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Research Article

Gastropods Diversity in Mangrove Forests of Govater Gulf in Sistan & Baluchestan

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Abstract

The present study was performed to investigate Gastropods diversity in mangrove forests located at Chabahar Township, Sistan & Baluchestan, Iran. For this purpose some homogenous forest masses were isolated and field visits were done. In each mass, three vertical transects were selected at the site of water contact up to land contact and sediment sampling was conducted from first (in contact with the water), middle, and end points of each transect. Three samples were collected in triplicates and during four successive seasons. Of 2119 collected gastropod samples, 44 species were identified from 35 genera and 22 families, among which three species were identified up to family level, nine up to genus level, and the remaining up to species level. Among the species identified, *Asseminea* sp.2 and *Asseminea* sp.1 were the most abundant species with 41.49% and 30.77%, respectively. Species *Cerithidea cingulata* (11.04%) and *Stenothyra arabica* (6.09%) were in subsequent rankings. The identified gastropods at the first point belonged to 13 families, 16 genera, and 17 species, among which five species were observed only in this area: *Cerithiopsis* sp., *Melampus castaneus, Haminoea cf vitra, Nassarius* sp. and *Umbonium vestiarium*. The gastropods had the highest species number at middle point belonging to 20 families, 28 genera, and 36 species and the number of 22 species (the highest species number) was observed only in this region. Except two species *Cerithium* sp. and *Finella pupoides*, other gastropod species of end point were also present in other regions. Gastropods of this region belonged to 7 families, 10 genera, and 12 species. Comparing this results with other mangrove forests shows that from the east to west the gastropods diversity has reducing trend; and the studied area is the most diverse region in Iran. This study recorded 13 new species from Iran that wasn't reported before.

Keywords: Mangrove Forests, Gastropods, Species Diversity, Govater Gulf, Sistan and Baluchestan Province.

Introduction

Mangrove forests create distinctive habitats distinguishable by a remarkable biological diversity. These forests provide the animals with various types of niches including mangrove leaves, barks, dead wood, roots (pneumatophore), water pool and muddy or sandy sediments. The animals inhibiting these ecosystems play an important ecological role, since they are a major component of nutrient cycling, food webs, and total energy turnover. Several factors such as species interaction, animal-sediment interaction, and environmental parameters (salinity, temperature, oxygen level, pH, etc) affect distribution of these organisms (Shafique *et al.*

2015). Among costal ecosystems, mangrove ecosystems need special attention not only because of their unique habitat characteristics, but also for their rich biodiversity (FAO 2007). They are a proper bed for several pelagic fish and crab species migrating to sea while maturing (Macintosh and Ashton 2002). Since several fish, crustacean, and bird species use this type of ecosystem or are dependent to it during their life cycles, biodiversity is increased more in mangrove habitats (Carugati *et al*. 2018).

As important scavengers of benthic environments, gastropods play a major role in tidal flat habitat and ecosystem (Zvonareva and Kantor 2016). With more than half of all nominated mollusks, gastropods are one of the best founded and most diverse animal groups (Leal 2006). Numerous mollusks reside mangrove habitats from which *Mactra*, *Hiatula*, *Calista*, *Dosinia* and *Chlamys* are some examples. Some gastropod genera inhabiting such ecosystems include *Trochus*, *Clanculus*, *Planaxis*, *Natica*, *Conus*, *Thais* and *Siphonaria* (El-Sorogy *et al.* 2016). High mollusk diversity in mangroves is possibly determined by availability of a wide range of microhabitats. Mollusks occupy all food web levels of mangroves as hunters, herbivores, saprophages, and filter feeders (Cannici *et al.* 2008). In a study about benthic micro fauna in Northern Queensland, Australia, among 39 identified taxa, Plychaeta were the most abundant group with 19 species and after them, gastropods were dominant with 9 species (Dittmann 2001). In an examination of diversity and abundance of benthic macro fauna along with Thalassia testudinum of in Ensenada de-Reyes area of Mochima Gulf, the highest (214 samples) and lowest (79 samples) abundance were reported in October and December, respectively (Jimenez *et al*. 2000).

Several references have studied gastropods diversity at different mangrove habitats. A study performed by Macintosh *et al*. (2002) showed mangrove vegetation diversity is correlated with gastropod diversity positively. Sri-aroon *et al.* (2005) studied gastropod assemblage in Gulf of Thailand. Lozouet and Plaziat (2008) investigated gastropod diversity in Bohol and Panglao Islands, central Philippines. Zvonareva *et al*. (2015) studied gastropod diversity associated with a planted and natural mangrove in Dam Bay of Vietnam and reported significant differences between these forests. Ullah *et al*. (2015*)* showed molluscs diversity is higher in summer and autumn and lower in spring and winter in two mangrove forests along the Karachi coast of Pakistan. Also Ullah *et al*. (2015) studied vertical distribution pattern of molluscs in these mangrove forest and proved that the number of species decreased from high to low tide zone. Zvonareva and Kantor (2016) studied 65 species of gastropod which 17 of them are considered as predominantly mangrove-associated. Some of studied performed in mangrove forest of Iran done by Danehkar (2001) at the distance between Khamir Port and Qeshm, Mohammadi Tahoori (2006) in Gheshm, Rouhipour (2007) in Sirik Protected Area and Ghasemi *et al*. (2010) at Hara Protected Area and Gaz and Hara Rivers Delta mangroves.

Identification and measurement of gastropods biodiversity and flux in mangrove forests are important for recognition of their ecosystems. As well, gastropods play an important role in mangrove ecosystem food chain. Regarding the lack of sufficient data about gastropods in mangrove forests of Sistan and Baluchestan and their population fluctuations, the present investigation was designed and performed to identify and determine gastropods diversity as symbiotic fauna with mangrove communities in mangrove forests of Govater Gulf of Sistan & Baluchestan.

Material and methods

Study area

The present investigation was accomplished in mangrove forests of Govater Gulf located at Chabahar Township of Sistan and Baluchestan Province, Iran. This gulf is located at

southeastern extreme on the shores of Sistan and Baluchestan Province (25°1' - 25°12'N and 61°25' - 61°46' E). With an area of about 270 square kilometers, it is 121 kilometers far from Chabahar, of which about 150 square kilometers belong to Iran. Bahu Kalat and Dasht Khur Rivers are flowing into this gulf, which is covered by mangrove forests. With complexes of aquatic systems including rivers, marshes and gulf and with an area of about 75,000 hectares, International wetland of Govater Bay and Hur-e-Bahu are among the 24 Iranian international wetlands listed in Ramsar International Wetlands List. This wetland is 85 kilometers far from Chabahar and classified in marine-coastal ponds and contains 60 kilometers of the length of Bahu Kalat River, Hur, and Govater Gulf, which is especially important because of having mangrove forests and waterfowls. Figure 1 shows the location of study site at Sistan and Baluchestan Province. Govater Gulf is one of the most valuable habitats rich in aquatic organisms. The flow of two important rivers (Bahu Kalat in Iran and Nahr Dasht in Pakistan) to this gulf and the entrance of Dashtiari Region's flood streams have prepered a habitat for different kinds of aquatic organisms, birds and vegetation of plants. This gulf has two bays in Iranian part consisting of Govater and Hur-e-Bahu (Erfani *et al*. 2013) that this study was conducted in Govater bay.

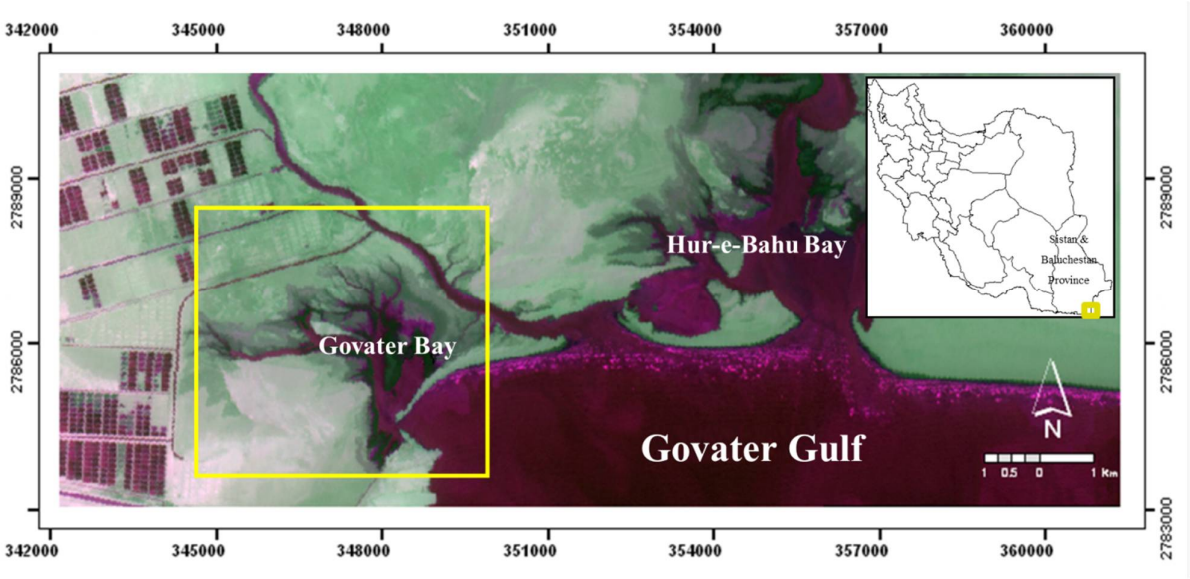

Figure 1. Location of study area

Sampling of gastropods in the study area

Some homogenous and integrated forest masses were isolated visually by the aid of the satellite images of the area (IRS-LissIII). In each isolated mass at the water contact site, some points were selected randomly on the image and linear transects were plotted vertically from these points to the coastal line. Then, from these transects, three were selected whose coverage homogeneity was better indication the relevant mass. After determining transects places, location information of three points along the intertidal zone (the first point at water contact edge, the second point at the middle of transect and the third point at the end of each transect) were converted into GPS data and the location of transects was identified in field operation. These samplings were carried out during four successive seasons.

Fixation, isolation and identification of Gastropods

The collected sediment samples were sifted, washed with sea water at the site, fixed with 4% formaldehyde, and transported to

biodiversity lab of Department of Environmental Sciences, University of Tehran. Then, the gastropods were separated from broken shells by the aid of loop and the individuals related to each sample were transferred to capped bottles and prepared for identification. Counting was done in each sample for each species. Species identification was done in two stages: preliminary and final. Preliminary identification was accomplished by the application of Compendium of Seashells Abbott and Dance (1998), Subba identification key (Subba *et al*. 1992), Bosch *et al.* Atlas (1989), and Smythe (2010). The identified species were sent to Museum of Amsterdam, Netherland for final approval.

Results

In this study, total number of 2119 gastropod samples were collected in four sampling phases from different tidal zones (water proximity, between sea and land and land proximity) during four seasons. The identified species and families and collected samples were related to 44 species from 35 genera and 22 families. Three species were identified up to family level, 9 up to genus level, and the others up to species level. Among the identified species, *Asseminea* sp.1 was the most abundant one with 858 samples and 41.49% of frequency and after that, *Asseminea* sp.2 was dominant with 652 samples and 30.77% of all species. Species *Cerithidea cingulata* (234 samples and 11.04%) and *Stenothyra arabica* (129 samples and 6.09%) were at lower ranks and one sample was identified for each of species below: *Alvania* sp., *Zafra* sp., *Obtortio pupoides*, *Pseudonobacolumen*, *Natica* sp., *Umbonium vestiarium*, *Finellapupoides*, *Melampus castaneus*, *Nassarius* sp., *Pelanispira nerita*, *Nedyma pesudominolia*, *Smaragdia souverbiana*, sp. (*Columbellidae*), sp. (*Pyramidellidae*), *Stosicia* annulata, and *Umboniumvestiarium*. The frequency and presence of different identified species is summarized in Table 1 Regarding the number of collected and identified samples, the maximum species, genus and family number observed is related to the first transect.

Table 1. Frequency of gastropods in different seasons and present/absent of them in transects and intertidal zones

	Seasons				Transects			Intertidal zones		
Species	**Spring**	**Summer**	**Autumn**	**Winter**	**1**	**2**	**3**	**1**	**2**	**3**
Pupa affinis	1	0	0	0	*	-	-	-	*	-
Salinator fragilis	0	2	0	1	-	-	*	*	*	-
Salinator sp.	0	1	0	16	-	*	*	*	*	-
Asseminea bedomeana	8	21	13	11	*	*	*	*	*	*
Asseminea sp.1	168	95	56	333	*	*	*	*	*	*
Asseminea sp.2	190	93	196	379	*	*	*	*	*	*
Cerithiopsis sp.	0	3	0	0	*	-	-	*	-	-
Mitrella cartwrighti	5	0	0	0	*	-	-	-	*	-
Sp.(from *Columbellidae*)	0	0	0	2	-	*	-	-	*	-
Zafra selasphora	4	0	0	0	*	-	-	-	*	-
Zafra sp.	0	0	0	1	-	*	-	-	*	-
Cyclostrema solariellum	2	0	0	0	*	-	-	-	*	-
Alvania sp.	1	0	0	0	*	-	-	-	*	-
Cerithidium cerithinum	0	3	0	0	-	*	-	*	*	-

Continued table 1. Frequency of gastropods in different seasons and present/absent of them in transects and intertidal zones

Cerithium sp.	0	3	0	0	*	-	-	-	-	*
Cassidula labrella	1	0	0	3	*	*	-	*	*	-
Melampus castaneus	1	0	0	0	-	*	-	*	-	-
Atys cylindrica	2	0	0	0	*	-	-	-	*	-
Haminoea cf vitra	0	2	0	1	*	-	*	*	-	-
Fairbankia bombayanaone	2	2	0	0	-	-	*	-	*	-
Iravadia quadrasi	6	13	23	18	*	*	*	*	*	*
Lucidinella sp.	3	0	3	1	*	*	-	*	*	*
Pseudonoba columen	1	0	0	0	*	-	-	-	*	-
Pseudonoba sp.	0	4	0	0	-	*	*	-	*	*
Sp. (from *Iravadiidae*)	0	0	4	0	*	-	-	*	-	*
Perunum terverianum	10	0	0	0	*	-	-	-	*	-
Granulina oodes	2	0	0	0	*	-	-	-	*	-
Nassarius sp.	0	0	0	1	-	-	*	*	-	-
Natica sp.	0	1	0	0	*	-	-	-	*	-
Neritia pelanispira	1	0	0	0	*	-	-	-	*	-
Smaragdia souverbiana	1	0	0	0	*	-	-	-	*	-
Finella pupoides	0	0	1	0	*	-	-	-	-	*
Cerithidea cingulata	13	57	152	12	*	*	*	*	*	*
Pyramidella maculosa	2	0	0	0	*	-	-	-	*	-
Sp. (from *Pyramidellidae*)	0	0	0	1	-	*	-	-	*	-
Stosicia annulata	0	0	0	1	-	*	-	-	*	-
Toratina inconspicua	5	0	0	0	1	-	-	-	*	-
Toratina involuta	4	0	0	0	*	-	-	-	*	-
Toratina persiana	0	0	1	1	*	*	-	*	*	-
Stenothyra arabica	9	48	54	17	*	*	*	*	*	*
Pesudominolia gradata	11	0	0	0	*	-	-	-	*	-
Pesudominolia nedyma	1	0	0	0	*	-	-	-	*	-
Umbonium vestiarium	0	1	0	0	*	-	-	*	-	-
Cyclostrema ocrinium	1	2	4	2	*	-	*	*	*	*
frequency	21.71	16.56	23.88	37.85						

Of total number of identified gastropods in all collected samples, 351 samples were identified in summer, 506 in autumn, 802 in winter, and 460 in spring. Therefore, the gastropods have the maximum frequency in winter and the minimum frequency in summer. *Asseminea* sp.1 and *Asseminea* sp.2. Have the highest density (number in m^2). *Cerithidea cingulata* had remarkable density during spring. *Asseminea* sp.2 and *Cerithidea cingulata* were the densest species during autumn. Examining gastropod density in different transects, it was determined that the highest density in all three transects was relate to *Asseminea* sp.1 and *Asseminea* sp.2. The gastropods have allocated the highest frequency to themselves in first,

second and third transects.

Five species of 22 identified species comprised 94% of sample frequency. All species of family Assiminiedae (*Asseminea* sp.1, *Asseminea* sp.2, *Asseminea bedomeana, Cerithidea cingulata*, *Cyclostrema ocrinium*, and *Iravadia quadrasi*) were observed in all transects along the intertidal zones and during all seasons.

Discussion

Of 2119 samples collected during four stages of this investigation, total numbers of 44 gastropod species were identified from 35 genera and 22 families. Mohammadi Tahoori (2006), Rouhipour (2007), Danehkar (2001) and Ghasemi *et al*. (2010) reported the number of identified gastropod in eastern regions of mangrove forest of Iran as 21, 30, 22 and 21 gastropod families and 23, 33, 30 and 28 gastropod species respectively.

Family Assiminieda with 1527 samples and total frequency of 73.76%, and species *sseminea bedomeana* with frequency of 2.50%, *Asseminea* sp.1 with frequency of 30.77%, and *Asseminea* sp.2 with frequency of 41.49% were the most abundant cases from 22 families identified. Species of this family were observed in all transects along the intertidal zones during all seasons. The higher number of species reported from this area indicates that this area has higher species diversity, which is probably originated from the zone's virginity (Danehkar 2001). The common species of all Iranian mangroves include *Iravadi aquadrasi*, *Cyclostrema ocrinium*, *Stenothyra arabica*, *Cerithidium cerithinum*, and *Cerithidea cingulata*.

Comparison of species diversity that was recorded from Indo-Pacific regions on different mangroves forest consisting of Vietnam (Zvonareva *et al*. 2015), Hong Kong, Malaysia (Zvonareva and Kantor 2016), Thailand (Macintosh *et al*. 2002, Sri-aroon *et al*. 2005) and Philippines (Lozouet and Plaziat 2008) showed that from the west to east gastropods diversity has reducing trend; this trend also was observed in the Iranian parts (Mohammadi Tahoori 2006, Rouhipour 2007, Danehkar 2001, Ghasemi *et al*. 2010). Only one reported case was against this trend that was conducted in two mangrove forests along the Karachi coast of Pakistan that recorded 40 molluscs (gastropods and bivalves) (Ullah *et al*. 2015).

Vertical distribution pattern of gastropods in this study delineated a decreasing trend from high to low tide zone that was the same as the results of other researchers like Ullah *et al*. (2015).

Species *Pupa affinis*, *Zafra selasphora* (from *Actenoidae), Zafra* sp., *Alvania* sp. (from *Columbellidae), Cerithium* sp., *Fairbankia bombayanaone* (from *Diastomatidae*), *Pseudonoba* sp. (from *Iravadiidae), Perunum terverianum*, *Neritia pelanispira* (from *Marginellidae*), *Smaragdia souverbiana*, *Toratina inconspicua* (from *Neritidae*) and *Toratina involuta* (from *Scaphandridae*) were identified in the present study, which were not reported in three studies mentioned in Iran.

Each of families *Turbinidae*, *Stenothyridae*, *Rissoidae*, *Potamipidae*, *Obtortionidae*, *Naticidae*, *Nassariidae*, *Cyclostarematidae*, and *Actenoidae* has one identified species, while families Iravadiidae with six species, *Columbellidae* with four species, and *Scaphandridae*, *Diastomatidae*, and *Assiminiedae* with three species have good species diversity. In studying the biodiversity of mangrove forests of protected Area of Sirik by Rouhipour *et al.* (2007) two species were reported for family *Iravadiidae* and three for family *Assiminiedae* and one species was reported for families *Stenothyridae* and *Ellobiidae*. Based on results of an investigation about identification and examination of macro benthos density and diversity in northern marshes of Bushehr Province, total number of 19 families was identified. The dominant families (based on percentage) included respectively *Cerithiidae* 34.1%, *Marginellidae* 13.5%, *Dentalidae*

10.1%, *Columbidae* 8.5%, and *Terebridae* 7% (Mirdar 2002). Therefore, it can be concluded that the results of this investigation about the frequency of different species are in accordance with other studies in Iran and the difference is in the higher number of species identified in this study.

Based on the results of present study, a meaningful observable difference was obtained in the frequency of species identified during sampling seasons. The highest frequency of 37.85% was for winter and the lowest was for summer with 21.71%. Prieto *et al*. (2000), Mirdar (2002), Rouhipour (2007) and Ullah *et al*. (2015) have also reported fluctuation in gastropods diversity between different seasons, but these studies didn't report the low diversity in summer. This fact may be due to Monsoon Current occurring at the end of summer in the study area.

According to Rouhipour (2007), species *Asseminea* sp.1 and *Asseminea* sp.2 had the highest density (number in m^2) in summer, winter and spring. Species *Cerithidea cingulata* also had remarkable density during spring. Species *Asseminea spp* and *Cerithidea* cingulata were the densest species in autumn.

Relating to density variations in transects species *Asseminea* sp.1 and *Asseminea* sp.2 had the highest density in all three transects. In general, the highest sample frequency (45%) was for transect 1 and the lowest was for transect 3. It is notable that high density and frequency of few species is observable in the area adjacent to land and low density and frequency of many species is highlighted in the area adjacent to the water. The intermediate zone has an average status in this respect.

Conclusion

According to the results obtained, gastropods of this region belonged to 22 families, 35 genera, and 44 species that have more diversity in the area adjacent to water. Comparison with other mangrove forests in Indo-Pacific regions showed the gastropods diversity has reducing trend from the east to the west and the study area is the most diverse region in Iran. This study recorded 13 new species that hadn't been reported before from Iran. Nothing the importance of Iranian mangrove forests from the perspectives of ecology, food chains, ecotourism, uniqueness of ecosystems and their special role in global development of mangrove forests, it is vital to study the ecosystem of these forests and to gain sufficient data about components effective on their ecosystem variations. These data are necessary to design and apply proper conservation and utilization management of these ecosystems.

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