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Gulf of Mannar Island coral reef associated gastropods assemblages: Distribution and diversity pattern

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ABSTRACT

Objective: To study the spatial and temporal variations of the distribution and diversity pattern of coral reef associated gastropods assemblages in Gulf of Mannar Island and to clarify the relationship between gastropods and surrounding coral reef ecosystem.

Methods: Gastropods were collected from three islands–Hare (Picnic spot), Vaan (Church Island) and Koswari (Karsuvar Island). The samples were taxonomically identified according to external structure of typical shells and classified according to their feeding habits. Statistical tool Primer (Ver. 6.1.11) was employed to find the species diversity, richness and evenness.

Results: A total of forty species of gastropods from 19 families were identified. The gastropods population density varied differently at stations, 479 species from Vaan islands, 390 species from Koswari islands and 254 species from Hare island were recorded. The gastropods species diversity, richness and evenness indices also varied differently at stations. The highest species diversity indice was recorded at Vaan Island (2.968), while both the highest richness and evenness indices were recorded at Hare Island with 0.937 and 0.942 respectively.

Conclusions: The results of present study provides useful informtation for biodiversity conservation as well as the management of coral reef habitat in India.

1. Introduction

The major reef formations in India are restricted to the Gulf of Mannar, Palk Bay, Gulf of Kutch, Andaman and Nicobar Islands and the Lakshadweep islands. Coral reefs in India are being damaged and destroyed at an alarming rate. They seem to face serious problems of stress from anthropogenic pressures and interference. However, it cannot be outlined about their population and geographical distribution, because of certain practical difficulties in monitoring underwater. The reef condition is generally poor and declining in near shore waters and areas of high population density. Relatively pristine reefs are located around uninhabited islands or barrier type reefs located away from population centres. Sedimentation, dredging and coral mining are damaging near shore reefs, while the use of explosives and bottom nets in fishing are damaging offshore reefs in specific sites. This seems to be the cause for the drastic change in their 30 community structure and ecological processes such as productivity and the calcium carbonate balance[1-9]. Most of the researches focused on algae, coral, sea urchin and fish interactions, while less insight have been put forth on other taxonomic groups. The wide variety of taxa and the habits of molluscs in these ecosystems are closely linked to coral cover and diversity[10]. Geographically, the coral reefs were enormously distributed in the Gulf of Mannar, a chain of 21 uninhabited islands in four groups that lie along 140 km of coastline with 36 stretches between Rameswaram and Tuticorin, at an average distance of 8–10 km from the mainland. These islands were reported to consist of 104 species of hard corals, 13 species of sea grasses which supports population of olive-ridley turtle, dugongs, 45 species of fishes, 79 species of crustaceans, 99 species of echinoderms, 108 species of sponges and 484 species of molluscs[11,12]. Thereby, the coral reef associated gastropods were observed to be abundantly found in this

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geographical location and seem to constitute a major node in the marine food web. At this juncture, the conservation and management of gastropod species in the Gulf of Mannar region necessitate a detailed inventory on current diversity and distribution patterns along the coastal regions[13]. Only few studies have been made on the coral associated gastropods in the coastal region[14-17]. Molluscs are likely to associate with the corals for which they used corals as their habitat and feed[18,19]. Conservation and management of gastropod species in the Gulf of Mannar region need a detailed inventory on current diversity, distribution patterns along the coastal regions. The present studies were directed toward the task of clarifying gastropods from the different coral reef habitats of Gulf of Mannar biosphere reserve, Bay of Bengal, India and towards the hope that the result would offer distinctive information for the biodiversity conservation as well as management of coral reef habitats in India.

2. Materials and methods

2.1. Study area

Study area was divided in three localities *viz*. Hare Island (Picnic spot, latitude 8°45' N; longitude 78°12' E), Vaan Island (Church islands, latitude 8°45' N; longitude 78°45' E) and Koswari Island (Karsuvar Island, latitude 8°86' N; longitude 78°23' E) with the help of GPS to avoid the possible land based activities (Figure 1).

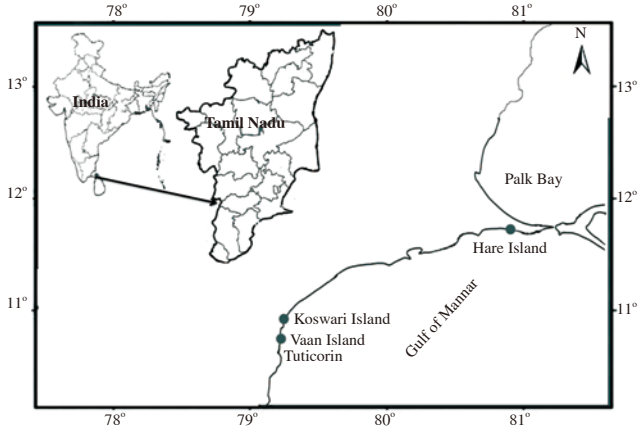

Figure 1. The sampling stations of the Tuticorin coast (group of Islands), Gulf of Mannar.

2.2. Method of survey and collection

This survey was conducted randomly in each habitat, where all the individuals were observed with the naked eye. Live animals were collected by handpicking including coral reef associated gastropod species. Each site consisted of three belt transects of 10 m^2 (10 m × 1 m) parallel to each other. Data were recorded for each 1 m^2 of transect (1 m × 1 m)[20]. Soon after fishing, they were brought to the laboratory and the shells were brushed to remove the fouling biomass and mud. They were then stocked in filtered seawater pumped in the laboratory from the estuary. Animals were then preserved in 70% alcohol for taxonomical identification of external structure of typical shells, especially, lunal, umbo and operculum. Gastropods exhibited habitat preferences that resulted in variation in presence or density across vegetation communities or other habitat features and few studies had examined their abundance and diversity at fine spatial scales[21]. The taxa of the gastropods collected were identified and classified into 19 families in terms of their feeding habits (carnivores, coralivores, herbivores, filter feeders, deposit feeders and scrap feeders) according to specialized bibliographies[22-31].

2.3. Statistical analysis

The gastropods samples were sorted and assigned to 19 major families *viz*. Cypraeidae, Muricidae, Strombidae, Naticidae, Trochidae, Fasiolariidae, Turbinellidae, Architectonicidae, Fasciolariidae, Turritellidae, Buccinidae, Cassidae, Conidae, Ranellidae, Personidae, Volemidae, Nassariidae, Neritidae and Olividae. The diversity indices, richness and evenness were caculated using the biodiversity software, PRIMER (Ver. 6.1.11) (Plymouth routines in multivariate ecological research). Biodiversity indices were calculated following the standard formulae and species diversity was calculated using the following formula H' = - $\sum pi$ Inpi, where, pi is the proportion of individuals of each species belonging to the i th species of the total number of individuals[32]. Species richness (D) was calculated using the following formula given by Simpson D = 1 - C; C = pi^2; $\sum pi$ = ni/N and evenness or equitability (S) was calculated using Pielou's formula J' = H'/Jns or H'/$\log_2$S[33,34].

2.4. Multivariate analysis

Multivariate techniques like principal component analysis (PCA) and multiple regression were powerful tools for relating environmental variables with the gastropods population density. These tools help to highlight underlying patterns and cluster among variables simultaneously. First, PCA was used to analyze the coral reef environment for fundamental trends among all the variables and to reduce the number of variables in order to handle data more easily, followed by multiple regression which was carried out to calculate the values of a dependent variable and to give a set of predicted variables which was used to determine the extent that the variables contributed to the gastropods population density.

3. Results

3.1. Species composition

A total of 40 species from 19 families of gastropods were identified from three islands (Table 1), of which, 7 belonged to Cypraeidae, 7 belonged to Muricidae, 3 each belonged to Strombidae, Naticidae and Trochidae, 2 each belonged to Fasiolariidae, Turbinellidae and

Buccinidae, 1 each belonged to Architectonicidae, Fasciolariidae, Turritellidae, Cassidae, Conidae, Ranellidae, Personidae, Volemidae, Nassariidae, Neritidae and Olividae. The higher numbers of gastropods was recorded at Vaan Island and the minimum was recorded at Hare Island.

Table 1

Checklist of gastropods faunal diversity during study period from selected islands of Tuticorin group.

Sample No.	Family	Name of the species	Hare Island	Vaan Island	Koswari Island
1	Architectonicidae	*Architectonica perspective* (Kobelt, 1875)		+	
2	Fasciolariidae	*Pleuroploca trapezium* (Linnaeus, 1758)	+	+	++
3	Turritellidae	*Turritella duplicata* (Linnaeus, 1758)	+	+	+
4	Buccinidae	*Cantharus undosus* (Linnaeus, 1758)	+	+	
5		*Phos senticosus* (Linnaeus, 1758)	+	++	++
6	Cassidae	*Casmaria erinaceus* (Linnaeus, 1758)		+	+
7	Muricidae	*Chicoreus ramosus* (Linnaeus, 1758)	+++	+++	+++
8		*H. haustellum* (Linnaeus, 1758)		+	
9		*Murex trapa* (Röding, 1798)	++	++++	++
10		*Murex tribulus* (Linnaeus, 1758)	+++	+++	+++
11		*Colubraria muricata* (Lightfoot, 1786)		+	+
12		*Purpura rudolphi* (Lamarck, 1822)		++	++
13		*Rapana bulbosa* (Dillwyn, 1817)			+
14	Conidae	*Conus amadis* (Bruquiere, 1792)	+	+	+
15	Ranellidae	*Cymatium lotorium* (Linnaeus, 1758)		+	
16	Cypraeidae	*Cypraea annulus* (Linnaeus, 1758)	++	+++	+++
17		*Cypraea caurica* (Linnaeus, 1758)	++	+++	++
18		*Cypraea labrolineata* (Gaskoin, 1849)	++	++	++
19		*Cypraea miliaris* (Gmelin, 1791)	+	+++	+++
20		*Cypraea moneta* (Linnaeus, 1758)	++	+++	+++
21		*Cypraea teres* (Gmelin, 1791)	+++	++	++
22		Cypraea *tigris* (Linnaeus, 1758)		+	+
23	Personidae	*Distorsio anus* (Linnaeus, 1758)		+	
24	Fasiolariidae	*Ficus ficus* (Linnaeus, 1758)		+	+
25		*Harpa* sp. (Lamarck, 1822)		+	
26	Volemidae	*Hemifusus pugilinus* (Born, 1778)	+++	++++	+++
27	Strombidae	*Lambis lambis* (Linnaeus, 1758)	++	+++	+++
28		*Strombus canarium* (Linnaeus, 1758)		+	
29		*Tectarium radiates*			+
30	Nassariidae	*Nassarius papillosus* (Linnaeus, 1758)	+	++	+
31	Naticidae	*Natica didyma* (Linnaeus, 1758)	+		
32		*Polinices aurantius* (Röding, 1798)	+	++	+
33		*Polinices pyriformis* (Récluz, 1844)	+	++	+
34	Neritidae	*Nerita polita* (Linnaeus, 1758)	++	+	
35	Olividae	*Oliva aurula* (Röding, 1798)		+	+
36	Trochidae	*Trochus radiatus* (Gmelin, 1791)	+++	++++	+++
37		*Trochus niloticus*	++	+++	+++
38		*Umbonium* sp. (Linnaeus, 1758)	++	++	++
39	Turbinellidae	*Vasum ceramicum*	++	+	
40		*Xancus pyrum* (Cuvier, 1795)		+	+

H. haustellum: *Haustellum haustellum*; +: Occasional; ++: Common; +++: Dominant; ++++: More dominant.

3.2. Population density

The gastropods population density varied differently at stations, 479 in Vaan Island, 390 in Koswari Island and 254 in Hare Island. The number of individual species in different gastropods groups started to increase from the Koswari Island and Hare Island and reached its maximum in the Vaan Island. The observed high population density and species diversity during the Vaan Island might be due to the predominance of gastropods such as *Chicoreus ramosus, H. haustellum, Murex trapa, Murex tribulus, Colubraria muricata, Purpura rudolphi, Cypraea annulus, Cypraea caurica, Cypraea labrolineata, Cypraea miliaris, Cypraea teres* and *Cypraea tigris*. Most of the species were commonly found in all the study areas except *Architectonica perspective, Cymatium lotorium, Harpa* sp., *H. haustellum* and *Natica didyma* which are found only in Hare and Koswari Islands.

3.3. Species diversity indices

The gastropods species diversity indices varied differently at islands (Table 2). The minimum species diversity indices were recorded at Hare Island (2.920) and the maximum species diversity indices were recorded at Vann Island (2.968). The gastropods species richness indices varied differently at islands. The minimum species richness indices were registered at Vann Island (0.930) and the maximum species richness indices were registered at Hare Island (0.937). The gastropods species evenness indices varied differently at islands. The minimum species evenness indices was registered at Vann Island (0.526) and the maximum at Hare Island (0.742).

Table 2

The species diversity indices of gastropods at three islands of Tuticorin group.

Station	Diversity indice	Richness indice	Evenness indice
Vaan Island	2.968	0.930	0.526
Koswari Island	2.936	0.934	0.628
Hare Island	2.920	0.937	0.742

4. Discussion

The diversity of gastropods at three coral reef localities of Gulf of Mannar biosphere reserve varies significantly. The major reason is that, ecologically this island has a combination of sea grass bed, sandy bottom and very good coral reef cover, which might be the attraction for more species and also these islands are spatially very closer to each other and similar environmental conditions might be explained for such similarity of faunal assemblages[13]. Coral reef environment was considered as one of the most important features that were capable of influencing the growth, abundance and diversity of gastropods in the marine environment and showed wide spatial differences. According to studies on reef environments, high molluscan richness is associated to coral cover[35,36]. The distribution of coral reef associated molluscs species in the coastal region of India was reported by earlier workers[37]. For the conservation and sustainable fishery of marine gastropods in Gulf of Mannar biosphere reserve, complete knowledge on biology and distribution of gastropods is essential. Since most of the marine gastropods are very closely associated with coral reef ecosystem either for food, shelter or reproduction, it is the utmost important to save the coral reef ecosystem which in turn conserves the gastropods. Kenya's coral reef associated gastropod fauna, like other tropical Indo-Pacific regions, is typified by low density and high variability and diversity[38-41]. Mohanraj *et al*. reported 51 species of molluscs in Gulf of Mannar regions[42]. In the present investigation, gastropods population density varied differently at stations, 479 in Vann Island, 390 in Koswari Island and 254 in Hare Island.

In relation to molluscan density, the low value for the species is a common characteristic in coral reef systems[43-45]. The higher abundance of few species found on the Maracajaú reef, a result also observed on Caribbean reefs, may be associated to environmental stress[44]. The low values for molluscan density and richness in the profiles of seagrass and sandy bottom habitats probably reflect the behavior of many individuals that habitually bury in the substrate and are not visible to the naked eye[46]. Our study supports the hypothesis that gastropods, like other coral reef populations, are regulated by density-independent factors, but not the hypothesis that they are non-equilibrium assemblages; they may be in equilibrium with their predators[47] and early post-settlement mortality[48,49]. In the present observation, gastropods species diversity indices varied differently at islands, 2.968 at Vaan Island, 2.936 at Koswari Island and 2.920 at Hare Island with the maximum at Vaan island.

The low gastropod richness found in this study (0.930) was compared among stations and it may be related to the characteristics of the Hare and Koswari Islands, which has low coral density and extensive covers of seagrass and fleshy algae. According to studies on reef environments, high molluscan richness is associated to coral cover[35]. The recorded 75 species of gastropods form 45 genera and 31 families recorded in Mudasai Odai Landing Cenre, Southeast Coast of India, whereas 67 species from 42 genera and 29 families were recorded in Nagapatinam, Tamilnadu[36]. The positive relationship between molluscan richness and the presence of corals can be observed in the Maracajaú reefs (45 spp.) and in the Abrolhos reefs (293 spp. of molluscs) of Brazil, which contain the highest coral richness in the country (18 spp. *vs* 4 spp. in Maracajaú)[50]. In the present study, the PCA provides an insight about the factors influencing the gastropods population, and the multivariate regressions provide the actual nature of influence of those variables. However, further studies must be developed in order to examine carefully the distribution patterns of gastropods fauna on these reef systems and the factors that influence them, which will enable us to evaluate the impacts of human activities (*e.g.* fishery and tourism) over the structure of benthic communities. There were 59 species of gastropods from 35 genera and 25 families in Mudasai Odai and 57 species from 35 genera and 25 families have been recorded from Cuddalore[51].

The present study attempted to record the diversity of variations of gastropod population density in relation with coral reef ecosystem of the Gulf of Mannar biosphere reserve. The gastropods play a significant ecological role in the coral reef ecosystems and rocky habitats are also suitable especially for gastropods. However, very little information is available on the gastropod biodiversity in coral reef environment of India. Hence, it is necessary to document the biodiversity of the group in the threatened ecosystems and there is an urgent need for conservation and sustainable utilization of molluscan species.

Conflict of interest statement

We declare that we have no conflict of interest.

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