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Comparative distribution and habitat preference of the sea cucumber *Holothuria atra* Jaeger at protected and unprotected sites inThoothukudi region of Gulf of Mannar, south-east coast of India

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ABSTRACT

The present study was conducted to understand the density, biomass, size distribution and habitat preference of the holothurian, *Holothuria atra,* at a protected and an unprotected site in Thoothukudi region of Gulf of Mannar.Water quality and sediment characteristics of these stations were also assessed. At the unprotected station (St. I), comparatively lower numerical density (mean 0.044±0.003 nos.m^{-2}) as well as lower biomass (6.33±0.99 g m^{-2}) of *H. atra* were observed, rubble constituted the dominant habitat and the population comprised entirely of adult specimens. At the protected station (St. 2), the numerical density varied between 0.17 to 1.43 nos. m^{-2} and biomass between 12.9 to 161.7 g m^{-2}. Sand constituted the dominant habitat and the population comprised both adults and fission pieces. Significant difference was noticed in the numerical density and biomass between stations ($p<0.001$). Except for the pH and high nitrite concentration, other water quality parameters were within the desired limit at St. 2. The sediment quality criteria, especially in terms of organic carbon (1.46±0.22%), organic matter (2.50±0.4%) and nitrogen concentration (0.12 ±0.02%) were comparatively higher in the sediment at St. 2. Significant differences were observed in the variation of organic carbon, organic matter and N_2 between stations ($p<0.001$).

Keywords: Density, Fission pieces, Gulf of Mannar, Habitat preference, *Holothuria atra*, Sea cucumber

Introduction

The sea cucumbers of the family Holothuriidae and Stichopodidae comprises an important item of trade in the Indo-Pacific areas. Due to high demand in international market, ease of harvesting and low cost of processing, the sea cucumber fisheries have developed rapidly in tropical waters (Conand, 2004; Lovatelli *et al*., 2004; Choo, 2008). Inadequate fishery management has led to overexploitation of this resources and signs of severe depletion in many producing countries have been felt (Lovatelli *et al*., 2004; Bruckner, 2006; Kinch *et al.,* 2008). Since studies indicated only slow and sporadic recovery of depleted population in many areas, the information on stock structure and ecology of sea cucumbers are essential for the efficient management of this resource throughout the world (Kinch 2002; Choo, 2008).

In India, the sea cucumber fishery which once existed along Gulf of Mannar and Palk Bay served as an important income source for the livelihood of many fishermen. At present, both fishery and trade of sea cucumbers have been banned by the Government of India and sea cumbers are protected under Schedule 1 of the Wild Life Protection Act of 1972, since 2003.

Holothuria atra commonly known as black sea cucumber, is one of the most abundant and widely distributed sea cucumber species in most parts of the Indo-Pacific region (Harriott, 1985; Uthicke,2001; Conand and Mangion, 2002; Taddei, 2006; Choo, 2008; Conand, 2008). They inhabit a wide range of depths and a broad variety of habitat ranging from rocky reefs to mudflats (Conand and Mangion, 2002;Conand, 2008; Purcell *et al*., 2009). Since most of the high-value sea cucumber stocks have been overexploited, fishery seem to have shifted towards low value species (Lovatelli *et al*., 2004; Conand and Muthiga, 2007; Choo, 2008), Apart from a localised fishery, independent study on sea cucumber population by Zoological Survey of India for a definite period (Venkataraman, 2007), we lack a reliable fishery dependent data on sea cumber stock and ecology from Indian waters. According to Sloan and von Bodungen (1980) and Slater and Jeffs (2010), bottom sediment characteristics are one of the crucial components affecting the habitat preference of sea cucumbers and hence studies on ecology of sea cucumber beds are essential. The present study was conducted to understand the population density, biomass and habitat preference of *H. atra* in Thoothukudi region of Gulf of Mannar, south-east coast of India, two different areas of varying protective measures.

Materials and methods

The study was carried out during the period from May 2010 to March 2011. Two stations were selected for the study, station1 (St.1) (N 08°45.075' E 078°11.573') is an unprotected area, with human interference and habitat disturbance, located south of Tuticorin Port and station 2 (St. 2) (N 08°45.788'E 078°11.922') is a protected area inside the green gate of Tuticorin Port Trust, which is devoid of human interference and habitat disturbances.

Transects of length 100 m were made by direct visual assessment method on a monthly basis for the estimation of density, biomass and distribution pattern at the two stations. The bottom substrate in each transect was visually estimated in terms of the percentage cover of sand, rubble, coral stone, terrestrial rock, sea grass and sea weed to identify the habitat preference of this species. The water and sediment samples were also collected simultaneously from these stations for analyses.

Observations were made *in situ* to assess the temperature using a high precision thermometer. The water quality parameters namely salinity, dissolved oxygen, pH and chlorophyll 'a' were estimated by following the standard procedures (Strickland and Parson, 1968). Ammonia was estimated by phenol hypochlorite method (Solarzano,1969). Nutrients were estimated using spectrophotometer (Genesis 5 model) as per the procedure of Grasshoff *et al*. (1999). Organic carbon, organic matter and nitrogen of bottom sediments were estimated by Walkley-Black (1932) method. The mean values of all parameters were used for statistical analysis to test the correlation and for one way analysis of variance (ANOVA) using SPSS 7.5 statistical package.

Results

Comparatively lower numerical density (mean 0.044±0.003 nos. m^{-2}) and lower biomass (6.33±0.99 g m^{-2}) of *H. atra* were observed at the unprotected station (St.1). Wide fluctuation was noticed in the numerical density and biomass of holothurians at the protected station (St. 2), where the numerical density varied from 0.17 to 1.43 with a mean of 0.6±0.102 nos. m^{-2} and biomass from 12.9 to 161.7 with a mean of 60.6±12.6 g m^{-2} (Fig.1). The density and biomass of *H. atra* varied significantly among the stations ($p<0.001$). A significant positive correlation was also noticed between density and biomass ($p<0.01$).

Maximum numerical density and biomass were observed during September 2010, subsequent to heavy rains. In March 2011, the numerical density and biomass of holothurians were the lowest at St. 2, which might be due to the construction of embankment in the middle of the breakwater, followed by the habitat disturbance and disruptions of tidal flow. In the subsequent month, St. 2 was demolished by the port authority, by converting it into a jetty as a part of their reclamation activities, hindering further studies in this site.

In the present study, the length (10.5 to 29 cm) and weight (68 to 360 g) of adults of *H. atra* were higher in the protected station (St. 2). In the unprotected station (St.1), the length and weight were 9 to 20.5 cm and 30 to 248 g respectively. In the unprotected St.1, rubble (56.7%) constituted the dominant habitat of *H. atra*,

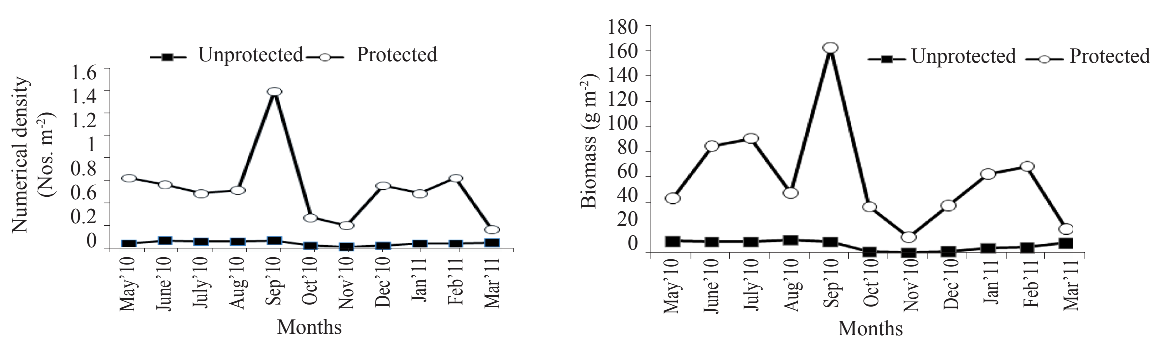

Fig.1. Variation in numerical density and biomass of *H. atra* at two sampling stations

followed by sea weed (13.6%), sea grass (11.3%) and sand (11.2%) respectively. In the protected station St. 2, sand (46.5%) constituted the dominant habitat followed by sea grass (35%), sea weed (12.5%) and rubble (6%) (Fig. 2).

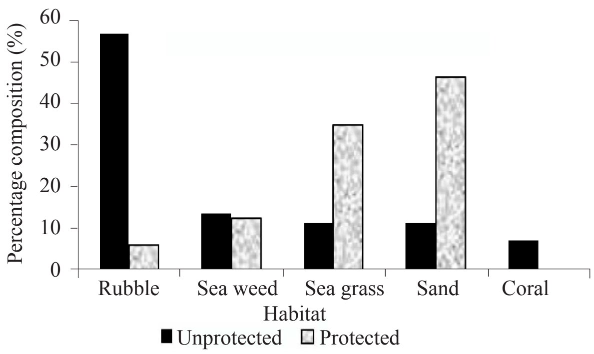

Fig. 2. Habitat preference of *H. atra* at two sampling station

Asexual reproduction by fission is the chief mechanism for population maintenance and increase in certain species of sea cucumber including *H. atra.* This phenomenon was found only at the protected station (St. 2), where the fission product of both anterior and posterior pieces constituted 21.7% to 54.5% of the total population. Anterior pieces were observed in maximum numbers among the fission pieces. During June, 100% of the population was adults and for the rest of the period, adults constituted 45.5 to 78.3% of the total population (Fig. 3). At the unprotected station (St.1), the population comprised only adult specimen and no fission pieces were observed. The length of the fission pieces ranged from 54 to 190 (101.4±4.4 mm) and weight from 20 to 130 g (49.6±3.8 g).

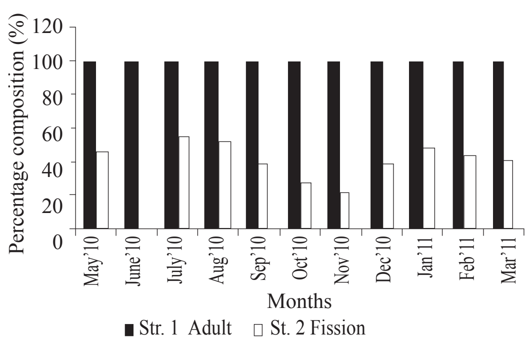

Fig.3. Percentage composition of *H. atra* populations at two sampling stations

The mean values of water and sediment quality parameters are given in Table 1. Not much fluctuation was observed in the air and water temperature between the two stations. The water quality parameters, especially high dissolved oxygen (2.766±0.27 ml l^{-1}) was observed at St.1 due to higher wave action. Due to freshwater influx, salinity was lower at both stations during November and December. Except for the pH and high nitrite concentration (0.72 ±0.07), other water quality parameters like ammonia, chlorophyll, phosphate and silicate were within the desired limit at St.2. Nitrate concentration was significantly higher at St. 2 ($p<0.01$). A positive correlation was observed between NO_2 and organic carbon and NO_2 and organic matter ($p<0.05$).

The sediment quality criteria, especially in terms of organic carbon (1.46±0.22%), organic matter (2.50±0.4%) and nitrogen concentration (0.12 ±0.02%) were comparatively higher in the sediment at St. 2. Organic carbon, organic matter and nitrogen concentration were significantly higher in station 2 ($p<0.001$).

Table 1. Water quality and sediment characteristics (mean ±S.E., n =11) at the sampling stations

Parameters	Stations	
	Unprotected (St.1)	Protected (St. 2)
Air temperature (°C)	28.8.2±1.1	28.8±1.1
Water temperature (°C)	28.9±0.5	28.7±0.6
DO conc. (ml l^{-1})	2.8±0.27	1.9±0.13
Salinity (ppt)	32.8±1.5	32.8±1.5
Chlorophyll (µg l^{-1})	0.82±0.25	0.99±0.2
Ammonia (µgl^{-1})	0.1±0.05	0.13±0.08
pH	7.9±0.12	7.9±0.1
NO_2 (µg l^{-1})	0.15±0.07	0.72±0.18
NO_3 (µg l^{-1})	5.9±3.8	6.0±4.14
PO_4 (µg l^{-1})	1.05±0.3	3.3±1.00
SiO_2 (µg l^{-1})	10±3.4	18.6±4.7
Organic carbon (%)	0.6±.0.12	1.5±2.23
Organic matter (%)	1.04±0.21	2.5±0.4
Organic nitrogen (%)	0.05±0.009	0.12±0.017

Discussion

In the present study, though a comparatively lower density (440 ind. ha^{-1}) of *H .atra*, population was recorded in the unprotected station (St.1), when compared with other studies the population is not as depleted as in the Milne Bay (21 ind. ha–¹), Timor MOU Box (27 ind. ha^{-1}) and in the Torres Strait (Skewes *et al.,*1999, 2002, 2006) and is higher than in the north-west of Sri Lanka (350 ind. ha^{-1}) as pointed out by Dissanayake and Stefansson (2010). In the protected station (St. 2), the estimated density (6000 ind. ha^{-1}) was greater than many of the better managed fishing grounds as in Moreton Bay (1035 ind. ha^{-1}) and Solomon Islands (1115 ind. ha^{-1}) (Skewes *et al.,* 2004; Buckius*et al.,* 2010) but lower than Heron Island (8460 ind. ha^{-1}) (Klinger and Johnson 1998). This type of higher abundance of low-value species in shallow waters has been previously reported by Conand (1990), Purcell *et al.* (2009) and Kinch *et al.* (2008). The length and weight of adult *H. atra* estimated in the present study is in agreement with the findings of Dissenayake and Stephanson (2010) in Sri Lankan waters.

The results of the present study proved the patchiness in distribution of *H. atra*, which is quite common in sea cucumbers and this phenomenon has been previously observed in La Grande Terre in New Caledonia (Purcell *et al.,* 2009), the Torres Strait (Skewes *et al*., 2006), Milne Bay Province (Skewes *et al.,* 2002) and most part of the western Indian Ocean (Conand, 2008). The patchy distribution of sea cucumbers could be linked to their feeding and bottom habitat characteristics (Hammond 1983; Uthicke and Karez, 1999). High densities of sea cucumbers in coastal sea grass beds, soft and hard substrates of coral reefs have been previously reported by Kinch *et al.* (2008) and the present results also support their findings. Dissanayake and Stefansson (2012) also reported higher densities of *H. atra* in rocky or coral habitat with sea grass and/or sea weed beds in Sri Lankan waters.

In the present study, the population comprised both adults and fission pieces in the protected station (St.2), whereas 100% of the population were adult in the unprotected station (St.1). Chao *et al.* (1993; 1994) indicated similar observation of low-density population of large individuals of *H. atra* without fission in one habitat, and a high-density population, where fission occurs throughout the year in Taiwan waters. The fission pieces were found to dominate during the cooler months of July and August in the present study. Dominance of fission during cool months in *H. atra* have been reported by many researchers (Ebert, 1978, Harriott 1982, 1985, Con and and De Ridder, 1990).

The length and weight of the fission pieces reported in the present study, is in concurrence with the findings of Jaquemet *et al.* (1999) in Reunion Island, who observed fission pieces in the range of 15-115 g. High density and the favourable environmental conditions at St. 2 might have triggered asexual mode of reproduction in *H. atra.* Bonham and Held (1963) suggested that fission in *H. atra* may be caused by variations in water temperature. More specific investigations are required to find out the triggering factors for asexual reproduction in *H. atra.*

Higher organic carbon, organic matter and nitrogen concentrations were recorded in the sediment at St. 2, which might have influenced the congregation of holothurians at St. 2. The habitat preference of sea cucumbers has been reported to vary from species to species and even within the different life stages of the same species (Conand, 1990; Mercier *et al*., 2000; Purcell, 2004; Shiel, 2004; James, 2005; Yamana *et al.,* 2006; Conand, 2008; Purcell *et al*., 2009; Slater and Jeffs, 2010). The main food sources of sea cucumbers are bacteria, microalgae and dead organic matter (Yingst, 1976; Massin, 1982; Moriarty, 1982). Hence high abundance of sea cucumbers in sea grass beds and macroalgal habitat could be attributed to the richness of detritus and nutrients in those areas and this finding is consistent with the observations made by Moriarty (1982) and Massin and Doumen (1986). Dissanayake and Stefansson (2012) pointed out that *H. atra* densities were highest in association with the mean grain size of about 0.7–1.2 mm and the organic contents between 2 and 3.5% of dry weight. With increasing depth, silt–mud content increased and gravel content is reported to be decreased (Martin *et al.,* 2009). The variation of sea cucumber densities with depth is reported to be related to the bottom sediment characteristics as there is a close relationship between the sediment grain size and the level of organic matter (Longbottom, 1970; Hargrave, 1972; Dale, 1974; Cammen, 1982). Sediment grain size could be considered as another important factor which governs the habitat preference of sea cucumbers. More concentrated studies/stock surveys are required especially on depth-wise variation of grain size and nutritive factors of various sea cucumber habitats to arrive at a precise conclusion on preferable habitat and to implement successful rehabilitation programmes.

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