

BIOSTRATINOMY OF REGULAR AND IRREGULAR ECHINOIDS FROM SELECTED LOCALITIES ON SAN SALVADOR ISLAND, BAHAMAS

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INTRODUCTION

Although regular echinoid species are relatively abundant today, the fossil record of these organisms is proportionately lacking. Kier (1977) records a total of 474 regular and 426 irregular species alive today as opposed to 185 regular and 924 irregular species known from the Miocene. One cannot assume, however, that this necessarily indicates a sudden proliferation of regular echinoids in the Holocene. What really needs to be understood to accurately evaluate this disparity are the biases involved in their breakdown and preservation. This study attempts to evaluate such biases for regular and irregular echinoid populations on San Salvador Island, Bahamas.

METHODS

Six locations were chosen for the study: North Point and Dump Reef on the north shore, Bonefish Bay, Bamboo Point and Fernandez Bay on the west shore, and French Bay on the south shore of the island. A transect was made at each location, approximately perpendicular to the shore, and profiles of beach topography along the transects were determined using a Jacob staff and plumb lines. A 1m² plastic grid was used to define sample counts by placing it on the substrate at intervals of 1 to 6 meters along the transect, taking the average of two different counts at each interval. Both living and dead organisms were noted as well as their state of disintegration. A scale of these disintegration states was devised in order to systematize the descriptions; 1=whole test of dead organism with spines and most membranes (with or without Aristotle's lantern), 2=whole test without spines and membranes (with or without lantern), 3=half or quarter test, 4=columns of plates, 5=three to four attached plates, 6=more fragmented (Fig.1). These echinoid "densities" were plotted as histograms along the transect profiles but for practical reasons in this paper, the data are presented in Table 1.

In the laboratory, sediment samples collected from dry, shallow and deep spots along the transects were hardened in casting resin and cut into thin sections for study under a polarizing microscope. Charts of echinoid and other grain abundances were constructed. Also, test samples brought to the lab were carefully scrutinized for signs of predation and fracture.

DATA

OBSERVED SPECIES (Classification as in Sterrer (1986) and Moore (1966))

Regular Urchins:

Echinometra lucunter (Lamarck) (rock urchin)

Reddish-brown with elliptical test and fairly robust spines commonly found burrowing in coral and lithified rocks.

Tripneustes ventricosus (Lamarck) (white urchin)

Numerous short white spines on larger purplish test and pore pairs in three vertical series commonly found in shallow water with turtle grass.

Diadema antillarum (Philippi) (spiny urchin)

Usually black with extremely long and delicate spines (up to 3x as long as test diameter); inhabits deep cavities in coral and rock.

Eucidaris tribuloides (Lamarck) (club/pencil urchin)

Brownish-purple with clubby, robust spines; commonly found on hard substrate, under rocks, and in grassy areas.

Irregular Urchins:

Clypeaster rosaceus (Linne)

Medium to large, often bright yellow in color, with robust, slightly flattened test; distinct "petals" on dorsal surface.

Meoma ventricosa (Lamarck) (Brissus sp.?)

Brownish with ovate test, slightly depressed ambulacra; often small and delicate.

Leodia sexiesperforata (Leske) (keyhole sand dollar)

Flat, delicate test with six lunules (holes); occasionally a few lunules open.

DISCUSSION

The clustering of living echinoids and of echinoid remains shown in Table 1 suggests preferred environments of habitation and favored environments of deposition after death. Shallow hardground flats, for example, appear to be the best suited habitats for rock urchins (Echinometra) of Fernandez Bay (Table 1). Similar clustering on the transects of Bonefish Bay, French Bay, Dump Reef and North Point are due to the characteristic nature of these urchins to burrow in hardground, coral platforms and cobbles. Tripneustes prefers similar habitats but does not burrow and is often found near grasses. Diadema and Eucidaris were found in slightly deeper waters, towards the end of the hardground flats. Clypeaster and Leodia were usually found farthest from shore, in sand flats and channels.

Although Echinometra was certainly the most abundant living species observed overall, whole tests and test fragments of this species were surprisingly scarce. At Fernandez Bay, for example, a total of 312 live rock urchins and 2 rock urchin tests were counted at intervals along the selected transect (Table 1). On the other hand, a total of 11 live white urchins (Tripneustes) and 21 white urchin tests were counted at the same intervals. Though there were only a few living specimens of Diadema and Eucidaris, absolutely no tests or test fragments of these species were found along the transect. Thin section examinations of sediment samples showed that echinoid fragments compose a very small portion of total grain composition, (portion increased slightly towards shore) but data was fairly irrelevant to species considerations as species were impossible to identify at that small scale. Certainly, factors operating between death and deposition have caused these discrepancies. Smith suggests that perhaps irregular urchins are preferentially preserved over regular ones partially because of the high rates of deposition in their sand flat habitats as opposed to the high energy, slightly erosive habitats of the regular urchins.

Smith (1984) suggests that predation is another important environmental factor in echinoid decomposition and preservation. Could rock urchins be more vulnerable to predators than white urchins? Quite a number of the tests collected from the shore at Fernandez Bay have distinct boreholes probably made by parasitic gastropods. Larger, irregular holes that break across plates indicate predation possibly by crabs, lobsters, starfish or birds. However, both white and rock urchin tests were equally plagued with such holes.

Lewin (1988) describes a "wave of death" that extinguished large portions of the Caribbean Diadema antillarum populations in February of 1983. This explains the observed lack of live specimens and might possibly have something to do with an ecological upset that has led to changes in the relative abundances of other species (according to De Ridder et al., 1982), most regular species observed here have similar diets). If the ecosystem was still trying to balance itself, certain species might be dying in great numbers.

Disintegration and preservation potential depends not only on environmental but also on internal factors. Once an urchin has died and decomposition has resulted in the loss of organic membranes, further disintegration depends on the degree to which the stereom of adjacent plates interdigitates across sutures. Smith (1984) has found that diadematoids and cidarids have poor connections between plate stereoms causing these genera to collapse quite easily in mild turbulence. This possibly explains the observed lack of Diadema and Eucidaris tests and suggests that perhaps rock urchins are somewhat more susceptible to turbulence than white urchins because of the nature of their stereom connections. Perhaps better interdigitation is also an important factor in the selective preservation of irregular urchins over regular ones. I am currently investigating these possibilities.

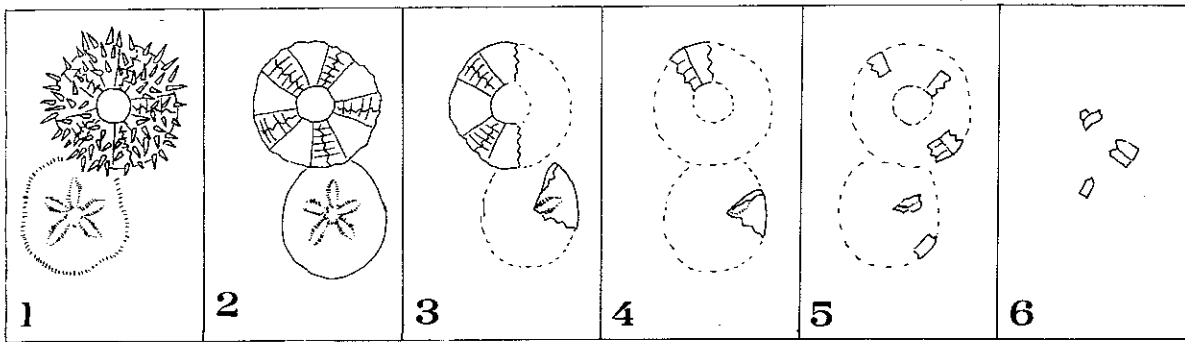


Figure 1. States of echinoid disintegration (according to criteria described in text).

Table 1. Locations of echinoid species at Fernandez Bay.

Dist. (m)	Depth (m)	Echino-metra	Trip-neustes	Dia-dema	Euci-daris	Clyp-easter	Meoma	Leodía
3	+1.5	-	4(3),5(4)	-	-	1(4)	-	1(4)
5	+1.25	1(1)	1(3)	-	-	1(6)	1(1)	-
7	+1	-	1(2)	-	-	-	-	-
10	0	7(L)	2(L)	-	-	-	-	-
12	-0.25	27(L)	1(L),1(1)	-	-	-	-	-
14	-0.5	-	2(L),1(1)	-	-	-	-	-
16	-0.75	7(L)	3(L),1(3)	-	-	-	-	-
18	-0.5	21(L)	1(L)	-	-	-	-	-
22	-0.5	50(L)	1(L)	-	-	-	-	-
26	-0.75	40(L)	1(3)	-	-	-	-	-
30	-1.5	33(L)	-	-	-	-	-	-
34	-1.5	21(L)	-	-	-	-	-	-
38	-2.0	14(L)	-	-	-	-	-	-
43	-2.25	23(L)	-	-	-	-	-	-
45	-2.25	30(L),1(2)	-	-	-	-	-	-
47	-2.0	26(L)	-	-	-	-	-	-
50	-1.5	9(L)	1(L)	1(L)	-	-	-	-
54	-1.5	4(L)	1(2)	2(L)	1(1)	-	-	-
60	-1.5	-	1(4)	-	1(L)	-	-	-
64	-2.0	-	1(5)	-	-	-	-	-
70	-2.5	-	1(4)	-	-	-	-	-
84	-2.5	-	1(2)	-	-	-	-	-
90	-2.75	-	1(4)	-	-	1(4)	-	-
100	-3.0	-	-	-	-	1(6)	-	-
104	-3.0	-	-	-	-	-	-	1(6)
109	-3.5	-	-	-	-	1(6)	-	-
124	-4.5	-	-	-	-	-	-	1(5),1(6)
130	-4.75	-	-	-	-	2(5)	-	-
133	-4.75	-	-	-	-	-	-	1(5),2(6)
141	-4.75	-	-	-	-	1(4)	-	-
TOTAL LIVE			12(L)	11(L)	3(L)	1(L)	0(L)	0(L) 0(L)
TOTAL FRAG			2(1,2)	21(1-5)	-	1(1)	7(4-6)	1(1) 4(4-6)

Dist. = horizontal distance from beginning of transect; Depth = depth below sea level at low tide; 1,2,3... = number of individuals of each species observed; (1,2,3,4,5,6) = disintegration state (according to Fig.1), and (L) = live individuals.

TAPHONOMIC HISTORIES OF THE SHELLS OF ARCOID BIVALVES,
SAN SALVADOR ISLAND, BAHAMAS

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Detailed taphonomic analysis of molluscan shells can be used to infer life habits of extinct taxa, and to reconstruct the biological and sedimentary processes by which the shells were modified prior to burial. Bulk samples including dead shells belonging to six living species in four arcoïd bivalve genera, Barbatia, Glycymeris, Striarca, and Arca, were collected from a variety of substrates around San Salvador Island, Bahamas. Post-mortem modifications of individual shells indicate the variety of pathways along which they are modified between the death of the organism and final burial (see Figure 1). Quantitative analysis of the proportions of shells of a given species with different taphonomic histories record processes acting in the depositional environment and the extent to which the shells have been reworked in place or transported from their habitats.

The shells exhibit two predominant kinds of post-mortem modification, fragmentation, and encrustation. Bivalved shells may be disarticulated and they may be broken as a result of predation, impact on hard rock surfaces or corals, or by tumbling under high energy conditions. The breakup of shells may be effected by biological as well as sedimentological processes. Shells of Barbatia cancellaria are commonly chipped along the ventral margin, adjacent to the byssal gape. In contrast, fresh shells of Glycymeris pectinata are fractured across the valves. These patterns reflect different predator behaviors and different shell morphologies. The activities of boring organisms, notably sponges, greatly increase the potential for shells to be fragmented by physical processes.

Varying degrees of encrustation are observed in our samples. Considering a shell as a sedimentary particle, we can apply fluid dynamic principles to predict its potential mobility. Encrustation increases the stability of a shell, thereby reducing the likelihood that it will roll or move by saltation. Encrustation may protect the shell from both abrasion and fragmentation. In many species, superposition of encrustations laid down by different organisms can be used to define a series of stages of shell modification prior to burial. Pre-mortem and post-mortem encrustations can frequently, but not always, be distinguished. In general, the extent and sequence of encrustation are related to the amount of time that elapsed between the death and final burial of the shell. However, species such as Barbatia cancellaria are heavily encrusted when alive and lose that encrustation to post-mortem abrasion in certain environments. This analysis, which will be continued during the summer of 1988 and concluded in 1989, will demonstrate that taphonomic processes are species-specific, depending on the habits and habitats of the species, as well as their shell characteristics. This opens up the possibility of developing more precise paleoenvironmental interpretations from taphonomic data.