The Study of Sea Cucumber (*Holothuria (Thymiosycia) arenicola* Semper, 1868) Population in the Coast of Chabahar Bay (Gulf of Oman – Iran)

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Abstract
This research aimed to study the Habitat preference features (abundance, distribution, and stability) of sea cucumber (*Holothuria arenicola*) population in the coast of Chabahar Bay during one year from November 2008 to September 2009. Sampling was randomly done bimonthly during low tide from 5 stations. Then, samples were counted and identified and their spatial and temporal variability were investigated. The results of the study showed that the highest abundance of *H. arenicola* was in January 2009. According to the results of Kruskal-Wallis analysis, abundance of sea cucumbers showed significant difference in different months and stations (P<0/05). Investigation of distribution and stability indicators revealed that dispersion of *H. arenicola* was random and its stability was rare.

Keywords: Sea cucumber, Abundance, Stability index, Chabahar Bay

1. Introduction

Echinoderms are marine organisms with various ecological, economic, and food importance (Manriquez et al., 2017). These organisms are useful in environmental monitoring to reach ecological and experimental aims because members of this phylum are sensitive to environmental changes and abundant in marine environments, the coastal benthic ecosystems, and shallow waters (Soares and Resgalla Junior, 2016). Moreover, they swallow mud and sand, leading to disturbance in the substrate, the prevention of sediment accumulation and bacterial activity, the increase of nutrients in the water, and consequently the population growth of other suitable marine organisms (Zamora et al., 2018).

Sea cucumbers have an elongate and worm-shaped body, radial symmetry, no arm and spine, free life in all depths (Kamarudin et al., 2017), and are used as food in many Asian countries and the Pacific islands (Xu et al., 2018). The gonad (raw and cooked) of sea cucumbers are also consumed in Europa, tropical regions of South America, and the Mediterranean region (Kiew and Don, 2012). Approximately 1,400 extant species have been reported in the class Holothuroidea (Dabbagh et al., 2012). Traditional, medical, and nutritional use of this invertebrate has a long history (Pangestuti and...
Dried and processed sea cucumbers, known as beche-de-mer or trepang, are sold as foodstuffs in Asian markets, which form the basis of a multi-million dollar industry (Aprianto et al., 2019). In addition to their high nutritional value, sea cucumbers are well known in the medical industry (Bordbar et al., 2011).

There are studies on Sea cucumbers belong to the Persian Gulf and Gulf of Oman. A previous study reported endangered and economically valuable species of sea cucumbers in the coastal waters of the UAE (Yaghmour and Whittington-Jones, 2018). Moreover, it was reported that *Holothuria arenicola* has dispersion in tropical areas from Bermuda to Brazil, the Gulf of Mexico, and Florida, as well as on the coastal sandy beaches of Pakistan (Siddique and Ayub, 2019). Moreover, this species was observed in Indo-Pacific, Indian islands, East Africa, Madagascar, Gulf of Suez, Gulf of Aqaba, Red Sea, Maldives, Gulf of Mannar, Bay of Bengal, Palk Bay, Australia, Philippines, China, Japan, and south Pacific islands to Hawaii.

In Iran, a few studies reported some sea cucumber species from the of Kish Island inshore waters. (Tehranifard et al., 2011; Tehranifard and Rahimibashar, 2012), in which the abundance of echinoderm was the highest in winter and spring, and gradually decreased with the onset of heat (Foroughian, 1997). Some species of sea cucumbers were identified in Bandar-e Bostāneh, Hormozgan Province, and reported that the abundance of echinoderms tends to decrease in the warm months (June and July) and increase in the cold months (March and December). Besides, the highest abundance of echinoderm was recorded in autumn (Azizzadeh, 1997; Ehsanpour et al., 2016). Karimzadeh (2006) reported three species of sea cucumbers from the Bandar-e-Lengeh on the coast of the Persian Gulf. One species of sea cucumber was identified by Badri (2007) in the Naiband Bay and the Kharg and Khargu Islands, and the highest abundance of echinoderms was recorded in the cold season. Rezaei and Kamrani (2008) studied the abundance and distribution of sea cucumbers in Bandar-e Bostāneh, identified 6 species of sea cucumbers, and reported that the abundance increases in the warm season, due to their tendency to live in water with high temperature. Some species of sea cucumbers were reported on the shores of Qeshm Island and the highest abundance of echinoderms was observed in winter (Izadi, 2008; Bastami et al., 2012). Shakuri (2008) monitored sea cucumber communities in the sub-tidal zone of Chabahar Bay, identified 7 species of sea cucumbers with the highest abundance in February and the lowest in July.

Regarding that echinoderms have an important role in the marine food chain and their feeding controls the distribution of related species such as bivalve, fish and coral (Grzimek, 2004), the evaluation of their abundance is important in further understanding the structure of marine communities (Lamare et al., 2009). On the other hand, this study can be compared with future conditions, revealing the need for extensive and scientific research on living organisms in the region and their relationship with the environment. Regarding the economic value of echinoderms, it is necessary to study the abundance and dispersion of these organisms, determine suitable species for breeding in the aquaculture industry, treating and nourishing in the medicinal and nutritional industry, and protect their natural resources from overexploitation. On the other hand, the more we know about the biology, dispersion, and habitat of a species, the more successful the effort to protect it. This study aimed to determine the abundance, dispersion, and sustainability of *H. arenicola* on the shores of Chabahar Bay.
2. Materials and methods

2.1. Study area and sampling stations

Chabahar Bay is located in southeast of Iran in Sistan and Baluchistan province between longitude 60° 24' 38" - 60° 39' 90" and latitude 25° 17' 15" - 25° 26' 80". This bay has an area of 320 km², an average depth of 6m, a maximum depth of 22 m in the opening, a diameter of 21 km, and 10 m above mean sea level (Komijani and Chegini, 2012). Five stations were selected in this area, the geographic coordinates of which were recorded using GPS. In addition to, substrate granulation and texture was performed according to Holmes et al. (2007) method and the type of substrate of each station was determined (Table 1).

Based on access to coasts, geomorphological differences of coasts and habitat diversity, as well as the dispersion and abundance of sea cucumbers in the intertidal zone of Chabahar Bay during Preliminary Field Research, 5 sampling stations were selected. At each station, 2 transects perpendicular to the sea, with a width of 30 m and a length corresponding to the tide, were considered at a distance of 100 m from each other. In each transect, 2 sections (low tide zone, mid tide zone) were identified and 10 repetitions were carried out in each section, randomly (PERSGA, 2004) (Fig. 1).

Table 1: The geographic coordinates of sampling stations (Chabahar Bay, 2008-09)

<table>
<thead>
<tr>
<th>Station</th>
<th>Location</th>
<th>substrate type</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Darya Bozorg</td>
<td>Rocky</td>
<td>25°16'51&quot;N</td>
<td>60°39'90°E</td>
</tr>
<tr>
<td>2</td>
<td>The university coast</td>
<td>Sandy-rubble</td>
<td>25°16'22&quot;N</td>
<td>60°36'90°E</td>
</tr>
<tr>
<td>3</td>
<td>Chabahar Diving Cottage</td>
<td>Rocky/coraline substrate</td>
<td>25°19'12&quot;N</td>
<td>60°37'28°E</td>
</tr>
<tr>
<td>4</td>
<td>Tiss</td>
<td>Rocky-sandy</td>
<td>25°17'71&quot;N</td>
<td>60°37'17°E</td>
</tr>
<tr>
<td>5</td>
<td>Konarak</td>
<td>Sandy</td>
<td>25°22'47&quot;N</td>
<td>60°24'38°E</td>
</tr>
</tbody>
</table>

Fig 1: Study area and sampling stations in the Chabahar Bay
2.2. Field and laboratory investigation

Sampling was performed once a year from November 2008 to September 2009. The sea cucumbers of each quadrat were counted, collected, transferred to plastic containers, and fixed in 10% formalin. Then, samples were studied and identified using a stereomicroscope. Because spicules are an important factor in identifying sea cucumbers, a fragment of their body wall was immersed in concentrated bleach (NaOCl) for at least half an hour until the spicules separated (Toral-Granda, 2006). Spicule images were taken using an optical microscope with a camera (Fig 2), and the sea cucumber species were identified based on the shape of the spicule. Water salinity, pH, and temperature were measured at each station once every two months and investigated their interaction with biotic parameters.

Fig 2: Sea cucumber *H. arenicola*

Species were determined by using the identification key (Conand, 1993; Samyn et al., 2006). Images and characteristics of sea cucumber specimens were approved by Dr. Gustav Paulay (The Florida Museum of Natural History, University of Florida, USA).

Physicochemical parameters such as water's temperature, salinity and pH was measured every bimonthly by using thermometer, refractometer, and pH meter, respectively.

2.3. Data analysis

The obtained data were analyzed by SPSS 16.0 statistical software. All studies were performed based on the monthly mean abundance of each species (m²) in each station. To compare abundance, a normality test was first used to determine whether the data had a normal or abnormal distribution. Shapiro-Wilk test showed that the data did not have a normal distribution (Sig= 0, P <0.05) and it was not possible to be normalized in different ways. Thus, the Kruskal-Wallis non-parametric test was used to compare abundances between various months.

The variance-to-mean ratio (χ²) in each station was calculated to determine the dispersion index. Then, the dispersion was expressed in regular, random, and cumulative form based on the calculated value, degree of freedom, and the dispersion table (Khatami, 2003).

The sustainability index (F%) we determined using the following formula:

\[ F = \left( \frac{\rho}{P} \right) \times 100 \]

F = sustainability index, \( \rho \) = the number of species, P = total abundance of individuals in the sample.

If the sustainability index is >50%, it is a sustainable species, if 10-50%, it is a common species, and if it is <10%, the species is rare (Arasaki et al., 2004).

3. Results

*H. arenicola* was observed on sandy-rocky shores and inside sand under stones at station 4. Measuring the average water temperature showed that the temperature decreased from November to December, increased from January to July, and decreased again from September. The minimum temperature was recorded in January and the maximum in July. The minimum average of salinity was 34 g/L in May and the maximum was 38.2 g/L in July. The range of changes in the pH was more limited than the other physical-chemical factors and the minimum pH level was 8.03 in May and the maximum was 8.36 in March (Table 2).
Table 2: The range of physicochemical parameters changes in different months (Chabahar Bay, 2008-09).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>November</th>
<th>January</th>
<th>March</th>
<th>May</th>
<th>July</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (˚C)</td>
<td>24.8˚-29.5˚</td>
<td>22.6˚-25˚</td>
<td>23.5˚-25.4˚</td>
<td>25˚-30.4˚</td>
<td>30.7˚-31.7˚</td>
<td>24.4˚-28.3˚</td>
</tr>
<tr>
<td>Salinity (g/L)</td>
<td>37-38</td>
<td>36-36.5</td>
<td>35-37.25</td>
<td>34-35</td>
<td>35.75-38.2</td>
<td>36-37</td>
</tr>
<tr>
<td>pH</td>
<td>8.11-8.33</td>
<td>8.2-8.33</td>
<td>8.2-8.36</td>
<td>8.03-8.19</td>
<td>8.05-8.23</td>
<td>8.2-8.24</td>
</tr>
</tbody>
</table>

A Spearman’s correlation study was carried out between biotic parameters (abundance) and physicochemical parameters. As shown in Table 3, significant negative correlation (P>0.05) was found between abundance of *H. arenicola* with temperature and salinity.

Table 3: Spearman’s correlation between biotic parameters (abundance) and physico-chemical parameters at Station 4 in different months (Chabahar Bay, 2008-09).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>Salinity</th>
<th>Abundance Correlation Coefficient</th>
<th>Sig.(2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spearman’s correlation</td>
<td>-0.880</td>
<td>-0.888</td>
<td></td>
<td>0.021</td>
</tr>
</tbody>
</table>

The monthly mean abundance (m²) of this species in station 4 was 1, 2, 1.25 ±0.447, 1.8±0.919, 1 and 1 in November, January, March, May, July, and September, respectively. The highest abundance was 2 ind.m⁻² in January (Fig. 3).

The Kruskal-Wallis test showed that there was a significant difference between the abundance of sea cucumbers in different months ((P <0.05); χ²(5) = 16.615). Moreover, the abundance of sea cucumbers in different stations was significantly different ((P <0.05 = 0.05; χ²(4) = 169.631).

The dispersion index was obtained from the variance-to-mean ratio of the samples at each station. The results showed that *H. arenicola* had a random dispersion pattern at Station 4 in March and May, and there was not a specific dispersion in other months due to the small number of specimens. The results of the sustainability index showed that *H. arenicola* is a rare species in all months (Table 4).
Table 4. Dispersion and sustainability index of *H. arenicola* in different months at Station 4 (Chabahar Bay, 2008-09).

<table>
<thead>
<tr>
<th></th>
<th>November</th>
<th>January</th>
<th>March (2.32)</th>
<th>May (4.14)</th>
<th>July</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>dispersion index</td>
<td>-</td>
<td>-</td>
<td>Random</td>
<td></td>
<td>2.36</td>
<td>0.37</td>
</tr>
<tr>
<td>sustainability index</td>
<td>2.08</td>
<td>1.59</td>
<td>6.17</td>
<td>3.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion and conclusion

The present study evaluated *Holothuria arenicola* in the inter-tidal zones of Chabahar Bay while it has previously been studied only in the sub-tidal zone of this Bay.

There was a significant difference (*P* < 0.05) in the abundance of sea cucumber at different months. Probably, the substrate type (Table 1) in the stations is one reason for this difference and it is widely associated with the presence or absence of specific benthic species as well as with their dispersion in benthic communities (Rizal and Nurruhwati, 2020). Rocky shores have more abundance than other shores due to their substrate stability and diversity of habitats, including the spaces under stones and the presence of intertidal pools (Lai et al., 2018). In addition to the substrate, the abundance can be related to other factors such as the amount of food. For example, algae as the food of sea cucumbers (Viyakarn et al., 2020), are more common on shores in the colder months and are likely to play a role in increasing the abundance (Table 3). Other researchers who have studied echinoderms in the Persian Gulf and the Gulf of Oman (Oman) reported that the maximum abundance of these animals is observed in cold months and it gradually decreases with the onset of heat (Dabbagh et al., 2011). In the present study, the abundance of *H. arenicola* was also observed in December with the lowest temperature. Seasonal changes, especially changes in temperature, can severely affect benthic communities (Piazza et al., 2020). Most studies showed that temperature fluctuations in intertidal organisms lead to thermal stress (Kon et al., 2020). Environmental stresses have a significant effect on the dispersion and physiologic performance of intertidal organisms (Torossian et al., 2020), and their success in the environment is dependent on their ability to adapt to environmental conditions (Li and Li, 2010). Some researchers believe that high density and diversity of benthos in winter is related to a lower temperature and the stability of environmental factors such as salinity (Sarvankumer et al., 2007), as observed in the present study with minimum salinity fluctuations in December.

The dispersion of this species was different in different months and did not follow a specific pattern. However, the dispersion index in this study further indicates random dispersion, which is mostly seen in normal population (Llacuna et al., 2016). Schmid (2006) evaluated the dispersion of benthos in Laptev See and reported that the substrate type plays a role in the benthic dispersion pattern. Generally, various factors are effective on the dispersion of benthos in the continental shelf. Regarding complex interactions in the environment, it is difficult to accurately identify biological and physical factors affecting organisms and determine its level, especially in shores with obvious effects of anthropogenic activities (Rodrigues and Pires-Vanin, 2012).

Based on the dispersion index calculated in the present study, *H. arenicola* is a rare species. On the other hand, stations under stress do not have rare species (Forjan et al., 2006) and thus the study area in the present study was not under any stress.

Evaluating echinoderms is considered the basis for resource management and the preservation of these species, and have scientific application in
environment and fishery management. Thus, it is suggested that extensive studies be conducted on its various aspects, such as identifying different species in tidal zones and various depths, determining abundance and dispersion, and providing aquaculture information and solutions to protect the biotope of sea cucumbers.

Acknowledgment

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