DOI: 10.31398/tpjf/31.2.2023-0019

SHORT COMMUNICATION

Abundance and Population Size Structure of the Crown-of-Thorns Seastar in Camiguin Island, Northern Mindanao

Oliver R.T. Paderanga* **and Neil Antun Flores**

Marine Biology Program, Institute of Arts & Sciences, Camiguin Polytechnic State College

ABSTRACT

The abundance and population size structure of two populations of the crown-of-thorns seastar (COTS), *Acanthaster* sp., were investigated as part of removal activities of the seastar due to population outbreaks in two areas of Camiguin Island, Northern Mindanao. Abundances reached 75 and 160 individuals/hectare for Pasil Reef and San Roque, respectively. Mean weights and diameters were 302.64g and 340.89g, and 21.37cm and 24.09cm for Pasil and San Roque, respectively. Size frequency distribution of the diameters and weights of the seastars indicate that the populations in both areas were composed of different cohorts. The COTS population in San Roque had characteristics of a relatively more mature population compared to that in Pasil Reef. The occurrence of Crown-of-Thorns Starfish (COTS) outbreaks on opposite sides of the island of Camiguin suggests that these outbreaks are not isolated and that other outbreaks are likely happening in other areas of the island. Regular monitoring and removal of COTS might be one of the best ways to manage reefs efficiently, and these initiatives may promote better reef health.

*Corresponding Author: *ortpaderanga@gmail.com*
Received: *September 3, 2023*
Accepted: *June 3, 2024*

Keywords: *Acanthaster sp., crown-of-thorns-seastar, Camiguin, outbreak*

The crown-of-thorns seastar (COTS), *Acanthaster* sp., has been a problem for reefs. Outbreaks of the seastar remain a major cause of coral mortality in the Indo-Pacific, contributing to the widespread and accelerating degradation of coral reef environments (Pratchett et al. 2014). Although the COTS has an ecological role in reefs (Ratianingsih et al. 2017), unnaturally high densities of the COTS could severely degrade the reef, both in terms of health and aesthetics.

The crown-of-thorns seastar (frequently abbreviated to COTS) is a large seastar that preys upon hard or stony coral polyps (Scleractinia) (Cole et al. 2008). It derives its name from the venomous thorn-like spines that cover its upper surface, resembling the biblical crown of thorns. It is one of the largest seastars in the world. *Acanthaster* sp. has an extensive Indo-Pacific distribution. It is perhaps most common around Australia but can occur at tropical and subtropical latitudes from the Red Sea and the East African coast across the Indian Ocean and the Pacific Ocean to the west coast of Central America (Peters 2015). It occurs where coral reefs or hard coral communities occur in the region. Adult crown-of-thorns seastars typically range in size from 25 cm to 35 cm (10–14 in) (Carpenter 1997). They have up to 21 arms. Although the body of the crown of thorns has a stiff appearance, it can bend and twist to fit around the contours of the corals on which it feeds. The underside of each arm has a series of closely fitting plates, which form a groove and extend in rows to the mouth (Lucas and Jones 1976). Depending on diet or geographic region, individuals can be purple, purple-blue, reddish gray, or brown with red or green with yellow spine tips (Lucas and Jones 1976). The color variation of COTS across regions suggested different species (Haszprunar et al. 2017), and phylogeographical variation was established by Vogler et al. (2013). COTS found in the Pacific were identified as a single species (Vogler et al. 2013), and Haszprunar et al. (2017) suggested using the name *Acanthaster* cf *solaris* for this species.

As is common for most marine invertebrates, *Acanthaster* sp. reproduces through spawning (Deaker and Byrne 2022). Bos et al. (2013) inferred that seastar spawning in the Philippines occurred from March to April. The findings of a study conducted in

Thailand (Scott et al. 2017) suggest the presence of two aggregation peaks occurring in March and October, which could potentially indicate spawning events. Once larvae have settled, their primary food source is coralline algae (Deaker et al. 2020). Their diets change as they age, with juveniles emerging from the rubble to start preying on coral as early as 4–6 months of age (8–18 mm diameter) (Lucas 1984).

Acanthaster sp. feeds on corals by climbing onto a section of living coral colony using its large number of tube feet, which lie in distinct ambulacral grooves on the oral surface (Belk and Belk 1975). It fits closely to the surface of the coral, even the complex surfaces of branching corals. It then extrudes its stomach out through its mouth over the surface to virtually its own diameter. The stomach surface secretes digestive enzymes that allow the seastar to absorb nutrients from the liquefied coral tissue. This leaves a white scar on the coral skeleton that is rapidly infested with filamentous algae (Belk and Belk 1975). An individual seastar can consume up to 6 square meters (65 sq ft) of living coral reef per year. In a study of feeding rates on two coral reefs in the central Great Barrier Reef region, large seastars (40 cm and greater diameter) killed about 61 cm^2/day in winter and 357–478 cm^2/day in summer. Smaller seastars, 20–39 cm, killed 155 and 234 cm^2/day in the equivalent seasons. The area killed by the large seastars is equivalent to about 10 m^2 (110 sq ft) from these observations (Keesing and Lucas 1992). Differences in feeding and locomotion rates between summer and winter reflect the fact that the crown-of-thorns, like all marine invertebrates, is a *poikilotherm* whose body temperature and metabolic rate are directly affected by the temperature of the surrounding water (Keesing and Lucas 1992; Lang et al. 2022). In tropical coral reefs, crown-of-thorns specimens reach mean locomotion rates of 35 cm/min (Mueller et al. 2011; Pratchett et al. 2020), which explains how outbreaks can damage large reef areas in relatively short periods.

Recently, there have been reports of high numbers of COTS around Camiguin Island, Northern Mindanao. Two areas that have reported high numbers are Pasil Reef in Bonbon, Catarman, and San Roque in Mahinog. Faced with this predicament, the Local Government Units (LGUs) of the municipalities of Catarman and Mahinog decided to remove as many COTS from their respective areas as possible and enlisted the help of the Camiguin-Wide Marine Protected Area Network (CWMPAN). The network consists of the provincial and municipal LGUs and national government agencies concerned with managing the marine protected areas (MPAs) around the island of Camiguin. Several initiatives have been implemented to control the population of the COTS (Fraser et al. 2000), and the most common of them is the manual removal or extraction of the COTS from the reef.

Knowledge of the demographics of a population is necessary to understand population regulation. No study has been conducted on the population structure of COTS in Camiguin, so this paper reports our effort to collect initial information on the abundance and population size structure of the COTS in two areas: Pasil Reef MPA, municipality of Catarman and San Roque MPA in the municipality of Mahinog, Camiguin. To do this, COTS that were encountered and removed from the two areas during collection or culling activities were measured, and the data used in this study.

COTS were collected from the Pasil Reef MPA (9° 12.404'N, 124° 37.952'E) on August 26, 2022, and the San Roque MPA (9° 9.218'N, 124° 47.778'E) on November 18, 2022 (Figure 1).

Before the collection of COTS commenced, the areas were surveyed to determine where the COTS were most concentrated. This was done through the manta-tow method, and the survey results were used to direct the efforts of the teams in charge of collecting the COTS.

COTS collection was done using bamboo and metal tongs, and metal hooks to pick up individuals of

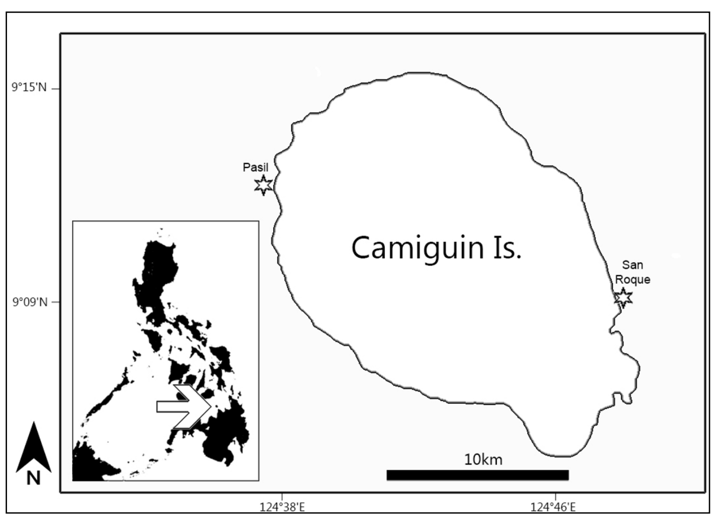

Figure 1. Map of Camiguin Island, Northern Mindanao, showing the locations of the study sites, Pasil Reef MPA and San Roque MPA. The inset shows Camiguin's location relative to the Philippines.

COTS either using scuba equipment or through skin diving. Collected sea stars were then placed in sacks or plastic crates and brought to shore. Upon arrival on shore, the weight and diameter of each seastar were measured and noted. Density was computed by plotting the area searched by the collectors, estimating the hectarage on Google Earth Pro (version 7.3.6.9345), and dividing the COTS collected by the estimated area.

Table 1 summarizes the number of COTS collected, including weight and diameter measurements.

Most of the 350 COTS collected from the Pasil Reef MPA (300) were collected in the afternoon from an area measuring approximately four hectares, indicating a density of 75 individuals/hectare. For the San Roque MPA, all were collected in the shallow portion of the MPA in an area of approximately 4.4 hectares, giving a density of 161.68 individuals/hectare. Both values are above the 15–40 sea stars/hectare threshold to indicate a COTS outbreak (Moran and De'ath 1992; Pratchett 2005).

The diameters of the COTS are comparable to those collected in outbreaks in Leyte (de Dios et al. 2012; de Dios et al. 2014) and Malapascua (Kensington 2019).

Table 2 shows the distribution of the collected COTS according to age class (Engelhardt et al. 1999). Most of the COTS for both sites can be classified as young adults, which is already capable of reproducing (Deaker and Byrne 2022), albeit not to the degree that adults are capable of. The different age classes suggest that both sites' populations belong to different COTS cohorts and are probably the result of continuous seeding from a source site.

The COTS population in San Roque has the characteristics of a more mature population compared to that of Pasil Reef: a higher percentage of adults (37.17% compared to 14% of that of Pasil), larger maximum size, larger mean size, larger mean weight (Table 1).

A comparison of the size frequency distributions of the two sites also shows that the San Roque population of COTS is more mature (Figure 2).

Table 1. Summary of collection data from the two sites.

Parameter	**Pasil Reef MPA**	**San Roque MPA**
Total COTS removed	350	713
Average Weight (g) ± std. dev.	302.64 ± 177.10g	340.89 ± 174.89g
Max weight (individual) (g)	1,100g	1,150g
Total Weight (g)	105,925g	243,055g
Average diameter (cm) ± std. dev.	21.38 ± 3.96cm	24.09 ± 4.44cm
Max diameter (individual) (cm)	36cm	50cm

Table 2. Distribution of the COTS collected from the two sites according to age class.

	Pasil Reef MPA		San Roque MPA	
Age class	n	%	n	%
Juvenile (< 14cm)	8	2.29%	9	1.26%
Young adult (14–25cm)	297	84.86%	439	61.57%
Adult (> 25cm)	49	14.00%	265	37.17%

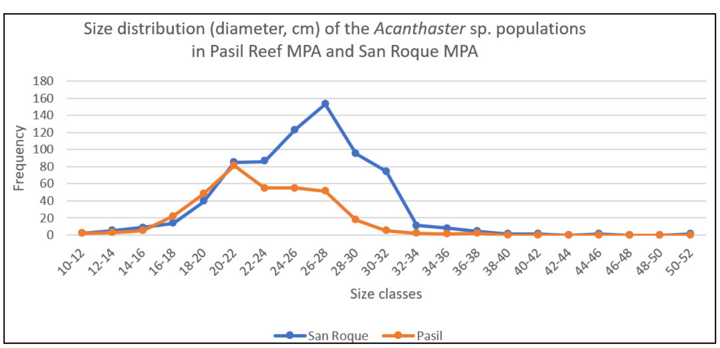

Figure 2. Frequency polygon comparing the size frequencies of the collected COTS from Pasil Reef and San Roque.

The densities of the COTS populations in the two areas surveyed indicate outbreaks, which, if left uncontrolled, could devastate the local coral communities. These populations accumulated gradually over time and are probably the result of seeding from source sites since the dispersion of the COTS is dependent on spawning. The size frequency distribution of the diameters and weights of the seastars indicates that the populations in both areas were composed of different cohorts.

COTS outbreaks on opposite sides of the island of Camiguin imply that these outbreaks are not isolated and that other outbreaks are currently occurring in other areas of the island. If these aggregations are spawning events (Scott et al. 2017), then it is important that individuals be removed to significantly lessen the number of offspring produced to help prevent future outbreaks. It is therefore recommended that more surveys be conducted to spot high densities of COTS before they devastate the corals of the island.

ACKNOWLEDGMENTS

The authors would like to acknowledge the workforce provided by the CWMPAN during the collections and the respective municipal LGUs and DENR for organizing the activities. Also acknowledged are the BS Marine Biology program students of the Camiguin Polytechnic State College, who provided most of the workforce of the CPSC contingent and were charged with measuring the weights and diameters of all the collected COTS.

AUTHOR CONTRIBUTIONS

Paderanga ORT: Conceptualization, methodology, formal analysis, writing- original draft, writing – review & editing. **Flores N**: Investigation, writing – review & editing.

CONFLICTS OF INTEREST

To the best of our knowledge, no conflict of interest exists.

ETHICS STATEMENT

No animal or human studies were carried out by the authors. The data collected in the study came from animals that were collected to control an outbreak and were to be disposed of by burying them in the sand.

REFERENCES

Belk MS, Belk D. 1975. An observation of algal colonization on *Acropora aspera* killed by *Acanthaster planci*. Hydrobiologia. 46(1):29–32. https://doi.org/10.1007/bf00038724

Bos AR, Gumanao GS, Mueller B, Saceda-Cardoza MME. 2013. Management of crown-of-thorns sea star (*Acanthaster planci* L.) outbreaks: Removal success depends on reef topography and timing within the reproduction cycle. Ocean & Coastal Management. 71:116–122. https://doi.org/10.1016/j.ocecoaman.2012.09.011

Carpenter RC. 1997. Invertebrate Predators and Grazers. In: Birkeland C, editor. Life and death of coral reefs. Springer. ISBN 978-0-412-03541-8.

Cole A, Pratchett M, Jones G. 2008. Diversity and functional importance of coral-feeding fishes on tropical coral reefs. Fish and Fisheries. 9(3):286–307. https://doi.org/10.1111/j.1467-2979.2008.00290

Deaker DJ, Byrne M. 2022. Crown of thorns starfish life-history traits contribute to outbreaks, a continuing concern for coral reefs. Emerging Topics in Life Sciences. 6:67–79 https://doi.org/10.1042/ETLS20210239

Deaker DJ, Agüera A, Lin HA, Lawson C, Budden C, Dworjanyn SA, Mos B, Byrne M. 2020. The hidden army: corallivorous crown-of-thorns seastars can spend years as herbivorous juveniles. Biol. Lett. 16(4):20190849. https://doi.org/10.1098/rsbl.2019.0849

de Dios HHY, Dy DT, Sotto FB. 2014. Abundance and size structure of an *Acanthaster planci* population (Echinodermata: Asteroidea) in Sogod Bay, Southern Leyte, Philippines. Asia Life Sciences. 23(1):65–73.

de Dios HHY, Reyes GM, Calva MR, Gatus JL, Pesquera NM, Ayop AN, Napala JJO, Caday SG, Evangelio MFNC. 2012. Underwater baseline assessment of the five proposed marine protected areas in Southern Leyte cum training for MPA monitoring team. Southern Leyte State University-Bontoc Campus and Deutsche Gesellschaft fur Internationale

Zusammenarbeit (GIZ) GmbH, Environment and Rural Development Integrated Coastal Management (EnRD- ICM). p. 180.

Engelhardt U, Hartcher M, Cruise J, Engelhardt D, Russell M, Taylor N, Thomas G, Wiseman D. 1999. Fine-scale surveys of crown-of-thorns starfish (*Acanthaster planci*) in the central Great Barrier Reef region. CRC Reef Research Centre Technical Report No 30. CRC Reef Research Centre, Townsville. 97 pp.

Fraser N, Crawford B, Kusen J. 2000. Best Practices Guide for Crown-of-Thorns Clean-ups. Proyek Pesisir Special Publication. Coastal Resources Center Coastal Management Report #2225. Coastal Resources Center, University of Rhode Island, Narragansett, Rhode Island. pp. 38. https://www.researchgate.net/publication/237218391_Best_practices_guide_for_Crown-of-thorns_clean-ups

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(2):22. https://doi.org/10.3390/d9020022

Keesing JK, Lucas JS. 1992. Field measurement of feeding and movement rates of the crown-of-thorns starfish *Acanthaster planci* (L.). Journal of Experimental Marine Biology and Ecology. 156:89–104. https://doi.org/10.1016/0022-0981(92)90018-6

Kensington N. 2019. An assessment of the population of crown-of-thorns starfish (*Acanthaster planci* L.) around the island of Malapascua, Republic of the Philippines. Master's thesis. Trinity College, Dublin.

Lang BJ, Donelson JM, Caballes CF, Uthicke S, Doll PC, Pratchett MS. 2022. Effects of elevated temperature on the performance and survival of pacific crown-of-thorns starfish (*Acanthaster* cf. *solaris*). Marine Biology. 169(4):43. https://doi.org/10.1007/s00227-022-04027-w

Lucas JS. 1984. Growth, maturation and effects of diet in *Acanthaster planci* (L.) (Asteroidea) and hybrids reared in the laboratory. J. Exp. Mar. Biol. Ecol. 79:129–147. https://doi.org/10.1016/0022-0981(84)90214-4

Lucas JS, Jones MM. 1976. Hybrid crown-of-thorns starfish (*Acanthaster planci* x *A. brevispinus*) reared to maturity in the laboratory. Nature. 263(5576):409–12. https://doi.org/10.1038/263409a0

Moran PJ, De'ath G. 1992. Estimates of the abundance of the crown-of-thorns starfish (*Acanthaster planci* L.) in outbreaking and non-outbreaking populations on reefs with the Great Barrier Reef. Marine Biology. 113:509–515. https://doi.org/10.1007/BF00349178

Mueller B, Bos AR, Graf G, Gumanao GS. 2011. Size-specific locomotion rate and movement pattern of four common Indo-Pacific sea stars (Echinodermata; Asteroidea). Aquatic Biology. 12(2):157–164. https://doi.org/10.3354/ab00326

Peters EC. 2015. Diseases of Coral Reef Organisms. Coral Reefs in the Anthropocene. Springer Netherlands. 147–178. https://doi.org/10.1007/978-94-017-7249-5_8

Pratchett MS. 2005. Dynamics of an outbreak population of *Acanthaster planci* at Lizard Island, northern Great Barrier Reef (1995-1999). Coral Reefs. 24:453–462. https://doi.org/10.1007/s00338-005-0006-4

Pratchett MS, Caballes CF, Rivera-Posada JA, Sweatman HPA. 2014. Limits to understanding and managing outbreaks of crown-of-thorns starfish (*Acanthaster* spp.). Oceanogr. Mar. Biol. Ann. Rev. 52:133–200. https://doi.org/10.1201/b17143-4

Pratchett MS, Caballes CF, Messmer V, Fletcher CS, Westcott DA. 2020. Movement patterns of Pacific crown-of-thorns starfish (*Acanthaster* cf. *solaris*) linked to habitat structure and prey availability. Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns. pp. 40.

Ratianingsih R, Ismawati N, Puspita JW, Jaya AI. 2017. The role of top-predator in the preservation of coral reefs ecosystem. Communication in Biomathematical Sciences. 1(1):54–61. https://doi.org/10.5614/cbms.2017.1.1.5

Scott CM, Mehrotra R, Hein MY, Moerland MS, Hoeksema BW. 2017. Population dynamics of corallivores (*Drupella* and *Acanthaster*) on coral reefs of Koh Tao, a diving destination in the Gulf of Thailand. Raffles Bulletin of Zoology. 65:68–79. https://zoobank.org/urn:lsid:zoobank.org:pub:E977D5BE-BF21-400B-893F-291E5550C83

Vogler C, Benzie JAH, Tenggardjaja K, Ambariyanto BPH, Wörheide G. 2013. Phylogeography of the crown-of-thorns starfish: genetic structure within the Pacific species. Coral Reefs 32:515–525. https://doi.org/10.1007/s00338-012-1003-z