# ASSESSING POPULATION STRUCTURE OF *DIADEMA ANTILLARUM* IN A SHALLOW REEF OF THE SOUTHEASTERN COAST OF THE DOMINICAN REPUBLIC

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Abstract

The sea urchin *Diadema antillarum* is an herbivore that plays an important ecological role in controlling benthic community structure in Caribbean reefs. After the mass mortality documented between 1982-1983, their populations were reduced by 94-99% triggering a phase shift from coral to macroalgae-dominated benthic communities across the Caribbean. Almost 4 decades after its regional collapse, it is not clear weather *D. antillarum* populations are recovering, thus local surveys are valuable to track the fate of this herbivore. This study aims to determine the population structure of this sea urchin in a shallow reef located southeast of the Dominican Republic. We conducted a visual survey in three haphazardly selected sites of the reef studying a total surface of 90 $m^2$ in which test size and *D. antillarum* densities were measured. Overall, the mean density of *D. antillarum* was 1.77 ± 1.07 ind/$m^2$ (Mean ± SD) with an average test size of 67.3 ± 22.7 mm (Mean ± SD) a median of 70 mm and a mode of 80 mm. Test diameter had a platykurtic distribution (kurtosis = 2.53) slightly skewed to the left (skewness = -0.1). This information is valuable to establish a local baseline to follow up the population dynamics of this key species.

Keywords: *Diadema antillarum*, Dominican Republic, density, test size.

EVALUACIÓN DE LA ESTRUCTURA POBLACIONAL DE *DIADEMA ANTILLARUM* EN LOS ARRECIFES SOMEROS DE LA COSTA SUDESTE DE LA REPÚBLICA DOMINICANA

Resumen

El erizo *Diadema antillarum* es un herbívoro clave en el control de las comunidades bentónicas del Caribe. Tras los eventos de mortalidad masiva de 1982-1983, sus poblaciones se redujeron un 94-99%, lo que provocó un cambio de fase de corales a comunidades dominadas por macroalgas en el Caribe. Casi 4 décadas después del colapso, esta especie no se está recuperando, por lo que los estudios locales son valiosos para conocer la tendencia de sus poblaciones. Nuestro objetivo es determinar su estructura poblacional en un arrecife poco profundo del sureste de la República Dominicana. Muestreamos en tres sitios del arrecife, explorando una superficie total de 90 $m^2$ en los que se midieron el diámetro del caparazón y las densidades de *D. antillarum*. La densidad media de *D. antillarum* fue 1,77 ± 1,07 ind/$m^2$ (Media ± DE) con un tamaño de caparazón medio de 6,73 ± 2,27 cm (Media ± DE), una mediana de 7 cm y una moda de 8 cm. La distribución del diámetro fue platicúrtica (curtosis = 2,53), ligeramente sesgada hacia la izquierda (asimetría = -0,1). Estos resultados sirven para establecer una línea base para el seguimiento de la dinámica poblacional de esta especie.

Palabras clave: *Diadema antillarum*, República Dominicana, densidad, diámetro de testa.



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The long-spine sea urchin *Diadema antillarum* (Philippi, 1845) is a key species across Western Atlantic reefs, often being conspicuous in a variety of shallow to intermediate habitats (Muthiga and McClanahan 2007). The species is regarded as an herbivore that has a great impact on the structure of the benthic community by regulating the biomass of macroalgae and algal turfs, thereby mediating competition for space between corals and algae (Sammarco 1980). Thus, several studies have shown that herbivory provided by *D. antillarum* promotes and benefits scleractinian coral recruitment by grazing the algae that may reduce coral survivorship by smothering both, recruits an adults colonies (Edmunds and Carpenter 2001).

*D. antillarum* was once one of the most abundant herbivores in the Caribbean, with some studies reporting densities of even >20 ind/m$^2$, however, between 1983 and 1984, a massive mortality event caused by an unknown pathogen reduced their populations by 94-99% in many Caribbean locations. Such drastic reductions had profound effects on benthic assemblages across the Caribbean region, because the lack and/or paucity of herbivory to control algal growth triggered a transition from a coral to a persisting algae-dominated state. Currently, the population status of this urchin is uncertain; with some studies recording local recovery, whereas others reporting low and/or a paucity in recovery.

In the Dominican Republic, studies which assess current *D. antillarum* populations are scarce, and therefore, there is not a baseline available to be used for future studies to evaluate the population trends of this urchin, at least in the area of Bayahibe. Bayahibe is an important tourism destination in the Dominican Republic with extensive reef development and increasing tourism pressure to coastal marine ecosystems (Bayraktarov et al. 2020). Herein we report results from a *D. antillarum* census aimed to provide basic demographic information (density and size structure) of a local population of *D. antillarum* at Playita, a 5-8 m patch reef located within the Southeastern Reefs Marine Sanctuary in Bayahibe, Dominican Republic (68°51' W; 18°22' N) (fig. 1). This reef is about 1 km from a populated coastline with high levels of coastal development. The benthic community is composed of hard substrate colonized by scattered scleractinian coral colonies accounting for 10-15% live coral cover as well as a high abundance of coral recruits (> 3 recruits per 0.25 m$^2$).

To estimate densities of *D. antillarum* at our study site we conducted a visual survey on October 25, 2019 at 9h AM. For this survey, three 10 m-long by 1 m-wide belt transects were randomly deployed parallel to the coastline at three haphazardly



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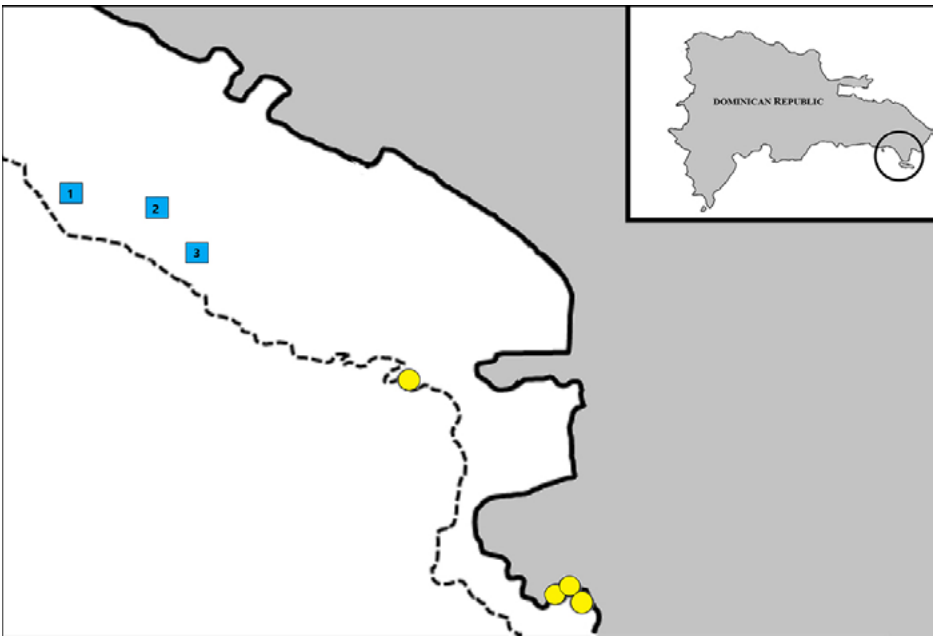


Figure 1. Location of the study area. Blue squares with numbers 1-3 represents the three sites where *D. antillarum* surveys were conducted in this study, yellow circles represent the location of previous surveys conducted by Del Río Torres (2015). The continuous line represent the coast line and the dashed line represent the reef slope.

selected sites, making a total of 9 transects, distributed between 6 and 8 m depth. We recorded all *D. antillarum* individuals within our belt transects measuring their test diameter *in situ* using a caliper. We built size frequency histograms for our study sites with descriptive statistical parameters for the whole urchins individuals surveyed; mean, median and mode, kurtosis, skewness, and standard deviation. Only a few individuals (near a 5%) could not be measured due to their inaccessibility into narrow gaps.

We found a mean density of $1.77 \pm 1.07$ ind/m$^2$ (Mean ± SD, n = 159) across sites, with higher values being recorded at Site 3 with a mean density of $2.03 \pm 1.67$ ind/m$^2$ (Mean ± SD, n = 61) (fig. 2A). While our results are only a snapshot of abundance for this species, previous surveys conducted in nearby areas (see in fig. 1) reported about half of the density (0.84 ind/m$^2$) compared to our study. However, differences between our data and previous studies could be related to seasonality and methodological discrepancies between surveys rather than real changes in the status of urchin population at the study site. We demonstrate that the species is present in Playita's reef at densities slightly above ranges currently reported in the Caribbean, and the highest densities ever recorded for this area. However, we

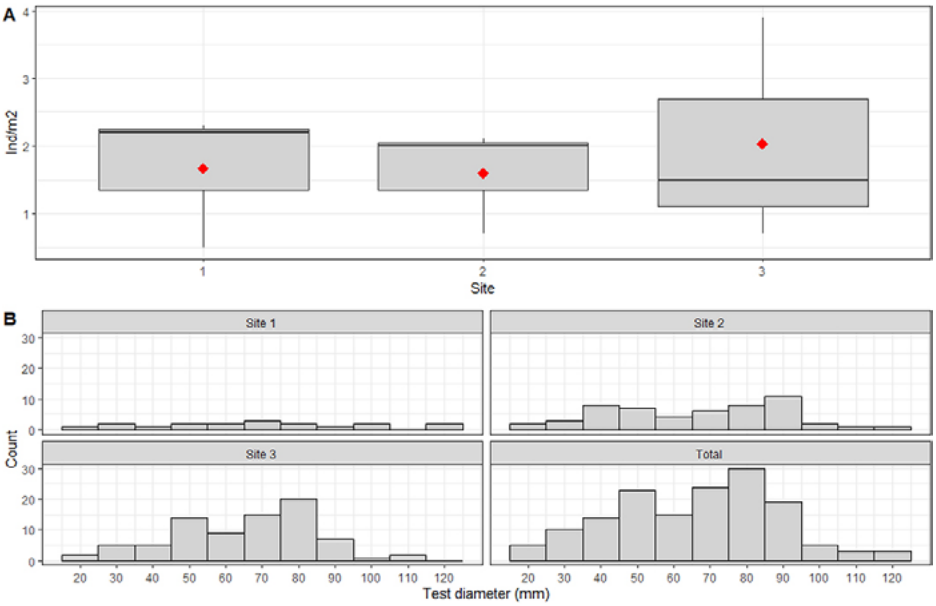


Figure 2. Population structure of *D. antillarum* in our study area. (A) Boxplots of *D. antillarum* densities in the three sites of study, red dots represent the mean in each site. (B) Frequency histogram of test diameter (mm) of *D. antillarum* in the three sites of study and total, each panel corresponds to one site.



cannot assert if there is a trend of recovery due to the absence of a long time series data at the study site.

Overall, the average test diameter of *D. antillarum* was 67.3 ± 22.7 mm (Mean ± SD, n = 151), the median was 7 cm and the mode was 8 cm, test diameter histogram had a platykurtic distribution (kurtosis = 2.53) and was slightly skewed to the left (skewness = -0.1). Specifically, Site 1 urchins had an average test diameter of 69.7 ± 29.3 mm (Mean ± SD, n = 18) with a test diameter histogram with a platykurtic distribution (kurtosis = 2.19) slightly skewed to the right (skewness = 0.12). Moreover, Site 2 urchins had an average test diameter of 68 ± 24.4 mm (Mean ± SD, n = 53) with a test diameter histogram with a platykurtic distribution (kurtosis = 2.09) slightly skewed to the left (skewness = -0.12). Finally, Site 3 urchins had an average test diameter of 66.5 ± 19.7 mm (Mean ± SD, n = 74) with a test diameter histogram with a platykurtic distribution (kurtosis = 2.8) slightly skewed to the left (skewness = -0.39).

Great variations in test diameter were observed depending on the study site (fig. 2B), however, in terms of total abundance, medium size urchins (50-80 mm test diameter) were the most dominant size class, whereas the smallest size class was scarce (<30 mm test diameter). Our results further indicate either small size

individuals are less common than larger ones and/or they hide in crevices where they are difficult to spot. Differences in behavior may also explain the paucity of small-size individuals as they may common out from crevices during the sunset or at night. However, low abundance of small individuals (<30 mm) could also be an indicator of low recruitment rates and/or low post-settlement survival, which is thought to be one of the causes that hinders population recovery in the Caribbean.

To conclude, because of the paucity of time series available assessing the spatial and temporal trends of *D. antillarum* in the Dominican Republic is challenging. Determining if this species is recovering in the Caribbean is particularly relevant for ongoing coral restoration efforts, particularly in Bayahibe, where herbivory by this sea urchin has been shown to benefit the survivorship of coral outplant (Cano *et al*. 2021).

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# REFERENCES


Bayraktarov, E., Banaszak, A.T., Maya, P.M., Kleypas, J., Arias-Gonzalez, J.E., Blanco, M., Calle-Triviño, J., Charuvi, N., Cortes-Useche, C., Galvan, V., Salgado, M.A.G., Gnecco, M., Guendulain-Garcia, S.D., Delgado, E.A.H., Moraga, J.A.M., Maya, M.F., Quiroz, S.M., Cervantes, S.M., Morikawa, M., Nava, G., Pizarro, V., Sellares-Blasco, R.I., Ramos, S.E.S., Cubero, T.V., Villalpando, M.F. and Frias-Torres, S. 2020. Coral reef restoration efforts in latin American countries and territories. *PLoS One.* doi: 10.1371/journal.pone.0228477.

Cano, I., Sellares-Blasco, R.I., Lefcheck, J.S., Villalpando, M.F. and Croquer, A. 2021. Effects of herbivory by the urchin Diadema antillarum on early restoration success of the coral Acropora cervicornis in the central Caribbean. *J. Exp Mar Bio Ecol.* doi: 10.1016/j.jembe.2021.151541.

Chiappone, M., Swanson, D.W., Miller, S.L. and Smith, S.G. 2002. Large-scale surveys on the Florida Reef Tract indicate poor recovery of the long-spined sea urchin Diadema antillarum. *Coral Reefs.* doi: 10.1007/s00338-002-0232-y.

De Ruyter van Steveninck, E. and Bak, R. 1986. Changes in abundance of coral-reef bottom components related to mass mortality of the sea urchin Diadema antillarum. *Mar Ecol Prog Ser.* doi: 10.3354/meps034087.

Del Río Torres, L. 2015. Diadema antillarum Population Status Assessment in Dominican Republic 30 Years after the Mass Mortality Event. *J. Aquac Mar Biol.* doi: 10.15406/jamb.2015.03.00066.

Edmunds, P.J. and Carpenter, R.C. 2001. Recovery of Diadema antillarum reduces macroalgal cover and increases abundance of juvenile corals on a Caribbean reef. *Proc. Natl. Acad. Sci.* USA. doi: 10.1073/pnas.071524598.

Hughes, T.P. 1994. Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science* (80-). doi: 10.1126/science.265.5178.1547.

Lessios, H.A. 2016. The Great Diadema antillarum Die-Off: 30 Years Later. *Ann Rev Mar Sci.* doi: 10.1146/annurev-marine-122414-033857.

Lessios, H.A. and Robertson, D.R. and Cubit, J.D. 1984. Spread of Diadema mass mortality through the Caribbean. *Science* (80-). doi: 10.1126/science.226.4672.335.

Muthiga, N.A. and McClanahan, T.R. 2007. Chapter 11 Ecology of Diadema. *Dev. Aquac. Fish Sci.* doi: 10.1016/S0167-9309(07)80075-5.

Rodríguez-Barreras, R., Pérez, M.E., Mercado-Molina, A.E., Williams, S.M. and Sabat, A.M. 2014. Higher population densities of the sea urchin Diadema antillarum linked to wave sheltered areas in north Puerto Rico Archipelago. *J. Mar Biol Assoc United Kingdom.* doi: 10.1017/S0025315414000666.

Sammarco, P., Levinton, J. and Ogden, J. 1974. Grazing and Control of Coral Reef Community Structure by Diadema antillarum Philippi (Echinodermata: Echinoidea): A Preliminary Study.

Sammarco, P.W. 1980. Diadema and its relationship to coral spat mortality: grazing, competition, and biological disturbance. *J. Exp Mar Bio Ecol.* doi: 10.1016/0022-0981(80)90061-1.