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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 152, NUMBER 2
PUBLICATION 4702

Charles D. and Mary Vaux Walcott
Research Fund

REVISION OF THE OLIGOPYGOID ECHINOIDS

(WITH 36 PLATES)

BY
PORTER M. KIER

Curator of Fossil Echinoderms
Division of Invertebrate Paleontology
United States National Museum
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PORT CITY PRESS, INC.
BALTIMORE, MD., U. S. A.

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INTRODUCTION

The oligopygoids are a group of echinoids common in Eocene rocks of the Caribbean and Florida. Most workers have considered them holectypoids, but new evidence and reevaluation of old evidence indicate that they have a much stronger affinity with clypeasteroids.

Previously, very little was known of the lantern in this group. It now has been possible to expose many lanterns because of the availability of hundreds of specimens in the U.S. National Museum, and the ease of dissection made possible by an air-abrasive machine. These lanterns are not at all like those found in holectypoids, but are very similar to clypeasteroid lanterns such as that of the fibularids. Discovery that the lantern supports are both ambulacral and interambulacral in origin is of considerable significance to understanding the evolution of the echinoid lantern supports. Previously, echinoids were known to have lantern supports formed from ambulacral or interambulacral plates, but never from both in the same species.

This group, although similar to the clypeasteroids in many characters, lacks the accessory pores present in all clypeasteroids. For this reason, a new order, Oligopygoida, is necessary for these echinoids.

All species having specimens available in American and European museums have been reillustrated and redescribed because many of the species had never been adequately described. Unfortunately, the type specimens of Sánchez Roig's Cuban species were not available for study.

The order, as herein delineated, includes two genera, *Oligopygus,* and *Haimea.* Of the 54 species previously referred to these genera, 24 are here redescribed, 11 are placed in synonymy, two are transferred to other genera, and one new species is described. Specimens of sixteen species were not available, and, therefore, are not redescribed or illustrated.

ACKNOWLEDGMENTS

Thomas F. Phelan, my research assistant, not only made many of the fossil preparations, but also did the crystallographic work. We discussed together many of the morphological and taxonomic problems, and my conclusions were improved by his opinions and ideas. Gary P. Fleming cleaned many specimens with the air-abrasive machine, and Larry B. Isham made the excellent figures illustrating the lantern and lantern support structures.

Professor J. Wyatt Durham, while a visitor here in the Museum, contributed much good advice. He and Carol Wagner read the manuscript and made suggestions for its improvement. Professor David M. Raup read over the section on crystallography.

The following people very kindly lent specimens from their institutions: Dr. L. G. Hertlein, California Academy of Sciences; Professor Bernhard Kummel, Museum of Comparative Zoology, Harvard (MCZ); Dr. Jean Roman, Muséum National d'Histoire Naturelle; Madame Letia, École National Supérieure des Mines; Dr. Marcel Beauvais, Université de Paris, Sorbonne; Dr. E. Gasche, Naturhistorisches Museum, Basel; Dr. E. Lanterno, Muséum D'Histoire Naturelle, Geneve; Professor Dr. G. H. R. von Koenigswald, Geologisch Instituut, University of Utrecht, and Professor J. Wyatt Durham, Museum of Paleontology, University of California, Berkeley, California.

Dr. Hans Kugler made available his large collection of echinoids from Trinidad, which has been of great assistance.

The research was supported by a National Science Foundation Grant and a Smithsonian Research Grant.

MORPHOLOGY

AMBULACRA

PETALS

Petals are well developed in all species of the Oligopygoida. Petal III is commonly the longest, petals II and IV the shortest. The poriferous zones of the same petal are of the same length, and normally depressed; the interporiferous inflated. The pores are strongly conjugate (pl. 2; pl. 3, fig. 1), and are oblique to the axis of the petal with the outer pore (text fig. 1) of a pore-pair distal to the inner, particularly towards the end of the petal. The inner pore is round; the outer elongated in the direction of the conjugation (pl. 3, fig. 1). Pore-pairs are introduced adapically throughout the adult life of the individual. In *Oligopygus haldemani* (Conrad) (text fig. 19A) a specimen 4 mm long had no pore-pairs in petal

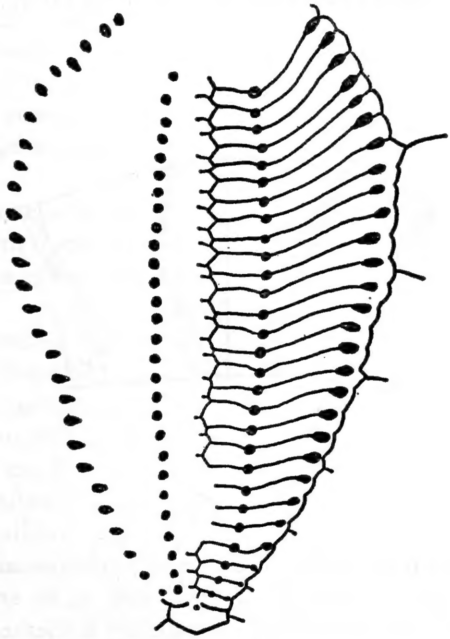


FIG. 1.—Petal I of *H. parvipetala* (Arnold and Clark): adoral curving of the ambulacral plates toward the end of petal resulting in the more adoral position of the outer pore of a pore-pair relative to the inner. This condition is present in most species of the Oligopygoida. Holotype, MCZ 3276 from Spring Mount, St. James Parish, Jamaica; ×10 (see pl. 32, fig. 6).

V but an individual 7.5 mm long had 9 pore-pairs in a single poriferous zone of petal V. Therefore, it is apparent that the first pore-pair is introduced in this petal in this species in an individual with a length slightly larger than 4 mm. From a study of the scatter diagram in text figure 38, it is apparent that the rate of introduction of new pore-pairs is greatest when the echinoid is small, and that this rate gradually decreases with growth.

The pores are situated in the transverse sutures between the ambulacral plates, whereas beyond the petals they are through the plates. In some species on the exterior of the test, the pores of the same pair are closer to each other than on the interior, due to the curving towards the perradial suture of the canal for the inner pore, but in other species the contrary is the case. Furthermore, in some species such as *O. wetherbyi* (text fig. 2) the canals of both pores of a pair slope towards the perradial suture so that in a weathered specimen the petal will appear narrower than in a well-preserved specimen. A species having the canal of the outer pore of a pair passing into the test at a higher angle than the inner, but having both canals slanted towards the perradial will have on a weathered specimen a narrower petal but wider poriferous zones than on an unweathered specimen. It is, therefore, most important when comparing specimens to bear in mind their state of preservation.

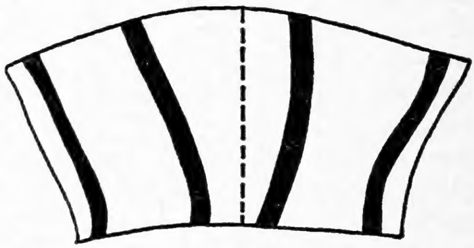


FIG. 2.—Transverse view near midlength of petal II of *Oligopygus wetherbyi* de Loriol showing the curving of the canals for the tube-feet toward the perradial suture. The upper side is exterior of test, the lower the interior. Because of this curving of these canals, the petals on a badly weathered specimen would be narrower and have narrower interporiferous zones than on a well-preserved specimen. USNM 649849, from the late Eocene Crystal River Formation, 6 miles SE. of Crystal River, Florida; ×18.

The petals are significant taxonomically. Their length relative to the length of the test, and their length relative to each other is quite constant within suites of specimens and presumably within a single population. One of the most reliable methods of differentiating species is with scatter diagrams of the number of pores in a petal relative to the length of the test. The variation within a population in this character is generally so small that the slightest difference in these two characters between two populations is readily apparent.

If one petal is longer than another, it retains this disparity throughout the growth of the individual echinoid, because the longer petal receives its first petaloid pores before the other petals. Therefore, if a comparison is being made between a few specimens of two different populations and the specimens from one of the populations are larger than those from the other, this difference in size can be discounted in determining the significance of a difference in the number of pore-pairs between petals of the same specimen. For example, if the specimens from locality A have a smaller difference between the number of pore-pairs in petal I than in petal II than the difference in those petals in specimens from locality B, this difference is significant even though all the specimens from locality A may be bigger or smaller than those from locality B.

DEMIPLATES

The presence in all species of demiplates in the ambulacra beyond the petals is one of the most characteristic features of the Oligopygoida. These plates are very small in surface area (text fig. 2), thin (usually less than one quarter the thickness of the primary ambulacral plates), and never extending through to the interior of the test. Each demiplate is perforated by a single pore. They are less numerous in *Haimea,* where, for example, in a specimen of *H. ovumserpentis* there are 44 demiplates in a single ambulacrum, but more common in *Oligopygus* with 52 in an ambulacrum in an *O. haldemani.* They occur in species such as *H. ovumserpentis,* in which there are fewer demiplates (text fig. 3) in the corners between the primary ambulacral plates, separated from each other by these primary plates. The ambulacral pores are in a zigzag pattern with the pore in the demiplate usually nearer the perradial suture than the pore in the primary plate. In a species with more demiplates such as *Haimea alta* (text fig. 5A) the demiplates are not separated from each other but occur side by side, and the primary ambulacral plates are occluded, not reaching the adradial suture. The pores are arranged in a double series. The species with the most developed ambulacra in this morphological series, such as *Oligopygus haldemani,* not only have crowded demiplates but also have many included plates (text fig. 4) inserted between the demiplates and the occluded primary plates. There are 12 included plates in an ambulacrum of a specimen of *O. haldemani.*

Perhaps this morphological series is phylogenetic with the primitive species having few demiplates and the later more advanced species having many demi- and included plates. Unfortunately, the species of the Oligopygoida are not well enough dated to make an estimate.

The demiplates do not extend to the peristome but are separated from the peristome by six to nine primary ambulacral plates in each half ambulacrum. The included plates occur between the petals and one-third to one-half the distance from the end of the petals and the

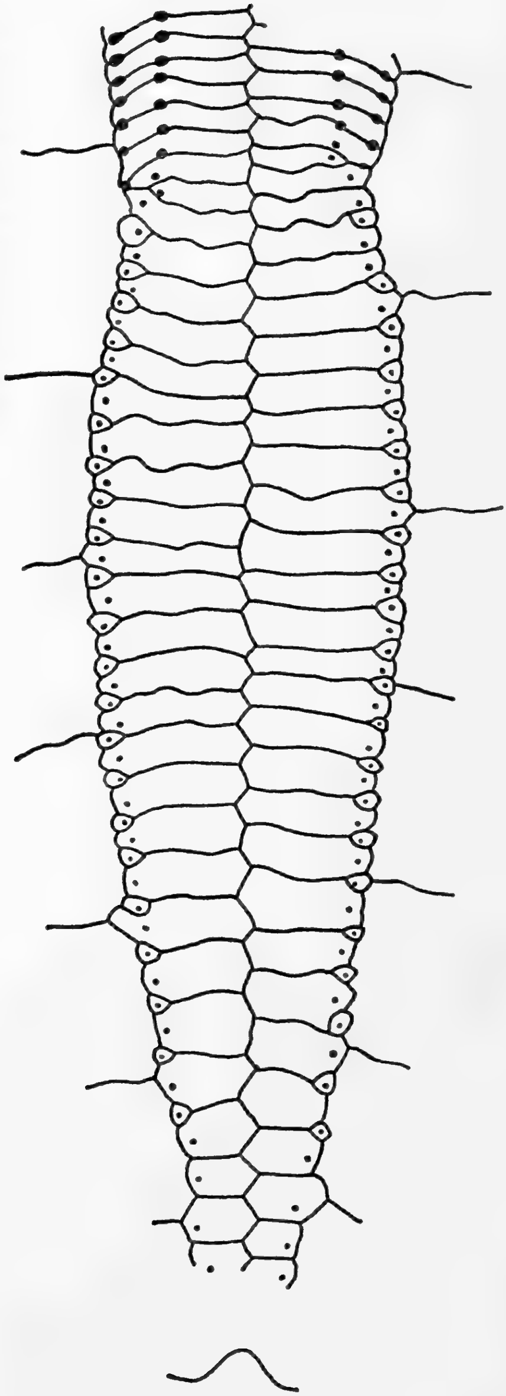


Fig. 3.—Plate arrangement of part of the petal and the area beyond the petal in ambulacrum III in a specimen of *H. ovum-serpentis* (Guppy) showing the distribution of the demiplates. Slightly weathered specimen's demiplates are smaller than they would be on an unweathered surface. The sutures of the ambulacral plates at the peristome were not visible. No. M6617, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×7.

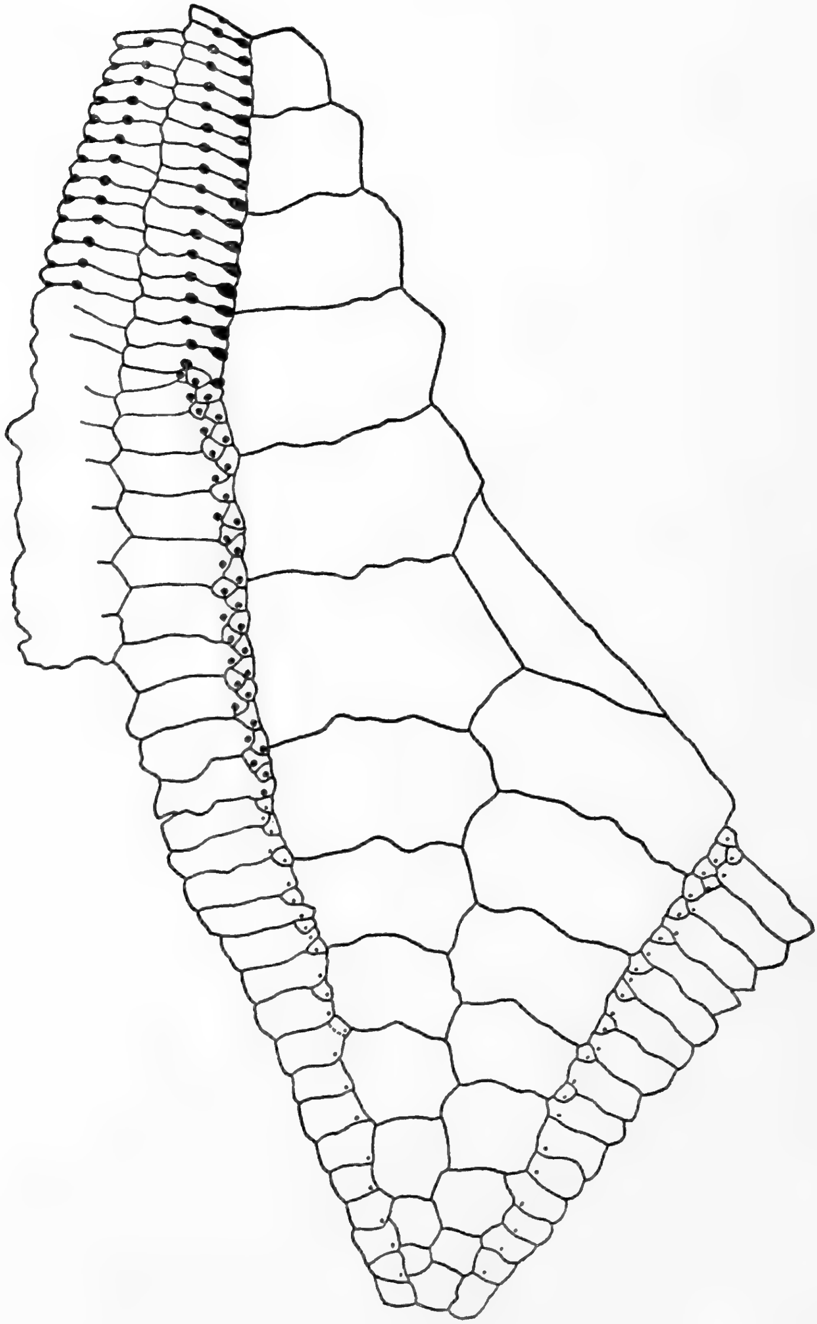
peristome. Nineteen occluded or primary ambulacral plates separate the youngest included plate from the peristome in *O. haldemani*. They are most abundant, in general, at the ambitus.

The adradial borders of the demiplates are inserted somewhat into the adjacent interambulacral plates. The deep pits where these plates fit can be seen along the adradial suture of the interambulacral plates (see pl. 11, figs. 4, 5). This insertion of these small plates would serve to hold them in place and prevent slippage along the sutures. It is interesting to note that many of the included plates extend underneath the adjacent demiplates and are also inserted into the adradial interambulacral plate. They probably should not be called included plates; but because they are separated at the surface where they are normally seen, I prefer to call them included to differentiate them from the demiplates which touch the interambulacral plates at the surface.

The arrangement and number of these ambulacral plates beyond the petals is fairly constant within a population and is, therefore, a good specific character. The pores are usually visible, although the plate sutures are not always clear, and it is, therefore, possible to know the number of these ambulacral plates. Because these plates are so thin, many or all of them have been lost on badly weathered specimens. The pores are still present, however, because the tube foot that passed through the demiplate also went through the primary or occluded ambulacral plate. It is possible by counting these pores to calculate how many demi- or included plates were present on a specimen from which they have all been removed by weathering.

The arrangement of the demi- and primary plates appears to be different on a weathered specimen than in a well-preserved specimen. Because the demiplates are so thin and wedge shaped, in a weathered specimen they are smaller in area at the surface of the test. The demiplates in a well-preserved specimen will be larger and in some species are in contact with each other isolating the primary plates from the adradial suture (text fig. 5A), whereas the demiplates in a weathered specimen of the same species are smaller, not in contact and do not separate the primary ambulacral plates from the adradial suture. Finally, in a more weathered specimen, the demiplates are absent (text fig. 5B). Because the disposition of these demiplates is an important specific character, the influence of weathering must always be borne in mind when studying specimens of the Oligopygoida.

Hawkins (1926, p. 374) evidently was not aware how thin these demiplates were when he described the ambulacral plate arrangement in *Haimea ovumserpentis*. He noted that on the weathered specimens



there were some ambulacral plates beyond the petals which had two pores. He suggested that the demiplate had been resorbed and the pore retained, resulting in the two pores in a primary plate. He attached great phylogenetic significance to this conclusion and stated that it supported his earlier belief that cassiduloid primaries resulted from the simplification of pyrinid triads. Undoubtedly, the demiplate was absent in Hawkins' specimens due to weathering, not resorption. The demiplates are present in all well-preserved specimens, but a few are absent in a slightly weathered specimen, and the pore which was in the demiplate is observed in the primary plate which lay underneath. All the demiplates are absent in a badly weathered specimen and two or more pores are present in each plate.

The number of ambulacral pores beyond the petals is a particularly useful taxonomic character because it is not affected by the growth of the echinoid after the first petaloid plate is introduced. This number of pores beyond the petals will be approximately the same for all the specimens with petals regardless of their size, because almost all the specimens collected in a sample are large enough to already have their first petaloid pores.

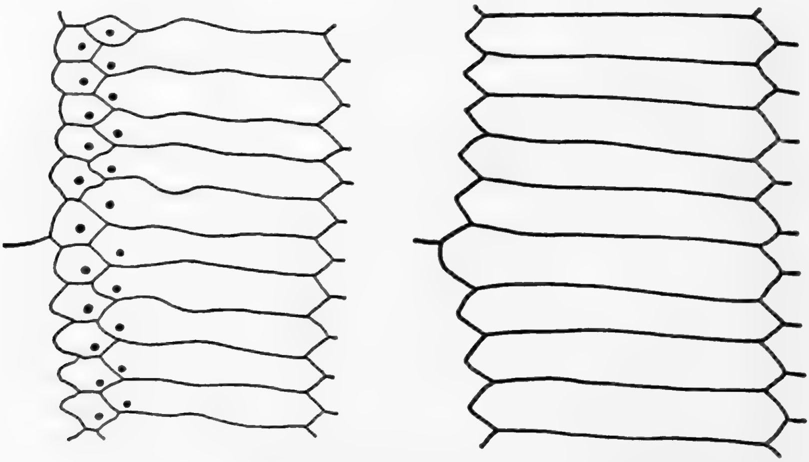
A young prepetaloid specimen would have an extraordinary number of tube feet. For example a specimen of *Oligopygus haldemani* only 6 mm long would have approximately 450 tube feet, and a small specimen of *Haimea alta*, 1350.

The canal leading from the tube foot in the demiplate must pass through the primary or large occluded ambulacral plates because the demiplate is separated from the interior by these large plates. During the growth of an individual, the new plates introduced to the ambulacra at the apical system probably would be approximately the same size and thickness at their introduction. As the echinoid grew the plates that were to become the primary plates would increase in size relative to those that were to be the demi- or included plates, and eventually separate these smaller and thinner plates from the interior

Fig. 4.—Plate arrangement in part of ambulacra III and IV and interambulacrum 3 in *Oligopygus haldemani* (Conrad). Part of the petal and all of ambulacrum IIIb beyond the petal show arrangement of the demiplates and occluded plates beyond the petal, and their absence near the peristome. The ambitus occurs near the point where ambulacrum IIIa is broken away. Because the adoral portion of the test is considerably more weathered than the adapical, the peripodia are absent and the pores appear to be smaller in this area. They are not visible on the first ambulacral plates (see pl. 3, figs. 1, 2). USNM 649834, from the late Eocene Ocala Limestone, at USGS 7097, Flint River at old factory above Bainbridge, Georgia, ×7.

of the test. In so doing, the primary plate would enclose the canal leading to the tube foot of a demiplate. In an adult this canal passes from the exterior through the demiplate and the underlying primary or large occluded plate towards the perradial suture. As a result, the pores are much nearer the perradial suture at the internal surface than at the external.

It is not possible to know for certain the function or functions of the hundreds of tube feet that protruded from all these ambulacral plates beyond the petals, because no members of this family are living today. Presumably, these tube feet, because no gills were present, must have aided in respiration of a young specimen before any petaloid respiratory tube feet were introduced. The tube feet would not be needed for respiration in the adult when the petals were fully developed. The fact that tube feet are most abundant on the ambitus suggests that they were probably used in an adult to obtain food. The echinoid may have lived with its adoral surface extending partially into the substratum. These tube feet probably extended out beyond the spines searching for and collecting food from the adjacent environment.



A B

FIG. 5.—Plate arrangement of the ambulacrum at the ambitus in two specimens of *Haimea alta* (Arnold and Clark) showing the effect of weathering: A, less-weathered specimen, demiplates present; B, badly weathered specimen, demiplates absent and pores not shown. A, ambulacrum II of paratype, MCZ 3395 from near Spring Mount, St. James Parish, Jamaica, ×19 (see pl. 26, figs. 2, 3). B, ambulacrum V of USNM 649850 from 3.5 km SE. of village of San Diego de los Baños, Pinar del Rio Province, Cuba, ×15.

NEUROPORE

The pores in the plates beyond the petals on an extremely well-preserved specimen of *Oligopygus haldemani* have a slight notch adorally (pl. 3, fig. 2). This notch is very similar to those figured in cidarids by Mortensen (1928, fig. 3) and called a neuropore. According to Mortensen the nerve for the tube foot passes through this pore. In most of the specimens of *Haimea* and *Oligopygus* the ambulacral pores appear to be single at the surface but within the plate there is a thin partition dividing the pore giving the appearance of a double pore. Perhaps this second pore is the pore for the nerve.

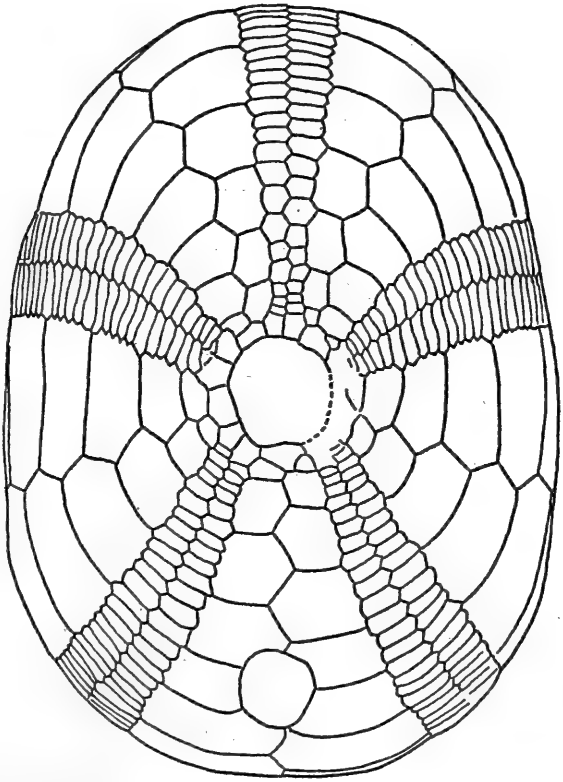


FIG. 6.—Adoral plate arrangement in *Haimea stenopetala* (Arnold and Clark) showing how much narrower ambulacrum III is than II or IV, and its higher plates. This specimen is badly weathered with the demiplates removed and the ambulacral pores obscured. Holotype, MCZ 3281 from near Spring Mount, St. James Parish, Jamaica (see pl. 35, figs. 1–3).

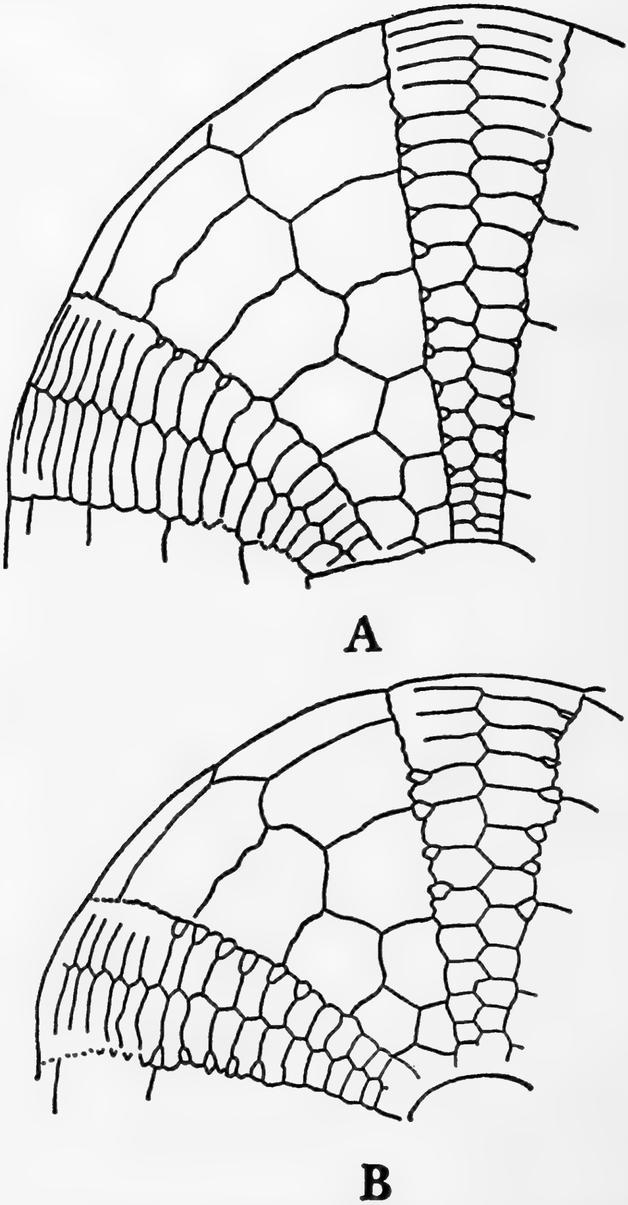


Fig. 7.—Adoral plate arrangement in ambulacra II, III and interambulacrum 2 in *O. wetherbyi* de Loriol (fig. A) and *O. zyndeli* (Jeannet) (fig. B) showing the higher plates in ambulacra III. In *O. wetherbyi* the plates are higher because the distance is greater from the end of petal III to the peristome than in ambulacrum II, but there are no more plates, whereas in *O. zyndeli* the distance is the same but there are fewer plates. Fig. A, USNM 164660 from the late Eocene Ocala Limestone Nigger Sink, 2 mi. S. of Gainesville, Florida, ×4 (see pl. 5). Fig. B, no. M6616, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad; ×6.

WIDTH OF AMBULACRA BEYOND PETALS

The anterior ambulacrum III beyond the petal is narrower (pl. 5) than the other ambulacra in most species of *Oligopygus* and *Haimea.* For example, in a specimen of *Haimea stenopetala* (text fig. 6) ambulacrum III midway between the peristome and margin is only 65 percent as wide as ambulacra II and IV. In *H. parvipetala,* ambulacrum III is 80 percent as wide as II or IV. This distinction in width is less developed in some of the species with a more circular test such as *Oligopygus nancei.*

HEIGHT OF AMBULACRAL PLATES BEYOND PETALS

The plates in ambulacrum III beyond the petals are commonly higher than the plates in the other ambulacra. For example, in *H. stenopetala* the 20th plate back from the peristome is 0.95 mm high, whereas the corresponding plate in the other ambulacra is only 0.52 mm high. This dichotomy in height is present in all species in which either the distance from the end of the petal to the peristome is longer in ambulacrum III than in the other ambulacra and there is the same number of plates; or the distance is the same, but fewer plates are in ambulacrum III. *O. wetherbyi* (text fig. 7A) is an example of the first case: approximately the same number of plates is beyond the petals but the distance is greater from the end of petal III than in the other petals, and in order to fill the space the plates are higher. However, in *O. zyndeli* (text fig. 7B) the distance is approximately the same but only 36 plates are beyond petal III whereas 64 are present in the other petals.

SEPARATION OF ADORAL AMBULACRAL PLATES FROM INTERIOR

One or more of the adoral ambulacral plates beyond the demiplates do not extend through to the interior of the test in some species of the Oligopygoida. This feature is easily observed in thin sections or in specimens that have broken apart along the perradial or adradial suture. A specimen of *Oligopygus haldemani* was found broken along its perradial sutures showing these isolated plates. Unfortunately, not all the ambulacra were present, but in the six half-ambulacra preserved (Ia, IIIa, IVa, IVb, Va, Vb) the second ambulacral plate is cut off from the interior of the test by the basicoronal plate and the third plate (text figs. 8A–E). In half-ambulacra IIIb (text fig. 8A), IVa (text fig. 8B), and Vb (text fig. 8C) this is the only plate so isolated, but in IVb (text fig. 8E) the fourth and seventh plates are

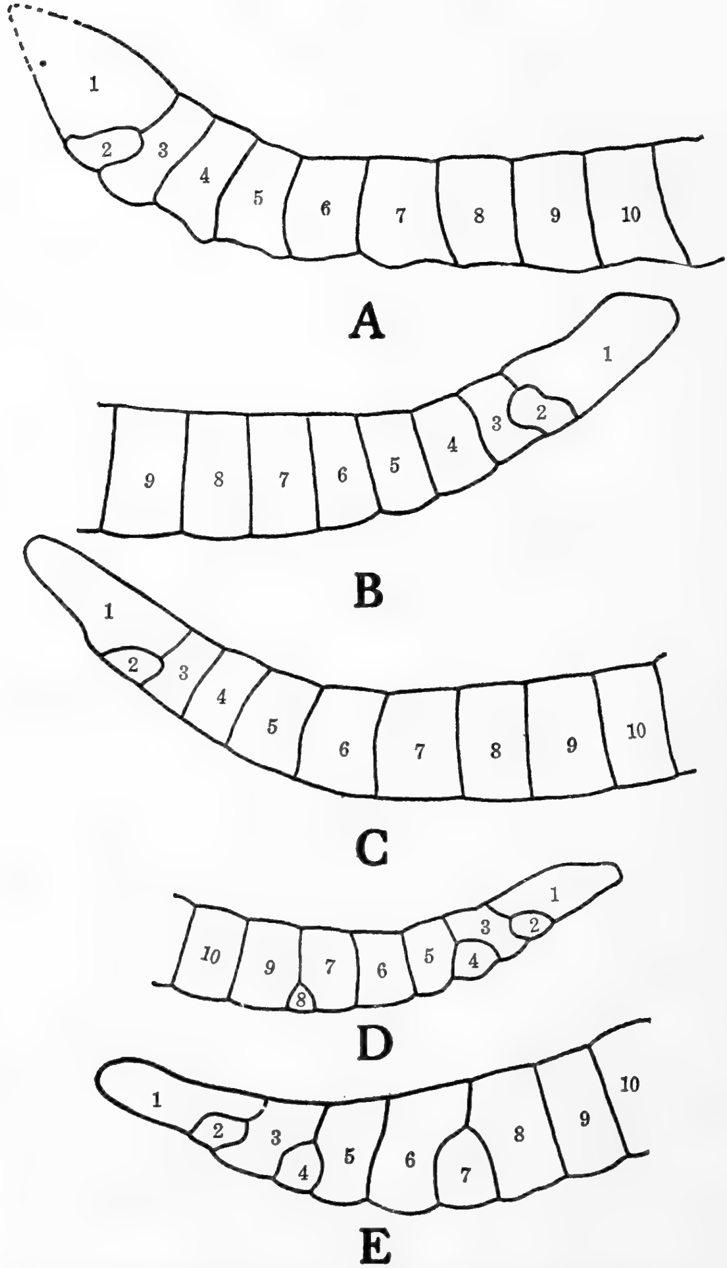


FIG. 8.—Arrangement of plates in adoral ambulacra at perradial suture in a specimen of *Oligopygus haldemani* (Conrad) showing that several of the plates do not extend through to the interior of the test. The plates are numbered chronologically from the peristome with the upper part of each drawing representing the interior of the test, the lower the exterior. Fig. A is ambulacrum IIIb, fig. B = IVa, fig. C = Vb, D = Va, and fig. E = IVb; figs. A, B, C, E ×20; D ×14. USNM 649834, from the late Eocene, Ocala Limestone, at USGS 7097, Flint River at old factory above Bainbridge, Georgia.

isolated from the interior, and in Va (text fig. 8D) the fourth and eighth. In half-ambulacrum Ia, only the first three plates are preserved so it is not known whether the second plate was the only isolated plate.

The pore from each of these isolated plates passes through one of the adjacent plates and reaches the interior of the test.

The reason for separation of these plates from the interior is not clear, but presumably it would serve to strengthen the test, because the number of sutures that extend through the test would be reduced. Because plate 2 does not extend through the test, plate 1 is larger and the area around the peristome is therefore stronger.

SHAPE OF TEST

The shape of the oligopygoid test varies from high, as in *Haimea caillaudi* Michelin with a height 88 percent of the length, to as low as only 40 percent in some specimens of *Oligopygus wetherbyi* de Loriol. The width is never greater than the length and varies from 72 percent of the length in some specimens of *O. sanchezi* to 99 percent in *O. nancei* Cooke.

Little variation occurs within a species in the width of the test as can be seen in the narrow path of points in a scatter diagram (text fig. 9A) of the length-width dimensions in *O. phelani* Kier, new species. The length-width ratio is quite constant in all of the collections of *Haimea* and *Oligopygus* in which there is some certainty that all the specimens came from the same stratigraphic interval, such as in the Florida collections of *O. wetherbyi, O. haldemani,* and *O. phelani.* The length-width ratios vary in the Trinidad and Jamaican collections, but these collections have little stratigraphic control and are probably not from the same stratigraphic interval.

More variation is present in the height of the test as evident in the wider scatter of points in the scatter diagram of these dimensions in *O. phelani* (text fig. 9B). Greater variation is present in all the species of *Haimea* and *Oligopygus* in which sufficient specimens are available. Although some of this variation may be due to post mortem flattening of the specimens, many of the lower forms show no indication of crushing.

The petals appear inflated in many species such as *Haimea rutteni* or *Oligopygus putmani* either due to the depression of the poriferous zones or to the inflation of the interporiferous zones. The inflation of the petals is a good specific character where the petals are strongly inflated; however, in some species the petals may appear slightly inflated in some specimens but flush in others.

In summary, relative width is a good specific character, but relative height and the inflation of the petals, where slight, are less significant.

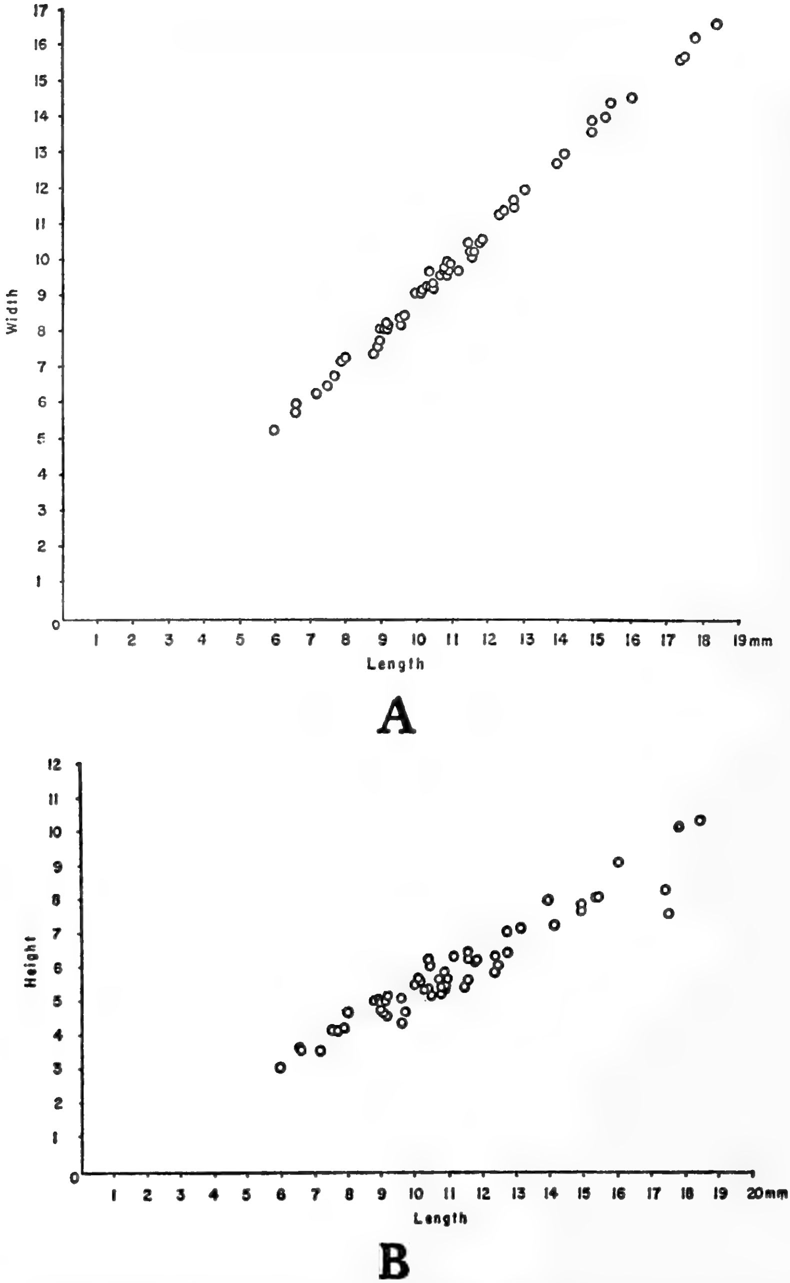


Fig. 9.—Scatter diagrams showing the width (fig. A) and height (fig. B) relative to the length in a collection of *Oligopygus phelani* Kier, new species, from the same locality. Note the small amount of variation in the width relative to the length as compared to the greater variation in the height.

SIZE

The largest oligopygoid observed is a specimen of *Oligopygus pingius* Palmer, 76 mm long. The average adult oligopygoid is between 20 and 40 mm long. One of the smaller species, *O. phelani*, has an average length of 10 to 13 mm with the largest specimen only 18.5 mm long.

The size of the specimens is of taxonomic significance when a large number of specimens of a species are available. *Oligopygus wetherbyi* de Loriol is a larger species than *O. haldemani*. One of the larger *O. wetherbyi* is 54 mm long (average 36 mm), whereas the largest *O. haldemani* I have seen is 37 mm long (average 21 mm). That this difference is biologically valid and not just an accident of collecting is indicated by the presence of genital pores in specimens of *O. haldemani* only 9.5 mm long whereas in *O. wetherbyi* they are present on no specimens less than 18 mm long.

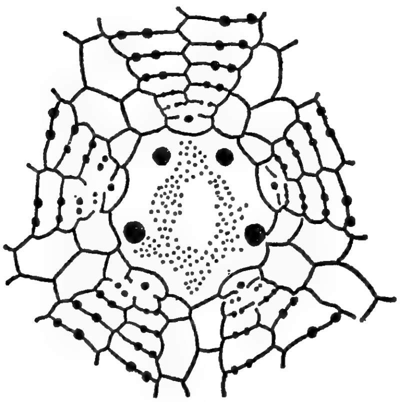


Fig. 10.—The apical system in *Haimea ovumserpentis* (Guppy) showing the monobasal system with discrete ocular plates and four genital pores found in all species of the Oligopygoida. No. M6617, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad; ×10.

APICAL SYSTEM

The apical system in the Oligopygoida is monobasal (pl. 1, figs. 1–4; text fig. 10) with four genital pores, and five discrete ocular plates. The genital pores are quite small in some of the specimens (pl. 1, fig. 2) but quite large in others from the same suite (pl. 1, fig. 1). This difference is not due to weathering, for many badly weathered specimens have small pores, and many well-preserved specimens big pores. Usually, there are no intermediates, the pores are either small or large. Presumably, this dimorphism is sexual. Mortensen (1948, p. 159) reports that in the fibularids the males commonly have small genital pores and the females large. This dimorphism will be described in detail in a later paper.

The test in a large species attains a larger size before the appearance of the genital pores than it does in a smaller species. In the larger *Oligopygus wetherbyi* de Loriol no specimens smaller than 18 mm long have genital pores, whereas in the smaller species *O. haldermani* (Conrad) they are present in a specimen only 9.5 mm long.

TUBERCULATION

The test is covered with small, irregularly arranged tubercles. Adapically the tubercles are not crowded (pl. 3, fig. 1) but at the ambitus they are more numerous (pl. 3, fig. 2) with their scrobicules almost in contact. The tubercles, adoral to the ambitus, are less numerous but are larger, with their scrobicules still almost in contact. The tubercles are smaller in the area around the peristome.

The tubercles have deep scrobicules with vertical sides. The boss is large, one-half to two-thirds the diameter of the scrobicule. It extends upward as high as the surrounding surface of the test. The boss is crenulated with approximately 15 crenulations on each boss. The mamelon is small, perforated, and two-fifths the diameter of the boss, and usually extends in height above the surface of the test.

Most workers have considered the tubercles imperforate and not crenulate (Mortensen 1948, p. 257). This error is due to the fact that the perforation and crenulations are not preserved on most of the specimens. The mamelon, and the upper part of the boss where the crenulations are, lies at or above the general level of the surface of the test, and this portion of the test is commonly weathered away on most specimens. These perforated mamelons and crenulated bosses are present in all well-preserved specimens of the family.

SPINES

No spines were found on any of the specimens. Presumably, short, slender spines covered the test of the living echinoid, considering the size, number, and arrangement of the tubercles. These spines were probably used primarily for locomotion.

BUCCAL PORES

Buccal pores are present in all the species of *Haimea* and probably in all species of *Oligopygus*. The pores are large and are situated on the margin of the peristome (pl. 11, fig. 8). Brighton (1926, fig. 1E) illustrated these pores in his figure of *Haimea ovumserpentis* (Guppy) var. *baldryi* Brighton, but Mortensen (1948, p. 258) stated that they were not pores but sphaeridial pits. Study of hundreds of specimens of *Haimea* has revealed buccal pores present in every specimen in which the peristomial region is well preserved. These pores definitely pass through the test and are not sphaeridial pits.

Buccal pores are not visible in most specimens of *Oligopygus*. They are present on the very edge of the peristome, which on most specimens is not visible either because the peristomal sulcus is filled with matrix or because the edge of the peristome, which is very thin, is broken away. Although now visible on only a few specimens, they were probably present on all originally.

SPHAERIDIA

Sphaeridia occur in all the species, situated in two rows near the perradial suture in each ambulacrum near the peristome (pl. 11, fig. 8).

INTERAMBULACRA

The interambulacra are composed of two columns of alternating plates except at the peristome where the first plate of each interambulacrum is a single large plate (text fig. 4).

PERISTOME

The peristome is commonly central or slightly anterior or posterior. The opening in *Oligopygus* commonly has four curved sides with the anterior blunt and the posterior pointed (pl. 4, fig. 1), whereas in *Haimea* it has a regular outline, is subpentagonal, and is pointed anteriorly but blunted posteriorly (pl. 4, fig. 3). A deep, transverse peristomal sulcus is present in most species of *Oligopygus* such as *O. haldemani* (pl. 23, fig. 4), *O. wetherbyi* (pl. 4, fig. 2) and *O. jamaicensis* (pl. 16, fig. 7). Commonly, this sulcus is anteriorly vertical, but posteriorly less steep. In *O. rotundus,* however, it is vertical all the way around. A pocket is present in the lateral side of the sulcus (pl. 19, fig. 3) in some specimens of some species, such as *O. sanchezi, O. pinguis,* and *O. wetherbyi.* The tubercles are small or absent in this pocket in some specimens. These pockets are variable in their development in the same species. Some specimens have deep pockets but others have none at all in a collection of specimens of *O. wetherbyi* from the same locality.

In *Haimea* the peristome differs considerably from that in *Oligopygus.* The opening is pentagonal not triangular and it is not situated in a deep transverse sulcus but in a depression only slightly larger than the opening itself and of the same outline as the opening.

In both genera, the position, shape, and size of the peristome are quite constant within a population and are presumably reliable specific characters.

PERIPROCT

The periproct is always inframarginal and may occur anywhere from near the peristome to near the posterior margin. The opening is small, flush with the test, circular or transversely elongate. It is a good specific character, provided only adult specimens are used, because its location is quite constant within specimens of the same suite. In immature individuals the periproct is commonly farther away from the peristome than in adults.

There is not always a direct relationship between the position of the periproct and the number of plates between the periproct and the peristome. A species with the periproct situated near the peristome may have as many plates between its periproct and the peristome as a species with the periproct at the posterior margin. Unfortunately it is very difficult to count the plates on most specimens and, therefore, I have been unable to determine the frequency of correlation between periproct distance and number of plates separating it from the peristome.

THICKNESS OF TEST

The test is extraordinarily thick in some species. For example, some of the plates are 4.0 mm thick in a specimen of *O. wetherbyi,* 50 mm long (text fig. 11A). In other species the test is relatively thin as in *O. nancei* (text fig. 11B) in which most of the test is only 2.0 mm thick in a specimen 63 mm long.

LANTERN

The lantern has never been adequately described in the Oligopygoida. Although Pijpers (1933, p. 86) described the lantern in his *Bonaireaster rutteni* (herein referred to *Haimea*), he placed his genus in the Clypeasteroida not knowing that a lantern was present in *Oligopygus* or *Haimea.* Durham and Melville (1957, p. 256) were the first workers who realized that a lantern was present in these two genera. Lanterns in *Oligopygus wetherbyi, O. haldemani, O. putmani,* and *Haimea rutteni* have now been exposed using an air-abrasive machine. Sections made through specimens of most of the other species of the Oligopygoida revealed similar lanterns. Although a lantern is illustrated herein for three of the above named species, they are all so similar that the description below applies to both *Oligopygus* and *Haimea.*

The lantern (text fig. 12) is large, well developed, and similar in general appearance to the lantern found in the fibularid and neolaganid

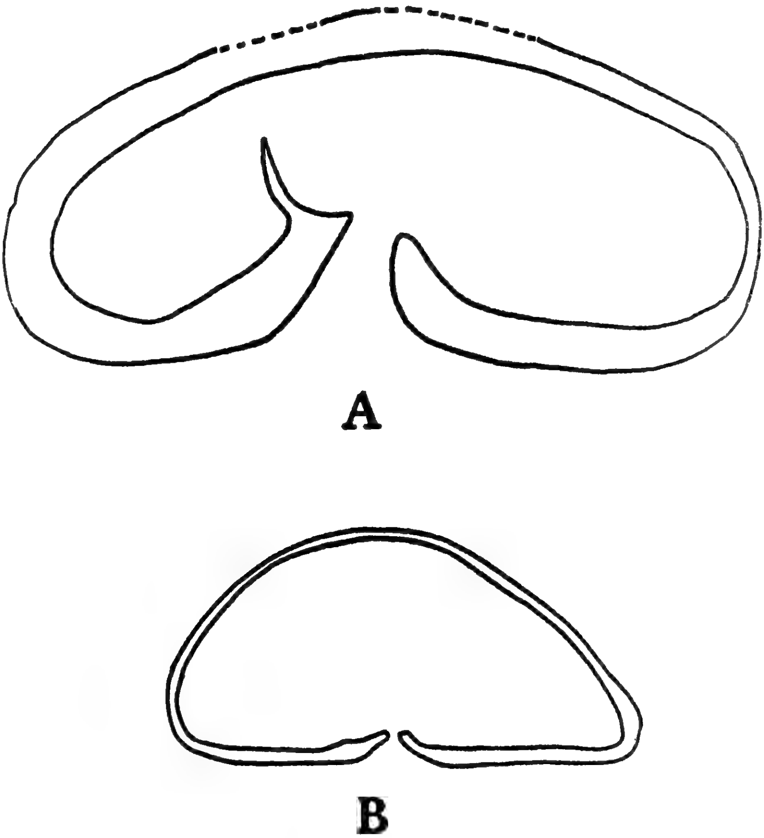


FIG. 11.—A, Cross section, length-wise, through (left side) *Oligopygus wetherbyi* de Loriol showing the deep invagination of the peristome, the great thickness of the test, and the outline of one of the auricles. USNM 649851, from the late Eocene, Crystal River Formation, St. Catherine Rock Company quarry, western edge of St. Catherine, S. of road running along railroad track, Sumter County, Florida, ×2. B, Cross section, length-wise, through (right side) *Oligopygus nancei* Cooke showing the shallow invagination of the peristome and the thin test. USNM 649852, from the late Eocene, Tinajitas Formation, Merecure group, Rio Amana, State of Monagas, Venezuela, ×1.

clypeasteroids. In length it is 35 to 40 percent as long as the test, its height approximately 50 percent of the height of the test, and it is about as wide as long.

The lantern, when in position in the test (pl. 6, fig. 6; pl. 7, fig. 6), tilts downward anteriorly. The marginal outline, as viewed from above (pl. 6, fig. 1; pl. 7, fig. 1; pl. 8, fig. 1), is pentagonal and starlike. The posterior pyramid, 5, is the largest, the paired posterior (4 and 1) intermediate in size, and the paired anterior (2 and 3) the smallest. Pyramid 5 is symmetrical (text fig. 12A; pl. 6, fig. 3;

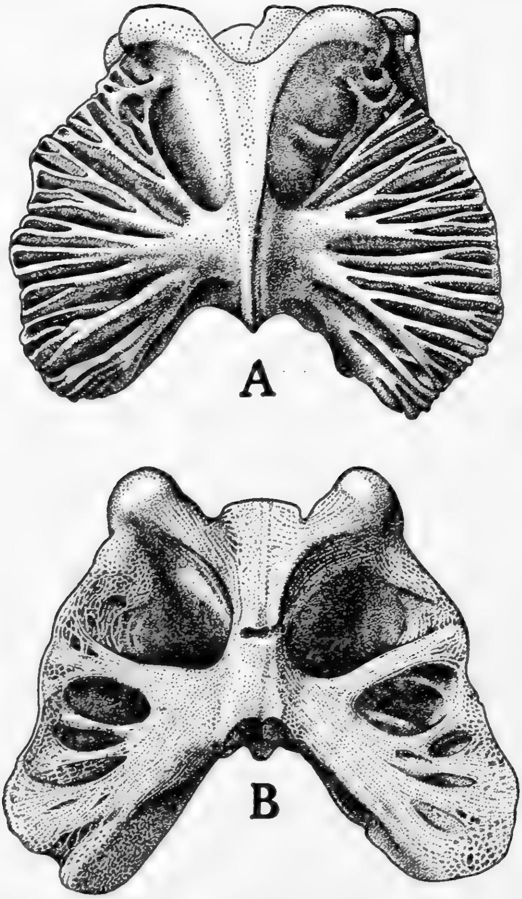


FIG. 12.—Pyramid 5 of *Haimea rutteni* (Pijpers) (fig. A) and *Echinocyamus megapetalus* Clark (fig. B) showing the similarity between an oligopygoid and fibularid pyramid. Fig. A, USNM 649836, from the late Eocene, of Bonaire, SW. of Seroe Montagne and Punta Blanco, ×8. Fig. B, USNM E8491 Recent from Ujelang Atoll, Marshall Islands, ×22.

pl. 7, fig. 5) but all the other pyramids are assymmetrical (pl. 6, fig. 4; pl. 7, figs. 3, 4) having their exterior posterior wing more developed than the anterior wing. The exterior wings expand marginally and adorally into the ambulacral region. Lamellae (pl. 6, fig. 3; pl. 7, fig. 5; pl. 8, fig. 3) are very well developed and radiate in polyfurcate fashion from the point of greatest curvature of the middle body. The interior wings (pl. 6, figs. 2, 4) are much shorter, convergent, and also have lamellar supports. The styloid projection (pl. 7, fig. 2) is sessile with the tooth slide nearly vertical.

The symphyses, the surfaces where the half-pyramids join, are narrow dorsally but wider and subtongue shaped ventrally (pl. 10, fig. 4). The compact middle body (pl. 6, fig. 4) is narrow, about one-third the horizontal width of the pyramid. Dorsally this middle body forms a V-shaped crest, (most pronounced in pyramid 5) the thickened ends of which form the supra-alveolar processes (pl. 6, fig. 4). These processes cut downward leaving a ledge to accommodate the epiphyses, which are flattened oval plates. Rotulae were not found but may have been present.

Fossae (the indentations where the auricles are inserted in some lanterns) are not present. The lantern supports curve upward around the outside of the lantern.

The teeth are very similar to those found in *Echinocyamus megapetalus* H. L. Clark and *Weisbordella cubae* (Weisbord). They are keeled (pl. 10, fig. 5) with a keel slightly broader than high and with a rounded crest tending in some cases to flatten dorsally. The lateral edges are rounded and protrude slightly but not enough to form a true flange.

Tooth number 5 is the largest and most symmetrical. To accommodate this large tooth, the tips of the interior wing of pyramid 5 curve anteriorly (pl. 6, fig. 2; pl. 7, fig. 2). The adjacent interior wings of pyramids 1 and 4 likewise curve anteriorly, but here they tend to close over their respective tooth, which is less developed. This curving of the interior wings is present in some clypeasteroids and is developed to the same extent in *Echinocyamus megapetalus* H. L. Clark, and *Weisbordella cubae* (Weisbord).

LANTERN SUPPORTS

The plate arrangement of the structures that form the lantern supports is very difficult to discern in the Oligopygoida. The plate sutures were easily visible in only a few specimens out of the hundreds studied. This obscuring of the sutures in this region seems to be due to the great thickening of the plates near the peristome, and the fact that many of these plate sutures are not vertical to the surface of the test and are not enlarged, therefore, by weathering. The task of determining the plate arrangement is also difficult because some of the plates near the peristome are not visible at all from the inside of the test. For example, in interambulacrum 4 in *O. haldemani* (text fig. 14) interambulacral plates 2, 3, and 4 are not visible in the interior because they are covered by interambulacral plate 1 and one of the primordinal ambulacral plates. These thickened plates curve back and lie on top of these plates.

The plate sutures were discernible only after extensive preparation of the specimens using dilute acid, stains, and by holding the specimens at various angles in reflected light in order to "flash" the calcite crystal. In some specimens it was necessary to make thin sections and use a polarizing microscope and crossed nichols to see the plate outlines. By using these techniques, however, it was possible to determine the plate arrangement of the lantern supports in many species of the Oligopygoida, and a similar arrangement was observed in all of them.

Previously, Pijpers (1933, p. 86) stated that the auricles in his *Bonaireaster rutteni* (herein referred to *Haimea*) "are blunt processes, closely approaching interambulacrad." These "auricles" are visible in his plate 1, figure 6. Durham and Melville (1957, p. 257, text figs. 2, 3, 4) described and figured the "auricles" in *Haimea ovumserpentis* and *Haimea rutteni.* Except for these two references no one else has described the lanterns or their supports in any oligopygoid.

One of the most surprising discoveries in this study of the Oligopygoida is that not all of these lantern supports are really auricles. Eight of the lantern supports are true auricles (as defined in the glossary of the Treatise, Durham and Wagner, 1966, p. U 352) in that they are ambulacral in origin; however, the lantern supports in the posterior areas of interambulacra 4 and 1 are formed from interambulacral plates and should therefore, by definition, be called apophyses. Many specimens were studied to make sure both auricles and apophyses were present in the same specimen because no such condition had been reported before in any echinoids. Both were found in every specimen studied in every species of *Oligopygus* and *Haimea* in which a sufficient number of specimens were present to permit dissection. Furthermore, the two apophyses are always in the areas of interambulacra 1 and 4. The lantern supports are described and illustrated below for three of these species.

OLIGOPYGUS HALDEMANI

There are three fragments of one specimen of *Oligopygus haldemani* in the U.S. National Museum that are exceptionally well preserved showing the micro features of the exterior of the test (pl. 3, figs. 1, 2), and with the sutures evident between most of the plates. These fragments were photographed at high magnification under glycerine, dried, and stained with red and black ink, and their sutures drawn on the photographs. The fragments were etched slightly with hydrochloric acid where the sutures were not visible, and stained. The specimen was also held at various angles in reflected light in order to "flash" the calcite crystals.

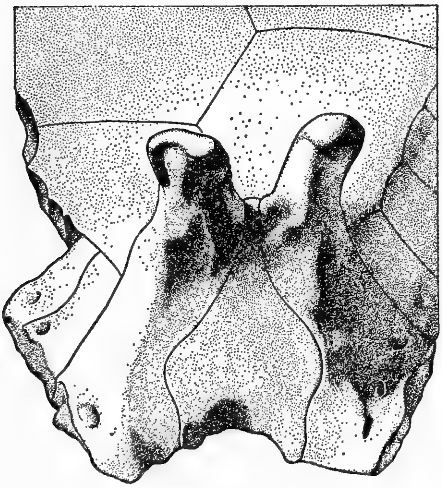


Fig. 13.—Fragment of a test of *Oligopygus haldemani* (Conrad) showing the lantern supports in interambulacrum 5: supports are auricles formed by the basicoronal ambulacral plates of half-ambulacra Vb and Ia which curve toward each other and almost meet over the first plate of interambulacrum 5. USNM 649834, from the late Eocene, Ocala Limestone, at USGC 7097, Flint River at old factory above Bainbridge, ×10.

One of the fragments is a portion of the adoral part of interambulacrum 5, ambulacrum Vb, Ia, and the posterior auricles. The auricles are clearly ambulacral in origin and are formed by the basicoronal ambulacral plates of half-ambulacrum Vb and Ia (text fig. 13). These plates curve towards each other and almost meet over the first plate (number 1) of interambulacrum 5. The plates are pierced by ambulacral pores and are undoubtedly ambulacral.

A second fragment is of a portion of the adoral part of interambulacral 4 and half-ambulacra IVb and Va. In this area, the anterior lantern support structure (text fig. 14) is an auricle formed by the basicoronal ambulacral plate of ambulacrum IVb, but the posterior support is an apophysis formed by interambulacral plate 1 of interambulacrum 4. While cleaning this specimen, the basicoronal plate of half-ambulacrum Va separated along its suture from the rest of the fragment. This separation was a fortunate accident in that it exposed interambulacral plates 2 and 4 (text figs. 14A, B). These two plates, together with 3, are visible from the outside of the test, but not from the inside. Plate 2 extends only a short distance into

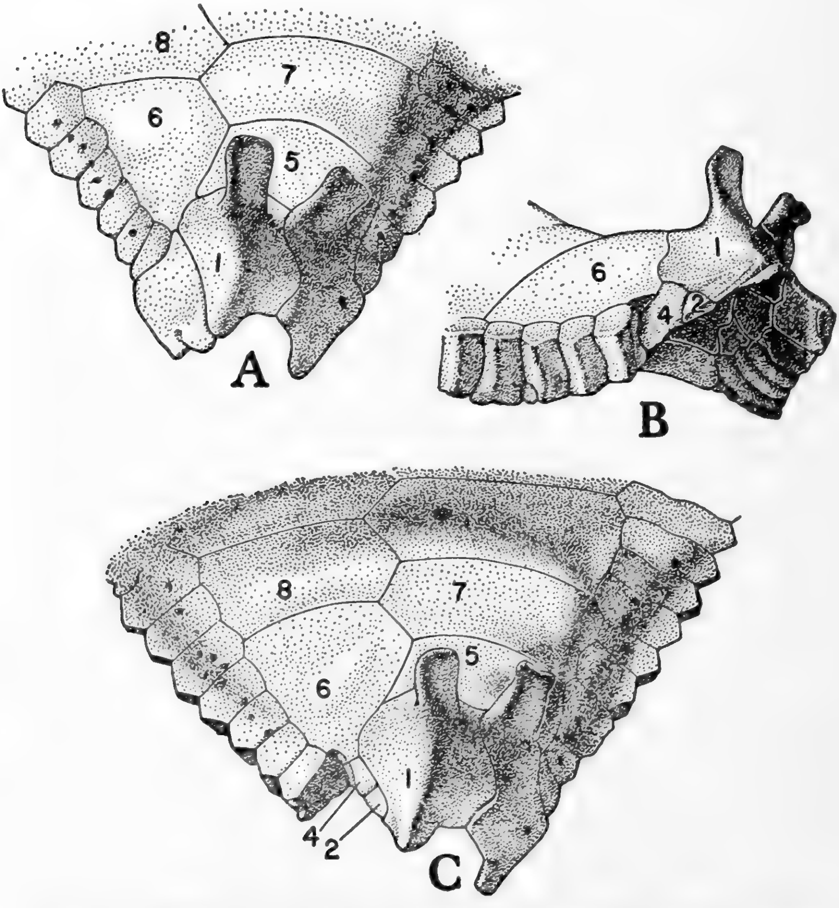


FIG. 14.—Fragment of a test of *Oligopygus haldemani* (Conrad) showing the lantern supports in interambulacrum 4: Fig. A, specimen before the basicoronal plate of half-ambulacrum Va was removed; anterior support structure (right) is an auricle formed by the basicoronal ambulacral plate of ambulacrum IVb, but the posterior support is an apophysis formed by interambulacral plate 1 of interambulacrum 4. Fig. B, side view of interambulacral plates 2 and 4 which are visible from the outside of the test but do not extend through to the interior. Fig. C, specimen after the removal of the basicoronal ambulacral plate. All figures are ×8 (see text figs. 13 and 15).

the test and is separated from the interior by plates 1 and 4. Plate 4 in turn is separated from the interior by plates 1 and 6.

The third fragment is of the adoral portion of interambulacrum 3 and half-ambulacra IIIb and IVa. The lantern supports are definitely auricles (text fig. 15) although the plate sutures are not as clear on this specimen. Interambulacral plates 2, 3, and probably 4 are not visible from the interior of the test.

The observations made on these fragments were later confirmed by the discovery of another specimen of *O. haldemani* (pl. 10, fig. 1) in which most of the plate sutures are discernible. The anterior paired lantern supports in interambulacra 2 and 3 and the posterior in interambulacrum 5 (text fig. 16) are also auricles (ambulacral). As in the other specimen, however, the posterior paired supports in interambulacra 4 and 1 are of mixed origin. The anterior support of each pair is an auricle but the posterior an apophysis. The reason for the interambulacral origin of this posterior support is apparent on this specimen. These lantern supports, as can be seen on text figure 16, are shifted so far anteriorly that the lantern supports occur at a considerable distance from the posterior paired ambulacra. This distance is so great that if the posterior element of the lantern support was an auricle it would have to be an extremely wide plate to extend from the ambulacra to its present anterior position.

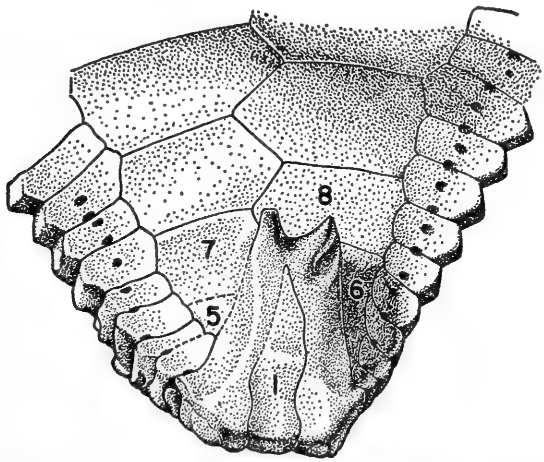


FIG. 15.—Fragment of a test of *Oligopygus haldemani* (Conrad) showing the lantern supports in interambulacrum 3: supports are auricles formed by the basicoronal ambulacral plates of half-ambulacra IIIb and IVa which curve toward each other and meet over the first plate of interambulacrum 3. Interambulacral plates 2, 3, and probably 4 are not visible from the interior of the test; ×8 (see text figs. 13 and 14).

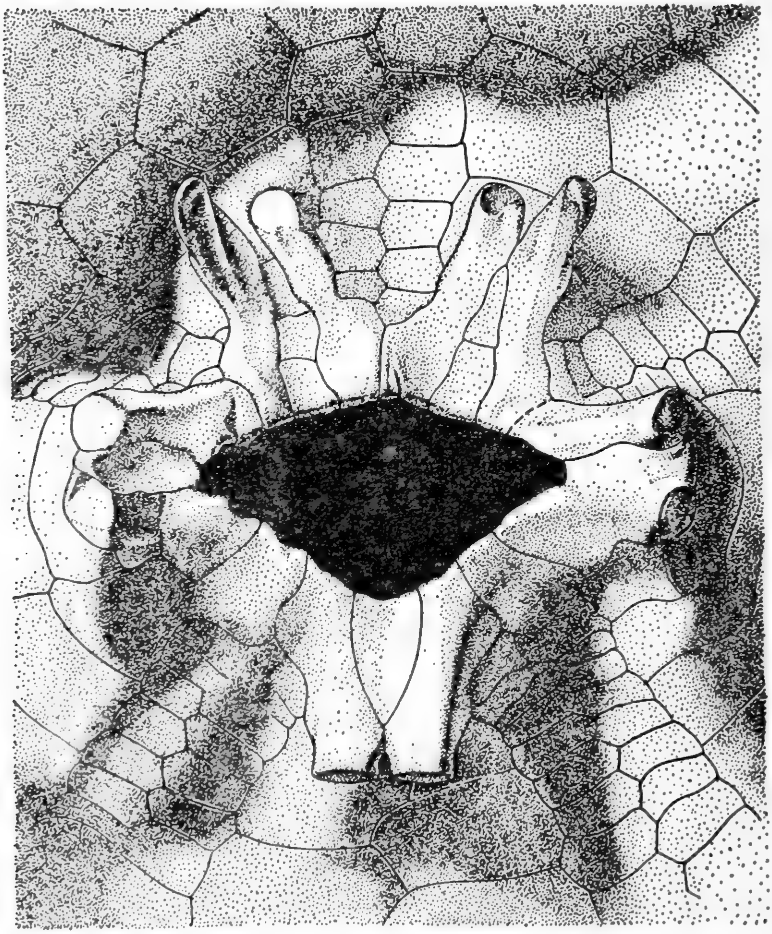


FIG. 16.—Lantern supports of *Oligopygus haldemani* (Conrad): anterior paired and single posterior supports are auricles formed by the basicoronal ambulacral plates; posterior paired supports are composed of both auricles and apophyses with the anterior support of each pair formed by an ambulacral plate, but the posterior by the first interambulacral plate. Note that interambulacral plate 1 in interambulacrum 1 is fractured producing a crack which resembles a suture. USNM 649840, from the late Eocene, Crystal River Formation, at Cunard Pit, 3.0 mi. N. of the crossing of U.S. 441 and U.S. 301 on U.S. 441, east side of road, near Ocala, Florida, ×8.

OLIGOPYGUS WETHERBYI

The lantern support structures in *O. wetherbyi* are similar in all respects to those in *O. haldemani.* The supports in interambulacra 2, 3, and 5 are pairs of auricles but in interambulacra 4 and 1 (text fig. 17) the anterior supports are auricles and the posterior apophyses. One of these apophyses is particularly evident in the specimen figured on plate 10, fig. 3 in which the suture is very evident between the basicoronal plate of ambulacrum V and the apophysis formed by the first plate of the adjacent interambulacrum 4. It was possible to see that interambulacral plates 2 and 3 do not pass through to the interior of the test (text fig. 17) in one of the specimens in which the plate sutures were visible on the outside and inside.

HAIMEA RUTTENI

The lantern supports in *Haimea rutteni* are similar in origin to those in the previously described species of *Oligopygus,* having auricles in interambulacra 2, 3, and 5, and anterior areas of 4 and 1, but apophyses in the posterior areas of 4 and 1 (text fig. 18). The plate sutures are particularly clear in the specimen figured on plate 9, and text figure 18, and there can be no doubt that the posterior supports in interambulacra 4 and 1 are apophyses.

The supports of *H. rutteni* differ from those in *O. haldemani* and *O. wetherbyi* in having the tips of a pair more widely separated, and a wider, larger basicoronal interambulacral plate (as exposed interiorly) between a pair of auricles. The basicoronal plates in interambulacra 2, 3, and 5 of *H. rutteni* (pl. 9; text fig. 18) are so broad that they completely separate the auricles, whereas in *O. wetherbyi* (text fig. 17A) and commonly in *O. haldemani* the auricles are in contact dorsally in these areas.

Finally, the lantern supports in interambulacra 4 and 1 (posterior paired) in *H. rutteni* are not as tilted anteriorly as those in *O. wetherbyi* and *O. haldemani.*

PROTRACTOR MUSCLE SUPPORTS

Structures that appear to be protractor muscle supports are visible in several of the better preserved specimens of *Haimea rutteni.* Two protuberances are present (see pl. 8, fig. 4) in each ambulacrum at the border of the peristome. Each is part of a basicoronal ambulacral plate extending dorsally and away from the edge of the peristome. These protuberances may have served for the attachment of the protractor muscles from the lantern.

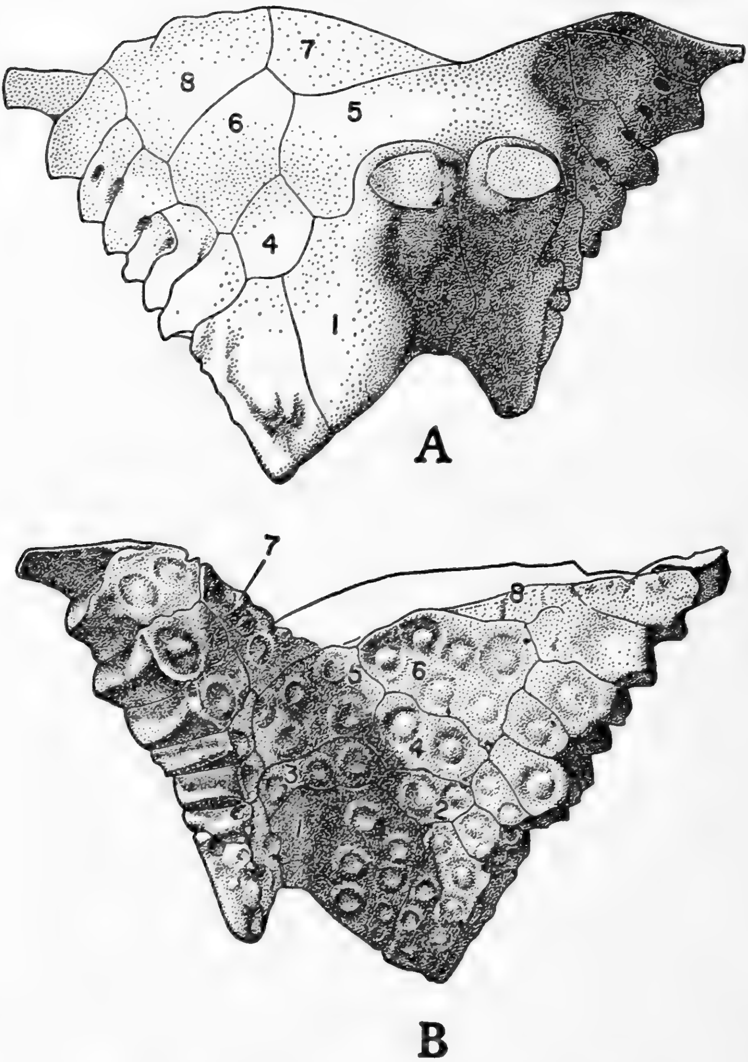


FIG. 17.—Fragment of a test of *Oligopygus wetherbyi* de Loriol with lantern supports and plate arrangement in interambulacrum 4: fig. A, the anterior support (right side) is an auricle formed from the basicoronal plate of ambulacrum IVb. The posterior support is an apophysis formed by the first plate of interambulacrum 4. Comparison of fig. A (interior) with fig. B (exterior) shows that interambulacral plates 2 and 3 do not extend through to the interior of the test. USNM 649853, from the late Eocene, Crystal River Formation from the Ocala Lime Co. quarry, 4.1 mi. N. of crossing of U.S. 301 and 441 near Ocala, Florida, ×8.

These structures were not visible on any of the other species of *Oligopygus* and *Haimea* although some thickening of the basicoronal plates occurs in *Oligopygus wetherbyi* and *O. haldemani.*

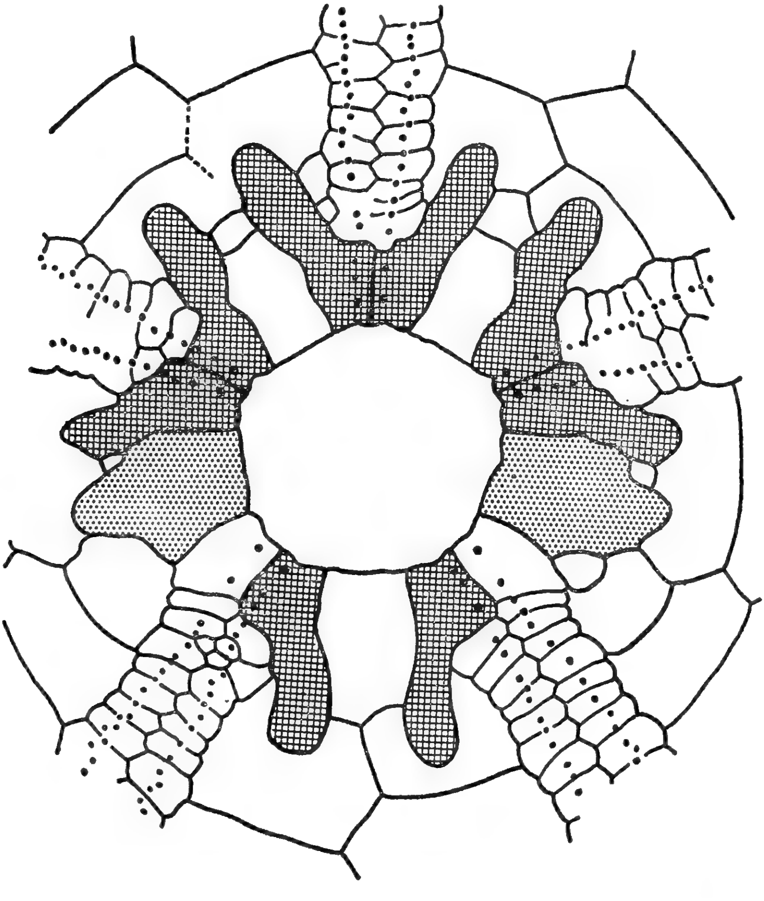


FIG. 18.—Plate arrangement of interior of test around peristome in *Haimea rutteni* (Pijpers) showing the plate arrangement of the lantern supports (indicated by stippling or cross hatching). The two anterior pairs of lantern supports and the single posterior pair are auricles formed by basicoronal ambulacral plates (cross hatched), but the two posterior pairs of supports are formed from both ambulacral and interambulacral plates. The anterior support of each pair is formed by the basicoronal plates of ambulacra II or IV but the posterior supports are formed from the first interambulacral plate (stippled) of interambulacra 4 and 1. USNM 649857, from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco; ×10.

SUTURES

The sutures between most of the plates in all the species of *Oligopygus,* but not in *Haimea,* are corrugated resulting in the interlocking of the adjacent plates. Similar corrugations have been reported in the temnopleurids, and are present in the clypeasteroid *Tarphypygus.* This feature is usually evident only on extremely well-preserved specimens in which the plate borders are not obscured by secondary calcite. It is well shown in a specimen of *Oligopygus haldemani* in which many of the plates were separated along their sutures. On this specimen it is easily demonstrated that these corrugations are interlocking and that what is a notch on one side of the suture is a groove on the other side. A rubber impression (pl. 11, fig. 3) was made of the sutural face of the lower plate after separating two interambulacral plates along their transverse suture. This rubber impression was identical with the sutural surface of the upper plate (pl. 11, fig. 2) showing that the sutural faces of the two plates fit one into the other.

The corrugations are random in their organization and occur on the transverse (pl. 11, figs. 1–3) and interradial (pl. 11, fig. 6) sutures between interambulacral plates, the adradial suture (pl. 11, figs. 4, 5) between ambulacral and interambulacral plates, and on the perradial suture between ambulacral plates. They are absent on the transverse sutures between ambulacral plates, this being a smooth sutural face.

These corrugations do not extend to the inner or outer margin of the plates. Here there is a narrow smooth band along the plate borders. Therefore, these corrugations are not evident at the surface of well-preserved specimens, but only on weathered specimens where the weathering has removed this smooth band and reached the inner corrugated section. The corrugations presumably occur on all individuals of a species.

These corrugations evidently served to strengthen the bond between the plates of the test. The interlocking of adjacent plates would help to prevent the shifting or sliding of the plates along their sutures. Furthermore, because of these corrugations, the sutural area is much greater than that found in smooth sutures. The greater this area, the greater the amount of tissue holding the plates together.

It is not clear why species of *Oligopygus* required such a strong test. From the paleoecological data available, it is apparent that individuals of this genus did not commonly live in the surf zone where a heavy rigid test would be advantageous. Therefore, it is more likely that the strong test was developed as protection against predators. A similar situation occurs in many of the Recent clypeasteroids such as *Clypeaster rosaceus* (Linnaeus) and *Encope michelini* Agassiz which have strongly reinforced tests (accomplished in a different manner) but do not live in the surf zone.

GLASSY TUBERCLES

Glassy tubercles are strongly developed on *Oligopygus zyndeli* and *O. kugleri.* They are prominent, rising above the general surface, and are scattered all over the test (pl. 10, fig. 2). Their presence on other species is uncertain because of the poor surface preservation of most of the specimens. A slight amount of weathering is sufficient to remove the "glassiness" from these tubercles, and only if they are extraordinarily large, as in *O. zyndeli* and *O. kugleri,* are they evident. Probably, many of the larger secondary tubercles found in the other species of the Oligopygoida were glassy tubercles.

BOURRELETS

The interambulacra at the peristome are externally inflated (pl. 4, fig. 3) forming bourrelets in most of the species of *Haimea. Oligopygus,* with its irregularly shaped peristome, has no bourrelets.

CHANGES DURING GROWTH

The smallest oligopygoid studied was a specimen of *Oligopygus haldemani* (Conrad) 4 mm long from a collection of specimens varying in length up to 37 mm. In this small specimen (text fig. 19A), there are no pore-pairs in any of the petals except petal III, which has four in each poriferous zone. It would be expected that pores would first appear in this petal because usually more than four more pore-pairs are present in adults in this petal than in any other of the petals.

The peristome is much larger relative to the length of the test in this small specimen (text fig. 19A) than in an adult (text fig. 19C). The width of the peristome is 27 percent of the length of the test in this specimen, but usually only 12 percent in an adult. Furthermore, in the small specimen the width of the peristome is about the same as the height, whereas in an adult the width greatly exceeds the height.

The periproct on the small individual is visible from the adapical side (text fig. 19A), but on a specimen 8.7 mm long (text fig. 19B) it is on the adoral surface, and in a larger specimen, 17.3 mm long (text fig. 19C) it is nearer the peristome.

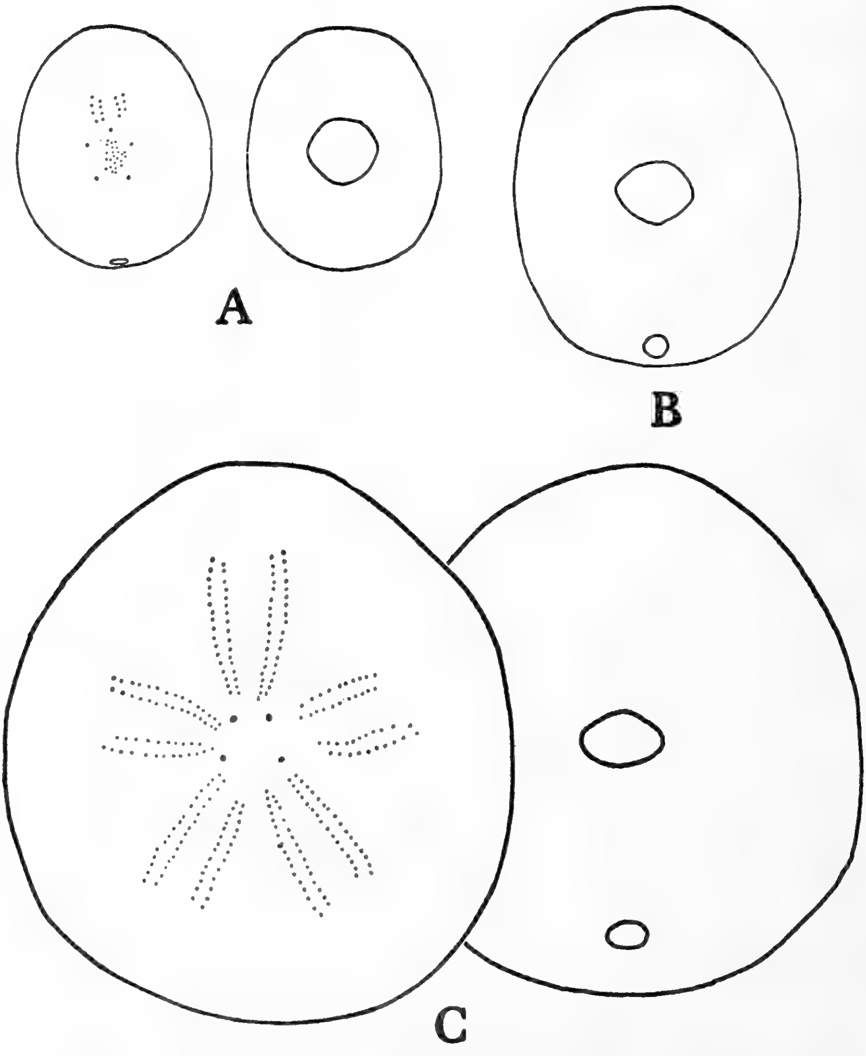


FIG. 19.—Three specimens of *Oligopygus haldemani* (Conrad) showing growth changes: Fig. A, 4 mm long (smallest), genital pores absent, no pore-pairs in petals except petal III, and periproct supramarginal. Adorally, peristome very large with height almost as great as width. Fig. B, 8.7 mm long, peristome relatively smaller, lower, and the periproct inframarginal. Fig. C, 17.3 mm long, peristome lower and periproct nearer peristome. Fig. A, Adapical and adoral view of USNM 649854; ×8. Figure B, adoral view of USNM 649855, ×4. Fig. C, adapical and adoral views of USNM 649856, ×4; all specimens from the late Eocene, Crystal River Formation from the Ocala Lime Co. quarry, 4.1 mi. N. of crossing of U.S. 301 and 441, near Ocala, Florida.

The apical system decreased in size relative to the test during growth. In the smallest specimen (text fig. 19A), it is 20 percent as long as the test, but in a larger specimen, 17.3 mm long (text fig. 19C) it is only 10 percent as long. No genital pores are present in the smallest specimen, and none were present in any specimens smaller than 9.5 mm long.

CRYSTALLOGRAPHY

Raup (1966, p. 562) reported that in *Oligopygus* the *c*-axis orientation in the calcite plates changed systematically along the plate column from the oldest to the youngest plates. The axes plunge toward the apical system in the oldest plates, but are perpendicular near the ambitus, and then increasingly plunge away from the apical system in the younger plates above the ambitus. Raup termed this type of orientation "ontogenetic variation type B." I have also found this type of orientation in all the specimens of this genus studied crystallographically.

Raup reported in *Haimea,* however, that the *c*-axes were not as in *Oligopygus,* but were uniformly perpendicular. He based this conclusion on crystallographic determinations made on a specimen referred to *H. alta* (Arnold and Clark), and a specimen referred to *H. gigantea* Sánchez Roig. It is apparent from studies of a large number of topotypic specimens that *H. gigantea* is a synonym of *H. alta* and that only one species is really represented. Although in *H. alta* the *c*-axes appear to be perpendicular, most of them are not, and they are similar to *Oligopygus* in belonging to ontogenetic variation type B.

The older plates in *H. alta* near the peristome, as shown in text figure 20A, have their *c*-axes plunging towards the apical system (in relation to a plane tangential to the plate surface). This plunge increases in the younger plates and by the fourth or sixth plate the axes are perpendicular. From this point on, the axes plunge more away from the apical system. Although this orientation is of the ontogenetic type B, the inclination of the axis from the perpendicular is so little that it is easy to see how it could have been mistaken for perpendicular.

The axes in *Haimea ovumserpentis* (Guppy) undergo a far wider range, and in the younger plates, as can be seen in text figure 21, are nearly parallel to the surface of the test. Their orientation is very similar to that described by Raup (1966, text fig. 2b) in *Oligopygus wetherbyi* de Loriol. In *Haimea rutteni* (Pijpers) (text fig. 20B)

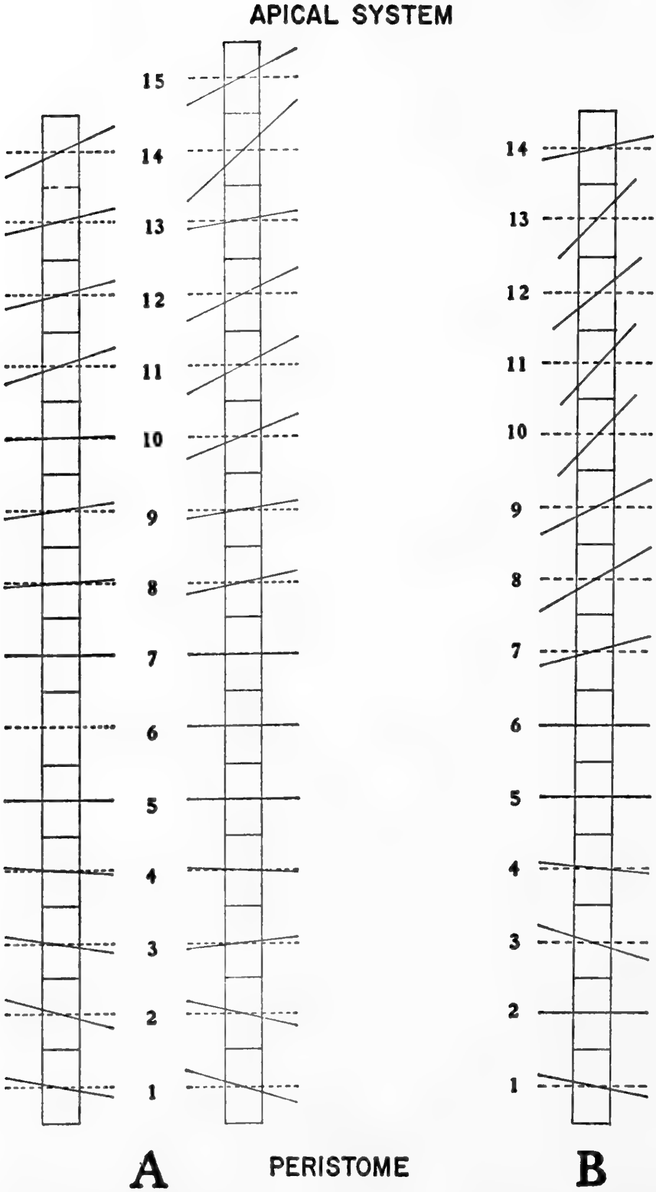


FIG. 20.—Orientation of *c*-axes in ambulacral plates in two specimens of *Haimea alta* (A) and one of *H. rutteni* (B): dashed line = line normal to the test; left side of column = inside of test, right side = outside; oldest plates near peristome are at the bottom, the youngest at the top. The values for the angles for the axes are given in table 1. Note, axes in the oldest plates plunge toward the apical system at an increasing angle until by plate 5 they are perpendicular. The shift continues apically with an increasing plunge away from the apical system. This orientation belongs to Raup's (1966) ontogenetic variation type B.

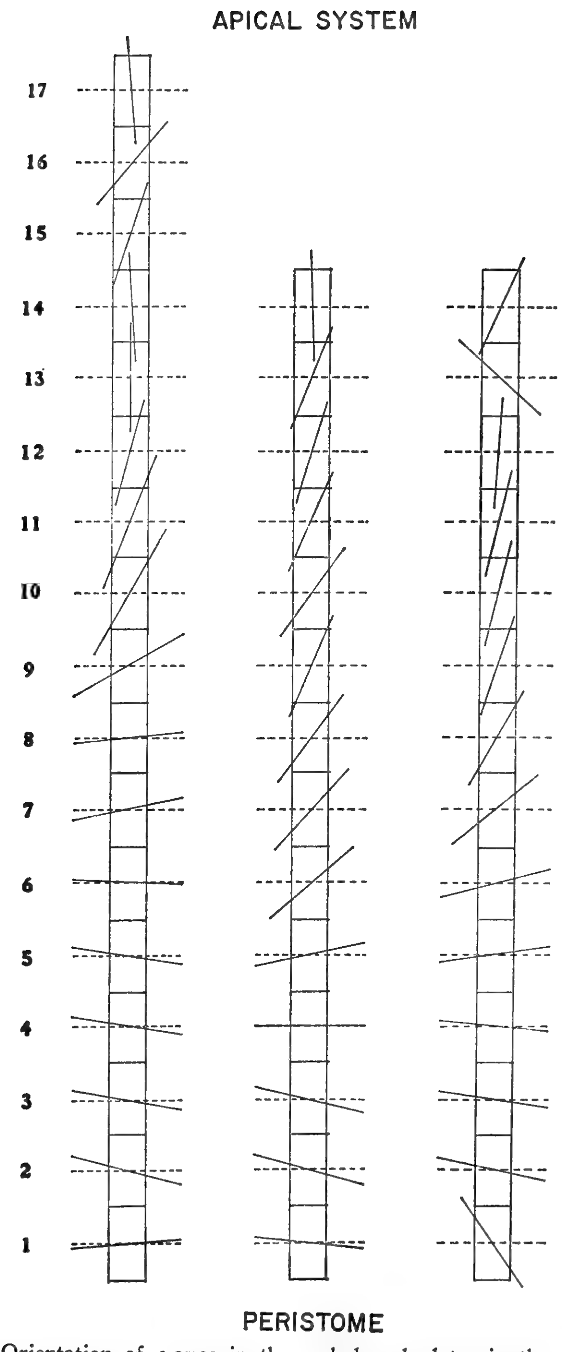


FIG. 21.—Orientation of *c*-axes in the ambulacral plates in three specimens of *Haimea ovumserpentis* (see fig. 20 for explanation of symbols). Note, axes in the oldest plates plunge toward the apical system at an increasing angle until by plate 4 to 7 they are perpendicular or tilt away from apical system. This tilt increases apically until in some plates the axis is parallel to the surface of the test. This orientation belongs to Raup's (1966) ontogenetic variation type B.

TABLE 1.—*Crystallographic data: The angle of plunge of the* c-*axes in ambulacral plates in specimens of* Haimea alta, H. rutteni, *and* H. ovumserpentis

[These axes are shown diagrammatically in text-figures 20 and 21. The angle is given for each plate chronologically from the peristome to the apical system with plate number 1 at the peristome. The plunge is positive if the axis plunges towards the apical system, negative if away from the apical system, and is measured from a plane parallel to the surface of the test. A tangential *c*-axis would be 0°, an axis perpendicular to the surface, 90°. Measurements in degrees.]

	PLATE NUMBERS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
H. alta																	
Spec. 1	+80	+75	+81.5	+87	90	-	90	—87	—82	—89	—71.5	—76	—77	—65.5			
Spec. 2	+73.5	+77	—84	+88	90	90	90	—79.5	—81	—78	—73	—74.5	—81	—57	—63.5		
H. rutteni	+79	90	+72	+85	90	90	—75	—60.5	—63.5	—43.5	—43	—51	—44	—78			
H. ovumserpentis																	
Spec. 1	—86	+74.5	+79.5	+81	+81	+88	—78.5	—84	—60	—29.5	—28	—14.5	0	+4.5	—19.5	—40	+4.5
Spec. 2	+84.5	+74	+76.5	90	—78	—48.5	—42	—36.5	—22.5	—36	—23	—17	—21.5	+1			
Spec. 3	+34.5	+78	+82	+84.5	—82	—75.5	—42	—29.5	—18.5	—13.5	—13.5	—3.5	+47	—24			

the *c*-axes of the older plates are similar to *H. alta* in being almost perpendicular, but in the younger plates are more inclined with more plunge away from the apical system.

The crystallographic data for two specimens of *H. alta,* three of *H. ovumserpentis,* and one of *H. rutteni* are given in table 1. It seems evident from these data that the orientation of the *c*-axis is probably significant at the specific level. In all the specimens of *H. alta* studied herein and by Raup (1966), the axes were nearly perpendicular, whereas in the three specimens of *H. ovumserpentis* the axes in the younger plates are much more inclined. In conclusion, both *Oligopygus* and *Haimea* exhibit "ontogenetic variation type B" crystallographic orientation.

ABNORMAL SPECIMENS

One specimen of *Haimea* sp. from Jamaica is a partial hexamerous variant (pl. 12, figs. 1, 2; text fig. 22). The normal number of genital pores are present in the apical system but six ocular plates are also present, the extra ocular being between the anterior genital pores. The extra ambulacrum extends from one of these oculars and continues until near the peristome where it merges with ambulacrum III behind the first two plates (bearing buccal pores). The two ambulacra partially merge adapically where the outer pores of each pair alternate in a single line. In text figure 22 the plate sutures are not shown between the two ambulacra because they are obscured on the specimen by the crowded pores. The extra interambulacrum is absent at the peristome but present immediately behind the first ambulacral plates. Adapically it ceases for a short distance causing the merger of the adjacent ambulacra.

Another Jamaican specimen of *Haimea* sp. is a tetramerous variant. On this specimen (pl. 12, fig. 3), ambulacrum III and its two adjacent half-interambulacra are evidently the missing components. The two anterior petals present on the specimens are both of equal length and shorter than the posterior two, leading to the supposition that they are the anterior paired petals, because they are normally the shortest and of equal length. Only three genital pores are present.

Five genital pores are present in a Jamaican *Haimea* sp. with the extra pore occurring between the posterior paired petals (pl. 12, fig. 5).

A specimen (pl. 12, fig. 4) of *Oligopygus jamaicensis* Arnold and Clark has its adapical plates distorted with the apical system displaced to the upper left, and its petals twisted. Both petals III and IV are shorter than normal. Adorally, the plate arrangement is normal showing that this distortion occurred after these adoral plates had been formed.

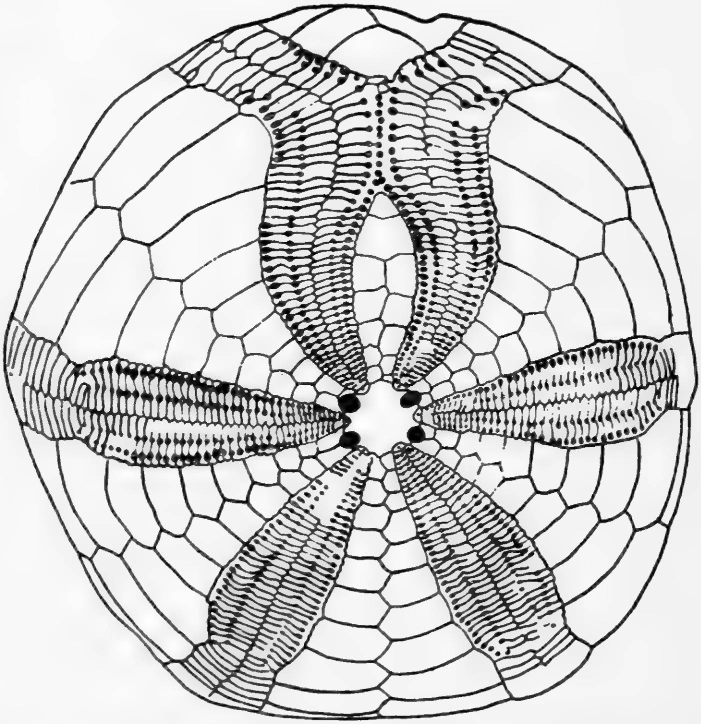


FIG. 22.—Partial hexamerous variant of *Haimea* sp.: Adapically, six ocular plates, six petals and part of sixth interambulacrum; extra petal merges with petal III for a short distance, and the outer pores of each alternate in a single line; plate sutures are obscured by crowded pores. Adorally, the extra ambulacrum and interambulacral half-areas do not reach the peristome, but are separated from it by the first ambulacral plates of ambulacrum III. MCZ 3471 from Jamaica (no further locality data available); ×2.5 (see pl. 12, figs. 1, 2).

CLASSIFICATION

HISTORY

Michelin (1851, p. 93) referred his genus *Haimea* to the cassiduloids because of what he considered to be its resemblance to *Echinoneus, Discoides, Globator, Pygaulus,* and *Pygorhynchus.* Desor (1857, p. 256) and Pomel (1883, p. 56) placed *Haimea* in the tribe

"Caratomes" of the cassiduloids, but noted its similarity to the fibularids. De Loriol (1888, p. 395) considered his genus, *Oligopygus,* related to *Echinolampas,* and Lambert and Thiéry (1921, p. 335; 1924, p. 387) placed *Haimea* with *Echinoconus,* but *Oligopygus* with *Echinolampas.* Later Lambert (1932) recognized the affinity of the two genera to each other and put them together in the tribe Oligopyginae of the subfamily Haimeidae [sic] of the family Echinobrissidae. Hawkins (1926, p. 372) regarded *Haimea ovumserpentis* as an holectypoid transitional between the Echinoneidae and the Echinolampadidae.

Pijpers (1933, p. 84) referred his genus *Bonaireaster* (herein considered a synonym of *Haimea*) to the Echinocyamidae. He did not compare his genus to *Oligopygus* or *Haimea.*

Mortensen (1948) placed *Haimea* and *Oligopygus* in the family Cassidulidae but thought that they resembled the fibularids. Because he thought that a lantern was absent in *Haimea* and *Oligopygus,* however, he considered that there was no relation between them and the fibularids. He placed *Bonaireaster* in incertae sedis among the cassiduloids, but stated that he considered it very similar to *Haimea* and *Oligopygus* except that a lantern was present in *Bonaireaster.*

It is important to note that none of the workers before Durham and Melville (1957, p. 256) realized that a lantern was present in *Haimea* and *Oligopygus.* Durham and Melville, and Wagner and Durham (1966, pp. U447–450) considered the Oligopygidae to include *Oligopygus, Haimea, Bonaireaster,* and perhaps *Protolampas, Microlampas,* and *Ovulechinus.* They referred the family to the suborder Conoclypina of the order Holectypoida. Phillip (1965, p. 59) retained the Oligopygidae in the Conoclypina but placed this suborder in the order Cassiduloida.

AFFINITIES

The Oligopygoida, because of their well-developed lantern and many other differing characters, are obviously excluded from the Holasteroida, Spatangoida, and Neolampadoida. They differ from the Pygasteroida by having petals, irregularly arranged crenulate tubercles, sphaeridia in the middle of the ambulacra, monobasal apical system, no branchial slits, bilateral symmetry, and interradial lantern supports. They are distinguished from the Cassiduloida by their lack of phyllodes, presence of demiplates at the ambitus, and well-developed lantern in adults.

The only two dentate orders of "irregulars" that remain for consideration are the Holectypoida and Clypeasteroida. The Oligopygoida have many characters in common with both these orders but can be distinguished from them.

Durham and Melville (1957, p. 256) divide the Holectypoida into three suborders: Holectypina, Echinoneina, and Conoclypina. The Oligopygoida differ from the Holectypina in having interradial auricles instead of radial, in having petals, and irregularly distributed tubercles. They differ from the Echinoneina in having petals. Durham and Melville included in the suborder Conoclypina two families: the Conoclypidae and the Oligopygidae. Although the petals in *Conoclypus* are similar to those in the Oligopygoida, the ambulacra beyond the petals are very different. In *Conoclypus,* the ambulacra from the end of the petal to near the peristome consist of primary plates pierced by single pores arranged in a straight line. Near the peristome, the pores are crowded and a phyllode is developed. Mortensen (1948, p. 346) was in error when he stated that the pore series remain in a straight line. Durham and Melville (1957, p. 258) considered the adoral ambulacral structure as a discoidiid pattern. Although some of the previous workers have given line drawings (Duncan and Sladen reproduced in Mortensen, 1948, text fig. 318) showing a discoidiid pattern, I have not seen this pattern on any of the many specimens I have studied. The arrangement of the pores and the plates is similar to that found in the phyllodes of many of the cassiduloids.

A well-preserved lantern has never been described in *Conoclypus* but according to de Loriol's (1880, pl. 2, figs. 16a, 16c; 1881, pl. 2, figs. 3, 4) figures the lantern appears to be high, with its greatest width near the top, and lacks lamellae. In the Oligopygoida the lantern has its greatest width low, and has well-developed lamallae.

By including *Conoclypus* in the Holectypoida, as done by Durham and Melville (1957, p. 256) and Wagner and Durham (1966, p. U 447) in the Treatise, it is necessary to assume that all the characters shared by a cassiduloid, such as *Echinolampas,* and by *Conoclypus,* such as the shape of the test, petal arrangement, apical system, phyllodes, bourrelets, and position of periproct, are the result of parallel evolution. It seems much more reasonable to presume that the two genera are closely related and that *Conoclypus* may simply be a cassiduloid that retained its lantern into adulthood.

The fact that a lantern is found in the young of *Echinolampas* indicates that it was present in the young of all its cassiduloid ancestors. Study of the lantern in the immature *Echinolampas* *depressa* Gray (to be described in a later paper) reveals that it was used by the young echinoid and not resorbed before the mouth opened as Mortensen (1948, p. 69) suggested for *Echinoneus.* If an individual cassiduloid retained its lantern longer than its brothers and if this retention was genetically controlled and was advantageous, then an evolutionary trend could develop for a retention of the lantern for a longer and longer period into adulthood, until the lantern was never resorbed.

Conoclypus could be considered a cassiduloid as did Phillip (1965, p. 52), although it might be more convenient to place it in a separate order closely related to the cassiduloids. It seems best not to decide between these two alternatives until a more careful study has been made of *Conoclypus.* The character of the lantern and lantern supports, still not well known, should provide valuable clues as to the affinities of the genus.

The Oligopygoida are very similar to the Clypeasteroida. Many of the clypeasteroids have a similar monobasal apical system with four genital pores and separate ocular plates. The sexual dimorphism of large genital pores in the female, suggested in the Oligopygoida, is also present in the fibularids. The petals of the Oligopygoida are very similar to those found in many of the clypeasteroids, and the shape of the test is very like that found in the fibularid *Tarphypygus.* Likewise the tuberculation in the Oligopygoida with small, irregularly arranged, deeply sunken, crenulate, perforate tubercles is common in the clypeasteroids.

Perhaps the most striking similarity between the two groups is in the lantern. The lantern in the Oligopygoida and the Clypeasteroida is similar in having the greatest dimension horizontal due to the great development of the external wings, pyramids that expand downward, pentagonal horizontal section with unequal pyramids, an expanded symphysis, and in most of the clypeasteroids lamellae present on the wings.

The oligopygoid lantern most resembles among the Clypeasteroida the lantern of the Fibularidae. They are similar to each other in having the largest tooth number 5, the smallest 2 and 3, and 1 and 4 intermediate. The symphysis is similar in both, and no fossae are present in either. Both lanterns are high with erect teeth, and in most of the fibularids lamellae (see pl. 8, fig. 4; text fig. 12) are present. Mortensen (1948, p. 162) is mistaken in his statement that no lamellar structure is present in the wings of the fibularids. Lamellae are present in six of the eight species of *Echinocyamus* and *Fibularia* in the collections of the U.S. National Museum (*Fibularia* *ovulum* Lamarck, *F. cribellum* de Meijere, *F. acuta* Yoshiwara, *F. volva* Agassiz, *Echinocyamus crispus* Mazzetti, and *E. megapetalus* Clark). They are lacking in *E. grandiporus* Mortensen and *E. pusillus* Muller. The lantern of the latter species is figured by Loven (1892, figs. 102–109, 141) under the name *E. angulosus.*

Although the Oligopygoida are so similar in many characters to the clypeasteroids, the absence of accessory pores and the presence of demiplates beyond the petals in the Oligopygoida distinguish the two groups. All the clypeasteroids have accessory pores but a careful search has revealed no accessory pores in any of the species of the Oligopygoida. Furthermore, in none of the clypeasteroids are demiplates present beyond the petals. Finally, in the Oligopygoida the ambulacra on the adoral surface are narrower than the interambulacra, whereas, in all the clypeasteroids they are wider.

Because the Oligopygoida are so distinct from all the other groups of echinoids there seems to be no other alternative but to place them in a separate order, the Oligopygoida. This order contains one family, the Oligopygidae including two genera, *Oligopygus* and *Haimea.*

ANCESTOR

It is very difficult to suggest the ancestry of this order because it is so distinct from other echinoids living at the same time and earlier. In fact there are no known echinoids that appear to be near ancestors. Probably an ancestor of the Oligopygoida had a well-developed lantern, and its periproct outside of the apical system. Only two orders of irregulars had well-developed lanterns, the Holectypoida and the Clypeasteroida. Most of the clypeasteroid families, however, are not known from rocks older than those bearing the Oligopygoida. The Fibularidae, oldest clypeasteroid family, have been found in the Paleocene and possibly in the Late Cretaceous, and it is with this family that the Oligopygoida have the greatest similarity. It appears most unlikely, however, that the Oligopygoida descended from them because the fibularids are typical clypeasteroids with broad adoral ambulacra and accessory pores. It seems more reasonable to suggest that both the Fibularidae (and probably all the clypeasteroids) and the Oligopygoida descended from very closely allied stocks. The predecessor must have been a holectypoid, perhaps a member of the Discoidiidae. The lantern supports in this family appear more closely similar to those found in the Oligopygoida and the Clypeasteroida than those found in any of the other holectypoids. The primary interambulacral plates in the clypeasteroids, the oligopygoids, and the Discoidiidae play an important part in the formation of the lantern supports, which are interradial in position.

Furthermore, the Oligopygoida are similar to the Discoidiidae in having demiplates adorally in the ambulacra. Although the demiplates in the Discoidiidae extend to the interior of the test and are not surficial as in the Oligopygoida their arrangement is similar, with the demiplates inserted in the transverse suture between the primary plates at the adradial suture, and with the greatest concentration of these plates near the ambitus.

It must be emphasized, however, that although the Discoidiidae appear to be the closest known ancestor, they seem very distinct evolutionarily from the Oligopygoida. The lack of petals in the Discoidiidae, presence of tetrabasal apical system, upright lantern with its greatest width high, and lack of large lamellate wings in the lantern indicate a profound gap between them and the Oligopygoida. The fact that the Oligopygoida are so distinct from any other echinoid suggests that there are many echinoid genera which must have lived in the lower Eocene, Paleocene and Late Cretaceous that have not yet been found.

DETERMINATION OF OLIGOPYGOID SPECIES

Unfortunately most of the described species of *Haimea* and *Oligopygus* have been based on specimens collected with little or no stratigraphic control.

For example, Arnold and Clark (1927) described two species of *Oligopygus* and twelve species of *Haimea* from Jamaica. Thirteen of these species were new. Arnold and Clark had little stratigraphic data and no idea of the amount of variation that could be expected within a population of a species, because most of their specimens were purchased from natives. They simply divided up the specimens into different morphological forms, which they called species. Although it seemed probable that they had erected too many species, I hesitated to lump their species, for just as they had lacked evidence for splitting, I likewise lacked evidence for lumping. A visit was made to Jamaica in the hope of finding specimens in measured sections so that a determination could be made of the variation within populations and the stratigraphic relationships of the echinoid-bearing beds. Unfortunately, the collecting was very poor. Most of the old road cuts, where the echinoids were found originally, are now grown over, and very few specimens were found in place. It was evident that the specimens of *Oligopygus* and *Haimea* had come from the Yellow

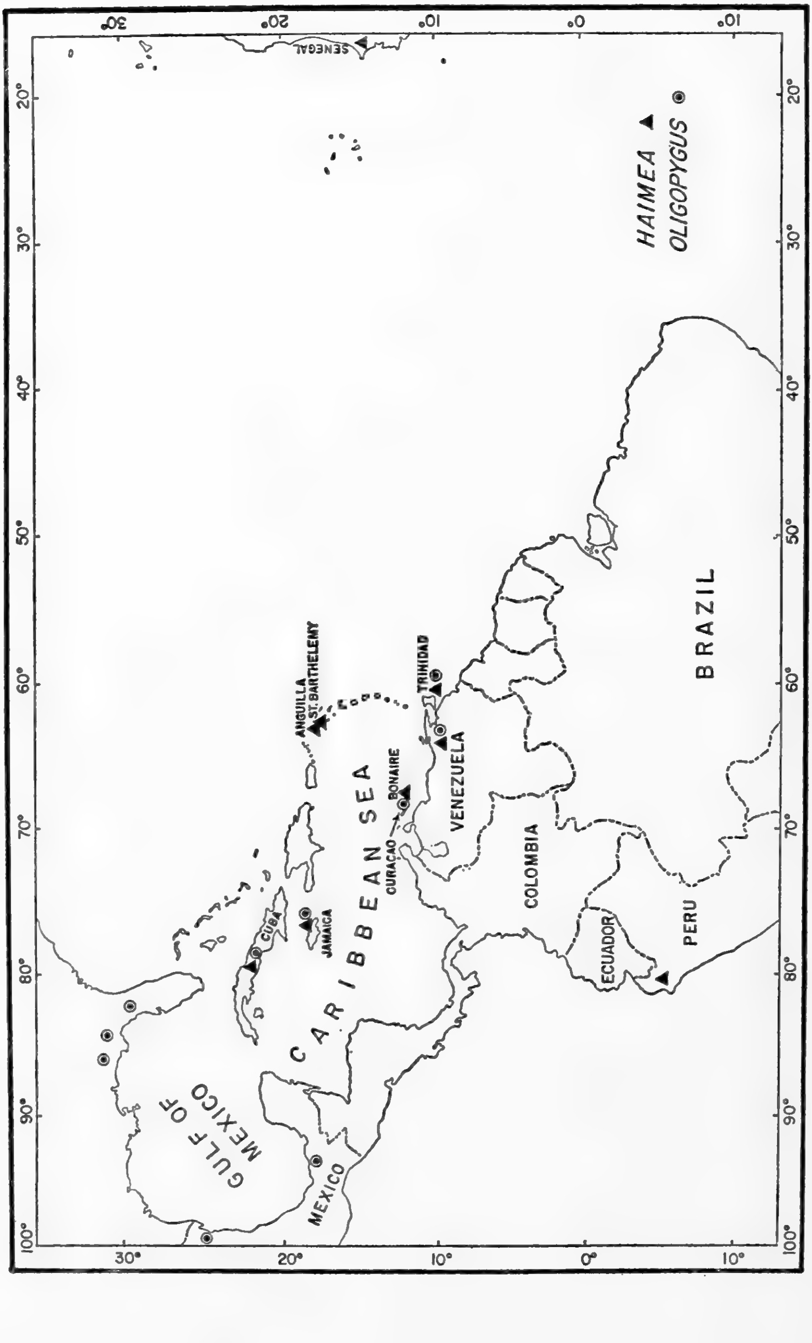


FIG. 23.—The distribution of the Oligopygoida.

Limestone, but considering the thickness of this limestone, and the great variation in the oligopygoids from it, they all could not be considered as living contemporaneously. Probably, the Yellow Limestone was deposited over a long enough period of time that evolution occurred in the echinoid fauna producing many species of oligopygoids.

Therefore, the synonymizing of some of Arnold and Clark's species may not be correct; however, a study was made of the variation in the three Florida species of *Oligopygus*: *O. phelani, O. haldemani,* and *O. wetherbyi.* Specimens of these species have been collected at restricted horizons and the collection can, with reasonable confidence, be assumed to represent a population. From a study of this material, some idea has been gained of the amount of variation that can be expected within a population of *Oligopygus* and which characters in particular are of specific importance. This knowledge is used in the evaluation herein of the validity of the species from Jamaica, and also from Trinidad, and Cuba.

EVOLUTION

It is not possible to determine evolutionary trends between the species because the age of most of the species, relative to each other, is unknown. Although some of the species are reported from the middle Eocene and others from the late Eocene, these age determinations are too unreliable to be used. Of all the species, there are only three whose stratigraphic relationships are certain. *Oligopygus phelani,* new species, is found in the Inglis Limestone which occurs below the Crystal River Limestone containing *O. wetherbyi* and *O. haldemani.*

DISTRIBUTION IN TIME AND SPACE

The oligopygoids (text fig. 23, table 2) have been found in southeastern United States, eastern and southern Mexico, the islands of the Caribbean, northern South America, and western Africa. It is apparent from this distribution that they preferred warm water. The fact that *Oligopygus* occurs further north than *Haimea* (no species of *Haimea* have ever been found in the United States, although *Oligopygus* occurs in great numbers) and *Haimea* further south, suggests that *Oligopygus* may have been less inhibited by cooler water.

The oligopygoids are known only from middle and upper Eocene strata.

TABLE 2.—*List of the nominal species, with their age and locality, that have been referred to* Haimea *and* Oligopygus *or their synonyms.*

Species	Age	Locality
HAIMEA		
H. alta (Arnold and Clark)	middle Eocene	Jamaica and Cuba
Synonyms:		
H. cylindrica Sánchez Roig, 1953, not Arnold and Clark, 1927		
H. subcylindrica Sánchez Roig		
H. pentagona Sánchez Roig		
H. gigantea Sánchez Roig		
H. caillaudi Michelin	late Eocene	Cuba
H. convexa (Arnold and Clark)	middle Eocene	Jamaica
H. cylindrica (Arnold and Clark)	middle and late Eocene	Jamaica
H. elevata (Arnold and Clark)	middle Eocene	Jamaica
H. meunieri (Lambert)	middle Eocene	Senegal
var. *inflata* Lambert		
var. *latipetala* Lambert		
var. *sulcata* Lambert		
H. ovumserpentis (Guppy)	middle and late Eocene	Trinidad, Jamaica, St. Bartholomew, Cuba, Peru, Bonaire
var. *baldryi* Brighton	Eocene	Peru
Synonyms:		
?*H. platypetala* (Arnold and Clark)	middle Eocene	Jamaica
?*H. lata* (Arnold and Clark)	middle Eocene	Jamaica
H. parvipetala (Arnold and Clark)	middle Eocene	Jamaica
H. pyramidoides (Arnold and Clark)	middle Eocene	Jamaica
H. rotunda (Arnold and Clark)	middle Eocene	Jamaica
H. rugosa (Arnold and Clark)	middle Eocene	Jamaica
H. rutteni (Pijpers)	late Eocene	Bonaire
H. stenopetala (Arnold and Clark)	middle Eocene	Jamaica
Inadequately known species of *Haimea:*		
H. camaqueyana Sánchez Roig	middle and late Eocene	Cuba
H. pusilla Sánchez Roig	middle and late Eocene	Cuba
H. globulosa Sánchez Roig	middle and late Eocene	Cuba
H. truncata Sánchez Roig	middle and late Eocene	Cuba
H. hernandezi Sánchez Roig	middle and late Eocene	Cuba
H. alvarezi Lambert and Sánchez Roig	middle and late Eocene	Cuba
Species incorrectly referred to *Haimea* or *Pauropygus*		
P. clarki Lambert		
P. stefaninii Lambert		

TABLE 2.—*Continued.*

Species	Age	Locality
OLIGOPYGUS		
O. costuliformis Jeannet	late Eocene	Trinidad
O. curasavica Molengraaff	late Eocene	Curaçao
O. haldemani (Conrad)	late Eocene	Florida, Georgia
Synonym:		
O. colsoni Lambert	late Eocene	Florida
O. jamaicensis Arnold and Clark	middle Eocene	Jamaica
Synonym:		
O. hypselus Arnold and Clark	middle Eocene	Jamaica
O. kugleri Jeannet	late Eocene	Trinidad
O. nancei Cooke	late Eocene	Venezuela
Synonym:		
?*O. circularis* Sánchez Roig	middle and late Eocene	Cuba
O. phelani Kier, new species	late Eocene	Florida
O. pinguis Palmer	middle and late Eocene	Cuba
O. rotundus Cooke	middle or late Eocene	Alabama
O. sanchezi Lambert	middle and late Eocene	Cuba
Synonym:		
? *O. mullerriedi* Sánchez Roig		
O. wetherbyi de Loriol	late Eocene	Florida
Synonym:		
O. floridanus Twitchell	late Eocene	Florida
?*O. floridanus* var. *laevis* Palmer	middle and late Eocene	Cuba
O. zyndeli Jeannet	late Eocene	Trinidad and Venezuela
Inadequately known species of *Oligopygus*		
O. camagueyensis Sánchez Roig	middle and late Eocene	Cuba
O. christi Jeannet	late Eocene	Trinidad and Venezuela
O. collignoni Lambert	middle and late Eocene	Cuba
O. costulatus (Desor)	Unknown	Unknown
O. cubensis Lambert	middle and late Eocene	Cuba
O. elongatus Palmer	middle and late Eocene	Cuba
O. herrerai Sánchez Roig	late Eocene	Cuba
O. putnami Israelsky	late Eocene	Mexico
O. sanjosephi Sánchez Roig	late Eocene	Cuba
O. tuberculatus Sánchez Roig	Eocene	Cuba

SYSTEMATIC DESCRIPTIONS

SUPERORDER GNATHOSTOMATA ZITTEL

ORDER OLIGOPYGOIDA, NEW ORDER

Apical system monobasal; ambulacra petaloid adapically, beyond petals ambulacra narrower than interambulacra, with demiplates, no accessory pores; lantern with broad, lamellate exterior wings, keeled teeth, lantern supports interradial in position; tubercles crenulate, perforate.

FAMILY OLIGOPYGIDAE DUNCAN

Apical system with four genital pores; petals well developed with conjugate pores, petal III longest; beyond petals ambulacra with demiplates, with or without included plates; buccal pores present; peristome regular or irregular in outline, flush or depressed; bourrelets present or absent; lantern supports consisting of five pairs of flaring buttresses with auricles in interambulacra 2, 3, and 5, and anterior areas of 4 and 1, apophyses in posterior areas of 4 and 1; crystallography, ontogenetic variation type B (Raup's classification).

Remarks.—Durham and Melville (1957, p. 257) and later Wagner and Durham (1966, p. U448) tentatively associated *Protolampas* Lambert, *Microlampas* Cotteau, and *Ovulechinus* Lambert with *Oligopygus* "on the grounds of general external similarity, though their internal structure has not been examined." As noted by Kier (1962, p. 228), however, *Ovulechinus* is a cassiduloid, and the type species is probably an immature individual of a species like *Clypeolampas leskei* (Goldfuss). I have not been able to locate any specimens of the type species of *Microlampas* but Cotteau (1890, ser. 3, vol. 5, p. 66) does not describe demiplates in the ambulacra beyond the petals, a diagnostic feature of the Oligopygoida. Likewise, no demiplates have been reported in *Protolampas*. Until specimens of both these genera have been studied, their affinities cannot be known.

GENUS *OLIGOPYGUS* DE LORIOL

Oligopygus de Loriol, 1888, Recueil. Zool. Suisse, ser. 1, vol. 4, no. 3, p. 395. Type-species by monotypy *Oligopygus wetherbyi* de Loriol.

Oligopygus de Loriol.—Cotteau, 1891, Mém. Soc. Zool. France, vol. 4, p. 632.

Oligopygus de Loriol.—Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 166.

Oligopygus de Loriol.—Brighton, 1926, Geol. Mag., vol. 63, no. 746, p. 365.

Oligopygus de Loriol.—Hawkins, 1926, Geol. Mag., vol. 63, no. 746, p. 371.

Oligopygus de Loriol.—Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 30.

Oligopygus de Loriol.—Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, p. 5.
Oligopygus de Loriol.—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 290.
Oligopygus de Loriol.—Weisbord, 1934, Bull. Amer. Paleont., vol. 20, no. 70C, p. 58.
Oligopygus de Loriol.—Mortensen, 1948, Monogr. Echinoidea, vol. 4, pt. 1, p. 256.
Oligopygus de Loriol.—Durham and Melville, 1957, Journ. Paleont., vol. 31, no. 1, p. 257.
Oligopygus de Loriol.—Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 27.
Oligopygus de Loriol.—Wagner and Durham, 1966, *in* Treatise on Invert. Paleont., pt. U, Echinodermata 3, p. u448.

GENERIC DESCRIPTION

Shape.—Elongate to circular, high to low with height varying from 40 to 80 percent of length, marginal outline rounded to pentagonal, adoral, adapical surface flattened or rounded, petals flush or inflated, nodes present or absent on interambulacral plates.

Apical system.—Slightly anterior, central, or slightly posterior, monobasal, four genital pores, large in some specimens, small in others of same species, presumably sexual dimorphism, anterior genital pores closer together than posterior.

Ambulacra.—Petals well developed, open or slightly closed, long or short, anterior petal (III) usually longest, posterior pair (V and I) usually shortest, pores strongly conjugate; equal number of pores in pore series of same petal; beyond petals ambulacra composed of primary plates, demiplates, and in some species included plates; demiplates and included plates always small, thin, not reaching interior of test, situated near adradial border; absent on badly weathered specimens, demiplates and included plates absent near peristome, most crowded at ambitus, buccal pores present in ambulacra at edge of peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; no bourrelets.

Peristome.—Slightly anterior, central, or slightly posterior, opening circular, not regularly angular, commonly in deep transverse depression or trough.

Periproct.—Inframarginal, varying from midway between peristome and posterior margin, to submarginal.

Sphaeridia.—Double row of pits in each ambulacrum near peristome.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above general surface of test; perforated; crenulations and mamelon present only on unweathered portions of test; small secondary tubercles scattered over area between primary tubercles; glassy tubercles present in some species.

Lantern supports.—Five pairs of flaring buttresses interradial in position with auricles in interambulacra 2, 3, and 5, and anterior areas of 4 and 1, and apophyses in the posterior areas of 4 and 1.

Lantern.—Large, pentagonal, starlike marginal outline; pyramid 5 largest, 2, 3 smallest; lamellae well developed, radiating in polyfurcate fashion from middle body; interior wings convergent, with lamellar supports; symphyses widen ventrally; teeth keeled.

Plate sutures.—Sutures between most of plates corrugated; corrugations usually visible only in well-preserved specimens.

Crystallography.—*C*-axis orientation of Raup's (1966) "ontogenetic variation type B" with axes plunging toward apical system in oldest plates, perpendicular near ambitus, and increasingly plunging away from apical system in younger plates above ambitus.

Comparison with Haimea.—*Oligopygus* is similar in all its characters to *Haimea* except that in *Oligopygus* the opening of the peristome is circular to irregular in shape, and, in most species, situated in a deep transverse trough. In *Haimea* the opening is subpentagonal to pentagonal, not in a trough, and with bourrelets. Furthermore, the sutures are corrugated in *Oligopygus,* whereas they are smooth in *Haimea.*

DISTRIBUTION

Oligopygus is known from Alabama, Florida, Venezuela, Jamaica, Trinidad, Curaçao, Cuba, and Mexico. It is confined to the middle and late Eocene.

TRINIDAD SPECIES OF *OLIGOPYGUS*

In the U.S. National Museum there is a large collection of specimens of *Oligopygus* from the quarry at Bella Vista, Trinidad, and Soldado Rock. It was from these two localities that Jeannet (1928) described his four species of *Oligopygus*: *O. kugleri, O. zyndeli, O. costuliformis,* and *O. christi.* Although specimens in this collection can be referred to all these species, there is so much overlap that no sharp line can be drawn between the groups of specimens referred to each species. I measured the length, width, and height of all the well-preserved specimens and plotted them on scatter diagrams. There was no distinct separation of the points into separate paths. Because these specimens were collected in float, it is not known whether they came from the same horizon. If they did come from the same horizon, and all lived simultaneously, then all the specimens would probably represent only one species. Considering the great variation between the specimens, however, I suspect that more than one time interval is represented. The differences between the "species" are probably caused by evolutionary change through time and not variation in just one population. Because of this possibility that this collection, and for that matter Jeannet's type specimens, do not represent the same time interval, it is not possible to describe the variation within these species. My descriptions are based primarily on the type specimens and do not describe the "species." Because most of Jeannet's specimens are not well preserved, I have used for study and illustration a few well-preserved topotypic specimens from the Kugler Collection, which are so similar to Jeannet's types that even without knowing the variation of the species, I feel confident that they were conspecific with them.

KEY TO THE SPECIES OF *OLIGOPYGUS*

Test circular (width 95 to 100 percent of length).
  Height less than 50 percent of length .... **O. nancei** Cooke
  Height 50–65 percent of length.................... **O. zyndeli** Jeannet
Test moderately elongate (width 80–95 percent of length).
  Periproct midway between peristome and posterior margin.
    Test wide (width over 90 percent of length).
      Large transverse peristomal trough.
        O. jamaicensis Arnold and Clark
      Small transverse peristomal trough........... **O. rotundus** Cooke
    Test moderately wide (width 80–90 percent of length).
      Test high (height 70–80 percent of length).... **O. kugleri** Jeannet
      Test low (height 40–50 percent of length)..**O. wetherbyi** de Loriol
    Test narrow (width 70–80 percent of length).
      Test high (height 50–60 percent of length)...... **O. pinguis** Palmer
      Test low (height less than 50 percent of length).
        O. sanchezi Lambert
  Periproct nearer posterior margin (60–100 percent distance from center of peristome to posterior margin).
      Test high (height 70 percent of length)...**O. costuliformis** Jeannet
      Test low (height 40–60 percent of length)..**O. haldemani** (Conrad)
      Test wide (width 87–89 percent of length....**O. putnami** Israelsky
      Test narrower (width 79–87 percent of length).
        O. curasavica Molengraaff
        Small peristomal trough........... **O. phelani** Kier, new species

OLIGOPYGUS WETHERBYI de Loriol

Plates 1 (figs. 3–5), 4 (figs. 1, 2, 4), 5, 8 (figs. 1–3),
10 (figs. 1, 3–5), 13, 14, 16 (fig. 8); text figs. 2, 7A,
11A, 17, 24, 25, 26, 30, 38, 39

Oligopygus wetherbyi de Loriol, 1888, Recueil. Zool. Suisse, ser. 1, vol. 4, no. 3, p. 396, pl. 17, figs. 7–7d, 8.

Oligopygus wetherbyi de Loriol.—Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 166, pl. 78, figs. 2a-d, 3a-b.

Oligopygus floridanus Twitchell, *in* Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 169, pl. 79, figs. 1a-f.

Oligopygus wetherbyi de Loriol.—Cooke and Mossom, 1929, Florida State Geol. Surv., 20th Ann. Rep., pl. 3, figs. 2a-b (after Clark and Twitchell).

Oligopygus wetherbyi de Loriol.—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 290.

Oligopygus wetherbyi de Loriol.—Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 8.

Oligopygus floridanus Twitchell.—Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 8.

Oligopygus wetherbyi de Loriol.—Cooke, 1945, Florida Geol. Surv. Bull. 29, fig. 5, no. 2 (after Clark and Twitchell).

Oligopygus wetherbyi de Loriol.—Mortensen, 1948, Monogr. Echinoides, vol. 4, pt. 1, p. 247, fig. 247 (after de Loriol).

Oligopygus wetherbyi de Loriol.—Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 28, pl. 8, figs. 9–12.

Oligopygus floridanus Twitchell.—Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 28.

Material.—Description based on 140 specimens from the Crystal River Formation near Ocala, Fla., the lectotype, and paralectotype.

Shape.—Test elongate, with greatest width posterior to center, greatest height at apical system, adapical surface slightly convex, sides smoothly curving, adoral surface deeply depressed in wide sulcus at peristome; shape of test only slightly variable, with length-width ratio quite constant, width 80–86 percent of length (text fig. 24) although length-height more variable, height 40–50 percent of length (text fig. 30B); large specimens subpentagonal in marginal outline, average length 36 mm, largest 54.

Apical system.—Central to slightly anterior; monobasal, central area strongly inflated (pl. 1, figs. 3, 4), two to four tubercles on madreporite; ocular plates (pl. 1, fig. 4; text fig. 25D) small, inflated on well-preserved specimens; four genital pores located in suture between madreporite and interambulacra; large genital pores in some specimens, very small in others, probably sexually dimorphic; anterior pair closer together than posterior; present on specimen 18 mm long.

Ambulacra.—Petals well developed, straight, open, with greatest width at extremities of petals, petal III longest, petals II, IV shortest;

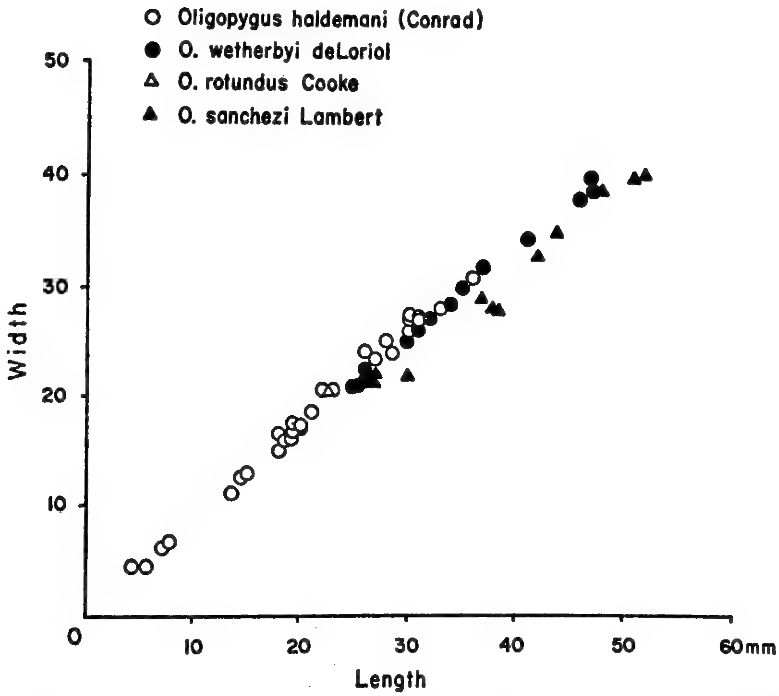


FIG. 24.—The width relative to the length in *Oligopygus haldemani* (Conrad), *O. wetherbyi* de Loriol, *O. rotundus* Cooke, and *O. sanchezi* Lambert.

interporiferous zones expanding distally, slightly constricted at extremities of petals, approximately twice as wide as poriferous zone at extremity of petal; pores strongly conjugate (pl. 2), oblique, with outer pore of pair more distal to inner; pores in sutures between plates, converging somewhat interiorly (text fig. 2), ambulacral plates of petals very thin; adradial suture surface not vertical resulting in ambulacra being narrower at interior of test than at exterior; in specimen 54 mm long 52 pore-pairs in single poriferous zone petal III, 47 in petal II, 48 in petal V; petal III with from 4 to 12 (average 6) more pore-pairs than petal II, petal II with from 1 to 7 (average 4) fewer pore-pairs than petal V (text figs. 38, 39).

Beyond petals ambulacral plates single pored; at extremity of petal (text figs. 25A, 26A) pores very numerous in many demi- and included plates; beyond this area and continuing most of length of ambulacrum each large primary has 3½ to 6 small demi- or included (text figs. 26B, C) plates along its adradial border; small plates very thin, on slightly weathered specimens some missing; all absent on moderately weathered specimen; in ambulacra II, III, and IV beyond petal approximately 66 primary plates, in ambulacra V and I, 82 large plates; near peristome pores less crowded (text fig. 25c); 115 pores in single poriferous zone of petal III; ambulacra terminate at peristome with two large plates arranged in normal manner with larger plate in right zone of ambulacrum III, adapical in ambulacrum IV, adoral in all others; buccal pores visible on some specimens, difficult to see on most.

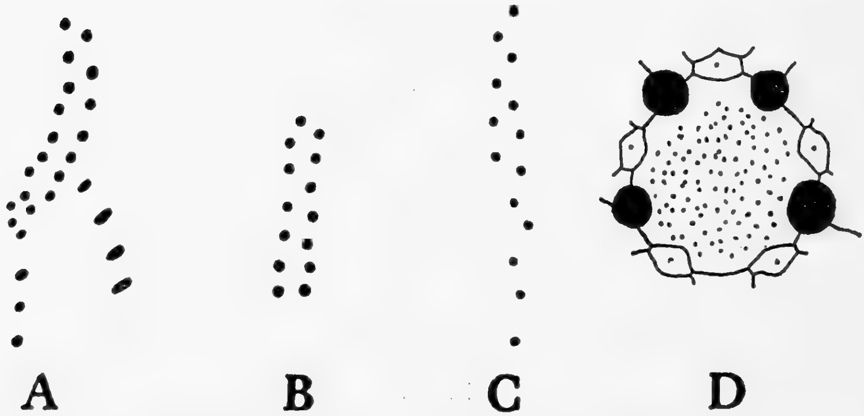


FIG. 25.—*Oligopygus wetherbyi* de Loriol: fig. A, arrangement of pores at end of petal III; fig. B, ambitus; fig. C, near peristome. USNM 649832 from the late Eocene, Crystal River Formation, Ocala Lime Company quarry, 4.1 mi. N. of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×11. Fig. D, apical system of USNM 137881B from the late Eocene, Ocala Limestone, Johnson's Limes Sink, Levy Co., Florida, ×11.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate; approximately 34 plates in interambulacra 4 or 1, 39 in 5, 36 in 2 or 3 (in specimen 37 mm long).

Peristome.—Central, wider than high (pl. 4, fig. 1), curved anteriorly, pointed posteriorly; located in deep, transverse depression (pl. 4, fig. 2) considerably wider than high, 40–50 percent as wide as test, anterior of depression more steeply sloping than posterior.

Periproct.—Small, 2.1 mm wide in specimen 45 mm long; circular, located midway between peristome and posterior margin in large specimens, slightly nearer the posterior margin in smaller.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep, with vertical sides; boss large, almost

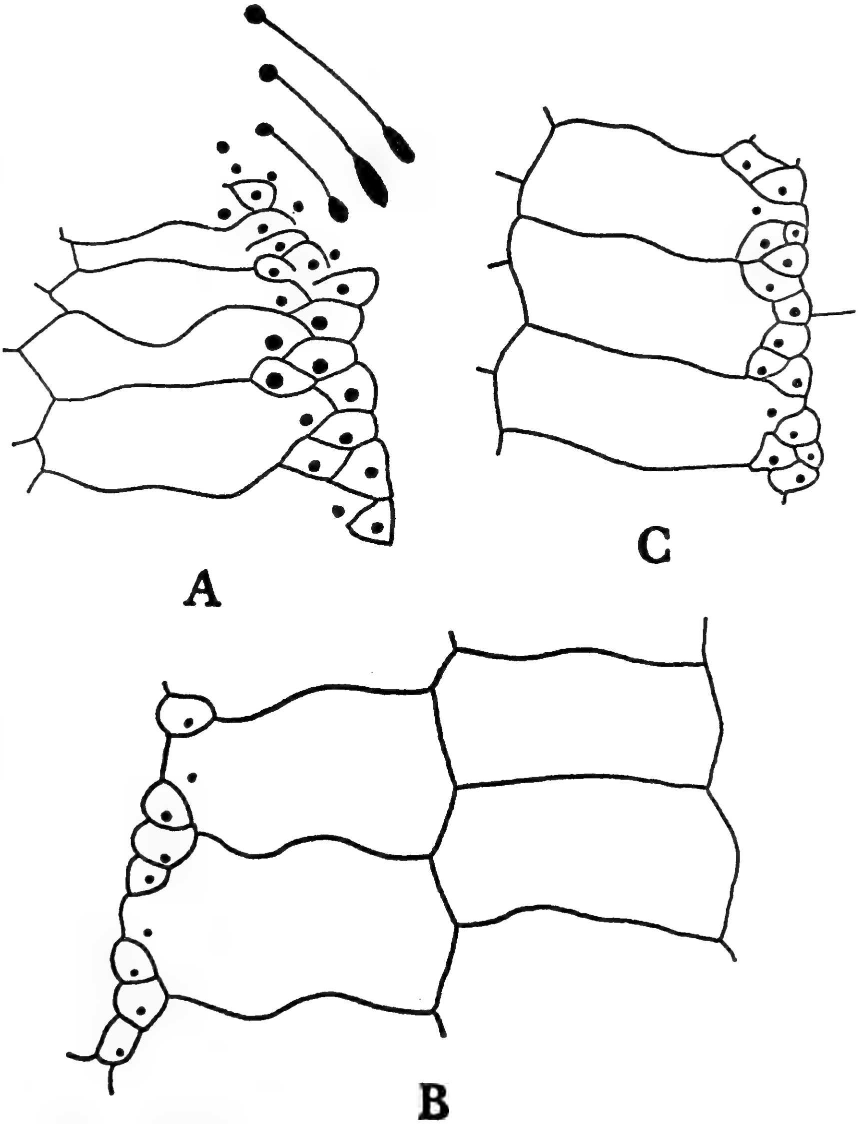


FIG. 26.—*Oligopygus wetherbyi* de Loriol: fig. A, plate arrangement near end of petal II; fig. B, midway between end of petal and ambitus (the demiplates are weathered away in the right area); fig. C, at ambitus, ×20. USNM 137881B from the late Eocene, Ocala Limestone, Johnson's Lime Sink, Levy Co., Florida.

two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Interior.—Test with thick plates (text fig. 11A), in specimen 47 mm long adapical ambulacral plates at midlength of petal III 3.6 mm thick, at adoral interambulacrum 5 midway between posterior margin and peristome 3.9 mm thick; on adoral surface ambulacra much thinner than interambulacra producing deep grooves in ambulacra in interior.

Location of type specimens.—The lectotype, herein designated, is the specimen figured by de Loriol (1888) on his plate 17, fig. 7, and herein on plate 13, figs. 1, 2. The paralectotype, figured on de Loriol's plate 17, fig. 18, is herein figured on plate 13, figs. 3, 4. These specimens are in de Loriol Collection at the Museum d'Histoire Naturelle in Geneva, Switzerland. Specimens figured by Cook and Kier (herein) are in the U.S. National Museum: USNM nos. 562271, 562272, 164660 (holotype of *O. floridanus*), 137881, 649832, 649833, 649838, 649841, 649842, 649843, 649849, 649851, 649853.

Occurrence.—Late Eocene, Crystal River Formation, and Williston Formation, Florida. For an extensive list of localities see Cooke (1959, p. 28).

Comparison with other species.—*O. wetherbyi* is found commonly with *O. haldemani* and on first impression they look quite similar. In *O. wetherbyi,* however, the periproct is always much nearer the peristome than in *O. haldemani.* I measured the distance from the periproct to the posterior margin in all the specimens from one locality and plotted them on a scatter diagram (text fig. 27). The points fall into two widely separated patterns with no overlap.

Usually the periproct opening in *O. wetherbyi* is more circular, there are more pore-pairs in petals III and V, I (text figs. 38, 39), the test is slightly narrower (text fig. 24), and the greatest width posterior (particularly in larger specimens). Also the interambulacral plates are more commonly tumid. These differences, however, are slight and not consistent. *O. wetherbyi* reaches a larger size than *O. haldemani*: one of the larger *O. wetherbyi* is 54 mm long (average 36 mm), the largest *O. haldemani* 37 mm (average 21 mm).

Remarks.—I agree with Cooke (1959, p. 28) in considering *O. floridanus* Twitchell as a junior subjective synonym of *O. wetherbyi.* Twitchell's holotype differs from specimens of *O. wetherbyi* that occur with it only in appearing to have narrower poriferous zones. This appearance is due to the fact that the holotype is a badly weathered specimen.

Palmer (*in* Sánchez Roig, 1949, p. 166) erected a variety *Oligopygus floridanus*, var. *laevis* for some specimens from the late Eocene (middle or late occurring to Brodermann, 1949, *in* Sánchez Roig, p. 325) of Cuba. Unfortunately he did not figure his specimens and from his description I cannot be sure that these specimens should be referred to *O. wetherbyi.*

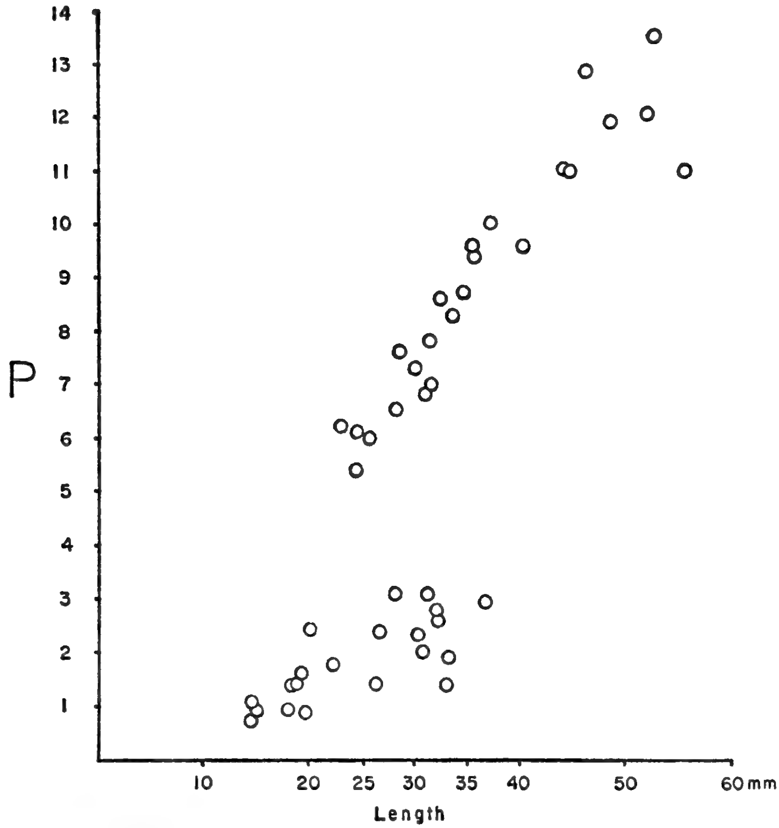


FIG. 27.—Distance of the periproct (P) from the posterior margin in a collection of *Oligopygus wetherbyi* de Loriol and *O. haldemani* (Conrad) from the same locality. Note, definite separation of the points into two paths indicating that the position of the periproct is a significant specific character in these two species. The lower group of points represent *O. haldemani,* the upper, *O. wetherbyi.*

OLIGOPYGUS NANCEI Cooke

Plate 15 (figs. 1–3); text fig. 11B

Oligopygus nancei Cooke, 1941, Journ. Paleont., vol. 15, no. 3, p. 305, 3 text figs.

Oligopygus nancei Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 13, pl. 2, figs. 10, 11.

?*Oligopygus circularis* Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 159, pl. 29, figs. 2–3.

?*Oligopygus circularis* Sánchez Roig.—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, pp. 13, 14.

Material.—Description based on holotype and six paratypes.

Shape.—Slightly elongate, width 95 percent of length; greatest width at center; adapical surface convex; greatest height at apical system, test low with height varying from 36–44 percent of height (this variation due partially to post mortem crushing); adoral surface flat; all specimens large, averaging 50 mm in length.

Apical system.—Central, small, madreporite highly inflated; oculars small; anterior genital pores closer together than posterior.

Ambulacra.—Petals well developed, straight, open, extending almost to margin, greatest width at extremities of petals, petals of equal length, each with 54 pore-pairs in single poriferous zone in specimen 50 mm long, poriferous zone one-half width of interporiferous at greatest width, narrowing at extremity of petal; pores strongly conjugate (pl. 15, fig. 1), oblique, with outer pore more distal to inner, pores in sutures between plates, ambulacral plates of petals very low; pores extending at oblique angle into test-making petals seem narrower in weathered specimens.

Ambulacra beyond petals composed of primary, demiplates, and presumably included plates (plate sutures not clear on type specimens but included plates are probably present, considering the large number of pores at the ambitus); pores arranged in double series in each half-ambulacrum at ambitus, in single series near peristome.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate.

Peristome.—Central, in deep depression, wider than high, opening nearly as large as depression; transverse width of depression 16 percent of width of test.

Periproct.—Small, circular, 2 mm in diameter in specimen 52 mm long; situated 52–60 percent (average 55%) distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Location of type specimens.—Holotype, USNM 498964a; figured paratype USNM 498964b, figured specimen USNM 649852.

Occurrence.—Venezuela: late Eocene: Tinajitas Formation. Holotype and paratypes from near headwaters of Rio Amana, Anzoátegui, approximately 5 kms southwest of Mundo Nuevo, Monagas. Rio Amana, 3¼ kms southwest of Mundo Nuevo, Monagas.

O. circularis, which is tentatively referred to this species, is known from the late Eocene of Cuba at Finca La Concepción, Barrio Marroquín, Morón, Camaguey.

Comparison with other species.—Cooke tentatively considered *O. circularis* Sánchez Roig from the late Eocene of Cuba as a junior subjective synonym. I have not seen the holotype or topotypes of *O. circularis* but from Sánchez Roig's figures; the two species appear to be synonymous.

O. nancei has the same general shape as *O. cubensis* from the middle and late Eocene of Cuba but the petals of *O. nancei* appear to be broader. Because I have not seen any specimens of *O. cubensis,* and it has never been adequately illustrated or described, it is not possible to know whether or not this difference is significant.

O. nancei differs from *O. zyndeli* in having a lower and larger test.

OLIGOPYGUS ZYNDELI Jeannet

Plate 15 (figs. 4–8); text figs. 7B, 28

Oligopygus zyndeli Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, p. 7, pl. 1, figs. 8, 9.

Oligopygus rotundus Cooke (in part).—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, pl. 3, figs. 4–6.

Material.—Jeannet had only one poorly preserved specimen when he erected this species. Its adapical surface is strongly pitted with only a small part of the petals preserved; however, there are many specimens in the U.S. National Museum from the same locality as Jeannet's holotype which appear to be conspecific with it. The following description is based on the holotype and these specimens.

Shape.—Test broad with width nearly as great as length (90–99 percent); greatest width anterior or central; some specimens pentagonal, pointed anteriorly, blunted posteriorly; test low, height 50 to 65 percent of length; greatest height at apical system; petals slightly inflated.

Apical system.—Central to slightly anterior, four genital pores, anterior pair closer together than posterior, some specimens with very large pores, some with very small, presumably sexually dimorphic; ocular plates small.

Ambulacra.—Petals well developed, anterior petal (III) longest with from 4 to 8 more pore-pairs in single poriferous zone than other petals that are of equal length; petal III open with inter-

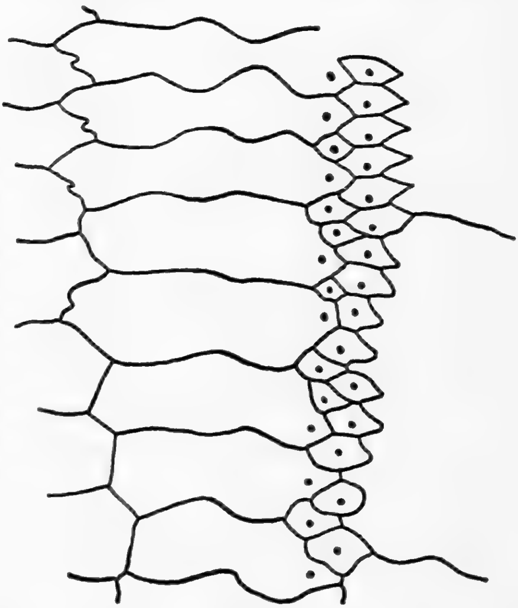


FIG. 28.—Plate arrangement just adoral to ambitus in half-ambulacrum Ib of *Oligopygus zyndeli* Jeannet showing large number of demiplates and occluded plates. No. M6618, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×20.

poriferous zones expanding distally, other petals with interporiferous zones slightly constricted distally, interporiferous zones almost twice width of poriferous zones; pores strongly conjugate, outer pore of pair distal to inner approaching end of petal.

Ambulacra beyond petals composed of primary, demiplates, and included plates, with demiplates and included plates at adradial margin, thin, not reaching interior of test; plates most crowded at ambitus where included plates commonly occur at junction between primary and demiplates (text fig. 28); pores in double series in each half-ambulacrum; buccal pores present at edge of peristome, difficult to see because of occurrence deep in peristomal trough.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; 30–31 plates in each interambulacrum in specimen 20 mm long.

Peristome.—Central, opening wider than high, four sided (pl. 15, fig. 7), in narrow transverse trough; width of trough 25 to 35 percent width of test; height 9 to 12 percent of length of test.

Periproct.—Inframarginal, opening small, located from near the margin to three-fifths the distance from peristome to margin.

Sphaeridia.—Visible only on better preserved specimens, in double row at top of peristomal trough.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test, crenulated; small perforated mamelons present on well-preserved specimens; small secondary tubercles scattered over area between primary tubercles; glassy tubercles prominent on some specimens, scattered all over test.

Location of type specimen.—Holotype no. M564 in the Naturhistorisches Museum, Basel, Switzerland; cast of holotype in the U.S. National Museum.

Occurrence.—Trinidad: late Eocene, San Fernando Formation, Bella Vista Road, Mount Moriah; Point Bontour.

Venezuela: late Eocene, Tinajitas Formation, Alta Casa Nueva, north of Altagracia de Orituco, Guárico. Bolívar district, Zulia.

Comparison with other species.—This species is very similar to *Oligopygus rotundus* Cooke from the middle or late Eocene of Alabama and differs only in that the peristomal trough is slightly smaller and lower longitudinally in *O. zyndeli.* Because only two specimens are known of *O. rotundus* it is not possible to know whether or not the size of its peristomal depression is constant enough to be specifically significant. Until more specimens have been found and this variability tested, it seems best not to synonymize these two species.

OLIGOPYGUS JAMAICENSIS Arnold and Clark

Plates 12 (fig. 4), 16 (figs. 1–7); text figs. 29, 30

Oligopygus jamaicensis Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 29, pl. 4, figs. 9–11.

Oligopygus hypselus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 28, pl. 4, figs. 6–8.

Material.—Description based on holotype and 28 paratypes in the Museum of Comparative Zoology, Harvard.

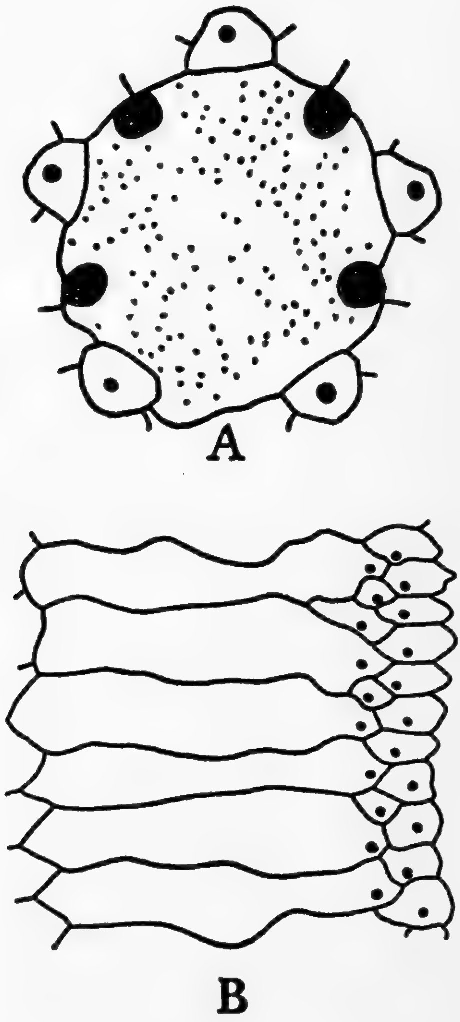


FIG. 29.—*Oligopygus jamaicensis* Arnold and Clark: fig. A, apical system of paratype, MCZ 3393c; fig. B, plate arrangement in half-ambulacrum Ib at ambitus showing large number of demiplates and presence of occluded plates, MCZ 3393d. From area north and west of Spring Mount, St. James Parish, Jamaica, ×20.

Shape.—Test elongate, moderate size, average 30 mm long, longest 40, greatest width anterior to center, averaging 91 percent of length (text fig. 30A); greatest height anterior to center, averaging 55 percent of length (text fig. 30B); adapical surface slightly convex, sides smoothly curving, adoral surface deeply depressed in wide, transverse sulcus, equal in width to one-half length of test; rest of adoral surface inflated.

Apical system.—Central, monobasal, central area inflated; ocular plates (text fig. 29A) small; four genital pores located near suture between madreporite and interambulacra; anterior pair, closer together than posterior.

Ambulacra.—Petals well developed, straight, open, slightly inflated on some specimens, flush in others, greatest width near extremities of petals, petal III longest with from 4–8 (average 5) more pore-pairs in single poriferous zone than petals II or IV, 2 to 5 (average 3) more than V or I; interporiferous zones expending distally, not constricted at ends of petals; pores strongly conjugate, oblique, with outer pore of pair more distal to inner; pores in sutures between plates.

Beyond petals ambulacral plates single pored; at extremity of petal pores very numerous in demi- and included plates; at midzone double series of pores in each half-ambulacra; primary plate separated from adradial suture by continuous series of demiplates (text fig. 29B); one included plate in suture between every other primary plate and demiplates; 68 primary plates in ambulacrum III, 74 in II or IV, 82 in V or I.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate; approximately 32 plates in interambulacra 2 or 3, 28 in 1 or 4, 32 in 5 in specimen 30 mm long.

Peristome.—Central, four sided with curved corners, wider than high, in deep transverse sulcus, 55–60 percent as wide as test (pl. 16, fig. 7).

Periproct.—Small, opening circular, opening 2.3 mm in diameter in specimen 30 mm long; located 50–60 percent of distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep, with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Occurrence.—Jamaica: Arnold and Clark found this species in area north and west of Spring Mount, St. James. According to the 1958 geological map of Jamaica this region lies in the middle Eocene Yellow Limestone.

Location of type specimens.— Holotype, MCZ 3270; 28 paratypes, MCZ 3393.

Remarks.—Arnold and Clark's (1927) *Oligopygus hypselus* is herein considered a junior subjective synonym of *O. jamaicensis*. I have studied the holotype and six paratypes of this species, which

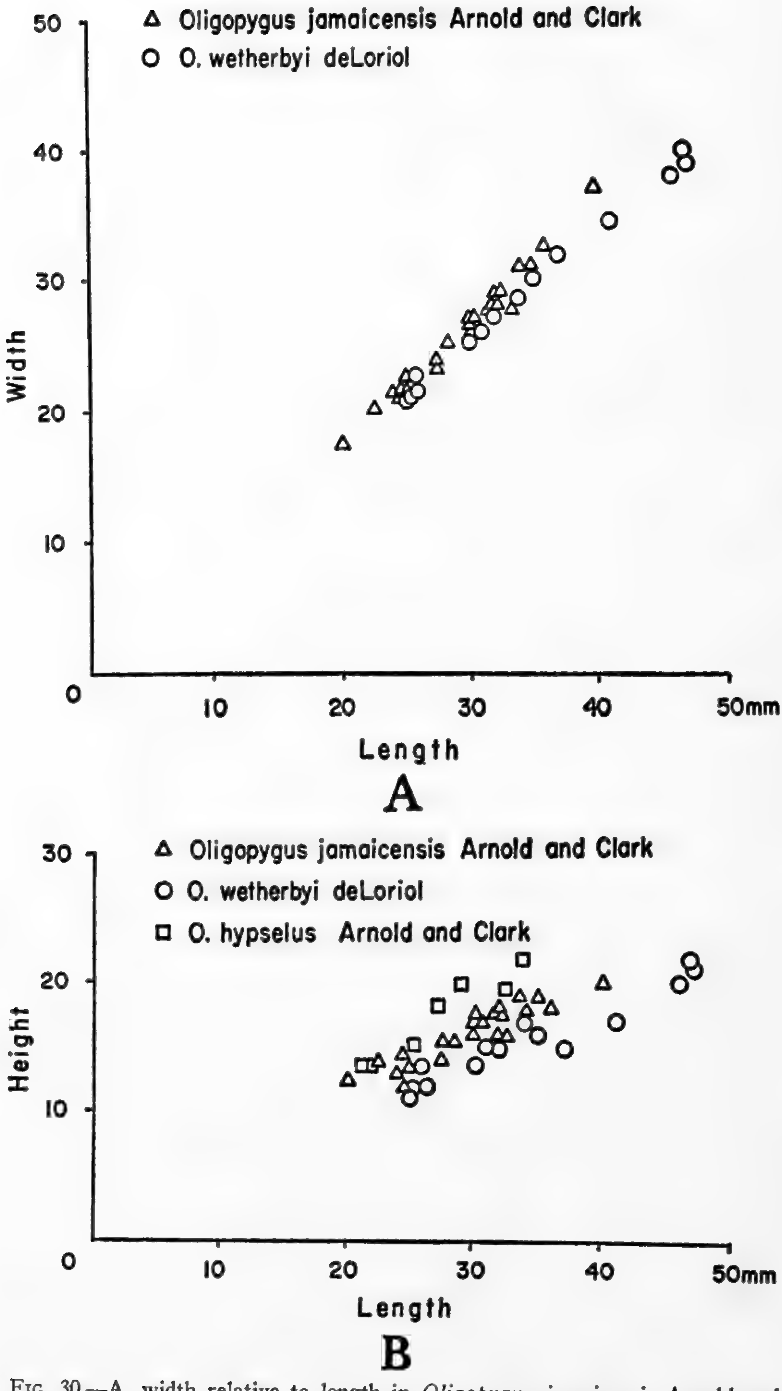


FIG. 30.—A, width relative to length in *Oligopygus jamaicensis* Arnold and Clark, and *O. wetherbyi* de Loriol. B, height relative to length in *O. jamaicensis* Arnold and Clark, *O. wetherbyi* de Loriol, and *O. hypselus* Arnold and Clark.

come from the same locality as *O. jamaicensis,* and can see no differences except that some of the specimens of *O. hypselus* are higher. Their dimensions are plotted on a scatter diagram with those of the types of *O. jamaicensis* (text fig. 30B), and there is no separation of the points into two separate paths. Because of this fact and their occurrence at the same locality, the two groups of specimens are probably conspecific.

The holotype of *O. hypselus* is figured herein on plate 17, figures 1, 2.

Comparison with other species.—*O. jamaicensis* is quite similar in general appearance to *O. wetherbyi* de Loriol, but differs in having a slightly wider and higher test. These differences are apparent in the scatter diagrams on text figure 30. *O. jamaicensis* further differs in having a more inflated adoral surface with a wider and lower peristomal sulcus. In *O. jamaicensis* the peristomial sulcus has a straight anterior border (pl. 16, fig. 7) whereas, in *O. wetherbyi* it is pointed anteriorly (pl. 16, fig. 8).

OLIGOPYGUS ROTUNDUS Cooke

Plate 17 (figs. 3–5); text figs. 24, 31, 38, 39

Oligopygus rotundus Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 9, pl. 2, figs. 1–3.
Oligopygus rotundus Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 29, pl. 8, figs. 1–5.
Oligopygus rotundus Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 12, pl. 3, figs. 4–6.

Material.—Description based on holotype, the other two specimens mentioned in Cooke's original description are not in the U.S. National Museum and presumably were at the Alabama Geological Survey.

Shape.—Test elongate, 22.2 mm long, greatest width anterior of center, 20.6 mm wide, greatest height at apical system, test 12.8 mm high; adapical surface convex, plates slightly inflated, sides smoothly curving, adoral surface deeply depressed at peristome, but peristomal depression small in area.

Apical system.—Slightly anterior, monobasal, central area strongly inflated; several tubercles on madreporite; ocular plates small; four genital pores, anterior pair closer together than posterior.

Ambulacra.—Petals well developed, straight, open, with greatest width two-thirds distance from apical system to extremity of petal; petal III longest with 28 pore-pairs in single poriferous zone, other petals equal in length with 23 pore-pairs; interporiferous zones slightly constricted at extremity of petal, at greatest width 2.7 times width of single poriferous zone; pores strongly conjugate, oblique, with outer pore more distal to inner; pores in sutures between plates, ambulacral plates of petals very low.

Beyond petals ambulacral plates single pored; at extremity of petal pores very numerous in many demi- and included plates; beyond this area and continuing length of ambulacrum each large primary has 2½ to 3 small demiplates along its adradial border.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate.

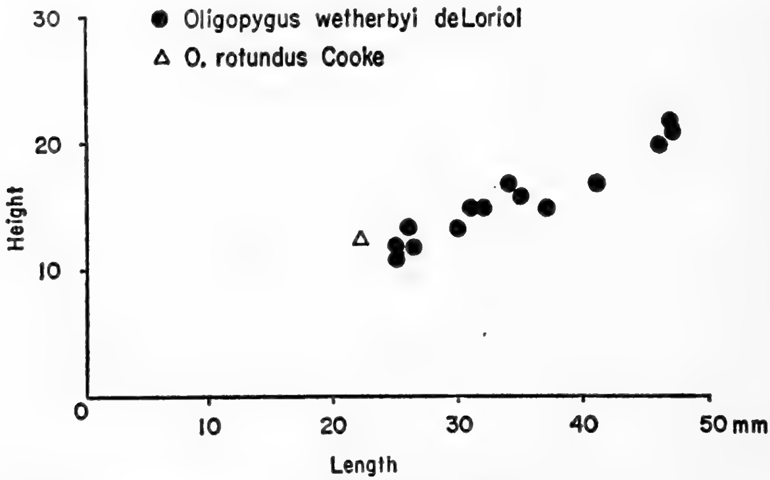


FIG. 31.—Height relative to length in *Oligopygus wetherbyi* de Loriol and *O. rotundus* Cooke.

Peristome.—Central, in small deep depression, wider than high.

Periproct.—Small, circular, or slightly wider than high, located 60 percent of distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test; perforated; crenulations and mamelon present only in well preserved portions of specimen; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Late Eocene, Moodys Branch Formation, or middle Eocene Claiborne (according to Cooke, 1959, p. 30): Alabama, Koons

Mill or Cripple Creek, Geneva Co.; bluff on east bank of Pea River 150 yards above the site of the abandoned County Line Bridge, Coffee Co.; Double Bridges Creek, Geneva Co.

Location of type specimens.—Holotype, USNM 498991; figured specimen USNM 562269.

Comparison with other species.—This species is very similar to *Oligopygus haldemani.* As can be seen from scatter diagrams (text figs. 24, 31) its length to width and height ratios and number of pores to petals is very similar. In adapical view the two species are indistinguishable. Adorally, however, the periproct in *O. rotundus* is more anterior than in *O. haldemani* and more posterior than in *O. wetherbyi.* In none of the hundreds of specimens I have studied of *Oligopygus haldemani* from the Crystal River Limestone is the periproct as far anterior as in *O. rotundus.* Furthermore, in *O. rotundus* the peristomal depression is smaller and has steeper sides.

O. rotundus is very similar to *O. zyndeli* from the late Eocene of Trinidad and may be a synonym of it. Although the peristomal trough in *O. rotundus* is slightly larger and higher longitudinally than it is in *O. zyndeli,* it is not possible to know the significance of this difference until more specimens of *O. rotundus* have been found and the variability of this feature is tested. The specimens from Trinidad and Venezuela which Cooke referred to *O. rotundus* are herein referred to *O. zyndeli.*

O. rotundus differs from *O. phelani* Kier, new species, in having a broader, deeper peristomal depression.

OLIGOPYGUS KUGLERI Jeannet

Plates 17 (fig. 6), 18 (figs. 1–4)

Oligopygus kugleri Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, pl. 1, figs. 1–7.

Oligopygus wetherbyi kugleri Jeannet.—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 11, pl. 3, figs. 9–11.

Material.—The following description is based on Jeannet's lectotype, four paralectotypes, and several topotypes.

Shape.—Test elongate to cylindrical, width varying from 80 to 88 percent of length in type specimens; height from 76 to 80 percent of length; lectotype 26.7 mm long, 21.4 mm wide, 21.4 mm high; sides steep, marginally straight in some specimens, greatest height anterior; petals slightly inflated; adoral surface depressed transverse to peristome.

Apical system.—Slightly anterior, central, or slightly posterior, not well preserved on type specimens; on topotypes four genital pores, very large on some specimens, small on others; madreporite higher than wide, inflated; ocular plates small.

Ambulacra.—Petals well developed, long, extending almost to margin; anterior petal (III) longest with from 6–10 more pore-pairs in single poriferous zone than petals II or IV, 3–10 more than petals V or I (in six topotypes); petal III widely open with interporiferous zone expanding distally, of greatest width at end of petal, other petals slightly constricted distally; interporiferous zones wide, slightly wider to twice width of poriferous zone; poriferous zones with strongly conjugate pores, narrowing distally, outer pore of pore-pair slightly more distal to inner at end of petal.

Ambulacra beyond petals composed of primary, demiplates, and included plates, with demiplates and included plates at adradial margin, thin, not reaching interior of test; plates most crowded at ambitus where pores in two to three series in each half-ambulacrum.

Interambulacra.—Two columns each area except at peristome where terminating in single plate.

Peristome.—Central, four sided (pl. 17, fig. 6), wider than high, depressed in transverse furrow slightly less than twice width of opening; transverse corners of depression with no tubercles.

Periproct.—Inframarginal, opening small, located approximately midway between peristome and posterior margin, position variable, in some specimens only one-third distance from peristome to posterior margin, in others more than one-half.

Sphaeridia.—Visible on better preserved specimens, but none of specimens well enough preserved to show location of all of them.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; small perforated mamelons present on well-preserved specimens; small secondary tubercles scattered over area between primary tubercles; glassy tubercles prominent on some specimens.

Location of type specimens.—Lectotype herein designated the specimen figured by Jeannet (1928, pl. 1, figs. 1–4), no M561/1, and four paralectotypes M561/2–3, M562, and M563 all in the Naturhistorisches Museum, Basel, Switzerland. A cast of the lectotype is in the U.S. National Museum.

Occurrence.—Late Eocene, San Fernando Formation, Trinidad: Soldado Rock and Bella Vista.

Comparison with other species.—Although Cooke considers *O. kugleri* a subspecies of *O. wetherbyi*, the two forms seem to me to be very distinct. *O. kugleri* has a much higher test with the height varying from 76 to 80 percent of the length as opposed to 40 to 50 percent in *O. wetherbyi*. Furthermore, in *O. kugleri* the peristomal notch is much narrower and less depressed.

OLIGOPYGUS PINGUIS Palmer

Plates 18 (figs. 5–7), 19 (fig. 1), 20 (fig. 7); text figs. 32, 33

Oligopygus pinguis Palmer.—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 165, pl. 28, figs. 2, 3.

Material.—Ten topotypic metatypes studied from the Museum of Comparative Zoology, and five specimens in the U.S. National Museum.

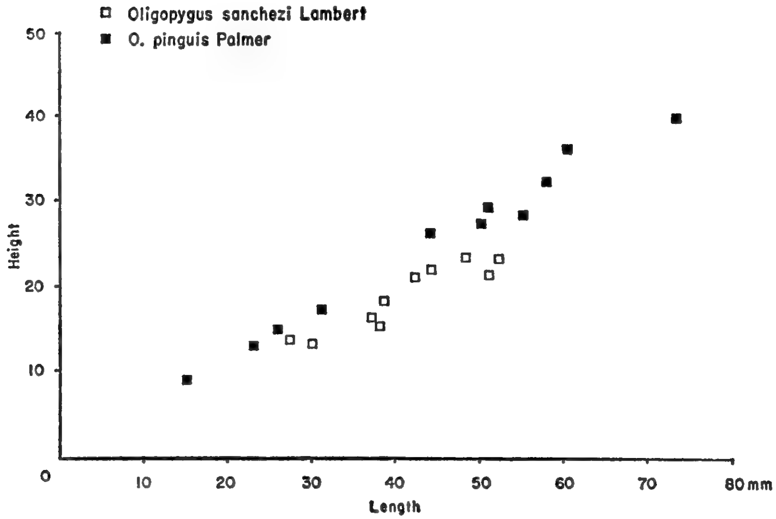
Shape.—Test large (largest specimen 73 mm long), elongate, average width 79 percent of length (text fig. 32B); greatest width posterior to center; test high, height varying from 50 to 60 percent of length, average 55 percent (text fig. 32A); greatest height anterior, adapical surface slightly convex, sides steeply sloping, adoral surface deeply depressed at peristome in transverse sulcus.

Apical system.—Central, monobasal, central area strongly inflated; ocular plates small, inflated; four genital pores located in suture between madreporite and interambulacra; anterior pair closer together than posterior; pores present in smallest specimen 15 mm long.

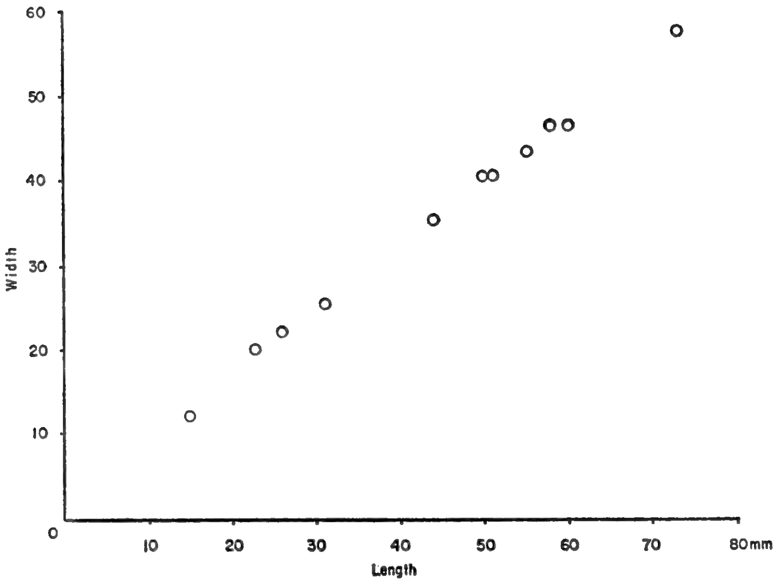
Ambulacra.—Petals well developed, straight, open, greatest width at extremity of petal; interporiferous zones twice width of poriferous zones; petal III longest with from 3 to 10 (average of 7) more pore-pairs in single poriferous zone than in petals II or IV, 1 to 6 (average 3) more pore-pairs than petals V and I, pores strongly conjugate (pl. 20, fig. 7), oblique, with outer pore of pair more distal to inner; pores in sutures between plates.

Beyond petals, ambulacral plates single pored; at extremity of petal (test fig. 33A) pores very numerous, at ambitus (text fig. 33B) double to triple series of pores; continuous column of demiplates at ambitus separating primary plates from adradial suture; included plates inserted between primaries and demiplates; near peristome primary plates extend to adradial suture, no included plates, one demiplate for each primary; buccal pores difficult to see.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate; 44 plates in interambulacra 2 or 3, 34 in 4 or 1, 40 in 5 in specimen 50 mm long.



A



B

FIG. 32.—A, Height relative to length in *Oligopygus sanchezi* Lambert and *O. pinguis* Palmer. B, Width relative to length in *O. pinguis*.

Peristome.—Central to slightly posterior; deeply depressed in transverse sulcus, pockets at each side of sulcus; opening four sided, wider than high.

Periproct.—Opening small, 3.2 mm in diameter in specimen 55 mm long, located midway between peristome and posterior margin in large specimens, more posterior in smaller specimens.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep, with vertical sides; boss large, extending almost upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated, crenulation and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

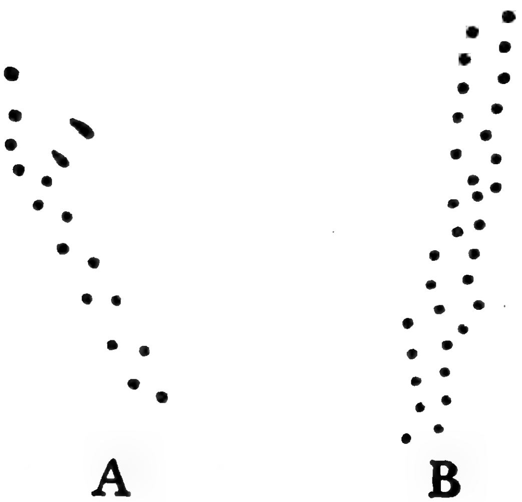


FIG. 33.—Arrangement of ambulacral pores in *Oligopygus pinguis* Palmer: fig. A, at tip of petal II; fig. B, at ambitus of ambulacrum I. MCZ 4091b from deep cut north of Grua 9, Ramal Juan Criollo, 13 km NE. of Jatibonica, Camagüey Prov., Cuba; ×10, ×18.

Location of type specimen.—Holotype, no. 247, in the Sánchez Roig Collection, the location of which is not known to me.

Occurrence.—Late Eocene according to Sánchez Roig (1949); middle and late Eocene according to Brodermann (*in* Sánchez Roig, 1949, p. 325); Cuba: deep cut north of Grua 9, Ramal Juan Criollo, 13 km. N.E. of Jatibonica, Camagüey Prov. (type-locality: Palmer locality 1640; 0.2 km. S.E. of Arroyo Blanco on road to Majaqua, Camagüey Prov.).

Comparison with other species.—*O. pinguis* is most similar to *O. sanchezi* Lambert also from Cuba, but is easily distinguished by its higher test (text fig. 32A), and more anterior periproct.

OLIGOPYGUS SANCHEZI Lambert

Plate 19 (figs. 2–4) ; text figs. 24, 32A, 34

Oligopygus haldermani Sánchez Roig (not Conrad), 1926, Bol. Minas, no. 10, p. 83, pl. 41, figs. 6, 7.
Oligopygus sanchezi Lambert, 1932, Soc. Géol. France, Bull., ser. 5, vol. 1, p. 292, pl. 17, fig. 8.
Oligopygus sanchezi Lambert.—Weisbord, 1934, Bull. Amer. Paleont., vol. 20, no. 70C, p. 224, pl. 6, figs. 4–15.
Oligopygus sanchezi Lambert.—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 163.
?*Oligopygus mullerriedi* Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 160, pl. 30, figs. 2, 3.

Material.—This description is based on 19 specimens, 10 from the U.S. National Museum and 9 from the Museum of Comparative Zoology, Harvard. Four of the USNM specimens were collected and identified by Sánchez Roig who labeled them as topotypes.

Shape.—Large, elongate, width averaging 77 percent of length, greatest width anterior or posterior to center; greatest height anterior, height (text fig. 32A) averaging 43 percent of length; poriferous zones of petals and beyond petals depressed forming grooves continuing almost to peristome; adapical surface slightly convex; adoral deeply depressed in broad transverse groove at peristome; deeper, without tubercles, pockets at both sides of groove (pl. 19, fig. 3).

Apical system.—Central to slightly anterior; monobasal, central area strongly inflated (pl. 19, fig. 5); ocular plates small, inflated; four genital pores located in or near suture between madreporite and interambulacra; anterior pair closer together than posterior.

Ambulacra.—Petals well developed, straight, short, tendency to close distally with interporiferous zones narrowing at ends of petals, interporiferous zones at greatest width almost twice as wide as single poriferous zone in well-preserved specimen; petal III (text fig. 34) longest with from 5 to 12 (average of 8) more pore-pairs in single poriferous zone than petals II or IV, 1–7 (average of 4) more pore-pairs than petals V and I; in single poriferous zone of petal III, 39 in petal II, 47 in petal V; pores strongly conjugate (pl. 19, fig. 6), oblique, with outer pore of pair more distal to inner; pores in sutures between plates, converging interiorly so that on weathered specimens poriferous zones of same petal closer together with narrower interporiferous zone; in specimen 52 mm long, 51 pore-pairs in petal III.

Beyond petals, ambulacral plates single pored; at extremity of petal pores very numerous in many demi- and included plates; at ambitus double series of pores with continuous column of demiplates separating primary plates from adradial suture; included plates inserted between primaries and demiplates; one included plate for each primary; near peristome primary plates extend to adradial suture, no included plates, one demiplate for each primary; in whole ambulacra beyond petal 29 primary plates in half-ambulacrum II, 33 in half-ambulacrum V; 135 pores beyond petal in half-ambulacrum II; buccal pores difficult to see.

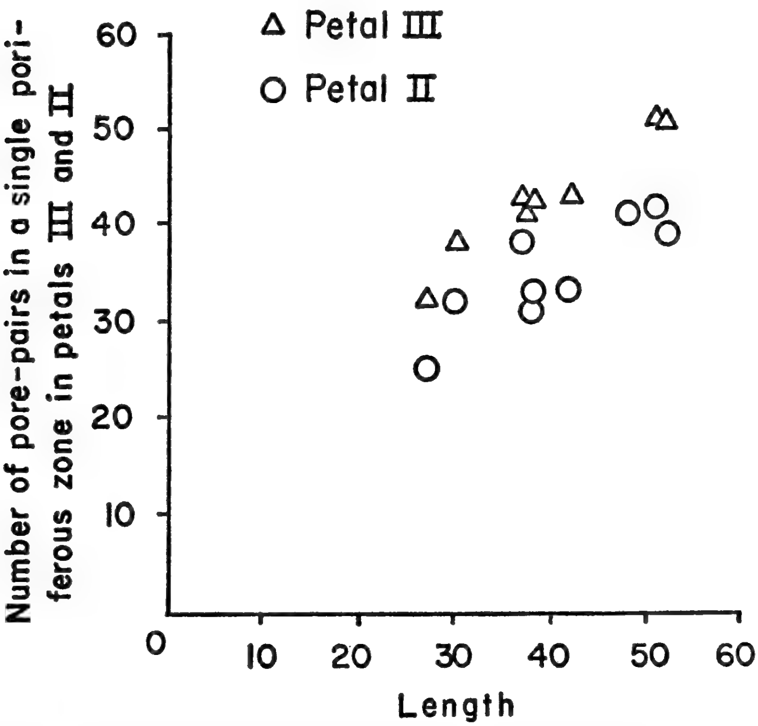


FIG. 34.—Number of pore-pairs in a single poriferous zone in petals II and III relative to the length in *Oligopygus sanchezi* Lambert.

Interambulacrum.—Two columns of plates in each area except at peristome where column terminating in single plate; 38 plates in interambulacra 2 or 3, 32 in 4 or 1, 36 in 5, in specimen 38 mm long.

Peristome.—Central, slightly wider than high (pl. 19, fig. 3), four sided; in deep transverse depression at least 60 percent as wide as test; depression with tubercleless pockets at each side.

Periproct.—Small, 3.2 mm in diameter in specimen 52 mm long, located near posterior margin, located 70 percent of distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep, with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulation and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Location of type specimen.—Unknown to me.

Occurrence.—According to Sánchez Roig (1949, p. 163) middle Eocene (Brodermann, *in* Sánchez Roig, 1949, p. 325, places it in the middle and late Eocene). Cuba: 2 km. S.E. of Arroyo Blanco or road to Majagua, Camegüey Prov.; Loma de Calixto; Nuevitas beach about km 73 on railroad to Pastelillo, Camagüey Prov.; Majagua, Camagüey Prov.; Canteras Caraballo; Loma La Caoba; San Diego de los Baños; Pinar del Rio.

Comparison with other species.—*O. sanchezi* resembles most *O. wetherbyi* de Loriol but differs in being narrower (text fig. 24), having shorter paired petals closing more distally, and a much more posteriorly situated periproct. It differs from *O. pinguis* in having a lower test and a more posterior periproct.

Remarks.—Sánchez Roig's *Oligopygus mullerriedi* appears to be synonymous with *O. sanchezi.* Both species have similar narrow short petals, a deep peristomal sulcus, similar shape, and their periproct in the same position. Because I have not seen the holotype or any other specimens referred by Sánchez Roig to *O. mullerriedi,* I only tentatively refer it to *O. sanchezi.*

OLIGOPYGUS COSTULIFORMIS Jeannet

Oligopygus costuliformis Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, p. 9, pl. 1, figs. 13–15.

Oligopygus haldemani costuliformis Jeannet.—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 11.

Remarks.—Jeannet based this species on one specimen, no. M566, in the Naturhistorisches Museum at Basel. I have not had an opportunity to study this specimen and, therefore, do not describe this species, but have photographs of it and a cast. The specimen seems to fall morphologically between *O. kugleri* and *O. zyndeli.* It is lower than *O. kugleri* having a height 70 percent of the length as compared to 80 to 86 percent in *O. kugleri,* but higher than *O. zyndeli* with a height only 50 to 65 percent of the length. Its test is wider

(86 percent of length) than most of the specimens of *O. kugleri* but narrower than *O. zyndeli.* Its periproct is in approximately the same position as in *O. zyndeli* but more posterior than in *O. kugleri.*

Cooke considered *O. costuliformis* as a subspecies of *O. haldemani,* but Jeannet's holotype is quite distinct from *O. haldemani.* The test is considerably higher (height 70 percent of length as opposed to 41–56 in *O. haldemani*) and the peristomal trough is much smaller.

Occurrence.—Trinidad: late Eocene, San Fernando Formation, Bella Vista quarry.

OLIGOPYGUS PUTNAMI Israelsky

Plates 7, 20 (figs. 2–6), 21; text figs. 35, 36

Oligopygus putnami Israelsky, 1933, Trans. San Diego Soc. Nat. Hist., vol. 7, no. 22, p. 275, pl. 18, figs. 1–4.

Material.—This description is based on four specimens Israelsky used for his description, and 48 topotypes in the U.S. National Museum.

Shape.—Elongate, width 87 to 89 percent of length (text fig. 35A), greatest width central to slightly anterior, greatest height anterior, height varying from 44 to 55 percent of length (text fig. 35B); adapical surface slightly flattened, sides steep, adoral surface deeply sunken in broad transverse sulcus at peristome, largest specimen 28.2 mm long, smallest 14.9 mm.

Apical system.—Central (pl. 21, fig. 6), depressed between petals, monobasal, madreporite slightly inflated; ocular plates small, highly inflated; four genital pores, anterior pair closer together than posterior.

Ambulacra.—Petals well developed, broad, highly inflated, with tendency to close distally; petals straight, with greatest width two-thirds distance from apical system to end of petal, petal III (pl. 21, fig. 4) longest with from 5 to 7 more pore-pairs in single poriferous zone than in petals II or IV, 3 more than in petals V or I; in smallest specimen, 14.9 mm long, 22 pore-pairs in single poriferous zone of petal III, in largest specimens, 28.2 mm long, 25 pore-pairs; petals II and IV slightly shorter than petals V and I; interporiferous zones at greatest width slightly beyond midlength of petal; pores strongly conjugate, oblique, with outer pore more distal to inner; pores in sutures between plates.

Beyond petals, ambulacral plates single pored; at extremity of petal (text fig. 36A) pores very numerous in many included and demiplates; at ambitus pores crowded in double to triple series (text

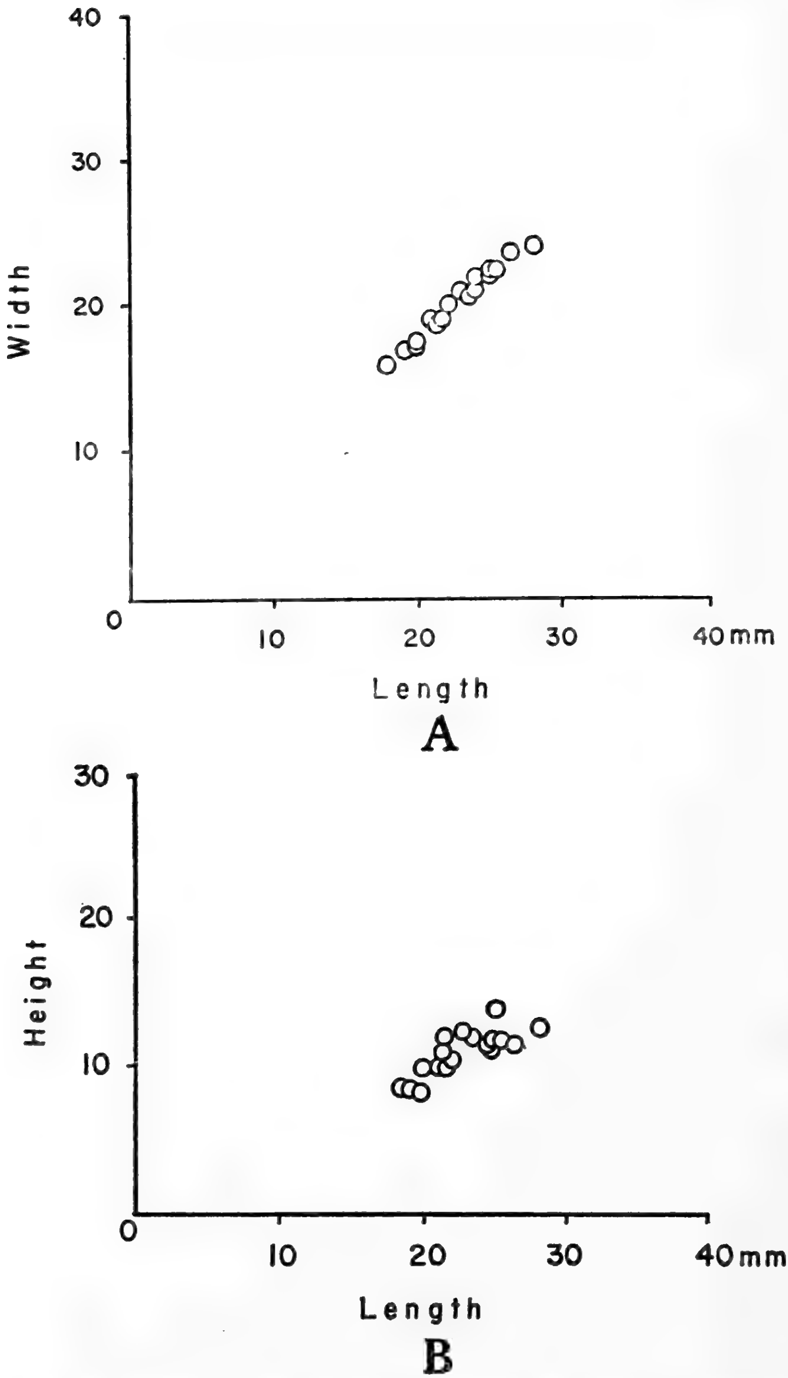


FIG. 35.—Width (A) and height (B) relative to length in *Oligopygus putnami* Israelsky.

fig. 36B) with continuous column of demiplates separating primary plates from adradial suture; some included plates inserted between primary and demiplates; nearing peristome pores less crowded with primary plates reaching adradial suture, no included plates, one demiplate for each primary plate; buccal pores difficult to see.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate.

Peristome.—Slightly anterior to center, large, broad, 4.75 mm wide in specimen 23 mm long, opening curved anteriorly (pl. 21, fig. 5), pointed posteriorly, located in deep transverse depression considerably wider than high; sides or corners of depression in interambulacra 1 and 4 smooth having no tubercles.

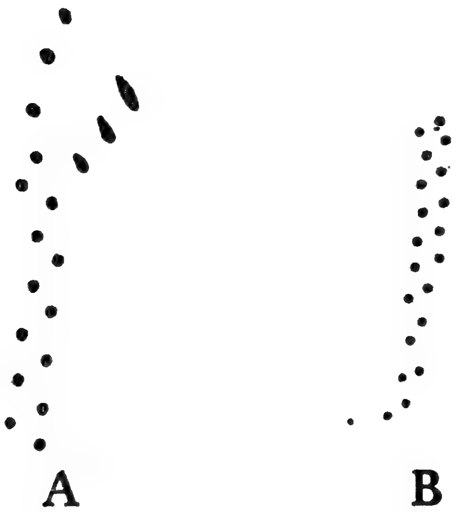


Fig. 36.—Pore arrangement of *Oligopygus putnami* Israelsky: fig. A, at end of petal II (no. 5215); fig. B, just below ambitus in ambulacrum V (no. 5214), California Academy of Sciences Type Collection from the late Eocene, 12 km. NE. of Abasola, Tamaulipas, Mexico, ×15.

Periproct.—Small, 1.4 mm wide in specimen 23 mm long, circular to wider than high, located 60 percent of distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small irregularly arranged tubercles (pl. 20, fig. 6); scrobicules deep, with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated, mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Occurrence.—Upper Eocene, 12 kms northeast of Abasola, Tamaulipas, Mexico.

Professor J. Wyatt Durham has collected specimens belonging to this species from the following localities, which he believes are equivalent in age to Moody's Branch Marl (early Jacksonian) although he states that they might be equivalent to latest Claibornian:

B–8123: From middle to late Eocene calcareous shales exposed along Ixtapa-Bochil-Simojovel highway about 3 kms south of village of San Juan El Bosque, which in turn is about 9 kms south of Simojovel. Collected in 1961 by J. Wyatt Durham and party, from outcrops about midway between km posts 9 and 10.

B–8202: From same middle to late Eocene calcareous shales as at loc. B–8123, but 1.6 km north of village of San Juan El Bosque, along highway about midway between km posts 19 and 20. Collected in 1961 by J. Wyatt Durham and party.

Type.—Lectotype herein designated Museum California Academy of Sciences No. 5211 figured by Israelsky on his plate 18, figure 1 and herein on plate 20, figure 4; figured specimens USNM 649837, Basel M 6615.

Comparison with other species.—*O. putnami* is most similar to *O. rotundus* from the late Eocene of Alabama but is distinguished by having a much wider, deeper depression for its peristome, flatter adapical surface, and more highly inflated petals.

OLIGOPYGUS CURASAVICA Molengraaff

Plate 31 (figs. 4–6)

Oligopygus curasavica Molengraaff, 1929, Geologie en Geohydrologie van het eiland Curaçao, p. 77, pls. 27, 28.

I have not been able to locate Molengraaff's specimens but his description is very detailed, and the specific characters well delineated. Photocopies of the lectotype (herein designated the specimen figured on his plate 27, fig. 2, plate 28, figs. 1, 3) are included on my plate 31, figs. 4–6.

Comparison with other species.—*O. curasavica* is similar to *O. haldemani* and *O. wetherbyi* in its shape having similar length to width and length to height ratios. Its petals are of the same shape with approximately the same number of pore-pairs in each petal (in a scatter diagram it overlaps the ranges of both *O. haldemani* and *O. wetherbyi*). It is easily distinguished, however, by the position of its periproct, 61 to 64 percent of the distance from the center of the peristome to the posterior margin. In *O. haldemani* the periproct is more posterior (76 to 84 percent of this distance), whereas in *O. wetherbyi* it is more anterior (50 percent).

O. curasavica is similar to *O. putnami* in the position of its periproct but differs in having a narrower test.

Occurrence.—Upper Eocene of Curaçao.

Location of type specimens.—Not known to me.

OLIGOPYGUS PHELANI Kier, new species

Plate 22; text fig. 9

Oligopygus haldemani Fischer (not Conrad), 1951, Florida Geol. Surv. Bull. 34, pt. 2, p. 56.

Material.—The following description is based on the holotype and 57 topotypic specimens.

Shape.—Small, elongate, width 83 to 88 percent of length, length-width ratio quite constant (text fig. 9A); in smaller specimens marginal outline oval, in large specimens subpentagonal, pointed anteriorly, blunted posteriorly with greatest width anterior; largest specimen 18.5 mm long, average specimen 10 to 13 mm long, smallest 6.0 mm long; greatest height commonly at apical system, in some specimens anterior; height quite variable varying from 42 to 60 percent of length (text fig. 9B); adapical surface slightly convex, sides smoothly curving, adoral surface lacking deep peristomal sulcus, only depressed immediately around peristome opening.

Apical system.—Central to slightly posterior; monobasal (pl. 22, fig. 3), madreporite strongly inflated, several tubercles on madreporite; ocular plates small; four genital pores, anterior pair closer together than posterior, pores large in some specimens small in others; not visible in any specimens smaller than 8 mm long.

Ambulacra.—Petals well developed, open in some specimens, straight, slightly closing in others; interporiferous zone widest in petal III where almost twice as wide as single poriferous zone; in other petals interporiferous zone slightly wider than poriferous zone; petal III longest with from 4 to 9 more pore-pairs in single poriferous zone than petals II or IV, 4 to 7 more than petals V or I; in largest specimen, 18.5 mm long, 23 pore-pairs in single poriferous zone of petal III, in smallest specimen, 6.0 mm long, 11 pore-pairs; outer pore of pair distal to inner; pores strongly conjugate (pl. 22, fig. 3), in sutures between plates.

Beyond petals, ambulacral plates single pored; at extremity of petal, pores very numerous in many included and demiplates; at ambitus pores most crowded in double series in each half-ambulacrum with continuous column of demiplates separating primary plates from adradial suture; a few included plates inserted between primaries and demiplates; included and demiplates near adradial border, plates thin not extending through test; nearing peristome primary plates extend to adradial suture, no included plates, one demiplate for each primary; buccal pores difficult to see.

Interambulacra.—Two columns in each area except at peristome where column terminating in single plate.

Peristome.—Slightly anterior, central, or slightly posterior, opening slightly wider than high, in specimen 17.5 mm long, opening 2.18 mm wide, 1.94 mm high, opening (pl. 22, fig. 5) curved anteriorly, slightly pointed posteriorly; not in deep sulcus, test only depressed in area immediately around opening.

Periproct.—Small, 1.4 mm wide in specimen 17.5 mm long, slightly wider than high; located between 54 and 73 percent of the distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical side; boss large, two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Location of type specimen.—Holotype USNM 649845; figured specimen USNM 649846.

Occurrence.—Late Eocene, Inglis Formation, Florida: NW ¼ NW ¼ Sec. 30, & 17S, R20E, Citrus Co.; S. bank Withlacoochee River about 50 ft. SE of Hwy. 200 bridge at Stokes Ferry. Florida Geol. Survey loc. I–5377, quarry in Citrus County south of Withlacoochee River one mile west of bridge at Inglis, Levy County; spoil banks along first 4 miles of Trans-Florida Canal near Inglis (loc. of holotype).

Remarks.—This species is named for Thomas F. Phelan of the U.S. National Museum who first recognized that the specimens of *Oligopygus* from the Inglis Formation were different in appearance from those of the Crystal River Formation.

Comparison with other species.—Specimens of this species have previously been referred to *Oligopygus haldemani* which occurs in the higher Crystal River Formation. Although *O. phelani* is very similar to *O. haldemani* in shape, having the same length to width and height ratios, and similar petals, it is easily distinguished from it by its lack of a deep peristomal trough and its more anteriorly situated periproct. In *O. haldemani* the peristome is in a deep transverse trough, whereas in *O. phelani* the test is only depressed in the area immediately around the opening. In *O. phelani* the periproct is located between 54 and 73 percent the distance from the center of the peristome to the posterior margin, whereas in *O. haldemani* it is located at 76 to 84 percent of this distance. Furthermore, *O. phelani* is a smaller species, the largest specimen being 18.5 mm long, whereas in *O. haldemani* the largest specimen is 37 mm long.

O. phelani likewise differs from *O. wetherbyi* in lacking a deep peristomal trough. Its periproct is more posterior than in *O. wetherbyi* and its test is smaller.

O. rotundus differs from *O. phelani* in having a broad and steep peristomal trough.

OLIGOPYGUS HALDEMANI (Conrad)

Plates 3 (figs. 1, 2), 11 (figs. 1–6), 23; text figs. 4, 8, 13–16, 19, 24, 37–39

Discoidea haldemani Conrad, 1850, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 2, p. 40, pl. 1, fig. 12.

Oligopygus haldermani (Conrad).—Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 167, pl. 78, figs. 4a-d, 5a-d.

Oligopygus haldermani (Conrad).—Cooke and Mossom, 1929, Florida State Geol. Surv., 20th Ann. Rep., pl. 3, figs. 3a-b (after Clark and Twitchell).

Oligopygus colsoni Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 290, pl. 17, figs. 1–4.

Oligopygus haldemani (Conrad).—Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 8.

Oligopygus haldemani (Conrad).—Cooke, 1945, Florida Geol. Survey Bull. 29, fig. 5, no. 3 (after Clarke and Twitchell).

Oligopygus haldemani (Conrad).—Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 29, pl. 8, figs. 6–8.

Oligopygus colsoni Lambert.—Cooke, 1959, U.S. Geol. Surv. Prof. Pap. 321, p. 29.

Material.—Description based on 120 specimens from the Crystal River Formation, Cunard Pit, Ocala, Florida.

Shape.—Test elongate, greatest width central or anterior to center, width 84–89 percent (text fig. 24), greatest height usually at apical system but in some specimens anterior, height 41–56 percent of length (text fig. 37), adapical surface slightly convex, sides smoothly curving, adoral surface deeply depressed in wide sulcus at peristome; shape of test only slightly variable; largest specimen 37 mm long, average 21 mm, smallest 4.0 mm.

Apical system.—Central to slightly anterior; monobasal (pl. 23, fig. 6), central area strongly inflated, several tubercles on madreporite; ocular plates small, inflated on well-preserved specimens;

four genital pores located in suture between madreporite and interambulacra; anterior pair closer together than posterior; large genital pores in some specimens, very small in others, probably sexually dimorphic; not present on specimens smaller than 9.5 mm long, absent in one specimen 15 mm long.

Ambulacra.—Petals well developed, straight, open (pl. 23, fig. 5), with greatest width at extremities of petals, petal III longest, petals II, IV shortest; interporiferous zones expanding distally, slightly constricted at extremities of petals, approximately twice as wide as poriferous zone at extremity of petal; pores strongly conjugate

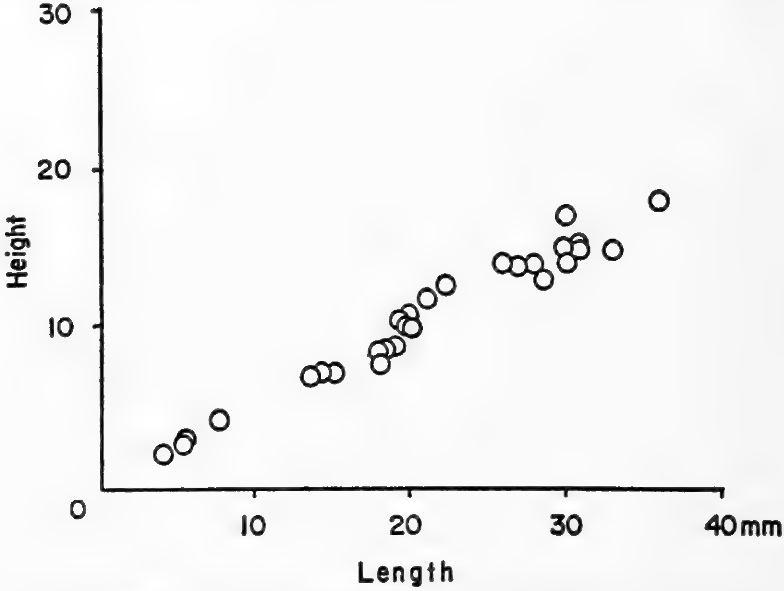


FIG. 37.—Height relative to length in *Oligopygus haldemani* (Conrad).

(pl. 3, fig. 1), oblique, with outer pore more distal to inner; pores in sutures between plates, ambulacral plates of petals very low; in specimen 28 mm long 29 pore-pairs in single poriferous zone in petal III, 24 in petals II or IV, 25 in petals V or I (see text figs. 38, 39 for scatter diagrams of number of pore-pairs in petals).

Beyond petals, ambulacral plates single pored; at extremity of petal (text fig. 4) pores very numerous in many included and demiplates; at ambitus double series of pores in each half-ambulacrum (pl. 3, fig. 2; text fig. 4) with continuous column of demiplates separating primary plates from adradial suture; included plates inserted between primaries and demiplates; one included plate for each primary; included and demiplates near adradial border, plates thin not extending through test; nearing peristome primary plates extend to adradial suture, no included plates, one demiplate for each primary; buccal pores difficult to see.

Interambulacra.—Two columns of plates in each area except at peristome where column terminating in single plate.

Peristome.—Slightly posterior to center, wider than high (pl. 23, fig. 4), four sided, curved anteriorly, pointed posteriorly, located in deep, transverse depression considerably wider than high, 35–50 percent as wide as test.

Periproct.—Small, 2.3 mm wide in specimen 30 mm long, wider than high, located near posterior margin, 76–84 percent (average 80) distance from center of peristome to posterior margin.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep, with vertical sides; boss large, two-thirds diameter of scrobicule, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test, perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between tubercles.

Interior.—Test with thick plates, on adoral surface ambulacra much thinner than interambulacra producing deep grooves in ambulacra in interior.

Location of type specimen.—Unknown. Figured specimens USNM 112506, 164661, 562270, 649834, 649854–7.

Occurrence.—Late Eocene Crystal River Formation: Georgia and Florida. For an extensive list of localities see Cooke (1959, p. 29). Although Fischer (1951, p. 56) reports this species from the Inglis Formation, all the specimens of *Oligopygus* from his locality and from everywhere I have collected in the Inglis are quite distinct from typical *O. haldemani* and are herein referred to a new species, *O. phelani.* Further fieldwork is necessary before I will know whether *O. phelani, O. wetherbyi,* or *O. haldemani* occur in the Williston Formation, which lies between the Crystal River Formation which has *O. wetherbyi* and *O. haldemani* and the Inglis Formation with *O. phelani.*

Comparison with other species.—*O. haldemani* is found commonly with *O. wetherbyi* and on first impression specimens of the two species look quite similar. In *O. haldemani,* however, the periproct is always much further away from the peristome than in *O. wetherbyi.*

I measured the distance from the periproct to the posterior margin in all the specimens from one locality and plotted them on a scatter diagram (text fig. 27). The points fall into two widely separated patterns without overlap.

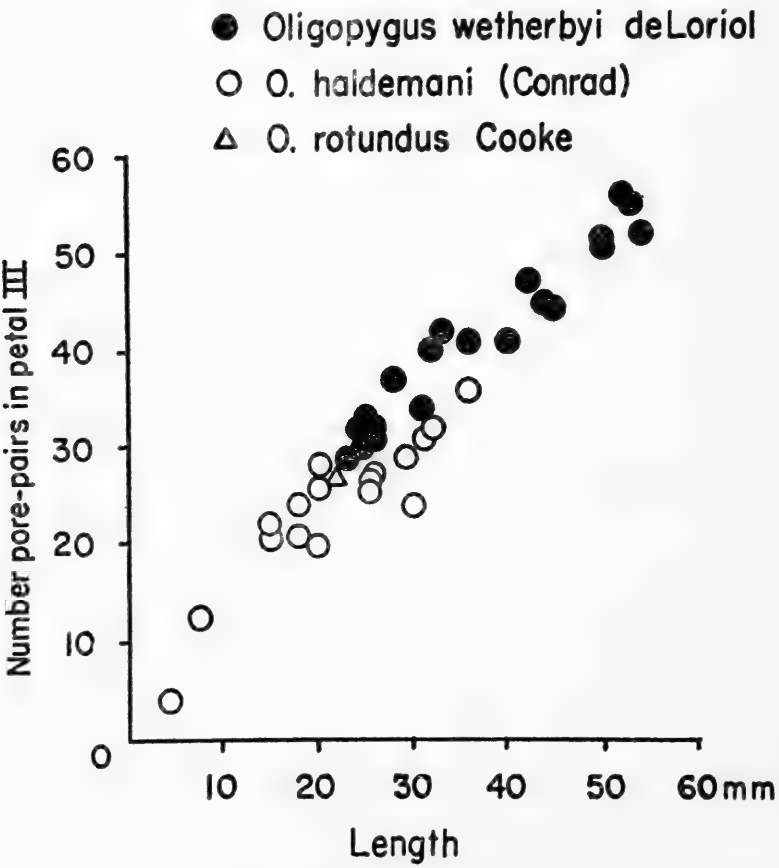


FIG. 38.—Number of pore-pairs in a single poriferous zone in petal III relative to the length in *Oligopygus wetherbyi* de Loriol, *O. haldemani* (Conrad), and *O. rotundus* Cooke.

Usually the periproct opening in *O. haldemani* is wider and less circular, there are fewer pore-pairs in petals III, V, and I (text figs. 38, 39), the test is wider (text fig. 24), and the greatest width more anterior. These differences, however, are slight and not always consistent. The largest specimens of *O. haldemani* are smaller than the largest of *O. wetherbyi*.

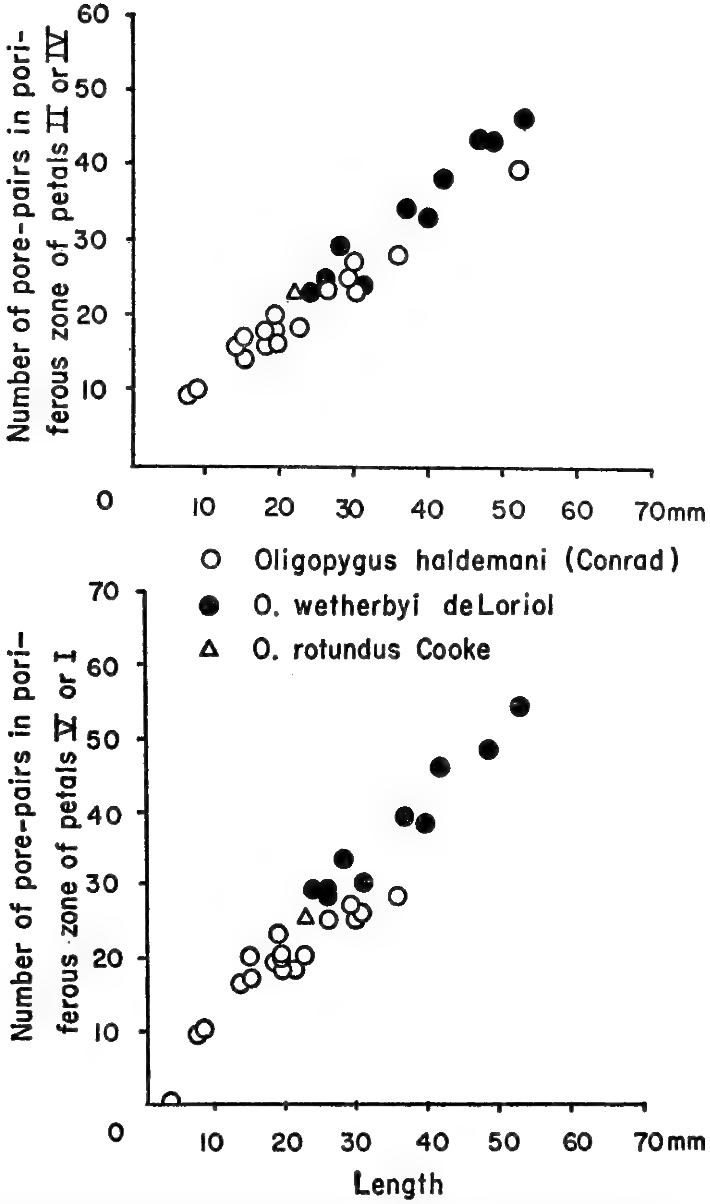


FIG. 39.—Number of pore-pairs in a single poriferous zone in petals V or I, and II or IV relative to the length of the test in *Oligopygus haldemani* (Conrad), *O. wetherbyi* de Loriol, and *O. rotundus* Cooke.

O. haldemani is very similar to *O. phelani* but differs in having a deep peristomal trough, and a more posteriorly situated periproct.

Remarks.—Lambert's *O. colsoni* is based on specimens from north of Marianna, Florida. Although I have been unable to locate the type specimens (according to Dr. M. Beauvais, personal communication 1966, the specimens are not in the Lambert Collection at the Sorbonne), I agree with Cooke that this species is a synonym of *O. haldemani*. *O. haldemani* is common in the area of Marianna, and Lambert's photographs show a specimen that is indistinguishable from young *O. haldemani*.

INADEQUATELY DESCRIBED SPECIES OF *OLIGOPYGUS*

OLIGOPYGUS CAMAGUEYENSIS Sánchez Roig

Oligopygus camagueyensis Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 162.

Unfortunately Sánchez Roig never figured this species and his holotype is not available to me. Until his holotype has been illustrated and described in more detail, most of the characters of this species will remain unknown.

Location of type specimens.—Sánchez Roig Collection, the location of which is not known to me.

Occurrence.—Late Eocene according to Sánchez Roig, middle and late Eocene according to Brodermann (1949, p. 325), Cuba: Grúa no. 9, Ramal Juan Criollo, Central Jatibonico, Camaguey.

OLIGOPYGUS COLLIGNONI Lambert

Oligopygus Collignoni Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 291, pl. 17, figs. 5–7.

Oligopygus collignoni Lambert.—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 164.

I have not been able to find the holotype of this species, and therefore have not been able to figure it. According to Dr. M. Beauvais (personal communication, 1966) it is not in the Lambert Collection at the Sorbonne in Paris. Presumably it is in the Sánchez Roig Collection, the location of which is unknown to me.

From a study of Lambert's photographs of the holotype, this species seems most similar to *O. rotundus* Cooke, but differs in having a broader (transversely) peristomal depression and in having its periproct nearer the posterior margin.

Occurrence.—Late Eocene according to Lambert and Sánchez Roig, but Brodermann (1949, p. 325) considers it middle and late

Eocene, Cuba: Ciego de Avila (holotype); Sánchez Roig also reports it from Finca Concepción. Barrio Marroqúin. Morón. Camagüey. Finca Sta. Inés. Barrio Majagua.

OLIGOPYGUS ELONGATUS Palmer

Oligopygus elongatus Palmer, *in* Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 166, pl. 30, figs. 4, 5.

The figures of this species are so poor that until the type has been redescribed and refigured, the important features of this species cannot be known. I have studied two topotype specimens in the U.S. National Museum, and one from the Museum of Comparative Zoology which have been identified by Palmer, but all three are too poorly preserved to describe or illustrate.

Location of type specimen.—Sánchez Roig Collection, the location of which is unknown to me.

Occurrence.—Late Eocene, according to Sánchez Roig, but middle and late Eocene according to Brodermann (1949, p. 325), Cuba: 150 meters east of Arroyo Blanco on road to Majagua, Camagüey.

OLIGOPYGUS CUBENSIS Lambert

Oligopygus wetherbyi Lambert and Sánchez Roig (not de Loriol), 1926, *in* Sánchez Roig, Bol. Minas Habana, no. 10, p. 82, pl. 13, figs. 10, 11.

Oligopygus cubensis Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 292.

Oligopygus cubensis Lambert.—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 163.

Oligopygus cubensis Lambert.—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 12.

This species has never been adequately figured or described. Cooke (1961, p. 12) stated that it appeared to be a synonym of *O. haldemani* (Conrad) but its periproct is more anterior than in typical *O. haldemani.* Until the holotype has been redescribed and refigured most of the specific characters of this species will remain unknown.

Location of type specimen.—Sánchez Roig Collection, the location of which is not known to me.

Occurrence.—Eocene according to Sánchez Roig, middle and late Eocene according to Brodermann (1949, p. 325), Cuba: San Diego de los Baños, 2 km from railway junction with central highway. Pinar de Río.

OLIGOPYGUS COSTULATUS (Desor)

Echinocyamus costulatus Desor, *in* Agassiz and Desor, 1847, Ann. Sci. Nat., ser. 3, vol. 7, p. 142.
Sismondia costulata Desor, 1857, Synopsis des échinides fossiles, p. 227.
Oligopygus costulatus (Desor).—de Loriol, 1888, Recueil. Zool. Suisse, ser. 1, vol. 4, no. 3, p. 398.
Oligopygus costulatus (Desor).—Lambert and Jeannet, 1928, Mém. Soc. Helvétique Sci. Nat., vol. 64, no. 2, p. 203, pl. 1, figs. 14–17.
Oligopygus costulatus (Desor).—Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, p. 9.

The holotype of this species has never been illustrated or adequately described. Cotteau (1891, vol. 4, p. 631, pl. 19, figs. 15–20) figured and described specimens that he thought were this species, but Lambert and Jeannet (1928, p. 203) state that Cotteau's specimens are different from Desor's. They studied and figured a cast of the holotype. Until the type has been found and described, the specific characters of this species can not be known.

Occurrence.—Unknown.

The three species listed below were described by Sánchez Roig from the Eocene of Cuba but not adequately described or illustrated. Many of their specific characters are unknown. The type specimens are in the Sánchez Roig Collection, the location of which is not known to me.

Oligopygus tuberculatus Sánchez Roig, 1951, Mem. Soc. Cubana Hist. Nat. "Felipe Poey," vol. 20, no. 2, p. 56, pl. 34, figs. 4, 5.
Oligopygus herrerai Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 154, pl. 6, figs. 6, 7, 9.
Oligopygus sanjosephi Sánchez Roig, 1953, op. cit., p. 155, pl. 7, figs. 1, 2.

OLIGOPYGUS CHRISTI Jeannet

Oligopygus Christi Jeannet, 1928, Mém. Soc. Paléont. Suisse, vol. 48, p. 10, pl. 1, figs. 16–19; pl. 6, fig. 2.

Remarks.—The type specimens of *Oligopygus christi* Jeannet have been lost. Jeannet's illustrations do not show sufficient detail for me to be confident enough of the specific characters to select a neotype. In general appearance his species seems most similar to *O. kugleri* having a similarly high test and similar position of periproct, but differs in having a wider test.

Occurrence.—Late Eocene, Venezuela, Rio Calderas, near Los Baños, Barinitas region, NNW of Barinas.

Trinidad, late Eocene, San Fernando Formation, Soldado Rock.

GENUS *HAIMEA* MICHELIN

Haimea Michelin, 1851, Rev. et Mag. Zool., ser. 2, vol. 3, p. 92–93. Type species by original designation: *Haimea caillaudi* Michelin.

Haimea Michelin.—Lambert, 1925, Comp. Rendu Soc. Géol. France, fasc. 17, p. 232.

Pauropygus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 30. Type species by original designation: *Echinolampas ovumserpentis* Guppy.

Haimea Michelin.—Lambert, 1932, Soc. Géol. France, Bull., ser. 5, vol. 1, p. 295.

Pauropygus Arnold and Clark.—Lambert, 1932, Soc. Géol. France, Bull., ser. 5, vol. 1, p. 292.

Bonaireaster Pijpers, 1933, Geology and paleontology of Bonaire (D.W.I.), p. 85. Type species by original designation: *Bonaireaster rutteni* Pijpers.

Haimea Michelin.—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Pauropygus Arnold and Clark.—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Haimea Michelin.—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, p. 258.

Bonaireaster Pijpers.—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, p. 262.

Pauropygus Arnold and Clark.—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, p. 258.

Haimea Michelin.—Durham and Melville, 1957, Journ. Paleont., vol. 31, no. 1, p. 257.

Bonaireaster Pijpers.—Durham and Melville, 1957, Journ. Paleont., vol. 31, no. 1, pp. 257–258.

Haimea de Loriol.—Wagner and Durham, 1966, *in* Treatise on Invertebrate Paleontology, pt. U, Echinodermata 3, vol. 2, p. U448.

Bonaireaster Pijpers.—Wagner and Durham, 1966, *in* Treatise on Invertebrate Paleontology, pt. U, Echinodermata 3, vol. 2, p. U448.

GENERIC DESCRIPTION

Shape.—Elongate to circular, high to low with height varying from 30 to 100 percent of length, marginal outline rounded to pentagonal, adoral, adapical surface flattened or rounded, petals flush or inflated, nodes present or absent on interambulacral plates.

Apical system.—Slightly anterior, central, or slightly posterior, monobasal, four genital pores, large in some specimens, small in others of same species, presumably sexually dimorphic, anterior genital pores closer together than posterior.

Ambulacra.—Petals well developed, open or slightly closed, long or short, anterior petal (III) usually longest, posterior pair (V and I) usually shortest, pores strongly conjugate; equal number of pores in pore series of same petal; beyond petals ambulacra composed of primary plates, demiplates, and in some species included plates;

demiplates and included plates always small, thin, not reaching interior of test, situated near adradial border; absent on badly weathered specimens, demiplates and included plates absent near peristome, most crowded at ambitus, buccal pores present in ambulacra at edge of peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; bourrelets present.

Peristome.—Slightly anterior, central, or slightly posterior, subpentagonal to pentagonal, not depressed in deep transverse trough.

Periproct.—Inframarginal, varying in position from submarginal to near the peristome.

Sphaeridia.—Double row of pits in each ambulacrum near peristome.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above general surface of test; perforated; crenulations and mamelon present only on unweathered portions of test; small secondary tubercles scattered over area between primary tubercles; glassy tubercles present in some species.

Lantern supports.—Five pairs of flaring buttresses interradial in position with auricles in interambulacra 2, 3, and 5, and anterior areas of 4 and 1, and apophyses in the posterior areas of 4 and 1.

Lantern.—Large, pentagonal, starlike marginal outline; pyramid 5 largest, 2, 3 smallest; lamellae well developed, radiating in polyfurcate fashion from middle body; interior wings convergent, with lamellar supports; symphyses widen ventrally; teeth keeled.

Plate sutures.—Sutures between plates not corrugated.

Crystallography.—*C*-axis orientation of Raup's (1966) "ontogenetic variation type B" with axes plunging toward apical system in oldest plates, perpendicular near ambitus, and increasingly plunging away from apical system in younger plates above ambitus.

Comparison with Oligopygus.—*Haimea* is similar to *Oligopygus* in its petal arrangement, ambulacra beyond the petals with demiplates, apical system, position of periproct, tuberculation consisting of irregularly arranged tubercles with small perforated mamelons, lantern and lantern supports. It differs in that its peristome is subpentagonal to pentagonal with bourrelets, whereas in *Oligopygus* the peristome is less regular in the shape of the opening, is usually situated in a deep transverse trough, and has no bourrelets. Furthermore, *Haimea* has smooth sutures as constrasted to the corrugated sutures in *Oligopygus*.

Arnold and Clark were unaware of Michelin's *Haimea* when they erected their *Pauropygus*. Later (Arnold and Clark, 1934) they considered *Pauropygus* to be a subjective synonym of *Haimea*. Lambert (1932) maintained it as a separate genus claiming that in *Pauropygus* the petals were more developed than in *Haimea*. Lambert was probably influenced by the erroneous figure by Michelin showing narrow underdeveloped petals in the type species *Haimea caillaudi*. Actually the petals in *H. caillaudi* (pl. 24, fig. 1) are well developed. Mortensen (1948) and Durham and Melville (1957) considered *Pauropygus* a subjective synonym of *Haimea*.

I have studied the type specimens of both genera and there is no doubt in my mind that they are congeneric. Both species differ only in characters which vary within or between other species of *Haimea*. The type species of *Pauropygus* is almost indistinguishable from *H. alta*, and Arnold and Clark considered it a synonym of their *H. elevata*.

When Pijpers erected his new genus *Bonaireaster*, he evidently was not aware that a lantern was present in *Haimea*. He had specimens of *Haimea* before him but made no comparison of specimens of his new genus with them. Mortensen (1948, p. 262) realized that *Bonaireaster* was very similar to *Haimea* and *Oligopygus* but he also was unaware of the existence of a lantern in *Oligopygus* and *Haimea*. I am convinced from a study of the type specimens of the type species of both genera that *Bonaireaster* is a subjective synonym of *Haimea*.

The type species of *Bonaireaster* is similar to *Haimea* in having the same general petal arrangement, demiplates, buccal pores, similar apical systems with small discrete ocular plates, similarly shaped peristomes, inframarginal periprocts, similar lanterns with well-developed lamellae, and similar lantern supports with auricles in interambulacra 2, 3, and 5 and anterior areas of 4 and 1, and apophyses in the posterior areas of 4 and 1. It differs in no significant character from the type species of *Haimea*, and is in fact almost indistinguishable from *Haimea rugosa*.

DISTRIBUTION

Haimea is known from the West Indies including Jamaica, Trinidad, Bonaire, Anguilla, Cuba, St. Bartholomew, and from northwest Africa, Senegal, and from Peru. It has never been found in Florida. At several localities it is reported from beds called Eocene but never from beds specifically labelled early Eocene and presumably, therefore, it is confined to the middle and late Eocene.

Eames and Blow (1965) consider the Vista Bella Limestone (where *Haimea* occurs in great numbers) to be Miocene based on the presence in this limestone of certain species of foraminifera. They also believe that the limestone contains much reworked late Eocene material. I have studied hundreds of echinoids from this limestone and they are clearly Eocene. Many species are present that occur in well-dated Eocene formations in Jamaica, Florida, St. Bartholomew, Peru, and elsewhere. None of the echinoids are present in Miocene beds anywhere else. Therefore, if Eames and Blow are correct in their age determination, then all these hundreds of specimens must be reworked, a very improbable alternative considering their good preservation and the large number of specimens and taxa involved.

KEY TO THE SPECIES OF *HAIMEA*

Test high (average height 65–90 percent of length).
  Demiplates numerous, in contact with each other.
    Width varying from 80 to 84 percent of length.
      H. elevata (Arnold and Clark)
    Width varying from 85 to 97 percent of length.
      Periproct near peristome (36 percent distance from peristome to periproct) .... **H. caillaudi** Michelin
      Periproct 50–65 percent distance from peristome to periproct.
        H. alta (Arnold and Clark)
  Demiplates not in contact with each other.
    Adapical surface inflated into sharp peak.
      H. pyramidoides (Arnold and Clark)
    Adapical surface not inflated into sharp peak.
      H. cylindrica (Arnold and Clark)
Test moderately high (average height 45–65 percent of length).
  Petals inflated, nodes on interambulacra.
    Peristome very high, twice width....... **H. convexa** (Arnold and Clark)
    Peristome moderately high.
      Demiplates numerous, in contact with each other.
        H. rutteni (Pijpers) or **H. meunieri** (Lambert)
      Demiplates not in contact with each other.
        H. rugosa (Arnold and Clark)
  Petals flush with test, nodes absent or slightly developed on interambulacra.
  Petals short, posterior petals extending less than one-half distance from apical system to posterior margin...... **H. parvipetala** (Arnold and Clark)
  Petals long, posterior petals extending more than one half distance from apical system to posterior margin.............. **H. ovumserpentis** (Guppy)
Test low (average height less than 45 percent of length).
  Petals broad, interporiferous zone wider than periferous.
    Haimea rotunda (Arnold and Clark)
  Petals narrow, interporiferous zones narrower than poriferous.
    H. stenopetala (Arnold and Clark).

HAIMEA CAILLAUDI Michelin

Plate 24 (figs. 1–4) ; text fig. 40

Haimea Caillaudi Michelin, 1851, Rev. et Mag. Zool., ser. 2, vol. 3, p. 92–93, pl. 2, figs. 2, 2a, 2b.
Haimea Caillaudi Michelin.—Desor, 1858, Synopsis des échinides fossiles, pl. 30, figs. 1–3 (copied from Michelin).
Haimea Caillaudi Michelin.—Lambert, 1925, Comp. Rendu Soc. Géol. France, p. 232.
Haimea Caillaudi Michelin.—Lambert and Jeannet, 1928, Mém. Soc. Helvétique Sci. Nat., vol. 64, no. 2, p. 206.
Haimea Caillaudi Michelin.—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1 (1931), p. 289, 295.
Haimea caillaudi Michelin.—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.
Haimea Caillaudi Michelin.—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, p. 259, figs. 248a–d.
Haimea caillaudi Michelin.—Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 143, pl. 3, fig. 3.

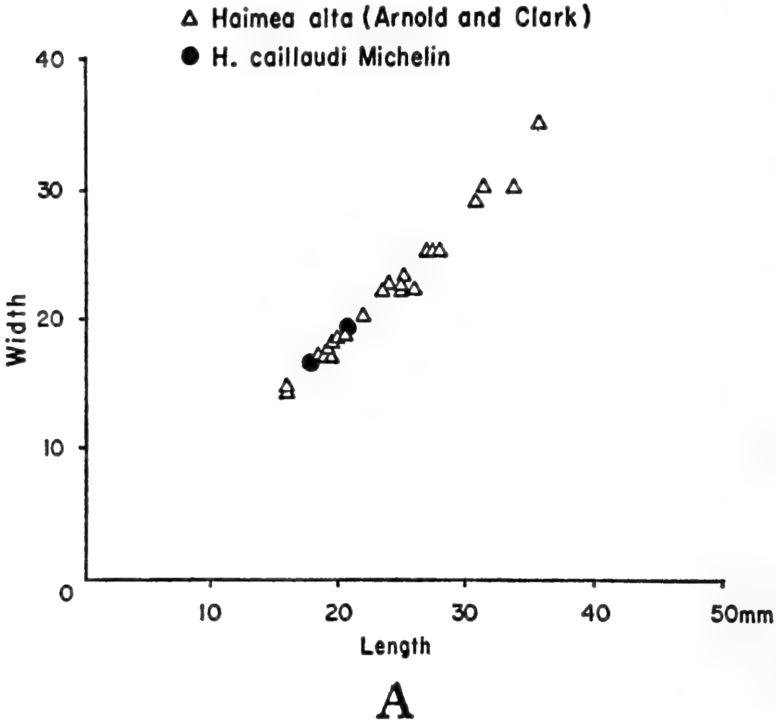
Material.—Description based on two of the three existent syntypes.

Shape.—Subspherical, lectotype 20.4 mm long, 19 mm wide, 18 mm high; paralectotype 18.3 mm long, 17.5 mm wide, 16.1 mm high, test nearly as wide as long with averaging 94 percent of length, greatest width central, height 88 percent of length; marginal outline rounded to slight pentagonal in larger specimen, with posterior surface slightly flattened, smoothly rounded, adoral surface convex except for slight flattening at peristome and periproct.

Apical system.—Central, four genital pores, anterior pair closer together than posterior, position of pores within or partially outside of madreporite not clear because of weathered condition of both specimens; oculars small.

Ambulacra.—Petals straight, extending two-thirds distance from apical system to margin, open, or with slight tendency to close distally (pl. 24, fig. 1), interporiferous zone at greatest width double width of poriferous zone; pores conjugate, outer pore of pair elongated transversely, more distal to inner; petal III longest with 20 pore-pairs in single poriferous zone in lectotype, 16–17 in paralectotype; posterior petals V and I slightly shorter with from 18–19 pore-pairs in lectotype, 16 in paralectotype; petals II and IV shortest with 16–17 pore-pairs in lectotype, 14 in paralectotype.

Beyond petals double series of pores in each half-ambulacrum (text fig. 40), at midzone in unweathered areas primary plate separated from adradial suture by continuous series of demiplates



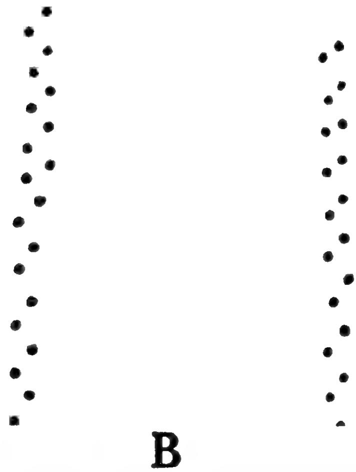


FIG. 40.—A, Width relative to length in *Haimea alta* (Arnold and Clark) and *H. caillaudi* (Michelin). B, Pores at ambitus in ambulacrum II of *H. caillaudi,* lectotype, École National Supérieure des Mines, Paris, locality unknown, ×15.

(like in *Haimea alta* in text fig. 5A) ; one demiplate to each primary, in weathered portions primary plate extends over to adradial suture; total of approximately 115 ambulacral plates in single poriferous zone of ambulacral II beyond petal; ambulacrum terminates at peristome with large plates with buccal pores.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Central to slightly posterior, height equaling width, pentagonal, flush with test except where slightly indented at ambulacra.

Periproct.—Inframarginal, located approximately 36 percent of distance from posterior edge of peristome to posterior margin in lectotype, 29 percent in paralectotype; opening large (pl. 24, fig. 2), in lectotype 2.1 mm long, 1.9 mm wide, pointed anteriorly, broadened posteriorly.

Sphaeridia.—Double row in each ambulacrum near peristome.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test; perforated; crenulations and mamelon present only on unweathered portions of test, not preserved on most tubercles.

Location of type specimens.—École National Supérieure des Mines, Paris.

Occurrence.—Origin of type specimens unknown. Lambert (1925, p. 232) reports the species from the late Eocene, Spring Mount, in Jamaica. According to the 1958 geological map of Jamaica, Spring Mount is in the middle Eocene Yellow Limestone. Sánchez Roig (1953, p. 144) records the species from the upper Eocene of Cuba at Loma Calisto, Nuevitas.

Remarks.—Michelin's type specimens of *Haimea caillaudi* have not been described or illustrated since he originally described them. The specimens were at the Museum d'Histoire Naturelle at Nantes, France, according to Michelin, and Lambert and Jeannet (1928, p. 206). Lambert (1925, p. 232) gives no evidence of having seen the types in his report of the discovery of *H. caillaudi* from the late Eocene of Jamaica. Because I knew that part of the Michelin Collection was at the École National Supérieure des Mines, I asked Madame Letia of that institution to look among the echinoids for specimens of this species. She found and sent me three specimens labeled "Haimea Caillaudi Michelin, Coll. Michelin." At the bottom of the label is written, in a different handwriting, "Eocene De La Jamaique." These specimens are with little doubt from the type lot. Michelin had no locality data for his specimens, and no locality data was known for the species until 1925 when Lambert reported it from the late Eocene of Jamaica. It was at this time or later when the locality data was probably added to the label. (The handwriting of this portion of the label is very similar to Lambert's writing on the label of another specimen identified by him as *H. caillaudi* from the late Eocene of Spring Mount, Jamaica. There is little doubt in my mind that Lambert found the type specimens in the Michelin Collection after he had reported the species occurrence in Jamaica and added the locality data to the label.) The fact that the specimens are from the Michelin Collection and that two of them are similar in all respects (except size) to his figures and description justifies considering them as from among his types. Michelin's drawings of the species are idealized and show no imperfection which could be found on the specimens, which, if they had been illustrated, might have been useful in identifying the figured specimen. His figure, however, is of a specimen 24 mm long and in his text he states that it has that length. Because the largest of his specimens in the École des Mines is only 20.4 mm long, I assume that his figured specimen has been lost, but because these other specimens seem to be so obviously a part of his originally studied collection, I select the specimen figured herein on plate 24, figures 1–3 as the lectotype.

One of the specimens of his suite is clearly not conspecific with the lectotype. This specimen (pl. 24, figs. 5–7) has much broader petals with broader poriferous zones with stronger conjugation. Its test is more elongate, lower, and the periproct is smaller and considerably more distant from the peristome. The specimen is certainly a *Haimea,* and resembles *Haimea cylindrica* (Arnold and Clark).

Comparison with other species.—*H. caillaudi* is most similar to *H. alta* (Arnold and Clark) from the Eocene of Jamaica. It differs in having a slightly higher test (text fig. 40A) with a height in both of the type specimens equal to 88 percent of the length whereas in 36 specimens (the holotype and paratype) of *H. alta* the height varied from 68–88 percent of the length with an average of 76 percent. In *H. caillaudi* the periproct is located much nearer the peristome, only 36 percent of the distance from the peristome to the posterior margin, whereas in *H. alta* it is 50–65 percent of this distance. Furthermore, the periproct in *H. caillaudi* is more pointed anteriorly.

Arnold and Clark (1934, p. 143) decided after studying Michelin's description and figures of *Haimea caillaudi* that their *Pauropygus elevatus* was a synonym of *H. caillaudi;* however, they did not see the types of *H. caillaudi.* I have compared their holotype and six of their paratypes of *P. elevatus* with the types of *H. caillaudi* and the two groups of specimens are quite distinct. In the types of *H. caillaudi* the test is considerably broader, higher, and the periproct much nearer the peristome.

HAIMEA ELEVATA (Arnold and Clark)

Plate 25 (figs. 1–4); text figs. 41, 42

Pauropygus elevatus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 35, pl. 5, figs. 1–3.

Haimea caillaudi Michelin (in part).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype and six paratypes.

Shape.—Elongate, width (text fig. 41) 80 to 84 percent of length, average 82 percent, greatest width central in some specimens, anterior in others; test high, height 71 to 75 percent of length, average 72 percent; largest specimen 29.0 mm long, smallest 14.4 mm; marginal outline oval to slightly pentagonal with anterior slightly pointed, posterior blunted; sides steep; adoral surface rounded, slightly depressed around peristome; petals flush.

Apical system.—Central, system slightly higher than wide, four genital pores, anterior pair closer together than posterior, genital pores very large in some specimens, small in others presumably indicating sex difference; ocular plates small.

Ambulacra.—Petals well developed, petal III longest with from 3 to 4 more pore-pairs in a single poriferous zone than in petals II or IV, 0 to 3 more than in petals V or I; in largest specimen (holotype) 29 mm long, 28 pore-pairs in single poriferous zone of petal III, 24 in petal IV, 28 in petal V; in smallest specimen, 14.4 mm long, 23 in single poriferous zone of petal III, 19 in IV, 20 in V; petals open, with slight narrowing of interporiferous and poriferous zones at end of petals; outer pore of pore-pair more distal to inner, near ends of petals.

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, in ambital region demiplates in contact with each other (text fig. 42) isolating primary plates from adradial suture, approximately 100 primary

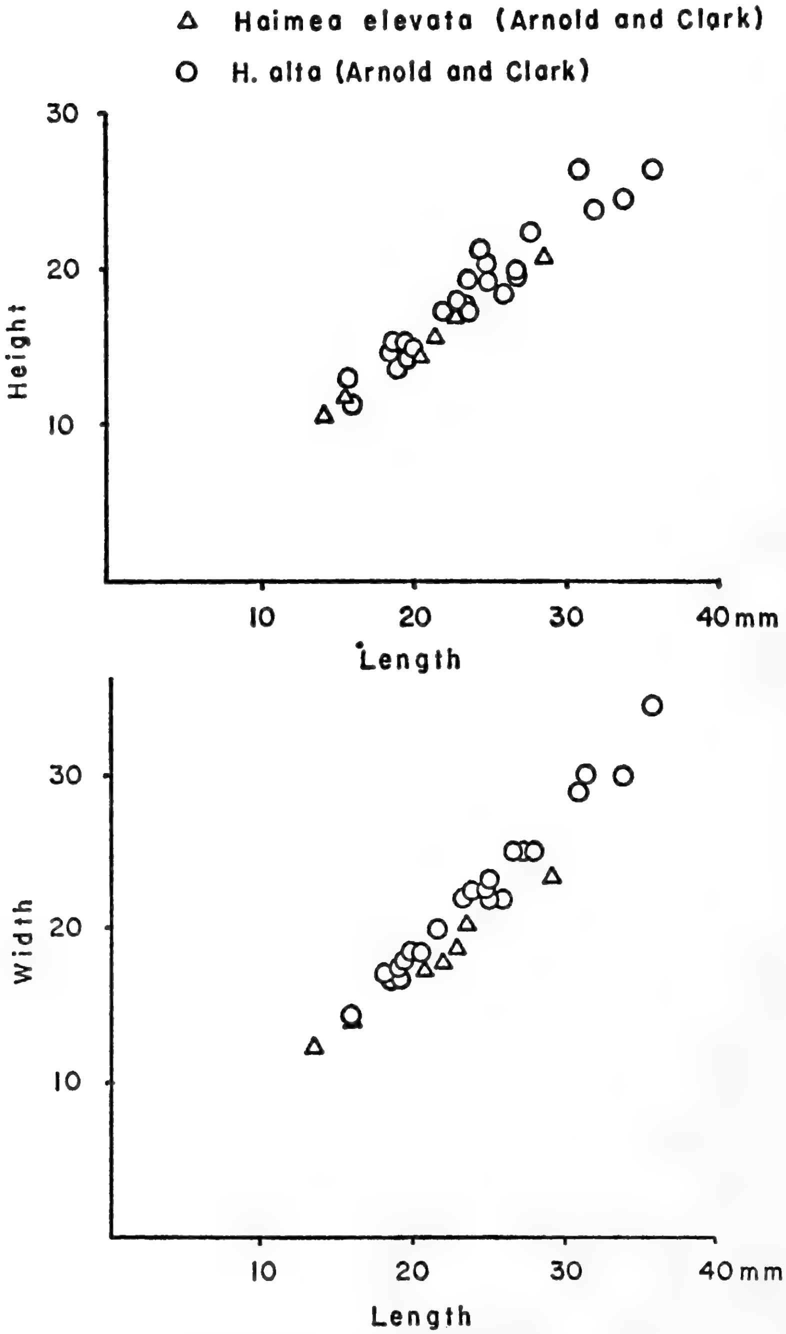


FIG. 41.—Height and width relative to length in *Haimea elevata* (Arnold and Clark) and *H. alta* (Arnold and Clark).

plates in ambulacrum III beyond petal, approximately 224 plates in ambulacrum III beyond petal; pores in double series with alternate pores (in primary plates) indented towards perradial suture; buccal pores present near peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Central, circular to slightly subpentagonal, bourrelets slightly developed.

Periproct.—Inframarginal, located from one-half to two-thirds distance from peristome to posterior margin.

Sphaeridia.—Double, alternating row in each ambulacrum near peristome; exact number not known because of poor preservation.

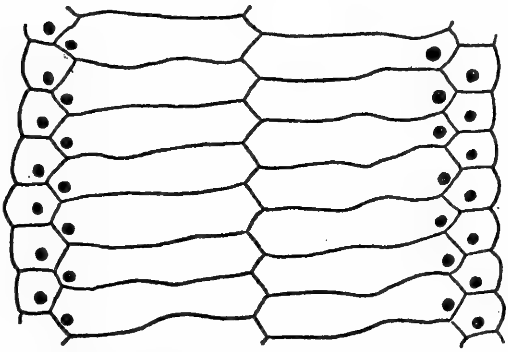


FIG. 42.—Plate arrangement in ambulacrum IV just above the ambitus in *Haimea elevata* (Arnold and Clark). Note, demiplates separate the primary plates from the adradial suture. Paratype, MCZ 3397a from the west side of the Yallahs River, St. Thomas Parish, Jamaica, ×15.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test, crenulated; small perforated mamelons typical in genus, absent presumably due to weathering (all specimens badly weathered); small secondary tubercles scattered over area between primary tubercles.

Occurrence.—West side of Yallahs River, St. Thomas, Jamaica. I have collected in this region and only found echinoids in the middle Eocene Yellow Limestone. Arnold and Clark also report the species from St. James Parish, Jamaica.

Location of type specimens.—Mus. Comp. Zool., Cambridge: holotype, 3274; 6 paratypes 3397.

Comparison with other species.—Arnold and Clark (1934, p. 143) decided after studying Michelin's descriptions and figures of *Haimea caillaudi* that *H. elevata* was a synonym of *H. caillaudi;* however, they did not see the types of *H. caillaudi.* I have compared the types of *H. elevata* with the types of *H. caillaudi* and the two groups of specimens are quite distinct. In *H. elevata* the test is much narrower, 80 to 86 percent of the length, whereas in the types of *H. caillaudi* the width is 94 percent of the length. *H. elevata* is lower with the height averaging 72 percent of the length as opposed to 88 percent in *H. caillaudi,* and its periproct farther from the peristome.

H. elevata is very similar to *H. cylindrica* in shape having the same length to width to height ratios, similar petals, position of periproct and shape of peristome (although in some specimens of *H. cylindrica* the bourrelets are better developed). In *H. elevata,* however, the demiplates at the ambitus are in contact with each other, whereas in *H. cylindrica* (text figs. 42, 45) they are separated from each other by the primary plates.

H. elevata is also very similar to *H. alta* differing only in having a slightly narrower test (text fig. 41). In *H. elevata* the width varies from 80 to 86 percent of the length, whereas in *H. alta* it varies from 85 to 97 percent. Ordinarily I would not consider this difference to be of sufficient significance to warrant maintaining these two species but the wider specimens (*H. alta*) have never been found with the narrower. *H. alta* is known from Spring Mount, St. James and Lucky Hill, St. Mary, but has never been found at the Yallahs River in St. Thomas, the type locality of *H. elevata.* Probably *H. elevata* could be considered as a geographic subspecies of *H. alta* but not enough is known of their stratigraphic occurrence to be certain that they are contemporaneous.

HAIMEA ALTA (Arnold and Clark)

Plates 4 (fig. 3), 25 (fig. 5), 26; text figs. 5, 20A, 41, 43, 44

Pauropygus altus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 33, pl. 4, figs. 15–17, pl. 5, figs. 7, 8.

Haimea alta (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Haimea caillaudi Michelin (in part).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143 (not Michelin).

Haimea cylindrica Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 141, pl. 3, figs. 6, 7 (not *Haimea cylindrica* (Arnold and Clark, 1927)).

Haimea subcylindrica Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 141, pl. 3, figs. 4, 5.

Haimea pentagona Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 142, pl. 3, figs. 8, 9.

Haimea gigantea Sánchez Roig, 1953, An. Acad. ciencias Medicas, Habana, vol. 91, fasc. 2, p. 143, pl. 3, fig. 11.

Material.—The following description is based on a study of the holotype and 35 paratypes.

Shape.—Slightly elongate, width varying from 85–97 percent of length (text fig. 44); largest specimen 36 mm long; greatest width anterior to center or central; adapical surface slightly convex, greatest height at apical system, varying from 68–84 percent (average 76) of length (text fig. 44), sides very steep, adoral surface flat with peristome slightly depressed, petals flush.

Apical system.—Central, four genital pores, anterior pair closer together than posterior, pores located within madreporite (text fig. 43c); pores present in smallest specimen, 16 mm long; pores large in some specimens, small in others, probably indicating sexual difference; ocular plates small.

Ambulacra.—Petals well developed, extending two-thirds distance from apical system to margin, straight, open, interporiferous zone at greatest width at extremity of petal, two times width of poriferous zone; pores strongly conjugate, oblique with outer pore more distal to inner, outer pore elongate transversely; petal III longest with average of 3 more pore-pairs in a single poriferous zone than in petal II or IV, one more than in petals V and I; towards end of petal outer pore of pore-pair more distal to inner.

Ambulacra beyond petals (text fig. 43A) composed of primary, demiplates, and a few included plates, with the small demiplates occurring at adradial margin, at ambitus demiplates most crowded and in contact with each other separating primary plates from adradial margin (text fig. 5A), total of from 250 to 270 plates in ambulacrum beyond petal; 140 primary plates in ambulacrum III beyond petal; pores in double series (text fig. 43B), with inner pores usually in primary plates; buccal pores present near peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Central, height equaling width (pl. 4, fig. 3), slightly depressed, bourrelets moderately developed.

Periproct.—Inframarginal, located approximately 50–65 percent of distance from center of peristome to posterior margin, opening circular, to wider than high, 2.5 mm wide in specimen 29 mm long.

Sphaeridia.—Double row in each ambulacrum near peristome.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test; perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Jamaica; according to Arnold and Clark this species was collected near Spring Mount, St. James Parish, in or near rather soft and disintegrated strata, and also on a hillside near Lucky Hill, St. Mary. Both these sites are in the middle Eocene Yellow Limestone according to the 1958 geological map of Jamaica.

Cuba, Loma Caoba, 3 km south of San Diego de los Baños, east of old road to canteras, Pinar Del Rio Prov., from the middle Eocene.

Location of type specimens.—Holotype, Mus. Comp. Zoology., Cambridge 3395; 25 paratypes, 3396; fig. spec. USNM 649835.

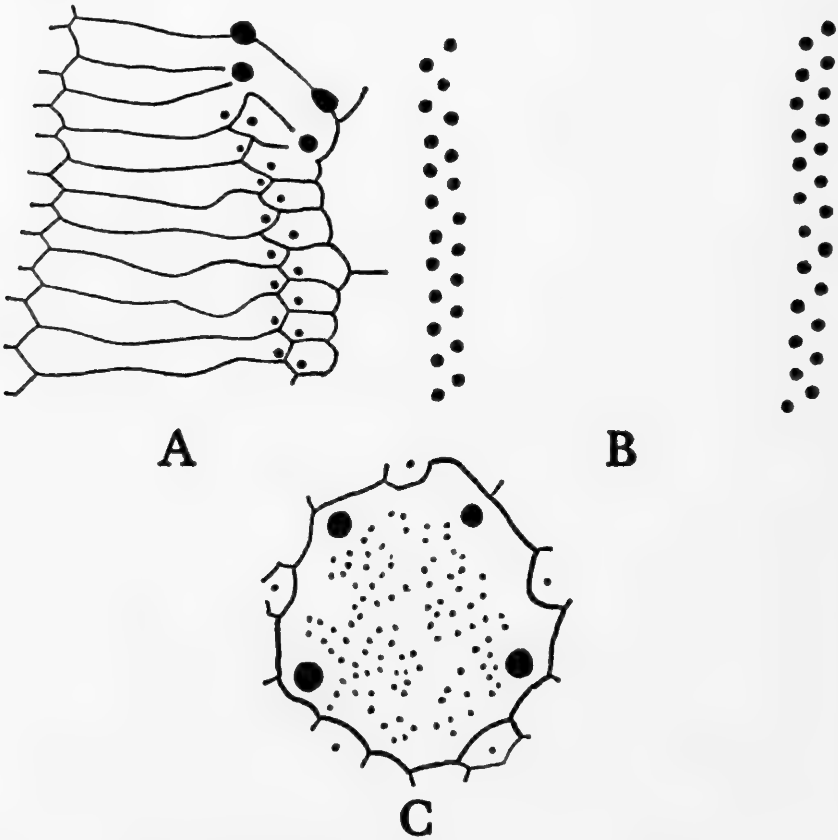


FIG. 43.—*Haimea alta* (Arnold and Clark): fig. A, ambulacral plate arrangement beyond end of petal I on holotype, MCZ 3271, ×14 (for ambulacral plates at the ambitus, see text fig. 5); fig. B, pore arrangement at ambitus in ambulacrum I of paratype, MCZ 3396b, ×4; fig. C, apical system of paratype, MCZ 3395, ×17. All from Spring Mount, St. James Parish, Jamaica.

Comparison with other species.—*Haimea alta* differs from *H. ovumserpentis* in having a higher test, with the height averaging 76 percent of the length as compared to 65 percent in *H. ovumserpentis;* shorter petals extending not so near the margin as in *H. ovumserpentis,* and petals more nearly equal in length with an average of only 3 more pore-pairs in a single poriferous zone in petal III than in petals II and IV as compared to a difference of 8 in *H. ovumserpentis.* The most striking difference between the two species is in the number of ambulacral plates beyond the petals. In *H. alta* there are 250 to 270 plates in each ambulacrum beyond the petals, whereas in *H. ovumserpentis* there are approximately only 180–220. In *H. alta* the demiplates (text fig. 5A) are side by side and separate the primary ambulacral plates from the adradial suture, whereas in *H. ovumserpentis* (text fig. 3) the primaries reach the adradial sutures separating the demiplates except at the ambitus where a few of the demiplates are in contact.

H. alta is very similar to *H. cylindrica* (Arnold and Clark) but differs in having more ambulacral plates beyond the petals with the demiplates in contact, whereas they are not in contact in *H. cylindrica.* The test is slightly wider in *H. alta* (text fig. 44). It is also very similar to *H. elevata* but differs in having a broader test (see discussion under *H. elevata*).

In 1953 Sánchez Roig described four new species of *Haimea* from the middle Eocene of Cuba: *H. cylindrica* (a junior homonym of *H. cylindrica* (Arnold and Clark)), *H. subcylindrica, H. pentagona,* and *H. gigantea.* All four species came from the same locality, Canteras de Caraballo, Loma Caoba, San Diego de los Baños. Unfortunately the types are not available for study, but a large collection of topotypes are in the U.S. National Museum. After studying this material, and Sánchez Roig's descriptions and illustrations, I am convinced that only one species is represented by his four, and that they should all be referred to *H. alta.* I plotted the length-width and length-height ratios on scatter diagrams for all the measurable specimens in the USNM topotype collection, and Sánchez Roig's specimens fell well within the scatter of these topotypic specimens. No significant differences between his species are apparent from his illustrations, and the differences cited in his descriptions are slight and insignificant.

The Cuban topotypic specimens are similar in every way to Arnold and Clark's types of *H. alta.* The petal arrangement, shape of peristome, position of periproct, and, of special importance, the

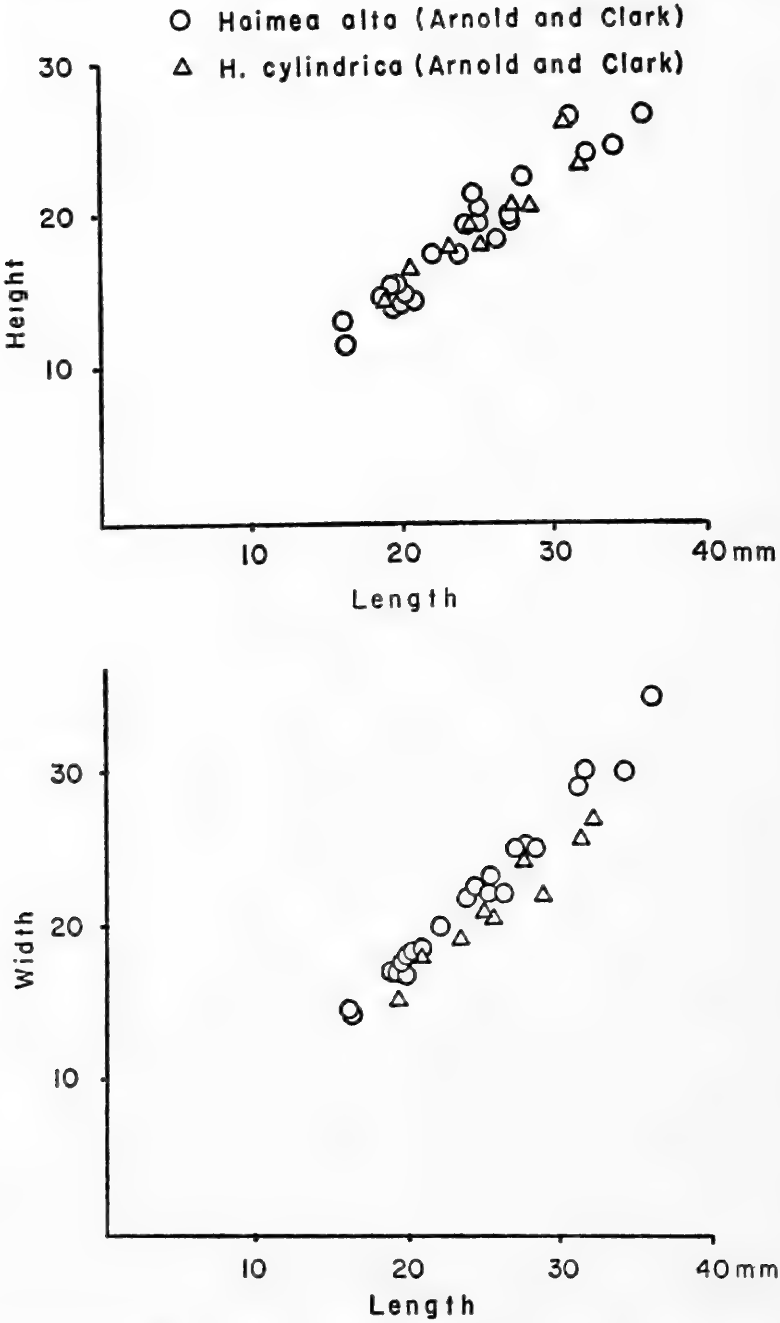


FIG. 44.—Height and width relative to length in *Haimea alta* (Arnold and Clark) and *H. cylindrica* (Arnold and Clark).

number and arrangement of the demiplates are the same in both group of specimens. One of these specimens is figured on plate 26, figures 4–6.

HAIMEA PYRAMIDOIDES (Arnold and Clark)

Plate 27 (figs. 1–5)

Pauropygus pyramidoides Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 39, pl. 5, figs. 19–21.

Haimea pyramidoides (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype. Although there are two paratypes in the collections at Harvard, one of the specimens is so badly distorted and weathered and the other so different in shape that I suspect they may not be conspecific with the holotype.

Shape.—Elongate, 25.3 mm long, 20.0 mm wide, greatest width central; test extremely high, 19.2 mm, 75 percent of length, greatest height at apical system; marginal outline oval with slightly pointed posterior; adoral surface rounded, peristome depressed; petals slightly inflated.

Apical system.—Slightly posterior, further details not visible.

Ambulacra.—Petals short, petal III longest with 31 pore-pairs in single poriferous zone, petals II or IV shortest with 24 pore-pairs, petals V or I with 25; interporiferous zones (pl. 27, fig. 4) narrowing slightly distally, greatest width approximately equal to greatest width of single poriferous zone; poriferous zones narrowing distally; near apical system pores of two pairs in straight line but throughout length of petal outer pore of pair becoming more distal to inner until at end of petal a line passing through two pores of a pair is at right angle to line passing through pores of pore-pair of other poriferous zone.

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, primary plates high, further details obscured by poor preservation.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Slightly anterior, large (pl. 27, fig. 6), slightly higher than wide, 3.2 mm high, 2.9 mm wide, squarish except for deep indentations of paired ambulacra, and swollen bourrelets; bourrelets particularly well developed in interambulacra 4, 5, and 1.

Periproct.—Inframarginal, near posterior margin, wider than high, opening more curved anteriorly.

Sphaeridia.—Presumably present but obscured by poor preservation.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; mamelons absent due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Hill west of Yallahs River, St. Thomas, Jamaica. I have collected in this area and only found echinoids in the middle Eocene Yellow Limestone.

Location of type specimens.—Holotype, Mus. Comp. Zool., Cambridge 3278; two paratypes, 3406.

Comparison with other species.—The highly inflated test raised in a sharp peak distinguishes the holotype from all other specimens of *Haimea.* Because there are no other specimens clearly conspecific with the holotype, it is possible that the holotype is just an aberrant specimen of another species.

HAIMEA CYLINDRICA (Arnold and Clark)

Plates 27 (fig. 6), 28, 29 (figs. 1, 2); text figs. 44, 45

Pauropygus cylindricus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 34, pl. 4, figs. 12–14.

Pauropygus cylindricus (Arnold and Clark).—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 294.

Haimea cylindrica (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype and nine paratypes.

Shape.—Elongate, width (text fig. 44) 77 to 88 percent of length, average 82 percent, greatest width central; test high, height 72 to 78 percent of length, average 74 percent, greatest height (text fig. 45) at apical system; largest specimen 31.7 mm long, smallest 19.0 mm; marginal outline oval in smallest specimens, pentagonal with pointed anterior, blunted posterior in larger specimens; sides steep, adoral surface rounded, slightly depressed around peristome; petals flush.

Apical system.—Central, system slightly higher than wide, four genital pores, anterior pair closer together than posterior, in well-preserved specimens pores situated within madreporite; ocular plates small.

Ambulacra.—Petals well developed, broad, relatively short, petal III longest with from 2 to 6, average of 4 more, pore-pairs in a single poriferous zone than in petals II or IV, 1 or 2 more than in petals V or I; in largest specimen 31.7 mm long, 33 pore-pairs in single periferous zone in petal III, 27 in petal II or IV, 31 in V or I; in specimen 20.5 mm long, 26 pore-pairs in a single zone of III, 22 in II or IV, 25 in V or I; petals open, interporiferous widening distally, (pl. 28, fig. 4) interporiferous zones at greatest width wider than poriferous; pores strongly conjugate; near apical system pores of two pairs in straight line but throughout length of petal outer pore of pair becoming more distal to inner until at end of petal a line passing through two pores of a pair is at right angle to line passing through pores of pore-pair of other poriferous zone; poriferous zones narrow distally, greatest width of petals approximately two-thirds distance from apical system to end of petal.

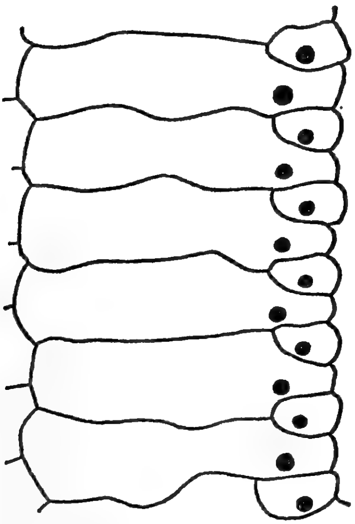


FIG. 45.—Plate arrangement at ambitus in half-ambulacrum IIIb of *Haimea cylindrica* (Arnold and Clark) of paratype, MCZ 2394a from St. James Parish, Jamaica, ×15.

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, alternating with primary plates (text fig. 45), demiplates not in contact with each other, primary plates reaching adradial suture, approximately 100 primary plates beyond petals in ambulacrum III, 110 in II or IV, 115 in V or I (exact count not possible because of poor preservation but number probably 5 to 8 percent accurate); approximately 200 plates in ambulacrum III beyond petals, pores in single series with alternate pores (in primary plates) indented towards perradial suture (text fig. 45); buccal pores present near peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; in specimen 24.5 mm long, 35 plates in interambulacra 2 or 3, 32 in 1 or 4, 36 in 5.

Peristome.—Central to slightly posterior of center, slightly wider than high (pl. 27, fig. 6), in specimen, 31.7 mm long, peristome 4.3 mm wide, 3.7 mm high; bourrelets moderately developed.

Periproct.—Inframarginal, located 60 to 70 percent distance from peristome and posterior margin, opening large, wider than high, pointed anteriorly, rounded posteriorly.

Sphaeridia.—Double, alternating row in each ambulacrum near peristome; exact number not known because of poor preservation but as many as 8 counted in one ambulacrum.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test, crenulated; small perforated, mamelons absent on most tubercles due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—In eroded material in hillsides between Seven Springs and Springfield, St. James, Jamaica. According to the 1958 geological map of Jamaica, both Springfield and Seven Springs lie in the middle Eocene Yellow Limestone separated by a strip of the White Limestone. Probably these specimens came from the Yellow Limestone but it is not possible to be certain.

Anguila, late Eocene as reported by Lambert (1932, p. 294).

Location of type specimens.—Mus. Comp. Zool., Cambridge: holotype, 3273, 9 paratypes, 3394.

Comparison with other species.—*H. cylindrica* is very similar to *H. alta.* Both species have very similar shape with the same length-height ratio (text fig. 44), similar petal arrangement, and position of periproct and peristome. In the types of *H. cylindrica,* however, there are fewer ambulacral plates beyond the petals (approximately 200 in ambulacrum III in *H. cylindrica,* 250–270 in *H. alta*) and the demiplates are not in contact, whereas they are in contact in well-preserved specimens of *H. alta.* The test is slightly narrower in *H. cylindrica* (text fig. 44) with the width varying from 77–88 percent of the length, whereas it varies from 85–97 percent in *H. alta.* I hesitate to attach much significance to such a slight difference in shape, but when coupled with a difference in the ambulacral plate arrangement beyond the petals, it may be important.

H. cylindrica is also very similar to *H. elevata* but differs in having its demiplates at the ambitus not in contact with each other, whereas in *H. elevata* they are in contact.

HAIMEA CONVEXA (Arnold and Clark)

Plate 29 (figs. 3–6)

Pauropygus convexus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 33, pl. 4, figs. 18–20.

Pauropygus convexus Arnold and Clark.—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 293.

Haimea convexa (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype, the only specimen known of the species.

Shape.—Elongate, 26.3 mm long, 21.8 mm wide, 14.6 mm high, width 82 percent of length, height 55 percent of length; greatest width central, greatest height posterior to center but test slightly distorted, exact shape not certain; petals inflated along midline, depressed along adradial margin; interambulacral plates inflated with node present on each adapical plate, depressed along interradial and transverse sutures; adoral surface slightly depressed around peristome.

Apical system.—Central or slightly posterior to center, system elongate (pl. 29, fig. 3) with four genital pores, anterior pair closer together than posterior, pores situated at or near margin of madreporite; ocular plates small.

Ambulacra.—Petals well developed, petal III the longest with 25 pore-pairs in a single poriferous zone as compared to 23 in other petals, and with higher ambulacral plates causing more separation between adjacent pores resulting in longer petal; petals II, IV appear to be wider than other petals but post mortem distortion makes it difficult to ascertain; petals decreasing in width distally due to narrowing of poriferous zones near end of petals; interporiferous zones of greatest width near extremity of petal, slightly wider than poriferous zone; pores strongly conjugate.

Ambulacra beyond petals composed of primary and demiplates, with small demiplates occurring at adradial margin alternating with the primary plates, demiplates not in contact with each other, primary plates reaching adradial sutures; pores in a single series with alternate pores slightly indented towards perradial suture particularly at the ambitus; approximately 90 pores beyond petals in ambulacra II, III, or IV; 110 in ambulacra V or I; buccal pores present at peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Although somewhat fractured and distorted by post mortem pressure, peristome (pl. 29, fig. 6) approximately twice as high as wide, probably widest anteriorly; bourrelets developed.

Periproct.—Inframarginal, located approximately 55–65 percent of distance from center of peristome to posterior margin; original shape of opening not known because of fracturing around opening.

Sphaeridia.—Double alternating row in each ambulacrum near peristome; 8 sphaeridia visible in ambulacrum III; number in other ambulacra uncertain because of poor preservation.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test, crenulated; small perforated mamelons absent on most tubercles due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Near Lucky Hill, St. Mary Parish, Jamaica. According to the 1958 geological map of Jamaica, Lucky Hill occurs in the middle Eocene Yellow Limestone.

Location of type specimen.—Holotype, Mus. Comp. Zool., Cambridge 3272.

Comparison with other species.—Unfortunately only one specimen is known of this species but it is easily distinguished from all the other specimens of *Haimea* by the combination of its strongly inflated petals with deeply depressed poriferous zones, adapical interambulacral plates with well-developed nodes, and very high peristome with its height twice its width.

HAIMEA RUTTENI (Pijpers)

Plates 1 (figs. 1, 2), 6, 8 (fig. 5), 11
(figs. 7, 8), 30 (figs. 3–6); text figs. 12A, 18, 20B, 46, 47

Bonaireaster rutteni Pijpers, 1933, Geology and paleontology of Bonaire (D. W. I.), p. 85, pl. 1, figs. 1–6.

Bonaireaster rutteni Pijpers.—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, p. 262, fig. 253.

Bonaireaster rutteni Pijpers.—Durham and Melville, 1957, Journ. Paleont., vol. 31, no. 1, p. 258, text figs. 3, 4.

Material.—Description based on 306 specimens including the types borrowed from the Geological Institute at Utrecht, and 8 specimens in the U.S. National Museum.

Shape.—Test of moderate size, largest specimens 34 mm long, elongate, width varying from 88 percent of the length (text fig. 46B) in the smaller specimens to 95 percent in the larger, greatest width anterior of center; adapical surface convex; marginal outline slightly pentagonal in adults; greatest height anterior of center,

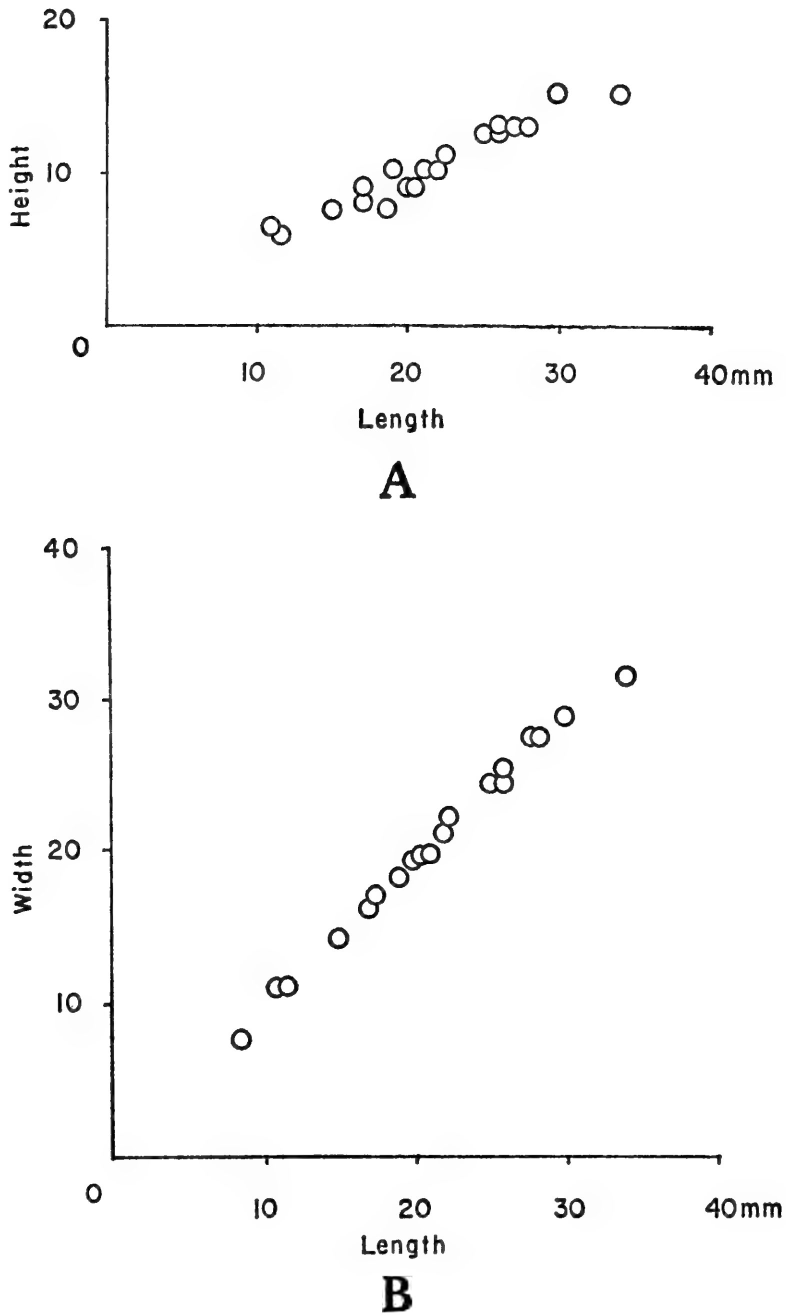


FIG. 46.—Height (A) and width (B) relative to length in *Hamea rutteni* (Pijpers).

varying from 40 to 50 percent of length of test (text fig. 46A); adoral surface flat, small depression around peristome.

Apical system.—Central to slightly anterior, four genital pores, (pl. 1, figs. 1, 2) anterior pair closer together than posterior, pores located in suture between madreporite and adjoining interambulacral plates; ocular plates small (pl. 1, fig. 1), inflated; madreporite strongly inflated; genital pores present in smallest specimen 11 mm long.

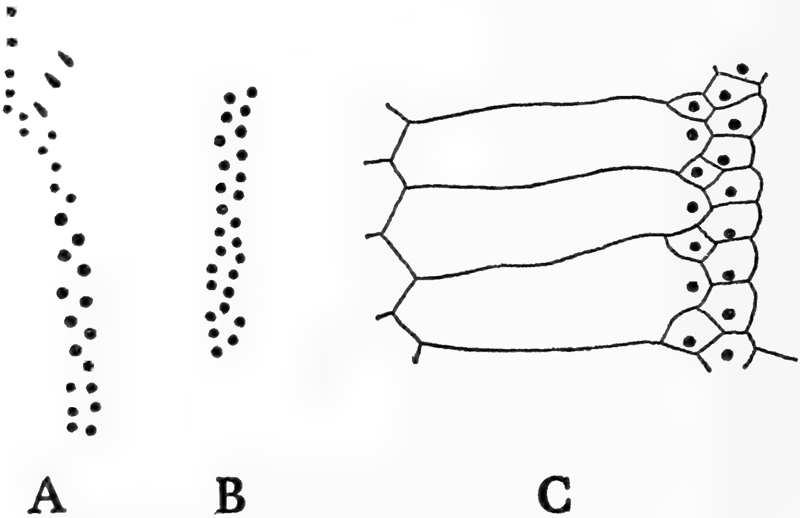


FIG. 47.—*Haimea rutteni* (Pijpers): fig. A, arrangement of pores near petal IV, ×15; fig. B, at ambitus, ×15. Fig. C, plate arrangement of half-ambulacrum Vb just adoral to ambitus, ×22. Geological Institute at the University of Utrecht, late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco.

Ambulacra.—Petals well developed, open, inflated interporiferous zones narrow, greatest width at end of petals, never wider than single poriferous zone; poriferous zones narrow toward end of petals; pores strongly conjugate (pl. 30, fig. 3), oblique with outer pore more distal than inner, outer pore elongated transversely; petal III longest with 1–5 (average of 3) more pore-pairs in single poriferous zone than petals II or IV; 0–5 (average of 2) more pore-pairs than petals V and I.

Ambulacral plates beyond petals (text fig. 47A) extremely numerous with 130 plates in half-ambulacrum of ambulacrum IV, near ambitus primary plates completely cut off from adradial suture (text fig. 47c), pores in two to three columns (text fig. 47b), a small included plate between each demiplate and primary plate, demiplates side by side along adradial suture; demiplates and included plates thin, not reaching interior of test; near peristome pores less crowded, no included plates, primary plate reaching adradial suture; buccal pores present (pl. 11, fig. 8).

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Central to slightly posterior of center, pentagonal (pl. 30, fig. 6) in outline, width equal approximately to height, in depression not much greater in area than opening, interambulacra inflated in bourrelets, ambulacra indented.

Periproct.—Opening small, 1.7 mm wide in specimen 27 mm long, located 60 to 86 percent distance from center of peristome to posterior margin.

Sphaeridia.—Double row of 8–12 sphaeridia in each ambulacrum near peristome (pl. 11, fig. 8).

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upwards as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test; perforated; crenulations and mamelon present only in well-preserved specimens; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Late Eocene, Bonaire: S.W. of Seroe Montagne and Punta Blanco.

Location of type specimens.—Lectotype herein designated, specimen numbered B874 figured in Pijpers (1933, pl. 1, figs. 2, 5) and paralectotypes in the collections of the Geological Institute at the University of Utrecht; figured specimens USNM 649830, 649831, 649836, 649839, 649857.

Comparison with other species.—*H. rutteni* is very similar to *H. rugosa* in its shape, inflated petals, and position of peristome and periproct, but differs in having more ambulacral plates beyond the petals. In *H. rutteni* the demiplates are so numerous that they are in contact with each other separating the primary plates from the adradial suture, whereas in *H. rugosa* the demiplates are fewer and not in contact.

H. rutteni, as discussed under *H. meunieri,* is very similar to *H. meunieri* and may be synonymous with it.

HAIMEA MEUNIERI (Lambert)

Plates 35 (figs. 5, 6), 36

Oligopygus meunieri Lambert, 1907, Bull. Soc. Nat. Ain, no. 21, p. 4, pl. 1, figs. 1, 2.

Pauropygus meunieri (Lambert).—Lambert, *in* Lambert and Jacquet, 1937, Bull. Soc. Géol. France, ser. 5, vol. 6, p. 350, pl. 23, figs. 6–8; 9, 10 (var. *inflata*); 11 (var. *latipetala*); 12, 13 (var. *sulcata*).

Haimea meunieri (Lambert).—Gorodiski, 1951, Bull. Mus. Hist. Nat. Paris, ser. 2, vol. 23, no. 3, p. 327, pl. 1, fig. 10–12.

Haimea meunieri (Lambert).—Tessier, 1952, Bull. Dir. Mines A.O.F., no. 14, p. 297, pl. 16, figs. 1–6.

Haimea meunieri (Lambert).—Roman and Gorodiski, 1959, Notes Serv. Géol. Miniere, p. 32, pl. 2, figs. 16–19.

Haimea meunieri (Lambert).—Élouard, 1962, Mém. Bur. Recherches Géol. et Min., no. 7, p. 248.

Material.—The following description is based on five specimens lent to me by Dr. Jean Roman from the Muséum National d'Histoire Naturelle, Paris. I have compared these specimens with the illustrations of the holotype and other specimens later figured by Lambert and feel certain that they are conspecific.

Shape.—Test broad with width varying from 91 to 93 percent of length, greatest width central to anterior; marginal outline subpentagonal with pointed anterior, blunted posterior; test low, height varying from 39 to 50 percent of length, greatest height anterior in some specimens, at apical system in others; adapical surface flat on some specimens, inflated in others; adoral surface flat with periproct slightly protruding; petals inflated.

Apical system.—Slightly posterior to slightly anterior, four genital pores, large on four specimens, small on fifth, anterior pair closer together than posterior, pores located in suture between madreporite and adjoining interambulacral plates; madreporite strongly inflated, two or three tubercles present on madreporite; ocular plates small.

Ambulacra.—Petals well developed, broad, inflated interporiferous zones, closing distally with interporiferous and poriferous zones narrowing distally; petal III longest with from 4 to 7 more pore-pairs in single poriferous zone than in petals II or IV, one more pore-pair in petals I or V than in II or IV; poriferous zone wider than interporiferous; pores strongly conjugate (pl. 36, fig. 4), outer more distal to inner near end of petal.

Ambulacral plates beyond petals extremely numerous with demiplates and presumably included plates (although sutures not clear large number of pores near ambitus indicates included plates) present near adradial suture; pores in two (almost three at ambitus) series, 110 pores in half-ambulacrum beyond petal I; buccal pores present at edge of peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Slightly anterior, pentagonal (pl. 36, fig. 5) in outline, in slight depression not much larger than opening, slightly higher than wide, bourrelets moderately developed, steepest, almost vertical, in anterior interambulacra, much less steep in interambulacrum 5; anterior ambulacra more indented than posterior.

Periproct.—Opening small, 1.6 mm wide in specimen 20.7 mm long, wider than high, located from near posterior margin to within 70 percent of distance from center of peristome to posterior margin.

Sphaeridia.—Double row of at least eight sphaeridia in each ambulacrum near peristome.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; mamelon small, extending in height above surface of test; perforated; crenulations and mamelon present only in well-preserved areas of test; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Middle Eocene (Lutetien superieur) of Senegal.

Location of type specimen.—Dr. Jean Roman (personal correspondence, 1966) believes that the holotype has been lost. He reports that he was unable to find it in the Lambert Collection in the Sorbonne but did find a specimen labelled in Lambert's hand "neotype." This is the specimen considered by Lambert (Lambert and Jacquet, 1937, pl. 23, figs. 6–8) to be the typical form of the species. The specimens I have figured are in the Muséum National d'Histoire Naturelle, Paris, number 927.

Remarks.—Lambert's variety *latipetala* was erected for a specimen with slightly wider and more inflated petals; his *inflata* for more elongate and inflated specimens, and his *sulcata* for a specimen with a flat adoral surface, prominent plastron, periproct less near the posterior margin, and grooves for the pores beyond the petals.

Comparison with other species.—This species is very similar to *H. rutteni* from the late Eocene of Bonaire. Some of the specimens from Bonaire are indistinguishable from Senegal specimens. Because I have studied only a few specimens of the Senegal species I hesitate to synonymize the two species. I suspect that although there is considerable overlap between these two groups of specimens, their means would be different enough to warrant specific differentiation; however, a study of many specimens of both species is necessary before this can be determined.

HAIMEA RUGOSA (Arnold and Clark)

Plate 31 (figs. 1–3)

Pauropygus rugosus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 41, pl. 6, figs. 4–6.

Haimea rugosa (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype. Although there are six paratypes in the Harvard Collection I am not reasonably sure that they are conspecific with the holotype and therefore I have not included them in the description.

Shape.—Test elongate, 31.4 mm long, 28.9 mm wide, 14.6 mm high; width 92 percent of length, greatest width central to slightly posterior; height 46 percent of length; adoral surface flattened; petals appear inflated due to depression of poriferous zones; interambulacral plates tumid; marginal outline subpentagonal with pointed anterior, blunted posterior.

Apical system.—Central, madreporite higher than wide, four genital pores, anterior pair closer together than posterior, ocular plates small.

Ambulacra.—Petals long, extending more than two-thirds distance from apical system to margin; petal III longest, with 36 pore-pairs in single poriferous zone, other petals with 32 pore-pairs in each zone; petals (pl. 31, fig. 1) open, interporiferous zones widening distally, at greatest width wider than poriferous zones; poriferous zones narrowing distally; outer pore of pair becoming more distal than inner towards end of petals.

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, alternating with primary plates, demiplates not in contact with each other, primary plates reaching adradial suture, approximately 62 primary plates beyond petals in ambulacra II, III, IV: 74 in V or I; pores in single series with alternate pores (in primary plates) indented towards perradial suture; buccal pores present near peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; 28 plates in interambulacrum 5, 29 in 2 or 3, 25 in 4 or 1.

Peristome.—Central (pl. 31, fig. 2), slightly wider than high, pentagonal, pointed anteriorly, blunted posteriorly, bourrelets well developed.

Periproct.—Inframarginal, wider than high.

Sphaeridia.—Double, alternating row in each ambulacrum near peristome; as many as eight in an ambulacrum.

Tuberculation.—Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; mamelons absent due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Near Yallahs River, St. Thomas, Jamaica. I have collected in this region and only found echinoids in the middle Eocene Yellow Limestone.

Location of type specimens.—Mus. Comp. Zool., Cambridge: holotype, 3280; 6 paratypes 3408.

Comparison with other species.—The holotype of *H. rugosa* is very similar to the holotype of *H. rotunda* and the two may be conspecific. *H. rugosa* only differs in having more inflated petals and a slightly lower test. The fact that the petals are more inflated in the holotype of *H. rugosa* may be due only to the better preservation of the specimen. Some of the paratypes of the two species are indistinguishable from each other; however, without more specimens collected with better stratigraphic control, I hesitate to formally synonymize these two species.

H. rugosa is similar in shape, petals, position of peristome and periproct to *H. rutteni* but differs in having fewer demiplates with its demiplates not separating the primary plates from the adradial suture.

HAIMEA PARVIPETALA (Arnold and Clark)

Plates 32 (fig. 6), 33 (figs. 1–3); text figs. 1, 48

Pauropygus parvipetalus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 38, pl. 5, figs. 13–15.

Haimea parvipetala (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype and five paratypes.

Shape.—Elongate, width 82 to 89 percent of length, greatest width anterior to center; height 48 to 60 percent of length, greatest height anterior to center; petals flush with surface of test; adoral surface only slightly depressed and peristome.

Apical system.—Central, madreporite higher than wide, four genital pores, anterior pair closer together than posterior, genital pores situated within madreporite, present on smallest specimen 14.8 mm long; ocular plates small.

Ambulacra.—Petals well developed, short, broad; petal III longest with from 4 to 7 more pore-pairs in single poriferous zone than petals II or IV, 34 pore-pairs in single zone in specimen 35.0 mm long (holotype), 22 in specimen 8.7 mm long; petals II and IV slightly shorter than petals V and I with one or two fewer pore-pairs in a single poriferous zone; greatest width of petals approximately two-thirds distance from apical system to end of petal; interporiferous zones narrower (pl. 32, fig. 6) than poriferous zones; petals decreasing in width distally due to narrowing of poriferous zones near end of petals, interporiferous zones narrowing only

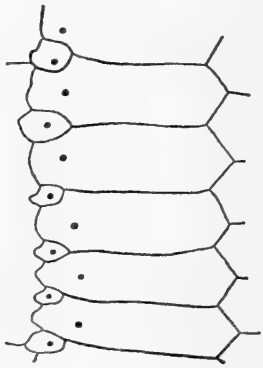


FIG. 48.—Plate arrangement in half-ambulacrum at ambitus in *Haimea parvipetala* (Arnold and Clark) showing the demiplates separated from each other by primary plates. Note that this is a very weathered specimen and that the demiplates on an unweathered surface would be larger. Holotype, MCZ 3276 from Spring Mount, St. James Parish, Jamaica, ×10.

slightly at end of petals; pores strongly conjugate; near apical system pores of two pairs in straight line, but throughout length of petal outer pore of pair becoming more distal to inner until at end of petal a line passing through two pores of a pair is at right angle to line passing through pores of pore-pair of other poriferous zone (text fig. 1).

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, alternating with primary plates (text fig. 48), demiplates not in contact with each other, primary plates reaching adradial suture, approximately 66 primary plates beyond petals in ambulacrum III, 72 in II or IV, 76 in V or I (exact count not possible because of poor preservation but number probably 5 to 8 percent accurate); pores in single series with alternate pores (in primary plates) indented towards perradial suture (text fig. 48); presence or absence of buccal pores not known because of poor preservation.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate in holotype, 35 mm long, approximately 33 plates in interambulacra 2 or 3, 29 in 1 or 4, 30 in 5.

Peristome.—Central, pentagonal, width approximately equal to height, with greatest width anterior, large, in holotype 5 mm high, 14 percent of length of test; bourrelets moderately developed.

Periproct.—Inframarginal, located near posterior margin, opening circular to slightly elongate transversely.

Sphaeridia.—Double alternating row in each ambulacrum near peristome; number not known because of poor preservation.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test, crenulated; small perforated mamelons absent on most tubercles due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—On hillside at Spring Mount, St. James, Jamaica. According to the 1958 geological map of Jamaica, Spring Mount occurs in middle Eocene Yellow Limestone.

Location of type specimens.—Mus. Comp. Zool., Cambridge: holotype, 3276; five paratypes, 3405.

Comparison.—This species seems to be quite well separated from the other specimens of *Haimea.* Its short broad petals, and submarginal periproct distinguish it from the others.

HAIMEA OVUMSERPENTIS (Guppy)

Plate 34; text figs. 3, 10, 21, 49, 50

Echinolampas ovum-serpentis Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 300, pl. 19, figs. 4, 5 (not 6).

Echinolampas ovum serpentis Guppy.—Cotteau, 1875, Kongl. Svenska Vetenskaps-Akad. Handl., vol. 13, no. 6, p. 20, pl. 3, fig. 13–21.

Echinolampas ovum-serpentis Guppy.—Cotteau, 1891, Paléont. francaise terrain Tertiaire, échinides Éocenes, vol. 2, p. 153.

Echinolampas ovum serpentis Guppy.—Egozcue y Cía, 1897, Bol. Com. Mapa Geol. Espãna, vol. 22, p. 62, pl. 16, figs. 5–9.

Oligopygus ovum serpentis (Guppy).—Stefanini, 1911, Riv. Ital. Paleont., vol. 17, p. 88–90.

Oligopygus ovum serpentis (Guppy).—Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, pp. 167, 170.

Echinolampas ovumserpentis Guppy.—Jackson, 1922, Carnegie Inst. Washington, publ. 306, p. 60, pl. 10, figs. 4, 5.

"Echinolampas" ovumserpentis Guppy.—Hawkins, 1924, Geol. Mag., vol. 61, p. 318.

Echinolampas ovum serpentis Guppy.—Sánchez Roig, 1924, Rev. Equinidos fosiles Cubanos, p. 29.

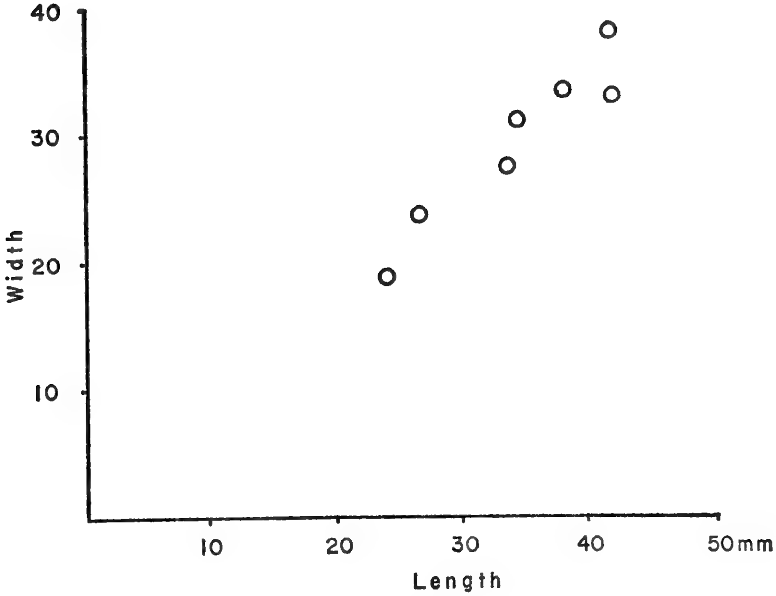
Oligopygus ovum-serpentis (Guppy).—Stefanini, 1924, Bull. Geol. Soc. America, vol. 35, no. 4, p. 844.

Oligopygus ovum serpentis (Guppy).—Lambert, 1925, Compte Rendu Soc. Géol. France, fasc. 17, p. 232.
Oligopygus ovum serpentis (Guppy).—Sánchez Roig, 1926, Bol. Minas, no. 10, p. 80.
Oligopygus ovumserpentis (Guppy).—Brighton, 1926, Geol. Mag., vol. 63, no. 746, p. 360.
Oligopygus ovumserpentis var. *baldryi* Brighton, 1926, Geol. Mag., vol. 63, no. 746, p. 361, pl. 26, figs. e–h; text fig. 1a–g.
Oligopygus ovumserpentis (Guppy).—Hawkins, 1926, Geol. Mag., vol. 63, no. 746, p. 372, figs. 1, 2.
Pauropygus ovumserpentis (Guppy).—Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 36, pl. 5, figs. 9–12 (not 7, 8).
? *Pauropygus platypetalus* Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 39, pl. 5, figs. 16–18.
? *Pauropygus latus* Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 35, pl. 5, figs. 4–6.
Pauropygus ovum-serpentis (Guppy).—Lambert, 1932, Bull. Soc. Géol. France, ser. 5, vol. 1, p. 293, pl. 17, fig. 13.
Pauropygus ovum serpentis (Guppy).—Pijpers, 1933, Geology and paleontology of Bonaire (D. W. I.), p. 87, pl. 1, figs. 7, 8.
Haimea ovumserpentis (Guppy).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.
? *Haimea platypetala* (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.
? *Haimea lata* (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.
Haimea ovumserpentis (Guppy).—Mortensen, 1948, Monograph Echinoidea, vol. 4, pt. 1, pp. 257, 259, fig. 246.
Pauropygus ovumserpentis (Guppy).—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 167.
Haimea ovumserpentis (Guppy).—Durham and Melville, 1957, Journ. Paleont., vol. 31, no. 1, text fig. 2.
Haimea ovumserpentis (Guppy).—Cooke, 1961, Smithsonian Misc. Coll., vol. 142, no. 4, p. 14, pl. 4, figs. 7–11.

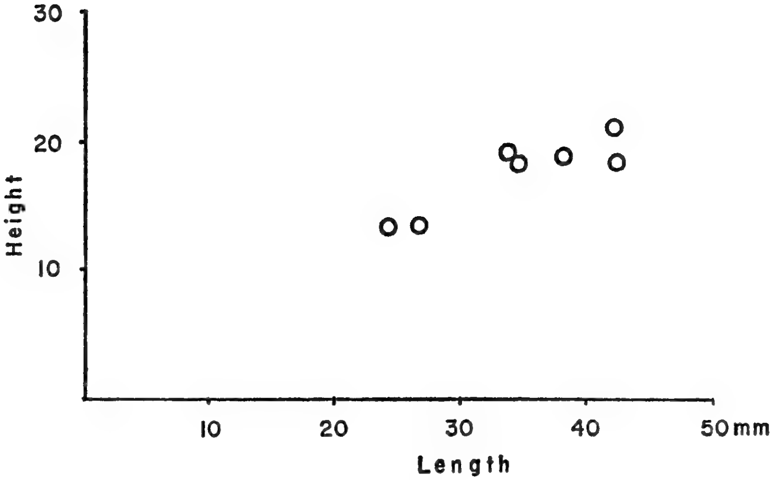
Material.—The following description is based on the lectotype and six paralectotypes.

Shape.—Elongate, width varying from 78 to 90 percent of length (text fig. 49A), largest specimen (lectotype) 42.1 mm long, greatest width central; test low, height varying from 43 to 57 percent of length (text fig. 49B), greatest height at apical system; marginal outline oval to subpentagonal with pointed anterior, blunted posterior; adoral surface flat to slightly depressed; poriferous zones to petals slightly to moderately depressed.

Apical system.—Central, madreporite (text fig. 10) higher than wide, four genital pores, anterior pair closer together than posterior, on three specimens pores very large, on other three very small; ocular plates small.



A



B

FIG. 49.—Width (A) and height (B) relative to length in the lectotype and paralectotypes of *Haimea ovumserpentis* (Guppy).

Ambulacra.—Petals well developed, long, extending almost to margin, petal III longest with from 6 to 11 more pore-pairs in single poriferous zones than in petals II or IV, 2 to 7 more than in petals V or I; in largest specimen (lectotype, 42.1 mm long) 47 pore-pairs in single poriferous zone in petal III, 36 in petal II, 41 in petal I (text fig. 50); petals open with broad interporiferous zone expanding distally, at greatest width interporiferous zone twice width of poriferous zone (pl. 34, fig. 1); outer pore of pair becoming more distal to inner toward end of petal; poriferous zones narrow distally.

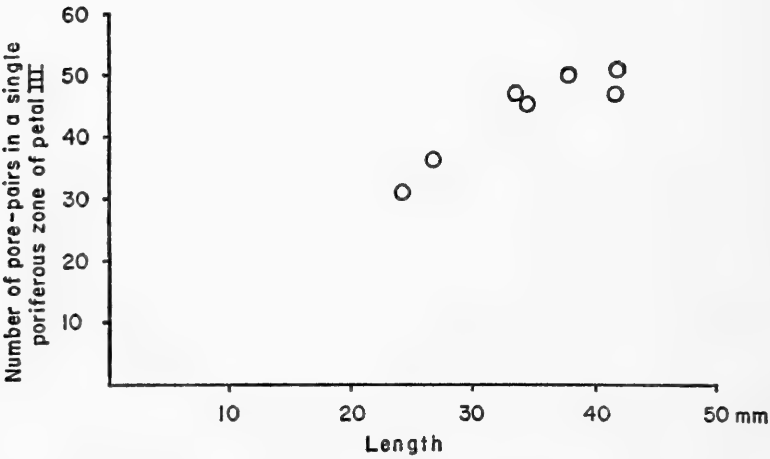


Fig. 50.—Number of pore-pairs in a single poriferous zone of petal III relative to the length in the lectotype and paralectotypes of *Haimea ovum-serpentis* (Guppy).

Ambulacra beyond petals composed of primary and demiplates (text fig. 3), with the small demiplates occurring at adradial margin, alternating with primary plates except at ambitus where in well-preserved areas demiplates in contact with each other isolating primary plates from adradial suture; approximately 64 primary plates beyond petals in ambulacrum III, 74 in II, 72 in I; pores near adradial suture with pore of primary plate indented (text fig. 3); approximately 180–200 pores beyond petal in ambulacra II or IV, 200–220 in ambulacra V or I, buccal pores present near edge of peristome, only visible on well-preserved specimens in which peristome has been excavated exposing first ambulacral plate.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; in specimen 42.0 mm long 36 plates in interambulacrum 2, 35 in interambulacrum 5.

Peristome.—Central, slightly wider than high, depressed with vertical sides; bourrelets moderately developed (pl. 34, fig. 5).

Periproct.—Inframarginal, located 60 to 77 percent distance from center of peristome to posterior margin, opening small, 2.3 mm wide in specimen 42.1 mm long (lectotype), wider than high.

Sphaeridia.—Double alternating row in each ambulacrum near peristome; as many as eight counted in one ambulacrum.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test; crenulated; small perforated mamelons absent on most tubercles due to weathering; small secondary tubercles scattered over area between primary tubercles.

Location of type specimens.—Lectotype (designated by Arnold and Clark, 1927, p. 36) USNM 115389a; 6 paralectotypes USNM 115389b–g.

Remarks.—Because there are only six specimens in the original collection, it is not possible to know the extent of variation within the species. Although there are hundreds of specimens of *Haimea* from Trinidad in the U.S. National Museum, there is not sufficient stratigraphic control to know whether or not they come from beds of the same age as the type specimens. Most of the specimens are from the Vista Bella quarry but it is not even certain that all these specimens are of the same age, otherwise a variation study could be made of this material.

Arnold and Clark (1927, pp. 37–38) had over a thousand specimens from Jamaica which they referred to *H. ovumserpentis.* They described the great variation among these specimens and considered it to represent variation within the species. Their specimens, however, came from many different localities in Jamaica, usually from float and never from a measured section. There is no way of knowing whether or not these specimens lived simultaneously. It is possible that some of this "variation" represents evolutionary change within different populations through time.

Occurrence of species.—Trinidad: San Fernando Formation (upper Eocene according to Kugler, 1957, p. 93), Mount Moriah Hill, San Fernando; Vista Bella quarry.

St. Bartholomew: St. Bartholomew Limestone (Eocene), for a detailed list of localities see Jackson (1922, p. 62).

Jamaica: Yellow Limestone (middle Eocene), in the hills between Spring Mount and Montpelier and in the Cambridge-Catadupa section.

Cuba: Eocene, Alcalá y Báguanos, Holguín; Sancti Spíritus, Santa Clara.

Peru: Atascadero Limestone (Eocene), Atascadero near the Pariñas Valley 20 miles east of Capa Blanco.

Bonaire: late Eocene, S.W. of Seroe Montagne; S. E. of Seroe Dochila, S.W. of Punta Blanco.

Arnold and Clark's *Haimea lata* does not seem sufficiently distinct from *H. ovumserpentis* to be specifically differentiated. Its length to width and length to height ratios are similar to *H. ovumserpentis* and although it has slightly fewer pore-pairs in petal III this difference is too slight to be considered significant. Its petals are identical in arrangement and shape to those in typical *H. ovumserpentis* and its apical system and peristome are similarly located. Although the periproct in the holotype of *H. latus* is more anterior than in most specimens of *H. ovumserpentis,* such is not the case in the paratypes. The position of the periproct is quite variable in specimens identified by Arnold and Clark as *H. ovumserpentis.* For these reasons *H. lata* is herein tentatively considered a synonym of *H. ovumserpentis.* Photographs of the holotype are included on plate 33, figs. 4, 5, and plate 35, fig. 4.

Arnold and Clark based their species *Haimea platypetala* on a single, badly weathered specimen which does not appear to be distinct from *Haimea ovumserpentis,* but because of the poor preservation of the specimen it seems best to only provisionally consider it as a synonym of *H. ovumserpentis.* Arnold and Clark thought that its wide petals and "unusual" form distinguished it from all the other species of the genus. There are specimens, however, identified as *H. ovumserpentis* by Arnold and Clark which are similar in all respects including petals and form to their holotype of *H. platypetala.* New photographs of the holotype are on plate 30, figs. 1, 2.

HAIMEA ROTUNDA (Arnold and Clark)

Plate 32 (figs. 1–5)

Pauropygus rotundus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 40, pl. 6, figs. 1–3.

Haimea rotunda (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype and one of the two paratypes. The second paratype is not included in this description because it has shorter petals than the holotype and may not be conspecific with it.

Shape.—Test subcircular, almost as wide as long with width 94 percent of length in holotype, 96 percent in paratype (holotype 27.3 mm long, 25.8 mm wide, 10.3 mm high; paratype 18.4 mm long, 17.8 mm wide, 9.9 mm high), greatest width central; test low, in holotype height 37 percent of length, in paratype 53 percent, greatest height anterior of center; petals flush; adoral surface flattened, slightly depressed around peristome.

Apical system.—Central, wider than high, four genital pores, anterior pair closer together than posterior; ocular plates small.

Ambulacra.—Petals short, extending less than two-thirds distance from apical system to margin, petal III (pl. 32, fig. 4) longest, with 27 pore-pairs in single poriferous zone in holotype, 24 in paratype, petals V and I shortest with 20 pore-pairs in single zone in holotype, 16 in paratype; petals II and IV with 22 in holotype, 18 in paratype in single zone; interporiferous zones expanding distally in petal III, slightly constricted in other petals; interporiferous zones at greatest width slightly wider than single poriferous zone; outer pore or pair slightly more distal to inner pore near end of petal poriferous zones narrow distally.

Ambulacra beyond petals composed of primary and demiplates, with the small demiplates occurring at adradial margin, alternating with primary plates, demiplates not in contact with each other, primary plates reaching adradial suture; pores in single series with alternate pores (in primary plates) indented towards perradial suture; buccal pores probably present near peristome but obscured by poor preservation.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate.

Peristome.—Central to slightly anterior, large, wider (pl. 32, fig. 5) than high with greatest width anterior, pentagonal.

Sphaeridia.—Double, alternating row in each ambulacrum near peristome; exact number not known because of poor preservation.

Tuberculation.—Test covered with small irregularly arranged tubercles; scrobicules deep with vertical sides; boss large extending upward as high as surrounding surface of test; mamelons absent due to weathering; small secondary tubercles scattered over area between primary tubercles.

Occurrence.—Near Spring Mount, St. James, Jamaica. According to the 1958 geological map of Jamaica, Spring Mount lies in the middle Eocene Yellow Limestone.

Location of type specimens.—Mus. Comp. Zool., Cambridge: holotype, 3279; 2 paratypes 3407.

Comparison with other species.—This species is distinguished from all the other species of *Haimea* except *H. rugosa* by its very low test, circular marginal outline with the width almost as great as the length, and large peristome. It is very similar to *H. rugosa,* and its holotype only differs from the holotype of *H. rugosa* in having flush petals and a lower test. This difference in petals may only result from the fact that the holotype of *H. rotunda* is considerably more weathered. I would synonymize these two species but I hesitate to do so with so few specimens and no stratigraphic control.

HAIMEA STENOPETALA (Arnold and Clark)

Plate 35 (figs. 1–3); text fig. 6

Pauropygus stenopetalus Arnold and Clark, 1927, Mem. Mus. Comp. Zool., vol. 50, no. 1, p. 41, pl. 6, figs. 7–9.

Haimea stenopetala (Arnold and Clark).—Arnold and Clark, 1934, Mem. Mus. Comp. Zool., vol. 54, no. 2, p. 143.

Material.—The following description is based on the holotype. Although three paratypes were available for study, they differ, as noted by Arnold and Clark, in shape and petal arrangement from the holotype and it seems best not to include them in a description of the species.

Shape.—Test elongate, 34.4 mm long, 24.5 mm wide, width 71 percent of length; greatest width slightly posterior to center; test low, 13.0 mm high, height 37 percent of length, greatest height anterior; petals flush; adoral surface depressed around peristome.

Apical system.—Central, so badly weathered that no further details visible.

Ambulacra.—Petals well developed; petal III longest, 13.5 mm long, petals II and IV shortest, 10.2 mm long, petals V and I from 11.5 to 12.5 mm long; petals II and IV the widest, 4.6 mm wide, other petals 4.2 mm wide; interporiferous zone narrow, narrower than single poriferous zone; 35 pore-pairs in a single poriferous zone of petal III, 28 in petals II or IV, 32 in petals I or V; ambulacral plates very strongly curved distally between inner and outer pore; curvature may be less on a less-weathered specimen.

Ambulacra beyond petals originally with many demiplates but all absent on holotype due to weathering; presence of many pores evidence of former presence of demiplates; 74 primary ambulacral plates beyond petal in each ambulacra, plates in ambulacra II, V, and I higher nearing peristome (text fig. 6) than those in ambulacra

II and IV; buccal pores present in first primary ambulacral plates near edge of peristome.

Interambulacra.—Two columns in each area except at peristome where terminating in single plate; 30–31 plates in interambulacra 2 or 3, 26–27 in areas 4 or 1, 32 in area 50.

Peristome.—Central, width approximately equal to height, opening very large in holotype but large size may be due to weathering; bourrelets not developed.

Tuberculation.—Tubercles all removed by weathering.

Occurrence.—Near Spring Mount, St. James, Jamaica. Spring Mount occurs in the middle Eocene Yellow Limestone.

Location of type specimen.—Mus. Comp. Zool., Cambridge, holotype, 3281.

Comparison with other species.—This specimen is so badly weathered that many of its specific characters are absent. One of the features that separates it from *H. ovumserpentis* is its narrow petals with narrow interporiferous zones; however, this feature may be due to the fact that the holotype is badly weathered. In the Oligopygoida the petaloid pores are closer together at the interior of the test (text fig. 2) than at the exterior. In a weathered specimen the petals and their interporiferous zones would, therefore, be narrower than in a well-preserved specimen.

Until more and better preserved specimens have been found, the validity of this species can not be ascertained.

INADEQUATELY DESCRIBED SPECIES OF *HAIMEA*

Sánchez Roig in 1949 described four new species of *Haimea* from Cuba. Because his descriptions are so brief, his illustrations so inadequate, and his type specimens not available, I can only list and give synonymies of his species below. Although Sánchez Roig states that these species are upper Eocene, Brodermann (1949, p. 322) records them as being middle and upper Eocene.

Haimea camagueyana Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 122, pl. 50, figs. 6, 7.

Haimea pusilla Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 123.

Haimea pusilla Sánchez Roig.—Sánchez Roig, 1951, Mem. Soc. Cubana Hist. Nat., vol. 20, no. 2, p. 64, pl. 39, fig. 1.

Haimea globulosa Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 124.

Haimea globulosa Sánchez Roig, 1951, Mem. Soc. Cubana Hist. Nat., vol. 20, no. 2, p. 64, pl. 39, figs. 8, 9.

Haimea truncata Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 124, pl. 50, figs. 8, 9.

Later in 1952 Sánchez Roig described a fifth species of *Haimea* from the upper Eocene which also can only be cited herein:

Haimea hernandezi Sánchez Roig, 1952, Mem. Soc. Cubana Hist. Nat., vol. 21, no. 1, p. 11, pl. 6, fig. 5.

Lambert and Sánchez Roig described a new species *Oligopygus alvarezi,* now referable to *Haimea,* from what they considered to be upper Eocene although Brodermann (*in* Sánchez Roig, 1949, p. 325) placed it in the middle Eocene. Unfortunately, the illustrations of this species are very poor and the type specimens not available so I can only give its synonymy, and can not compare it with other species.

Oligopygus alvarezi Lambert and Sánchez Roig, 1926, *in* Sánchez Roig, Bol. Minas Habana, no. 10, p. 82, pl. 11, figs. 3–5.

Pauropygus alvarezi (Lambert and Sánchez Roig).—Lambert, 1932, Soc. Géol. France Bull., ser. 5, vol. 1, p. 294.

Pauropygus alvarezi (Lambert and Sánchez Roig).—Sánchez Roig, 1949, Paleont. Cubana, vol. 1, p. 168.

SPECIES INCORRECTLY REFERRED TO *PAUROPYGUS* OR *HAIMEA*

Lambert's (1932, p. 294, pl. 17, figs. 10–12) *Pauropygus clarki* is a *Tarphypygus,* as noted by Sánchez Roig (1949, p. 168). I have studied many specimens of this species: their single columned interambulacra near the apical system, wide ambulacra beyond the petals which are devoid of demiplates but have accessory pores, lack of discrete ocular plates in the apical system, and position of periproct near the peristome clearly indicates that this species is a *Tarphypygus* and not an oligopygoid.

Lambert's (1932, p. 293, pl. 17, fig. 9, text fig. 1) *Pauropygus stefaninii* can not belong in the Oligopygoida if his drawing of the plates near the peristome is correct. He shows the interambulacra terminating in double plates at the peristome whereas in the Oligopygoida the interambulacra always terminate in a single plate. Possibly the peristome has vertical sides and is filled with a matrix covering up single plates which terminate the interambulacra. In his drawing he shows the periproct very close to the peristome, a condition suggesting that his species may be a *Tarphypygus,* but in his photograph of the adapical side there appear to be two columns in each interambulacrum at the apical system, whereas in *Tarphypygus* there is only one. Until Lambert's specimen has been more adequately described and illustrated, it is not possible to know its generic affinities.

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EXPLANATION OF PLATES

PLATE 1

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Haimea rutteni (Pijpers) 17

1, 2, Apical system in what is assumed to be a female (fig. 1) and a male (fig. 2). Note the considerably larger genital pores in the female. USNM 649830 (fig. 1), USNM 649831 (fig. 2), from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco, ×15.

Oligopygus wetherbyi de Loriol 17, 18

3, 4, Apical system in a small (fig. 3) and large specimen (fig. 4). USNM 649832 (fig. 3), from the late Eocene, Crystal River Formation, Ocala Lime Company quarry 4.1 mi. N of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×15. USNM 649833 (fig. 4) from the late Eocene, Crystal River Formation, St. Catherine Rock Company quarry, western edge of St. Catherine, S. of road running along railroad track, Sumter County, Florida, ×12.

5, The tuberculation in interambulacrum 1 between the petals showing the irregular arrangement of the tubercles typical in the oligopygoids. Note the deep scrobicules with vertical sides, and the crenulated bosses. The mamelons are small with the perforation preserved on only several of them. On most specimens the mamelons are eroded away. Same specimen as figure 4.

PLATE 2

Oligopygus wetherbyi de Loriol 3

Enlarged view of the apical area and part of the petals showing arrangement of the tubercles, pore-pairs, and apical system in a particularly well-preserved specimen. USNM 649833, from the late Eocene, Crystal River Formation, St. Catherine Rock Company quarry, western edge of St. Catherine, S. of road running along railroad track, Sumter County, Florida, ×5.8.

PLATE 3

Oligopygus haldemani (Conrad) 3, 9, 25

Enlarged views of portions of the test of an extremely well-preserved specimen, USNM 649834, from the late Eocene, Ocala Limestone, at USGS 7097, Flint River at old factory above Bainbridge, Georgia, ×20. A drawing of the plate arrangement of part of this specimen is on text figure 4.

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1, Area near end of petal III showing petaloid pores with the outer pore elongated transversely and joined to the inner by a deep conjugation furrow. The ridges separating these furrows are topped by a row of four or five small secondary tubercles. Note the perforations of the mamelons, and the crenulations on the bosses; these features are not preserved on most specimens due to weathering.

2, Area near the ambitus showing ambulacrum IIIb and portions of the adjacent half ambulacrum and interambulacrum. The demiplates and several included plates are visible.

PLATE 4

Oligopygus wetherbyi de Loriol 19

1, A view of the opening of the peristome showing its triangular shape, typical in *Oligopygus*. In most specimens this opening is either broken away or covered with a matrix.

2, A view of the same peristome but with different lighting to show the shape of the deep peristomal sulcus. USNM 649833, from the late Eocene Crystal River Formation, St. Catherine Rock Company quarry, western edge of St. Catherine, S. of road running along railroad track, Sumter County, Florida, ×3.4.

Haimea alta (Arnold and Clark) 19

3, Peristome showing the regular pentagonal shape of the opening, and the presence of bourrelets. These two characters are typical in *Haimea* and distinguish this genus from *Oligopygus* with its curved triangularly shaped peristome, lack of bourrelets, and commonly deep sulcus. USNM 649835, from the middle Eocene of Cuba (Loma Caoba, 3 km. S. of San Diego de los Banos, E. of old road to canteras, Pinar Del Rio Prov.), ×6.

Oligopygus wetherbyi de Loriol 7

4, View of ambulacrum IV at the ambitus showing the crowded pores of the demiplates and included plates typical in the Oligopygoida. USNM 649832, from the late Eocene, Crystal River Formation, Ocala Lime Company quarry, 4.1 mi. N. of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×16.

PLATE 5

Oligopygus wetherbyi de Loriol 13

Adoral view of a weathered specimen immersed in alcohol showing clearly the plate sutures. Note the narrower ambulacrum III, corrugations in sutures, and location of demiplates. Because of the invagination at the peristome, the first interambulacral plate is not visible in each area. The opening to the peristome has been broken in this specimen; for a view of the peristome in this species see pl. 4, fig. 1. USNM 164660, from the late Eocene, Ocala Limestone, from Nigger Sink, 2 mi. S. of Gainesville, Florida, ×4.

PLATE 6

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Haimea rutteni (Pijpers) 20

1, Ventral view of lantern showing the star-like marginal outline.

2, Dorsal view of lantern showing short, convergent interior wings with their lamellar supports.

3, Side view of pyramid 5 showing its compact central body with its dorsally V-shaped crest, the thickened ends of which form the supra-alveolar processes, and the well-developed lamellae radiating in polyfurcate fashion from the central body.

4, 5 Oblique and side view of lantern showing asymmetrical pyramid 1. [All the above figures are ×6.5.]

6, View of lantern in test, ×2.

USNM 649836, from the late Eocene, of Bonaire, SW. of Seroe Montagne and Punta Blanco.

PLATE 7

Oligopygus putnami Israelsky 20

1, Ventral view showing the star-like marginal outline. A half-pyramid of number 1 is missing.

2, Dorsal view showing the short convergent wings and two of the keeled teeth.

3, Anterior view showing pyramids 2 and 3.

4, Side view showing pyramid 4.

5, Oblique view showing the posterior pyramid and the position of the auricles in relation to it. [All the above pictures are ×7.5.]

6, View of lantern in test, ×3

USNM 649837, from the upper Eocene, 12 km. NE. of Abasola, Tamaulipas, Mexico.

PLATE 8

Oligopygus wetherbyi de Loriol 20

1, 2, 3, Ventral, dorsal, and posterior view of lantern, USNM 649838, the late Eocene, Crystal River Formation, from the Ocala Lime Company quarry, 4.1 mi. N. of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×3.6.

Echinocyamus megapetalus Clark 22

4, Pyramid 5 showing its similarity to the pyramid of *O. wetherbyi*, USNM E8491, Recent, from Ujelang Atoll, Marshall Islands, ×21. A drawing of this specimen is on text-figure 12B.

Haimea rutteni (Pijpers) 29

5, View of the lantern support structures showing the auricles and apophyses and the small protuberances in each ambulacrum at the border of the peristome which may have been used for the attachment of the protractor muscles, ×5. USNM 649839, from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco.

PLATE 9

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Haimea rutteni (Pijpers) 29

View of inside of test showing lantern supports. As can be seen in this unretouched photograph, the anterior paired supports (in interambulacra 2 and 3) and the single posterior (interambulacrum 5) are auricles formed by the adjacent basicoronal ambulacral plates. The paired posterior supports (interambulacra 4 and 1) are composed anteriorly of auricles but posteriorly of apophyses formed by the first interambulacral plates. See text figure 18, for a drawing of this specimen. USNM 649857, from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco, ×12.

PLATE 10

Oligopygus haldemani (Conrad) 27

1, View of inside of test showing lantern supports. The anterior paired supports (in interambulacra 2 and 3) and the single posterior (interambulacrum 5) are auricles formed by the adjacent basicoronal ambulacral plates. The paired posterior supports (interambulacra 4 and 1) are composed anteriorly of auricles but posteriorly are composed of apophyses formed by the first interambulacral plates. What appears to be a suture posterior to the auricles in interambulacrum 4 is actually a fracture (see text fig. 16 for a drawing of the plate arrangement). USNM 649840, from the late Eocene, Crystal River Formation, Ocala Lime Company quarry, 4.1 mi. N. of U.S. routes 301 and 441, near Ocala, Florida, ×2.3.

Oligopygus zyndeli Jeannet 33

2, View of petaloid area showing glassy tubercles, ×5. No. M6611, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad.

Oligopygus wetherbyi de Loriol 29

3, View of interior showing interambulacrum 4 on the left, 5 on the right. As can be seen in the photograph, the left lantern support in interambulacrum 5 is an auricle formed by the extension of the right basicoronal plate of ambulacrum V. Although most of the lantern supports are broken off in interambulacrum 4, it can be easily seen that the right support is an apophysis formed from the first interambulacral plate. Note the suture between the left basicoronal plate of ambulacrum V and this first interambulacral plate. USNM 649841, same locality as specimen in figure 1.

4, View of symphysis and tooth of half-pyramid 5b, USNM 649842, from same locality as specimen in figure 1.

5, Cross section of tooth, USNM 649843, from same locality as specimen in figure 1.

PLATE 11

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Oligopygus haldemani (Conrad) 32

1–6, Sutural surface on interambulacral plates of USNM 649834, from the late Eocene, Ocala Limestone, at USGS 7097, Flint River at old factory above Bainbridge, Georgia, ×16. 1–2, Transverse sutures between adjacent interambulacral plates. The plate in figure 1 was originally joined to the plate in figure 2 along the sutural surfaces illustrated. Note the deep corrugations. 3, A photograph of the rubber impression made of the transverse suture in figure 1. The fact that this impression is identical with the sutural surface of the adjacent plate (fig. 2) proves that these corrugations are interlocking, and not canals. 4, 5, Adradial sutures of interambulacral plates showing where adjacent ambulacral plates fit into the sutural surface of the interambulacral plates. Note in figure 4 the impression of an included plate. 6, Interradial suture of an interambulacral plate.

Haimea rutteni (Pijpers) 2, 18, 19

7, View of inside of test showing much narrower interporiferous zones than at exterior (see pl. 30, fig. 3) due to curving of canals of tube-feet interiorly toward perradial suture, ×5.

8, Ambulacrum II at peristome showing the sphaeridia in two rows near the perradial suture, and a pair of buccal pores at the edge of the peristome, ×20. Both specimens in the Geological Institute at the University of Utrecht, from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco.

PLATE 12

ABNORMAL SPECIMENS

Haimea sp. 39

1, 2, A partial hexamerous variant: 1, Adapical view showing the six ocular plates, six petals, and part of a sixth interambulacrum. The extra petal merges with petal III for a short distance, and the outer pores of each alternate in a single line. 2, Adorally, the extra ambulacrum and interambulacral half-areas do not reach the peristome, but are separated from it by the first ambulacral plates of ambulacrum III. A drawing of the adapical area of this specimen is on text figure 22. MCZ 3471 from Jamaica (no further locality data available), ×2.

3, A tetramerous variant. On this specimen, ambulacrum III and its two adjacent half-ambulacra are evidently the missing components. MCZ 3403, from Jamaica, ×2.

Oligopygus jamaicensis Arnold and Clark 39

4, A specimen in which the apical system is displaced to the upper left, petals III and IV are shorter than normal and are twisted. Note the single large interambulacral plate extending across the width of interambulacrum 2. Adorally this specimen is normal showing that this distortion occurred after these adoral plates had been formed. MCZ 3470 from Jamaica, ×3.

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Haimea sp. 39
5, A specimen having five genital pores with the fifth occurring between the posterior paired petals. MCZ 3399, from Jamaica, ×8.

PLATE 13

Oligopygus wetherbyi de Loriol 54
1, 2, Adapical, adoral views of lectotype in the de Loriol Collection at the Museum d'Histoire Naturelle, Geneva, Switzerland, from near Gainesville, Florida (figured by de Loriol, 1888, pl. 17, figs. 7, 7a, b, c, d), ×1.5.
3, 4, Adapical, adoral views of paralectotype from same locality and in same museum as lectotype, ×1.5.

PLATE 14

Oligopygus wetherbyi de Loriol 54
1, 2, Adapical and adoral views of USNM 649832, from the late Eocene, Crystal River Formation, Ocala Lime Company quarry, 4.1 mi. N. of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×2. An enlarged view of the peristome of this specimen is on plate 16, fig. 8.
3, 4, 5, Adapical, left side, adoral views of USNM 649833 from the late Eocene, Crystal River Formation, St. Catherine Rock Company quarry, western edge of St. Catherine, S. of road running along railroad track, Sumter County, Florida, ×1.5, 1, 1.5.

PLATE 15

Oligopygus nancei Cooke 60
1, 3, Adapical, right side of holotype, USNM 498964a from the late Eocene Tinajitas Formation, from near headquarters of Rio Amana, Anzoátegui, approximately 5 km SW. of Mundo Nuevo, Monagas, ×1.
2, Adoral view of figured paratype, USNM 498964b (same locality as holotype), ×1.
Oligopygus zyndeli Jeannet 61
4, 5, 6, Adapical, left side, adoral views of specimen no. M6612, Naturhistorisches Museum, Basal, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×2.
7, Peristome of same specimen, ×6.
8, Adapical view of holotype, no. M564, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Soldado Rock, Trinidad, ×3.

PLATE 16

Oligopygus jamaicensis Arnold and Clark 63
1, 2, Adapical, adoral views of holotype, MCZ 3270, from area north and west of Spring Mount, St. James, Jamaica, ×1.
3, 4, 5, Adapical, adoral, left side of paratype MCZ 3393a, from same locality as holotype, ×1.5.

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6, Adapical view of paratype MCZ 3393b from same locality as holotype, ×1.5.

7, Peristome of specimen in figures 3, 4, 5, ×3. Note the straighter anterior border of the peristome as compared to *O. wetherbyi* of figure 8.

Oligopygus wetherbyi de Loriol 54

8, Peristome of USNM 649832 from the late Eocene, Crystal River Formation, Ocala Lime Company quarry, 4.1 mi. N. of crossing of U.S. routes 301 and 441 near Ocala, Florida, ×3. Picture included here for comparison with *O. jamaicensis* in figure 7.

PLATE 17

Oligopygus hypselus Arnold and Clark 65

1, 2, Adapical, adoral view of holotype, MCZ 3269 from Spring Mount, St. James, Jamaica, ×2. This species is herein considered a subjective synonym of *O. jamaicensis* Arnold and Clark.

Oligopygus rotundus Cooke 67

3, 4, 5, Adapical, adoral, right side of holotype, USNM 498991 from late Eocene, Moddy Branch Formation, or middle Eocene Claiborne (according to Cooke, 1959, p. 30) at Cripple Creek, Geneva County, Alabama, ×2.

Oligopygus kugleri Jeannet 69

6, Adoral view of no. M6613, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×2.

PLATE 18

Oligopygus kugleri Jeannet 69

1, 2, Adoral, left side of paralectotype no. M562, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Soldado Rock, Trinidad, ×2.

3, 4, Adapical, left side of no. M6614, Naturhistorisches Museum, Basel, Switzerland, from late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×2.

Oligopygus pinguis Palmer 71

5, 6, 7, Adapical, left side, adoral views of MCZ 4091a from deep cut N. of Grua 9, Ramal Juan Criollo, 13 km NE. of Jatibonica, Camagüey Prov. (type locality: Palmer locality 1640, ×1).

PLATE 19

Oligopygus pinguis Palmer 71

1, Adoral view showing shape of peristome and peristomal groove of MCZ 4091b from deep cut N. of Grua 9, Ramal Juan Criollo, 13 km NE. of Jatibonica, Camagüey Prov., Cuba (type locality: Palmer locality 1640, ×2).

Oligopygus sanchezi Lambert 74

2, 3, 4, Adapical, adoral, left side of USNM 649844 from limestone cliff

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0.2 km SE. of Arroyo Blanco on road to Majagua, Camagüey Prov., Cuba, ×1.

5, Apical system of same specimen, ×12.

6, Portion of adapical surface of same specimen showing details of petals, ×4.

PLATE 20

Oligopygus costuliformis Jeannet 76

1, Adapical view of holotype no. M566, Naturhistorisches Museum, Basel, Switzerland, from the late Eocene, San Fernando Formation, Bella Vista quarry, Trinidad, ×3.

Oligopygus putnami Israelsky 77

2, 3, Adapical and right side of topotype, no. 5215, California Academy of Sciences Type Collection, from the late Eocene, 12 km NE. of Abasola, Tamaulipas, Mexico, ×2.

4, Adapical view of lectotype, no. 5211 in same collection, ×2. This is the specimen figured by Israelsky (1933, pl. 18, fig. 1).

5, Adoral view of paralectotype, no. 5210 in same collection, ×2 (specimen figured by Israelsky 1933, pl. 18, figs. 2–4).

6, Tuberculation in interambulacrum 2 just adapical of ambitus in topotype no. M6615, Naturhistorisches Museum, Basel, Switzerland, ×15. Other views of this specimen are on plate 21.

Oligopygus pinguis Palmer 71

7, Petal III and apical region of MCZ 4091a from deep cut N. of Grua 9, Ramal Juan Criollo, 13 km NE. of Jatibonica, Camagüey Prov. (type locality: Palmer locality 1640, ×4). This specimen is figured on plate 18, figs. 5, 6, 7.

PLATE 21

Oligopygus putnami Israelsky 77

1, 2, 3, Adapical, right side, adoral views of no. M6615, Naturhistorisches Museum, Basel, Switzerland, upper Eocene, 12 km NE. of Abasola, Tamaulipas, Mexico, ×2.

4, View of ambulacrum III of same specimen, ×7.

5, Peristome and peristomal groove on same specimen, ×4.

6, Apical system of same specimen, ×12.

PLATE 22

Oligopygus phelani Kier, new species 81

1, 2, Adapical, right side, of holotype, USNM 649845 from the late Eocene, Inglis Formation, from spoil banks along first 4 mi. of Trans-Florida Canal near Inglis, Florida, ×4, 3.

3, Apical system and petal III of holotype, ×10.

4, Adoral view of holotype, ×3.

5, 6, Adoral, right side of USNM 649846 from the late Eocene Inglis Formation on south bank of Withlacoochee River about 50 feet SE. of Hwy. 200 bridge at Stokes Ferry, Florida ×4, 3.

PLATE 23

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Oligopygus haldemani (Conrad) 83

1, 2, 3, Adapical, right side, adoral views of USNM 649847 from the late Eocene Crystal River Formation near Ocala, Florida (Cunrad pit, 3.0 mi. N. of crossing of U.S. routes 441 and 301 on 441, east side of road, ×2.

4, Peristome of same specimen, ×5.

5, Petal III of same specimen, ×5.6.

6, Apical region of same specimen, ×13.

PLATE 24

Haimea caillaudi Michelin 95

1, 2, 3, Adapical, adoral, right side of lectotype in École National Supérieure des Mines, Paris; locality unknown; ×3.

4, Adapical view of paralectotype in same museum, ×2.5.

Haimea cf. *H. cylindrica* (Arnold and Clark) 98

5, 6, 7, Adapical, right side, adoral views of specimen included among probable syntypes of *H. caillaudi* in the École National Supérieure des Mines, Paris, ×2.

PLATE 25

Haimea elevata (Arnold and Clark) 99

1, 2, Adapical, adoral views of holotype, MCZ 3274 from the west side of the Yallahs River, St. Thomas, Jamaica, ×2.

3, Right side of holotype, ×1.

4, Petal III of same specimen, ×4.

Haimea alta (Arnold and Clark) 102

5, Peristomal region and periproct of paratype, MCZ 3396a, from Spring Mount, Jamaica, ×6.5.

PLATE 26

Haimea alta (Arnold and Clark) 102

1, Adapical view of holotype, MCZ 3271, from near Spring Mount, St. James Parish, Jamaica, ×1.5.

2, 3, Left side, adoral view of paratype, MCZ 3395, from near Spring Mount, St. James Parish, Jamaica, ×1.5.

4, 5, 6, Right side, adapical, adoral views of USNM 649848 from the middle Eocene of Cuba (Loma Caoba, 3 km S. of San Diego de los Baños, east of old road to canteras, Pinar Del Rio Prov., ×2.

PLATE 27

Haimea pyramidoides (Arnold and Clark) 107

1, 2, 3, Adapical, right side, adoral views of holotype, MCZ 3278, from hill west of Yallahs River, Jamaica, ×2.

4, Petal I of holotype, ×8.

5, Peristome of holotype, ×4.

Page

Haimea cylindrica (Arnold and Clark) 108

6, Peristome of paratype MCZ 2394a from St. James Parish, Jamaica, ×5.

PLATE 28

Haimea cylindrica (Arnold and Clark) 108

1, 2, 3, Adapical, right side, adoral views of holotype, MCZ 3273, from between Seven Pines and Springfield, St. James Parish, Jamaica, ×2.

4, Petal III and apical region of holotype, MCZ 3272, from near Lucky Hill, St. Mary, Jamaica, ×6.

PLATE 29

Haimea cylindrica (Arnold and Clark) 108

1, 2, Adapical, adoral view of paratype, MCZ 2394a from St. James Parish, Jamaica, ×2. A photograph of the peristome of this specimen is on plate 27, fig. 6, and an enlarged view of petal III on plate 28, fig. 4.

Haimea convexa (Arnold and Clark) 111

3, 4, 5, Adapical, right side, adoral view of holotype, MCZ 3272, from near Lucky Hill, St. Mary, Jamaica, ×2.

6, Peristome of the holotype, ×4.5.

PLATE 30

Haimea platypetala (Arnold and Clark) 126

1, 2, Adapical, right side of holotype, MCZ 3277, from the western end of Jamaica, ×2. This species is herein tentatively considered a subjective synonym of *Haimea ovumserpentis* (Guppy).

Haimea rutteni (Pijpers) 112

3, 4, 5, Adapical, right side of lectotype in the Geological Institute at the University of Utrecht, ×2.

6, Peristome of USNM 649830, ×6.

All these specimens came from the late Eocene of Bonaire, SW. of Seroe Montagne and Punta Blanco.

PLATE 31

Haimea rugosa (Arnold and Clark) 118

1, 2, 3, Adapical, adoral, left side of holotype, MCZ 3280 from near the Yallahs River, St. Thomas Parish, Jamaica, ×2.

Oligopygus curasavica Molengraaff 80

4, 5, 6, Adapical, right side, adoral views of lectotype (herein designated), from the upper Eocene of Curaçao. Photocopied from Molengraaff (1929, pl. 27, fig. 2; pl. 28, figs. 1, 3). Location of lectotype not known to me.

PLATE 32

Page

Haimea rotunda (Arnold and Clark) 126

1, 2, 3, Adapical, right side, adoral views of holotype, MCZ 3279 from near Spring Mount, St. James, Jamaica, ×2.

4, Petal III of holotype, ×6.

5, Peristome of holotype, ×4.5.

Haimea parvipetala (Arnold and Clark) 119

6, Petal I of holotype, MCZ 3276 from Spring Mount, St. James Parish, Jamaica, ×4. Other views of specimen on plate 33, figs. 1–3.

PLATE 33

Haimea parvipetala (Arnold and Clark) 119

1, 2, 3, Adapical, adoral, right side of holotype, MCZ 3276 from Spring Mount, St. James Parish, Jamaica, ×2. An enlarged view of petal I is on plate 32, fig. 6.

Haimea lata (Arnold and Clark) 126

4, 5, Adapical and adoral view of holotype, MCZ 3275 from hills west of Spring Mount, St. James, Jamaica, ×2. A view of the right side of this specimen is on plate 35, fig. 4. This species is herein tentatively considered a subjective synonym of *Haimea ovumserpentis* (Guppy).

PLATE 34

Haimea ovumserpentis (Guppy) 121

1, 2, 3, Adapical, adoral, right side of lectotype, USNM 115389a from the late Eocene San Fernando Formation, San Fernando, Trinidad, ×2.

4, Adapical view of paralectotype, USNM 115389b from the same locality as the lectotype, ×1.5. Photographed immersed in alcohol.

5, Peristome of same specimen, × 6.

PLATE 35

Haimea stenopetala (Arnold and Clark) 128

1, 2, 3, Adapical, right side, adoral views of the holotype, MCZ 3281 from near Spring Mount, St. James Parish, Jamaica, ×2.

Haimea lata (Arnold and Clark) 126

4, Right side of the holotype, MCZ 3275 from hills west of Spring Mount, St. James, Jamaica, ×2. Adapical and adoral views of this specimen are on plate 33, figs. 4, 5. This species is herein tentatively considered a subjective synonym of *Haimea ovumserpentis* (Guppy).

Haimea meunieri (Lambert) 116

5, 6, Adapical and adoral views of specimen 927L (Gorodiski Coll.) in the Muséum National d'Histoire Naturelle, Paris, from the Lutétien supérieur, Ourour (Senegal), ×3.

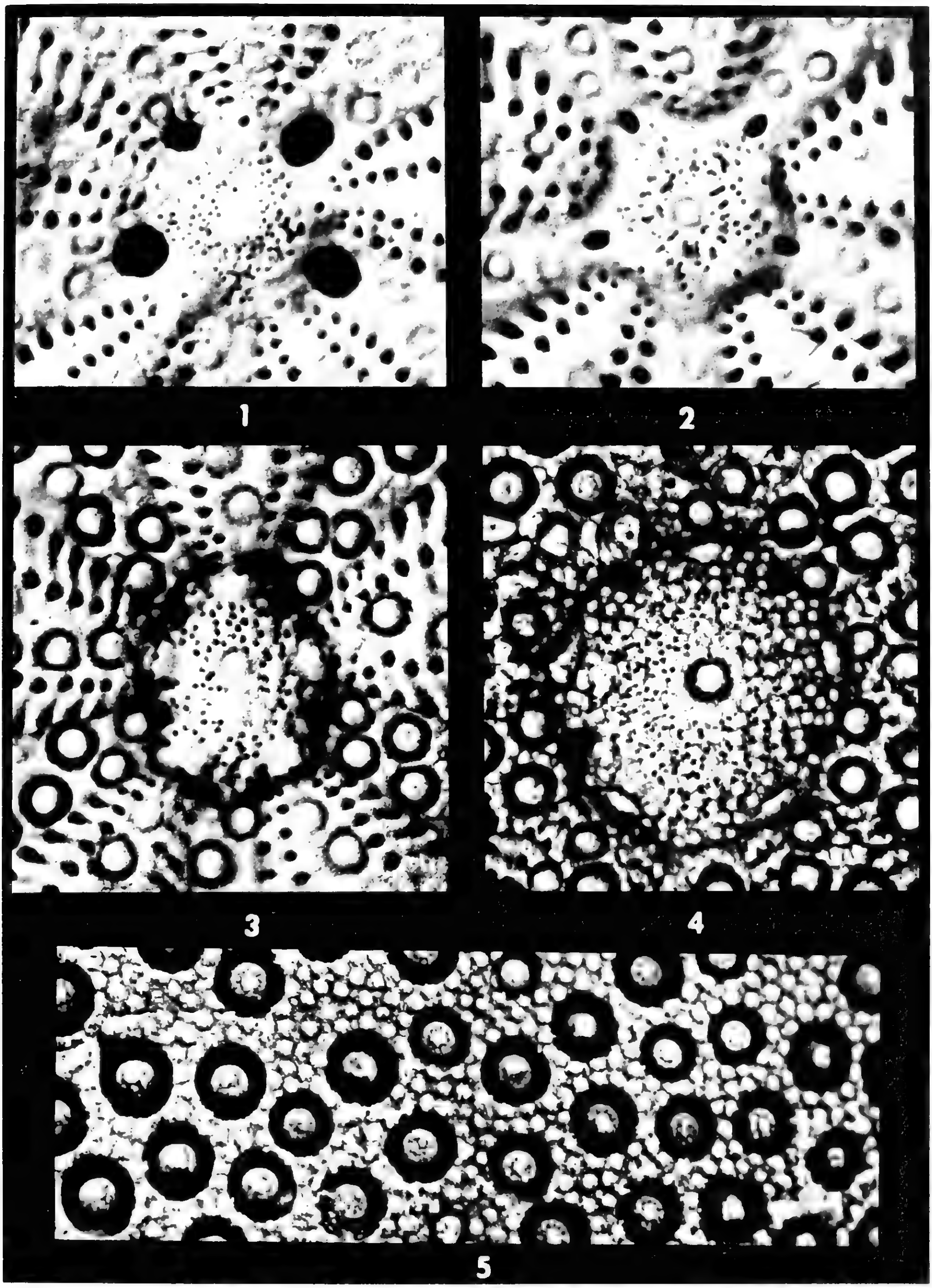
PLATE 36

Haimea meunieri (Lambert) 116

1, 2, 3, Adapical, right side, adoral views of specimen in École National Superieure des Mines, Paris, from Kaleni, Senegal, ×2.

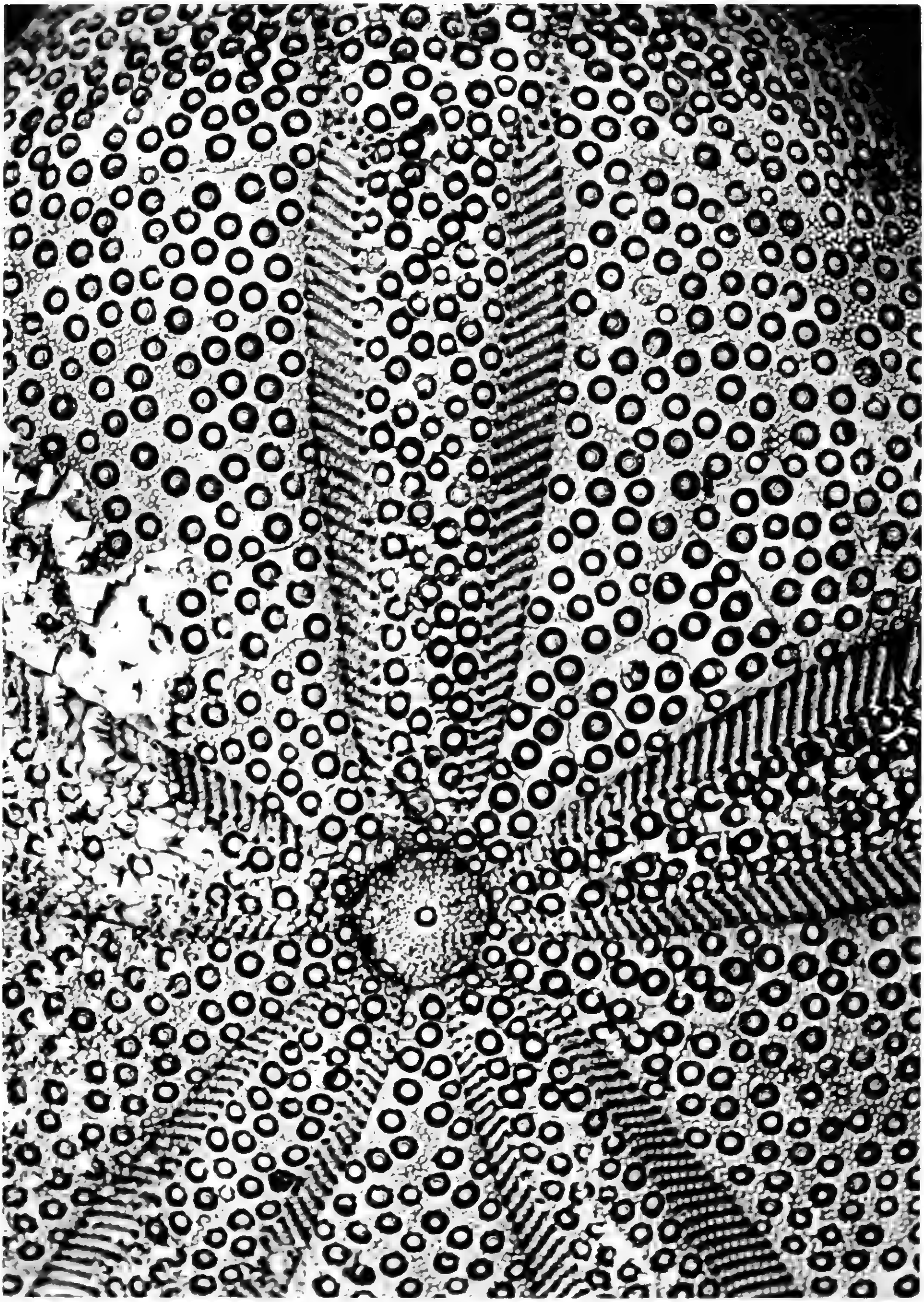
4, Petal I of same specimen in plate 35, figs. 5, 6, ×8.

5, Peristome and periproct of same specimen, ×7.4.



1-2, FEMALE, MALE APICAL SYSTEM IN *HAIMEA RUTTENI* (PIJPERS); 3-4, APICAL SYSTEM; 5, TUBERCULATION IN *OLIGOPYGUS WETHERBYI* DE LORIOL

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



APICAL, PETALOID REGION IN *OLIGOPYGUS WETHERBYI* DE LORIOL

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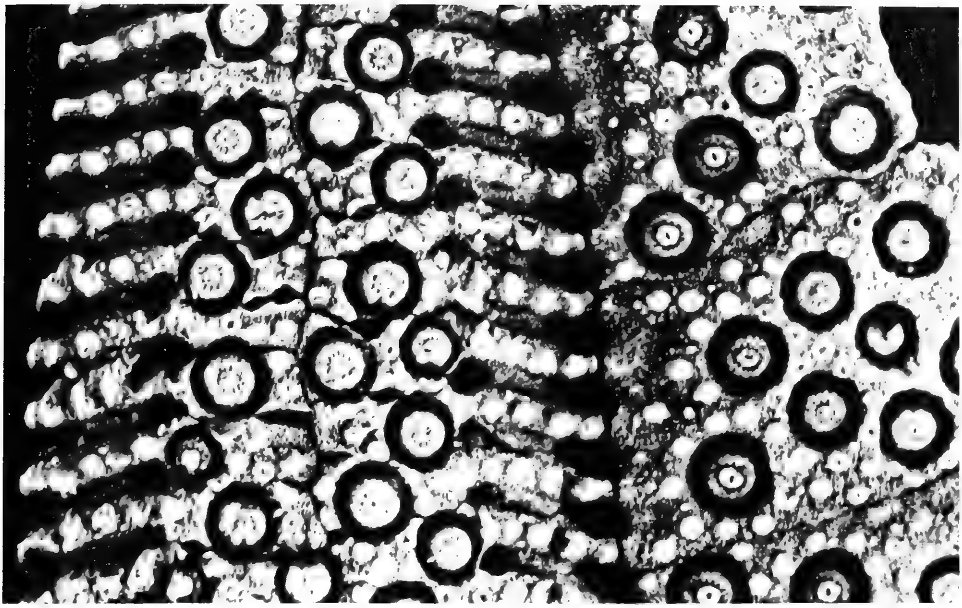

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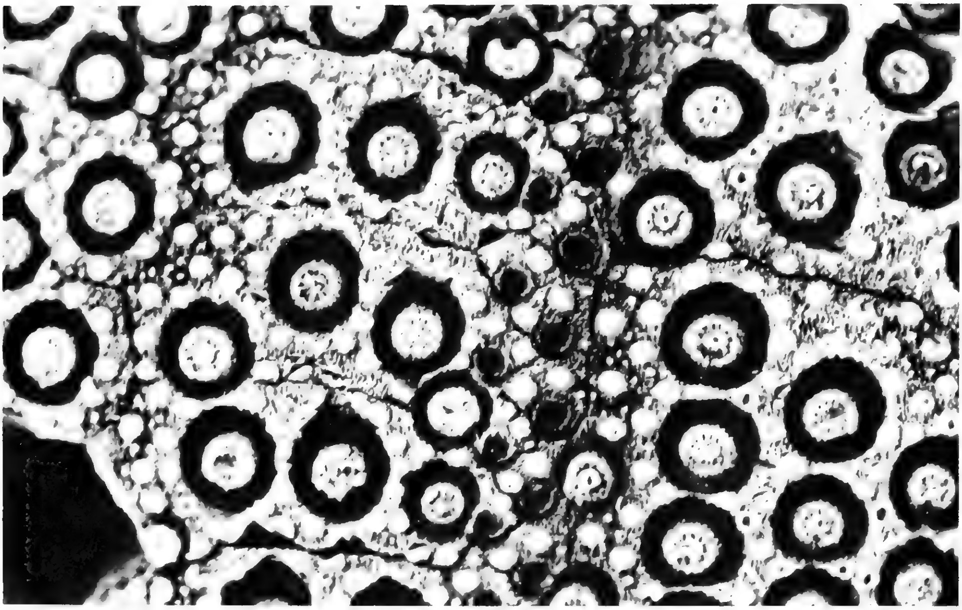

2

1, PETAL; 2, AMBULACRUM NEAR AMBITUS IN *OLIGOPYGUS HALDEMANI* (CONRAD)

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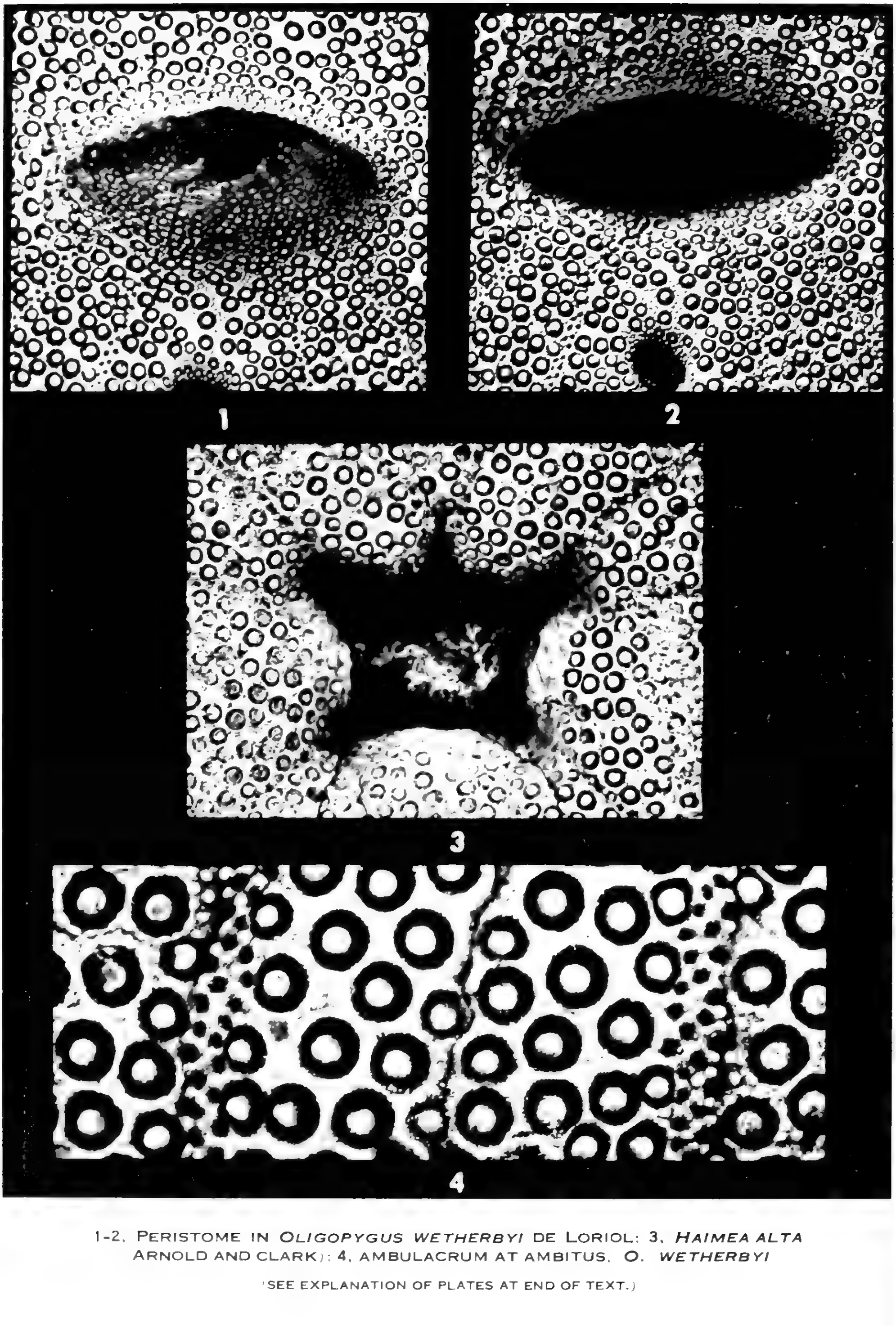


1-2, PERISTOME IN *OLIGOPYGUS WETHERBYI* DE LORIOL; 3, *HAIMEA ALTA* (ARNOLD AND CLARK); 4, AMBULACRUM AT AMBITUS, *O. WETHERBYI*

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

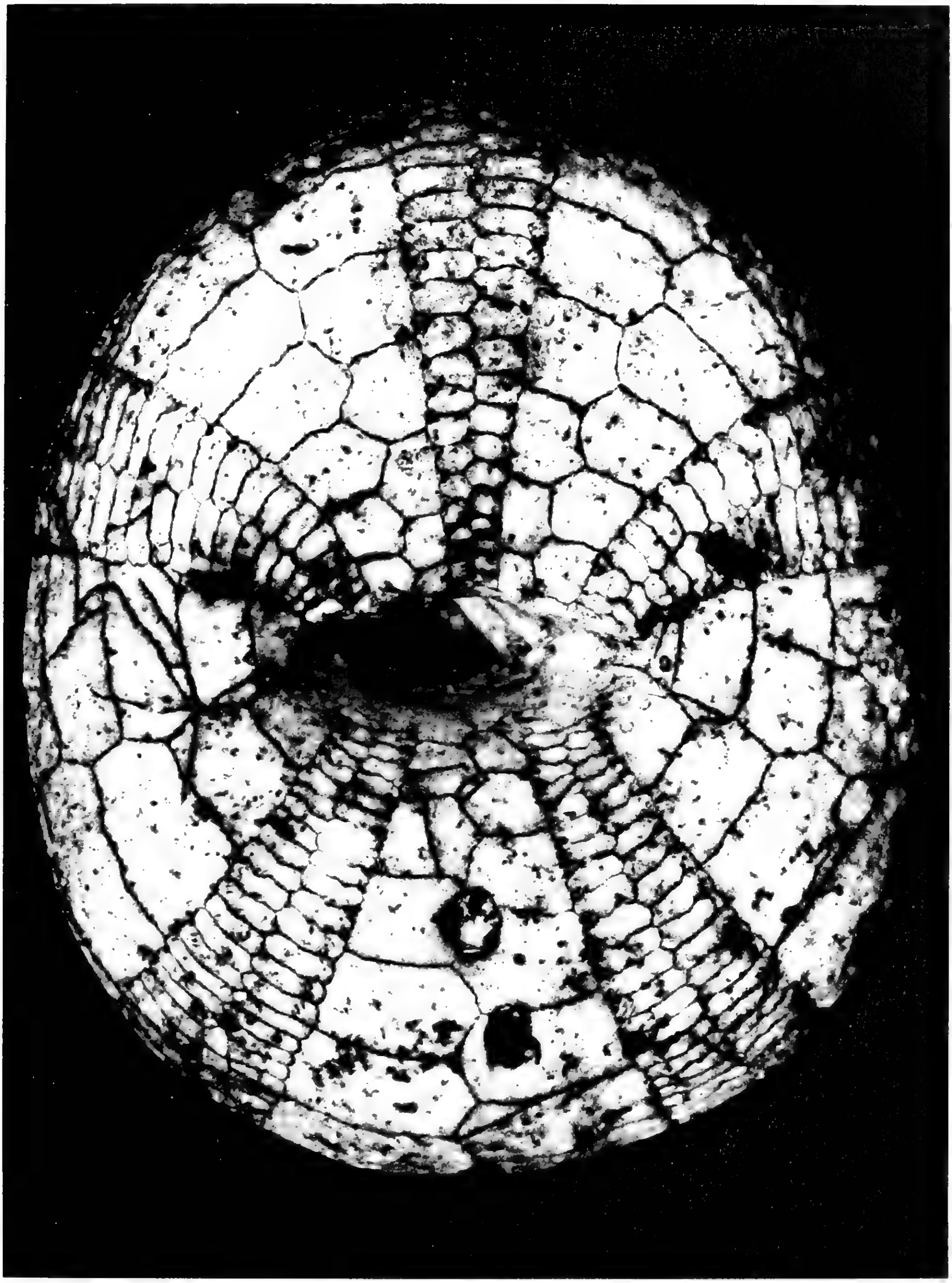
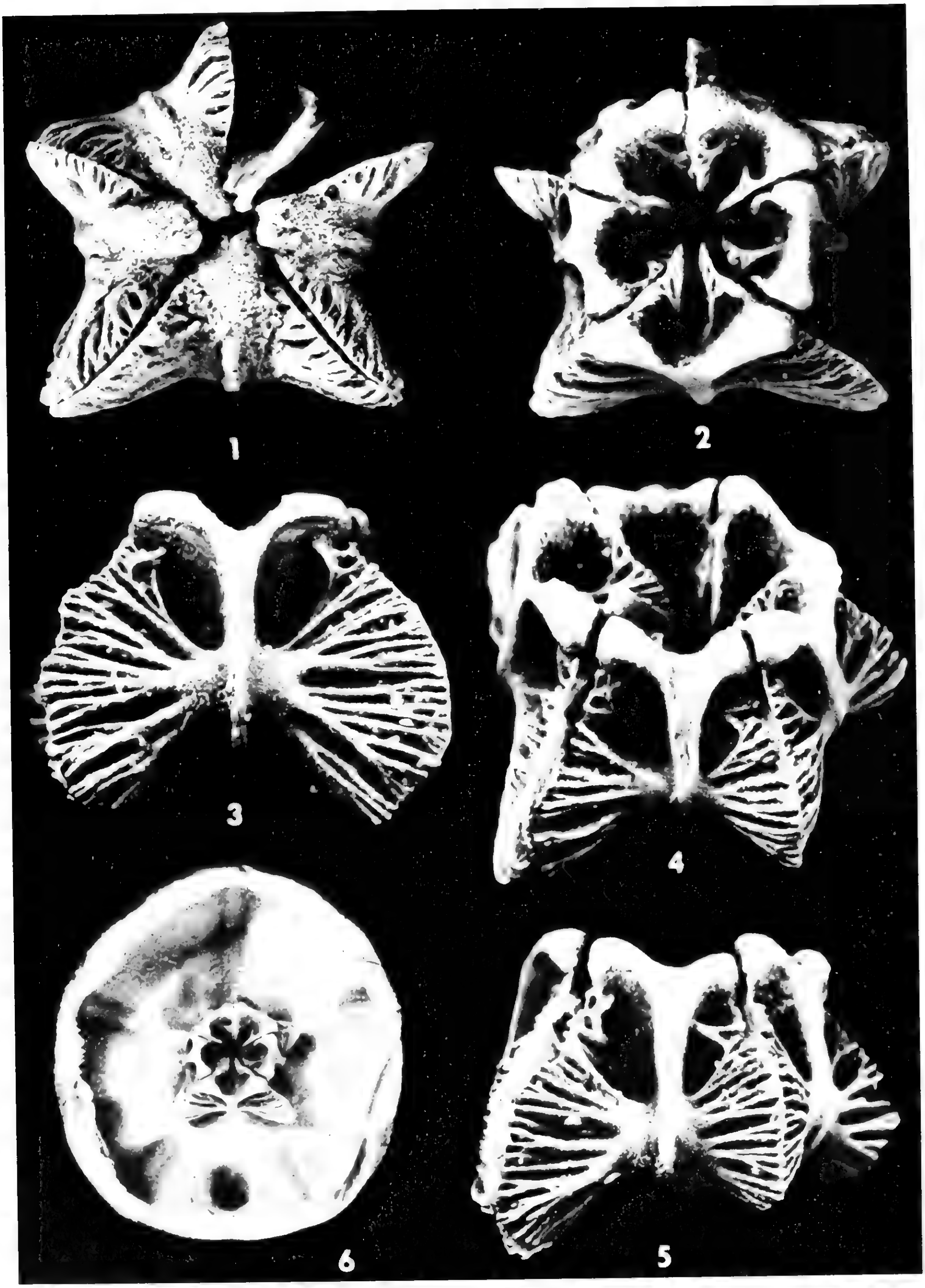


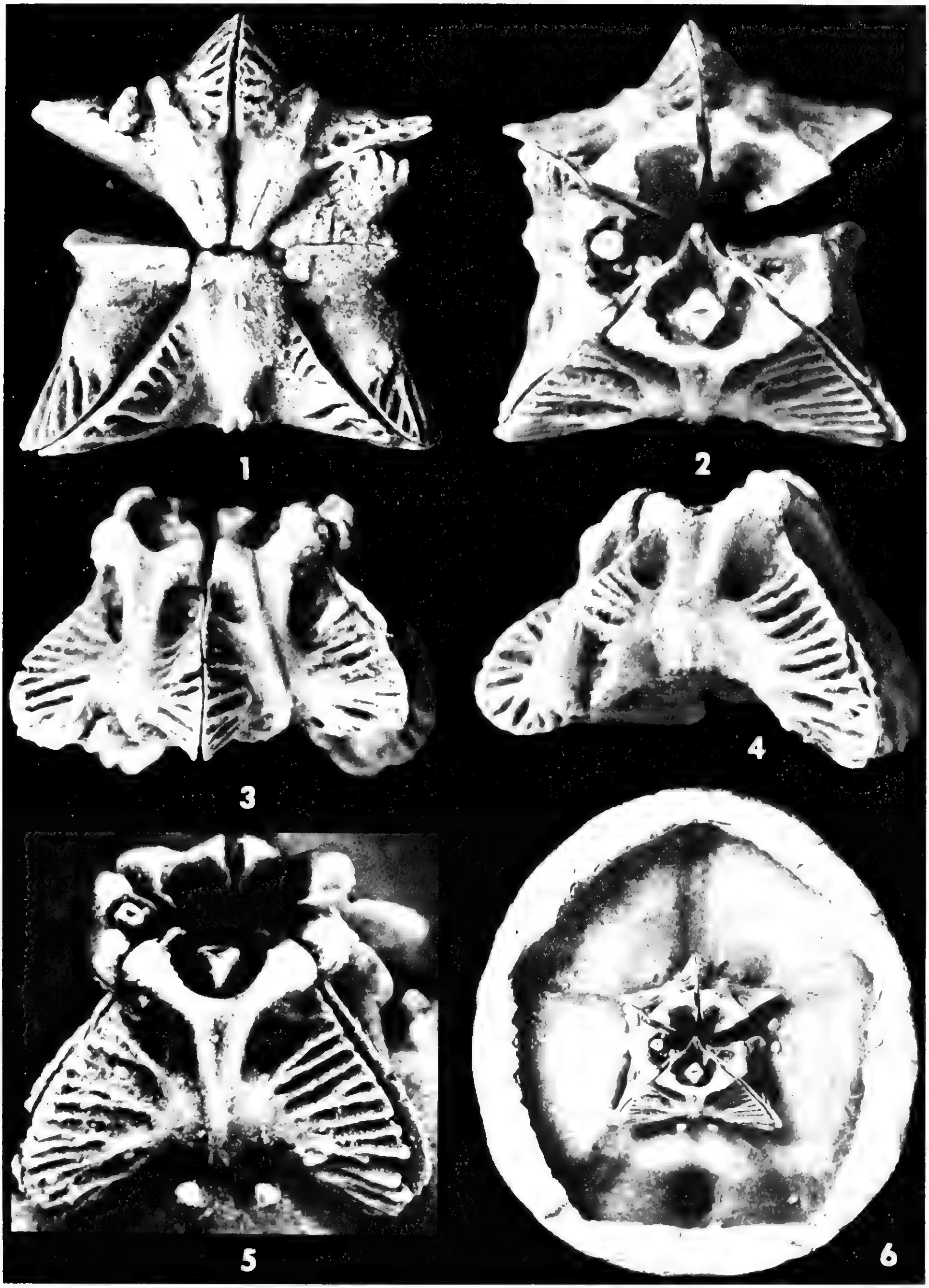
PLATE SUTURES ON ADORAL SURFACE OF *OLIGOPYGUS WETHERBYI* DE LORIOL

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



LANTERN OF *HAIMEA RUTTENI* (PIJPERS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



LANTERN OF *OLIGOPYGUS PUTNAMI* ISRAELSKY

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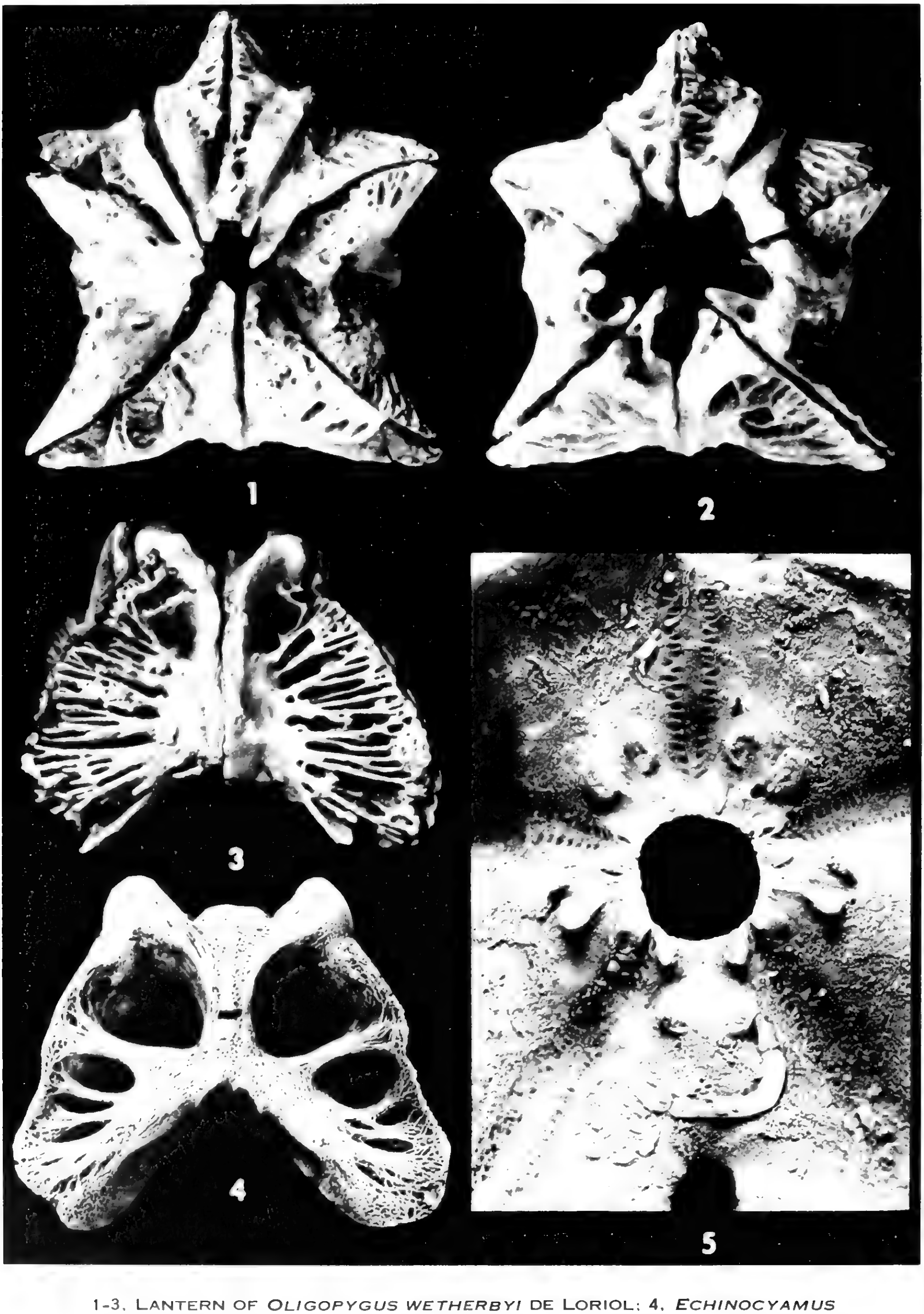
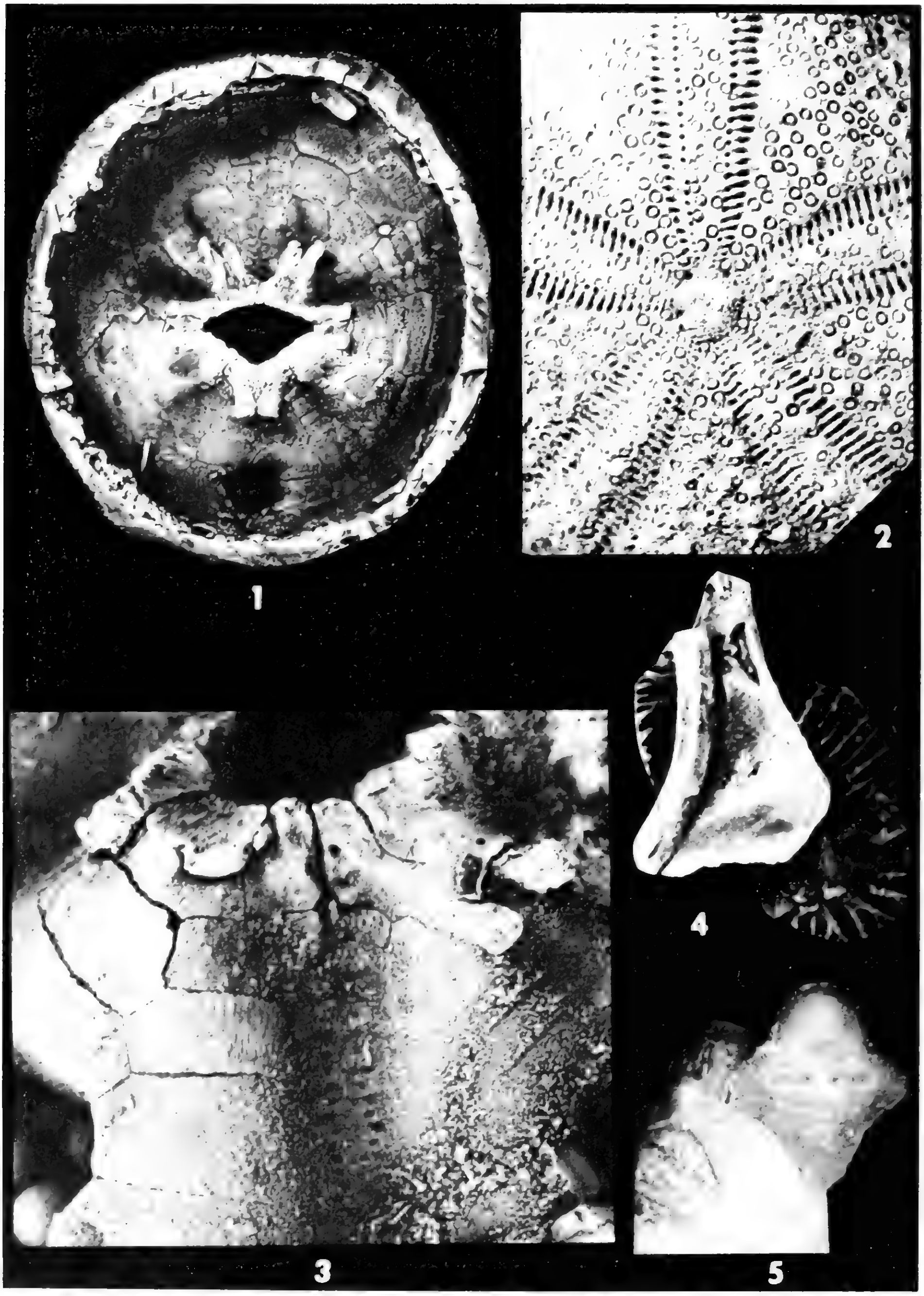


1-3, LANTERN OF *OLIGOPYGUS WETHERBYI* DE LORIOL; 4, *ECHINOCYAMUS MEGAPETALUS* CLARK; 5, LANTERN SUPPORTS IN *HAIMEA RUTTENI* (PIJPERS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

LANTERN SUPPORT IN *HAIMEA RUTTENI* (PIJPERS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



1, LANTERN SUPPORTS IN *OLIGOPYGUS HALDEMANI* (CONRAD); 2, GLASSY TUBERCLES IN *OLIGOPYGUS*; 3, LANTERN SUPPORT; 4-5, TOOTH IN LANTERN OF *O. WETHERBYI* DE LORIOL

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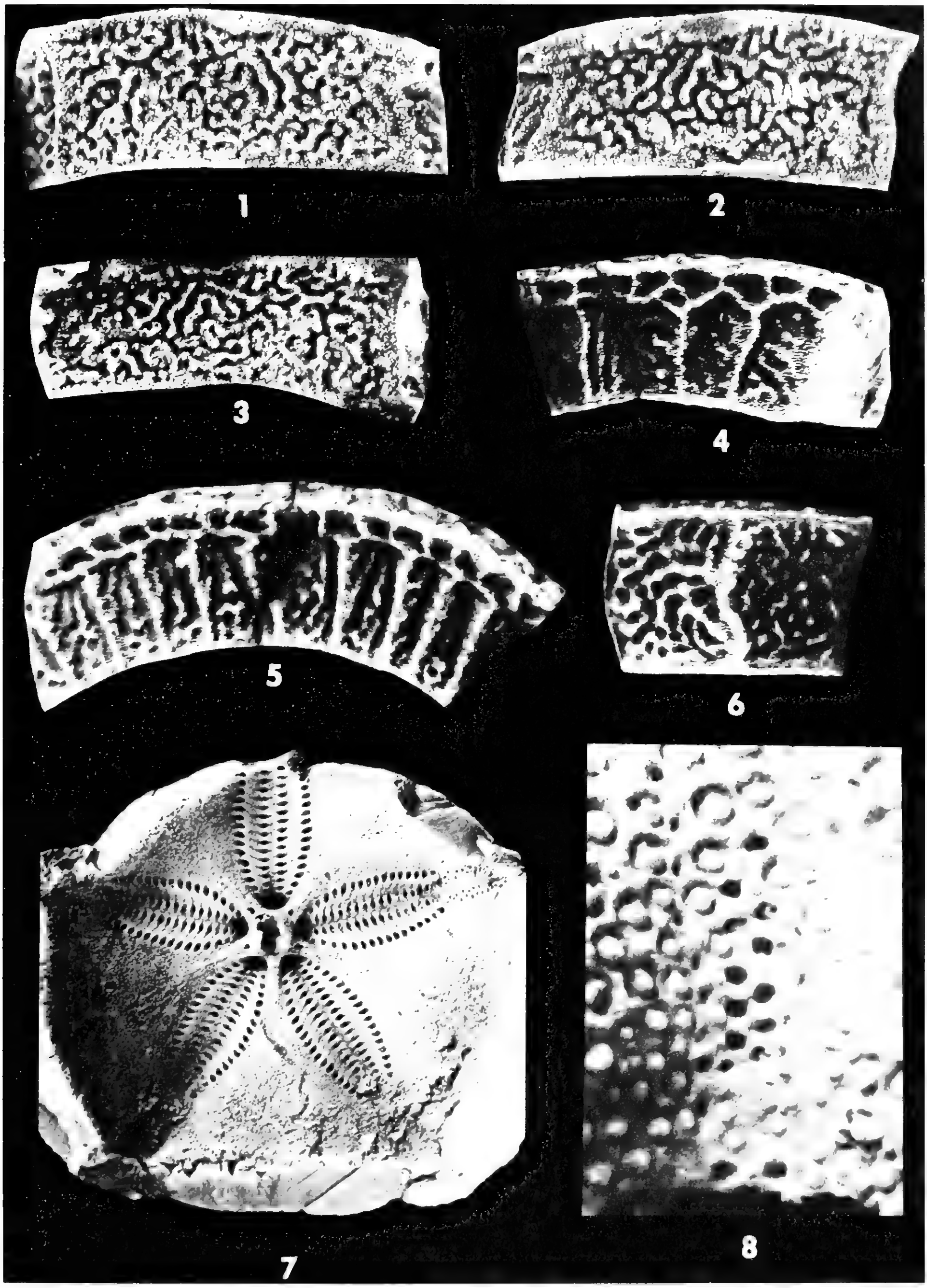
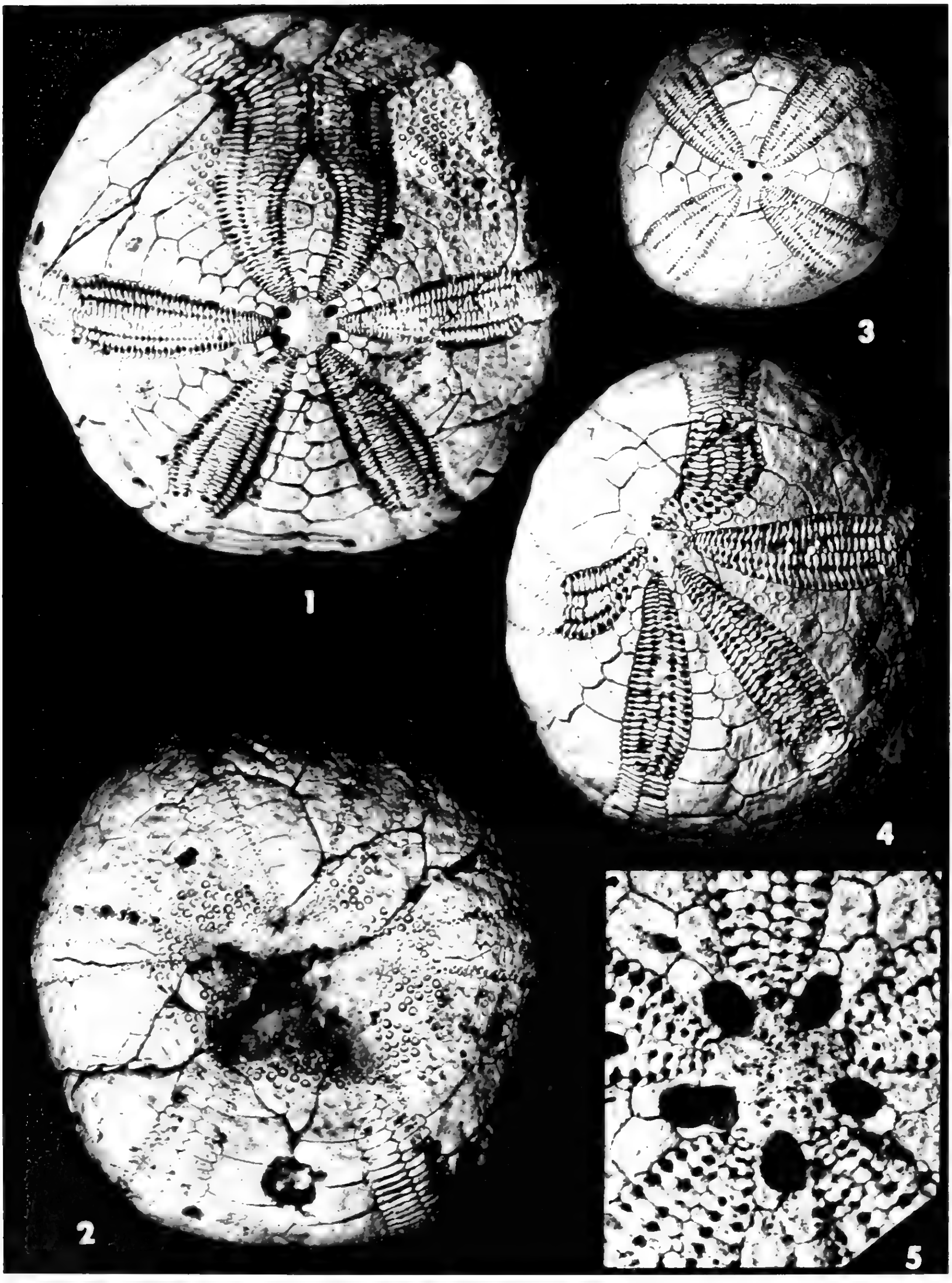


1-6, SUTURAL SURFACES IN PLATES OF *OLIGOPYGUS HALDEMANI* (CONRAD); 7, INTERIOR ADAPICAL SURFACE; 8, SPHAERIDIA, BUCCAL PORES IN *HAIMEA RUTTENI* (PIJPERS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



ABNORMAL SPECIMENS OF *HAIMEA* AND *OLIGOPYGUS*

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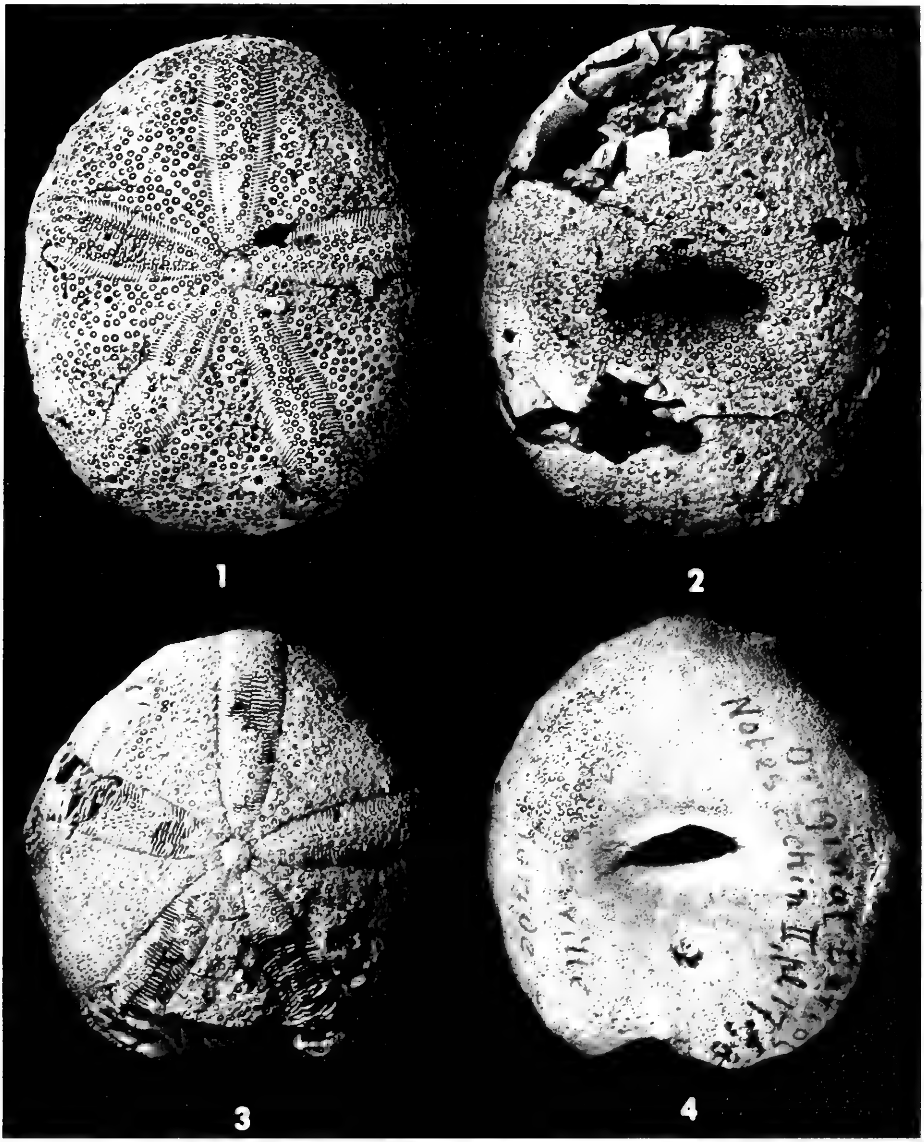
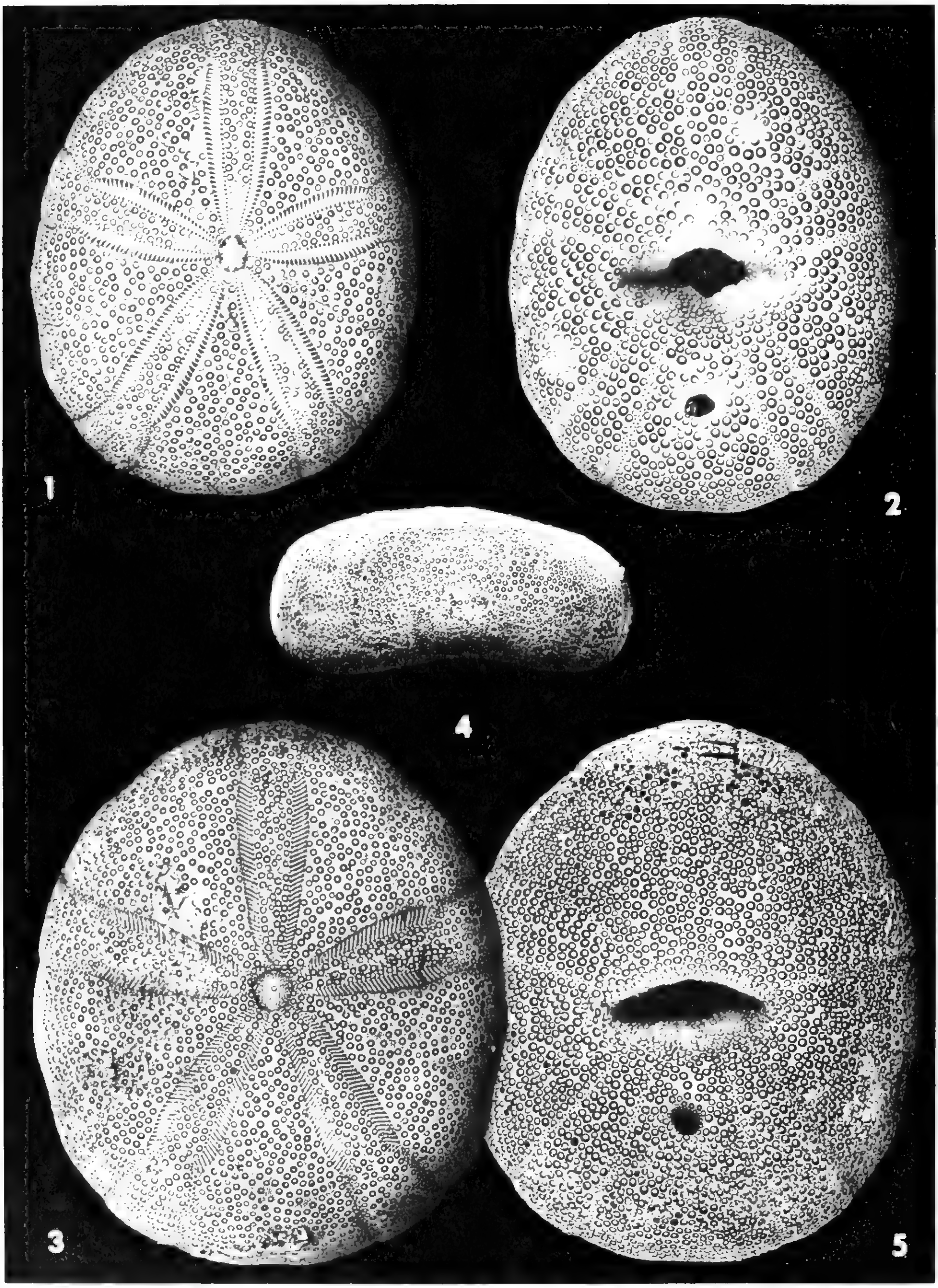


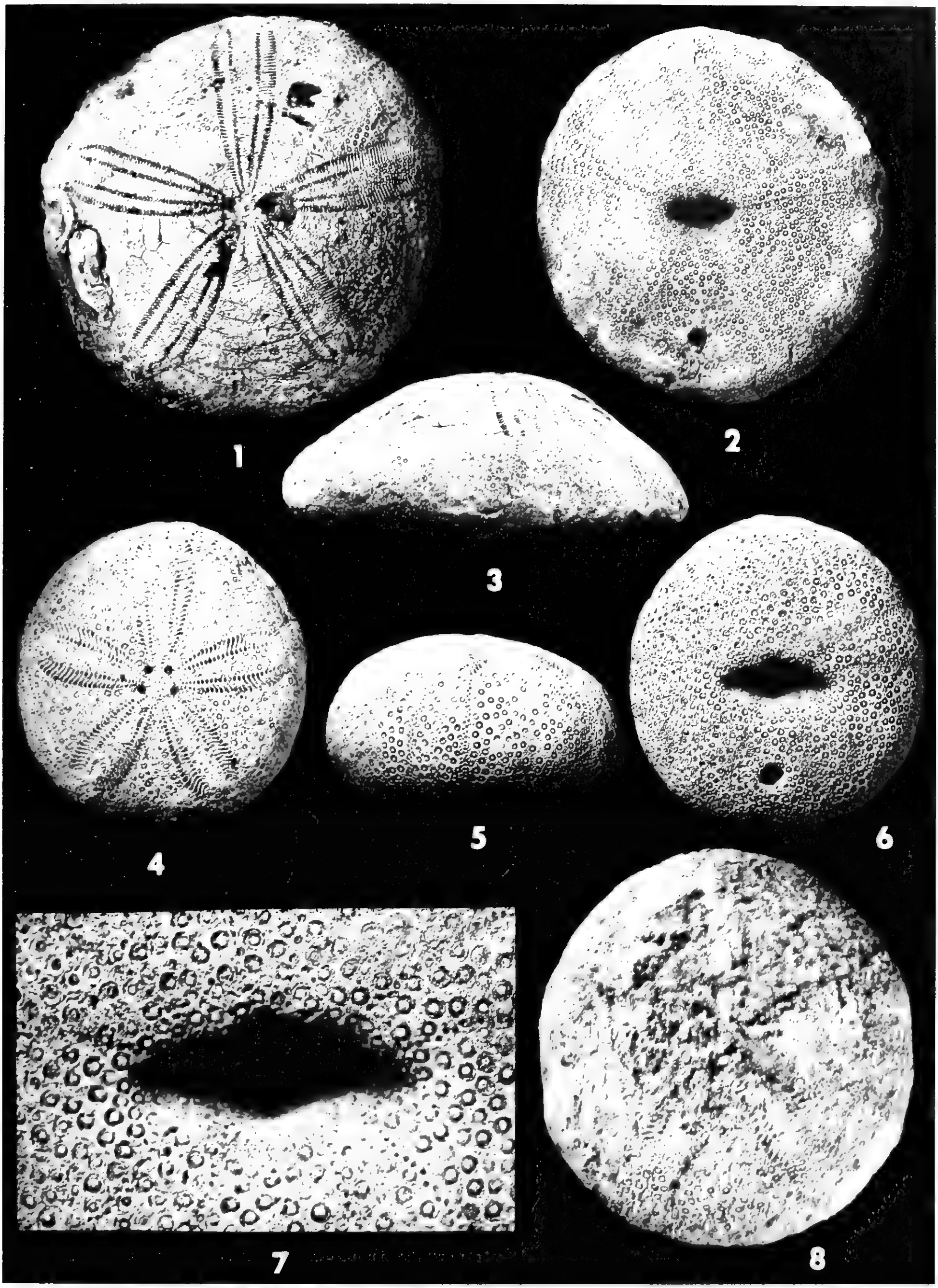
1-2, LECTOTYPE; 3-4. PARALECTOTYPE OF *OLIGOPYGUS WETHERBYI* DE LORIOL

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



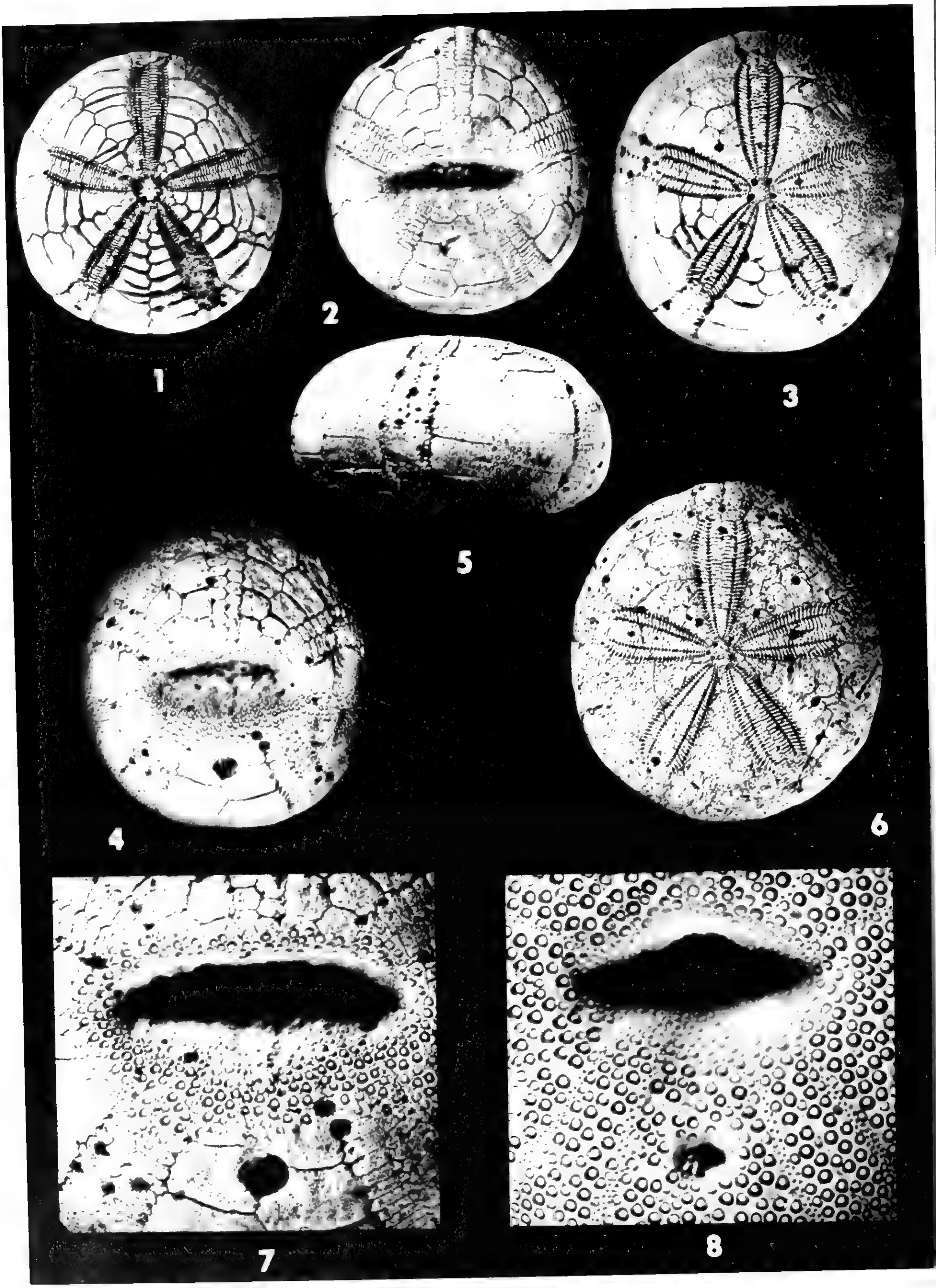
OLIGOPYGUS WETHERBYI DE LORIOL

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



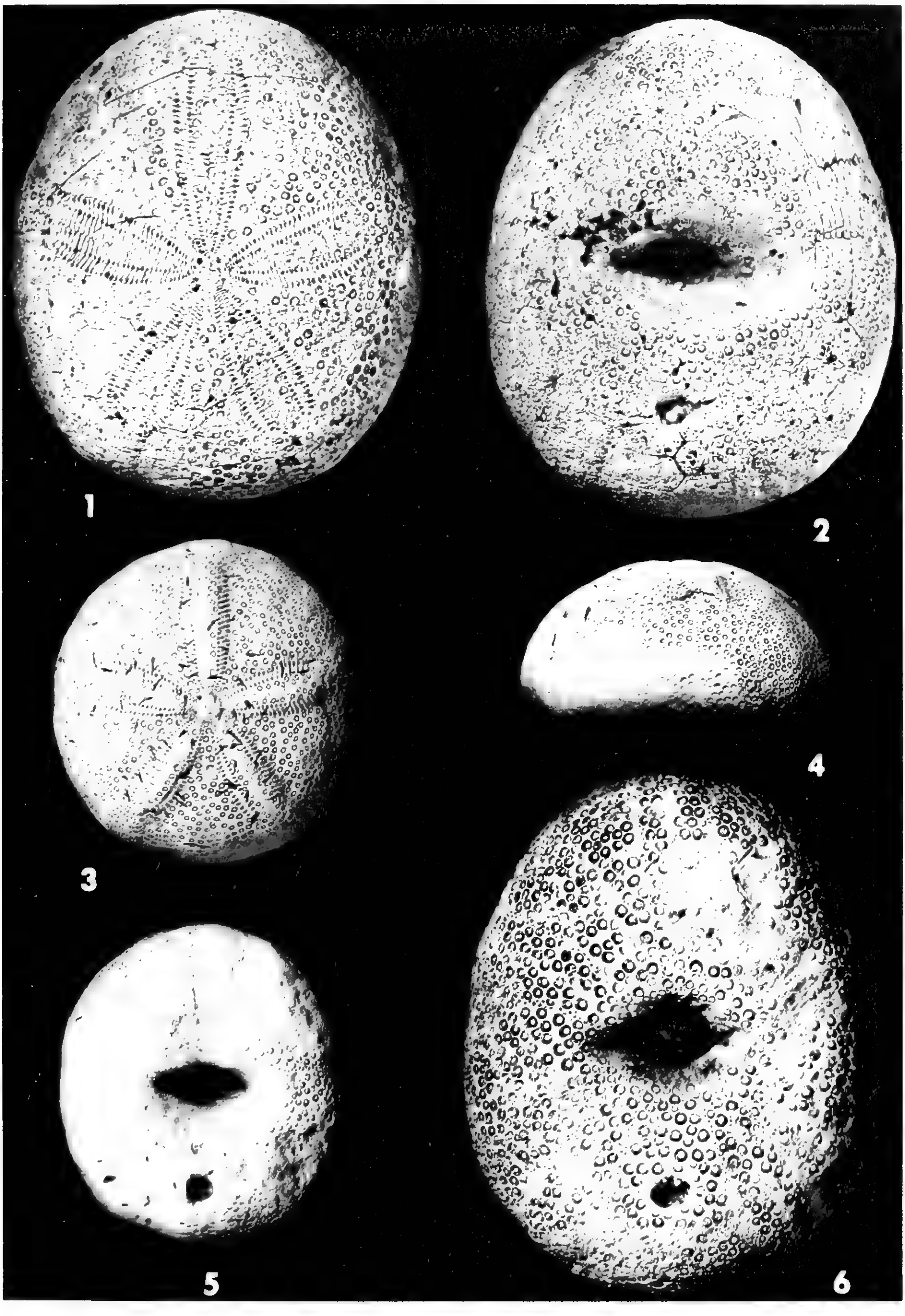
1-3, *OLIGOPYGUS NANCEI* COOKE; 4-8, *O. ZYNDELI* JEANNET

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



1-7, *OLIGOPYGUS JAMAICENSIS* ARNOLD AND CLARK; 8, PERISTOME OF *O. WETHERBYI* DE LORIOL

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



1-2, *OLIGOPYGUS HYPSELUS* ARNOLD AND CLARK; 3-5, *O. ROTUNDUS* COOKE; 6, *O. KUGLERI* JEANNET

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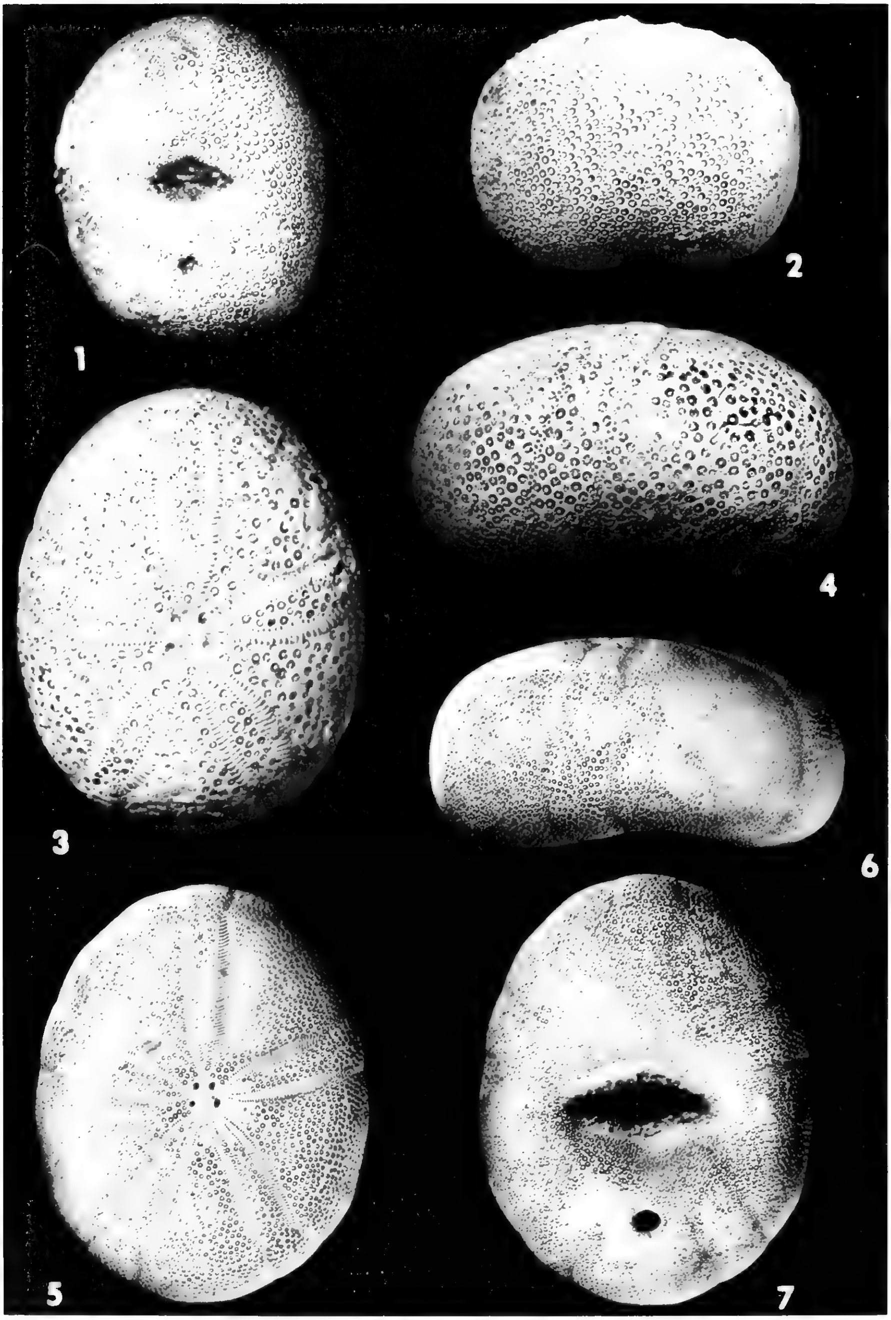

1-4, *OLIGOPYGUS KUGLERI* JEANNET; 5-7 *O. PINGUIS* PALMER

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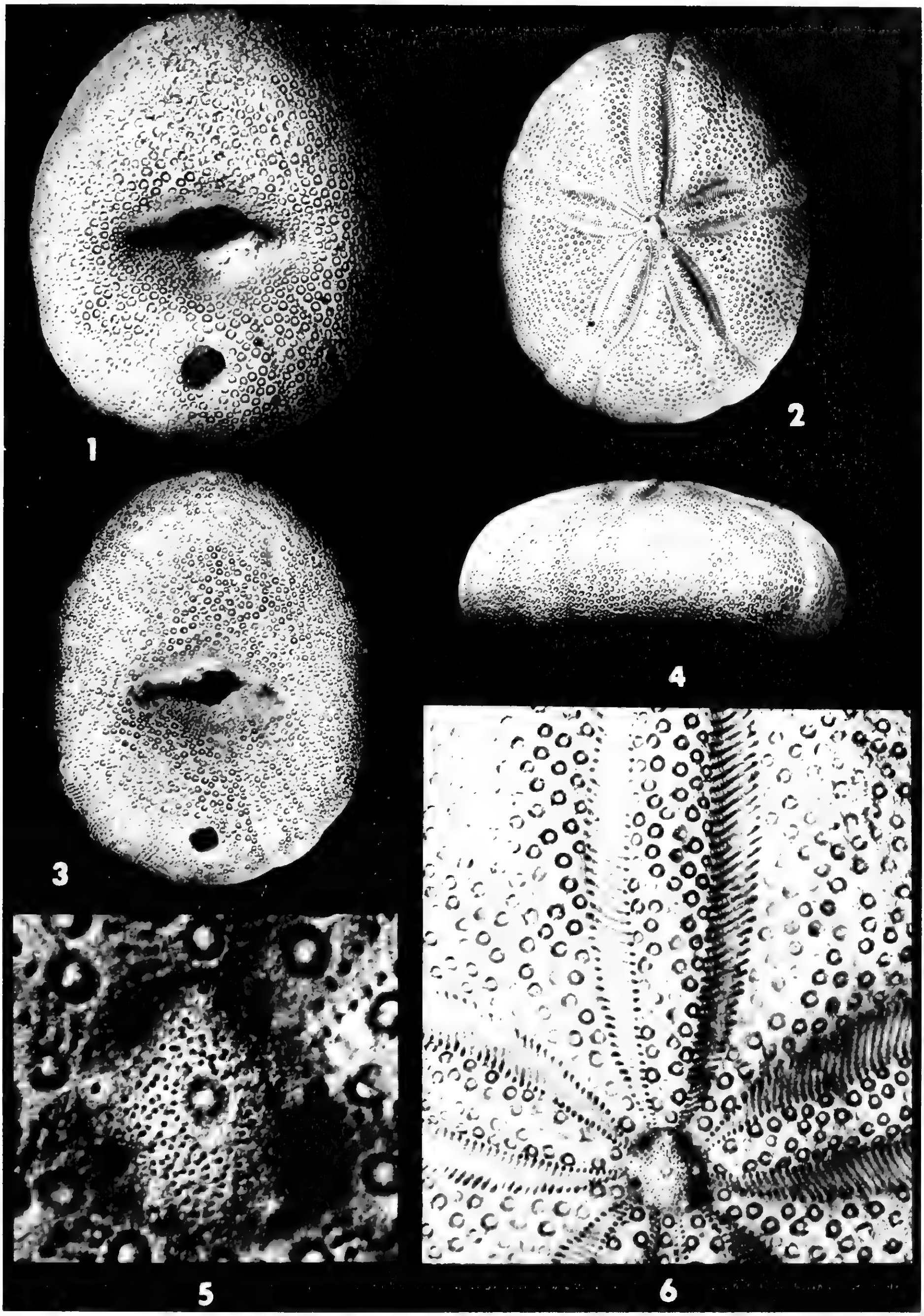

1, *OLIGOPYGUS PINGUIS* PALMER; 2-6, *O. SANCHEZI* LAMBERT

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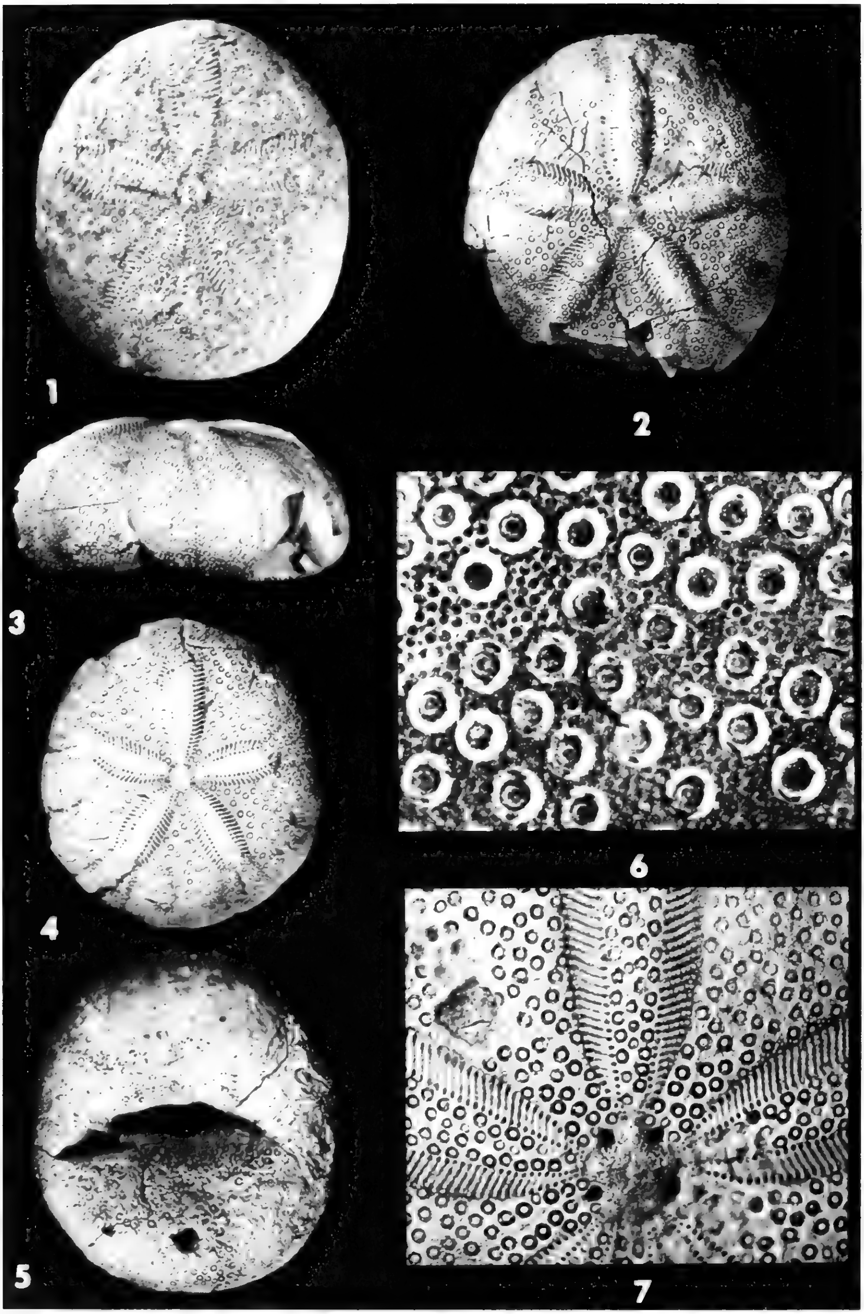
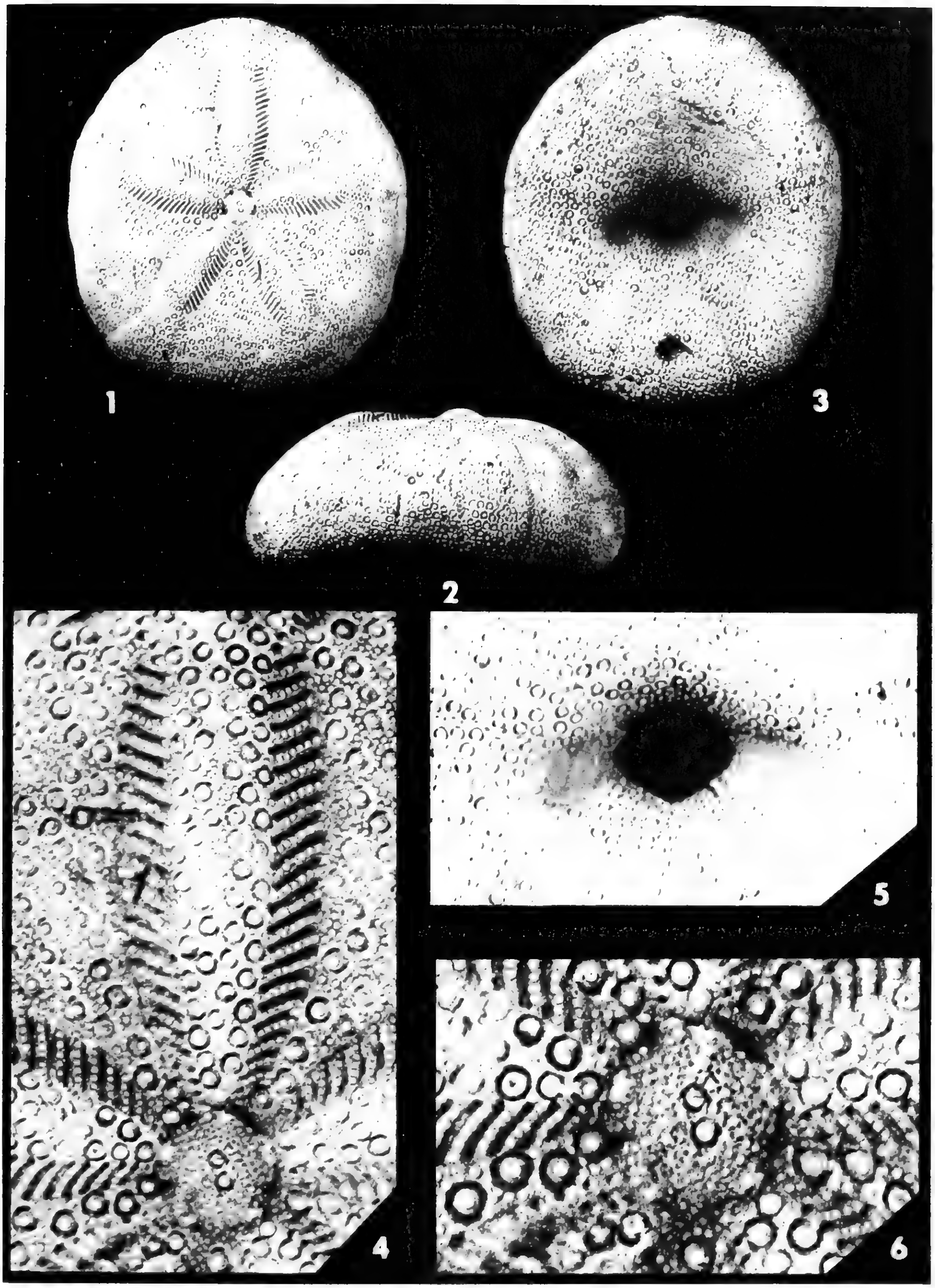


1, *Oligopygus costuliformis* Jeannet; 2-6, *O. putnami* Israelsky; 7, *O. pinguis* Palmer

(See explanation of plates at end of text.)



OLIGOPYGUS PUTNAMI ISRAELSKY

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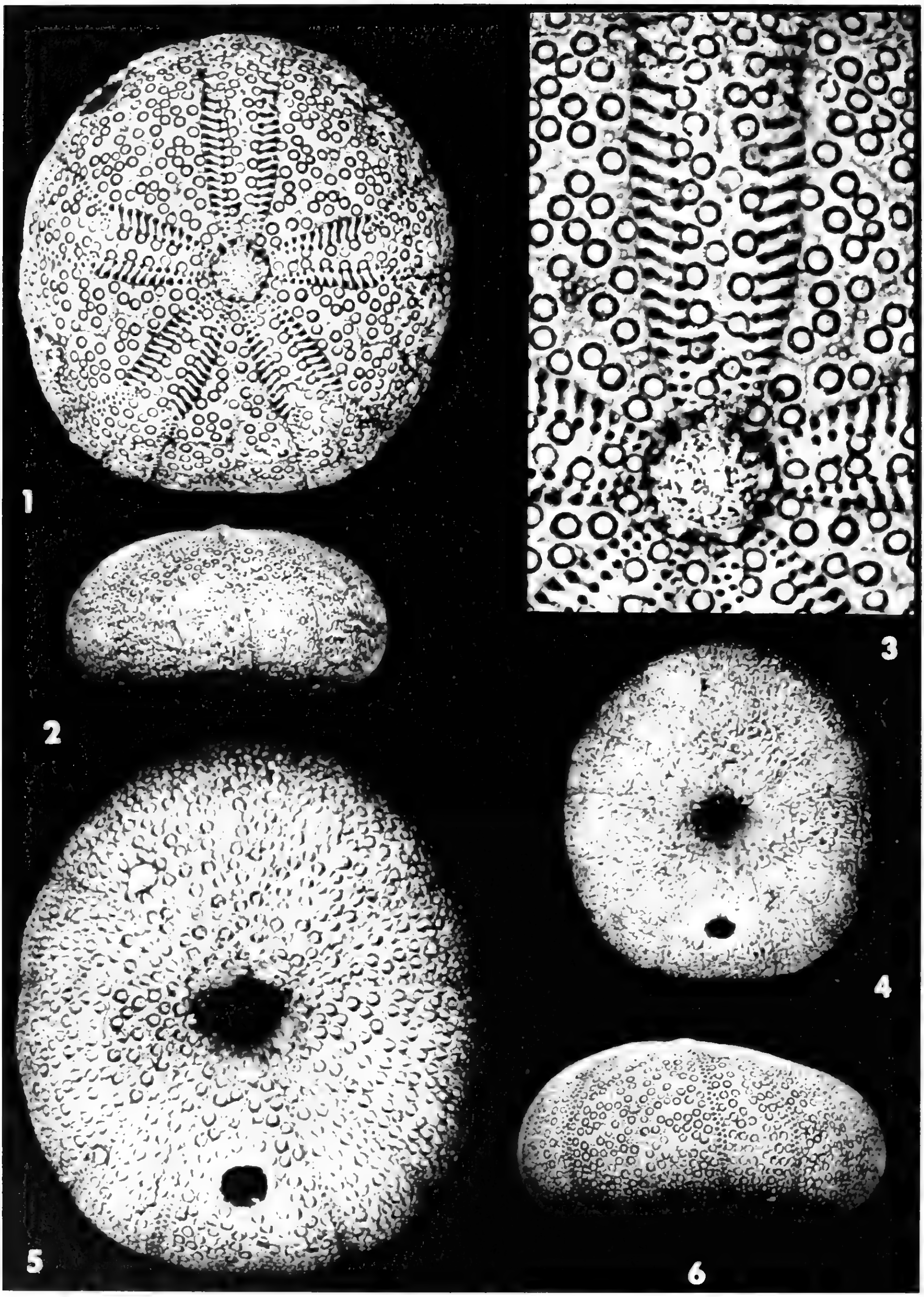

OLIGOPYGUS PHELANI KIER, NEW SPECIES

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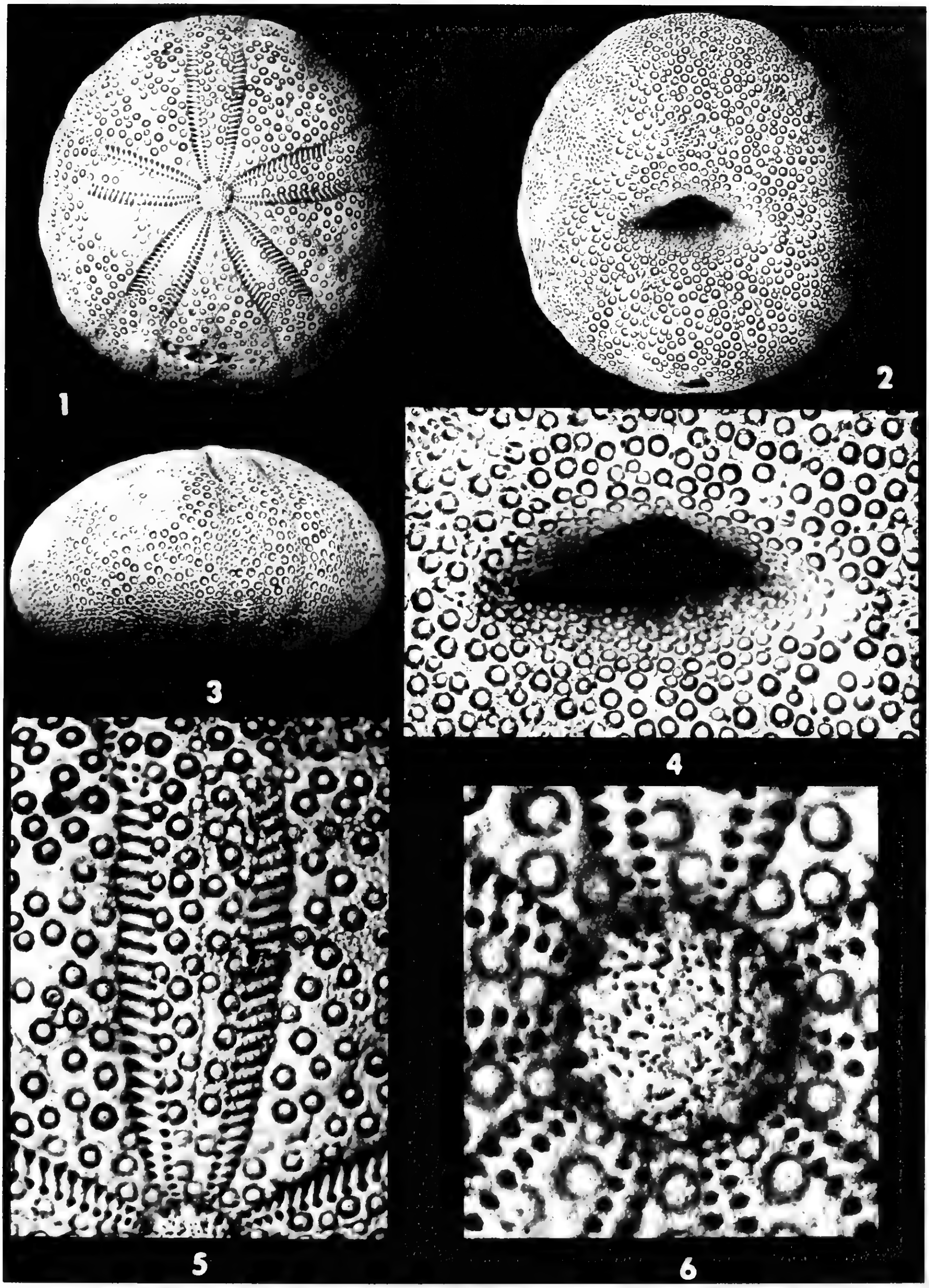

OLIGOPYGUS HALDEMANI (CONRAD)

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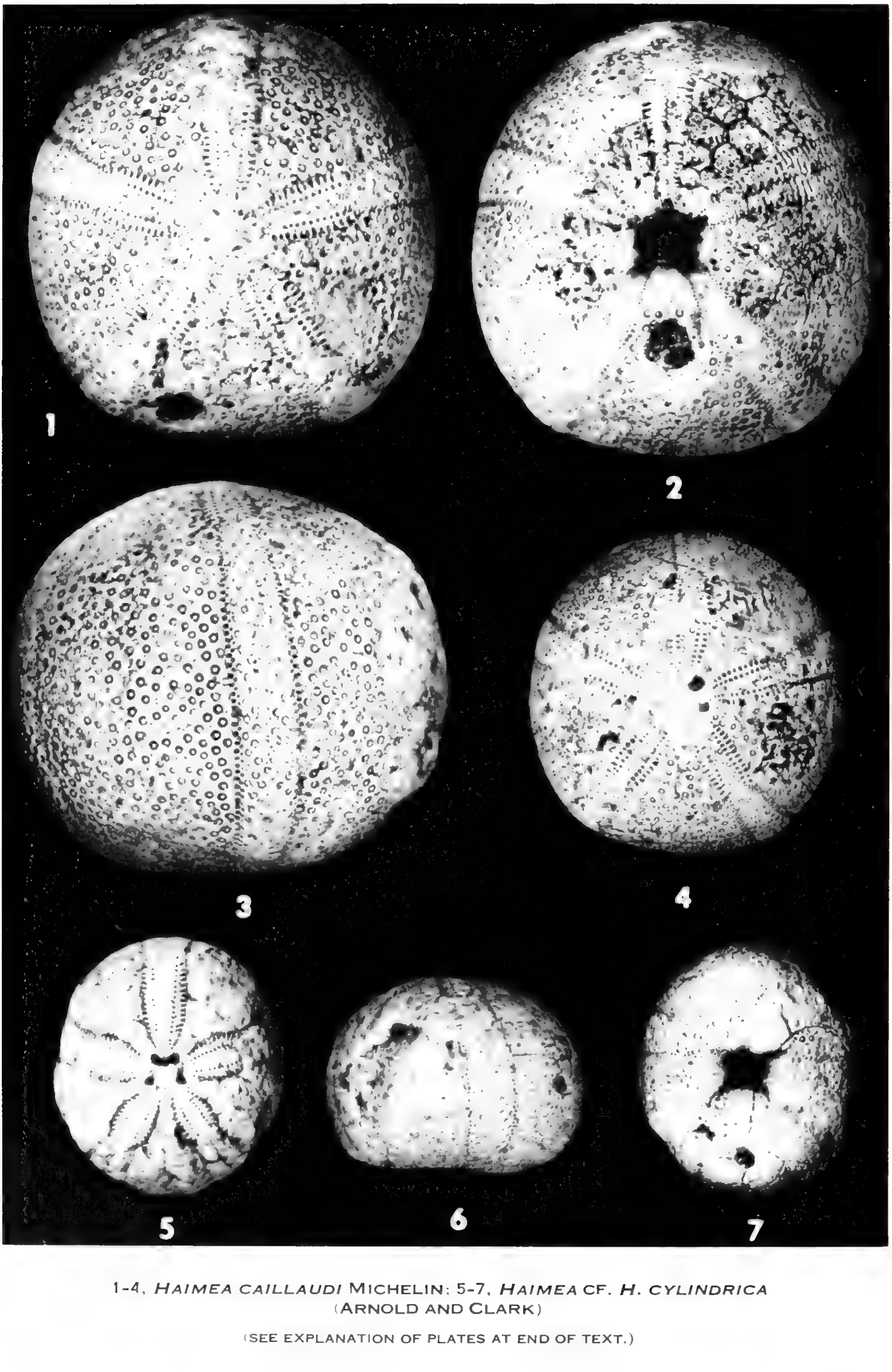

1-4, *HAIMEA CAILLAUDI* MICHELIN; 5-7, *HAIMEA* CF. *H. CYLINDRICA* (ARNOLD AND CLARK)

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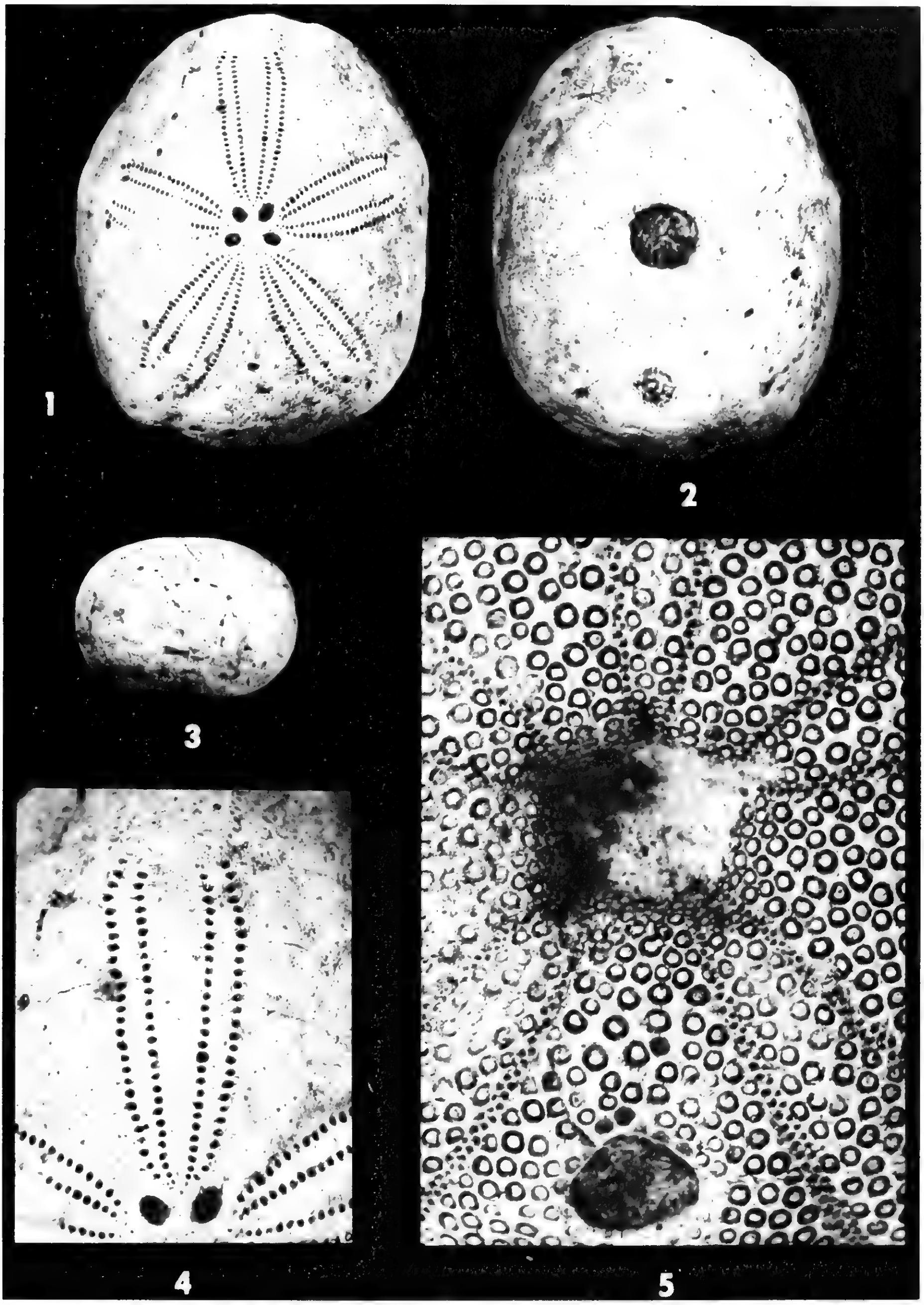

1-4, *HAIMEA ELEVATA* (ARNOLD AND CLARK); 5, *HAIMEA ALTA* (ARNOLD AND CLARK)

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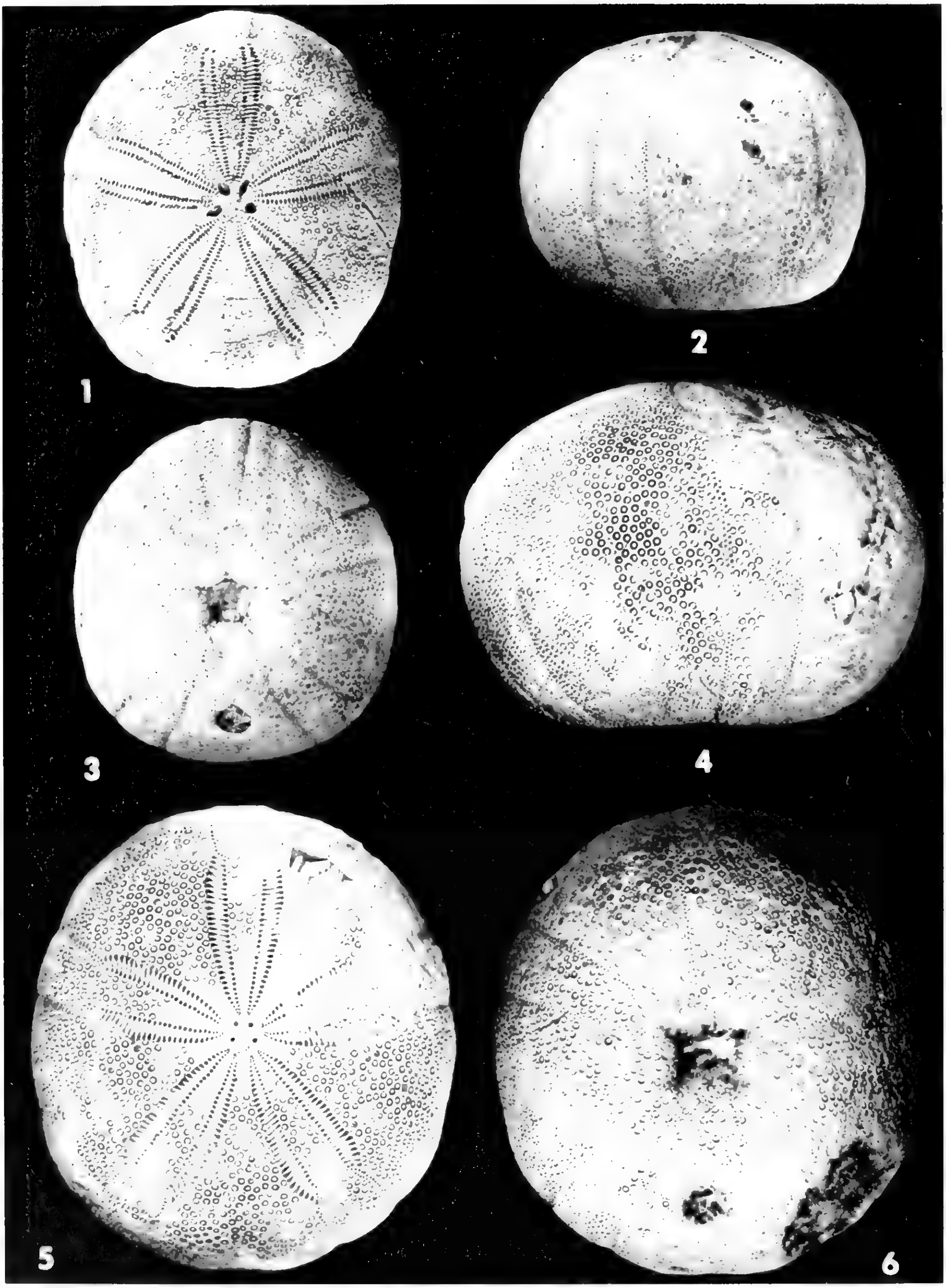

HAIMEA ALTA (ARNOLD AND CLARK)

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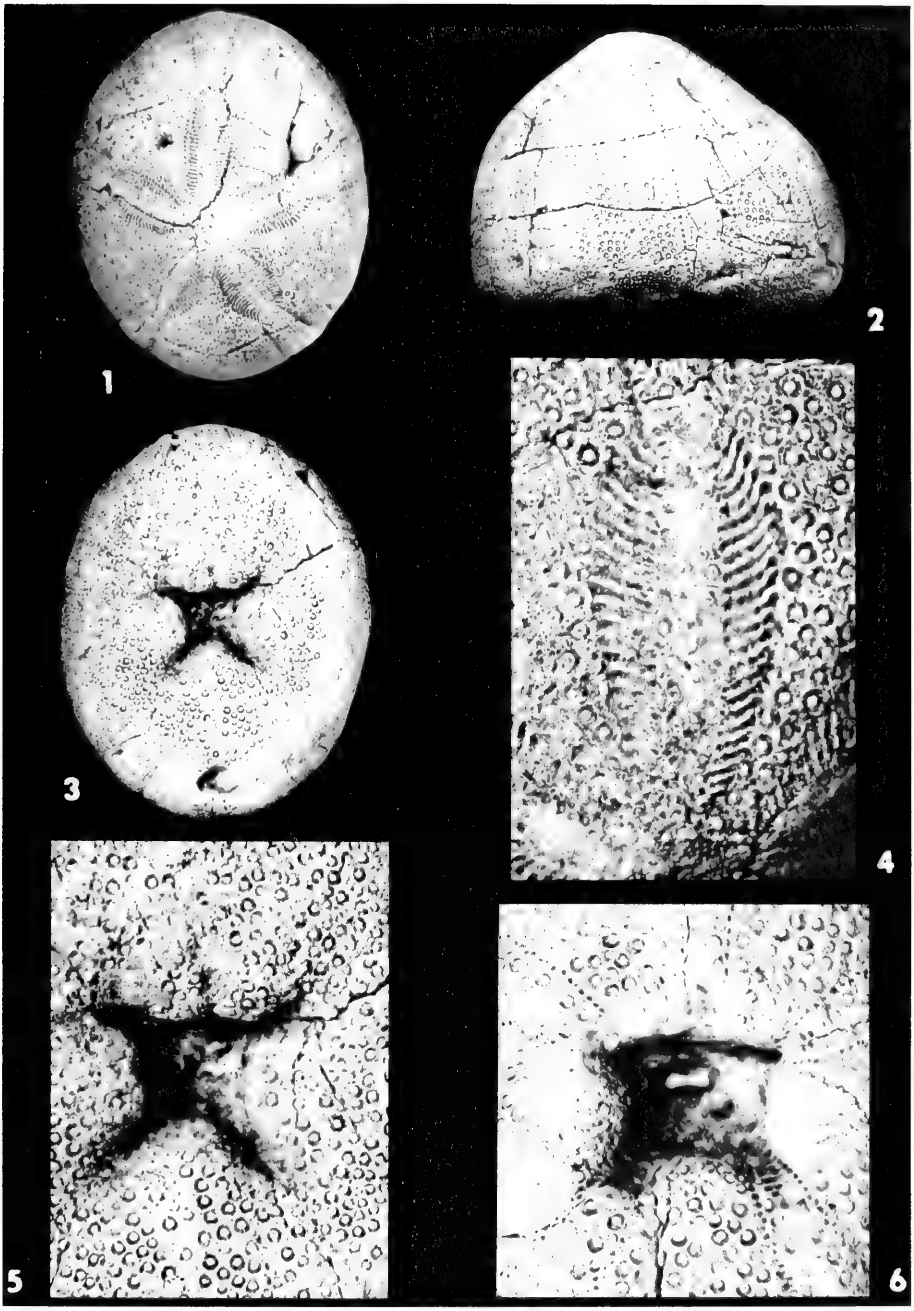

1-5, *HAIMEA PYRAMIDOIDES* (ARNOLD AND CLARK); 6, *H. CYLINDRICA* (ARNOLD AND CLARK)

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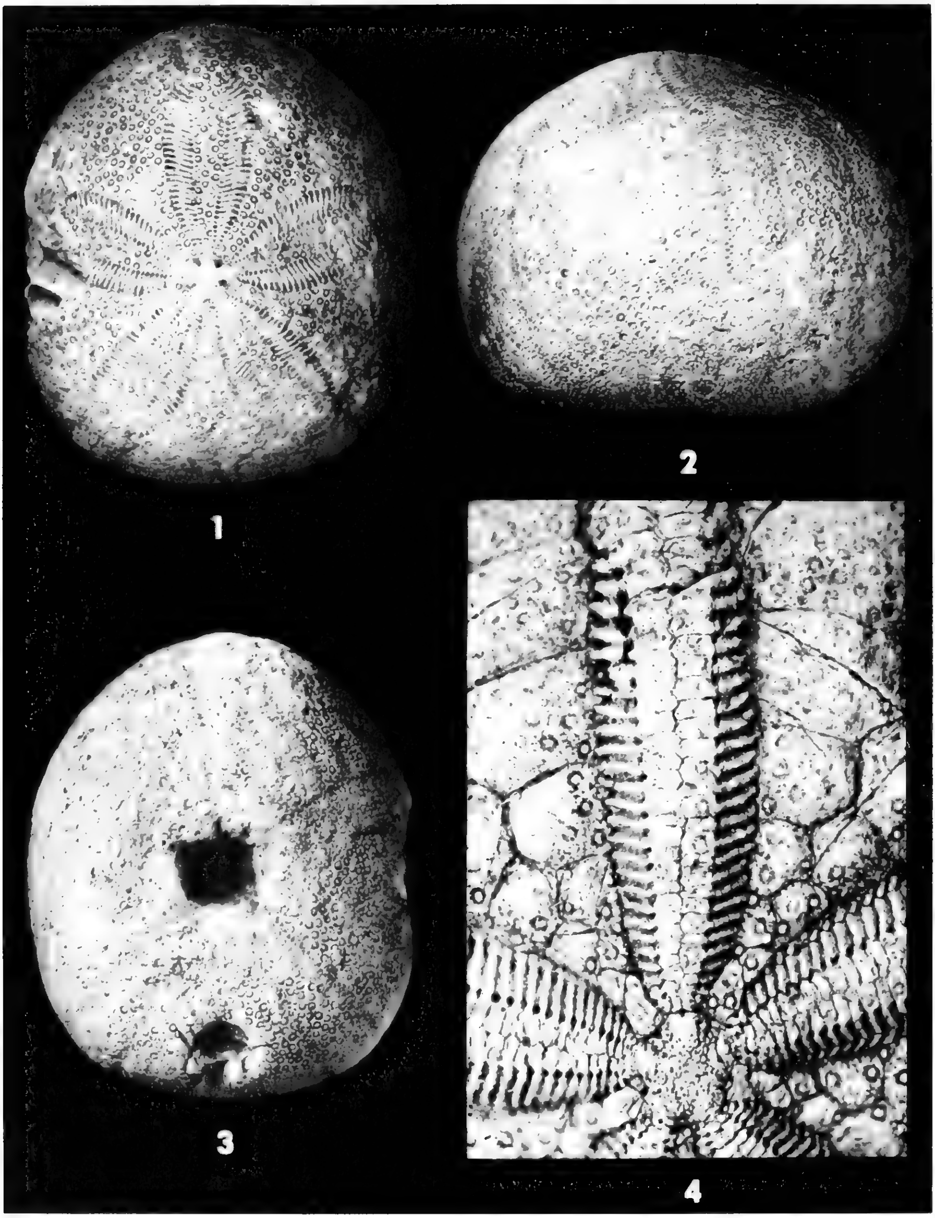

HAIMEA CYLINDRICA (ARNOLD AND CLARK)

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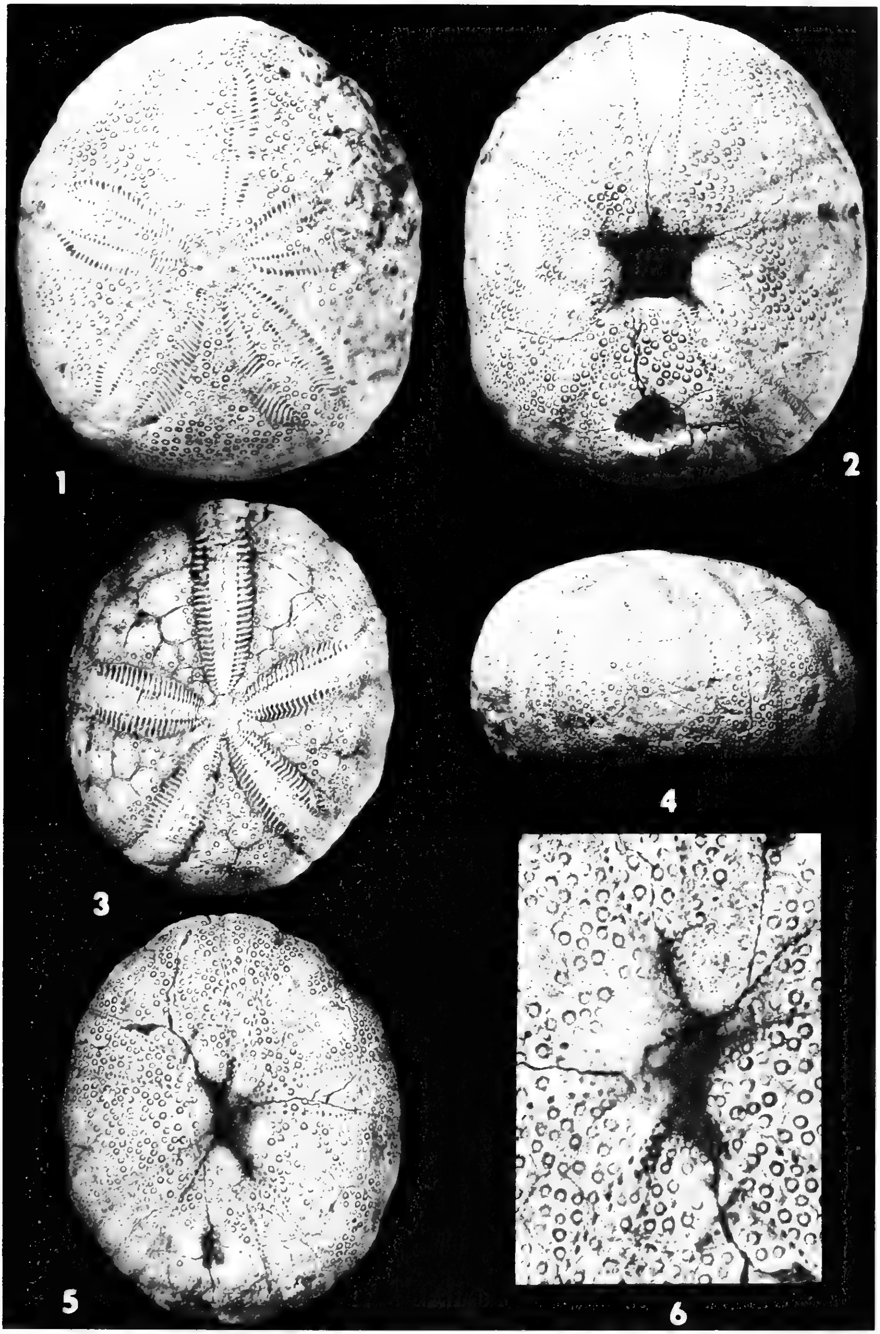

1-2, *HAIMEA CYLINDRICA* (ARNOLD AND CLARK); 3-6, *H. CONVEXA* (ARNOLD AND CLARK)

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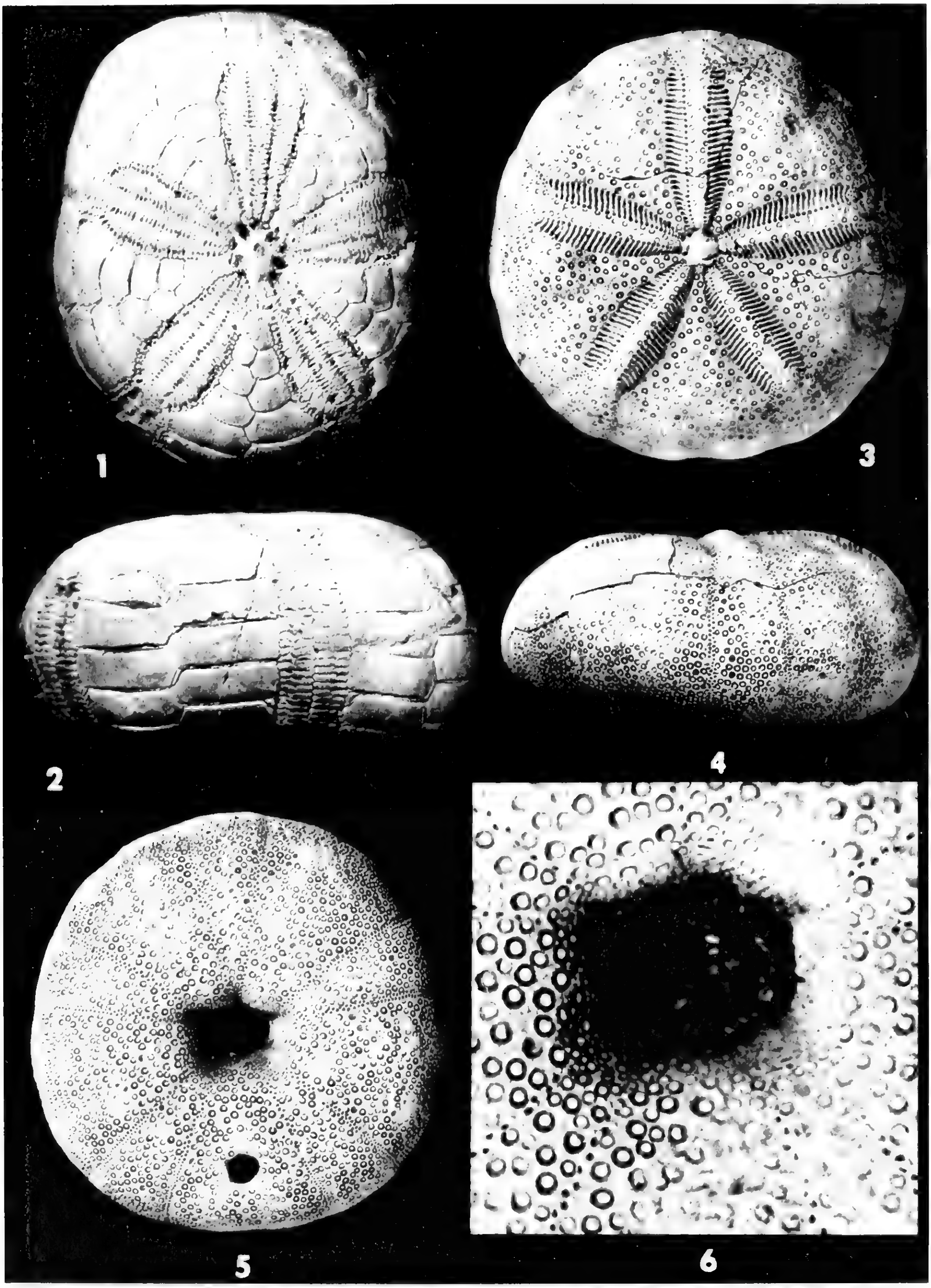

1-2, *HAIMEA PLATYPETALA* (ARNOLD AND CLARK); 3-6 *HAIMEA RUTTENI* (PIJPERS)

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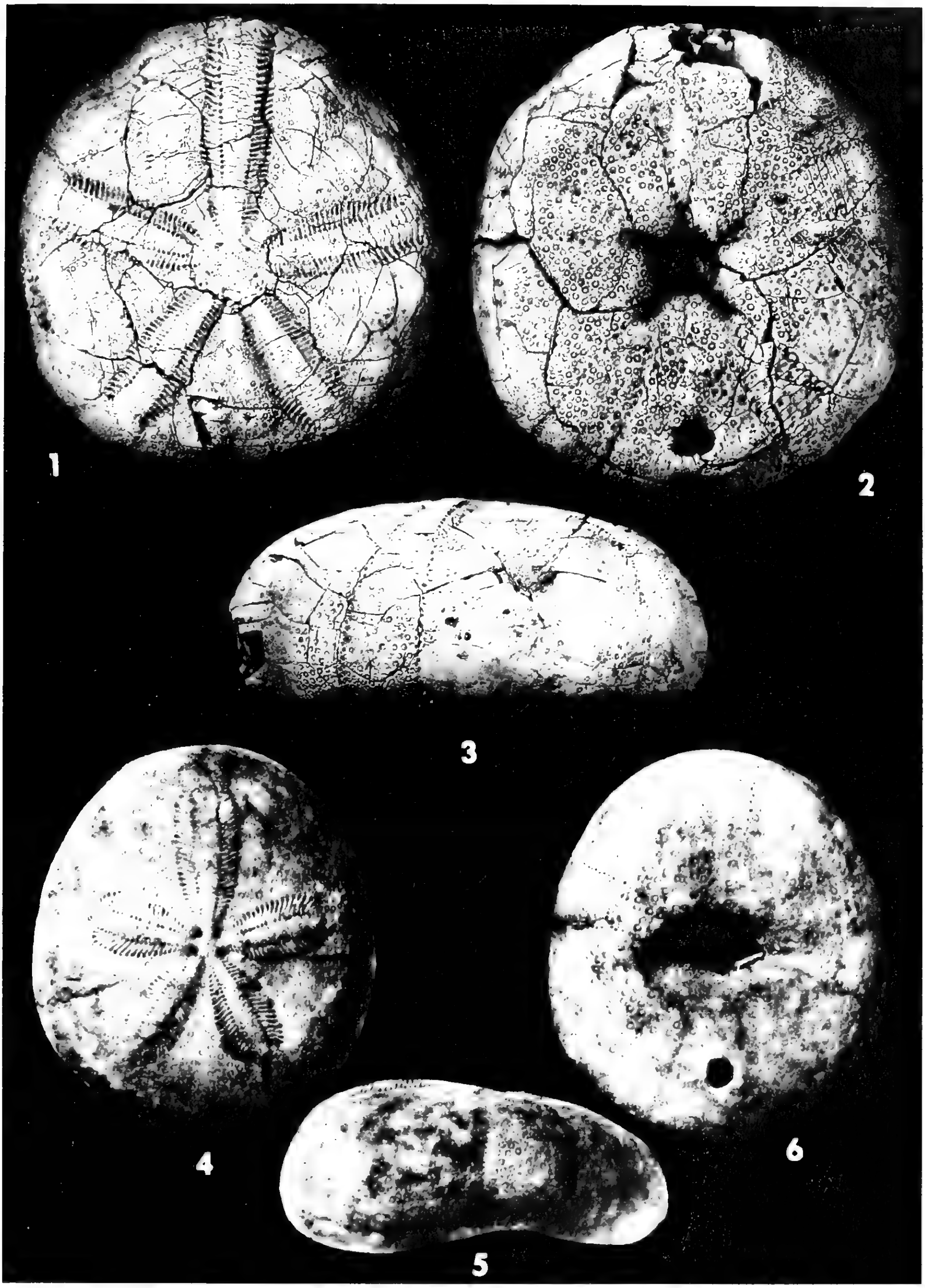

1-3, *HAIMEA RUGOSA* (ARNOLD AND CLARK); 4-6, PHOTOCOPIES OF LECTOTYPE OF *OLIGOPYGUS CURASAVICA* MOLENGRAAFF

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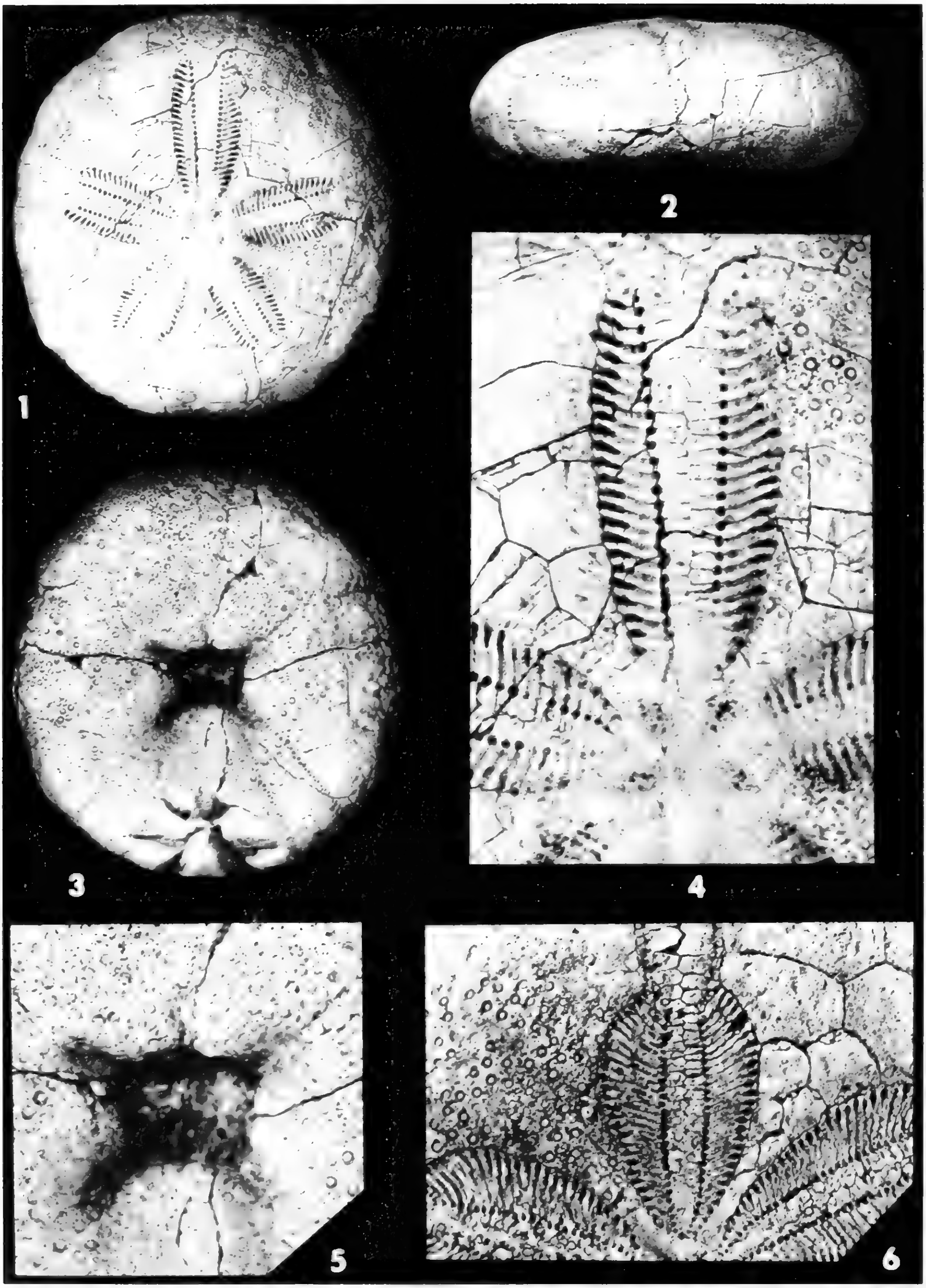

1-5, *HAIMEA ROTUNDA* (ARNOLD AND CLARK); 6, *H. PARVIPETALA* (ARNOLD AND CLARK)

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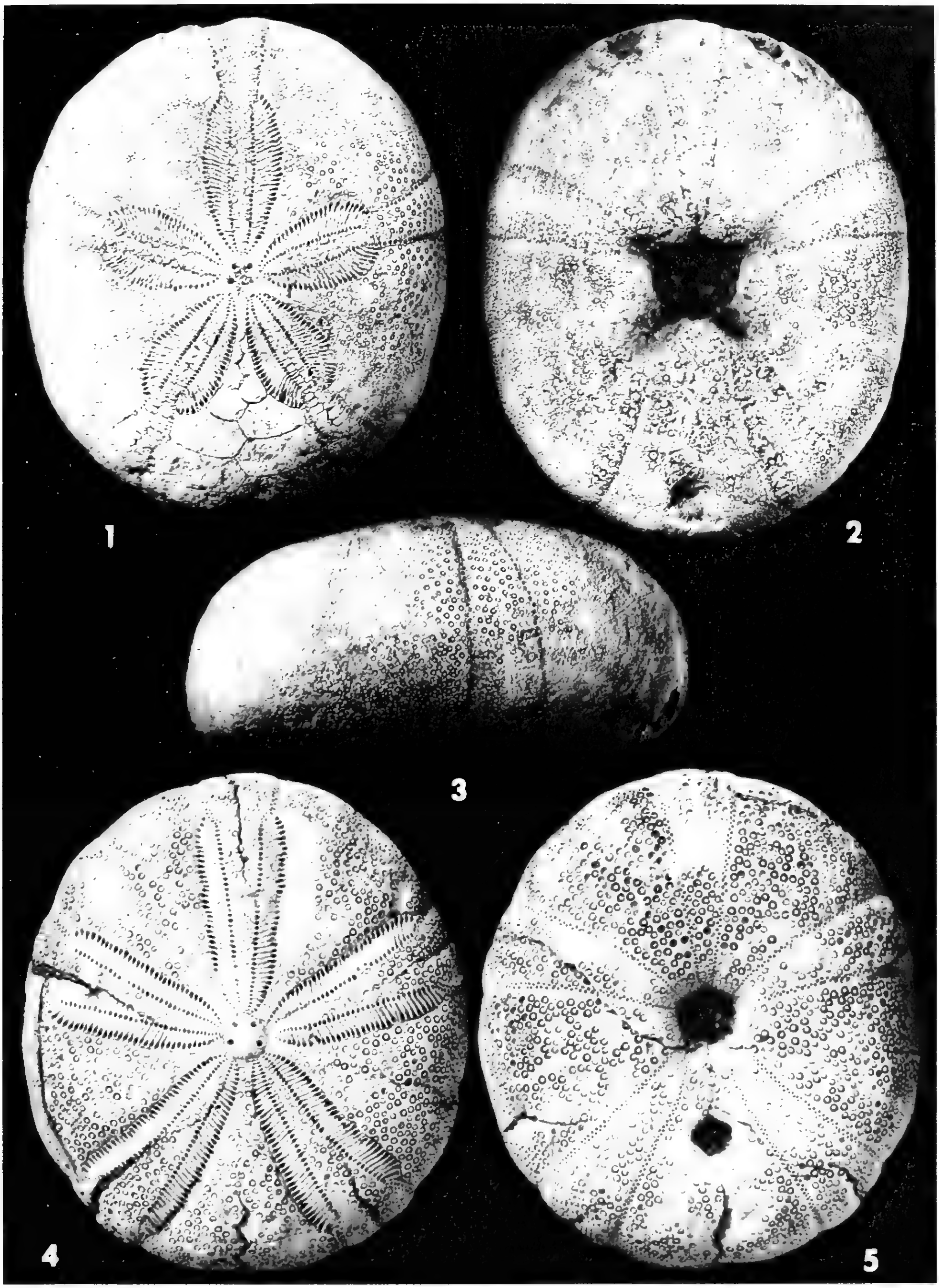

1-3, *HAIMEA PARVIPETALA* (ARNOLD AND CLARK); 4-5, *H. LATA* (ARNOLD AND CLARK)

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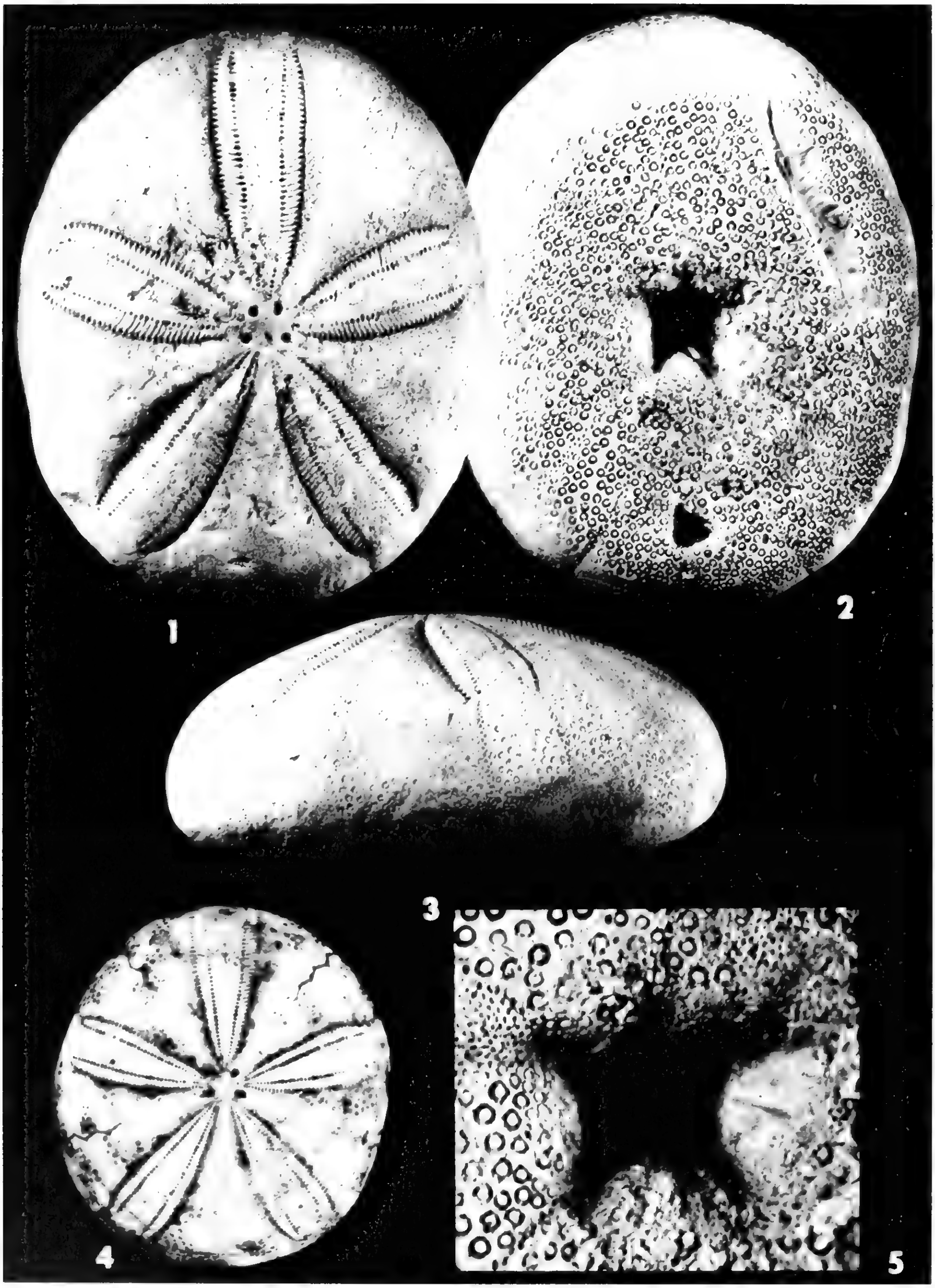

HAIMEA OVUMSERPENTIS (GUPPY)

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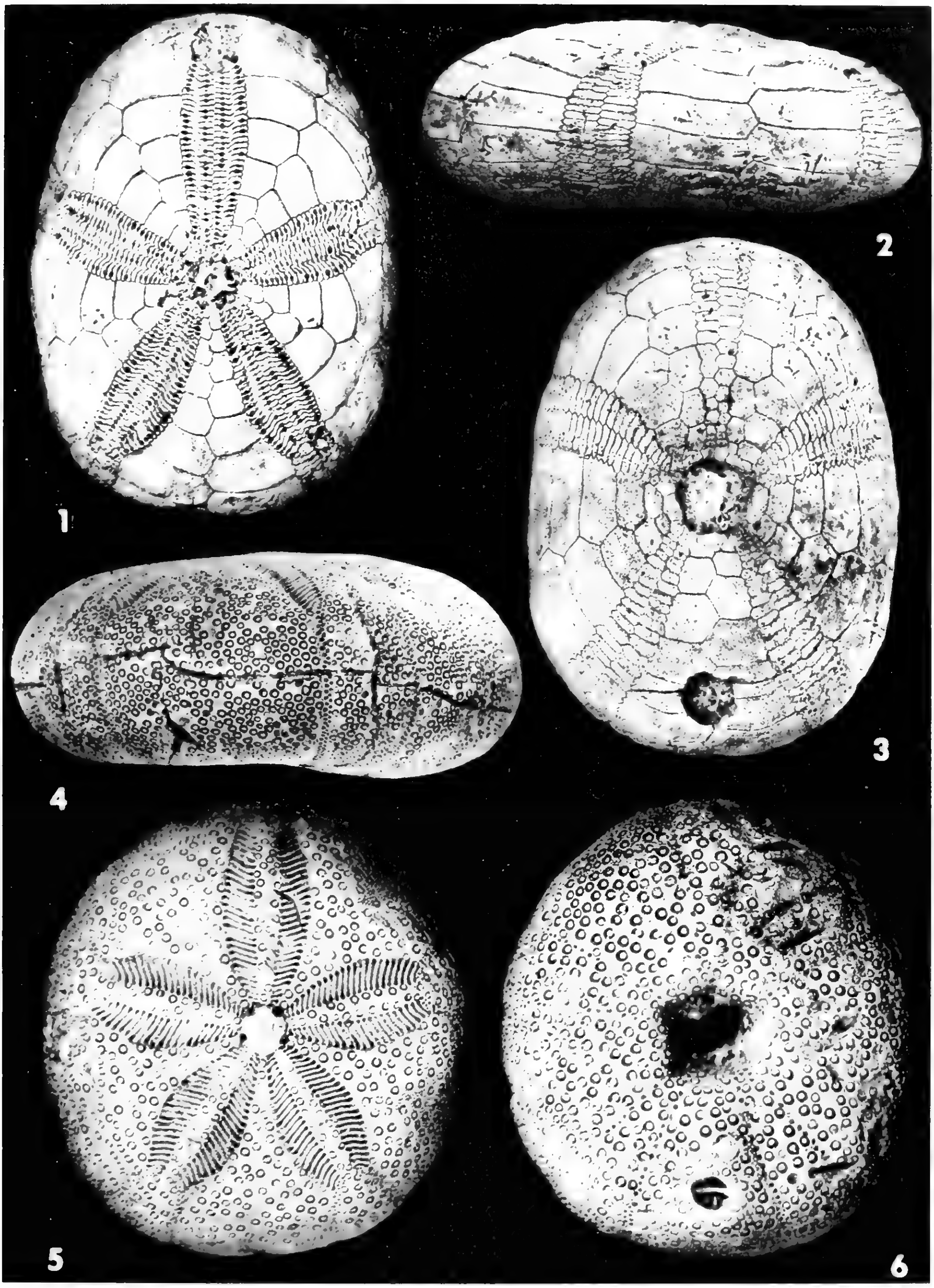
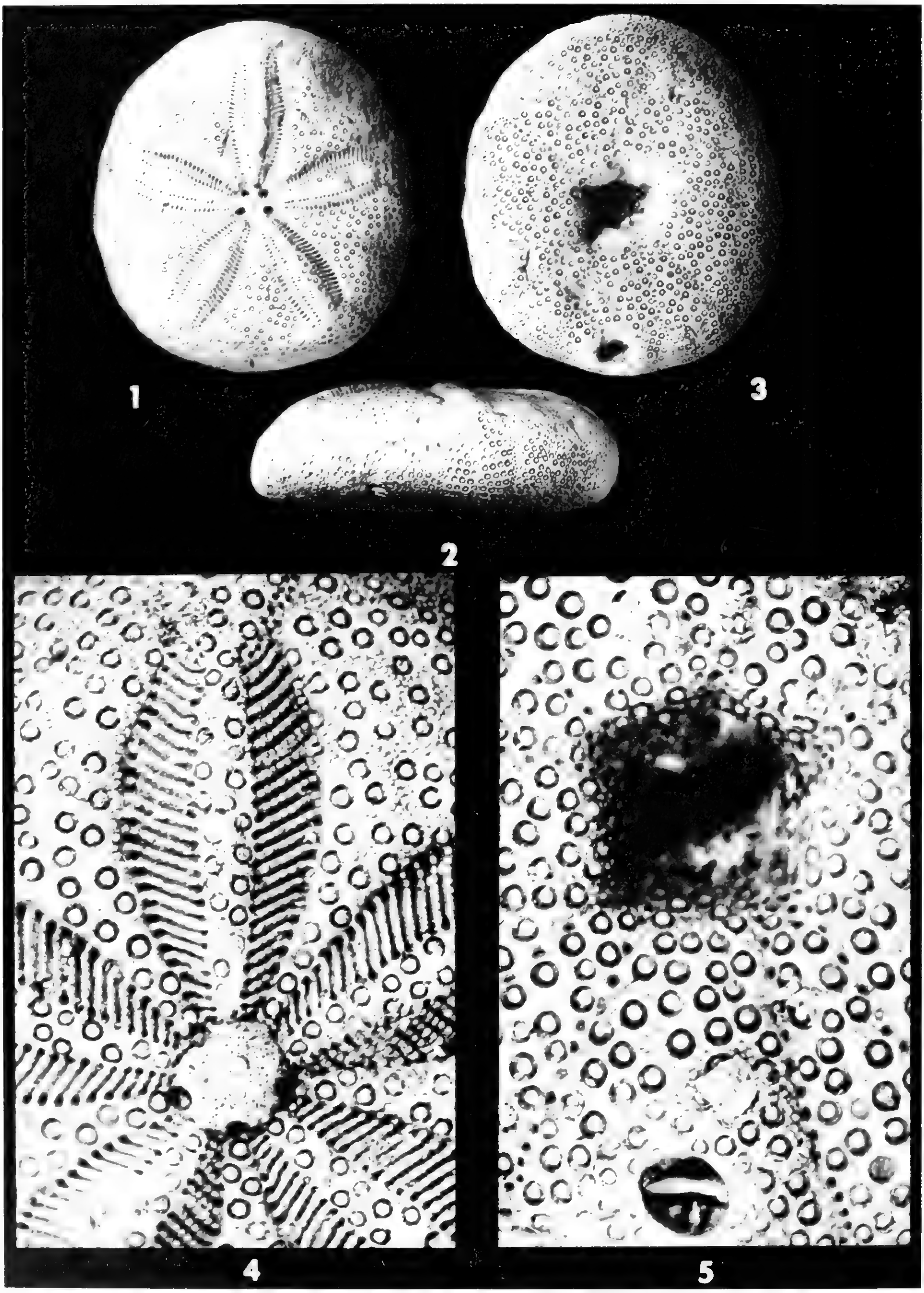


1-3, *HAIMEA STENOPETALA* (ARNOLD AND CLARK); 4, *H. LATA* (ARNOLD AND CLARK); 5-6, *HAIMEA MEUNIERI* (LAMBERT)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



HAIMEA MEUNIERI (LAMBERT)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

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