS AND DISCUSSION

The recent investigation informs about the first record of two marine bivalves, *Parvicardium exigum* [12] and *Trachycardium procerum* [13] belonging to the family cardiidae from the Coastal Islands of Bangladesh.

3.1 Systematics of *Parvicardium* sp.

Class BIVALVIA

Sub-class HETERODONTA

Order VENEROIDA

Super family CARDIOIDEA

Family CARDIIDAE

Genus *Parvicardium* Monterosato,

Parvicardium exigum (Figure 2)

3.1.1 Material examined

Locations of the sample collection area were geo-referenced using Global Positioning System. The place was situated at Kutubdia Island (21.8167°N, 91.8583°E), i.e., South Kutubdia Island-Ali Akberdeil to be more exact. The shell was collected from the surface of the intertidal sand muddy zone and the shell size of the matured living individual was measured to be 10-24 mm. According to WoRMS, the shell length was found to be varied from 10 to 20 mm. Similar shell length of the species up to 20 mm was also documented [14].

3.1.2 Description (shell)

The thick shell (equivalve) with prominent beaks in front of midline, anterior strong hinge line and tumid were documented. It comprised of 20-22 width radial ribs, with distinguished concentric ridges; at young, short tubercle-like spines were present on all ribs and in mature stage, these spines were seen at anterior and posterior ends, when ventral margin gently curved. During the distinct development stage, two small cardinal teeth in each valve, two anterior teeth in right valve and one lateral tooth in posterior part with small upper anterior portion was monitored. Moreover, the single anterior in the left valve with lateral posterior part have been seen while more prominent anterior found at the same time. Marginal crenulations with interlocking ribs, interspaces, not extended in interior, apparent pallial line and adductor scars, smooth ovale lunule and prominent ligament on short nymph was also documented.

3.1.3 Distribution

Specimen was found in sand, gravel or mud; from the lower shore into the shallow sublittoral zone, often extended into the estuaries [16] and also sub tidal to 5 meter for common species

[17]. The species also occurred shallow burrow in the sand, muddy sand and mud from the low intertidal to shallow shelf depths, extending into estuaries. The genus of the family was observed in shallow burrow of the sandy to muddy-sand flats, forming beds [11]. The species inhabited in the depth range between intertidal continental shelf to 200 m, were found to be widely distributed in the Indo-Pacific and also occurred in the Mediterranean [14]. However, no previous record of this species from the coastal Islands of Bangladesh was evident.

3.1.4 Remark

The new record for *Parvicardium exigum* was discovered from the Kutubdia Island, Bangladesh. The species are mostly available and found only in sandy-muddy zone of the intertidal area. It prefers an aerial exposure on 0-5% and is found in rough sand and sand gravel spun with a byssus thread [18]. The genus of the family was found in intertidal and shallow sublittoral waters to a depth of about 15 m [11]. It was also found on the rock under algae with byssal attachment [19]. The species was also reported from widely distributed coastal area of Norway to the Mediterranean common [17].



a. Dorsal view

b. Ventral view

Figure 2. Photograph of *Parvicardium exigum* [12]: a) Dorsal view and b) Ventral view.

3.2 Systematics of *Trachycardium* sp.

Class BIVALVIA

Sub-class HETERODONTA

Order VENEROIDA

Super family CARDIOIDEA

Family CARDIIDAE

Genus *Trachycardium*

Trachycardium procerum (Figure 3)

3.2.1 Material examined

Locations of the sample collection area were geo-referenced using Global Positioning System. The collection place was in Kutubdia Island (21.8167°N, 91.8583°E), more exactly referred to as the South Kutubdia Island-Ali Akberdeil. The shell was collected from the intertidal mangrove planted (sand-muddy) zone and shell size of matured living individuals was up to 105 mm. The shell length varies from 50.0 to 122.5 mm (WoRMS), and Coan and Valentich-Scott [15] documented the shell length of 102 mm and height of 117 mm.

3.2.2 Description (shell)

The documented shell (ovate) was thick with nearly rounded posterior periostracum. Shell height was larger than its length. Radial ribs were covered by weak crossbars on top with 22-23 radial ribs. Inner margin was crenulated with more flattened radial ribs at the anterior and posterior ends. External color of it had tan to medium brown with flecks.

3.2.3 Distribution

The species was originated from marine environment, more specifically on the Mexican part of the North Pacific Ocean and Chilean Exclusive Economic Zone in South Pacific Ocean (WoRMS). It has been found mostly at the Pacific coast of Baja California, and most specimens occurred from the Golfo de California [15] and also recognized from the northern end of the Panamic Province [20]. Finally, Abbott and Dance [17] collected this species in shallow waters from the SW Mexico to Chile. No previous record of this species from the coastal Islands of Bangladesh was reported except the existing three species (Table 1) found from Bangladesh. The species commonly inhabited shallow burrows in sandy to muddy-sand flats, forming beds. It usually has separate sexes and the development proceeded with free swimming larval stage, and occurred inside burrows in the intertidal and shallow sublittoral waters to a depth of about 15 m [10, 11].

Table 1. List of species of the family Cardiidae, identified from the coastal zone of Bangladesh.

Family	Species	References
Cardiidae	<i>Trachycardium asiaticum</i>	Ahmed [10], Siddique et al. [11]
	<i>Trachycardium flavum</i>	Ahmed [10], Siddique et al. [11]
	<i>Trachycardium enode</i>	Siddique et al. [11]

3.2.4 Remark

The new record was identified from the Kutubdia Island, Bangladesh. This species is common and mostly found in mangrove planted intertidal (sandy-muddy) area. Siddique et al. [11] had noticed that the habitats of the species from same genus (Table 1) were between St. Martin Island and Sonadia Island, widespread in the Indo Pacific from East Africa to the Philippines, Taiwan and Indonesia, including India, Myanmar and Sri Lanka [11]. The species was also reported from coastal area of North and South Pacific Ocean (WoRMS), SW Mexico to Chile [17], and Pacific coast of California [15].



a. Dorsal view

b. Ventral view

Figure 3 Photograph of *Trachycardium procerum* [13]: a) Dorsal view and b) Ventral view.

The survey had been conducted for collecting mollusks from the coastal zone of Bangladesh by the scientific community as well as individual researcher since 1940. The specimens are now under the preservation of laboratory and many of them are documented in well-known scientific articles. A total of 142 marine and 6 freshwater bivalves were monitored [11], in which 125 species belonging to 19 families were documented in Kutubdia, Maheskhali and Sonadisa [21]. Among them, 6 species were from the family Cardiidae, which has been included in the recent record. We collected a lot number of specimens during our field studies but were able to work on a limited number of species for the time being. Therefore, further studies are required to make a complete precision on the species and speciation processes of the bivalves around the region.

4. CONCLUSION

To sum up, studies and survey on taxonomy and systematic on marine bivalves will provide new dimensions for further research about Molluscs. Moreover, the study provides a new issue for further studies leading to uses, maintenance, management as well as protection of our molluscs and their habitats in Bangladesh [22].

REFERENCES

1. Vaughn CC, Hoelle TJ. Bivalves impacts in fresh water and marine ecosystems. *Annual Review of Ecology, Evolution, and Systematics*. 2018;49(1):83–208.
2. Molla MHR, Hasan MT, Jang WJ, Diaz CDS, Appenteng P, Marufchoni H, Jahan B, Brown CL. Thyroid hormone- induced swim bladder and eye maturation are transduced by IGF- 1 in zebrafish embryos. *Aquaculture Research*. 2019;00:1–9.
3. Gifford S, Dunstan RH, Connor W, Koller CE, MacFarlane GR. Aquatic zoo remediation: deploying animals to remediate contaminated aquatic environments. *Trends in Biotechnology* 2007;25:60–65.
4. Zieritz A, Bogan AE, Froufe E, Klishko O, Kondo T. Diversity, biogeography and conservation of freshwater mussels (*Bivalvia: Unionida*) in east and southeast Asia. *Hydrobiologia* 2018;810:29–44.
5. Venier P, Gerdol, M, Domeneghetti S, Sharma N, Pallavicini A, Umberto R. *Biotechnologies from Marine Bivalves*. In: Smaal AC, Ferreira JG, Grant J, Petersen JK, Strand Ø. Editors. *Goods and Services of Marine Bivalves*, Springer Open, Library of Congress Control Number: 2018951896, 2019;95–112.

6. FAO (Food and Agricultural Organization). FAO Yearbook of Fishery and Aquaculture Statistics 2015. Rome: Food and Agricultural Organization, UN. 2017.
7. Rick TC, Reeder-Myers LA, Hofman CA, Breitburg D, Lockwood R. Millennial-scalesustainability of the Chesapeake Bay Native American oyster fishery. Proceedings of the National Academy of Sciences of the United States of America 2016;113:6568–73.
8. Coomans HE. The marine Mollusca of St. Martin. Lesser Antilles, collected by Krebs HJ. Studies on the Fauna of Curafao. 1963;16:59–87.
9. Ali S, Aziz KMS. A systematic account of molluscan fauna of the Saint Martin’s Island. Bangladesh Journal of Zoology. 1976;4(2): 23–33.
10. Ahmed ATA. Studies on the identity and abundance of molluscan fauna of the Bay of Bengal. Final report, Bangladesh Agricultural Research Council (BARC), Dhaka. 1990;118.
11. Siddique KU, Islam MA, Kabir SMH, Ahmed M, Ahmed ATA, Rahman AKA, Haque EU, Ahmed, ZU, Begum ZNT, Hasan MA, Khondker M and Rahman MM (eds). Encyclopedia of Flora and Fauna of Bangladesh. Molluscs. Asiatic society of Bangladesh. 2007;17:415.
12. ter Poorten J, Gofas S. *Parvicardium exiguum* (Gmelin, 1791). Accessed through: World Register of Marine Species. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=139008> on 2015-03-27.2015.
13. ter Poorten J, Bouchet P. *Trachycardium procerum* (G. B. Sowerby I, 1833). Accessed through: World Register of Marine Species. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=519474> on 2015-03-27.2015.
14. Van Aartsen JJ, Goud J. European marine mollusca: notes on less well-known species. XV. Notes on Lusitanian species of *Parvicardium Monterosato*, 1884, and *Afrocardium richardi* (Audouin, 1826) (Bivalvia: Heterodonta: Cardiidae). Basteria. 2000;64: 171–186.
15. Coan EV, Valentich-Scott P. Bivalve Seashells of Tropical West America. Marine Bivalve Mollusks from Baja California to Northern Peru. 2012. 2 vols. Santa Barbara: Santa Barbara Museum of Natural History. 2012:1258.
16. de Kluijver MJ, Ingalsuo SS, de Bruyne RH. Macro benthos of the North Sea [CD-ROM]: 1. Keys to Mollusca and Brachiopoda. World Biodiversity Database CD-ROM Series, Expert center for Taxonomic Identification (ETI): Amsterdam. ISBN 3-540-14706-3.1 cdrom. 2000.
17. Abbott RT, Dance SP. Compendium of Seashells. Odyssey Publishing, USA. 2000;424.

18. Jelnes JE, Hopner Petersen, G. & Russell PJC. Isoenzyme taxonomy applied on four species of *Cardium* from Danish and British waters with a short description of the distribution of the species (Bivalvia). *Ophelia*. 1971;9:15–20.
19. Petersen GH, Russell PJC. *Cardium hauniense* compared with *C. exigum* and *C. glaucum*. *Proceedings of the Malacological Society of London*. 1971;39:409–420,
20. Keen AM. *Sea shell of Tropical West America; Marine Mollusks from Baja California to Peru*. Stanford University press, Stanford. 1971;1064.
21. Hossain MS, Sharifuzzaman SM, Chowdhury SR, Chowdhury SHN, Sarker S, Islam MR, Talukder A. *Sea Shells of Bangladesh. Marine Gastropod and Bivalve, Mollusc biodiversity. Center of Coast, climate and community, University of Chittagong*. 2014;1–56.
22. Molla, MHR, Islam, MS, Rahman MA, Lee, SG, Jahan, B, Iqbal, J, & Mamtaz, S. An assessment of geo- morphology and hydrobiological factors of major wetlands of Bangladesh. *Water Science Technology*. 2018;78:578–587. <https://doi.org/10.2166/wst.2018.328>.