Abundance Of Molluscs (Gastropods) At Mangrove Forests Of Iran

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ABSTRACT: This study determined the abundance and diversity of molluscs (focused on gastropod) at Hara Protected Area (HPA) and Gaz and Hara Rivers Delta (GHRD) mangroves, southern of Iran. Point count sampling method was employed in this study. A total of 1581 individual of gastropods, representing 28 species and 21 families, were observed in the two sites. The PCA plot indicated that all species have correlation with winter excluding species namely *Ethalia sp.*, *Haminoea sp.*, *Trichotropis sp.* and *Tibia insulaechorab curta* at HPA and *Telescopium telescopium*, *Stocsicia annulata*, and *Stenothyra arabica* at GHRD. The mean number of species was estimated 6.88±2.77 (per plot) versus 9.65±6.63 (per plot) at HPA and GHRD respectively. The results of χ^2 test indicated that there was a high significant difference between total gastropod population observed at 4 seasons ($\chi^2_{3,1}$=31.9, *p*<0.001), but there was no significant difference in term of number of species between sites in order to seasonal observation ($\chi^2_{3,1}$=0.84, *p*>0.05). The results of diversity comparisons indicated that the highest diversity was in the HPA as compared to GHRD. Furthermore, the SIMPER analysis indicated that mangroves of HPA and GHRD were dominated with Asseminea sp., although the number of population was much higher at *R. mucronata* habitat. Eight species namely *Asseminea sp.*, *Stenothyra arabica*, *Cerithidium cerithinum*, *Littoria intermedia*, *Telescopium telescopium*, *Iravadia quadrasi*, *Atys cylindrica* and *Cyclostrema ocrinium* represented more than 91% of observations at HPA, while at GHRD, there were only three species namely *Asseminea sp.*, *Stenothyra arabica* and *Cerithidea cingulata* which represented more than 90% of observations. The result states that the great importance of HPA and GHRD for gastropod assemblages as main food resource for wading birds must be recognized and the protection of these sites from threats must be thoroughly enhanced.

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INTRODUCTION

The term molluscs refer to an ecological group of invertebrates that belong to many lesser known creatures (Mardiastuti, 2001). Phylum Mollusca with more than 100000 recognized species (Feldkamp, 2002) play an important role in ecosystem function for forage of predators in their habitats.

The term molluscs are relatively known compared to other components of the mangrove habitats (Kober, 2004; Mardiastuti, 2001; Smith & Nol, 2000). The Gastropoda with an estimated 75000 to 150000 species are the most diverse class of molluscs in the marine habitats (Strong *et al.*, 2008) such as mangroves (Vermeij, 1973) and terrestrial habitats (Barker, 2001). It has been shown that gastropod assemblages massively contribute to feeding resources of waders within the mangrove ecosystem (Al-Sayed *et al.*, 2008). Although classically the role of mangrove gastropods in nutrient dynamics has been largely overlooked, studies have demonstrated their central ecological role (Fratini *et al.*, 2008).

Mangroves are intertidal vegetation along tropical and subtropical shorelines (Zhang *et al.*, 2007), which have special physiological adaptations to frequently inundate by the tides (Lewis Iii, 2005). These unique ecosystems provide a large number of biological, ecological, economic, scientific, environmental, aesthetic and ethical values (Mitsch, 2005) including controlling tide level (Varnell *et al.*, 2003) reducing effects of wave and wind energy against shorelines (Miththapala, 2008), stabilizing shorelines (Lee & Shih, 2004). Thus mangroves protect inland structures (Lewis Iii, 2005), support coastal fisheries (Walters *et al.*, 2008), provide diverse habitat to support wildlife communities including a large number of waterbirds, especially waders (Lewis Iii, 2005), and so many other direct and indirect benefits (Gustavson *et al.*, 2009; Zhou *et al.*, 2010).

The total area of mangrove forests in Iran, which covering an area of 12481 ha, is estimated to be less than 0.1% of the total area in the world (Safiari, 2002). These mangroves including only two species of *Avicennia marina* (with the most parts) and *Rhizophora mucronata*, are scattered in the eastern coastal of Oman Sea in Goatr Bay Protected Area within quadrant 25˚ 11΄-25˚ 16΄N and 61˚ 35΄-61˚ 28΄E (with 671.53 ha), up to mid of Persian Gulf coastal in the Mel-e-Gonzeh Protected Area in the position of 27˚ 52΄ N and 51˚ 35΄E (with 22 ha). Each one of the mangrove habitats is widely known as one of the most productive with diverse attributes including a typical fauna (Behrouzi-Rad 1991; Danehkar, 2001a; Mohammadizadeh *et al.*, 2009; Safa, 2006; Zehzad *et al.*, 2002) and are highly important because of their role in the food resources, shelter, nesting and roosting sites for wide range of globally important species (Zahed *et al.*, 2010). It has been estimated that approximately 527 bird species occurred in Iran (Lepage, 2010), as if mangroves in Persian Gulf and Oman Sea hold more than 20% of them.

However there is no qualitatively account of diversity of the molluscs, particularly the gastropods, in rich tropical forests not only in the Hormozgan province (Danehkar, 2001), but also in the Indo-West-Pacific mangrove habitats (Lee, 2008). Moreover, to date no detail studies have been done to observe the seasonal diversity and abundance of molluscs as a food resource especially for waders in mangroves of Hormozgan, Iran. Therefore, the main objective of this study was to describe the mollusc's species diversity and abundance based on four seasons in the Hara Protected Area (HPA) and Gaz and Hara Rivers Delta (GHRD) mangrove forest, south of Iran.

MATERIAL AND METHODS

Study Area: The study areas included Hara Protected Area (HPA) and Gaz River and Hara Rivers Delta (GHRD), which are located within quadrants 26˚ 23΄–26˚ 59΄ N and 55˚ 32΄–55˚ 48΄ E, and 26˚30΄–26˚50΄ N and 57˚00΄–57˚40΄ E respectively (**Fig. 1**).

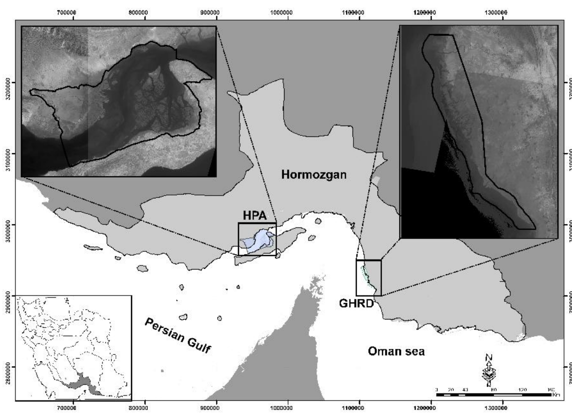

Fig. 1 The location of study areas

Biospheric reserve of Hara Protected Area (HPA) or 'Khouran Straits' is located in the southern Persian Gulf between the region of the Mehran river and Kol river deltas and the island of Qeshm. Within the straits, there are 100,000 ha of low-lying islands, mangrove, mudflats and creeks which constitute much of the largest mangrove/mudflat ecosystem in Iran. The main area of mangrove and mudflat (82360 ha) was designated a Protected Region in 1972. This was later increased to 85,686 ha and upgraded to a National Park (Hara National Park), but downgraded to Protected Area in the 1980s. The entire area is known as 'Khouran Straits' (100000 ha) and was designated a Ramsar Site in 1975, while the reserve (85686 ha) was designated a Biosphere Reserve in 1976 (Danehkar, 1996). The annual mean, minimum and maximum temperatures are 27.6˚C, 2˚C and 48˚C in a 30 years period (1975-2005), respectively. The mean annual rainfall is about 80.3 mm that mainly occurs in the winter. The mean monthly relative humidity is 83.4% and the range of high tide is 4.33 m from the Port of Shahid Rajaee, nearest to the study site. The mangrove species of *Avicennia marina* is the pure stand in this area.

The international wetland of Gaz and Hara Rivers Delta (GHRD), with 15000 ha area, is a large area of intertidal mudflats and mangrove swamps at the mouths of two rivers on the eastern shore of the Straits of Hormoz, at the entrance to the Persian Gulf. The entire wetland has been designated a Ramsar site in 1975 and has been identified as an Important Bird Area by Birdlife International. The minimum, maximum and annual mean temperatures are 3.5˚C, 49.6˚C and 26.5˚C over a 30 year period (1975-2005) at the Minab meteorological station, respectively. The mean annual rainfall is about 40.6 mm that mainly occurs in the winter. The lowest mean monthly rainfall (0 mm) occurred over 6 months, between April and October. Highest monthly rainfall (19.6 mm) occurred in January. The mean annual relative humidity is 77.9%. The patch of mangrove forest, at the mouth of the rivers, is probably the finest stand of *Rhizophora*, in terms of tree size and density.

Survey Design: Square plot sampling method carried out in its most basic form. Each site was divided by many intertidal channels. A total of 3 transects had been established on the map randomly within three main channels in each area. Transects were run parallel to creek at the pre-decided locations distributed in each area (**Fig. 2**). A total of 35 point count stations (300 m apart from each other) were established within transect 1, 30 points in transect 2 and 32 points in transect 3, randomly in the HPA and similar trends spread on GHRD, which 30 points were established within each transect.

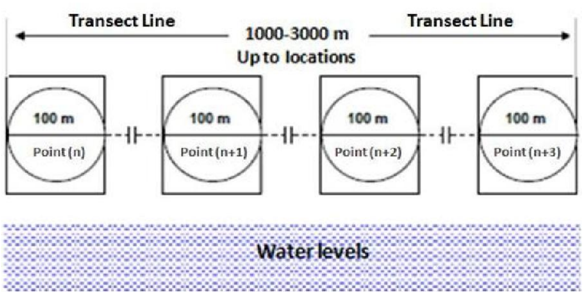

Fig. 1 Randomization of sampling points among transects

Gastropod survey: Overall, the survey was established during four seasons including fall, winter, spring and summer.

All molluscs (gastropods) were collected by hand picking, using 0.0625 square meter quadrates with size of 25 x 25 cm that were chosen randomly within each selected point. At the same time the foulers like mussels and oysters were collected by scrapping those using knives or spatula from the quadrate. Also, gastropod (larger than 0.5 mm) was measured to a depth of 10 cm using special sediment sample dishes (10 cm Diameter). After washing with sea water and sieving the samples, 70% Ethyl alcohol and formalin (4%) was added drop by drop to water in which animals were kept. Then the samples were transferred to the laboratory of Azad University-Bandar Abbas branch. In the laboratory, each sample was washed by fresh water. Gastropod samples were identified using field guides and identification keys (Dance, 1974) and counted.

***Data Analysis*:** Gastropod communities in the studied plots were characterized and counted per each 0.625 square meter plot. The relative abundance (%) of species was determined using the expression: $n/N \times 100$ (Where n is numbers of recorded species and N is total observations recorded) (Zakaria *et al.*, 2009).

The mean of parameters (±SE) and one-way analysis of variance (ANOVA) followed by a *post hoc* multiple comparison (Tukey's test) were calculated to compare the mean values of observation based on season.

A X^2 test was applied to look at significant differences between gastropod communities in the *A. marina* and *R. mucronata* habitats. Additionally, a principal components analysis (PCA) was used to determine the level of contribution of species by seasons.

All statistical analyses were also performed with SPSS version 16.0 (SPSS Inc., Chicago, Illinois, USA).

As a noted by Seaby & Henderson (2007), even a quite modest field survey can produce a bewildering amount of information on the presence and abundance of species. As it is commonly difficult to identify the main features and inter-relationships between communities, thus, the similarity percentages (SIMPER), analysis of similarity (ANOSIM) and cluster analysis of communities were tested for comparing and classifying communities using the community analysis package software (CAP version 4.0).

RESULTS

For a period of one year of sampling, started from September 2^{1th} 2008, a total of 1581 individuals of gastropods, representing 28 species and 21 families, were observed in the two sites. Based on the data in each site, a total of 770 gastropods, belonging to 28 species were recorded at the *A. marina* habitat in the mangroves of HPA, while a total of 811 individuals, belonging to 20 species at the *R. mucronata* habitat of GHRD. **Table 1** gives the classification and relative abundance of gastropods according to superfamily and family in the two types of mangrove forests.

The observations were categorized based on different season, where a total of 210 (21 spp.), 336 (23 spp.), 131 (17 spp.) and 93 (12 spp.) observations were recorded at HPA in the fall, winter, spring and summer, respectively. While, a total of 268 (13 spp.), 248 (20 spp.), 150 (9 spp.) and 145 (8 spp.) observations were recorded at GHRD in the same seasons, respectively. The mean value of gastropod species in HPA during fall, winter, spring and summer seasons were estimated at 7.50±3.22, 12±4.56, 4.68±1.68 and 3.32±1.34 individuals per plot respectively. While, the mean value in GHRD were estimated at 12.75±8.56, 11.81±7.85, 7.14±5.04 and 6.90±5.08 individuals per plot in the same seasons, respectively. Moreover, the results showed that there was a significant difference between the number of individuals observed due to seasons ($p<0.01$) in both habitats. *Post hoc* multiple comparisons also clearly indicated that more individuals were recorded in winter than in the fall ($p<0.05$), spring ($p<0.05$) and summer ($p<0.05$) in both habitats.

The correlation of various gastropod species and season of winter as presented in the principal component analysis (PCA) plot indicated that most species were correlated with winter excluding four species namely *Ethalia sp.*, *Haminoea sp.*, *Trichotropis sp.* and *Tibia insulaechorab curta* at HPA **(Fig. 3)**, and three species namely *Telescopium telescopium*, *Stocsicia annulata*, and *Stenothyra arabica* at GHRD (**Fig. 4**). The axis 1 and 2 explained 60.88% and 26.64% for HPA and 59.97% and 31.22% for GHRD respectively. The results also showed that the eigenvalues for axes 1, 2, 3 and 4 were 0.819, 0.112, 0.069 and 0.000 respectively, and also cumulative percentage variance of species data for axes 1, 2, 3 and 4 were 81.9, 93.1, 100.0 and 0.0 for HPA respectively, while for GHRD, the eigenvalues for axes 1, 2, 3 and 4 were 0.803, 0.150, 0.048 and 0.000 respectively, and also cumulative percentage variance of species data for axes 1, 2, 3 and 4 were 80.3, 95.2, 100.0 and 0.0 respectively.

Number of individual and species of molluscs at two sites in each season were compared (**Table 2**). Mean value of molluscs' species was estimated at 6.88±2.77 (sp. per plot) versus 9.65±6.63 (sp. per plot) at HPA and GHRD respectively. The results of X^2 test indicated that there was a high significant difference between total gastropod population observed at four seasons ($X^2_{3,\ 1}$=31.9, $p<0.001$), but there was no significant difference in term of number of species between sites in order to seasonal observation ($X^2_{3,\ 1}$=0.84, $p>0.05$). Furthermore, diversity comparisons of gastropod assemblages by Rényi diversity profiles (**Fig. 5**) and sample rarefaction (**Fig. 6**) at HPA and GHRD indicated that the highest diversity was at HPA as compared to GHRD.

A similarity percentage (SIMPER) analysis indicated that mangroves of HPA and GHRD were dominated with Asseminea. However, the number of populations was much higher at *R. mucronata* habitat (SIMPER, percentage of contribution to similarity of 37.96 % and 79.15 %, respectively) (**Table 3**). Eight species namely *Asseminea sp.*, *Stenothyra arabica*, *Cerithidium cerithinum*, *Littoria intermedia*, *Telescopium telescopium*, *Iravadia quadrasi*, *Atys cylindrica* and *Cyclostrema ocrinium* represented more than 91% of observations at HPA, while at GHRD, there were only three species namely *Asseminea sp.*, *Stenothyra arabica* and *Cerithidea cingulata* which represented more than 90% of observations. There was no new species in GHRD than HPA. Cluster analysis illustrated that gastropod abundances, fell into two main groups based on season accessions (**Fig. 7).**

The analysis of similarity (ANOSIM) was also performed to test the patterns of the species composition between two habitats. The ANOSIM determined that there was significant difference between composition of gastropod species in the two habitats ($p<0.01$) (**Table 4**).

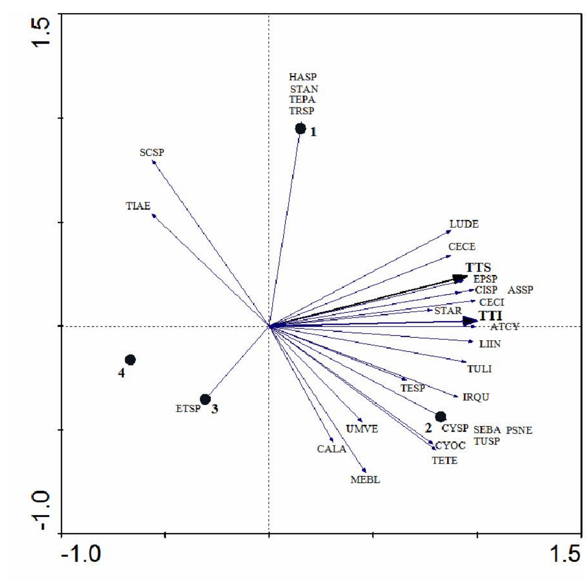

Fig. 3 The correlation of gastropods based on seasons using PCA plot in the HPA

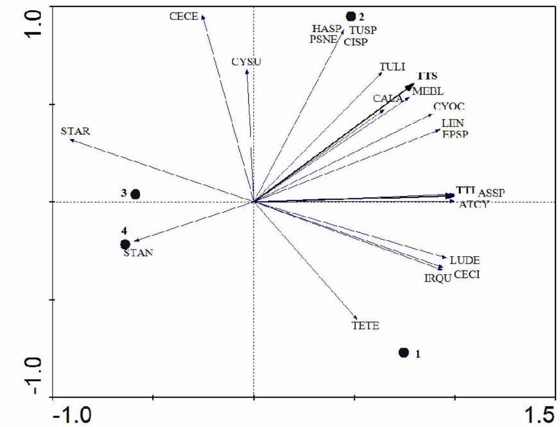

Fig. 4 The correlation of gastropods based on seasons using PCA plot in the GHRD

Samples - 1: fall, 2: winter, 3: spring and 4: summer

Species - ASSP: Asseminea sp., ATCY: Atys cylindrica, CALA*: Cassidula labrella*, CECI*: Cerithidea cingulata*, CECE*: Cerithidium cerithinum*, CISP: Citharmagllia sp., CYOC*: Cyclostrema ocrinium*, CYSU*: Cyclostrema supremum*, EPSP: Epithonium sp., HASP: Haminoea sp., IRQU*: Iravadia quadrasi*, LIIN*: Littoria intermedia*, LUDE*: Lucidinella densilabrum*, MEBL*: Mitrella blanda*, PSNE*: Pseudominolia nedyma*, STAR*: Stenothyra arabica*, STAN*: Stocsicia annulata*, TETE*: Telescopium telescopium*, TULI*: Turbonilla linjaica*, TUSP: Turitella sp. , TTI: Total Individual Observations, and TTS: Total Species Observations

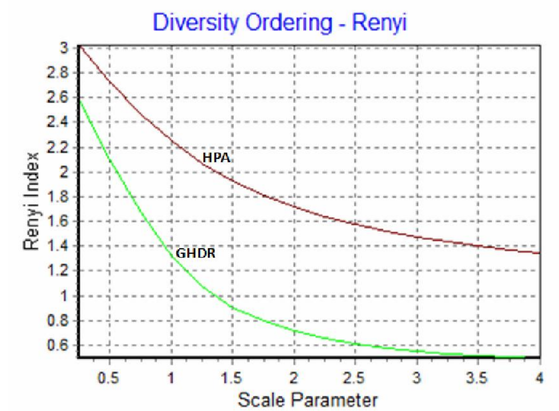

Fig. 5 Diversity comparisons of gastropod assemblages by Rényi diversity profiles at HPA and GHRD

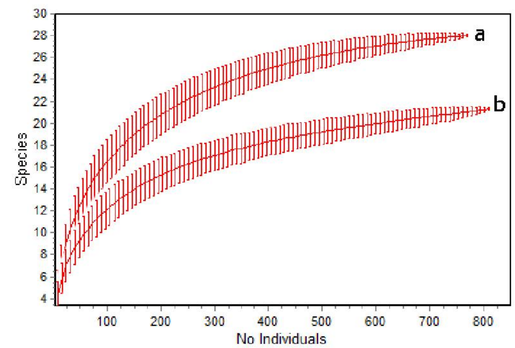

Fig. 6 Rarefaction patterns of gastropods at HPA (6) and GHRD (6)

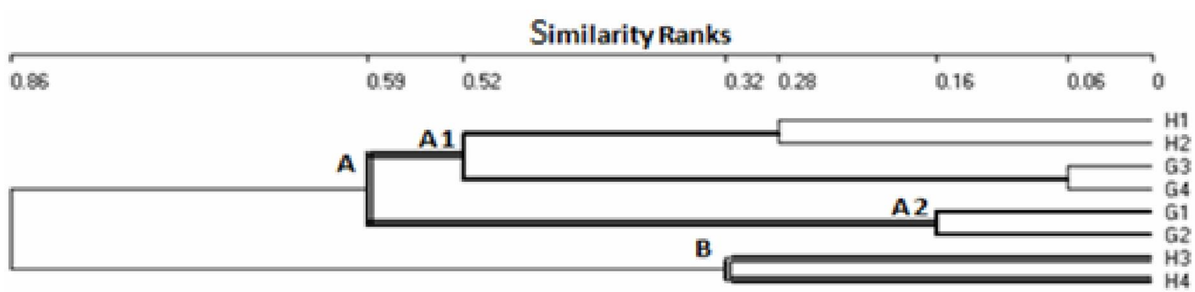

Fig. 7 Grouping of gastropod assemblages as defined by cluster analysis across seasonal changes at HPA (H) and GHRD (G). Note: 1-fall, 2-winter, 3-spring and 4- summer

Table 1 Classification and relative abundance of Gastropods according to Superfamily and family in the HPA and GHRD mangrove forest

Superfamily	Family	Species	Abundance	
			HPA	GHRD
Buccinoidea	Columbellidae *Swainson,1840*	*Mitrella blanda* (Sowerby, 1844)	2	8
Capuloidea	Capulidae *Fleming, 1822*[1]	*Trichotropis sp.*	1	0
Cerithioidea	Diastomatidae *Cossmann, 1894*[2]	*Cerithidium cerithinum* (Phlippi, 1849)	7	5
	Potamididae *Adams & Adams,1854*[3]	*Cerithidea cingulata* (Gmelin, 1791)	90	62
		Telescopium telescopium (Linnacus, 1758)	39	14
		Terebalia palustris (Linnaeus,1767)	2	0
	Turritellidae *Mörch, 1852*	*Turitella sp*	3	1
Conoidea	Turridae *Adams & Adams,1854*	*Citharmagllia sp.*	6	1
	Terebridae *Mörch, 1852*	*Terebra sp.*	7	0
Ellobioidea	Ellobiidae *Pfeiffer,1854*	*Cassidula labrella* (Deschayes,1830)	8	8
Epitonioidea	Epitoniidae *Berry, 1910*	*Epithonium sp.*	3	3
Haminoeoidea	Haminoeidae *Pilsbry, 1895*	*Atys cylindrica* (Helbling,1779)	34	5
		Haminoea sp.	3	1
Littorinoidea	Littorinidae *Chilren,1834*	*Littoria intermedia* (Philippi, 1846)	61	3
Pyramidelloidea	Pyramidellidae *Gray,1840*	*Turbonilla linjaica* (Melvill & Standes, 1901)	6	6
Rissooidea	Assimineidae *Adams & Adams,1856*	*Asseminea sp.*	279	560
	Iravadiidae *Thiele, 1928*	*Iravadia quadrasi* (Boettger,1893)	38	31
		Lucidinella densilabrum (Melvill, 1912)	4	30
	Rissoidae *Gray,1847*	*Stocsicia annulata* (Dunker, 1860)	2	1
	Scaphandridae	*Scaphander sp.*	12	0
	Stenothyridae	*Stenothyra arabica* (Neubert, 1998)	106	55
Stromboidea	Strombidae *Rafinesque, 1815*	*Tibia insulaechorab curta* (Sowerby II, 1842)	9	0
Triphoroidea	Cerithiopsidae *Adams and Adams,1854*	*Selia bandorensis* (Melvill,1893)	1	0
Trochoidea	Turbinidae *Rafinesque, 1815*	*Cyclostrema ocrinium* (Melvill & Standes, 1901)	26	11
Trochoidea	Turbinidae *Rafinesque, 1815*	*Cyclostrema supremum*	2	5
	Trochidae *Rafinesque, 1815*	*Ethalia sp.*	2	0
		Pseudominolia nedyma (Melvill, 1897)	1	1
		Umbonium vestiarium (Linnacus,1958)	16	0

[1]Synonyms: Trichotropidae Gray, 1850; Verenidae Gray, 1857; Pileopsidae Chenu, 1859; Siriidae Iredale, 1931; Cerithhiodermatidae Hacobjan, 1976
[2] Synonyms: Ewekoroiidae Adegoke, 1977
[3] Synonyms: Telescopiidae Allan, 1950; Cerithideidae Houbrick, 1988

Table 2 Number of gastropod species and individuals at HPA and GHDR

Location/Season	No. Species	No. Individuals	Relative Abundance	Mean Value	SE
HPA	**28**	**770**	**100.00**	**6.88**	**2.70**
Fall	21	210	27.27	7.50	3.22
Winter	23	336	43.64	12.0	4.56
Spring	17	131	17.01	4.68	1.68
Summer	12	93	12.08	3.32	1.34
GHRD	**20**	**811**	**100.00**	**9.65**	**6.63**
Fall	13	268	33.05	12.76	8.56
Winter	19	248	30.58	11.81	7.85
Spring	9	150	18.50	7.14	5.04
Summer	8	145	17.88	6.90	5.08

Table 3 Contribution of mollusc's species towards differentiating the types of mangroves habitat (SIMPER Analysis)

Location and Species	Average Abundance	Average Similarity	Contribution (%)	Cumulative (%)
HPA		***60.04***		
Asseminea sp.	69.75	22.79	37.96	37.96
Stenothyra arabica	26.50	10.98	18.30	56.25
Cerithidea cingulata	22.50	6.54	10.89	67.15
Littoria intermedia	15.25	3.79	6.31	73.45
Telescopium telescopium	9.75	3.61	6.02	79.47
Iravadia quadrasi	9.50	2.76	4.60	84.07
Atys cylindrica	8.50	2.74	4.57	88.64
Cyclostrema ocrinium	6.50	1.65	2.75	91.39
GHRD		***72.77***		
Asseminea sp.	140.00	57.60	79.15	79.15
Stenothyra arabica	13.75	4.28	5.88	85.04
Cerithidea cingulata	15.50	4.13	5.67	90.71

Table 4 The ANOSIM pair-wise tests for similarity between sites due to 4 seasons

First Habitat	Second Habitat	Permutations done	P Value	Level %	No >= Obs.	Quadrate Stat.
HPA	GHDR	35	0.01	2.85	1	0.5

DISCUSSION

Mangrove forests offer a considerable variety of food resources for many waterbird species (Skilleter & Warren, 2000). The molluscan community is a key component of the mangroves' food chain (Morrisey *et al.*, 2003; Nanami *et al.*, 2005; Okuda & Nishihira, 2002), and play a vital role in the abundance of waders (Al-Sayed *et al.*, 2008; Perez-Hurtado *et al.*, 1997; Piersma *et al.*, 1993) and of some seabirds (Bond & Diamond, 2007; Petry *et al.*, 2008). On the other hand, abundance and diversity of molluscs have been, historically, used as an indicator of ecosystem health and of local biodiversity in mangrove (Amin *et al.*, 2009; Bryan *et al.*, 2009).

The studies dealing with the molluscan community at mangroves areas are insufficient not only in the Hormozgan province (Rohipour, 2007), but also in the Persian Gulf and Oman Sea (Alsharhan & Kendall, 1994; Barth, 2003). The purpose of the present study was to determine the assemblage structure of invertebrates in relation to four seasons to finding the effect of their abundance in the abundance of waterbirds in the mangroves of Hormozgan province.

The structure of the molluscan community present in the HPA and GHRD mangrove forests showed that family of Assimineidae, Potamididae and Stenothyridae were the dominant family. Comparing with similar studies (Danehkar, 1994; Rohipour, 2007; Safa, 2006) conducted in the Hormozgan mangroves the results showed a similarity in molluscan diversity among them, where *Asseminea sp.*, *Stenothyra arabica* and *Cerithidea cingulata* are usually present in the Persian Gulf mangrove areas. The same is also true for Oman Sea. Additionally, the results of this study showed that the diversity of the molluscan fauna in the HPA was higher than in GHRD, however the total abundance in GHRD had also been considered. This can be reflected in the fluctuation of waterbird populations, where the presence of molluscs showed temporal oscillations in order to seasons. It may be related in part to a combination of factors, including temperature, low water flow, the rate of organic matter and subsequent decrease of dissolved oxygen concentration.

The finding of *Terebralia palustris* at HPA is interesting. Since this species was rarely found and have been declining in the world in the recent decades, this finding has ecological and conservational importance. This large and distinctive edible gastropod was absent in the previous studies (Al-Khayat, 1997; Al-Sayed *et al.*, 2008; Dodd *et al.*, 1999; Rohipour, 2007) in the mangroves of Persian Gulf coast. It is suggested that the reasons for the contemporary absence of *T. palustris* within the Persian Gulf remain speculative. Elsewhere in the Indo-Pacific it is typical (Fratini *et al.*, 2004), although not always (Feulner & Hornby, 2006), closely associated with mangrove forests, so the reduced presence of mangroves in Persian Gulf limits, where they are near the margin of their winter frost tolerance, has been tentatively invoked to explain the absence of *T. palustris* there.

As mentioned in the literature review, despite the lower species richness, abundance of gastropods is generally high. It is related to low degree of environmental favorableness in mangrove habitats, which have remarkable adaptations to changes in environmental conditions and are able to attain high levels of primary productivity. Part of the adaptation, however, is to minimize nutrient drain through organic matter loss. Also, the results showed the highest number of molluscs during waterbird migratory seasons (winter at HPA and fall at GHRD) than non-migratory season and the assemblages are dominated by large populations of few species that are adapted to the environmental limitations.

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