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COMMUNICATION

Seagrass ecosystems of Ritche's Archipelago in the Andaman Sea harbor 'Endangered' *Holothuria scabra* Jaeger, 1833 and 'Vulnerable' *Actinopyga mauritiana* (Quoy & Gaimard, 1834) sea cucumber species (Echinodermata: Holothuroidea)

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Abstract: This study reports the presence of 'Endangered' sea cucumber *Holothuria scabra* for the first time from the mixed seagrasses of Havelock Island, and the 'Vulnerable' *Actinopyga mauritiana* from the monospecific *Thalassia hemprichii* meadows from Neil Island of Ritche's Archipelago of Andaman & Nicobar Islands (ANI). Both species were found during field survey of intertidal seagrass ecosystems of Ritche's Archipelago. Morphometric measurements were carried out in the field using a vernier caliper, and identification was confirmed using the identification guide for sea cucumbers of ANI provided by the Zoological Survey of India. The total body length of the *H. scabra* specimen was 15.7 cm, mouth width of 3.2 cm and body circumference of 5.7 cm. The specimen was a juvenile, grey in color with a total of 17 black and yellow transverse stripes along the body. The average body length of *A. mauritiana* specimens examined differed between those from seagrass meadows (20.4 cm) non-seagrass areas (15.7 cm) as did mouth width and total circumference. Mono and mixed seagrass meadows of ANI are critical habitats for sea cucumbers and require monitoring and protection for conservation of declining populations.

Keywords: Andaman & Nicobar Islands, biodiversity, *Cymodocea rotundata,* Echinoderm, India, tropical islands.

Editor: Anonymity requested.

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Author contributions: AKM, SHF—conceptualization, design, methods, field work, data analysis, writing, final validation, funding. RR—field work, data analysis, writing DK—field work, data analysis, writing.

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INTRODUCTION

Sea cucumbers are marine invertebrates of the family Holothuroidea, that possess unique morphological characteristics such as leathery skins, feeding tentacles and elongated bodies, which aid in their survival as bottom detritus feeders (Idreesbabu & Sureshkumar 2017; Mohammednowshad et al. 2021). These animals play an important role as a biotic component in the benthic zone of coastal marine ecosystems (Gamage et al. 2021) by regulating micro-algae growth, nutrient recycling and mixing the upper sediment layers through bioturbation (Costa et al. 2014; Arnull et al. 2021). These ecological interactions also allow the sea cucumbers to inhabit soft bottom coral reef areas and intertidal seagrass ecosystems (Navarro et al. 2014; Floren et al. 2021).

The coastal ecosystems of India are home to 200 species of holothurians, of which 98 species are found in the Andaman & Nicobar Islands (ANI; Raghunathan & Venkataraman 2014; Vinod et al. 2017). *Holothuria scabra* Jaeger, 1833 and *Actinopyga mauritiana* (Quoy & Gaimard, 1833) have high value leading to increased fishing and over exploitation. *H. scabra* is economically important and famous for 'beche-de-mer' or 'trepang' which is highly valued in traditional diets and for medicinal purposes in China, Japan, Malaysia, Thailand, Vietnam, Indonesia and the Philippines (Purcell et al. 2012; Arnull et al. 2021; Aulia et al. 2021). Similarly, *A. mauritiana* is also heavily fished for its commercial importance in traditional Chinese medicines (Raghunathan & Venkataraman 2014), and by subsistence fisheries as a direct food source (Kinch & Friedman 2008). In the late 1990's Indian fishermen exported more than 50 tonnes of 'beche-de-mer' to other Asian countries (Vinod et al. 2017). This led to overexploitation of both species and collapse of populations from the coast of India. The Ministry of Environment, Forests and Climate Change (MoEFCC) imposed a blanket ban on fishing and trading of all holothurian species from Indian waters in 2001, under schedule I of the Indian Wildlife Protection Act, 1972 (MoEFCC 2001). However, the illegal fishing of sea cucumbers in the Indo-Pacific region, including the areas around Andaman Sea is still active and has pushed some species towards being endangered (*H. scabra*) and vulnerable (*A. mauritiana*) according to the last IUCN assessment (Conand et al. 2013; Hamel et al. 2013).

In India, for better conservation and management actions, understanding the population trends, habitat settings and effects of presence of various coastal keystone ecosystems (such as coral reefs, seagrass, and macroalgae systems) on sea cucumber distribution in shallow waters is important (Idreesbabu & Sureshkumar 2017; Mohammednowshad et al. 2021). In ANI, there is a single study showcasing the positive role of different habitat types (such as intertidal reef flats, rock pools, dead coral rubbles covered with macroalgae and mono-specific seagrass beds) and role of various abiotic factors (such as pH, sea surface temperature, salinity) on the distribution of five sea cucumber species, i.e., *H. atra*, *H. leucospilota*, *Stichopus chloronotus*, *Synapta maculata*, and *Actinopyga mauritiana* has been recorded (Gole et al. 2022). The distribution of *A. mauritiana* in the above study was restricted to only intertidal hard substratum (Gole et al. 2022). However, studies showcasing the importance of the presence or absence of intertidal seagrass meadows on sea cucumber distribution in these islands are less understood. Therefore, this study aimed to assess the presence of various sea cucumber species from areas with and without seagrass meadows of Andaman & Nicobar Islands.

METHODS

This study surveyed two islands of the Ritche's Archipelago (RA) situated in southern part of Andaman Islands of ANI of India that consists of eight islands including both Swaraj Dweep and Shaheed Dweep (Figure 1). We selected Swaraj Dweep (hereafter Havelock) and Shaheed Dweep (hereafter Neil) islands, as both islands are most visited by tourists and is inhabited by mixed and monospecific seagrass meadows (Mishra & Mohanraju 2018; Mishra & Apte 2020; Mishra et al. 2021). In each location, we selected two sites, i.e., one with seagrass meadows and another without seagrass. At each site, we surveyed an area with seagrass meadow (site 1: 500 ha) and another area without seagrass (site 2: 500 ha) situated 2 km away from site 1 (Figure 1). The survey was carried out during low tide for collection of sea cucumber specimens. All morphometric measurement of the sea cucumbers were recorded in situ. The threatened sea cucumber *H. scabra* was found within the mixed seagrass (i.e., *Thalassia hemprichii*, *Cymodocea rotundata*, *Halophila ovalis*, *Halodule uninervis*, and *Syringodium isoetifolium*) areas of the Vijay Nagar beach of Havelock Island (Image 1a). It is important to note here, that the presence of *H. scabra* was opportunistic and we did not observe a second specimen even after surveying the entire intertidal area of our site at Havelock Island. There was no observation of *H. scabra* from the intertidal areas without seagrass (site 2) of Havelock Island. The

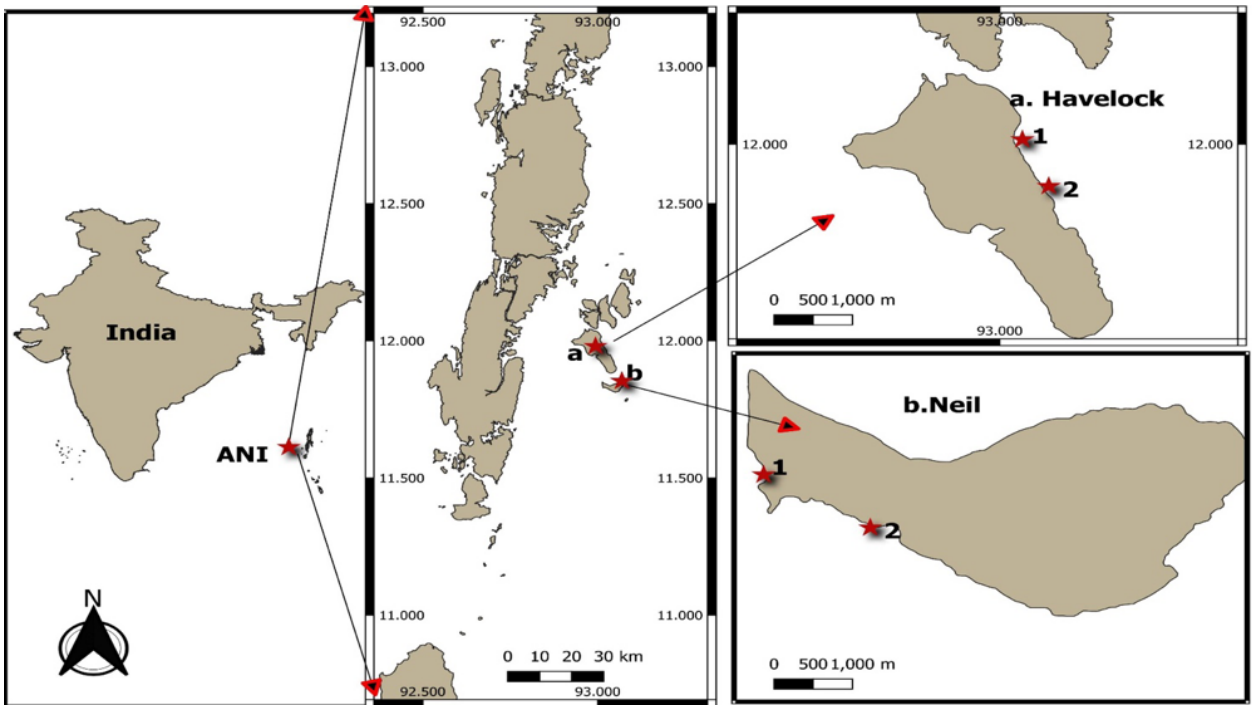

Figure 1. Andaman & Nicobar Islands showing the locations: a—Havelock | b—Neil Island where the sea cucumbers were recorded. The site (1) and (2) of each location represent areas without seagrass and with seagrass respectively.

threatened sea cucumber *A. mauritiana* was found inhabiting both the intertidal monospecific seagrass (*T. hemprichii*) meadows and areas without seagrass at Neil Island (Gole et al. 2022). Morphometric traits (such as body length, mouth width and circumference of the body) were measured in the field using a vernier caliper and measurement tape. An unpaired t-test was carried out to check the statistical significance between body morphometrics of only *A. mauritiana* with and without seagrass meadows. The specimen was identified using the field guide to sea cucumbers of ANI of India (Purcell et al. 2012; Raghunathan & Venkataraman 2014) and pictures were taken for photographic evidence. Due to the Schedule-I status of India's sea cucumber species (MoEFCC 2001), no specimen was collected from the field for any laboratory analysis. However, ban on collection of specimen samples in India also hinders scientific research for sea cucumbers. Furthermore, to address this issue, short-term permits may be provided for restricted sample collection, so that it can help in generating data on current population trends and increase our understanding on the various sea cucumber species of India.

RESULTS & DISCUSSION

Havelock Island

In Havelock Island, we did not find any sea cucumber species within the areas without seagrass. However, in the mixed seagrass species we observed a single specimen of *H. scabra* within *C. rotundata* and *T. hemprichii* mixed meadows (Image 1a). The total body length of *H. scabra* was 15.72 cm, mouth width of 3.19 cm and body circumference of 5.69 cm (Table 1). *Holothuria scabra* specimen was grey in color with a total of 17 black and yellow transverse stripes along the body (Image 1). The average width between these stripes was 1.49 ± 0.47 cm with a maximum width of 2.57 cm and minimum of 0.80 cm (Table 2). The specimen in our study is considered a juvenile as matured individuals have total body length > 40 cm for the Indian Ocean region (Purcell et al. 2012). The specimen in our study was also smaller than the *H. scabra* specimens observed from the coast of the Philippines (Jontila et al. 2017). Furthermore, we believe our specimen was a juvenile because the observed band widths on our specimen was within the range for juvenile, i.e., 1.50–2.57 cm (Purcell et al. 2012), as observed in this study (Table 2). The presence of *H. scabra* within seagrass meadows indicates favorable habitats for the threatened species, possibly due to: (i) high organic matter content in the sediment in seagrass

Table 1. Morphometric traits of *Holothuria scabra* collected from the intertidal seagrass and non-seagrass ecosystems of Neil and Havelock Islands, ANI, India. Maximum length (ML) was obtained from FAO 2012 guidelines. No record (Nr).

Location	Species (number of specimens)	Length (cm)	Mouth width (cm)	Body width (cm)	FAO 2012
Havelock (with seagrass)	*H. scabra* (n = 1)	15.72	3.19	5.69	ML: 40 cm
Havelock (non- seagrass)	Nr	-	-	-	-

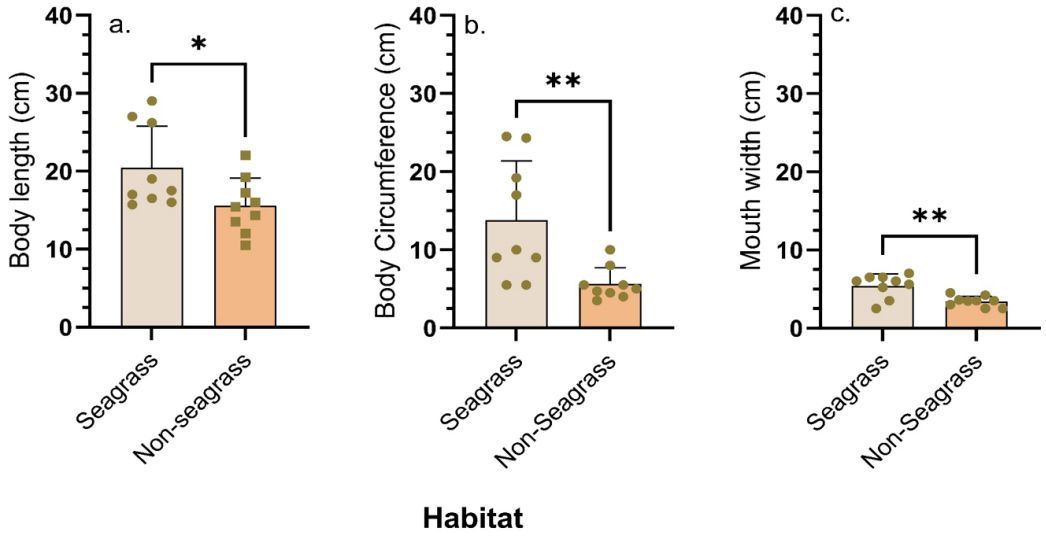

Figure 2. Mean ± standard deviation and range of morphometric traits: a—body length | b—circumference | c—mouth width presented only for *A. mauritiana*. Significance (p <0.05) was tested with unpaired t-test (<0.05*, 0.005) between seagrass and non-seagrass areas from ANI, India.**

areas (51.55%) compared to the non-vegetated (35%) areas (Mishra & Farooq 2022; Mishra et al. 2023) and (ii) fine grain sediment structure within seagrass meadows for burial of this species (Mishra & Apte 2020; Mishra et al. 2021). The first record of this species from Havelock Island also indicates the migration of this species from South Andaman region (Raghunathan & Venkataraman 2014) to these island ecosystems probably due to less exploitation or pressure from clandestine fishing activities as these regions are more tourism dependent.

Neil Island

From Neil Island, *A. mauritiana* was observed both from monospecific seagrass meadows and the adjacent areas without seagrass (Image 1). The average total body length of *A. mauritiana* differed between seagrass and non-seagrass areas (Image 1a). The body length within the seagrass meadows (20.4 ± 5.3 cm) was 1.3-fold higher than that of non-seagrass (15.7 ± 4.2 cm) areas (Figure 2a). Similarly, total circumference of the body and mouth width differed between seagrass and non-seagrass areas (Figure 2). The overall body circumference of *A. mauritiana* was 2.5-fold higher within seagrass

Table 2. Unique bands of *Holothuria scabra* (Image 2b) and the respective band widths (in cm) recorded in-situ from the mixed seagrass ecosystems of Havelock Island, ANI, India.

Species	Band order (from mouth towards back)	Band width (cm)
Holothuria scabra	1	2.57
	2	1.18
	3	1.82
	4	1.52
	5	1.20
	6	1.22
	7	1.42
	8	2.0
	9	1.10
	10	1.21
	11	1.00
	12	0.80
	13	1.68
	14	1.69
	15	2.48
	16	1.18
	17	1.38

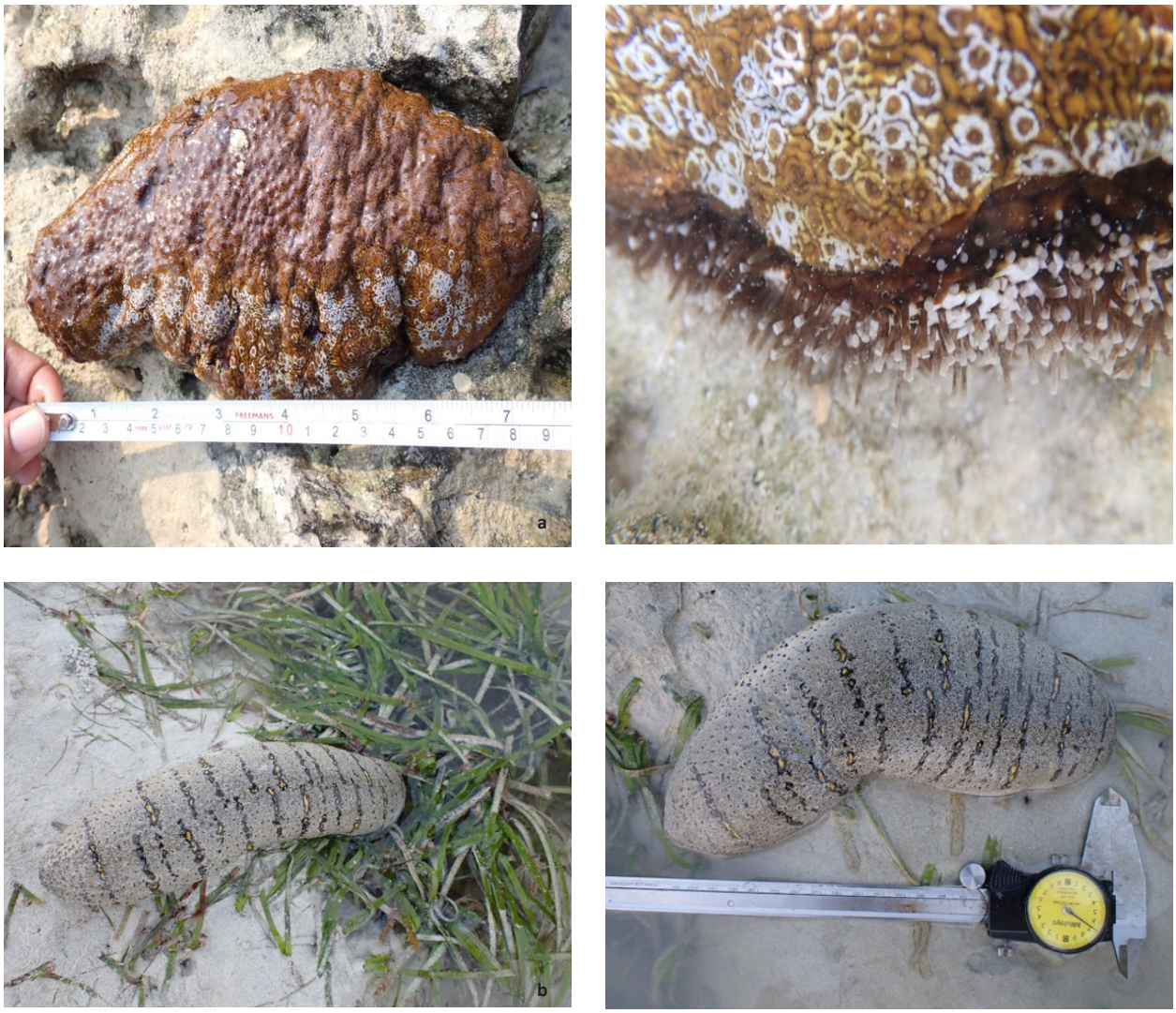

Image 1. a—*Actinopyga mauritiana* | b—*Holothuria scabra* specimen recorded in the field during seagrass surveys in Neil and Havelock Island of Ritche's Archipelago of ANI, India. The yellow and black band widths of *H. scabra* are unique to their identification. © Amrit Kumar Mishra.

(13.7 ± 7.6 cm) areas than the non-seagrass (5.47 ± 2.02 cm) areas (Figure 2b). Similarly, the mouth width of *A. mauritiana* of seagrass areas (5.4± 1.5 cm) was 1.6-fold higher than non-seagrass (3.3± 0.6 cm) areas (Figure 2c). The *A. mauritiana* specimens of our study are juvenile individuals, as the average mature individuals in the Indian Ocean region reach 23 cm (Purcell et al. 2012). This difference in average body length was more prominent in the areas without seagrass, probably due to less organic matter content and lack of fine grain sediments (Mishra et al. 2023). Our findings agree with previous study from Neil Island, which suggested these vulnerable sea cucumber species prefers mono-specific seagrass meadows rich in organic matter and fine grain sediments to fulfill their energy needs (Gole et al. 2022).

The presence of threatened sea cucumber species from intertidal seagrass meadows of ANI, indicates the importance of these mono and mixed seagrass species and their food and habitat provisions for infauna organisms, which has been observed for other seagrass ecosystems of the Indo-Pacific region (Kinch & Friedman 2008; Costa et al. 2014; Aulia et al. 2021; Arnull et al. 2021; Gole et al. 2022). This positive association between declining sea cucumber populations of India and intertidal seagrass species also emphasizes the need for continuous monitoring of seagrass ecosystems of ANI and India, and maintain the health of these seagrass ecosystems, which are under decline in Neil and Havelock islands of ANI (Mishra & Apte 2020; Mishra et al. 2021). The decline of intertidal keystone systems and their

negative effects on sea cucumber population of India have been documented from the islands of Lakshadweep (Idreesbabu & Sureshkumar 2017; Mohammednowshad et al. 2021) and Gulf of Mannar region of Sri Lanka (Gamage et al. 2021) showcasing the ecosystem services of these systems to India's declining sea cucumber populations. Similarly, migration of endangered *H. scabra* from South Andaman to Ritche's Archipelago also calls for monitoring and surveys of other island systems of ANI to assess the presence of this species and create subsequent protection and management action plans.

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