WIO Journal of Marine Science Special Issue 2/ **2021** 197-201

Sightings of sea stars (Echinodermata, Asteroidea) and a first record of crown-of-thorns starfish *Acanthaster* at Saya de Malha Bank, Mascarene Plateau

Sundy Ramah [1,2]*, Deepeeka Kaullysing [2], Ranjeet Bhagooli [2]

[1] Albion Fisheries Research Centre, Ministry of Blue Economy, Marine Resources, Fisheries and Shipping, Albion, Petite Rivière 91001, Republic of Mauritius

[2] Department of Biosciences and Ocean Studies, Faculty of Science & Pole of Research Excellence in Sustainable Marine Biodiversity, University of Mauritius, Réduit 80837, Republic of Mauritius

* Corresponding author: sundy.ramah@gmail.com

Sea stars or starfish, belonging to the phylum Echinodermata and class Asteroidea, are ecologically important and diverse members of marine ecosystems. They are found at various depths ranging from the intertidal to abyssal zones (Gale, 1985). The estimated number of species in this class is 1900, belonging to seven extant orders (Mah and Blake, 2012). The rich fossil history of sea stars dates back to the early Paleozoic (Gale, 1985). Sea stars predate mostly on benthic invertebrates (Wells *et al*., 1961; Mauzey *et al*., 1968; Sloan and Robinson, 1983; Magnesen and Redmond, 2012), and are known to regenerate damaged parts or lost arms (Mladenov *et al*., 1989).

The ecologically important corallivorous crown-of-thorns starfishes (COTS) *Acanthaster* spp. have gained particular attention among the sea stars due to their significant contribution to the loss of hard coral cover globally (Conand, 2001; Emeras *et al*., 2004; Conand *et al*., 2016; Pratchett *et al*., 2017; Conand *et al*., 2018; Caragnano *et al*., 2021). The displacement of COTS principally occurs at night, ranging between less than 1 m to 19 m day^{-1}. This wide difference in the daily movement is dependent on the availability of the preferred coral prey, *Acropora* spp. (Ling *et al*., 2020). Despite the uncertainty about the main causes leading to COTS outbreaks, Babcock *et al*. (2016) proposed that elevated nutrients leading to phytoplankton blooms, acting as abundant food sources for *Acanthaster* larvae, and removal of key predators can cause or exacerbate an outbreak, eventually resulting in a decrease in coral cover. They also suggested that multiple factors act together to initiate an outbreak.

Numerous reports on the devastating effect of COTS have emanated from various regions globally, particularly from the Indo-Pacific region. The Great Barrier Reef (GBR) has witnessed four outbreaks since the 1960s (in 1962, 1979, 1993 and 2009) (Babcock *et al*., 2016; Pratchett *et al*., 2017), resulting in the average hard coral cover across the GBR halving during the period from 1985–2012, largely attributed to *Acanthaster* cf. *solaris* (Babcock *et al*., 2020; Westcott *et al*., 2020). Saponari *et al*. (2015) reported an average density of 120±51 COTS per 900 m^2 at Mama Ghiri, Ari Atoll in the Republic of Maldives. This led to approximately 70 % coral mortality comprised almost entirely of tabular *Acropora* mainly belonging to the species *A. cytherea, A. clathrata,* and *A. hyacinthus*. Moreover, Plass-Johnson *et al*. (2015) noted high densities of COTS reaching up to 37 individuals per 250 m^2 in a region close to two river mouths, which resulted in the loss of half the live coral at 2 out of the 12 islands studied in Indonesia.

In the Western Indian Ocean (WIO) region, there have been some reports of high densities of COTS; for instance in Seychelles in 1997 and 2014 (Obura *et al*., 2017). In 1994, a COTS outbreak was reported on the reefs of northern KwaZulu-Natal, South Africa, with the hard coral genera *Acropora*, *Montipora* and *Fungia* being initially favoured, followed by the frequently avoided colonies of *Pocillopora* (Schleyer, 1998). This was in contradiction with other observations where *Pocillopora* was found to be one of the preferred coral genera of COTS (Pratchett, 2001, 2007; De'ath and Moran, 1988). There appears to be a gap in

http://dx.doi.org/10.4314/wiojms.si2021.2.17

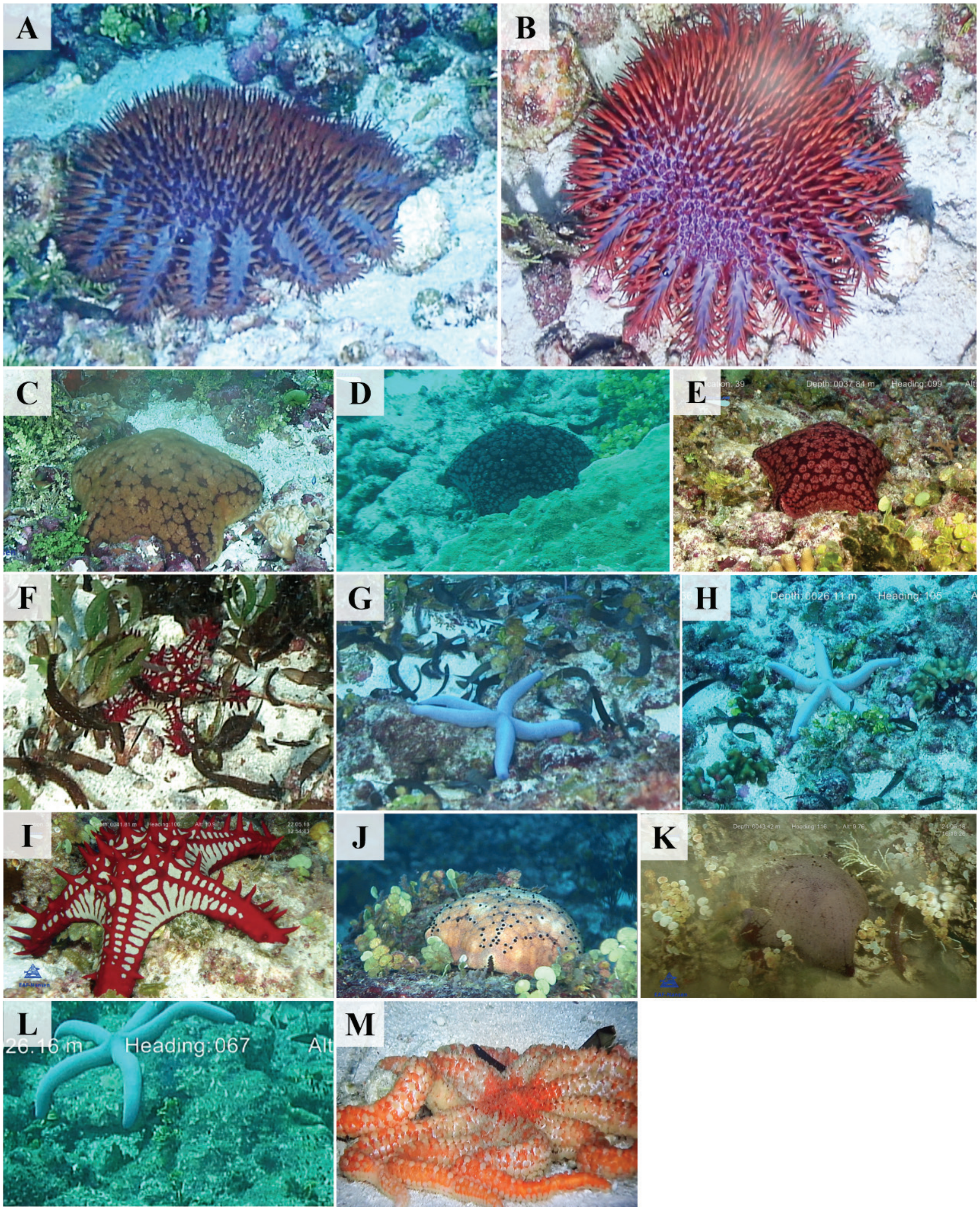

Figure 1. A, B. Crown-of-thorns starfish *Acanthaster* sp. spotted on a rhodolith bed at 38.11 m at Saya de Malha Bank; C–N. Sea stars spotted at Saya de Malha Bank. C. *Culcita* sp. 1 - Location 36 at a depth of 38.71 m and 25.07 m, respectively; D, E. *Culcita* sp. 2 - Location 39 at a depth of 37.84 m; F. *Protoreaster lincki* - Location 13 at a depth of 31.5 m; G. *Linckia* sp. - Location 39 at a depth of 33.09 m; H. *Linckia* sp. - Location 36 at a depth of 26.11 m; I. *Protoreaster lincki* - Location 39 at a depth of 41.81 m; J. *Culcita schmideliana* - Location 39 at a depth of 32.74 m; K. *Culcita* sp. 3 - Location 40 at a depth of 43.42 m; L. *Linckia* sp. - Location 36 at a depth of 26.16 m; M. *Rathbunaster* sp. - Location 38 at a depth of 175.23 m.

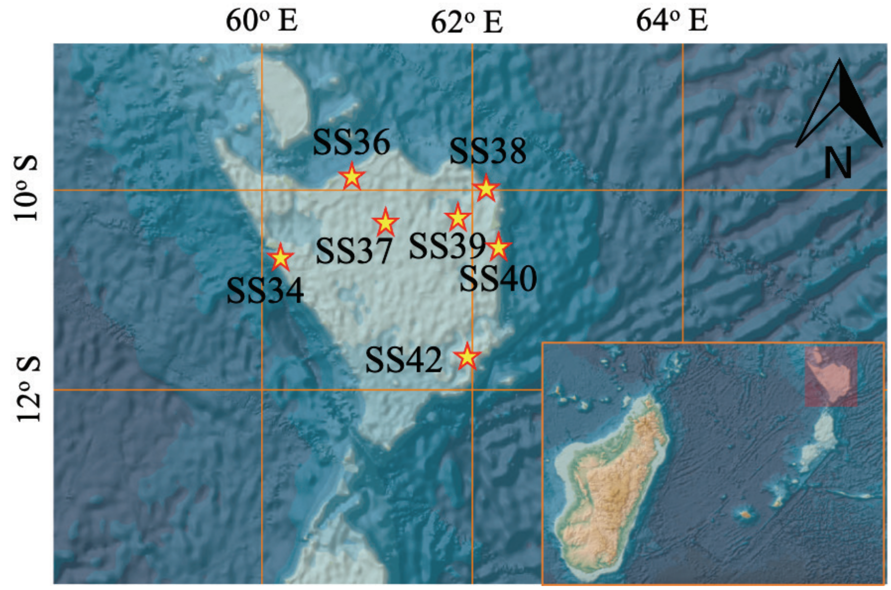

Figure 2. Map showing the seven locations (SS where the sea stars were observed indicated in yellow and red border stars. Map prepared using the GEBCO Bathymetry Grid layer data 2020.

the scientific information available in the WIO region on COTS species. Although research has shown the occurrence of *Acanthaster mauritiensis* in this region (Haszprunar *et al.*, 2017), additional information is required to provide a broader understanding on the phylogeography and evolution of these species.

In May 2018, the Indian Ocean Research Expedition conducted under the EAF-Nansen Programme at the Saya de Malha Bank of the Mascarene Plateau enabled the sighting of one *Acanthaster* sp. individual (Fig. 1A, B) using the Argus Remotely Operated Vehicle (ROV). A total of 12 transects at 7 locations for an average of 30 min to 1 hour were covered. The *Acanthaster* sp. was observed at locations 38 (SS38) on a rhodolith bed at a depth of 38.11 m. The presence of the coralline green macroalga *Halimeda* on the bed was also noted while the corals in the vicinity were widely spaced and included *Porites* sp., branching *Acropora* sp., *Pocillopora* sp., *Heliopora coerulea* and other massive hard corals. Further visual inspection revealed the presence of at least 17 other individuals of non-corallivorous sea stars (with *Protoreaster* sp., *Linckia* sp. and *Culcita* spp. being more dominant) during the cruise at depths ranging between 23 m to 50 m (Fig. 1 C-M) at locations at locations SS34, SS36, SS37, SS38, SS39, SS40 and SS42 (Fig. 2). The substrata on which the sea stars were spotted were sand, rhodolith beds, corals, macroalgae and seagrass beds.

Koonjul *et al.* (2003) reported 28 COTS around Mauritius Island, spread over a reef area of 0.6 km^2 (about 4.67 x 10^{-5} per m^2, or 0.01 per 250 m^2, or 0.04 per 900 m^2) with a substrate mix comprising corals, algae, sand, and coral rubble. The first observation of only one individual of *Acanthaster* sp. at one location (out of 7) after 30 min of video time at Saya de Malha Bank does not signify any warning of significant damage to corals in that region. However, this information is noteworthy as it brings forth new knowledge on Asteroids from the Saya de Malha Bank, an unexplored region of the WIO which appears to harbour a high diversity of sea stars.

There are considerable challenges to addressing the knowledge gaps relating to the biology, ecology and genetics of *Acanthaster* spp. Differences in morphology, in particular colour patterns, among COTS species reported from the Pacific and the Indian Oceans suggest divergent biology and ecology (Haszprunar, 2017). Further research on and exploration of the seabed is required to build a more robust and in-depth understanding of the sea star distribution at the Bank, especially the corallivorous COTS. Thorough morphological, morphometric, and genetic analyses are necessary to characterize the COTS from this region to assist any future development of key actions required for management.

Acknowledgements

The underlying work was made possible with the support of the EAF-Nansen Programme "Supporting the Application of the Ecosystem Approach to Fisheries Management considering Climate Change and Pollution Impacts" executed by Food and Agriculture

Organization of the United Nations (FAO) and funded by the Norwegian Agency for Development Cooperation (Norad). The authors are thankful to FAO for funding and supporting the Indian Ocean research expedition 2018 on the Saya de Malha Bank and Nazareth Bank with the R/V *Dr Fridtjof Nansen*, the Department of Continental Shelf, Maritime Zones Administration & Exploration of Mauritius for co-leading and coordinating the scientific expedition, the Mauritius-Seychelles Joint Commission of the Extended Continental Shelf for their support and assistance and granting the necessary authorisations, the Ministry of Blue Economy, Marine Resources, Fisheries & Shipping for hosting and spearheading the Habitat Mapping Workshop in Mauritius and for granting necessary authorization to carry out research in the Nazareth Bank; the Institute of Marine Research, Norway for leading the expedition and providing the technical and logistic support. The authors also thank the participating scientists, the crew members and the VAMS / Argus ROV technicians for their work and contribution during the expedition and to the anonymous reviewers for their insightful comments which have significantly improved the manuscript.

References

Babcock RC, Dambacher JM, Morello EB, Plagányi ÉE, Hayes KR, Sweatman HPA, Pratchett MS (2016) Assessing different causes of crown-of-thorns starfish outbreaks and appropriate responses for management on the Great Barrier Reef. PLoSONE 11: e0169048 [doi:10.1371/journal.pone.0169048]

Babcock RC, Plagányi É, Condie SA, Westcott DA, Fletcher CS, Bonin MC, Cameron D (2020) Suppressing the next crown-of-thorns outbreak on the Great Barrier Reef. Coral Reefs 39: 1233-1244

Caragnano A, Basso D, Spezzaferri S, Hallock P (2021) A snapshot of reef conditions in North Ari Atoll (Maldives) following the 2016 bleaching event and *Acanthaster planci* outbreak. Marine and Freshwater Research 72: 987-996

Conand C (2001) *Acanthaster planci*. Bulletin des sciences naturelles et de géologie. Mayotte 5: 26-29

Conand C, Ribes-Beaudemoulin S, Trentin F, Mulochau T, Boissin E (2016) Oursins, étoiles de mer & autres echinodermes. Biodiversité de La Réunion. Les éditions du cyclone. 168 pp

Conand C, Ribes-Beaudemoulin S, Trentin F, Mulochau T, Boissin E (2018) Marine biodiversity of La Reunion Island: Echinoderms. Western Indian Ocean Journal of Marine Science 17: 111-124

De'ath G, Moran PJ (1988) Factors affecting the behaviour of crown-of-thorns starfish (*Acanthaster planci* L.) on the Great Barrier Reef, 1: Patterns of activity. Journal of Experimental Marine Biology and Ecology 220: 83-106

Emeras J, Falquet M-P, Conand C (2004) *Acanthaster planci* on La Reunion reefs (Western Indian Ocean). Reef Encounter 32: 26-27

Gale AS (1987) Phylogeny and classification of the Asteroidea (Echinodermata). Zoological Journal of the Linnean Society 89: 107-132

Haszprunar G, Vogler C, Wörheide G (2017) Persistent gaps of knowledge for naming and distinguishing multiple species of crown-of-thorns seastar in the *Acanthaster planci* species complex. Diversity 9: 22 [doi:10.3390/d9020022]

Koonjul MS, Mangar V, Luchmun JP (2003) Eradication of crown of thorns starfish (*Acanthaster planci*) infestation in a patch reef in the lagoon off Ile aux Cerfs, Mauritius. AMAS. Food and Agricultural Research Council, Réduit, Mauritius. pp 333-338

Ling SD, Cowan Z-L, Boada J, Flukes EB, Pratchett MS (2020) Homing behaviour by destructive crown-of-thorns starfish is triggered by local availability of coral prey. Proceedings of the Royal Society B 287: 20201341 [http://dx.doi.org/10.1098/rspb.2020.1341]

Magnesen T, Redmond KJ (2011) Potential predation rates by the sea stars *Asterias rubens* and *Marthasterias glacialis*, on juvenile scallops, *Pecten maximus*, ready for sea ranching. Aquaculture International 20: 189-199

Mah CL, Blake DB (2012) Global diversity and phylogeny of the Asteroidea (Echinodermata). PLoS ONE 7: e35644 [doi:10.1371/journal.pone.0035644]

Mauzey KP, Birkeland C, Dayton PK (1968) Feeding behavior of asteroids and escape responses of their prey in the Puget Sound region. Ecology 49: 603-619

Mladenov PV, Bisgrove B, Asotra S, Burke RD (1989) Mechanisms of arm-tip regeneration in the sea star, *Leptasterias hexactis*. Roux's Archives of Developmental Biology 198: 19-28

Obura D, Gudka M, Rabi FA, Bacha Gian S, Bijoux J, Freed S, Maharavo J, Mwaura J, Porter S, Sola E, Wickel J, Yahya S, Ahamada S (2017) Coral reef status report for the Western Indian Ocean. Global Coral Reef Monitoring Network (GCRMN)/International Coral Reef Initiative (ICRI). 144 pp

Plass-Johnson JG, Schwieder H, Heiden J, Weiand L, Wild C, Jompa J, Ferse SCA, Teichberg M (2015) A recent outbreak of crown-of-thorns starfish (*Acanthaster* *planci*) in the Spermonde Archipelago, Indonesia. Regional Environmental Change 15: 1157-1162

Pratchett MS (2001) Influence of coral symbionts on feeding preferences of crown-of-thorns starfish *Acanthaster planci* in the western Pacific. Marine Ecology Progress Series 214: 111-119

Pratchett MS (2007) Feeding preferences of *Acanthaster planci* (Echinodermata: Asteroidea) under controlled conditions of food availability. Pacific Science 61: 113-120

Pratchett MS, Caballes CF, Wilmes JC, Matthews S, Mellin C, Sweatman HPA, Nadler LE, Brodie J, Thompson CA, Hoey J, Bos AR, Byrne M, Messmer V, Fortunato SAV, Chen CCM, Buck ACE, Babcock RC, Uthicke S (2017) Thirty years of research on crown-of-thorns starfish (1986–2016): Scientific advances and emerging opportunities. Diversity 9: 41 [https://doi.org/10.3390/d9040041]

Saponari L, Montano S, Seveso D, Paolo G (2015) The occurrence of an *Acanthaster planci* outbreak in Ari Atoll, Maldives. Marine Biodiversity 45: 599-600

Schleyer MH (1998) Observations on the incidence of crown-of-thorns starfish in the Western Indian Ocean. Reef Encounter 23: 25-27

Sloan NA, Robinson SMC (1983) Winter feeding by asteroids on a subtidal sandbed in British Columbia. Ophelia 22: 125-140

Wells HW, Wells MJ, Gray IE (1961) Food of the sea-star *Astropecten articulatus*. The Biological Bulletin 120: 265-271

Westcott DA, Fletcher CS, Kroon FJ, Babcock RC, Plagányi EE, Pratchett MS, Bonin MC (2020) Relative efficacy of three approaches to mitigate crown-of-thorns starfish outbreaks on Australia's Great Barrier Reef. Scientific Reports 10: 12594 [doi:10.1038/s41598-020-69466-1]