acted to antigens induced by both HSV_1 and HSV_2, some serums reacted to one but not to the other antigen. The antigens of the two types appear to contain common and specific antigenic sites (*7*). The exact nature of the antigens and the relatedness between the two types of HSV remain unknown. Certain cytomegalic virus strains have been isolated from primary lung cancer cell cultures; there are indications that other members of the HSV group infecting humans induce similar antigens (*10*). The relation between the antigens of the HSV group, however, has not been established.

The continued presence of antibodies to the nonvirion antigens after successful treatment of the malignancy paralleled the finding of a high incidence of cellular immune abnormalities in both tumor-bearing and cured squamous carcinoma patients (*11*). If the antibodies were produced to antigens related specifically to the tumor cells, removal of the tumor should eliminate the antigen source and result in a subsequent disappearance of antibodies. However, removal of the malignancy may not eliminate all cells producing the antigens; clinically normal adjacent mucosa may, nevertheless, contain transformed cells. This may explain the well-documented, repeated development of new primary squamous cell carcinomas in these patients. On the other hand, cells in the premalignant stage of the disease might remain, or nonmalignant cells lytically infected with virus during recurrent infection might provide an antigen source for continued antibody stimulation. For these reasons it is important to determine the relations of antibodies to the antigens, to each other, and to the cancer. Similarly, a possible relation between expression of nonvirion antigens and the prolonged immune cellular abnormalities in the squamous cell cancer patients deserves attention. Further knowledge of the rates of antibody appearance and cancer development is necessary before the techniques can be applied clinically.

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Grazing by the Echinoid Diadema antillarum Philippi: Formation of Halos around West Indian Patch Reefs

Abstract. *Between patch reefs and marine grass communities there is normally a zone or "halo" of heavily grazed grass 2 to 10 meters wide. Grazing by the echinoid* Diadema antillarum *Philippi during nocturnal migrations off the reefs is found to be the major factor in the formation of halos.*

A common feature associated with patch reefs in the West Indies is a band of nearly bare sand between the base of the reef and the outlying beds of marine monocotyledons *Thalassia testudinum* (turtle grass) and *Syringodium filiforme* (manatee grass). This so-called halo is commonly 2 to 10 m in width and is reminiscent of the bare zones reported between California shrub and grassland communities (*1*). Generally, the area closest to the reef is totally barren. The portion of the halo closest to the outlying beds of sea grasses usually has a moderate density of closely cropped plants and appears bare when viewed from afar or in aerial photographs (*2*).

Some attention has been paid to the origin of these halos. Previously it was held that certain physical factors such as large particle size and rapidly shifting sands made growing conditions unfavorable in halos. However, it was found that halos were present over a wide range of physical environments. Neither the slope of the bare area, nor exposure to high-energy wave surge had any bearing on the presence or absence of the halo. Furthermore, analysis of the sediment revealed little difference in particle size between areas on the halo and areas in the grass beds (*2*).

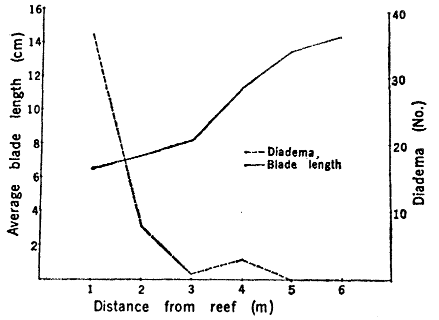

Fig. 1. Mean blade length of *Thalassia* and number of *Diadema* per meter (total of five midnight counts on each of four transects) as functions of distance from the reef edge. The distance 4 m corresponds to the visual edge of the halo. The data were taken in December 1972.

Randall (*2*) presents some evidence that grazing fish—primarily surgeonfish (Acanthuridae) and parrot fish (Scaridae)—are responsible for the absence of vegetation in the halos. Recent observations have cast doubt on the extent to which herbivorous fish are responsible for halo formation and maintenance. First, grazing fish in the area of patch reefs on St. Croix, U.S. Virgin Islands, are under intense fishing pressure and are not common. Second, close observation of the short cropped grass within the halos surrounding these patch reefs shows that many of the blades do not display the scalloped edges characteristic of fish grazing. Rather, the blades are terminated in the ripped and jagged form which characterizes grazing by the echinoid *Diadema antillarum* Philippi (*3, 4*).

In the West Indies, *D. antillarum* is found in abundance on patch and barrier reefs (*5*). It remains inactive on found in abundance on patch and barrier reefs (*5*). It remains inactive on the reef during daylight hours and feeds at night. Observations and experiments on the behavior of *D. antillarum* were carried out from April 1972 to February 1973. The work was concentrated on two small patch reefs about 50 m in diameter in Knight Bay on the northeast coast of St. Croix. Both of these reefs (PR-2 and PR-3) had well-developed halos.

The total number of *Diadema* in the halo of PR-3 was recorded at various times throughout the day. Urchins begin to move into the halo between 1500 and 1800 hours, reach a maximum between 2100 and 2400 hours, and return to the reef by 0600 hours. By day there are no urchins in the halo.

The area of PR-3 is about 1500 m^2. The total population of *Diadema* on the reef was estimated by transect counts to be between 10,000 and 13,000 individuals. From 7 to 9 percent of the population was observed to migrate into the halo each night. It is suspected that this proportion is quite variable and may be strongly influenced by wave action (*6*). The gut contents of the *Diadema* feeding in the halo consist entirely of *Thalassia* and carbonate sand. The remainder of the population which does not migrate on a particular night feeds on algal mats on the reef surface (*7*).

On PR-3, four transects (2 m by 6 m) were set up, each running from the base of the reef 6 m out through the halo. Each transect was divided into rectangles 1 m by 2 m in size. For each rectangle in each transect the mean length of 20 randomly harvested *Thalassia* blades was determined. The means for the rectangles were averaged for the four transects and plotted (Fig. 1).

Observations of these transects were made on 5 nights. As the nocturnal distribution of *Diadema* is fully established by 2400 hours, the number of *Diadema* in each of the six areas of the four transects was recorded at 2400 hours. The total number of *Diadema* observed in each rectangle on all 5 nights was plotted. The length of *Thalassia* blades in the halo correlates with the decreasing numbers of *Diadema* found at increasing distances from the reef (Fig. 1). The halo is the farthest that *Diadema* will venture during nocturnal feeding.

In another series of observations, the perimeter of PR-3 was divided into 12 sectors and the maximum number of urchins per linear meter of reef perimeter in each sector was recorded. The movement of the urchins into the halo is not uniform. The sectors of the reef to the north received the most urchins during each nocturnal migration. Note that sector 9, which received the fewest urchins, also has a point in which the edge of the halo dips closest to the reef (Fig. 2). The reasons for this irregular distribution during migration are not known, but urchins could be responding to the current (from the northeast) or some features of the reef topography (*8*).

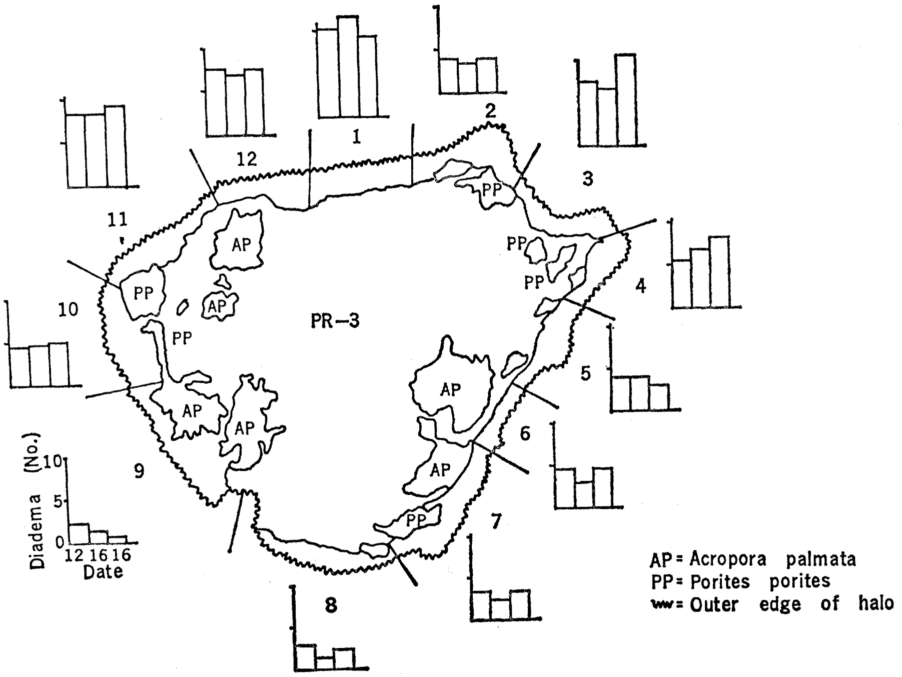

Fig. 2 Patch reef 3 showing the maximum number of *Diadema* per linear meter of perimeter in each of 12 reef sectors. *Acropora palmata* and *Porites porites* are corals. The data were taken in 1973, on 12 January (2130 hours), 16 January (0015 hours), and 16 January (2200 hours).

On occasion, small clusters of four to ten *Diadema* were seen during the day in the *Thalassia* beds surrounding the reefs. Frequently, these clusters would be associated with a bare patch in an otherwise lush growth of sea grass. However, the very low numbers of *Diadema* involved make it unlikely that they are exerting a significant influence on the extensive sea grass beds outside the halos.

In April 1972 all of the *D. antillarum* were cleared from PR-2. Periodic reclearing (every 2 months) insured that the reef was not repopulated (*9*). Aerial photographs taken before this time showed a well-developed halo. Eight months after the clearing, PR-2 had no halo at all. The former bare area around the reef was invaded by new growths of *Thalassia* and *Syringodium.*

The question remains as to the relative importance of the grazing pressures exerted by *Diadema* compared with those exerted by herbivorous fish. On PR-3, parrot fish and surgeonfish were observed to occasionally feed on *Thalassia* and its epiphytes in the halo, but their numbers are very few compared to the hundreds of urchins moving into the halo each night. After the clearing, PR-2 showed a definite increase in numbers of herbivorous fish, but these were all juvenile in size, and apparently find sufficient food in the increased algal growth on the reef. They do not feed in the *Thalassia* beds.

The presence of high densities of *Diadema* on patch reefs and not in the open *Thalassia* beds implies that the reefs provide some protection. The major predators of *Diadema* are over 15 species of fish and the king helmet shell *Cassis tuberosa* (*10*). Many of these predators, especially grunts, triggerfish, and the helmet shells, have been severely overfished in recent years near the study area. However, the behavior pattern which has apparently evolved in response to this predation remains.

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6. *Diadema* do not move as much on stormy nights. This may be because they could be tumbled about by surge on the unconsolidated substrate of the halo.
7. The surface of PR-3 appears completely barren at first glance, but actually has abundant growth in mats which are actively fed upon by *Diadema*. See Ogden *et al.* (*3*) for a detailed discussion of the feeding habits of *Diadema*. It is not known whether all urchins eventually end up feeding in the halo. J. Konigsberg and I. Braverman (personal communication) found that the percentage of *Thalassia* in the guts of *Diadema* on the reef decreases with distance from the halo, but many urchins on the reef have *Thalassia* in their gut contents. The major exploiters of the halo region, however, are the urchins at the perimeter of the reef. J. B. Lewis [*Can. J. Zool.* **42**, 549 (1964)] found that *Diadema* feed largely on algae. In nature, feeding was concentrated in the late afternoon and early evening, while in the laboratory feeding occurred at night.
8. The coral *Acropora palmata* on PR-3 provided much daytime hiding space for *Diadema*. Another coral, *Porites porites*, was rarely crossed by moving *Diadema*. These corals may well influence movement into the halo. The urchins are not distributed uniformly on the reef surface. The largest populations are found in the northeast portion. Another possibility is that the urchins concentrate grazing on certain portions of the halo at a time, shifting slowly so that eventually the entire halo is grazed.
9. The area of PR-2 is approximately 1000 m^2 and over 7000 urchins were removed. The reef is repopulated at a rate of up to 500 urchins per month, which move in from the shoreline or other reefs. Almost all of the urchins on the patch reefs are of adult size (mean test diameter between 50 and 60 mm). Following the clearing of PR-2 a lush growth of benthic algae rapidly developed on the formerly bare substrate. The dominant species was the brown alga, *Padina sanctae-crucis*.
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Recovery of Feeding and Drinking by Rats after Intraventricular 6-Hydroxydopamine or Lateral Hypothalamic Lesions

Abstract. *Rats given intraventricular injections of 6-hydroxydopamine after pretreatment with pargyline become aphagic and adipsic, and show severe loss of brain catecholamines. Like rats with lateral hypothalamic lesions, these animals gradually recover ingestive behaviors, although catecholamine depletions are permanent. Both groups decrease food and water intakes markedly after the administration of α-methyltyrosine, at doses that do not affect the ingestive behaviors of control rats. Thus, both the loss and recovery of feeding and drinking behaviors may involve central catecholamine-containing neurons.*

6-Hydroxydopamine (6-HDA) administered intracerebrally along the nigrostriatal bundle (*1, 2*), within the lateral hypothalamus (*1, 3*), or by way of the lateral ventricles (*4*), can produce aphagia, adipsia, and prolonged anorexia in rats. The same effects occur after bilateral electrolytic lesions of the far lateral aspects of the ventrolateral hypothalamus (*1, 4–9*) or of other areas along the nigrostriatal pathway (*10*). Ungerstedt (*1*) and others (*4, 9*) have suggested that the disruptions of ingestive behaviors are due to the almost complete disappearance of striatal dopamine that is observed in each of these preparations. In the present studies, we sought to determine whether details of the progressive recovery from aphagia and adipsia after intraventricular administration of 6-HDA were similar to the well-known syndrome that is observed following electrolytic damage to the lateral hypothalamus (*7, 8*). We now report that they are. We also report that residual brain catecholamines appear to make a significant contribution to the recovery of ingestive behaviors in rats with either 6-HDA or electrolytic lesions.

Twenty-two rats of the Sprague-Dawley strain (Zivic-Miller Laboratories, Pittsburgh), weighing 250 to 300 g, were given pargyline (50 mg/kg, intraperitoneally) followed 30 minutes later by an intraventricular injection of 6-HDA (200 μg) (*11*), as in previous studies (*4*). The animals were aphagic and adipsic for 24 hours, but ingestive behaviors resumed within the next day or two. Control animals given either pargyline or 6-HDA alone showed no aphagia or adipsia. Four days after the first treatment, animals were given the same injections of pargyline and 6-HDA for a second time. Sixteen of them became aphagic and adipsic and were given access to highly palatable foods, such as Pablum, Metrecal, and sucrose solution; nevertheless, eight rats remained aphagic or anorexic, lost more than 35 to 40 percent of their body weights, and died within 1 to 2 weeks. We attempted to keep the other eight rats alive by intragastric feeding. Of these, one rat continued to lose body weight and died, but the other seven rats ultimately recovered feeding and drinking behaviors. Five were eating dry Purina laboratory chow pellets and drinking water within 2 to 3 weeks, while two rats recovered much more slowly. These seven rats displayed the same general pattern of recovery, which differed only in its time course.

Consideration of a rat which recovered slowly will highlight features of the recovery sequence (Fig. 1). At first, this animal ate nothing and had to be maintained by daily intragastric intubations of liquid diet. After 4 days, the animal passed into a second stage in which it would ingest the palatable foods. Gradually, larger amounts of these special foods were consumed, and eventually tube feeding was no longer required for body weight maintenance. After 58 days, the animal entered a third stage in which it would eat dry chow, but only if hydrated. Although it still would not drink water, the rat would accept 5 to 10 percent sucrose solutions and thereby maintain body fluid hydration. Finally, 92 days after the second 6-HDA treatment, the animal entered a fourth stage in which it maintained body weight on dry chow and tap water, although at a level that was considerably below that of control rats.

In contrast to these 16 animals, the other six rats recovered from the second 6-HDA treatment within a few days. These animals were given the same injections of pargyline and 6-HDA for a third time. Aphagia and adipsia were observed in each rat. In four of them, this was followed by an extended recovery period that was similar to (and, in two instances, even longer than) that just described. However, two animals never did progress