# FEEDING PREFERENCES OF THE CUSHION STAR *CULCITA NOVAEGUINEAE* IN THE PRESENCE OF THE CROWN OF THORNS STARFISH *ACANTHASTER PLANCI*

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*Abstract.* Crown of thorns starfish (*Acanthaster planci* Linné 1758) are notorious coral reef devastators; they decimate coral populations, thus changing the coral reef habitat and killing many organisms that depend on the coral. *Culcita novaeguineae* (Muller and Troschel 1842), or cushion stars, are corallivores and generalists that live in Pacific reefs. Because *C. novaeguineae* and *A. planci* have similar food preferences, the presence of crown of thorns may change cushion stars' eating habits. This study explored cushion star ecology and their laboratory feeding preferences in the presence and absence of crown of thorns. Laboratory experiments were conducted with three coral food choices (*Porites* sp., *Acropora* sp., and *Monopora* sp.) and algae covered rock. Cushion stars only ate *Acropora* sp. and *Monopora* sp. in laboratory experiments. They found among all three of those coral genera in the field and were rarely found near *Pocillopora* sp. Crown of thorns presence had no significant impact on the food choice in the lab or substrate choice of cushion stars in the field. General laboratory trends indicate cushion stars ate more frequently and preferred rock as substrate in the presence of crown of thorns.

*Key words:* Culcita novaeguineae; Acanthaster planci; *starfish; competition; corallivore; Mo'orea, French Polynesia*

## INTRODUCTION

An organism's niche is the ecological space it occupies. Niche overlap between two populations is limited in ecosystems by competition; if the niches of two species are too similar, one species will outcompete the other (Hardin 1960). The principle of limiting similarity says that two species must differ in one aspect of their respective niches (Abrams 1983). Exploitative interspecific competition occurs when two species both use the same limiting resource so one species' use of that resource indirectly affects the other species (their niches overlap too much) (Abrams 2008).

Sea stars that live in the same habitat may predate upon the same animals but their coexistence suggests a mechanism of niche partitioning (Menge and Menge 1974). Niche partitioning occurs when the shared resource is used differently by the organisms (i.e. temoral or spatial partitioning). Competition's effects can diminish due to spatial or temporal partitioning or niche divergence (Holbrook and Schmitt 1989). In tropical Pacific coral ecosystems, cushion stars (*Culcita novaeguineae* Muller and Troschel 1842) predate upon coral on a continuous basis (Goreau *et al* 1972). However, crown of thorns starfish (*Acanthaster planci* Linné 1758) occur periodically in outbreaks across the Pacific (the last outbreak

at the study site was 27 years previously [Berumen and Pratchett 2006]); these outbreaks destroy coral communities because of crown of thorns' large appetite for coral (De'ath and Moran 1998).

Crown of thorns and cushion stars often occupy the same habitat on the reef in Mo'orea, French Polynesia (personal observation). Cushion stars may generally live in shallower water than crown of thorns (Sea McKeon, personal communication) but I have personally observed crown of thorns at shallow depths. Previous studies on cushion stars and crown of thorns have shown that they are both more active at night (Hawkins 2006, De'ath and Moran 1998). These observations eliminate possible spatial and temporal partitioning of coral resources and suggest niche shifts are occurring.

Goreau *et al* 1972 and Bertics 2003 noted that *C. novaeguineae* may not be solely feeding on coral but may also eat algae or feed on coral rubble. *Culcita schmideliana* has a diverse diet consisting of sea grass, sponge, and rarely coral which varied with the habitat it was found in (Thomassin 1976). Thus, though the coral-eating habits of *C. novaeguineae* are the most well-documented, they may have a generalized diet as well. Because *Culcita* has a more general diet than *Acanthaster*, it is more likely to change its niche/food items in response to competitive pressure.

Coral food choice experiments have been done on Pacific cushion stars in Hawaii (Glynn and Krupp 1986) and in Mo'orea to determine coral preference; Bertics 2003 also included *Halimeda sp.* in her experiment. These studies demonstrated the cushion star's preference for *Pocillopora* and *Acropora* over other types of coral (*Porites, Montipora,* and *Fungia*). Studies on feeding preference of *A. planci* have also been conducted around the world but vary in results of preferences though most agree that in low coral abundance, they will eat any coral present (De'ath and Moran 1998). Feeding preferences for coralliovres are likely based on crustacean guards, cnidocyst toxicity, skeleton shape, coral height, and depth of coral cells in the carbonate skeleton (or accessibility of organic matter) (Glynn and Krupp 1986).

Since the feeding preferences of *A. planci* and *C. novaeguineae* overlap where they co-occur, they are competing; since both are still relatively abundant on the reef, there must be some mechanism to compensate for this competition. I hypothesize that *Culcita* change their eating habits to compensate for this competition. Cushion stars may feed on algae, a less preferable food source, in the presence of crown of thorns, the superior competitor, in order to mitigate population effects caused by competition. Field studies should show cushion stars near crown of thorns on different substrates or near different corals than those not in the crown of thorns' presence. Laboratory experiments should show different cushion star feeding preferences in the presence or absence of crown of thorns.

## METHODS

### *Study Organisms*

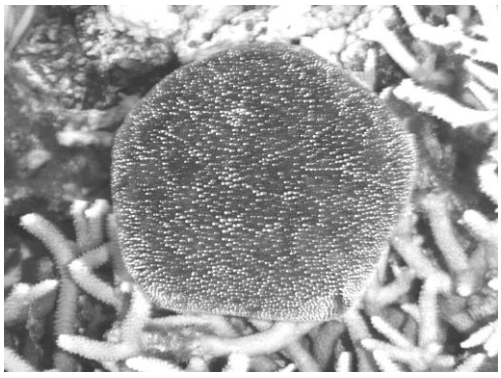

Figure 1. *Culcita novaeguineae* on *Acropora*

*Culcita noavaeguineae* (Figure 1) eat a variety of organisms from algae to sponges to bryozoans and coral. They strongly prefer to eat coral over other prey (Glynn and Krupp

1986) though they are not known to cause significant harm to coral reefs. They eat only small amounts of coral at a time and occur in low enough densities not to have a strong effect on the overall health of the reef.

*Acanthaster planci* are the second-largest sea stars. They appear in large outbreaks in reefs around the world, eat almost all of the coral in the reef, and move on to another location (Zann *et al* 1990). Their high densities and large quantity of food eaten greatly affect the health of the reef, leaving almost no coral left alive and healthy (Pratchett 2001).

*Field observations*

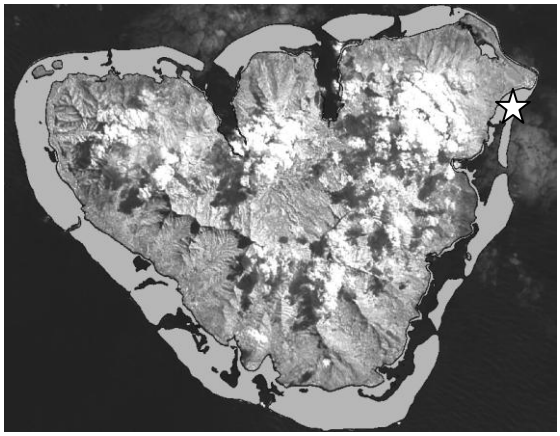

Figure 2. Satellite picture of Mo'orea with reefs outlined in grey. Study site at Temae shown with a star.

I observed cushion stars at the patch reefs at Temae Beach in Mo'orea, French Polynesia in October and November 2008 (Figure 2). I recorded substrate and coral genus in the cushion star's immediate vicinity, and crown of thorns' presence within ten meters of the cushion star (Figure 3). If possible, cushion stars were picked up to note stomach eversion, which signified that the cushion star was eating. Observations were made within a ten meter radius of random points within viable cushion star habitat in the morning. Areas excluded include those that cushion

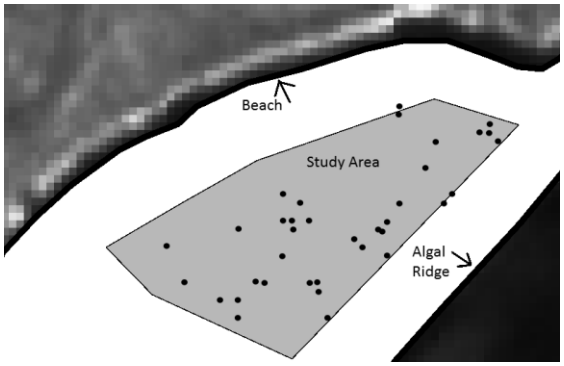


Figure 3. Close up of reef area and study area of Temae patch reefs. Dots indicate random quadrats.

stars had not been seen in such as sand and the algal ridge.

To determine normal substrate composition at Temae, I conducted three point-intercept transects with Ben Ginsburg. The transects began at a random point and ran in a random direction for 50 meters; the substrate touching the transect tape at each centimeter was recorded. The mean of these three transects was used to represent the typical assemblage at the Temae patch reef and the standard error of each substrate type was found.

Goodness of fit statistics were used to find nearest coral preferences of cushion stars by determining if they differed significantly from the relative abundance of corals. Coral preference of cushion stars not near crown of thorns was compared to those near cushion stars using a goodness of fit test to determine if those near crown of thorns significantly differed in their nearest coral.

*Laboratory study*

Cushion stars for a laboratory study were collected in Cook's Bay, Mo'orea and returned after experimentation. Two crown of thorns starfish were taken from and returned to the fringing reef next to Gump Station. All study animals were starved for approximately fifty

hours prior to experiments in order to ensure they would eat during the experiment.

Live coral rubble was collected from the patch reefs at Temae. Algae-covered rocks were collected from the fringing reef adjacent to Gump Station. All coral and rocks were returned to the water next to Gump Station. Rocks and corals were chosen to approximate equal surface area, thus food content for the starfish; rocks, *Porites* sp., and *Monopora* sp. were from baseball to softball size; two to four branches of *Acropora* sp. were used in this study. When not being used in experiments, animals were kept in tanks with running seawater; cushion stars were kept with Diadema urchins due to space contraints, crown of thorns were kept together, and food choices were kept separate from corallivores.

Lone food choice experiment:

One cushion star was placed in the center of a round tank with flowing sea water. It was allowed to choose from four food choices (*Monopora, Acropora, Porites,* and algae-covered coral rubble) placed randomly around the tank, equidistant from each other and the cushion star (Figure 4). Animals were placed in tanks between four and five in the afternoon, in order to acclimate them to their new environment before their active nocturnal feeding times. The cushion star's location and state of food choices (whether there were feeding scars noted by a white circle) was monitored every 1.5 hours until 11:30pm and checked again at 6am the following morning. Between noon and 2pm the cushion star was put back in its holding tank and food choices returned to the lagoon. To determine if cushion stars have a food preference, goodness of fit test was used. This test was performed in Excel from J. McDonald's file (http://udel.edu/~mcdonald/statgtestgof.html).

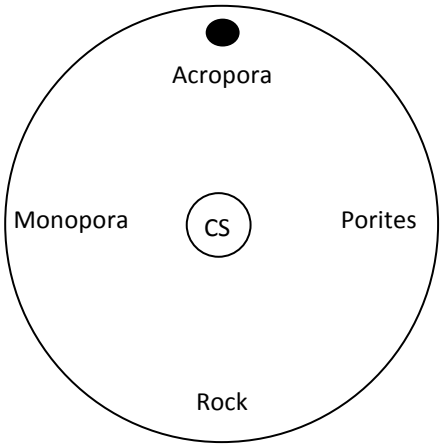


Figure 4. Representative lone feeding choice experiment set-up. The black circle at the top represents the tank's outflow tube.

Food choice in the *Acathaster* presence:

Using the same methods to evaluate food choice, a crown of thorns and a cushion star were placed in the center of the tank. The location of food choices was random with respect to where the cushion star and crown of thorns are placed. Each cushion star was used in both feeding experiments. Crown of thorns feeding scars are more irregular in shape and larger than cushion star feeding scars, although on coral this size, they are indistinguishable except on *Acropora*. Which animal fed on a food choice was inferred from position throughout the monitoring period. Goodness of fit was also used here to determine if the food choice in crown of thorns presence differed significantly from lone food choices.

## RESULTS

### *Field Observations*

The transects revealed that the most common coral at the Temae patch reefs was *Porites,* followed by *Acropora*, then *Monopora* (see Figure 5). The most common substrate was sand and the least common was rock. No cushion star was seen to eat in the field. Of 42 observed cushion stars, only five were within ten meters of a crown of thorns (Figure 6).

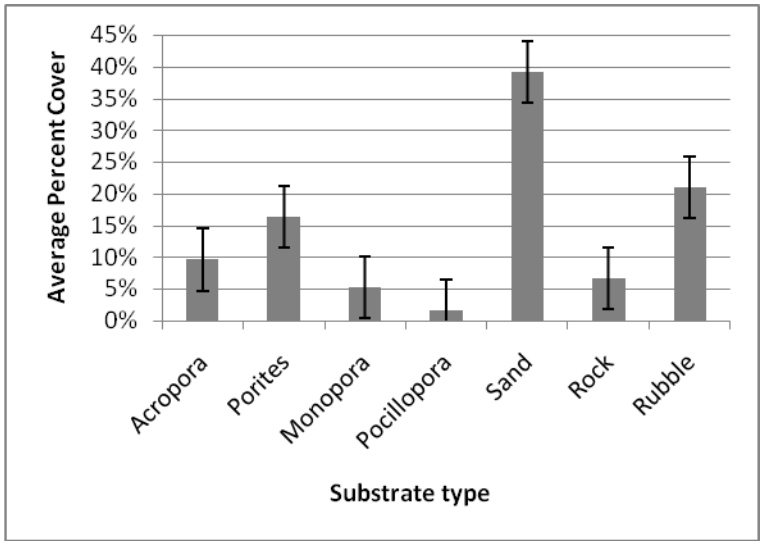


Figure 5. Percent cover of substrate types (±1 SE) at Temae Beach, Mo'orea based on point-intercept of three random 50m transects.

substrates. There was signficant coral preference against *Pocillopora* (G-test; P≈0). The five *Culcita* found near crown of thorns were found nearest *Monopora*, and *Acropora*, and were not found at all nearest *Pocillopora*. They were found on rock and rubble, but not on sand. However these results do not differ signficantly from cushion stars not near crown of thorns (G-test; P=0.69).

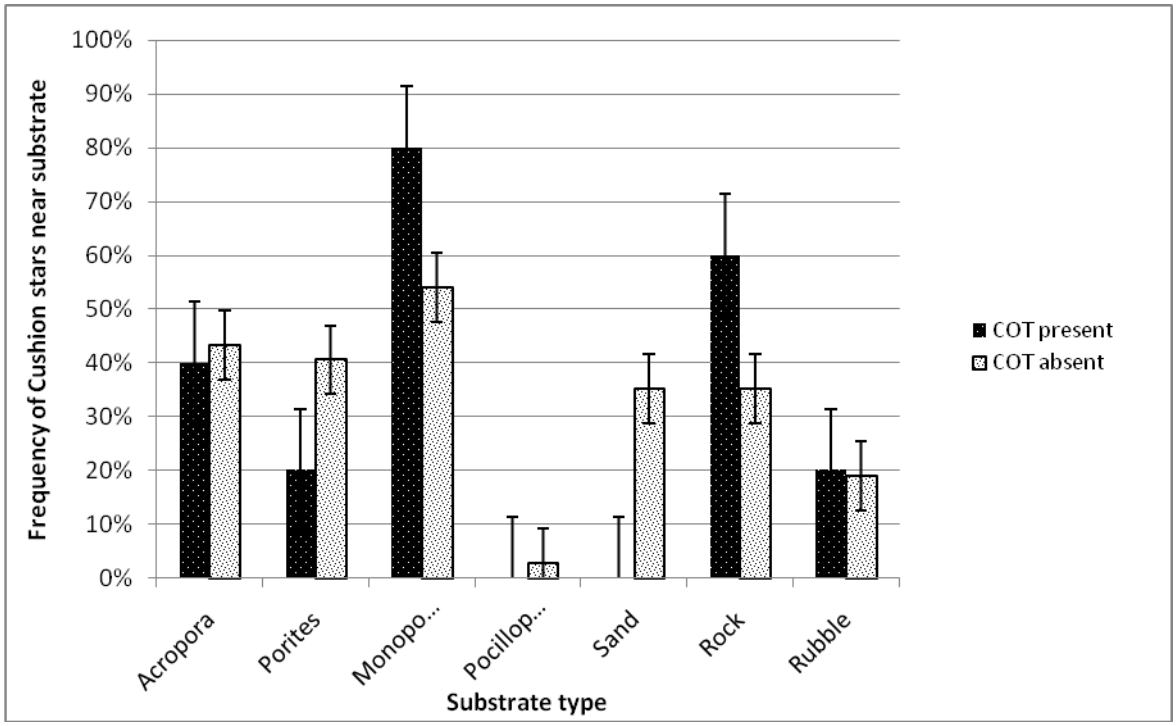


Figure 6. Frequency that cushion stars were found on substrate and the nearest coral to the cushion star in the presence (black) and absence (gray) of *Acanthaster planci*.

The 37 cushion stars not near an *Acanthaster* did not have a significant preference between *Porites, Monopora,* or *Acropora* and were not seen very frequently near *Pocillopora*; they were most often seen on sand and rubble

*Lone Feeding Experiments*

Some cushion stars did not eat, and no cushion star ate the algae on the rock or *Porites* coral. They significantly preferred *Acropora*

which was eaten 46% of the time; *Monopora* was eaten 18% of the experiments (Figure 7; G-test, P=.01)

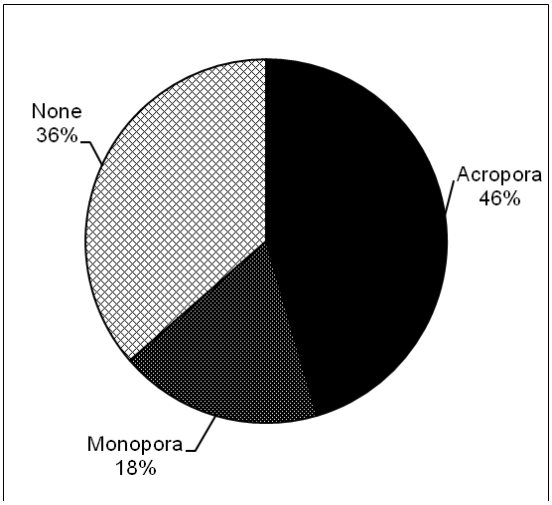


Figure 7. Lone feeding preferences of cushion stars.

*Food Choice in Presence of Crown of Thorns*

Most cushion stars ate in these experiments, but still none ate algae or *Porites*. *Acropora* was preferred even more as was *Monopora* (Figure 8). However, these results do not vary significantly from lone feeding choice (G-test, P=0.35). In almost half of the experiments the crown of thorns did not eat anything. When it did eat, it ate *Acropora* most, then *Monopora*, and then *Porites*.

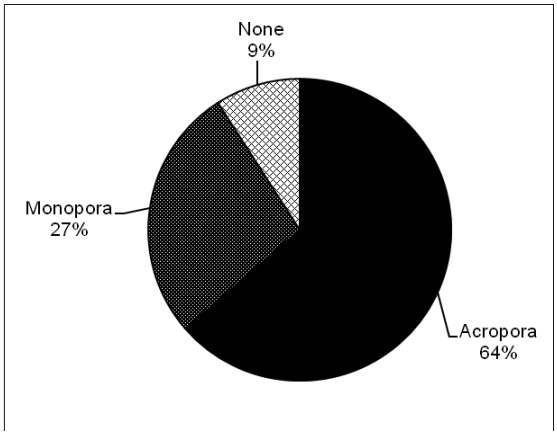


Figure 8. Feeding choice of cushion stars in the presence of crown of thorns starfish.

## DISCUSSION

The field observations indicate cushion stars prefer *Monopora* and *Acropora* over *Porites* considering the relative coral abundances at Temae. They dislike sand as a substrate and prefer to live on rock during the day. Substrate and coral preferences do not change in the presence of crown of thorns. Laboratory tests indicate that cushion stars prefer to eat *Acropora* and *Monopora* which also does not change in the presence of crown of thorns.

This laboratory study confirms *Culcita*'s preference for *Acropora*. The fact that more *Monopora* was eaten in the presence of crown of thorns indicates that cushion stars may be broadening their diet. However, the cushion stars ate more in general so it is possible that the other corallivore's presence merely spurs them to eat faster or more frequently. Previous studies had shown a food preference for *Pocillopora* and *Acropora* in cushion stars but since *Pocillopora* was scarce at Temae, it was not chosen for this study. Previous studies noted a difference in lab feeding preference and field observations but I did not see such a disparity (Bertics 2003).

Field observations occurred in the morning but lab experiments indicate cushion stars are already finished eating by morning. Because cushion stars were observed during the day instead of at night, it is impossible to be certain what they were actually eating. However, the nearest coral likely indicates their latest prey because feeding scars were commonly present and the cushion stars in lab experiments did not usually move far from their food item by morning. Cushion stars likely choose their daytime location to avoid predation through physical protection and crypsis. Their refuges also protect them from wave and current action that could easily transport them away from the coral into the deep lagoon or shore.

The laboratory experiments did not have significant results perhaps because the crown of thorns has different feeding habits; it is generally known that crown of thorns feed at night (Pratchett 2001) but they also feed more quickly and are more physically active than cushion stars (personal observation). The crown of thorns did not eat as early in the night as the cushion star did so exploitative competition was not evident. The cushion star may have more incentive to reach a food item quickly and start feeding since they take longer to eat and move slower than crown of thorns. This study may be improved by allowing the crown of thorns to choose a food item first, before introducing the cushion star into the tank to simulate the high density of *Acanthaster* consuming coral previous to cushion stars having the opportunity to feed.

Significant results may be lacking because of low sample size; time constraints limited the number of lab experiments and few cushion stars were found within 10m of crown of thorns at Temae. It may be too early in the invasion at Mo'orea to see much of an effect of *Acanthaster* on the patch reef ecosystem.

Further study to observe actual feeding activity and preferences at night would be illuminating, though this can be logistically complicated. Population estimates of *Culcita* before, during, and after crown of thorns outbreaks could indicate crown of thorns' true effects on cushion stars.

Crown of thorns outbreaks may not negatively affect cushion stars at all; once all the coral has been eaten the cushion star population can still survive by eating algae or scavenging though their eating habits would obviously have changed at that point. There may be little or no exploitative competition occurring on these reefs until crown of thorns completely changes the habitat. Cushion stars appear to be hardy creatures that can eat almost anything to survive even though they prefer coral. Crown of thorns may devastate reefs worldwide but one organism they do not appear to drastically affect on the reef is the cushion star.


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