HOMING AND AGGREGATING IN *DIADEMA ANTILLARUM*

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Abstract: The long-spined black sea urchin, *Diadema antillarum,* forages on algae at night and then aggregates during the day in coral crevice refuges. The urchins often return to their same crevices (homing). We hypothesized that because urchins receive many benefits from aggregating that , when isolated, they would return to a group. We also hypothesized that homing in *D. antillarum* occurs when the benefits of returning to a known area outweigh the costs of returning. If you increase the cost by moving groups of urchins farther from their reef patch, homing should decrease. We found that urchins do not return to their groups, perhaps because the cost of travel is greater than the benefits of being in a group. When entire groups of urchins were moved short distances from their patch, some individuals did return to their specific coral patch, but this behavior decreased as the distance to return to the patch increased. Our results suggest that there is a tradeoff between the costs and benefits of homing in *Diadema antillarum.*

Key Words: Discovery Bay, group benefits, Long-spined Black Urchin, travel cost

INTRODUCTION

Diadema antillarum, the long-spined black sea urchin, is an important circumtropical grazer of algae on coral reefs when the abundance of large herbivorous fish is low (Carpenter 1990). They exhibit a diel activity pattern, foraging from dusk to dawn and then aggregating in crevices throughout the day (Ogden et al. 1973). The benefits of being in these aggregations could be increased fertilization success since *D. antillarum* are dioecious external spawners and gamete release by an isolated individual often results in low success (Snyder 1970). *D. antillarum* also prefer to eat algal turf and crustose algae over mature macroalgae (Carpenter 1981) because the macroalgae has increased levels of calcification and secondary metabolites (Hay 1994). The maintenance of these algal turfs requires high levels of herbivory that might only be obtained by group grazing. Finally, the interlocking spines of a group of *D. antillarum* might decrease predation and dislodgement. We hypothesized that the benefits conferred to an urchin by being in a group would outweigh the cost associated with traveling to reach a group. We predicated that individual urchins, when removed from a group and placed by themselves, would return to the nearest group.

D. antillarum have been shown to return to the same crevice every morning for long periods of time (Carpenter 1984). This high tendency to home is due to the benefits received by having a known territory: having an adequate refuge when refuges are limited and are necessary to avoid predation (Carpenter 1984), increased surge protection (Morell 1981), and partitioning of food resources across the urchin population (Carpenter 1984). Traveling to return to specific sites costs the urchin in both the form of energy expenditure and

increased exposure to predators and surge while traveling (Carpenter 1984). We hypothesized that homing in *D. antillarum* occurs when the benefits of homing outweigh the cost. We predicted that the frequency of homing in a group of urchins would decrease as a function of increasing cost when we defined cost as the distance an urchin must travel to return to its original reef.

METHODS

We sampled on 23-25 February 2005 on the backreef of Discovery Bay, Jamaica. We established 10 patch reef sites varying between 1-3 m in diameter with *D. antillarum* present. At each of the sites we recorded urchin abundance on the patch reef (urchins within a half meter of the reef were counted as well). To test our first prediction that urchins would return to their original groups, we moved one individual from each site to another patch reef that was ≈5 m away. There were no other patches with *D. antillarum* that were closer than their original group. We chose 5 m because we wanted them to be isolated but capable of returning and *D. antillarum* have been observed to move up to 8 m during one night (Carpenter 1984). The following day we counted the number of urchins at each of our sites to see if the individual that was removed had returned.

To test the second prediction that groups of urchins would return to their original patch, we moved all the urchins from 10 patch reefs to another patch reef either zero, two, five, or ten m away. Each group ranged from 2 - 15 urchins. There were four 0 m replicates (control) and two sites for each distance treatment. The following day we counted urchins on the original patch reefs and on the treatment patch reefs to see if the urchins had returned to their original reefs or stayed on their new reefs. We used a linear regression to determine the relationship between the frequency of homing and the distance removed.

Table 1. The abundance of *D. antillarum* at different sites over time.

Site	# day 1	# day 2	Distance moved	# day 3 old rock	# day 3 new rock	Night 1	Night 2
1	9	8	2	1	8	.	.
2	5	4	0	4	.	4	3
3	16	15	0	15	.	12	8
4	10	9	5	0	9	.	.
5	5	4	10	0	5	.	.
6	12	11	0	11	.	3	2
7	5	4	0	4	.	3	3
8	3	2	2	1	1	.	.
9	6	5	5	1	3	.	.
10	6	5	10	0	2	.	.

Some urchins do not leave their crevice on any given night (Brosnahan 2002). We needed to establish that the urchins in Discovery Bay were moving. To determine if urchins were actually homing or simply never leaving their crevices, we surveyed the number of urchins on 10 patch reefs at both day and night. Urchins were considered to have moved off the reef if they were more than 0.5 m away. All data were analyzed using JMP 5.0.1.

RESULTS

Of the 10 individuals that we moved 5 m away from their original group and reef, none returned to the group and many remained where they were placed. However, when the entire group of urchins was moved, some urchins did return and there was a decreasing return rate with increased distance moved (Fig. 1). Most of the urchins in the group relocation experiment did not move; three unchins did return to their original reef, and four were unable to be located.

On the control reefs, 44% of the urchins moved off their reefs at night and all returned to their original reefs in the morning, so urchins are indeed capable of moving and homing under normal conditions.

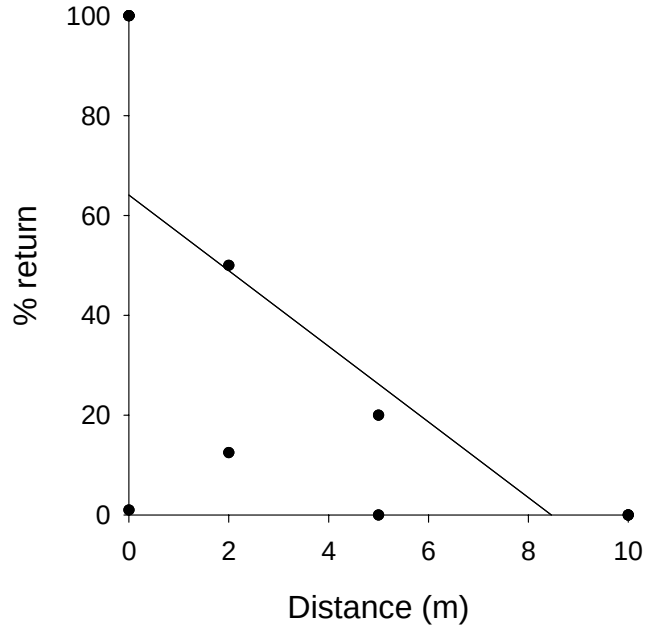

Figure 1. Effect of the distance *Diadema antillarum* was displaced from its original patch reef during the day on the percentage of individuals that returned the following day. Two points overlap at distance of ten and zero meters ($y = 0.82 - 0.1x$, $r^2 = 0.71$, df = 8, P = 0.002).

DISCUSSION

Since none of the urchins that had been removed singly from their groups returned to their groups, it appears that the cost of traveling back to join the group may be greater than the benefits derived from being with the group. The majority of the removed urchins did not even attempt to return, perhaps because our treatment distance was not far enough to remove the effect of group benefits such as maintenance of algal turfs and increased fertilization success. We only saw one urchin move 5 m so we do not know if the majority of this population of *D. antillarum* tends to only move distances less than 5 m, making our treatment level unrealistic.

The tendency of *D. antillarum* to return to their original patch reef when moved as a group supports the idea that there are benefits to homing, such as familiarity with refuges and the availability of known resources. Familiarity with a certain area has been shown to be an important factor in determining territoriality and homing in other species like gastropods (Cook 1979, Stimson 1973). However,

the sharp decline in homing with distance moved indicates that there may be a high cost to travel which eclipses the benefits of homing. Because we moved entire groups of urchins, which remained together at the new location, the benefit of being in a group was not altered. The cost for the whole group to return to the original site may be greater than the benefit to the group of returning to the original site.

Future studies could examine the effect of different levels of predation on the distance that urchins are willing to traverse to get back to their original reef. The effects of group size on *D. antillarum* homing should also be examined to see if certain group sizes provide optimum benefits to individuals in those groups, causing them to have a higher tendency to remain in the group. Additionally, more work is needed to quantify the benefits and costs associated with homing behavior.

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