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Decadal status of *Acanthaster planci* (Linnaeus, 1758) along the coral reef habitat of Andaman and Nicobar Islands

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The coral reef habitats have been facing insightful threats from natural and anthropogenic sources across the world; while natural threats are creating major ecological pressure with the maximum percentage of devastation to the entire ecosystems. The *Acanthaster planci* (L) or Crown-of-Thorns Sea star (CoTS) is known as potential natural predator of corals and can disrupt the entire reef ecosystem with their outbreaks within the much-stipulated time. CoTS are reported from all the reef areas of Andaman and Nicobar Islands with a mean density of 0.71/ hectare within the range of 1.08±0.33 to 0.40±0.18 per hectare between North & Middle Andaman and Nicobar respectively. The distributional pattern of CoTS signifies that the reef crest represents maximum occurrence in comparison with reef slop and reef top; while an inversely proportional relationship can be seen between the occurrence of individuals and depth gradients. Maximum association of the CoTS is recorded with acroporidae corals while corallivorous impacts of CoTS are also recorded with poritidae corals which are not much reported across the world. No observation on the population outbreaks of CoTS was made during the decadal study period from Andaman and Nicobar Islands while the density is intrinsically noted within the limit of the natural population level of CoTS. The presence of natural predators like CoTS in Andaman and Nicobar Islands used to take a leading role in the balancing of reef ecology which denotes the healthy reef ecosystem of this archipelago.

[**Keywords**: *Acanthaster planci* (L), Andaman and Nicobar Islands, Coral reefs, Corallivorous, Crown-of-Thorns Sea star (CoTS)]

Introduction

The reef ecosystems of Andaman and Nicobar Islands are known to share the Indo-West Pacific province of the world's oceans with healthy and diversified scleractinian corals mostly with fringing types of developmental patterns. The health dynamics and sustainability of any reef ecosystem are intrinsically associated with environmental influences or climatic changes; while the occurrence of *Acanthaster planci* (Linnaeus, 1758) or Crown-of-Thorns Sea star (CoTS) on massive scale is also referred to influence notably in reef destruction up to the maximum level of 80 % of killing due to its corallivorous mode of feeding behavior[1-6]. The voracious mode of feeding of CoTS is imposing a major threat to the coral reef habitat[7]. The predatory impact of the CoTS is mostly reported on scleractinian corals in the reef ecosystem while some other studies indicate that soft corals are also reported as the prey for these faunal communities[8-10]. The phase shift in the choice of predation was documented due to the degradation of stony coral cover in those reef areas[10]. The concept of normal range as well as an outbreak of *A. planci* is defined by several workers with numerical ideologies. Chesher narrated that the presence of 100 CoTS/ 20 min of swim or Manta Tow survey can be considered as the outbreak of population[8] while Pearson & Endean established findings of 40 CoTS/ 20 min of swim as the population outbreak[11]. Further, Endean & Stablum considered that presence of 14 CoTS/ 1000 sq. m. as outbreak status[12] whereas, Pearson & Garrett mentioned that the observation of 10 CoTS/ 1 min of spot check as the outbreak condition[13]. The presence of CoTS individuals below the aforementioned observations is considered as a normal occurrence for any reef ecosystem[14]. Moran & De'ath recorded 15 CoTS/ hectare as the outbreaks from the Great Barrier Reef[15]. The occurrence of *A. planci* in the reef habitats of Indian waters is reported from most of the reef areas and the documentation is acknowledged as the threat to reef habitat due to its predation on corals[16]. The present study includes the reporting population status of *A. planci* from Andaman and Nicobar Islands along with their impacts over a period of ten years.

Material and Methods

Underwater studies were carried out in Andaman and Nicobar Islands from August 2009 to July 2019

for a period of 10 years by employing SCUBA diving up to the maximum depth limit of 43 m. Line Intercept Transect method was applied followed by Manta Tow method[17,18] to record the occurrence of *A. planci* or CoTS. The studies were made at the reef crest, reef slope, and reef top areas to document the species abundance vertically[4]. Three replicates of the 50×4 m best transect were applied at the study areas[4]. The statistical analysis of population trend was narrated by Principal Component Analyses with help of PAST software, version 1.83(ref. [19]). Substrate specificity was also documented during the study period.

Results

The studies on the population density of CoTS in reef areas were documented for a period of 10 years from Andaman and Nicobar Islands. Data interpretations in this study are made based on geographical region. The maximum density of CoTS was recorded in South Andaman region (1.08±0.33/ hectare) followed by North & Middle Andaman (0.65 ±0.26/ hectare) and Nicobar (0.40 ±0.18/ hectare) with the mean density of 0.71/ hectare from this archipelago (Figs. 1 & 2). The occurrence of individuals was greater in the reef crest (1 – 6 m) and reef slope areas (6 – 12 m) apart from the reef top area (12 – 18 m). The occurrence of CoTS was noted as inversely proportional to the depth ranges. The rate of occurrence of *A. planci* in North & Middle Andaman region (R^2 = 0.94) was profoundly negatively correlated with the depth in comparison with South Andaman as well as Nicobar (R^2 = 0.96). Extremely rare sighting of CoTS was recorded beyond the depth of 18 m in the reef areas of

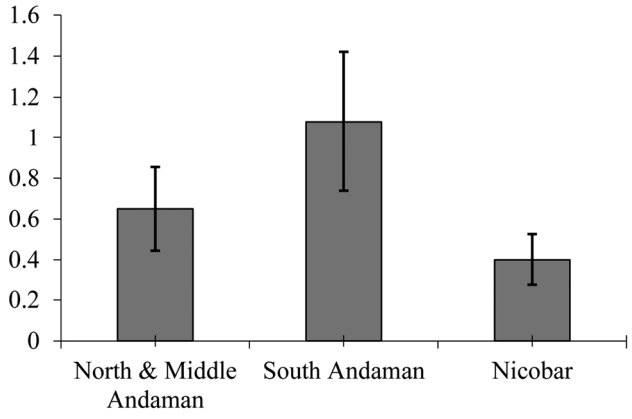

Fig. 1 — Occurrence of *A. planci* (CoTS) in Andaman and Nicobar Islands

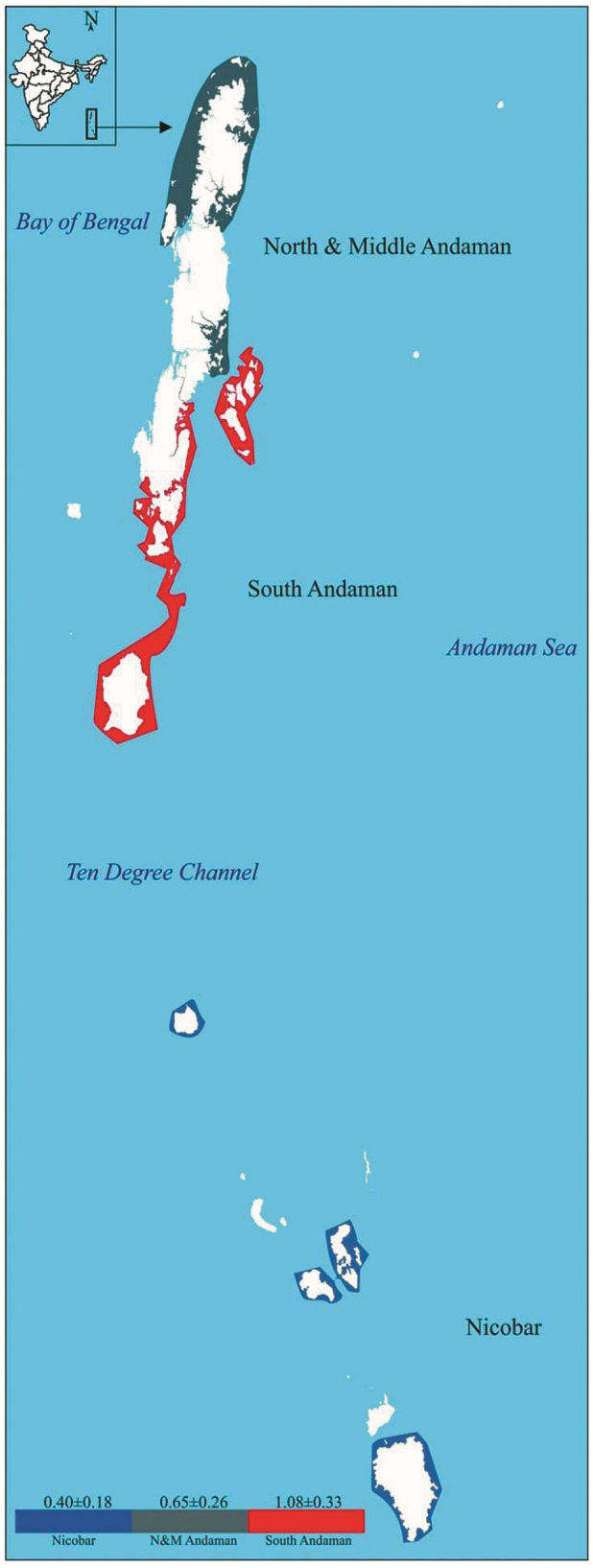

Fig. 2 — Zone-wise occurrence map of *A. planci* (CoTS) in Andaman and Nicobar Islands

Andaman and Nicobar Islands (Fig. 3). The data analysis on the population of CoTS defines the stable population size in Andaman and Nicobar Islands from all the reef areas (Fig. 4). The substrate specificity of the individual is mostly recorded during their grazing period. It is found that most of the individuals are recorded on acroporid corals (33 %) followed by poritid corals (30 %), dead corals with algal cover (17 %), coral crevices (10 %), other groups of live corals (7 %) and the least number of individuals (3 %) are documented from other substrates like grazing on sponges or sandy bottom (Figs. 5 & 6).

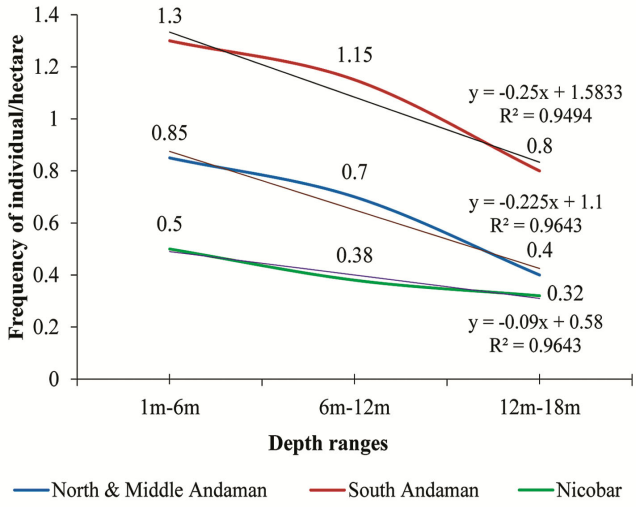

Fig. 3 — Depth-wise occurrence of *A. planci* (CoTS) in Andaman and Nicobar Islands

Discussion

The studies on the occurrence of CoTS are documented from all the reef areas of India by several authors[20-22]. Most of the studies or reporting of CoTS were concentrated as the reporting of echinoderm fauna from the reef habitats in the Indian context. Major devastation of reef habitat due to the occurrence of *A. planci* was recorded from Mahatma Gandhi Marine National Park (MGMNP) of South Andaman in 1989 and the report was made by Wood[23]. James *et al.* carried out exclusive studies on the CoTS from Andaman waters to record its infestation[22]. Massive devastation of coral cover followed by the mortality of corals due to the outbreak of CoTS was documented from the several reef habitats of the Indo-Pacific region by Lourey *et al.*[24], Goldberg & Wilkinson[25], Sweatman *et al.*[26], Pratchett[27], Baine[28], Bruno & Selig[3] which is a prime risk factor for the marine biodiversity[4]. The numerical density of the CoTS outbreak in the Indian, as well as the Pacific Oceans was documented in several countries like Panama, Japan, Great Barrier Reef, Japan, Cocos-Keeling Island, Micronesia, Red Sea, Papua New Guinea, Indonesia, Banda Island,

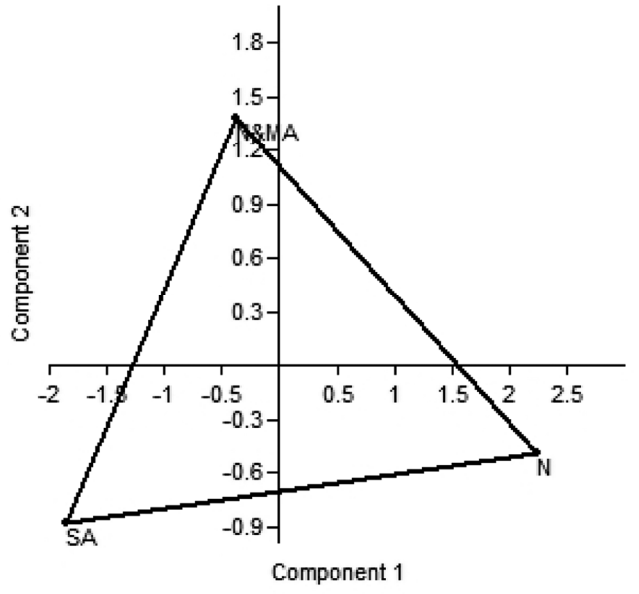

Fig. 4 — PCA of *A. planci* (CoTS) population in Andaman and Nicobar Islands (N&MA- North & Middle Andaman, SA- South Andaman, N-Nicobar)

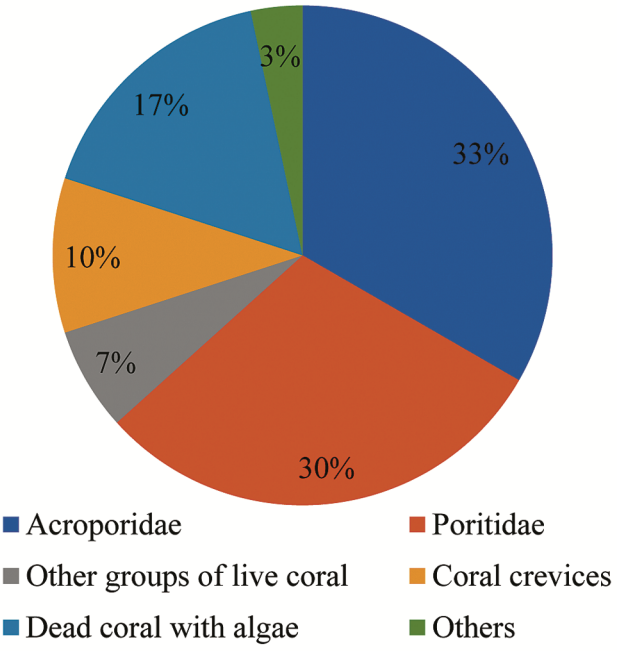

Fig. 5 — Substrate specificity of *A. planci* (CoTS) in reef habitat of Andaman and Nicobar Islands

Sumatra, Norther Sulawesi, etc. with the maximum occurrence of 20000 individuals of CoTS per hectare area[14,29-37]. There is no report of population outbreaks of *A. planci* during the period of the last 10 years from the Andaman and Nicobar Islands. The detailed observations and recommendations are cited below.

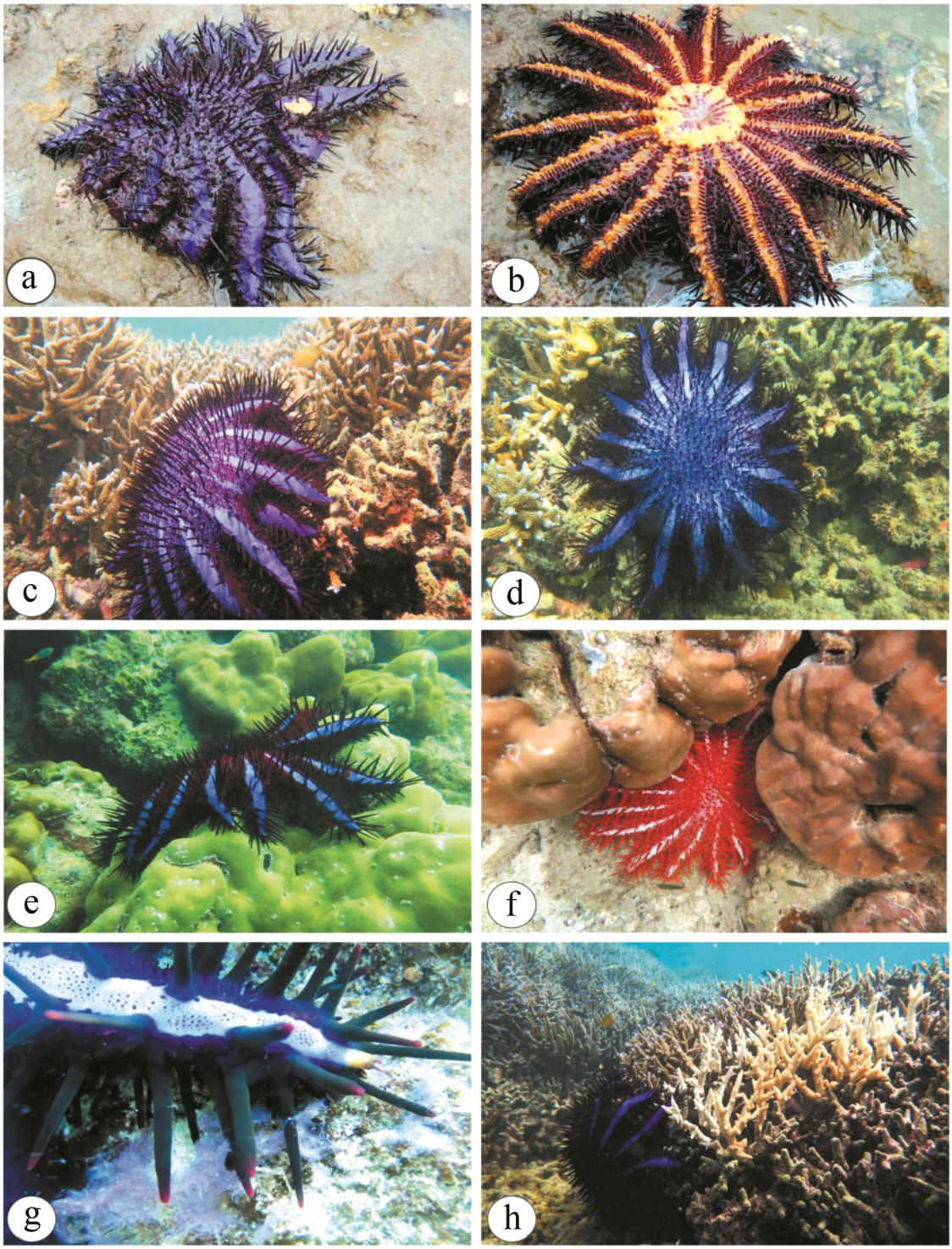

Fig. 6 — Substrate specificity of *A. planci* (CoTS) in Andaman and Nicobar Islands (a - Dorsal view of *A. planci*; b - Ventral view of *A. planci*; c & d - Animal grazing on Acroporidae corals; e - Animal grazing on Poritidae corals; f - Animal in coral crevice; g - Animal grazing on sponges and algae; and h - Feeding scar on aroporid corals due to *A. planci*

Major observations and recommendations

- The occurrence of CoTS was only found in the natural reef areas of Andaman and Nicobar Islands. There is no record of any CoTS from artificial reef areas like shipwrecks, pontoons, jetties, undersea buoys, or any other man-made structures, etc.
- The occurrence of the CoTS is recorded from the healthy reef areas of A&N Islands while none of the individuals is recorded from the extensively dead reef areas or massively altered reef areas which were created due to the impact of the Tsunami.
- The CoTS are represented by two different types of coloration patterns or colour morphs. The individuals of the Indian Ocean are recorded with the colouartion of blue to pale red; while the specimens from the Pacific Ocean are documented as grey-green to reddish brown[38]. During the present study, it is found that most of the individuals (80 %) are recorded with blue morphometry; while the rests of the individuals (20 %) are with a pale reddish colour.
- The occurrence of the CoTS is noted as high in the monospecific coral reef areas while the occurrence is comparatively less in the multi-specific coral reef areas.
- There is no documentation of CoTS from the reef areas adjoining to mangrove areas and the areas with greater sedimentation load like some islands of North and Middle Andaman region.
- The coral colonies under the family Acroporidae especially coral species under the genus *Acropora* are extensively preferred by the CoTS and this study also supports the earlier reports[4] and represents the maximum occurrence of 37 % of the individuals from acroporid corals.
- The previous studies of De'ath & Moran[39] and Pratchett[27] documented that the species under the genus *Porites* are less preferred by the CoTS but during the present study it is found that around 33 % of the individuals are documented from the poritidae corals in this archipelago.
- The impact of the CoTS on the reef ecosystem of A&N Islands is very negligible. Massive damage due to the predation of *A. planci* is not recorded during the present study period apart from the damages of a maximum of one to four colonies in some regions.
- Based on the present study for a period of one decade, it is found that the mean population of *A. planci* is recorded as 0.71 individuals/ hectare in the Andaman and Nicobar Islands which signifies the natural population rate of *A. planci* in the Indo-Pacific region and also agrees with the observations made by Birkeland & Lucas[1] *i.e.* < 1 individual/ hectare.
- The ingesting rate of the CoTS is dependent on the size of the animal and it is found that the maximum consumption of corals recorded by the CoTS with a diameter of 30 cm[40]; while the major consumption of corals was recorded by *A. planci* with a diameter of 23 – 32 cm from the Andaman and Nicobar Islands.
- Andaman and Nicobar Islands are the part of Indo-Pacific zone but there is no record of CoTS outbreaks while other neighboring countries have been experiencing the massive stress effect as well as the devastation of live reef cover due to the outbreak of CoTS.
- Several groups of faunal communities are known as the potential natural predators of CoTS which are used to balance the ecosystem by consuming the CoTS at any stage of its life cycle like egg, larva, juvenile, or adult[14]. Among the predators, *Pocillopora damicornis* is found in all the reef areas of Andaman and Nicobar Islands with the most abundant occurrence. This species consumes the CoTS in its larval stage as well as in the juvenile stage and is used to keep the reef areas of Andaman and Nicobar Islands out of the threats from the outbreaks of *A. planci*. The brachyuran crab species under the family Xanthidae are also known to predate on juveniles of CoTS[14]. A total of 107 species of xanthid crabs are recorded from Andaman and Nicobar Islands[41] which is used to minimize the population load of CoTS in the reef habitat of this area. Fishes like *Arothron hispidus*, *Balistoides viridescens* and species under the family Lethrinidae are recorded to feed upon juveniles as well as adults of the CoTS[14]. Apart from *A. hispidus*, *B. viridescens* and 34 species of Lethrinidae are documented from A&N Islands which take a pivotal role in the regulation of *A. planci* population. The CoTS predatory molluscs *Charonia tritonis* is found in A&N Islands which also imparts to control the population size of *A. planci* by predating the juveniles and adult stages. A recent study by Cowan *et al.*[42] suggested that a total of 80 faunal species are feeding upon the CoTS and most of those recorded species are found in the Andaman and Nicobar Islands.

- Though the predation by CoTS on the corals is a massive threat to reef habitat and of global concern especially in the Indo-Pacific region, but there is no threat of population outbreaks of CoTS in the reef habitats of Andaman and Nicobar Islands due to the presence of reef-associated healthy faunal communities which are taking the supervisory role for its own development and in sustainability by consuming the CoTS as the natural food chain of marine faunal communities. The presence of *A. planci* in Andaman and Nicobar Islands is neither detrimental nor devastative for the maintenance of healthy reef biodiversity rather; it is maintaining ecological harmony by consuming the Crustose Coralline Algae (CCA), macro-algae, as well as sponges, cover by dead coral reef areas which can be used as a substrate for the larval settlement of new coral colonies.
- Consecutive studies are required to monitor the health of coral reefs with long-term observational approaches to compare ecological as well as biological alteration of the habitat which can be managed through proper sustainable management activities to safeguard the natural reef ecosystem.
- Healthy reefs are self-sustaining ecosystems along with a number of associated faunal communities. The presence of pre-predator strategies in reef habitats can be fulfilled with the presence of healthy coral reefs.
- This decadal study on the reef habitat can be considered as a pilot study or observation of the reef habitat of Andaman and Nicobar Islands to understand the cohesion of the reef ecosystem along with its natural environment. The present observation also refers to the natural reef management and dynamics of Andaman and Nicobar Islands without any given anthropogenic condition.
- As a concluding remark, it can be said that the coral reef ecosystems of Andaman and Nicobar Islands are fundamentally associated with its associated faunal communities which provide essential services towards the maintenance of the entire reef ecosystem in a balanced state by controlling its predators.

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Conflict of Interest

There is no competing or conflict of interest.

Author Contributions

Both the authors contributed substantially to the preparation of this manuscript.

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