Abundance, distribution and some biological aspects of *Holothuria edulis* off the northwest coast of Sri Lanka

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Abstract

The stock status of *Holothuria edulis* off the northwest coast of Sri Lanka was estimated by surveying an area of 1,779 km^2 (using an underwater visual census technique) in October 2009. Five hundred sampling sites were randomly selected and surveyed. The estimated mean density was 122 ± 365 ind ha^{-1} while the standing stock biomass was 1,724 t. Uneven distribution of *H. edulis* was observed within survey sites and *H. edulis* was reported in most habitats, including seagrass beds, coral reefs, open sandy bottom areas and macroalagae-rich areas. The population was dominated by a 16.5 cm (mid-length) length class, and asexual reproduction was promising during the survey time. The findings of this study can be used to develop a proper management plan for the sustainable exploitation of this resource in the future.

Introduction

The sea cucumber fishery was introduced to Sri Lanka by the Chinese in late 19th century (Hornell 1917). Even today, sea cucumbers are of interest in coastal, multi-species fisheries throughout the coastal areas of Sri Lanka. Fishing activities, however, are predominant in the northern, eastern and northwestern parts of the island. Fishing is greatly influenced by monsoons; in the east and the north, fishing occurs during the southwest monsoon season (May to September), and in the northwest, fishing occurs during the northeast monsoon season (October to April). Sea cucumbers are mainly harvested by hand either by skin diving or scuba diving with the aid of fiberglass boats powered by 15–25 hp outboard motors (Dissanayake and Wijayarathne 2007).

About 24 sea cucumber species were reported from the coastal waters of Sri Lanka, and 20 species are considered to be commercially important (Dissanayake et al. 2010). *Holothuria edulis* is the most abundant and widely distributed sea cucumber species around Sri Lanka, and *H. atra* is the second most dominant species (Dissanayake and Athukorala 2009, Dissanayake and Stefansson, 2010). Although *H. edulis* is not frequently exploited on a commercial scale, light exploitation has been carried out from time to time depending on market demand, especially by the aquarium industry (Dissanayake and Athukorala 2009).

According to recent studies, most of Sri Lankan sea cucumbers belonging to the high- and medium-value categories are showing signs of over exploitation, and low-value species are becoming dominant in commercial landings (Dissanayake and Athukorala 2009). As such, there is a potential to exploit *H. edulis* on a large scale from the coastal waters of Sri Lanka as practiced in other Asian countries.

The present study aims to assess the stock status of *H. edulis* off the northwestern coast of Sri Lanka, giving special attention to some biological aspects, including length-weight distribution and reproductive biology.

Materials and method

An underwater visual census was carried out off the northwest coast of Sri Lanka in October 2009.
The study area extended from Mampuri to Vankalai (see Fig. 1). Randomly selected five hundred sampling sites were surveyed within the study area, bounded by Puttlam and Mannar fisheries districts (Fig. 1). The study was confined to water depths of up to 30 m, and the survey area was 1779 km^2. The survey was carried out at the beginning of fishing season by temporarily closing the commercial fishing activities and the survey period was four weeks. The survey used rapid marine assessment technique that have been employed in sea cucumber surveys in Australia's Torres Strait (Long et al. 1996) and Moreton Bay (Skewes et al. 2002), the Timor MOU Box (Skewes et al. 1999), Papua New Guinea's Milne Bay Province (Skewes et al. 2002) and the Seychelles (Aumeeruddy et al. 2005). Fieldwork was

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undertaken by a team of divers operating from small boats. Sample sites were located by using a portable global positioning system (GPS). At each site, a diver (or divers) swam along a 100-m transect collecting sea cucumbers and reporting habitat information on a 1-m swath on either side of the transect line. At each site, the substrate was described in terms of the percentage cover of sand, rubble, limestone platform, coral or terrestrial rock and mud. The percentage cover of other conspicuous biota (e.g. seagrass and algae) was also recorded.

H. edulis collected during the survey were brought to the base station where they were individually weighed and measured for total length. Information on maturity stages and reproductive pattern was also collected. Population density, total abundance and standing stock biomass were calculated and mapped.

Results

Abundance and distribution

H. edulis was observed in 23% of sampling sites with an average density (± SD) of 122 ± 365 ind ha^{-1} off the northwest coast of Sri Lanka. Total abundance was 22 x 10^6 (individuals) while total biomass was 1,724 t.

The distribution of *H. edulis* was highly patchy and the highest densities were recorded close to the lagoon mouth and the upper part of the survey area (Fig. 2). *H. edulis* was found in most habitat types, including seagrass beds (Fig. 3A), coral reefs (Fig. 3B), open sandy bottom areas (Fig. 3C), and macroalgae -rich areas (Fig. 3D). In some areas, *H.edulis* could be found together with *H. atra* (Fig. 3D).

Length-weight frequency distribution

The length and weight frequency distribution of *H. edulis* is summarised in Figure 4. The length of *H. edulis* ranged from 4.5–40.5 cm, and the most frequent length category was 16.5 cm followed by 13.5 cm. The mean length of *H. edulis* was 16.4 ± 4.4 cm and the length frequency distribution was unimodal.

The total weight of *H. edulis* ranged between 10 g and 400 g, and the highest frequency was observed in the 50 g weight category. The mean weight (total) of the northwest population of *H. edulis* was 78.0 ± 15.2 g in 2009.

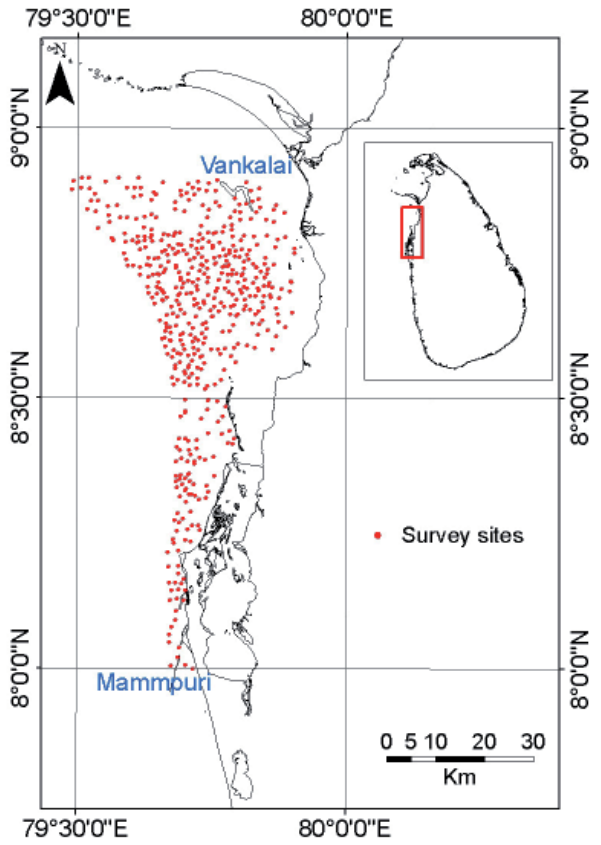

Figure 1. Sea cucumber survey sites off the northwestern coast of Sri Lanka.

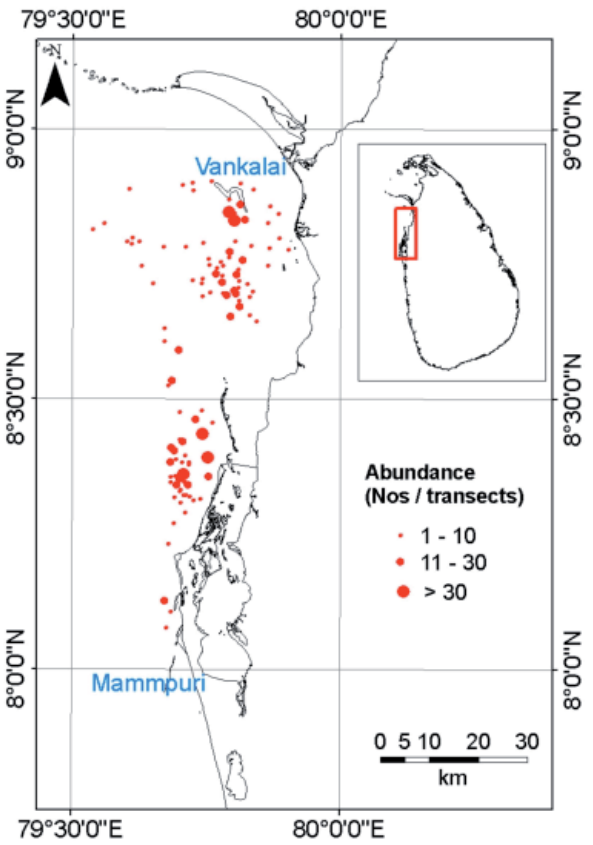

Figure 2. Abundance and distribution of *H. edulis* off the northwestern coast of Sri Lanka in 2009.

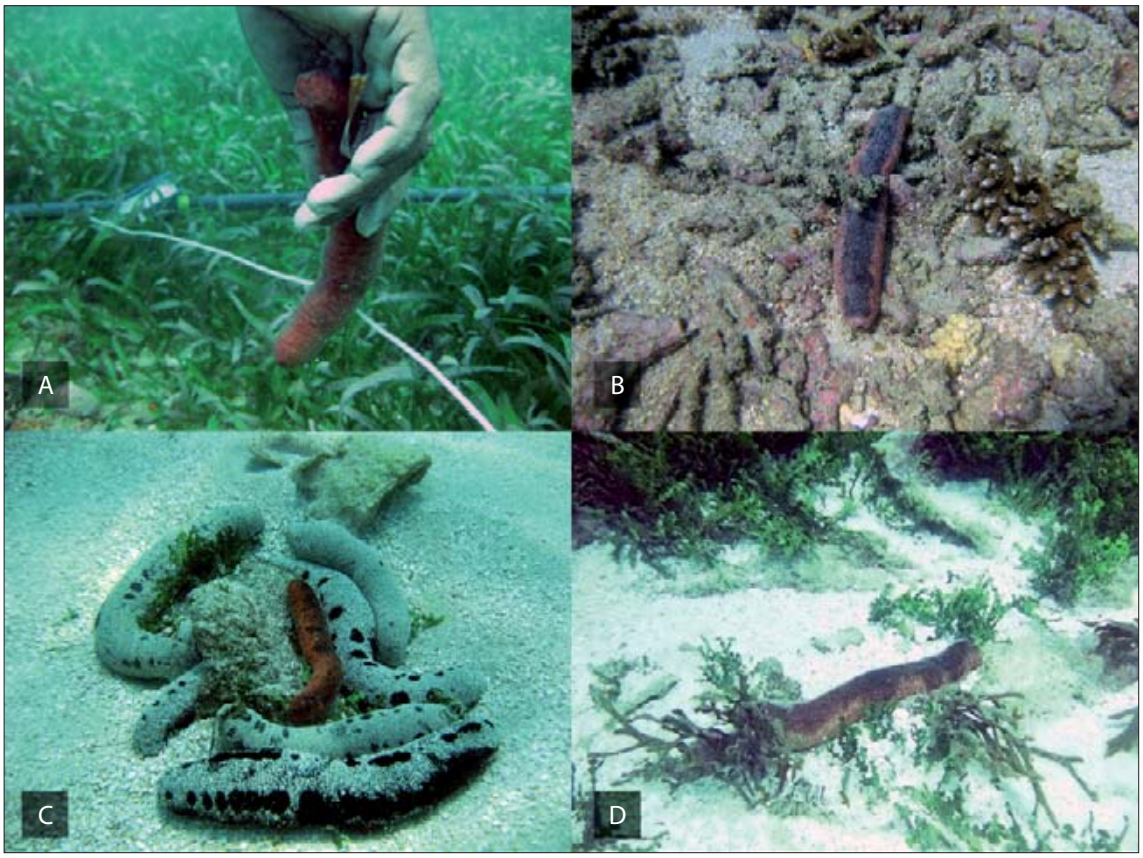

Figure 3. Habitat types within survey areas.
A: *H. edulis* collected from a seagrass bed.
B: *H. edulis* in a coral associated area.
C: *H. edulis* with *H. atra* in an open sandy bottom area.
D: *H. edulis* in macroalgae-rich habitat.

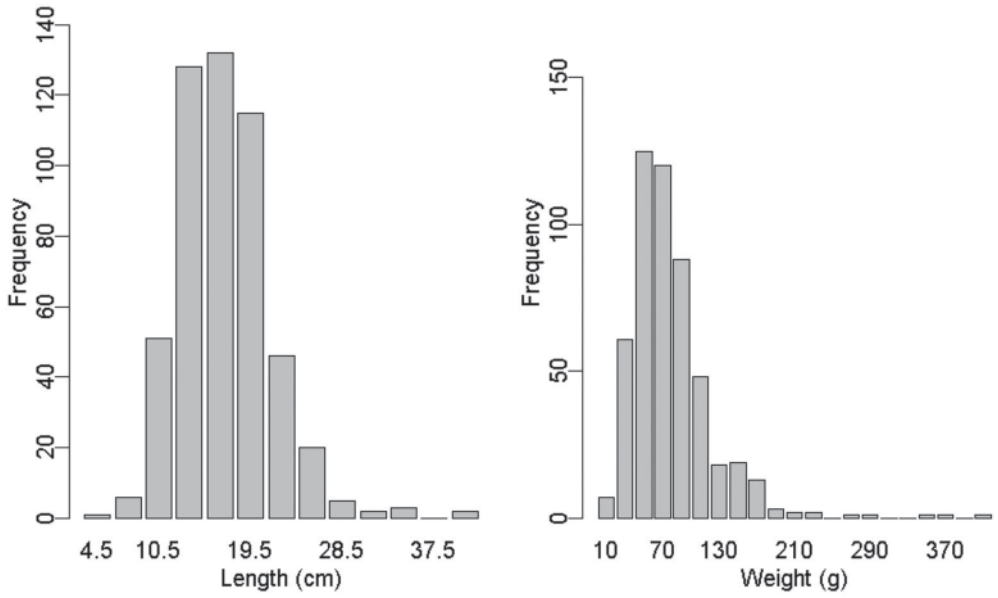

Figure 4. Length and weight (total) frequency distribution of *H. edulis* off the northwestern coast of Sri Lanka.

Reproduction

About 256 individuals of *H. edulis* collected from the survey were dissected in order to study the maturity stages (Fig. 5), although none had mature or developed gonads. However, 23.4% of individuals showed signs of asexual reproduction where the body had divided into two or more parts (Fig. 6).

Figure 5. Dissecting *H. edulis* to study the sexual maturity stages.

Discussion

H. atra is the most common and most abundant sea cucumber species in most parts of the Indian Ocean (Conand and Muthiga 2007), including Mayotte (Pouget 2005) and Reunion Island (Conand and Mangion 2002), and another survey has found that *H. edulis* is the most abundant species in Sri Lankan (Dissanayake and Athukorala 2009). Although *H. edulis* is considered to be a commercial species, it is rarely and seasonally exploited off the coastal waters of Sri Lanka, and this is probably a reason for its higher abundance. The abundance and distribution of *H. edulis* was quite uneven among survey sites, and according to Conand and Muthiga (2007) this is a common phenomenon in other areas of the Indo-Pacific region for all sea cucumber species. The observed discrepancy among survey sites could be linked with the habitat preference of *H. edulis*. In this survey, *H. edulis* was found in different habitat types and was very common in seagrass and coral reef areas. A higher abundance of sea cucumbers in coral reefs and seagrass beds has been discussed by various authors highlighting the importance of these habitats for the protection, sheltering and feeding of sea cucumbers (Sloan and Bodungun 1980; Conand 1990; Conand 2008).

The length distribution pattern of *H. edulis* was unimodal and showed a similar pattern of length-frequency distribution to other holothurian species, including *H. scabra* (Kithakeni and Ndaro

Figure 6. Asexual reproduction (fission) of *H. edulis*.

2002). The results revealed that *H. edulis* can grow up to 41 cm but the population was dominated by individuals that were 16.5 cm (mid-length). These differences in size may be a function of fishing pressure, survey sampling depth, environmental factors and substrate type (Mercier et al. 1999).

Several studies have examined the asexual reproduction of sea cucumbers by fission (Emson and Wilkie 1980; Emson and Maldenov 1987; Boyer et al. 1995; Reichenbach et al. 1996; Uthicke 2001; Conand and Uthicke 2001; Howaida et al. 2004; Conand 1993, 2004; Laxminarayana 2006). Asexual reproduction of sea cucumbers in nature is a very common and seasonal event. According to Uthicke (2001), most holothurian species that reproduce asexually do so by "twisting and stretching" in such a way that the anterior and posterior sections rotate in opposite directions, resulting in a constriction in the holothurian. In the second step, the two halves slowly move in opposite directions until the body wall tears at the constriction point, and the two halves become completely separated. Asexual reproduction of *H. edulis* by transverse fission has been observed by Uthike (1997, 1998, 2001) on the Great Barrier Reef, by Harriott (1980) at Heron Island, and by this study. However, due to a lack of time series data it was not possible to make any conclusion about the sexual reproduction pattern of this species. The absence of mature or developed gonads could be due to the seasonality of sexual reproduction or the species' exclusively asexual mode of reproduction. However, further studies are needed to confirm these hypotheses.

With the increasing demand for beche-de-mer from the Asian market, there is a possibility of exploiting *H. edulis* on a large scale in the near future. Therefore, the findings of this study can be used to develop a proper plan for sustainably exploiting this resource in the coastal waters of Sri Lanka.

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References

Aumeeruddy R., Skewes T., Dorizo J., Carocci F., de Lion, Henriette A. and Cedras M. 2005. Resource assessment and management of the Seychelles sea cucumber fishery, Final project Report.1–37.

Boyer C., Cailasson S. and Mairesse K. 1995. Asexual reproduction in *Holothuria atra* on a reef of Reunion Island in the Indian Ocean. SPC Beche-de-Mer information Bulletin 7:7–9.

Conand C. 1990. The fishery resources of Pacific Island countries. Part 2 Holothurians. FAO Fisheries Technical Paper No. 272, Rome, FAO. 143 p.

Conand C. 1993. Reproductive biology of the characteristic holothurians from the major communities of the New Caledonia lagoon. Marine Biology 116:439–450.

Conand C. 2004. Monitoring a fissiparous population of *Holothuria atra* on a fringing reef on Reunion Island (Indian Ocean). SPC Beche-de-Mer information Bulletin 20:22–25.

Conand C. 2008. Population status, fisheries and trade of sea cucumbers in Africa and the Indian Ocean. p. 143–193. In: V. Toral-Granda, A. Lovatelli and M. Vasconcellos (eds). Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Rome, FAO.

Conand C. and Mangion P. 2002. Sea cucumbers on La Reunion Island fringing reefs: diversity, distribution, abundance and structure of the populations. SPC Beche-de-Mer Information Bulletin 17:27–33

Conand C. and Muthiga N. 2007. Commercial sea cucumbers, A review for the Western Indian Ocean, WIOMSA Book Series 5:123–129

Conand C. and Uthicke S. 2001. Asexual reproduction in *Holothuria* (*Holothuroidea*): A comparison between Pacific (GBR, Australia) and Indian Ocean (La Reunion) populations of *Stichopus chloronotus* (poster). Ninth International Coral Reef Symposium, Bali. p. 300.

Dissanayake D.C.T. and Wijayarathne M.J.S. 2007. Studies on the sea cucumber fishery in the North Western coastal region of Sri Lanka. Sri Lanka Journal of Aquatic Science 12:19–37

Dissanayake D.C.T. and Athukorala S. 2009. Status and management of sea cucumber fishery in Sri Lanka. Final project report (FAO,CIDA and IFAD). 100 p

Dissanayake D.C.T., Athukorala S. and Amarasiri C. 2010.Present status of sea cucumber fishery in Sri Lanka. SPC Beche-de-Mer information Bulletin 30:14–20.

Dissanayake D.C.T and Stefansson G. 2010 Abundance and distribution of commercial sea cucumbers in the coastal waters of Sri Lanka. Aquatic Living Resources 23 (3): 303 -313

Emson R.H. and Maldenov P.V. 1987. Studies of the fissiparous holothurian *Holothuria parvula* (Salenka) (*Echinodermata: Holothuroidea*). Journal of Experimental Marine Ecology 111:195–211.

Emson R.H. and Wilkie I.C. 1980. Fission and autotomy in echinoderms. Oceanography Marine Biology, A. Review, 18:155–250.

Howaida R.G., Ahmed I.A., Hanafy H.M., Lawrence J.A., Ahmed I.M. and Salah G. ELEtreby. 2004. Sea cucumbers of the Red Sea: The Egyptian experience. p. 373–384. In: Lovatelli A., Conand C., Purcell S., Uthicke, S. Hamel J.-F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. FAO, Rome Hornell J. 1917. Indian beche-de-mer industry: Its history and recent revival. Madras Fisheries Bulletin 11(4):119–150.

Kithakeni T. and Ndaro S.G.M. 2002. Some aspects of sea cucumber, *Holothuria scabra* (Jaeger, 1935) along the coast of Dar-es-Salaam. Western Indian Ocean Journal of Marine Science 1, 163–168.

Laxminarayana A. 2006. Asexual reproduction by induced transverse fission in the sea cucumbers *Bohadschia marmorata* and *Holothuria atra*. SPC Beche-de-Mer Information Bulletin 23:35–37.

Long B.G., Skewes T.D., Dennis D.M., Poiner I.R., Pitcher C.R., Taranto T., Manson F., Polon F., Karre B., Evans C., Milton D., 1996. Distribution and abundance of beche-de-mer on Torres Strait reefs. CSIRO Division of Fisheries Final Report.

Mercier A., Battaglene S.C., Hamel J-F. 1999. Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors. Journal of experimental. Marine Biology and Ecology 239:125–156.

Pouget A. 2005. Abundance and distribution of holothurians on the fringing reef of Grande Terre, Mayotte, Indian Ocean. SPC Beche-de-Mer Information Bulletin 21:22–26

Reichenbach Y.N., Nishar, Y. and Saeed A. 1996. Species and size related in asexual propagation of commercially important species of tropical sea cucumbers. Journal of the World Aquaculture Society 27:475–482.

Skewes T., Dennis D., Jacobs D., Gordon S., Taranto T., Haywood M., Pitcher C., Smith G. and Milton D. 1999. Survey and stock size estimates of the shallow reef (0-15 m deep) and shoal area (15–50 m deep) marine resources and habitat mapping within the MOU74 box. Volume 1: Stock estimates and Stock status. CSIRO Final Report. 1–88.

Skewes T., Dennis D., Wassenberg T., Austin M., Moeseneder C. and Koutsoukos A. 2002. Surveying the distribution and abundance of *Holothuria scabra* (sandfish) in Moreton Bay. CSIRO Division of Marine Research Final Report. 1–20.

Sloan N.A. and Bodungun B.V. 1980. Distribution and feeding of the sea cucumber *Isostichopus badionotus* in relation to shelter and sediment criteria of the Bermuda Platform. Marine Ecological Progress series 2:257–264.

Uthicke S. 1997. Seasonality of asexual reproduction in *Holothuria atra*, *Holothuria edulis* and *Stichopus chloronotus*. (Holothuroidea – Aspidochirotida) on the Great Barrier Reef. Marine Biology 129:435–441.

Uthicke S. 1998. Regeneration of *Holothuria atra*, *Holothuria edulis* and *Stichopus choronotus*. Intact individuals and products of asexual reproduction. p. 531–536. In: Moori R. and Telford M. (eds). Echinoderms. Proceedings of the Ninth International Echinoderm Conference, Balkema, Rotterdam

Uthicke S. 2001. Influence of asexual reproduction on the structure and dynamics of *Holothuria* (Holodeima) *atra* and *Stichopus chloronotus* populations of the Great Barrier Reef. Marine and Freshwater Research 52:205–215.