Diadema Recovery: Effects of Population Density on Reproductive Success

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Until 1983, the black sea urchin *Diadema antillarum* was one of the most important organisms in Caribbean reef communities; its presence affected the abundance, distribution, and health of the sedentary organisms found among the coral reefs. Between 1983 and 1984, however, *Diadema* experienced the worst mass mortality of any marine organism in recorded history. An unidentified pathogen reduced *Diadema* by more than 93% and drastically affected the health of many other reef species (Lessios 1995). Research conducted by H. A. Lessios (1995) and Don R. Levitan (1989) suggests that the population density of *Diadema* is an important factor in reproductive success. Though each researcher had a unique area of interest, together they provide a larger view concerning the outlook of *Diadema* recovery in the Caribbean.

Experiments by Lessios (1995) were designed to understand the factors contributing to the rate of recruitment and population recovery of *Diadema*. Over ten years (May 1983 to May 1993), Lessios (1995) monitored permanent 25m² quadrats trying to answer two primary questions concerning *Diadema*: (1) does an absence of adults affect larval settlement? and (2) does competition with other echinoids, especially *Echinometra viridis*, affect recruitment? He found that after 10 years *Diadema* populations remained over 95% lower than the peak population values achieved just before the 1983 mass mortality. Additionally, he determined that recruitment rates were not affected by the presence or absence of adult *Diadema*, but were significantly higher in quadrats where *E. viridis* was present. Contrary to predictions, Lessios (1995) concluded that the presence of competitors, rather than conspecific adults, increases either larval recruitment or juvenile survivorship; the manner in which this aid occurs could be a topic for further study. Lessios (1995) asserted that even though little recovery occurred over the 10-year period, fecundity was not to blame; the fecundity of the urchins remained high despite the mass mortality. His explanation was that perhaps the urchins were unable to produce enough larvae to survive the planktonic stage. This lack of fertilization success could be a direct result of the extremely low population density of the free spawning adults.

Levitan (1989) examined density-dependent size regulation in *Diadema*. The experiment was designed to show how size regulation could maintain fecundity and survivorship in periods of limited food sources. His research contained both a field and a laboratory experiment. In the field, he moved large (35-40 mm) and small (25-30 mm) specimens into a common cage where he could control the density. After the study, measurements of the individuals' tests revealed a common size in all cages; the urchins converged at 36 mm in the low-density cage and 30 mm in the high-density cage. In the laboratory experiment, he placed same sized urchins (43.5 mm) in cages with varying food availability (4, 2, 1, and 0 g of food). At the end of the experiment he found that the test sizes were 45.4, 42.5, 40.3, and 37.8 mm for the 4, 2, 1, and 0 g treatments, respectively. Since the data from the field experiment suggested that test sizes converged at a common size based on the number of *Diadema* present and the laboratory experiment suggested that test sizes converged based on food availability, Levitan (1989) concluded that the size differences were caused by differential growth rates in the urchins. Additionally, he found that the urchins experienced no change in fecundity; the gonad sizes of the urchins (dissected at the end of the experiment) remained proportional to the body size and the reproductive patterns were not affected. This study suggests that urchins can regulate body size based on food availability (a function of population density) while maintaining a proportional level of fecundity.

The research by Lessios (1995) and Levitan (1989) provide answers to separate aspects of the overall recovery of *Diadema*. The unifying element is whether or not *Diadema* can recover from the most severe mass mortality in marine history. Levitan (1989) showed that the urchins could regulate their own size as necessary in order to maximize food resources while maintaining fecundity, but as Lessios (1995) showed, the dwindling population densities can affect the survival of the offspring in even the most fecund of organisms. The reproductive potential of these urchins is perhaps their greatest asset, but their recovery has been decidedly slow according to both Lessios (1995) and Levitan (1989). Both researchers carried out lengthy, accurate studies, but the best study for understanding the recovery of *Diadema* might simply be waiting for the proper environmental conditions to allow new recruitment. Specifically, each experimenter answered his original questions, but the recovery of *Diadema* might hinge on something else. The effects of population density on reproductive success are negligible when describing a healthy urchin population (Levitan 1989), but given the mortality of 1983, *Diadema* has struggled to rebound due to a lack of density (Lessios 1995).

Literature Cited

Lessios, H. A. (1995). Diadema antillarum 10 Years after Mass Mortality: Still Rare, despite Help from a Competitor. Proceedings: Biological Sciences 259(1356): 331-337.

Levitan, Don R. (1989). Density-Dependent Size Regulation in Diadema Antillarum: Effects on Fecundity and Survivorship. Ecology 70(5): 1414-1424.

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