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CONTRIBUTIONS TO THE GEOLOGY AND PALEON-  
TOLOGY OF THE CANAL ZONE, PANAMA, AND  
GEOLOGICALLY RELATED AREAS IN CEN-  
TRAL AMERICA AND THE WEST INDIES

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FOSSIL ECHINI OF THE PANAMA CANAL  
ZONE AND COSTA RICA

By ROBERT TRACY JACKSON  
*Of Peterborough, New Hampshire*

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Extract from Bulletin 103, pages 103-116, with Plates 46-52



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# FOSSIL ECHINI OF THE PANAMA CANAL ZONE AND COSTA RICA.

By ROBERT TRACY JACKSON,  
*Of Peterborough, New Hampshire.*

## INTRODUCTION.

The following is essentially a reprint of my paper bearing the same title published in the Proceedings of the United States National Museum, volume 53, pages 489-501, plates 62-68, September 24, 1917:

The fossil echini of the Panama Canal Zone were submitted to me for study and description by Dr. T. Wayland Vaughan as part of the studies he is making in that region in connection with his investigations of the geology of the Coastal Plain of the United States and of the West Indies. The material contains some very interesting species, particularly in the genus *Encope*, of which there are three new forms. Some of the material is well preserved, and parts are fragmentary. A number of specimens too poorly preserved, or too fragmentary for specific determination, indicate that a more extensive echinoid fauna may be found by further search.

I wish to express my heartiest thanks to my friend, Dr. Hubert Lyman Clark, of the Museum of Comparative Zoölogy, who, with his great knowledge of Clypeastroids and Spatangoids, helped me materially in preparing this report.

## LIST OF SPECIES AND THEIR GEOLOGIC OCCURRENCE.

*Clypeaster lanceolatus* Cotteau. Upper Oligocene, Emperador limestone, Gaillard Cut, stations 5866b, 6671.

*Clypeaster gatuni* Jackson. Miocene,<sup>1</sup> Gatun formation, station 5662, near Gatun Dam site; and at station 6237, north of Ancon Hill, about 4 miles south of Diablo ridge.

*Encope annectans* Jackson.<sup>1</sup> Miocene, Gatun formation, station 5846, Spillway, Gatun Dam.

*Encope platytata* Jackson. Miocene,<sup>1</sup> Gatun formation, station 6029a, one-quarter to one-half mile from Camp Cotton, toward Monte Lirio.

<sup>1</sup> This formation is more appropriately referable to the lower Miocene, i. e., Burdigalian, than to the upper Oligocene.—T. W. V.

*Encope megatrema* Jackson. Miocene,<sup>1</sup> Gatun formation, station 6030, about one and one-half miles from Camp Cotton, toward Monte Lirio.

*Echinolampas semiorbis* Guppy. Upper Oligocene, Emperador limestone, Gaillard Cut, stations 5866*b* and 6019*g*.

*Schizaster armiger* W. B. Clark. Miocene(?),<sup>1</sup> Bonilla, Costa Rica.

*Schizaster cristatus* Jackson. Miocene(?),<sup>1</sup> Brazil, Costa Rica, station 5505.

*Schizaster panamensis* Jackson. Miocene,<sup>1</sup> Gatun formation, near Gatun, at stations 6008 and 7294.

#### DESCRIPTION OF SPECIES.

##### CLYPEASTER LANCEOLATUS Cotteau.

Plate 46, figs. 1, 2.

*Clypeaster lanceolatus*, COTTEAU, Description de los Equinoides Fossiles de la Isla de Cuba, Bol. Com. del. Mapa Geologico de Espana, vol. 22, 1897, p. 39, pl. 9, figs. 1, 2, 3.—JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 490, pl. 62, figs. 1, 2.

This species is one of the few in the series from the Panama Canal Zone that seems referable to an already published species. There are seven specimens, all in good condition of preservation and representing two localities which, however, from the character of the material may be nearly associated. I give measurements of the largest specimen of the set. Length, 95 mm.; width, 77mm.; height, 21 mm. Test elongate, wider behind than in front, moderately elevated, deeply concave in ventral view. Ambulacral petals elevated, distally acuminate, nearly closed and pinched up as if squeezed between the thumb and finger. Anterior petal III equal in length to petals I and V and a few millimeters longer than are the anterior pair II and IV. The anterior petal III is more widely separated from petals II and IV than are those latter from I and V. Interporiferous areas of petals are elevated, wide, being about equal to both poriferous areas. Interambulacra are narrow, extremely so near the apical disk. Tubercles are small and of about the same size dorsally and ventrally. Apical disk is central, mouth central, deeply sunken, periproct ventral, about four mm. from the posterior border of the test. The original material described by Cotteau is from the "Miocene" of Matanzas, Cuba, where he says it is very rare. It is apparently more or less common in the Canal Zone, as there are seven specimens from that region.

<sup>1</sup> This formation is more appropriately referable to the lower Miocene, i. e., Burdigalian, than to the Upper Oligocene.—T. W. V.

*Localities and geologic occurrence.*—Upper Oligocene; Emperador limestone. Upper Limestone, Las Cascadas, Panama, D. F. MacDonald, collector, U. S. National Museum station No. 6671, two specimens, U. S. Nat. Mus. Cat. No. 324452; also Panama Canal Zone, upper Limestone bed, near Tower "N" (opposite Las Cascadas, Gailard Cut) D. F. MacDonald, collector, 1911, U. S. National Museum station No. 5866 b, five specimens, U. S. Nat. Mus. Cat. No. 324451.

CLYPEASTER GATUNI Jackson.

Plate 47, fig. 1; plate 48, fig. 1.

*Clypeaster gatuni* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 491, pl. 63, fig. 1; pl. 64, fig. 1.

This species is represented by a fine, large specimen in perfect condition of preservation. Two additional specimens much worn and incomplete are also referred to it.

The type measures 146 mm. in length, 122 mm. in width, and 35 mm. in height. The test is elongate, moderately pentagonal in outline, with slight incurving of the borders in interambulacral areas 1, 2, 3, and 4. Its greatest width is across ambulacra II and IV. Ventrally the test is deeply concave, being flat only on the border. The ambulacral petal III is equal in length to petals I and V and a few millimeters longer than are petals II and IV. The petals are equidistant, highly elevated, and open at their distal ends. Ventrally, five deep ambulacral grooves extend to the mouth. Interambulacra are broad on the border of the test, narrowing up dorsally and very narrow near the apical disk. Each of the interambulacra between the petals are strongly elevated as if pinched up. The apical disk is slightly anterior to the middle of the test and is very small. The mouth is central, deeply sunken. The periproct is ventral, slightly elliptical, its posterior border 5 mm. from the posterior limits of the test. Tubercles are small, covering the dorsal surface of the test, ventrally the same, but slightly larger.

*Clypeaster gatuni* approaches nearest, perhaps, to *C. bowersi* Weaver, but differs in the shape of the test, the deeply concave base, the shape and proportionate size of the petals and interambulacra dorsally, and the fact that the periproct is ventral instead of terminal.

*Locality and geologic occurrence.*—Gatun formation, Miocene. Panama Canal zone, near Gatun Dam site, D. F. MacDonald, collector, 1911, holotype, U. S. National Museum, station No. 5662, one specimen.

Limestone in swamp, north of Ancon Hill, about 4 miles south of Diablo Ridge in the upper Oligocene Emperador limestone, U. S. National Museum, station No. 6237, two specimens.

*Holotype.*—Cat. No. 324453, U.S.N.M.

This species is present on both the Atlantic and Pacific sides of the Isthmus.

## ENCOPE ANNECTANS Jackson.

Plate 49, figs. 1, 2; plate 50, fig. 1.

*Encope annectans* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 491, text fig. 1; pl. 65, figs. 1, 2; pl. 66, fig. 1.

This interesting species is represented by three specimens which include two tests free from matrix and more or less complete, and a sandstone mould of the exterior of the ventral side of a specimen which is the largest of the three.

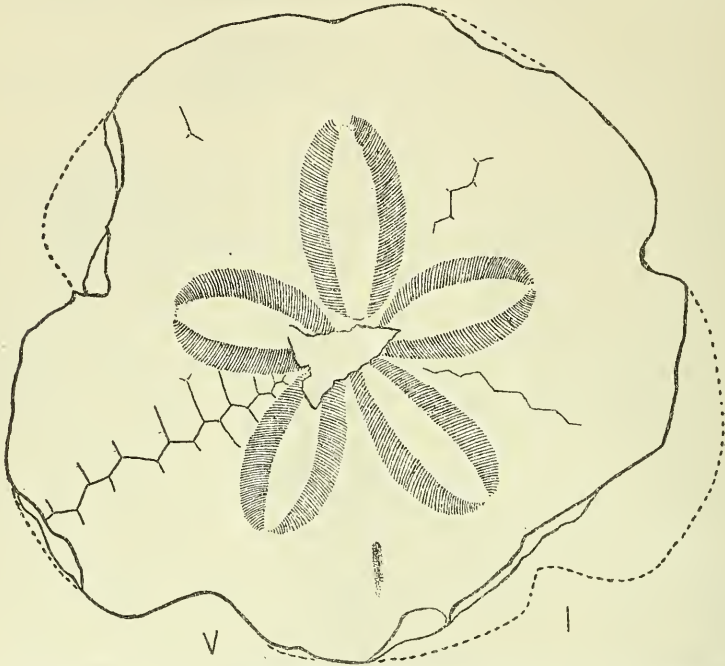


FIG. 1.—ENCOPE ANNECTANS. DRAWING OF THE TYPE-SPECIMEN, NATURAL SIZE. RESTORED PARTS ARE INDICATED BY DOTTED LINES.

In shape, the specimens are thin, flattened, and nearly circular in outline, excepting for the reëntrant marginal ambulacral notches. The edges are thin, exceptionally so for the genus, and the whole test superficially is scutelliform. In the anterior ambulacrum III there is a shallow rounded notch, and in the lateral ambulacra are deeper and narrower notches, the deepest being in the posterior pair of ambulacra, IV and V. The apical disk is central. The peristome is small and also central. Continuing posteriorly from the peristome on the ventral side is a quite deep groove, and on the dorsal side is a shorter and shallower groove. These grooves do not form a hole through the test, but represent the incipient beginnings of the



lunule which is characteristic in *Encope* of the posterior interambulacrum 5. This is most interesting and is discussed later at length.

The type-specimen measures 86 mm. in length, 89 mm. in width, and 8 mm. in height. The highest point is distinctly anterior to the middle of the test. The specimen represented by a mould of the ventral side is somewhat larger than the type. It measures about 93 mm. in length by about 96 mm. in width.

In the type, the ambulacral petals are broad, about equal in length in the several areas, the posterior pair extending back to a line with the anterior limit of the lunule in interambulacrum 5. Ventrally, the ambulacral furrows are deep, slightly curved outward from the median line of each ambulacrum, forking near the border of the test, each furrow giving off a forked branch at nearly a right angle to the main furrow. The apical disk is central, but details are obscured owing to local imperfections in both specimens showing the dorsal side. Interambulacral areas are narrow in the petaloid areas, wide near the margin of the test. The whole dorsal surface of the test is covered with small tubercles; on the ventral side of the test the tubercles are somewhat larger, but they are reduced in size or wanting along the lines of the ambulacral furrows. The mouth is small and central in position. The periproct is small, oval in outline, and situated at nearly one-third the distance from the mouth to posterior border of the test.

The lunule of interambulacrum 5 is the remarkable and most interesting feature of this species. Ventrally, it consists of an impressed area 15 mm. long by 2 mm. wide, extending to and being confluent with the opening of the periproct. Dorsally, the lunule also consists of an impressed area lying above the middle of the ventral lunular depression and measuring 10 mm. in length by 2 mm. in width. This is the only species in the genus recorded in which the lunule fails to make an opening through the test. Structurally, it is most interesting, as it closely resembles the condition in a young specimen of *Mellita sewiesperforata* (Leske) from the west coast of Florida, 30 fathoms, No. 2900, Museum of Comparative Zoölogy. This young *Mellita*, which measures 9 mm. in length, has no notches or lunules as yet developed in the ambulacral areas, but in interambulacrum 5, as viewed ventrally, there is a distinct impressed area marking the initial beginnings of a lunule as in our specimen of adult *Encope annectans*. It should be stated that this specimen of *Mellita* is probably exceptional in holding this youthful character so late, as in a small series of younger specimens of *M. sewiesperforata* measuring from 4 to 7 mm. in length, all have a perforate lunule in interambulacrum 5. This latter set is from Salt Key, Bahamas, No. 2439, Museum of Comparative Zoölogy. As pointed out by Mr. Agassiz (Revision of the Echini, pp. 320-324) in *Mellita sewiesperforata*, the

ambulacral and interambulacral lunules develop by resorption through the test, whereas in the other species of *Mellita*, as far as known, the ambulacral lunules are developed by the inclusion of marginal notches and the interambulacral lunule alone is formed by invagination through the test.

*Encope annectans* is primitive like the other fossil species of *Encope* in that the ambulacral notches are not inclosed to form lunules but are still shallow and open. It is undoubtedly the most primitive of the genus in that the lunule in interambulacrum 5 is still imperforate. It makes an approach to the Recent *Encope michelini* Agassiz of the Gulf of Mexico and *E. grandis* Agassiz of the Gulf of California which are the only living species characterized by open marginal notches. On the other hand, *E. annectans* resembles *Encope micropora* Agassiz of the West Coast in the form of the test and the position of the interambulacral lunule.

*Locality and geologic occurrence.*—Gatun formation, Miocene, Panama Canal Zone, Spillway at Gatun Dam site, D. F. MacDonald, collector, U. S. National Museum station No. 5846, three specimens.

*Type.*—Cat. No. 324454, U.S.N.M. *Paratype.*—Cat. No. 324466, U.S.N.M.

#### ENCOPE PLATYTATA Jackson.

Plate 51, figs. 1, 2.

*Encope platytata* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 494, text fig. 2; pl. 67, figs. 1, 2.

There is only a single specimen representing this species, and while it is imperfect, it yet has the essential parts preserved that are necessary for a description. As in the last described species, *E. annectans*, this species, *E. platytata*, is thin, flattened, and if complete, apparently would be nearly circular in outline excepting for the ambulacral notches. If complete, the specimen would measure as estimated about 100 mm. in length and 100 mm. in width. The greatest height of the test is in the apical region, where it measures 10 mm. As the ventral side of the test is somewhat concave instead of being flat, the thickness of the test at the center, as measured by calipers, is somewhat less than the height and measures only 8 mm.

The anterior ambulacral notch of area III is very shallow and rounded. The notches of the lateral anterior ambulacra II and IV are also rounded but deeper than the notch of area III. Presumably the notches of the posterior ambulacra I and V, if preserved, would be similar but somewhat deeper, as this is the usual character in associated species. The lunule in interambulacrum 5 is small, but passes directly through the test instead of being imperforate as in *Encope annectans*. This lunule is only preserved for the anterior part of its extent as shown in the figures. The mouth is small and

central in position, the periproct is elongate oval, its anterior border is 13 mm. posterior to the border of the mouth opening. Posteriorly the periproct is confluent with the infolded depression of the interambulacral lunule.

The ambulacral petals are rather narrow in this specimen, measuring 13 mm. in width. The odd anterior ambulacral petal is longer than the others, and measures 36 mm. in length, whereas the posterior petals of the trivium measure 28 mm. in length. The petals of the bivium, or I and V, are longer than the posterior pair of the



FIG. 2.—ENCOPE PLATYTATA. DRAWING OF THE TYPE-SPECIMEN, NATURAL SIZE. RESTORATIONS ARE INDICATED BY DOTTED LINES.

trivium, but as they are incomplete posteriorly, a measurement can not be given. On the ventral side, the ambulacral furrows are strongly marked and each gives off a few weakly impressed branches.

The apical disk is quite well preserved, shows clearly the ocular pores and four of the five genital pores, which are a characteristic feature of *Encope*. The only genital pore wanting is that occurring in area 1, which is destroyed by a local fracture of the test. Minute tubercles cover the dorsal side of the test. Ventrally the tubercles are larger except near the ambulacral furrows where they are minute.

*Encope platytata* is a near ally of *Encope tenuis* Kew<sup>1</sup> of the Miocene of California, but differs from that species in that the greatest height of the test is central, and the periproct is confluent with the lunule.

*Locality and geologic occurrence.*—Gatun formation, Miocene, Panama Canal Zone, from lowest horizon in big cut, one-fourth to one-half mile beyond Camp Cotton toward Monte Lirio, D. F. MacDonald and T. W. Vaughan, collectors, 1911, U. S. National Museum station No. 6029a, one specimen.

*Type.*—Cat. No. 324455, U.S.N.M.

ENCOPE MEGATREMA Jackson.

Plate 52, fig. 1.

*Encope megatrema* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 496, text figs. 3, 4; pl. 68, fig. 1.

This species is represented by one fairly good test with its counterpart, and in addition some 12 fragments which yield helpful facts on close study. From the incompleteness, measurements and some details will have to be given in general terms or omitted. As a whole, the test is low, elongated, thin on the borders and with shallow ambulacral notches and an enormous lunule in interambulacrum 5.

From the best specimen, which is figured, the length probably was about 120 mm. and the width about 106 mm.; thickness of the test at its center is 10 mm. Ambulacral notches are shallow and quite wide in areas II and V, indicating that this is the character in the two posterior ambulacra I and V and also in the paired anterior ambulacra II and IV. This evidence is supported by several of the fragments which show shallow lobes like the type, but it can not be definitely stated which areas they represent. The notch of the anterior odd ambulacrum III is not known, but it was probably shallower than the others, as is characteristic of species of the genus. The most striking feature of this species is the lunule in interambulacrum 5, which is enormous. It is situated about midway between the apical disk and posterior limits of the test, and is roughly triangular in shape, the apex of the triangle pointing anteriorly. It measures at the surface of the opening 27 mm. in length and 27 mm. in width at the widest part posteriorly. The walls of the lunule slope outward from the center, as seen looking from above, as is well shown in two of the fragmentary specimens. From this sloping character of the walls, it results that the width of the lunule would be greater by about 6 to 10 millimeters on the ventral side than it is on the dorsal. The height of the wall of the lunule is 12 mm., which is doubtless the highest point of the test. The lunule in this species is, relatively to the size of the specimens, the largest known in any species of the

<sup>1</sup> Kew, W. S. W. Tertiary echinoids of the Carrizo Creek Region in the Colorado Desert. University of California Bull., Dept. Geology, vol. 8, No. 5, pp. 39-60, pls. 1-3, 1914.

genus, fossil or living. It is striking that this great size of the lunule, a progressive character, should be associated with small and shallow ambulacral notches which, for the genus, is a relatively primitive character.

The ambulacral petals are beautifully distinct and well preserved for part of their extent in the type and one other specimen. The

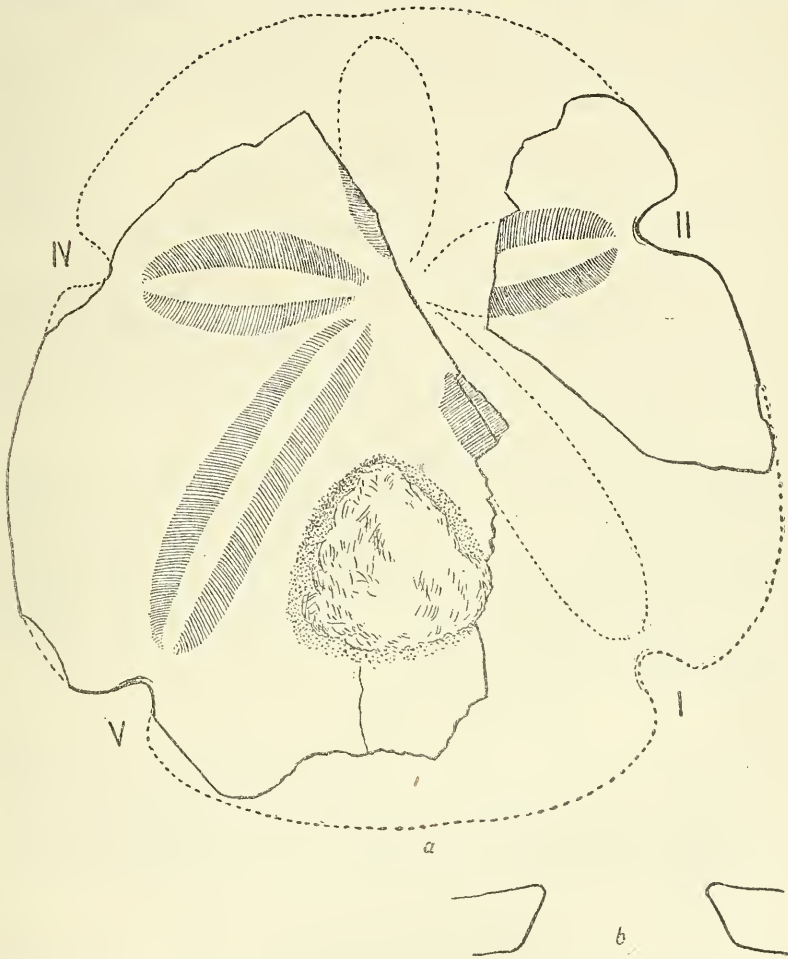


FIG. 3.—*a*, ENCOPE MEGATREMA. HOLOTYPE, NATURAL SIZE. THE AREA SHOWING PART OF AMBULACRUM II IS DRAWN FROM A FRAGMENT. RESTORATIONS ARE INDICATED BY DOTTED LINES. *b*, SECTION OF LUNULE TO SHOW THE INCLINED FACES, DRAWN FROM TWO FRAGMENTS.

posterior pair, I and V, are long and narrow with a relatively wide poriferous area and narrow median interporiferous area. The width of the petal of ambulacrum V is 11 mm. and its length is 50 mm. It extends posteriorly in a wide curve around the lunule of interambulacrum 5 and reaches a line coincident with the posterior end of the

lunule. It also extends to within 5.5 of the ambulacral notch of the area in which it lies. Ambulacrum IV is much shorter than ambulacrum V, measuring 30 mm. in length and 12 mm. in width at its widest part. This ambulacrum extends to within 3.5 mm. of its marginal notch. The features of the ambulacra V and IV, as described, indicate the character of ambulacra I and II, which are only preserved in part in the holotype, though one of the fragments has ambulacrum II quite perfectly preserved. Ambulacrum III is represented only in part (for a length of 25 mm.) by the left side of its petaloid area; it probably had about the length and width of the petal of ambulacrum IV, as in the allied species *Encope macrophora* Ravenel. Ambulacral furrows on the ventral side are deep, strongly marked, with some forking near the periphery of the test. The interambulacra are very wide, not narrowing markedly near the apical disk. Minute tubercles cover the dorsal surface of the test, and ventrally the tubercles are larger excepting on the lines of ambulacral furrows, where they are minute or wanting. Details of the apical disk, peristome and periproct are entirely wanting. This species does not make a close approach to any other known species, but its nearest ally is *Encope macrophora* Ravenel from the upper Miocene of South Carolina and the Pliocene of Florida.<sup>1</sup>

*Locality and geologic occurrence.*—Gatum formation, Miocene, Panama Canal Zone. From 85-foot cut north side of big swamp on relocated line, Panama R. R., about one and one-half to two miles beyond Camp Cotton, toward Monte Lirio, D. F. MacDonald and T. W. Vaughan, collectors, 1911. Fourteen specimens, including fragments, U. S. National Museum station No. 6030.

*Type.*—Cat. No. 324456, U.S.N.M.

#### ECHINOLAMPAS SEMIORBIS Guppy.

*Echinolampas semiorbis* GUPPY. On Tertiary Echinoderms from the West Indies, Quart. Journ. Geol. Soc. London, vol. 22, 1866, p. 299, pl. 19, fig. 7.—COTTEAU, Echinides Tertiaires des Iles St. Barthélemy et Anguilla, Kongl. Svensk. Vetenskaps. Akad. vol. 13, 1875, p. 24, pl. 5, figs. 1-2; pl. 6, fig. 1.—JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 498.

This species is abundant in the Oligocene Tertiary of the West Indies, material from Anguilla having been described by Guppy, and Cotteau erroneously records it from St. Bartholomew. Dr. T. Wayland Vaughan in 1914 collected abundant, fine specimens in the Island of Anguilla.

From the Panama Canal Zone a number of specimens were collected from a hard gray limestone. The specimens are for the most part uncompressed and in very good condition of preservation. One

<sup>1</sup> Clark, William Bullock, and Twitchell, Mayville W. Mesozoic and Cenozoic Echinodermata of the United States. Monograph, U. S. Geol. Survey, vol. 54, 1915, p. 206, pl. 93, figs. 2a-e; pl. 94, figs. 1a-f.

of the largest specimens measures 107 mm. in length, 103 mm. in width, and 53 mm. in height.

*Locality and geologic occurrence.*—Upper Oligocene. Emperor limestone, Panama Canal Zone. Upper Limestone bed near Tower "N" (opposite Las Cascadas, Gaillard cut), D. F. MacDonald, collector, 1911, U. S. National Museum station No. 5866*b*, one specimen, U. S. Nat. Mus. Cat. No. 324457. Also Panama Canal Zone, from 5th or topmost limestone, Gaillard cut, opposite Las Cascadas, U. S. National Museum station No. 6019*g*, D. F. MacDonald and T. W. Vaughan, collectors, 1911, 4 specimens. U. S. Nat. Mus. Cat. No. 324458.

SCHIZASTER ARMIGER W. B. Clark.

*Schizaster armiger* CLARK and TWITCHELL, Mesozoic and Cenozoic Echinodermata of the United States, Monograph U. S. Geol. Survey, vol. 54, 1915, p. 152, pl. 70, figs. 1*a-d*.—JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 498.

In this species the test is rather large, cordiform; upper surface slopes at first rapidly, then more slowly from the anterior margin to the apical system beyond which an elevated sharp ridge continues to the truncated posterior margin. Length, 59 mm.; width, 50 mm.; height, 25 mm. The ambulacra are broad and the odd anterior ambulacral petal III is situated in a deep groove that indents the anterior margin. The two lateral anterior ambulacra II and IV are in deep, broad grooves, with petals 18 mm. long. The posterior ambulacra I and V, similar but shorter, are 9 mm. long. Peripetalous fasciole is broad and distinct. Interambulacra gibbous, the posterior No. 5 being built up into an elevated keel. The peristome is indistinct in our specimen, but as shown in W. B. Clark's excellent figures, is wide and near the anterior margin. The periproct is high on the truncated posterior end.

The type material described by Clark is ascribed to the upper (Jackson) Eocene of Choctaw County, Alabama.

*Locality and geologic occurrence.*—Miocene(?),<sup>1</sup> Bonilla, Costa Rica, Hill collection, U. S. Nat. Mus. Cat. No. 135214, one specimen.

SCHIZASTER CRISTATUS Jackson.

Plate 52, figs. 2-4.

*Schizaster cristatus* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 499, pl. 68, figs. 2-4.

The material of this species consists of two internal moulds; as the plates are entirely wanting, of course external characters can not be given. The more perfect of the two specimens measures 40 mm. in length, 36 mm. in width, and 22 mm. in height. Test is moderate

<sup>1</sup> According to Hill and Dall the rocks exposed at this locality are of the same age as those at Gatun, Canal Zone. For a further discussion see the last chapter (by Vaughan) in this volume.

sized, cordiform, sloping gradually from the anterior border up to the median crest, the widest portion being through the middle of the test. The most striking feature of this species is the median keel-like crest that rises sharply from the summit of interambulacrum 5 at the posterior border of the test.

The petal of ambulacrum III is sunken in a deep, wide groove, extending to the anterior border of the test and measuring 23 mm. in length. The petals of the lateral anterior ambulacra II and IV are in deep grooves measuring 13 mm. in length and having about 22 plates in each half ambulacrum, as is indicated by the casts of the pores. The petals of the posterior ambulacra I and V are widely divergent from the anterior pair, nearly parallel and directed backward in deep, sunken grooves. The grooves are 7 mm. long, and there are about 14 plates in each half ambulacrum at this point, as indicated by casts of the pores. The periproct is situated on the posterior face and coincides with the base of the crest in interambulacrum 5. The peristome is wide and situated far forward, the tip which almost closes the mouth being 10 mm. from the anterior border of the test.

*Locality and geologic occurrence.*—Miocene (?), Brazil, Costa Rica, A. Alfaro, collector, U. S. National Museum station No. 5505, two specimens.

*Type.*—Cat. No. 324460, U.S.N.M.

SCHIZASTER PANAMENSIS Jackson.

Plate 50. figs. 2-3.

*Schizaster panamensis* JACKSON, Proc. U. S. Nat. Mus., vol. 53, 1917, p. 500, pl. 66, figs. 2, 3.

The material consists of an internal mould free from matrix, and three specimens more or less complete, embedded in porous, dark-colored volcanic tuff which also bears some fragments of lignite. The specimen, free from matrix, is the most completely preserved, although somewhat compressed dorso-ventrally, and is selected as the type. The specimen measures 48 mm. in length, 40 mm. in width, and 25 mm. in height. The petals of the ambulacra are situated in broad, deep furrows. The anterior petal III extends to the anterior limit of the test and measures 23 mm. in length. The paired anterior ambulacra II and IV are in grooves 13 mm. long and diverge widely from the anterior petal. The posterior petals I and V are shorter than the anterior pair, measuring 5 mm. in length, and are directed almost straight backward. The position of the periproct is not clearly indicated on the mould, but apparently it is near the upper part of the posterior face. The peristome is wide and rounded, and is situated 16 mm. from the anterior border of the test. The peri-



petalous fasciole is quite wide and is fairly well shown in areas II and IV on the type-specimen and still better in one of the fragments, which is a counterpart of the dorsal side of the same.

One of the specimens, which is an external mould, shows the impress of the outline of the plates of part of a test, and gives measurements of considerable interest. It measures about 50 mm. in length, about 45 mm. in width, and about 38 mm. in height. From incompleteness of the specimen no exact measurements can be given, yet those available indicate a very high test.

*Locality and geologic occurrence.*—Gatun formation, Miocene, Panama Canal Zone. Second cut, south of Gatun R. R. Station, Goldman Coll., U. S. National Museum station No. 7294, four specimens. Holotype, U. S. Nat. Mus. Cat. No. 324461. Another specimen, imperfect and much worn, with a very high test, and apparently referable to this species, is from Panama Canal Zone, Gatun, section A, from middle of Bed "E," D. F. MacDonald, collector, U. S. National Museum station No. 6008, one specimen. U. S. Nat. Mus. Cat. No. 324462.

## DESCRIPTION OF PLATES.

## PLATE 46.

- FIG. 1. *Clypeaster lanceolatus* Cotteau, dorsal view, natural size. The dark spot in interambulacrum 5 is a yellow label that took black in the photograph.: U. S. Nat. Mus., Cat. No. 324451, Station 5866b.
2. Another specimen of the same, ventral view, natural size, U. S. Nat. Mus. Cat. No. 324451, Station 5866b.

## PLATE 47.

- FIG. 1. *Clypeaster gatuni* Jackson, dorsal view. Holotype, slightly reduced, U. S. Nat. Mus. Cat. No. 324453, Station 5662.

## PLATE 48.

- FIG. 1. *Clypeaster gatuni* Jackson, ventral view; same specimen as Plate 47. Holotype, slightly reduced, U. S. Nat. Mus. Cat. No. 324452, Station 5662.

## PLATE 49.

- FIG. 1. *Encope annectans* Jackson, dorsal view, natural size. Holotype, U. S. Nat. Mus. Cat. No. 324454, Station 5846.
2. The same, ventral view.

## PLATE 50.

- FIG. 1. *Encope annectans* Jackson, another specimen, external mould of ventral side seen from above. Natural size, Paratype, U. S. Nat. Mus. Cat. No. 324466, Station 5846.
2. *Schizaster panamensis* Jackson, dorsal view, natural size. Holotype, U. S. Nat. Mus. Cat. No. 324461, Station 7294.
3. The same, ventral view. The dark spot in interambulacrum 5 is a yellow ticket that took black in the photograph.

## PLATE 51.

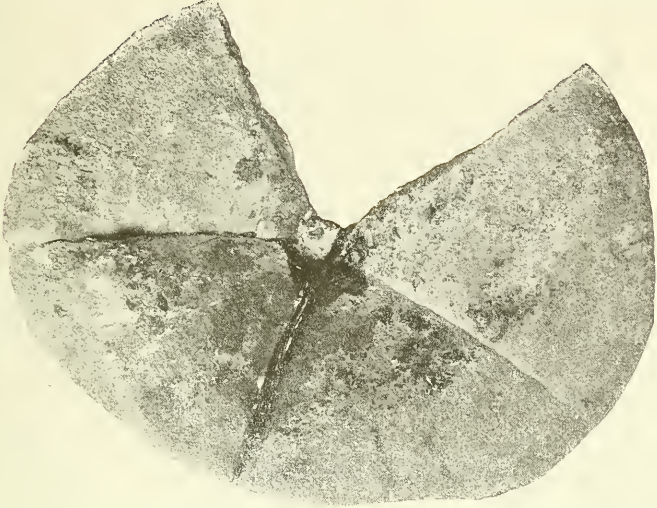
- FIG. 1. *Encope platytata* Jackson, dorsal view, natural size. Holotype, U. S. Nat. Mus. Cat. No. 324455, Station 6029a.
2. The same, ventral view. The dark spot in interambulacrum 4 of fig. 1 and in interambulacrum 2 of fig. 2 are yellow tickets that took black in the photographs.

## PLATE 52.

- FIG. 1. *Encope megatrema* Jackson, dorsal view, natural size. Holotype, natural size, U. S. Nat. Mus. Cat. No. 324456, Station 6030.
2. *Schizaster cristatus* Jackson, dorsal view, natural size. Holotype, U. S. Nat. Mus. Cat. No. 324460, Station 5505.
3. The same, ventral view.
4. The same, side view.



1

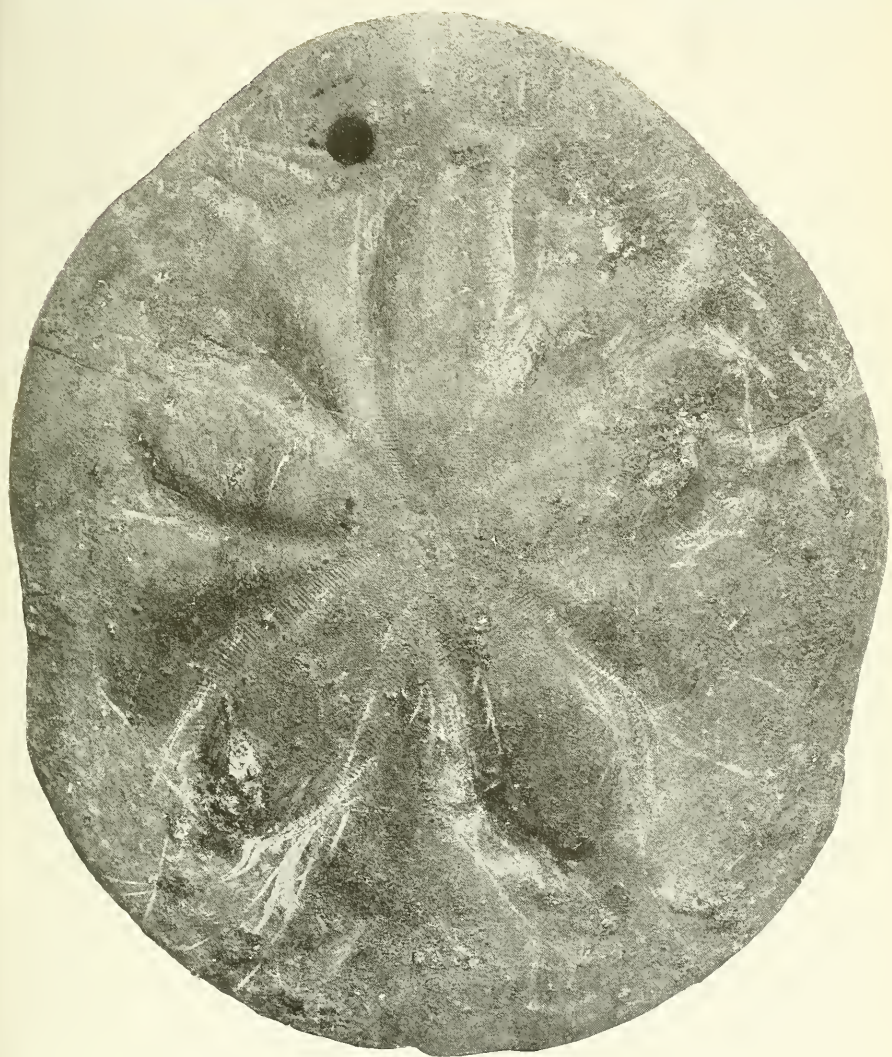


2

DORSAL (1) AND VENTRAL VIEWS (2) OF CLYPEASTER LANCEOLATUS.

FOR EXPLANATION OF PLATE SEE PAGE 115

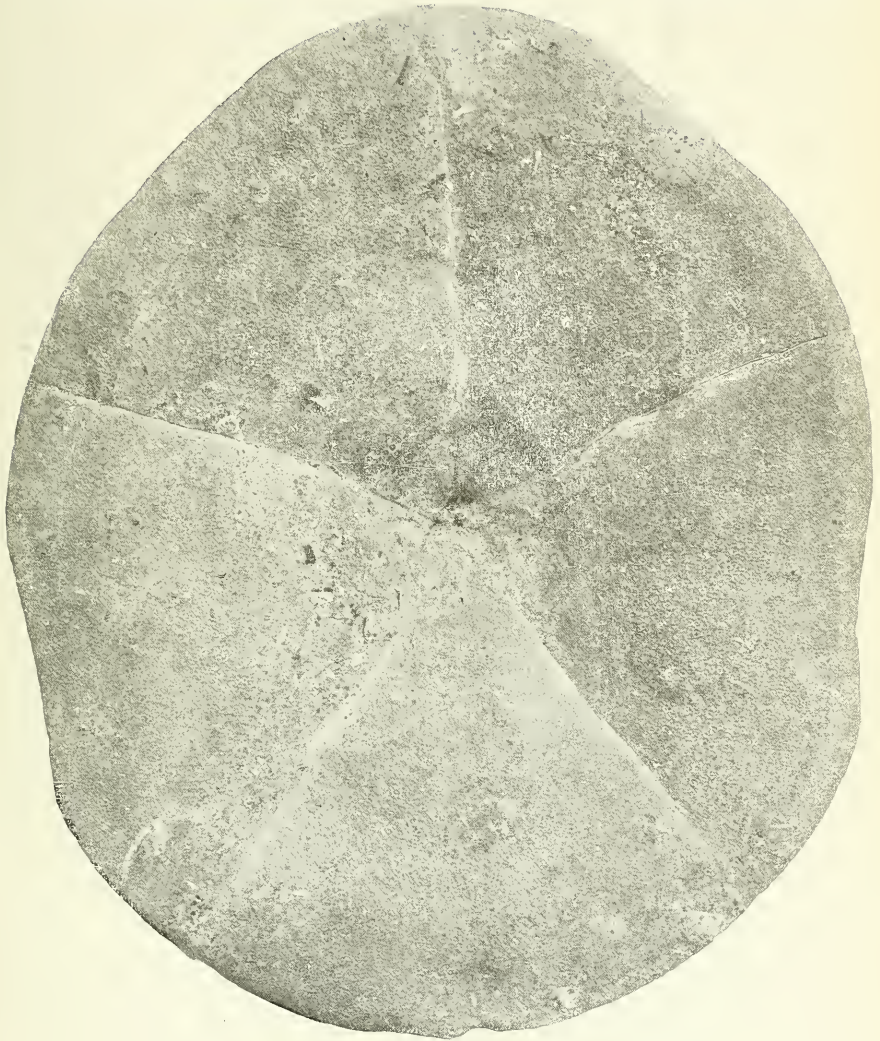




DORSAL VIEW OF CLYPEASTER GATUNI.

FOR EXPLANATION OF PLATE SEE PAGE 115.



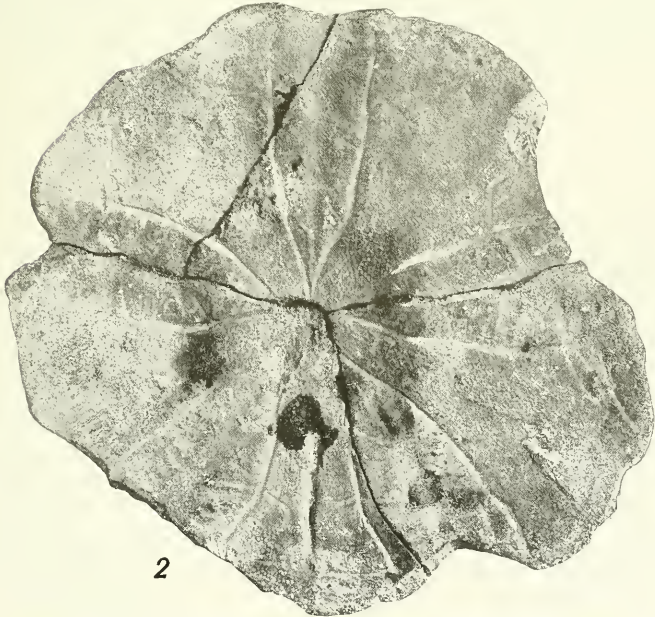
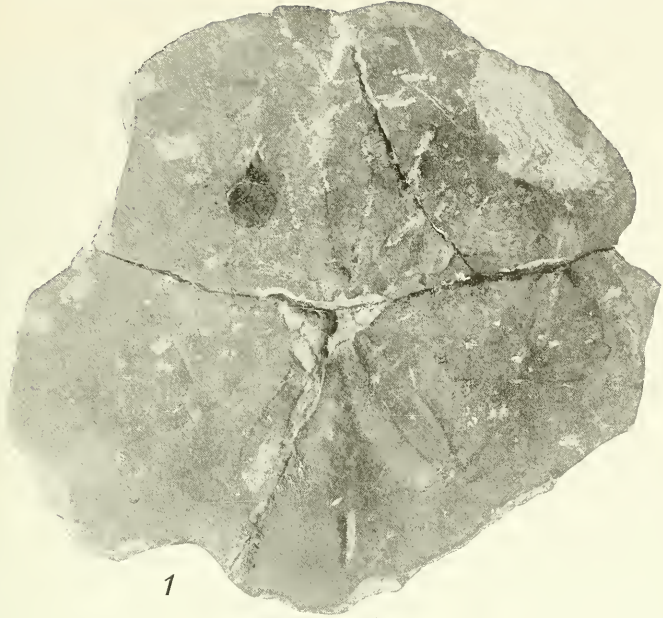


VENTRAL VIEW OF CLYPEASTER GATUNI.

FOR EXPLANATION OF PLATE SEE PAGE 115.



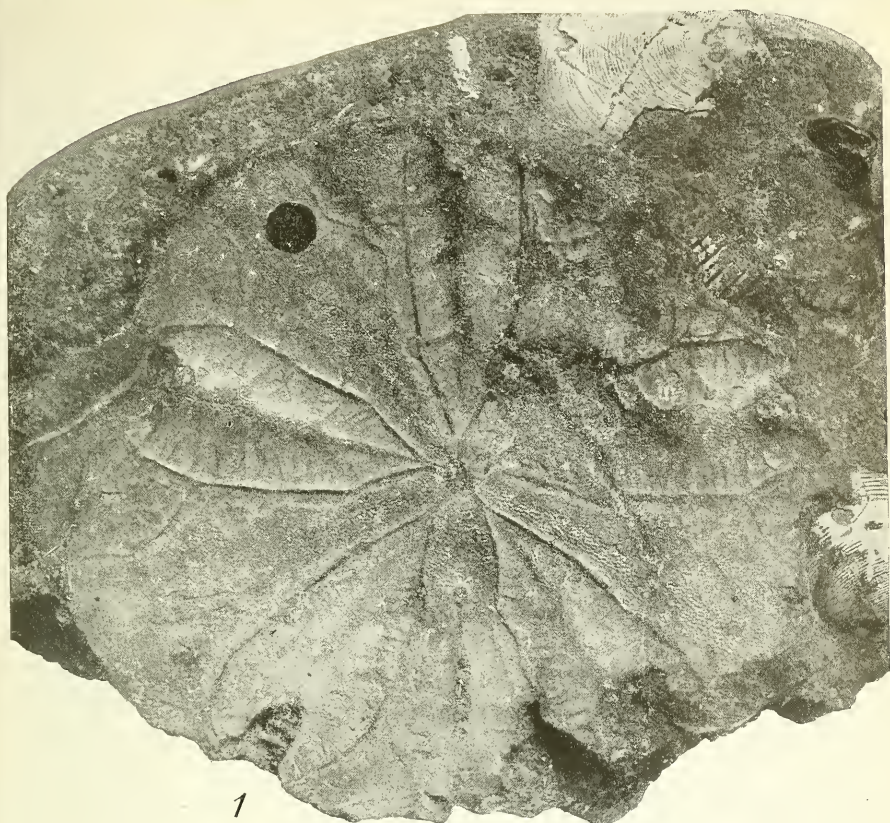




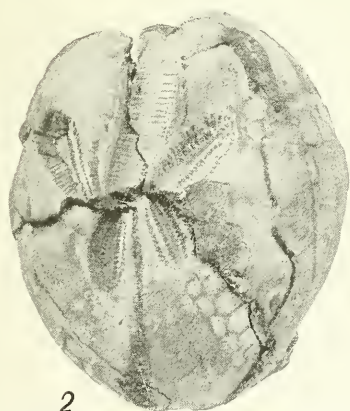
DORSAL (1) AND VENTRAL VIEWS (2) OF ENCOPE ANNECTANS.

FOR EXPLANATION OF PLATE SEE PAGE 115.

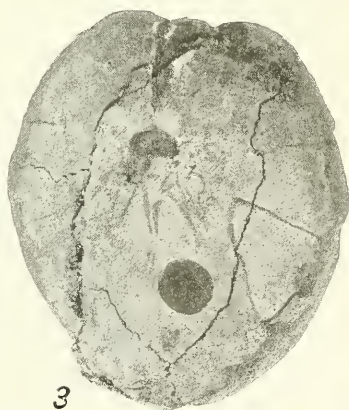




1



2

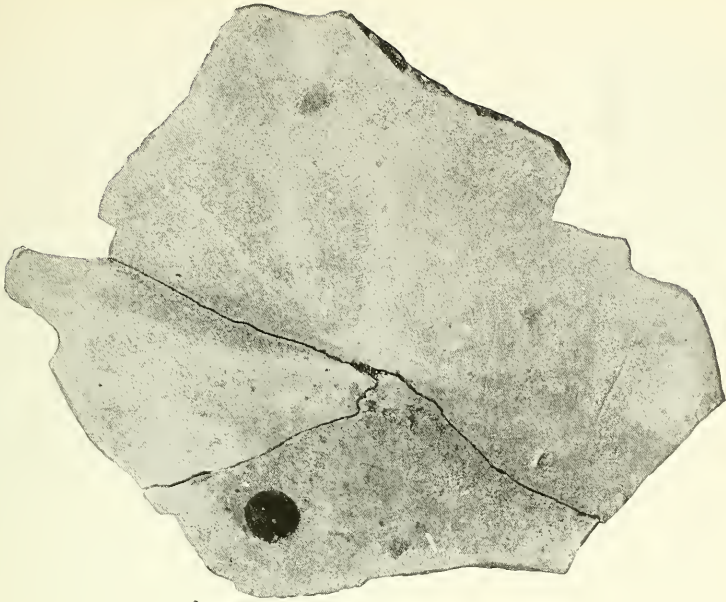


3

1. MOULD OF VENTRAL SIDE OF ENCOPE ANNECTANS SEEN FROM ABOVE, (2) DORSAL, AND (3) VENTRAL VIEWS OF SCHIZASTER PANAMENSIS.

FOR EXPLANATION OF PLATE SEE PAGE 116.





1



2

DORSAL VIEW (1) AND VENTRAL VIEW (2) OF ENCOPE PLATYTATA

FOR EXPLANATION OF PLATE SEE PAGE 116.





1



2



3



4

I. DORSAL VIEW OF ENCOPE MEGATREMA. DORSAL (2), VENTRAL (3), AND SIDE (4) VIEWS OF SCHIZASTER CRISTATUS.

FOR EXPLANATION OF PLATE SEE PAGE 116.





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