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Predation of the Sea Urchin *Diadema antillarum* Philippi on Living Coral

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Summary. On the coral reefs of Curaçao and Bonaire (Netherlands Antilles) the sea urchin *Diadema antillarum* is a major coral predator. In areas with high coral cover, up to 8.2% of the *Diadema* population (with a density of 8.5 animals/m^2) was feeding on living coral surfaces at night. *Acropora* species are the most heavily attacked corals.

For reasons such as the largely unknown causes of death of corals and the impact of *Acanthaster planci* recently in the Pacific, predation on stony corals (Scleractinia) has been the subject of much research lately. Few animals are known to eat living coral in the Caribbean. A recent summary (Glynn, 1973) names only five invertebrate predators. On Barbados, only two coral predators are of consequence (Ott and Lewis, 1972). In addition to invertebrates, some fishes are known to eat coral. Our field observations are in accord with those of Randall (1967) in that fish only occasionally feed on living coral colonies, although in other areas, their effect is more important (Glynn, 1973).

Over the past year we have noticed scars on coral colonies that could not be explained by predation of the fire worm, *Hermodice carunculata* or the gastropod, *Coralliophila abbreviata* (apparently most common invertebrate coral predators in Curaçao). Night diving with SCUBA gear, revealed that the sea urchin *Diadema antillarum* is a very common predator on various coral species. It is commonly regarded as a herbivore (Lewis, 1964; Randall *et al.*, 1964; Sammarco *et al.*, 1973, 1974) but it also feeds on detritus and sediment and occasionally as a carnivore (Lewis, 1964; Quinn, 1965). None of the authors mentions *Diadema* as feeding on living coral.

The strong and extendable chewing apparatus of *Diadema* scrapes off the living tissue with part of the underlying calcium carbonate skeleton. The urchins are normally found in one of three locations on coral heads: 1. on the boundery between the living coral and the bare dead skeleton, 2. on the edge of an existing scar on the living tissue, and 3. on a fresh scar on the coral surrounded by living tissue (Fig. 1). Examination of urchin gut contents within an hour after collection showed coral tissue, mucus, nematocysts and zooxanthellae to be present. We did our quantitative observations on size and distribution of the *Diadema antillarum* population and the number of coral eating urchins and their prey species, on a reef on the southwest coast of Curaçao. Due to the complexity of the substrata on the deeper reef, our observations are restricted to the shallow

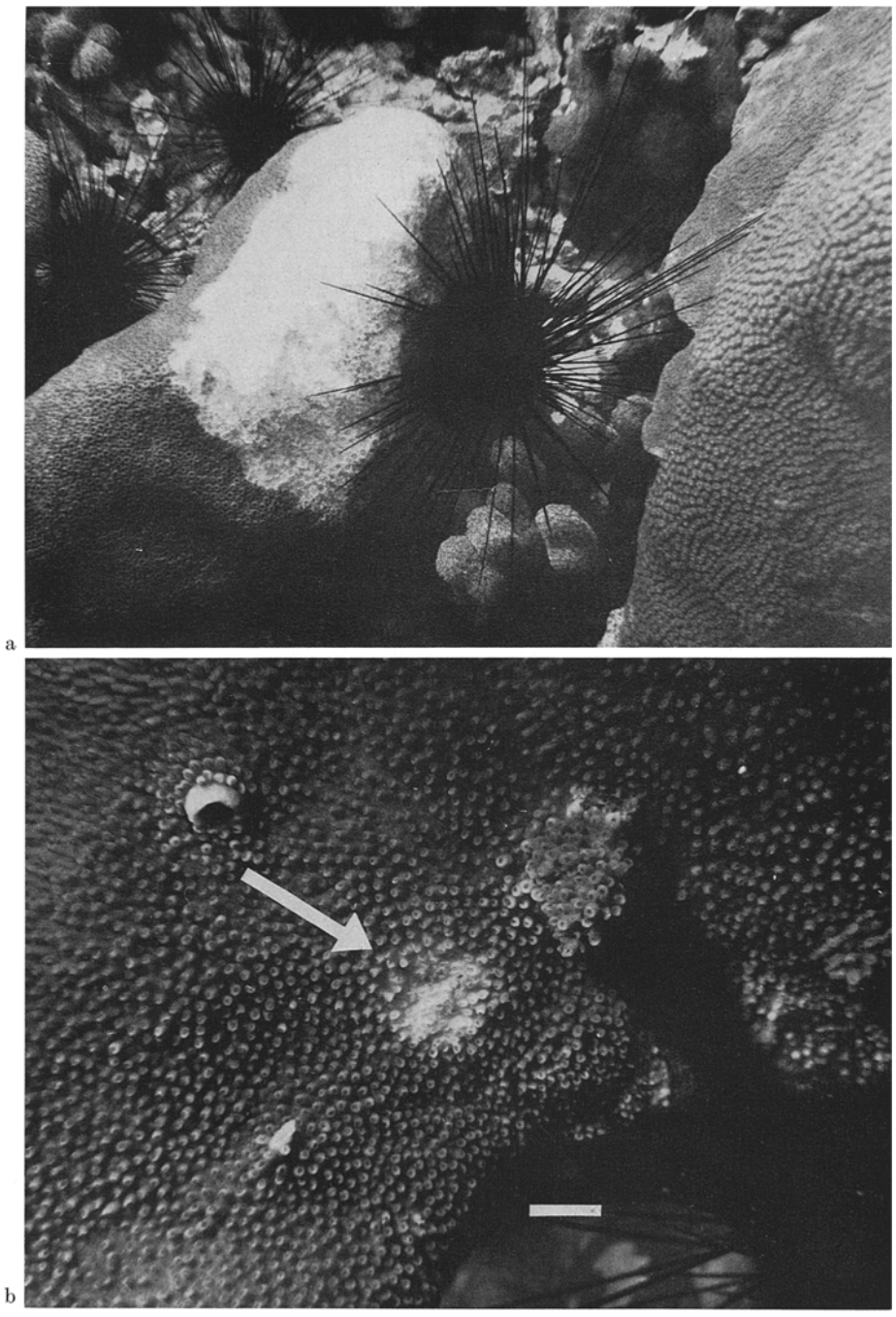

Fig. 1. (a) A *Diadema* feeding on the edge of a large scar in the tissue of *Montastrea annularis*. Coral tissue and corallites are scraped off. (b) A feeding *Diadema* is removed to show the lesion in the living coral tissue. This small scar in the living coral surface of *Acropora palmata* (see arrow) shows how *Diadema* bites off the living tissue with part of the underlying skeleton. Scale bar represents 1 cm

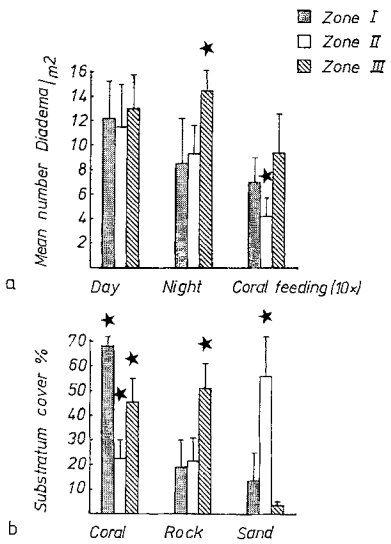

Fig. 2. (a) Mean numbers of *Diadema antillarum* in the different reef zones during day and night and the number of coral feeding animals ($\times 10$). (b) Percentage of reef zone covered by living coral, coral rock and sand. Vertical lines represent standard deviation. Values significantly different (t tests, $P < 0.05$) from other two zones are marked with an asterisk

reef platform (12–2 m depth). This platform is 40–50 m wide and extends from the first dropoff to the shore zone (Bak, in press). The platform can be divided in three main zones: zone I is the deepest zone with abundant coral cover; zone II intermediate in depth with much sediment; and zone III is the shallow *Acropora palmata zone*. We did three types of census along one meter wide transects. One census established the number and distribution of *Diadema* during the day; another provided these data for the noctural feeding population; and a third census gave the numbers of *Diadema* found feeding on living coral and their prey species. A line transect method (Loya, 1972) was used to quantify the types of the substrata (living coral, rock or sand) over the reef.

The results are shown in Fig. 2. The data on coral feeders are minimum figures because *Diadema* starts to move when disturbed by diver-induced water movements and light (both inherent in SCUBA diving at night). Many more fresh scars were found than the number of animals actually feeding. The greatest supply of benthic algae, the normal food of *Diadema*, is found on the reef rock which is most abundant in zone III. The significantly higher density of urchins in this zone at night suggests a nightly movement to this area for feeding. Coral is fed upon in all zones but mostly in the zones where living coral is most abundant. The percentages of the population feeding on coral in zone I, II and III are respectively 8.2, 4.5 and 6.5%. The only other active predator we observed were five specimen of *Hermodice carunculata*. In zone I, the coral diversity is high and almost all species are attacked by the urchins, including the Hydrozoan *Millepora*

species. Most *Diadema* feeding on corals were found on *Madracis mirabilis*, *Agaricia agaricites* and *Montastrea annularis*. These are also the most common species in this area. In zone II, coral cover is low; many species are present and most are attacked. *Acropora cervicornis*, in particular, is invariably fed upon when present. In zone III, *Acropora palmata* is the dominant coral and 86% of the coral-feeding *Diadema* were found on this species. The individual fresh scars are up to 10 cm in diameter, because urchins repeatedly feed around the same lesion, the total area of a scar can be enlarged to cover most of a branch of an *A. palmata* colony. The available data in the literature (Randall *et al.*, 1964; Sammarco *et al.*, 1973, 1974; Smith, 1973) suggest that the population density of *Diadema antillarum* is extremely high in our study area. A food shortage might explain the change in feeding behaviour from a principally herbivorous animal to a facultative coral feeder. The only other known echinoderm predator on living coral is *Acanthaster planci*, and it recently became well known as a coral destroyer when there were population explosions of this starfish in the Pacific. The increase in populations densities of *Acanthaster* was attributed to a number of causes, amongst which pollution and other human activity are prominant (Endean, 1973). As we observed heavy predation on the relatively unpolluted reefs of Bonaire, pollution does not seem to be necessarily responsible for predation on living coral by *Diadema*. In Bonaire, as well as in Curaçao, *Acropora* species appear to be the corals most heavily attacked. This pattern may either be because of a preference of *Diadema* for this prey, or because *Acropora* species are dominant in certain habitats. It should be noted that despite similarities between populations of *Diadema* and *Acanthaster* (*e.g.* the rarity of small specimens on the reef (Yamaguchi, 1973), *Acanthaster* populations feed principally on corals, while *Diadema* must be classified as a facultative coral predator.

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