

Fossil Spatangoid Echinoids of Cuba

Porter M. Kier

Introduction

An extraordinary total of 401 fossil echinoids have been described from Cuba. Most of the species are Eocene to Miocene, with 157 Eocene, 179 Oligocene, and 33 Miocene species. None has been reported from the Pliocene, but 10 are present in the Pleistocene. Twenty-two have been reported from the Cretaceous, but none are older.

Most of these species were described by Dr. Mario Sánchez Roig, a medical doctor in Havana, who over a period of thirty years amassed a large collection of echinoids. With great patience and perseverance, he collected thousands of specimens from all over Cuba. He dedicated all his free time to this effort, spending days at one site searching for specimens. Many professional and amateur collectors gave or sold him their specimens as his dedication to this work became known throughout Cuba. Workers in the quarries would save him any specimens that they found.

From 1920 to 1953 he described and illustrated in numerous publications this vast collection. Although not formally trained in the field, his research was equal in quality to that of echinologists elsewhere in the world. He maintained his own collection for many years, until it eventually became the property of the Cuban Academy of Sciences, which is now responsible for its care and curation.

Sánchez Roig did not have adequate photographic equipment; most of the illustrations of his 291 species are of poor quality. Consequently, echinoid workers outside Cuba have found it difficult to use his work. Generally his species have been ignored, and this great Cuban echinoid fauna has not received the attention that it deserves.

This present work is devoted to a redescription of all the Cuban fossil spatangoid echinoids—in particular those in the Sánchez Roig Collection. All Cuban specimens in other museums throughout the world have also been studied. These include specimens in the Cotteau and Lambert collections in France, the Palmer Collection at the Academy of Natural Science in Philadelphia, and the collection at the University of California in Berkeley. Also examined were the Cuban specimens (some identified and presented by Sánchez Roig) in the Smithsonian's National Museum of Natural History, the American Museum of Natural History, and the Museum of Comparative Zoology at Harvard. Furthermore, where possible, specimens from elsewhere in the Caribbean were studied for comparison with the Cuban echinoids. In particular, all the specimens of Jamaican Eocene echinoids in the great Arnold Collection at the Museum of Comparative Zoology were compared to the Cuban material.

Of 179 spatangoid species reported from Cuba, 61 (described by Sánchez Roig) are herein considered to be synonyms. This decision to place so many species in synonymy reflects a differing

Porter M. Kier, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

concept of what amount of variation can be expected within a species. Sánchez Roig, who had very few specimens of many of his species, could not know the extent of this variation. If in doubt, he seemed to prefer naming a new species. However, the number of species of the same genus from one locality is far higher than one would expect. For example, Sánchez Roig recognized 11 species of *Eupatagus* from his "Cervantes" locality. In my opinion the differences between these species either fall within the range of variation common to single species or result from postmortem deformation.

The validity of many species is difficult to determine because of the paucity of well-preserved specimens. It has been necessary to make numerous arbitrary decisions with which another worker could disagree. For this reason the type specimens of the synonymized species are described and re-illustrated herein so that other workers can make their own judgments as to the validity of the species. Synonymized species are not redescribed unless the type specimens were available. A questionmark before the generic name indicates my uncertainty as to whether or not it is a synonym, such as *?Eupatagus calistoides* Sánchez Roig. Uncertainty of a generic identification is indicated by a question mark immediately after the generic name as in *Linthia? avilensis* Sánchez Roig.

The only way to increase the accuracy of the identification would be to obtain more specimens. However, many of the original localities are now covered with vegetation. Those sites that are still exposed yield few specimens. For example, Drs. Albear and Formell took me to the quarry at "Cervantes" where so many of Sánchez Roig's specimens were collected; only a few fragments of echinoids were located.

Not only is the number of specimens inadequate, but most are badly weathered. This is particularly unfortunate with the spatangoids because they lose their fascioles postmortem—an extremely important character in specific and generic identification. The position of the fascioles on many specimens must be inferred. One advantage of this weathering, however, is that it etches

out the sutures, making the plate arrangement visible. The plate sutures on unweathered specimens are normally invisible.

All of the extant Cuban type specimens are described herein and re-illustrated. The description of species follows the procedures prescribed by Cheshier (1968), who noted that many spatangoid characteristics remain the same regardless of the size of the specimen. These characters are, therefore, particularly useful in systematic comparisons. For example, the fascioles cross particular plates on the test and remain on those same plates throughout the growth of the echinoid. Therefore, Cheshier (1968:5) recommended that echinoid workers always record which plate (numbered from the peristome) bore a part of a fasciole. Likewise the same plates will continue to surround the periproct, and specific plates will carry the first petaloid pores throughout the animal's life. Wherever possible, I have tried to determine these characters. Unfortunately the fascioles of many specimens are not visible; and on others not enough plate sutures are visible to allow a count of the number of plates to the peristome.

All the available specimens were used in the description. Unfortunately only one specimen each is known of many species, making it impossible to evaluate the extent of variation within a species.

An interpretation of the living habits of each genus is made possible by the discoveries of Smith (1980), whose comparative studies of living material have revealed the relationship between the character of a pore and the tubefoot that extends from it. One can discern on the basis of the fossil's pores, particularly in the anterior ambulacrum, whether and into what kind of sediment the spatangoid could burrow.

PREVIOUS WORK.—The first published record of fossil echinoids in Cuba was by Parra in 1787, in which he included figures of some specimens. Sagra (1855) noted that species of echinoids described by d'Orbigny were also present in Cuba. Agassiz, in Agassiz and Desor (1847:22, 143, 144, 168) mentioned four species that occurred in Cuba including his new species, *Asterostoma excen-*

tricum. Cotteau (1871) described two new species of *Asterostoma* from Cuba and redescribed *A. ex-centricum*.

Later, Michelin (1855) described a new species and mentioned two others as occurring in Cuba. Cotteau (1875), in his introduction to a monograph of the fossil echinoids of St. Bartholomew and Anguilla, briefly described 10 species from Cuba, 5 of which were new. Cortázar (1880) described one new *Encope* from Cuba. In 1881, Cotteau published a major monograph of fossil echinoids from Cuba, in which 20 species (5 of which were new) were described. Egozcue y Cia in Cotteau (1897) used Cotteau's descriptions and illustrations and reported some new occurrences for species previously known elsewhere. Forty-one species were included.

In 1922, Jackson completed a monograph on all the fossil echinoids of the West Indies. Forty-seven species were from Cuba, including three new species. Lambert (1928) described one new species of *Echinoneus* and noted the presence of an African species of *Discoides* in Cuba; in 1932 he described 9 more Cuban species. Weisbord (1934) described 22 new species, including 10 spatangoids, that he collected at 5 localities in Cuba. Finally, Žitt (1981) very skillfully redescribed 2 species of the spatangoid *Aguayoaster* and discussed their living habits.

Sánchez Roig started publishing on fossil echinoids in 1920 and continued until 1953. In 1949 he produced a monograph of all the known fossil echinoderms of Cuba with 309 species, 110 of which were his own new species, 14 of Palmer's, 5 of Lambert and Sánchez Roig's, and 2 of Lambert's. Subsequently, Sánchez Roig described 153 more species. All his echinoid papers are listed in the bibliography.

ACKNOWLEDGMENTS.—This volume is dedicated to Dr. Mario Sánchez Roig. His extreme dedication resulted in the assembly of one of the most important echinoid collections in the world. Without his efforts, the presence of this large echinoid fauna in Cuba might never have been known. His contributions to the study of fossil echinoids rank with those of Lambert, Cotteau, and d'Orbigny.

This revision could have never been accomplished without the help and full cooperation of the Cuban Academy of Sciences. I thank Dr. Wilfredo Torres Iribar, President of the Academy, for his support. Ing. Amelia Brito Rojas and Ing. Lenia Montero Zamora, directors of the Instituto de Geología y Paleontología, helped in every way possible. They provided access to the Sánchez Roig Collection (SRC) and gave permission to borrow specimens for preparation here in Washington. Drs. Francisco de Albear and Francisco Formell guided field trips to some of the more important Cuban echinoid localities. Dr. Albear was of great assistance in providing current stratigraphic information on Sánchez Roig's localities. Consuelo Diaz Otero and Rafaela Pérez aided me in my search for specimens in the Sánchez Roig Collection. Lic. Sergio Jorge Pastana, Director of international relations of the Academy, working in conjunction with the Smithsonian Institution, made all the arrangements necessary for my visits to Havana to study the collection. Here at the Smithsonian, Ross Simons set up the original program for the exchange of scientists with the Cuban Academy and expedited subsequent travel to Havana. Finally Dr. Abelardo Moreno, the Director of the National Zoos and Aquaria, encouraged me throughout this study.

Mary Hurd Lawson, Smithsonian Institution, did all the photography, the computer programming, preparation of the bibliography, much of the literature search plus many other tasks too numerous to name. She did all these tasks with great skill and ingenuity.

I thank the following individuals who kindly lent specimens from their institutions: Richard P.S. Jefferies and David N. Lewis of the British Museum (Natural History), London, England; A. Prieur and L. David (Cotteau Collection) of the Université Claude Bernard, Lyons, France; Daniel Pajaud (Lambert Collection) of the Université Pierre et Marie Curie, Paris, France; Jean Roman of the Institut de Paléontologie, Muséum National d'Histoire Naturelle, Paris, France (MNHN); C.G. Rümke and G.H.R. von Koenigswald of the Instituut voor Aardwetenschappen

Ryksuniversiteit, Utrecht, The Netherlands; Peter Jung and John Saunders of the Naturhistorisches Museum, Basel, Switzerland; George Ubahgs of the Laboratoire de Paléontologie Animale, Université de Liège, Liège, Belgium; Charles E. Mitchell and Vickie Kohler of the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Peter U. Rodda of the California Academy of Sciences, San Francisco, California; J. Wyatt Durham of the University of California, Berkeley, Museum of Paleontology (UCB); George Davis of the Academy of Natural Sciences of Philadelphia, Pennsylvania (ANSP); Bruce Haugh and Niles Eldredge of the American Museum of Natural History, New York, New York (AMNH); Peter Hoover of the Paleontological Research Institution, Ithaca, New York (PRI).

I thank Charles G. Messing and John Miller who sent me photographs of *Paleopneustes*, which were taken from a submarine. The manuscript was read by David Pawson and Richard Grant. I am indebted to both of them for their helpful suggestions. Edward Robinson of Robertson Research, Inc., Houston, Texas, provided information on the age of echinoid-bearing deposits in Jamaica.

Finally, I am indebted to Joan B. Horn, editor at the Smithsonian Institution Press, who with patience, persistence, and with her usual great skill edited this paper.

The Cuban Echinoid Faunas

Although 179 species of spatangoid echinoids have been reported from Cuba, only 79 species are recognized herein. This reduction is due partially to the loss of some of the type specimens, but mainly to the placing of many species in synonymy. No species are known to be older than the late Cretaceous from which 10 species have been reported. They are most common in the Eocene (36 species), decrease in number in the Oligocene-Miocene (20 species) and the Miocene (11 species). Two species, *Meoma?* *brodermanni* (Sánchez Roig) and *Meoma antillarum* (Cotteau), are of uncertain age.

CRETACEOUS

Cretaceous spatangoids are rare in the Caribbean. Only 10 species are recognizable from Cuba:

Cardiaster cubensis Jackson
C. palmeri Sánchez Roig
Echinocorys ovatus Leske
Douvillaster triangularis (Sánchez Roig)
Hemiaster? *gonzalezmunoz* Sánchez Roig
H. herverae (Lambert and Sánchez Roig)
H. madrugensis Weisbord
H. siboneyensis Weisbord
Linthia? *avilensis* Sánchez Roig
L. brodermanni Sánchez Roig

Only one species, *Echinocorys ovatus*, occurs outside of Cuba, but I suspect that the specimens of this species supposedly collected in Cuba came from the Chalk of western Europe. None of these Cretaceous species resembles any species from elsewhere in the Western Hemisphere.

EOCENE

The Cuban Eocene echinoid fauna includes the following spatangoid species:

Sanchezaster habanensis Lambert
Pericosmus atolladosae (Sánchez Roig)
Schizaster bathypetalus Arnold and Clark
S. camagueyensis (Weisbord)
S. cubitabellae (Weisbord)
S. formelli, new species
S. gerthi Pijpers
S. llagunoi Lambert and Sánchez Roig
S. nuevitasensis (Weisbord)
S. santanae Sánchez Roig
S. subcylindricus Cotteau
Agassizina clevei Cotteau
A. inflata Jackson
Aguayoaster aguayoi Sánchez Roig
A. nuevitasensis (Sánchez Roig)
Caribbaster loveni (Cotteau)
Lambertona lamberti (Sánchez Roig)
Linthia monteroeae, new species
Prenaster parvus Palmer
Habanaster sanchezi Lambert
Brissus cabrerai (Sánchez Roig)
B. camagueyensis Weisbord
B. caobaense Sánchez Roig
B. durhami (Sánchez Roig)
Cyclaster drewryensis Cooke
C. sanchezi Lambert

Macropneustes (Deakia) armadilloensis Sánchez Roig
Meoma antiqua Arnold and Clark
Eupatagus alatus Arnold and Clark
E. siboneyensis Weisbord
E. turibacoensis Sánchez Roig
Rojasia rojasi Sánchez Roig
Asterostoma excentricum Agassiz
A. subcircularis Sánchez Roig
Antillaster albeari, new species
A. arnoldi Clark

Comparison of these echinoids with non-Cuban species confirms the age determination of Cuban localities that had been considered to be Eocene. The quarry at Loma Caoba, near San Diego de los Baños in Pinar del Rio Province, is considered middle to late Eocene. It contains 11 species of spatangoids, 7 of which occur in deposits elsewhere that are considered by all modern workers to be Eocene:

Schizaster bathypetalus Arnold and Clark
S. gerthi Pijpers
S. subcylindricus Cotteau
Agassizia inflata Jackson
Aguayoaster aguayoi Sánchez Roig
Brissus caobaense Sánchez Roig
B. durhami (Sánchez Roig)
Meoma antiqua Arnold and Clark
Eupatagus alatus Arnold and Clark
Asterostoma excentricum Agassiz
Antillaster albeari, new species

Three of these species also occur in the Eocene of Jamaica: *Schizaster bathypetalus*, *Meoma antiqua*, and *Eupatagus alatus*. *Schizaster gerthi* is present in Bonaire in beds considered to be late Eocene. *Schizaster subcylindricus* is present in the Eocene of St. Bartholomew and Jamaica. *Agassizia inflata* is present in the Eocene of St. Bartholomew and Jamaica and in the middle Eocene Castle Hayne Limestone of North Carolina. *Asterostoma excentricum* is also present in the Eocene of Jamaica.

Many specimens of *Oligopygus* also occur at Loma Caoba. This oligopygoid genus is found elsewhere only in the Eocene.

Many spatangoid species occur at another Eocene locality—Loma Calisto, Nuevitas, Camagüey Province, Cuba. The following spatangoids have been found there:

Schizaster camagueyensis (Weisbord)
Agassizia clevei Cotteau

Aguayoaster nuevitasensis (Sánchez Roig)
Carribaster loveni (Cotteau)
Brissus camagueyensis Weisbord
Eupatagus siboneyensis Weisbord
E. turibacoensis Sánchez Roig

Carribaster loveni also occurs in the Eocene of Jamaica and St. Bartholomew. *Aguayoaster nuevitasensis* is probably a synonym of *Aguayoaster aguayoi*, which is found in the Eocene at Loma Caoba. Many specimens of *Oligopygus* also occur at Loma Calisto as does the clypeasteroid *Tarphypygus*, a genus apparently restricted to the Eocene of Cuba and Jamaica.

Three species that occur in Eocene strata in a deep cut north of Grua 9, Ramal, Camagüey Province are

Schizaster camagueyensis (Weisbord)
Cyclaster drewryensis Cooke
Eupatagus alatus Arnold and Clark

Cyclaster drewryensis is known from the early Oligocene of Alabama, but *Schizaster camagueyensis* occurs also in the Eocene at Loma Calisto. *Eupatagus alatus* is not only present in Eocene rocks at Loma Caoba but also in the Eocene of Jamaica. Finally, the Eocene *Oligopygus* occurs at this locality.

OLIGOCENE-MIOCENE

The following species occur in beds considered by Sánchez Roig or Brodermann to be Oligocene:

Pericosmus aguayoi (Sánchez Roig)
P. blanquizalensis Sánchez Roig
P. camagueyanus Sánchez Roig
P. mortenseni (Sánchez Roig)
Schizaster cartagensis (Sánchez Roig)
S. egozcuei Lambert
S. munozi Sánchez Roig
S. rojasi Sánchez Roig
S. sanctamariae Sánchez Roig
Agassizia alveari Sánchez Roig
Brissus minutus (Sánchez Roig)
Brissopsis aguayoi Sánchez Roig
Macropneustes? (Macropneustes) palmeri (Sánchez Roig)
Meoma? gomezmazae (Sánchez Roig)
Fernandezaster mortenseni Sánchez Roig
Eupatagus santanae Sánchez Roig
E. clevei (Cotteau)
Antillaster fernandezii (Sánchez Roig)
A. lamberti Jeannet
A. vughani (Jackson)

Many of these species may be Miocene. In the last 20 years some workers, on the basis of the foraminifera and ostracodes, have placed most of what was thought to be the Cuban Oligocene into the Miocene. Unfortunately Sánchez Roig usually did not state from what formation his echinoids were collected. Brodermann (1949) revised some of Sánchez Roig's age determinations and gave a section listing formations he considered to be Oligocene. His early Oligocene Adelina Formation was considered middle Oligocene by Bermúdez and Hoffstetter (1959:7) and Bermúdez (1961:57) but early Miocene by Eames et al. (1962, fig. 5) and Eames and Savage (1975:305). Brodermann (1949) placed the Colon Formation in the middle Oligocene, but Bermúdez (1961:74) put it in the Aquitanian, which he considered late Oligocene. Eames et al. (1962, fig. 2) and Eames and Savage (1975:415) regard the Aquitanian as early Miocene. Brodermann's late Oligocene included the Jaruco, Tarará, Cojimar, and Limonar-Capellánias formations, all of which are considered now to be Miocene. Bermúdez (1961:69, 72, 104, 108, 141) places these formations in the Aquitanian and Burdigalian; Brönnimann and Rigassi (1963:467) attribute a Miocene age to the Cojimar. Van den Bold (1965, table 5) places the Jaruco and Cojimar in the Miocene as does Albear (1980, personal communication). Eames and Savage (1975) consider them all to be Miocene. Therefore, herein, species that Sánchez Roig considered to be Oligocene will be dated as Oligocene-Miocene except when it is known from what formations they came, or when new information is available on the age of the locality.

Elsewhere in the Western Hemisphere, formations formerly considered Oligocene are now placed in the early Miocene by some workers. These formations will be dated herein as Oligocene-Miocene. Brönnimann and Rigassi (1963:466) revised the age of some of Sánchez Roig's echinoid localities in the Cojimar and Marianao areas. In particular they considered the locality Finca "La Noria" and quarries at the entrance of Cojimar to be Miocene. The following spatangoids occur at these localities and herein are considered Miocene:

goids occur at these localities and herein are considered Miocene:

Agassizia clevei Cotteau
Eupatagus sanchezi (Lambert)
Migliorinia habanensis (Sánchez Roig)

MIOCENE

Very few Miocene echinoids are known in the Caribbean basin outside of Cuba; therefore, the Cuban species from localities attributed to the Miocene (with no correlations outside the island) are of little use in confirming the age. The one exception is the collecting site at "Cervantes" farm near San José de las Lajas, Habana Province. Here a large number of specimens representing one-half of all the Miocene species in Cuba have been found. Included among them is *Eupatagus cubensis* (Cotteau), a species that is present in the Miocene Ponce Limestone of Puerto Rico. Miocene species include the following:

Schizaster fernandezi Sánchez Roig
S. delgadoi (Sánchez Roig)
Agassizia clevei Cotteau
A. pinarensis Sánchez Roig
Brissoopsis jimeno Cotteau
Lajanaster jacksoni Lambert and Sánchez Roig
Eupatagus cubensis (Cotteau)
E. sanchezi (Lambert)
Hernandezaster hernandezi Sánchez Roig
Migliorinia habanensis (Sánchez Roig)
Antillaster sanchezi Lambert

CONCLUSION

The Eocene age of the Cuban echinoid-bearing localities is confirmed by the presence outside Cuba of many of the same species in beds dated on other fossils. Some evidence supports the Miocene determinations, but the echinoids are of little assistance in resolving the question of whether the Cuban beds attributed to the Oligocene are Oligocene or Miocene.

Comparison with European Faunas

The Cuban and other Caribbean spatangoids of the Eocene to Miocene are quite distinct from

those in Europe and the Mediterranean region. No species are definitely common, but then I have not seen specimens of many of the non-Caribbean species. The illustrations of many of these species are inadequate; and without seeing the specimens, one cannot be certain of any comparison of species. However, of the 17 Eocene spatangoid genera known from Cuba, eight are not present in Europe. They include *Antillaster*, *Asterostoma*, *Fernandezaster*, *Caribbaster*, *Rojasia*, *Sanchezaster*, *Habanaster* and *Lambertona*. All these genera, except for *Lambertona*, are found only in the Caribbean region. *Lambertona* is known also from New Zealand.

The genera *Antillaster* and *Asterostoma* are very well represented in Cuba and Jamaica by many specimens. *Antillaster* ranges from the Eocene through the Miocene and includes many species. No specimens of either genus have been recorded outside the Caribbean.

The provinciality of the Caribbean Tertiary echinoids is confirmed by the non-spatangoid echinoids. Among the clypeasteroids, the family Neolaganidae has never been found outside the Caribbean and Gulf of Mexico region. This family includes 7 Eocene-Oligocene genera and 13 species. This is also true of the family Protoscutellidae, *Periarchus*, and *Protoscutella*, which are very common in the Caribbean Eocene and are restricted to this region. In addition the Mellitidae, which are common as fossils in the Caribbean, do not occur in the European-Mediterranean region.

The order Oligopygoida is also confined to the Caribbean Eocene except for one species from Senegal.

Comparison with Other Faunas in the Caribbean

JAMAICA

The Jamaican echinoid fauna (Arnold and Clark, 1927, 1934) shares many species with Cuba. Of the 39 spatangoid species in Jamaica, 9 species also occur in Cuba:

Schizaster bathypetalus Arnold and Clark
S. subcylindricus Cotteau (= *S. brachypetalus* Arnold and Clark)
Agassizia inflata Jackson
Caribbaster loveni (Cotteau) (= *Hypselaster perplexus* Arnold and Clark)
Meoma antiqua Arnold and Clark
Eupatagus alatus Arnold and Clark
E. clevei (Cotteau) (= *E. grandiflorus* (Cotteau))
Asterostoma excentricum Agassiz
Antillaster arnoldi Clark

More of the species are very similar to Cuban species and may be synonymous. The Jamaican specimens that Arnold and Clark referred to *Schizaster dumblei* Israelsky are very similar to *Schizaster subcylindricus* Cotteau, which occurs in Cuba. *Caribbaster dyscritus* is probably a synonym of *Caribbaster loveni* (Cotteau) (= *Hypselaster perplexus* Arnold and Clark). *Eupatagus attenuatus* Arnold and Clark appears to be similar to *Eupatagus alatus* Arnold and Clark, which also occurs in Cuba. *Eupatagus longipetalus* Arnold and Clark should be referred to *Antillaster* and is similar to the Cuban *Antillaster vaughani* Jackson. Finally Arnold and Clark's *Victoriaster jamaicensis* may be a synonym of the Cuban *Lambertona lamberti* Sánchez Roig.

The following Jamaican species are very different from any Cuban species:

Linthia trechmanni Hawkins
Schizaster hexagonalis Arnold and Clark
Eupatagus defectus Arnold and Clark
Plagiobrissus abruptus Arnold and Clark
P. elevatus Arnold and Clark
P. latus Arnold and Clark
P. loveni Arnold and Clark
P. perplexus Arnold and Clark
P. robustus Arnold and Clark
Homoeopetalus axiologus Arnold and Clark
Asterostoma pawsoni, new species
Macropneustes stenopetalus Arnold and Clark
Metalia dubia Arnold and Clark
M. jamaicensis Arnold and Clark

Eight of Arnold and Clark's species from Jamaica are based on material too poorly preserved for comparison with Cuban species:

Periaster elongatus Cotteau
Schizaster altissimus Arnold and Clark
Macropneustes angustus Arnold and Clark
M. parvus Arnold and Clark

Linthia obesa Arnold and Clark
Cyclaster sterea Arnold and Clark
Macropneustes dyscritus Arnold and Clark
M. sinuosus Arnold and Clark

In summary, of the 24 identifiable spatangoids from the Eocene of Jamaica, 9 species or 37 percent also occur in Cuba. Of the species of Eocene Cuban spatangoids, 25 percent occur also in Jamaica.

ST. BARTHOLOMEW

The St. Bartholomew (Leeward Islands) echinoid fauna (Cotteau, 1875) is very similar to the Cuban. Four species occur in both places:

Schizaster subcylindricus Cotteau
Agassizia inflata Jackson
Caribbaster loveni (Cotteau)
Eupatagus clevei (= *E. grandiflorus* (Cotteau))

Two species occur in St. Bartholomew that are not present in Cuba: *Schizaster antillarum* Cotteau and *Plagiobrissus loveni* (Cotteau).

Antillaster cubensis (Cotteau), a Cuban species, is reported to occur in St. Bartholomew, but I have seen no specimens. *Periaster elongatus* Cotteau from St. Bartholomew is based on a holotype too poorly preserved for comparison. In summary, of the six recognizable species of spatangoids in the Eocene of St. Bartholomew, 5 species or 83 percent are also present in Cuba.

ANTIGUA

Two spatangoids were reported by Jackson (1922:77, 97) from the Oligocene-Miocene of Antigua and Cuba: *Schizaster clevei* (Cotteau) and *Antillaster vauhani* (Jackson). I have seen no Cuban specimens of *S. clevei* but there are several specimens from Cuba that can be referred to *A. vauhani*.

UNITED STATES

The Eocene echinoid fauna of southeastern United States (Cooke, 1959; Kier, 1980) is surprisingly different from the Cuban, considering the proximity of the two regions. Forty species of

Cuban spatangoids and 23 American species are known, but only 3 have been found in both Cuba and the United States:

Agassizia clevei Cotteau (= *A. floridana* de Loriol)
A. inflata Jackson (= *A. wilmingtunica* Cooke)
Eupatagus clevei (Cotteau) (= *E. ingens* Zachos)

The American *Schizaster beckeri* Cooke is similar to *Schizaster subcylindricus* Cotteau, but all the rest of the recognizable American species are quite different.

Linthia wilmingtunica Clark
L. hanoverensis Kellum
L. harmatuki Kier
Schizaster armiger Clark
S. ocalanus Cooke
Unifascia carolinensis Clark
Marelia arguta Clark
M. subrostrata (Clark)
Macropneustes mortoni (Conrad)
Brissopsis steinhatchee Cooke
B. biarrizensis Cotteau
Plagiobrissus? dixie (Cooke)
P. curvus (Cooke)
Eupatagus gardnerae Cooke
E. carolinensis Clark
E. ocalanus Cooke
E. alabamensis Cooke
E. wilsoni Kier
E. lawsonae Kier

One American species, *Linthia hollandi* Barry, is based on such poor material that it cannot be compared to the Cuban. Further evidence of distinction between the two faunas is the absence of any specimens of *Asterostoma* and *Antillaster* in the United States. These genera are extremely well represented in Cuba.

The Oligocene-Miocene spatangoid fauna of Cuba is much larger than the American. Only one species, *Cyclaster drewryensis* Cooke, occurs in both countries. In Cuba it is found in the late Eocene. Also different from the Cuban species are the other four American species:

Agassizia mossomi Cooke
Lovenia alabamensis Cooke
Brissopsis blanchi Grant and Hertlein
Schizaster americanus Clark

Likewise the Cuban Miocene fauna is much

larger than the American. Only three American spatangoid species are now recognized as being Miocene, but none of them occur in Cuba:

Lovenia clarki (Lambert)

Echinocardium orthonotum (Conrad)

Plagiobrissus holmesii (McCrady)

In summary, only 4 of the 34 Eocene-Miocene American spatangoid species occur in Cuba. It may be significant that no species of *Pericosmus*, *Antillaster*, or *Asterostoma* occur in the United States. These genera are represented by a large number of specimens in Cuba. Most living species of *Pericosmus* now occur in water 200–500 m deep. Although *Antillaster* and *Asterostoma* are now extinct, their lack of fascioles suggests they could not burrow but lived exposed on the sea floor. Presumably they lived in deep water. I know of no irregular echinoid with its test not covered that lives today in the shallower lighted part of the sea. Perhaps the available habitats were generally deeper in Cuba than in Florida. This might explain the great difference in their echinoid faunas.

Brönnimann and Rigassi (1963:465) estimated on the basis of the microfossils that the Eocene in the Havana region was deposited in depths of about 600 m. They disagreed with Brodermann's (1949:309) inference from the echinoids that the early and middle Eocene Universidad Formation was deposited in shallow seas. They suggested that the "light tests of echinoids were capable of floating after death, similar to those of cephalopods, and thus could be transported from their original shallow-water habitat into the open sea." Echinoid tests do not float after death. It is much more reasonable to suggest that the echinoids were not living in shallow water.

Although the seas were deep in Cuba during the Eocene, Randazzo and Saroop (1976:287) propose that the Eocene of Florida, where most of the American Eocene spatangoids occur, was deposited in shallow water environments—at times even above the strand line. It is not surprising that the echinoid faunas are so different. In modern seas most of the species living in shallow water do not range below 50–100 m.

BONAIRE

Five Tertiary (Eocene) spatangoids are known from Bonaire (Pijpers, 1933). One of them, *Schizaster gerthi* Pijpers, occurs in Cuba. The specimens Pijpers referred to *Agassizia conradi* (Bouvé) appear to be conspecific with *Agassizia inflata* Jackson, which also occurs in Cuba. (The type specimen of *A. conradi* is unidentifiable (Cooke, 1959:75).) The other three specimens are distinct from any Cuban forms: *Antillaster bonairensis* Pijpers, *Eupatagus aloysii* (Pijpers), and *Prenaster jeanneti* Pijpers.

TRINIDAD

Two of the three spatangoids from Trinidad (Jeannet, 1928) also occur in Cuba, *Brissopsis jimenoi* Cotteau and *Agassizia clevei* Cotteau. The third species is *Linthia caraibensis* Jeannet.

VENEZUELA

Nine spatangoid species have been described from the Tertiary of Venezuela (Jeannet, 1928). Three of them occur in Cuba: *Antillaster lamberti* Jeannet, *Eupatagus clevei* (Cotteau), and *Agassizia clevei* Cotteau. *Pericosmus stehlini* Jeannet is very similar to the Cuban *Pericosmus camagueyanus* Sánchez Roig and may be a synonym. The other species are *Brissus unicolor* (Leske), *Brissopsis antillarum* Cotteau, *Rhynobrissus rostratus* Cooke, *Brissonoma vonderschmitti* Jeannet, and *Plagiobrissus lamberti* Jeannet.

PUERTO RICO

Four spatangoids have been reported in Puerto Rico (Jackson, 1922; Gordon, 1963). Three of these also occur in Cuba: *Agassizia clevei* Cotteau and *Antillaster elegans* (Jackson)—which Sánchez Roig (1949:182) cites as present in Cuba (I have not seen these specimens). The third, *Eupatagus depressus* Jackson, is a synonym of the Cuban *E. cubensis*. *Paraster loveni* (Cotteau) is not present in Cuba.

ANGUILLA

The five spatangoids known from Anguilla (Cotteau, 1875) include one, *Agassizia clevei* Cotteau, also known from Cuba and two species, *Schizaster clevei* Cotteau and *Schizaster loveni* Cotteau, very similar to *Schizaster munozi* Sánchez Roig from Cuba. *Meoma clevei* (Cotteau) has been reported in both Cuba and Anguilla, but I have not seen any Cuban specimens. The Anguillan species, *Brissopsis antillarum* Cotteau and *Brissus exiguus* Cotteau, do not occur in Cuba.

MEXICO

Twelve spatangoids are known from a wide area along the Gulf Coast of Mexico (Dickerson and Kew, 1917; Jackson, 1937), but in general the fauna is different from that of Cuba. *Antillaster mexicanus* (Jackson) appears to be a synonym of *Antillaster vaughani* (Jackson), which occurs in Cuba. The Mexican specimens referred to *Agassizia clevei* Cotteau are very similar to *Agassizia inflata* Jackson, which is present in Cuba. The other species appear to be different from Cuban species:

Schizaster dumblei Israelsky
S. cristatus Jackson
Lovenia dumblei Kew
L. mexicana Jackson
Plagiobrissus cumminsi (Kew)
Brissopatagus mexicanus (Kew)
Paraster tampicoensis Israelsky
Agassizia regia Israelsky
Macropneustes dubius Israelsky
Paleopneustes elevatus Israelsky (may be a synonym of *Antillaster vaughani* (Jackson)).

COSTA RICA

All the spatangoids from Costa Rica are Miocene and were described by Durham (1961); none of them resemble Cuban species:

Pericosmus israeli Durham
Schizaster costaricensis Durham
Plagiobrissus costaricensis Durham
Schizobrissus kewi Durham
Plagiobrissus malavassii Durham

PANAMA

Only one of the four species from Panama (Jackson, 1918; Cooke, 1948) occurs in Cuba: *Eupatagus clevei* Cotteau. Two of the species are based on specimens too poorly preserved to be compared with Cuban material: *Schizaster cristatus* Jackson and *Schizaster panamensis* Jackson. *Schizaster armiger* Clark is unlike any species in Cuba.

Order DISASTEROIDA Mintz, 1968

Family HOLASTERIDAE Pictet, 1857

Genus *Cardiaster* Forbes, 1850

Test low, apical system with anterior genital plates separated from posterior by junction of ocular plates II and IV, 4 genital pores; ambulacrum III not petaloid, paired ambulacral petals, pores of anterior poriferous zones smaller than posterior, pores comma-shaped; periproct marginal, marginal fasciole.

Two species are known of this genus in Cuba. One, *Cardiaster palmeri* Sánchez Roig, is easily distinguished from the other Western Hemisphere species of *Cardiaster* by its lack of an anterior groove. The other, *Cardiaster cubensis* Jackson, differs from *Cardiaster deciper* Cooke from the Maestrichtian of Arkansas in its more posterior apical system.

HABITAT.—This genus probably lived buried in coarse sediments. It was unable to maintain a burrow in mud because it lacked funnel-building tubefeet as indicated by the small pores in the dorsal part of ambulacrum III. Furthermore, its petals are not depressed as in typical mud-living species.

Cardiaster cubensis Jackson

Cardiaster cubensis Jackson, 1922:69, pl. 12: fig. 1.—Sánchez Roig, 1926:85; 1949:171.

MATERIAL.—The holotype and only known specimen is probably in an unknown private collection; I was unable to locate it. However, it

was thoroughly described and well illustrated by Jackson.

OCCURRENCE.—Cretaceous, from high slopes in the valley of Rio Yateras, about 21 mi (33.6 km) NE of Guantanamo, Oriente Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from *Cardiaster palmeri* Sánchez Roig from the Late Cretaceous of Cuba by its deep anterior groove.

***Cardiaster palmeri* Sánchez Roig**

FIGURE 1; PLATE 1: FIGURES 1-3

Cardiaster palmeri Sánchez Roig, 1949:172, pl. 5: figs. 3-5.—Mortensen, 1950:53.

MATERIAL.—Only one specimen is in the collection (SRC 4024), and it is one of two syntypes figured by Sánchez Roig (1949, pl. 5: fig. 5). This specimen is designated the lectotype. Unfortunately, the posterior portion of this specimen is absent.

SHAPE AND SIZE.—Length uncertain but other syntype had length of 51 mm according to Sánchez Roig. Width 53.0 mm, height 26.3 mm.

APICAL SYSTEM.—Anterior, distance from anterior margin 24.0 mm. Genital plates 2, 3, separated from posterior genital plates by junction of ocular plates II, IV (Figure 1); 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove at anterior margin; porepairs not enlarged dorsally.

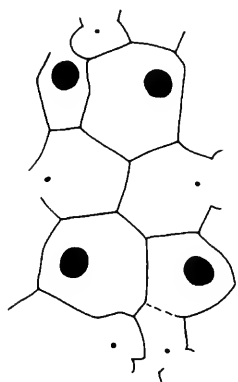


FIGURE 1.—*Cardiaster palmeri* Sánchez Roig, apical system of the lectotype, SRC 4024, $\times 24$.

Anterior petals (II and IV) long, extending almost to margin; length 29.3 mm, greatest width 8.7 mm. Posterior poriferous zones much wider than anterior with greatest width 3.7 mm; outer pore of pair slit-like. Anterior poriferous zone narrow with greatest width near end of petal where width 1.7 mm; 110 porepairs in petal.

Posterior petals (V and I) shorter than anterior, length 21.2 mm, greatest width 7.0 mm. Posterior poriferous zones much wider than anterior with width 2.7 mm as opposed to 1.1 mm in anterior poriferous zones; 80 porepairs in petal.

Phyllodes double pored, with large peripodia, number not clear.

PERISTOME.—Anterior, distance of anterior edge of opening to anterior margin 11.7 mm; opening wider than high, width 8.7 mm, height 3.6 mm.

PERIPROCT.—Not preserved.

FASCIOLAS.—Although no fascioles are visible on the lectotype, their absence may be due to weathering. Sánchez Roig reports in the lost syntype a distinct marginal fasciole passing below the periproct.

ORAL PLATE ARRANGEMENT.—Sutures not clear.

OCCURRENCE.—Late Cretaceous, lectotype from "Cantabria" farm, Agua district, Cienfuegos, Santa Clara (now Las Villas) Province, Cuba. Sánchez Roig reports other specimens from Palmer loc. 895P, N of Grua Esperanza, 150 m, 6 km E of Madruga, Habana Province; WNW of Central Perseverancia, 1.8 km, on road to Aguada, in creek bank of Arroyo Vaquito, to 300 m N of culvert, Santa Clara (now Las Villas) Province; Km 2.2 WNW of Central Perseverancia, 50 m S of Linea Principal, abandoned water well, Santa Clara (now Las Villas) Province, Cuba.

REMARKS.—This species differs from the typical *Cardiaster* in lacking a deep anterior notch, but Mortensen (1950:53) considers the presence of the marginal fasciole as confirmation of its generic assignment to *Cardiaster*. It resembles *Cardiaster leonensis* Stephenson from the late Maestrichtian of Texas, which has the least depressed anterior

groove of any other species of this genus. It differs from this Texas species in having a larger higher test and shallower anterior groove. It differs from *Cardiaster cubensis* Jackson from the Cretaceous of Cuba in lacking an anterior groove.

Genus *Echinocorys* Leske, 1778

Test very high, ventral surface flat, apical system elongate, ambulacra subpetaloid, no fasciole or only a diffuse perianal fasciole; periproct inframarginal.

HABITAT.—Lacking well-developed petals and fascioles, *Echinocorys* probably could not borrow. Stephenson (1963:468) suggested that the echinoid lived on the surface of the sea bed, at most sunk into the sediment to just above the level of the ambitus. I suspect that this echinoid must have lived in deeper water. I know of no living irregular echinoid that occurs in shallow water with its test exposed. J.M. Hancock of King's College, London, an authority on the Chalk reports (1982, personal communication) that the Chalk in Britain where *Echinocorys* occurs was probably deposited at depths of 200–600 m.

Echinocorys ovatus Leske *cubensis* Sánchez Roig

PLATE 1: FIGURES 4, 5, 6

Echinocorys ovatus Leske *cubensis* Sánchez Roig, 1949:175, pl. 4: figs. 3, 4.

MATERIAL.—Holotype (SRC 4069) slightly deformed with apex pushed to the left when viewed from above. Test weathered, with plate sutures very clear.

SHAPE AND SIZE.—Test 77 mm long, 67 mm wide, width 87% of length of test (L). Oral surface flat except where elevated just anterior of periproct.

APICAL SYSTEM.—Anterior, located at distance from anterior margin 44% L, apical system with height equal to 14% L; system elongate with anterior genital plates separated from posterior by junction of ocular plates II and IV; genital plate 2 larger than other genital plates.

AMBULACRA.—Because of weathering not possible to tell length of petal; ambulacrum III similar to other ambulacra. Pores appear larger and porepairs are less separated from one another than one-half distance from apical system to margin in paired ambulacra: approximately one-half in ambulacrum III. Ambulacra dorsally of approximately same width as interambulacra; 90 plates in ambulacrum III, 90 in IV, 86 in V.

INTERAMBULACRUM.—41 plates each in interambulacrum 3 and 4; 48 in 5.

PERISTOME.—Anterior located at distance from anterior of test to anterior edge of peristome at distance equal to 20% L. Opening with width 9.1% L, height 4.4% L.

PERIPROCT.—Inframarginal, higher than wide; height 8.4% L; width 6.6% L. Located within interambulacral plates 7–9.

ORAL PLATE ARRANGEMENT.—Labrum with height 6.7% L, extending posteriorly $\frac{2}{3}$ height of second adjacent ambulacral plates. Plates alternating.

OCCURRENCE.—Late Cretaceous, Palenque, near Cienfuegos, Santa Clara (now Las Villa.)

Echinocorys ovatus Leske *villarensis* Sánchez Roig

FIGURE 2; PLATE 2

Echinocorys ovatus Leske *villarensis* Sánchez Roig, 1949:176.

MATERIAL.—Only one specimen (SRC 4174) of this subspecies is in the collection. Although Sánchez Roig did not figure any specimens, this specimen is certainly the holotype. It is labelled as the type, with the locality cited by Sánchez Roig, and has the dimensions given by him. The specimen is well preserved except where flint covers the peristome.

SHAPE AND SIZE.—Length 84 mm, width 53 mm (63% L), height 44 mm (53% L); greatest width and height slightly anterior of center. Ventral surface flat except along interambulacrum 5 where slightly inflated and where depressed around peristome.

APICAL SYSTEM.—Anterior, distance from an-

terior margin to center of system 31% L; 4 genital pores, anterior genital plates separated from posterior by ocular plates II and IV (Figure 2; Plate 2; figure 5). Apical system with length 18% L, width 10% L.

AMBULACRA.—No petals; porepairs adapically of approximately same size, smaller at margin and ventrally. Ambulacrum III with 78 plates, II with 86, I with 96. Ambulacrum III at greatest width 17% L, II 21% L, I 22% L. Phyllodes well developed with large peripodia with a prominent node separating pores of a pair; 10 peripodia in ambulacra II or IV, 7 in V or I, number unknown in III.

PERISTOME.—Opening obscured by flint.

PERIPROCT.—Inframarginal, distance of posterior margin from posterior edge of opening 3.7% L. Opening with length 7.9% L, width 6.4% L.

ORAL PLATE ARRANGEMENT.—Labrum followed by single plate extending across interambulacra, third and subsequent plates alternating.

OCCURRENCE.—According to Sánchez Roig, Late Cretaceous, Sancti Spiritus, near Ciudad, Santa Clara (now Las Villas) Province, Cuba.

REMARKS.—I suspect that this specimen did

not come from Cuba. It was collected, according to Sánchez Roig, by Dr. Ricardo de la Torre who also collected the holotype of *Conoclypeus sancti-spiritensis* Sánchez Roig supposedly at the same locality. This latter species is a *Conulus* probably *C. subrotundus* Mantell, a western European species. Both holotypes have tests of the typical white color of Chalk echinoids. The matrix inside the holotype of *E. ovatus villarensis* is flint, identical to that found so commonly in Chalk echinoids. The matrix in the holotype of *C. sancti-spiritensis* is chalk.

Family URECHINIDAE Duncan, 1889

Genus *Sanchezaster* Lambert, 1924

Test large, high, no petals, anterior ambulacrum narrower than others, in groove crossing margin, pores minute, single in all ambulacra, interambulacral plates similar in shape and size to ambulacral; apical system elongate; periproct supramarginal, small; peristome very anterior, small; marginal fasciole.

HABITAT.—This echinoid could not have burrowed deeply. Its lack of petals and any funnel-building tubefeet suggest that it lived on the surface of the sea floor. Considering its lack of large spines for protection, it probably lived in deep water where the reduced light would help to protect it from predators.

REMARKS.—This genus is very similar to *Chelonechinus*. Bather (1934:858) differentiated them on the following characters of *Sanchezaster*: (1) anterior sulcus, (2) transversely elliptical peristome, (3) periproct on ventral surface, (4) marginal fasciole, and (5) double ambulacral pores.

Bather saw only the Harvard specimen of this monotypic genus. My study of all available material convinces me that three of the supposed diagnostic features do not occur in *Sanchezaster*. The peristome is not well preserved on any of the specimens, but it does not appear to be any more transversely elliptical than in *Chelonechinus*. The periproct is supramarginal, not on the ventral surface. Finally the ambulacral pores are single,

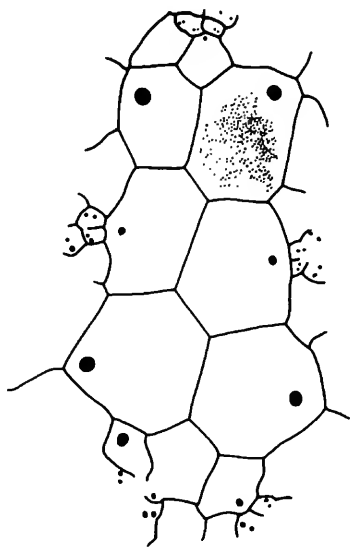


FIGURE 2.—*Echinocorys ovatus* Leske *villarensis* Sánchez Roig, apical system of the holotype, SRC 4174, $\times 4$.

not double. The specimen that Bather studied has many small holes scattered irregularly over the ambulacral and interambulacral plates. These holes are apparently the result of postmortem erosion or organic action. One of the USNM specimens has its plates well preserved and only one pore is present in each ambulacral plate (Figure 3B; Plate 3: figure 4). The genera differ in that an anterior groove and a marginal fasciole are present in *Sanchezaster*. Perhaps these differences do not warrant generic separation.

It is not clear, but the labrum may be separated from the peristome by ambulacral plates. *Sanchezaster* is known only from Cuba.

Sanchezaster habanensis Lambert

FIGURE 3; PLATES 3-5

Sanchezaster habanensis Lambert in Sánchez Roig, 1924a:14, pl. 3: fig. 1, pl. 4: fig. 1; 1926:86, pl. 14: fig. 1, pl. 15: fig. 1; 1949:174.—Mortensen, 1950:125, fig. 114.—Fischer, 1966:U537, fig. 420-1.

MATERIAL.—I have studied the holotype (SRC 4958), two specimens (both paratypes) in the USNM, and a paratype in the Museum of Comparative Zoology, Harvard University. The holotype is a large, flattened specimen with its ventral side poorly preserved. One of the USNM paratypes is flattened and distorted showing most of the plates of the test. The second USNM specimen has only one-quarter of its plates preserved but appears to display well the profile shape of the test. The Harvard specimen is badly flattened, with the dorsal plates weathered.

SHAPE AND SIZE.—Length 100 to 140 mm, height probably approximately 55% L, test high with steep sides; test appears to be wider than high. Test with very thin plates, thickness of plate 0.4 to 0.8% L.

APICAL SYSTEM.—Because of distortion of the tests, it is not possible to be certain of the position of the apical system; but it appears to be nearly central. It is intact in none of specimens, but it appears to be elongate and not disjunct—probably similar to *Chelonechinus suvae* Bather (see Bather, 1934, fig. 1). Genital plate 2 (Figure 3A)

is smaller than the other genital plates with a larger pore.

AMBULACRA.—No petals, a very small, single

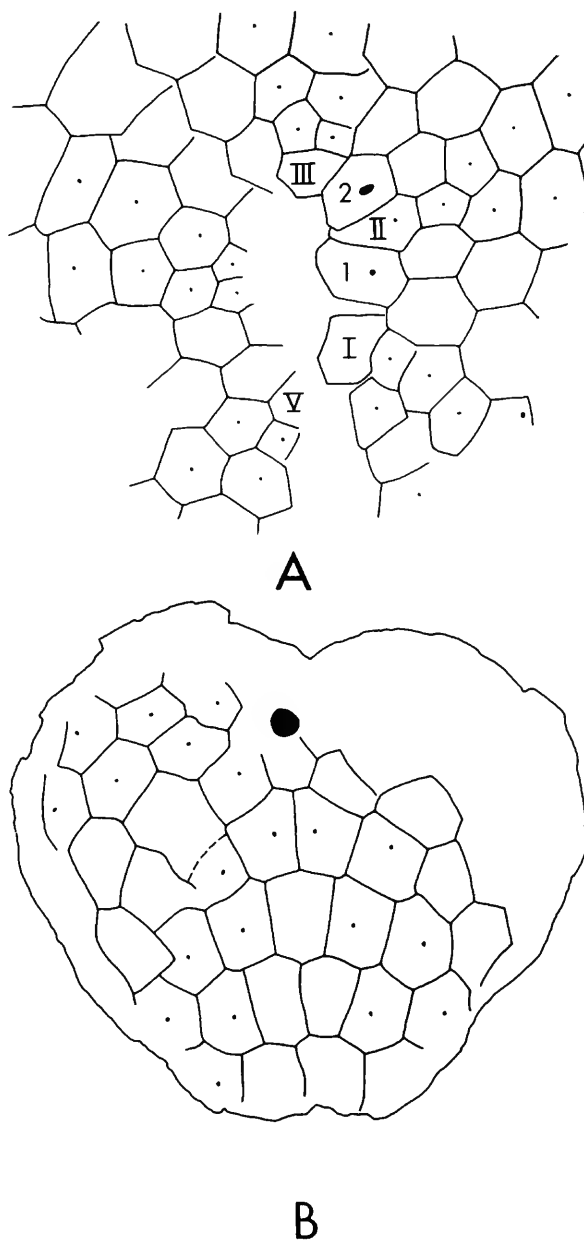


FIGURE 3.—*Sanchezaster habanensis* Lambert: A, apical region of the holotype, SRC 4958, $\times 1.4$; B, ventral view of paratype, USNM 341249, $\times 0.6$. The ocular plates are designated by Roman numerals, the genital plates by Arabic.

pore near middle of each plate; ambulacra of approximately same width as interambulacra, dorsally, most plates hexagonal with a single node near center of each plate. Anterior ambulacrum III with smaller plates than in other ambulacra, grooved at margin. Each ambulacral column with 9–11 plates. No phyllodes.

PERISTOME.—Anterior, located at distance from anterior edge of opening to anterior margin equal to 8.0% L (est.). Opening probably circular, small with diameter 6.3% L.

PERIPROCT.—Preserved on USNM 341248, where it occurs above the margin with a trough extending down from the periproct to margin; opening small, wider than high, width estimated at 8.5% L.

FASCIOLAE.—A very distinct marginal fasciole with width 1.1% L passing around test below margin; crossing plate 2 in ambulacrum III.

TUBERCULATION.—Dorsally tubercles very small (Plate 3: figure 2), scattered irregularly over plates, scrobicules absent or very small. Tubercles around periproct (Plate 3: figure 3) larger, scrobiculate. Ventrally, tubercles larger, scrobiculate, eccentric as typical in spatangoids, more regularly arranged (Plate 3: figure 4); tubercles largest anterior of peristome.

ORAL PLATE ARRANGEMENT.—Plates of interambulacrum 5 not larger than adjacent ambulacral plates (Figure 3B). Labrum large, height 9.5% L, width 11% L, separated from next plate of interambulacrum by junction of ambulacral plates. Although it is not certain because of the distortion of the specimens and subsequent displacement of the plates, the labrum appears to be separated from the peristome by the first ambulacral plates of ambulacra V and I.

OCCURRENCE.—Eocene, quarries of Tejar "Consuelo," Ciénaga, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—No other species of this genus are known, but a specimen of *Chelonechinus crassus* Gregory from the Eocene or Oligocene of Barbados is very similar to *S. habanensis*. Only one specimen is known of the Barbados species, and it is very poorly preserved with few specific characters evident.

Order SPATANGOIDA Claus, 1876

Suborder TOXASTERINA A.G. Fischer, 1966

Family TOXASTERIDAE Lambert, 1920

Genus *Douvillaster* Lambert, 1917

Test large, broad, with anterior groove, apical system ethmophract with four genital pores, five petals, pores in petal III transverse, peristome anterior near margin, periproct inframarginal, no fasciole or only traces of a peripetalous fasciole.

Only one species of this genus is known from Cuba and no others are known elsewhere in the Western Hemisphere.

HABITAT.—This genus lacks fascioles and funnel-building tubefect (ambulacrum III is respiratory) and therefore could not maintain a burrow. Nichols (1959:425) suggested that *Isomicraster*, a genus very similar to *Douvillaster*, did not burrow or had only the lower part of its body submerged. Probably *Douvillaster* lived with its test shallowly covered in well-aerated, coarse sediment. It is unlikely that this echinoid would live with its test exposed. Only in deep water do modern irregular echinoids live on the surface of the seafloor with the test exposed.

Douvillaster triangularis (Sánchez Roig), new combination

PLATE 6

Macraster triangularis Sánchez Roig, 1949:217, pl. 34: figs. 1, 2.

MATERIAL.—The figured holotype (SRC 4722) is the only specimen known. Although the specimen is compressed, the exterior is well preserved with much of the tuberculation preserved.

SHAPE AND SIZE.—Length 88 mm, width 101% L, height 43% L but originally higher before postmortem compression. Greatest width very anterior of center; greatest height at apical system. Anterior groove deep.

APICAL SYSTEM.—Slightly posterior of center, distance from anterior margin to center of genital

pores 46% L. Four genital pores. Although the plates are not all discernible, genital plate 2 appears to separate the posterior genital plates but not the posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III petaloid, extending two-thirds distance to margin, length 40% L, greatest width 6.3% L. Pores conjugate, outer pore more elongate (Plate 6: figure 4) than inner, not arranged in chevrons; interporiferous zone slightly wider than single poriferous zone; 122 petaloid porepairs. In groove extending from apical system to peristome; depth of groove at margin 5.2% L. First petaloid porepair in plate 12 or 13.

Anterior petals (II and IV) long, extending almost to margin, length 51% L, curving anteriorly, in groove with greatest depth 2.9% L, greatest width 8.4% L. Porepairs conjugate, outer pore more slit-like, with interporiferous zones slightly wider than poriferous; 164 petaloid porepairs.

Posterior petals (V and I) shorter, extending four-fifths distance from apical to margin, length 40% L, width 8.4% L; curving slightly posteriorly. Porepairs similar (Plate 6: figure 5) to anterior petals; 122 petaloid porepairs. Pores double beyond petals.

PERISTOME.—Situated near anterior margin, distance from margin to anterior edge of peristome 6.9% L. Opening very small, width 9.2% L, height indeterminate because of distortion of test.

PERIPROCT.—Inframarginal, on sharply overhanging posterior truncation. Opening small, height 7.0% L, width 7.1% L; located within interambulacral plates 6–8.

FASCIOLAS.—No fasciolas. Tuberculation well preserved so that fasciolas would be visible on this specimen if they had been originally present.

ORAL PLATE ARRANGEMENT.—Labrum large, narrow, high, with height 21% L. Plastron composed of two plates, long, narrow with combined length of 47% L, width 30% L.

OCCURRENCE.—Cretaceous, Palmer loc. 128, silicified marine sediments, one league S of Santa Clara, Santa Clara (now Las Villas) Province, Cuba.

COMPARISON WITH OTHER SPECIES.—I have compared this species with all the other species of the genus and it falls near *Douvillaster variusulcatus* (Gauthier) from the Albian of Algeria. Both species have a large, broad test and curved anterior petals, but the Cuban species differs in having a deeper anterior groove and shorter petal III and posterior petals.

REMARKS.—This species has an anterior petal (III) with pores that are transverse like those in the other petals. In *Macraster* the pores in this petal are arranged in chevrons. For this reason this species is transferred from *Macraster* to *Douvillaster*, a genus not previously known from the Americas.

Suborder HEMIASTERINA A.G. Fischer, 1966

Family HEMIASTERIDAE Clark, 1917

Genus *Hemiaster* L. Agassiz, 1847

Test of medium size, broad, truncated posteriorly; apical system ethmophract as in *Hemiaster* (*Hemiaster*) or ethmolytic as in *Hemiaster* (*Trachyaster*), 4 genital pores; anterior ambulacrum III not petaloid, other ambulacra with well-developed petals, anterior longer than posterior; peripetalous fasciole.

Nine species from Cuba have been referred to *Hemiaster* (*Hemiaster*) or *Hemiaster* (*Trachyaster*); but the type specimens have been lost for five of them and they are not recognizable. One species (*lamberti*) is transferred to another genus (*Linthia*) and one (*herreræ*) is transferred from *Opissaster* to *Hemiaster*. The species are listed in Table 1.

Only one of the Cuban species is well enough known to permit comparison with other species in the Western Hemisphere: *H. herreræ*. It is quite similar to *Hemiaster texanus* Roemer from the Late Cretaceous of Texas but differs in having more flexuous anterior petals which distally turn more anteriorly.

HABITAT.—Species of *Hemiaster* probably lived buried in mud. The crowded, enlarged peripodia dorsally in ambulacrum III indicate the presence

TABLE 1.—Disposition herein of Cuban species of *Hemiaster*
(*T.* = subgenus *Trachyaster*)

Disposition	Oligocene-Miocene	Cretaceous
Recognized species		<i>H.?</i> (<i>T.</i>) <i>gonzalezmunoz</i> <i>H.</i> (<i>T.</i>) <i>herrer</i> <i>H. madrugensis</i> <i>H. siboneyensis</i>
Unrecognizable species	<i>H. globulosus</i>	<i>H. antillensis</i> <i>H. dewalquei</i> <i>H.</i> (<i>T.</i>) <i>minutus</i> <i>H.</i> (<i>T.</i>) <i>simpaticus</i>
Referred to other genera		<i>H. lamberti</i> (= <i>Linthia brodermanni</i>)

of funnel-building tubefeet. Likewise, the peripetalous fasciole and depressed petals would aid life in this habitat. According to Mortensen (1950: 377) modern hemiasterids are all deep sea forms occurring at depths of 140 to 400 m and probably all of them are mud-dwellers.

***Hemiaster (Hemiaster) madrugensis* Weisbord**

PLATE 8: FIGURES 2-4

Hemiaster madrugensis Weisbord, 1934:35, pl. 3: figs. 4-6.—
Sánchez Roig, 1949:236.

I have studied the holotype and twelve paratypes of this species in the Paleontological Research Institution (PRI 3804) and have nothing to add to Weisbord's detailed description except the following dimensions of the holotype: length 30 mm, width 29 mm, height 22 mm, distance from apical system to anterior margin 11 mm, length of petal II 10 mm, width of petal II 3.7 mm, length of petal I 6.9 mm, width of petal I 3.1 mm, numbers of porepairs in petal II 58, number of porepairs in petal I 44. The first petaloid porepair in petal II is in plate 14.

OCCURRENCE.—Late Cretaceous, on the property of Central San Antonio, 150 m NW of the sugar cane loading rack at Esperanza switch, 10 km E of the mill and town of Madruga, near the eastern boundary of Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species differs from *H. herrer* (Lambert and Sánchez Roig), also from the Late Cretaceous of Cuba, in having a more anterior apical system, less flexuous anterior petals, and probably a narrower anterior ambulacrum. It is very different from any *Hemiaster* in North America.

***Hemiaster (Hemiaster) siboneyensis* Weisbord**

PLATE 8: FIGURES 5-7

Hemiaster siboneyensis Weisbord, 1934:37, pl. 3: figs. 7-9.—
Sánchez Roig, 1949:237.

I have nothing to add to Weisbord's detailed description except the following dimensions of the holotype (Paleontological Research Institution, PRI 3805): length 24.8 mm, width 26.1 mm, height 19.6 mm, distance apical system to anterior margin 11.5 mm, length of petal II 9.5 mm, width of petal II 3.4 mm, length of petal I 4.6 mm, width of petal I 3.0 mm, number of porepairs in petal II 54, number of porepairs in petal I 36.

OCCURRENCE.—Late Cretaceous, on the property of Central San Antonio, 150 m NW of the sugar loading racks at Esperanza switch, on private railroad of Central San Antonio, of Madruga, near the eastern boundary of Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from *Hemiaster madrugensis* Weisbord with which it occurs, by its much shorter posterior petals and more posterior apical system.

***Hemiaster?* (*Trachyaster*) *gonzalezmunoz*
Sánchez Roig**

PLATE 7: FIGURES 1–3

Hemiaster gonzalezmunoz Sánchez Roig, 1953c:170, pl. 11: figs. 3, 4.

MATERIAL.—The holotype (SRC 4248) is the only known specimen and is extremely poorly preserved. Most of the test is broken away and the rest is very badly weathered.

SHAPE AND SIZE.—Length 64.7 mm, width 96% L, greatest width anterior to center, greatest height posterior.

APICAL SYSTEM.—Posterior, distance from anterior margin to center of genital pores 49% L. Appears to be ethmolytic with 4 genital pores but sutures not clear.

AMBULACRA.—Anterior ambulacrum III depressed in deep groove; depth of groove at ambitus 8.8% L; greatest width 11% L. Region with enlarged pores extending almost to anterior groove; pores large.

Anterior petals (II and IV) long, extending almost to margin, length 43% L; width 9.9% L; petals flexuous, pores conjugate; interporiferous zones slightly wider than single poriferous zone; 96 porepairs in petal.

Posterior petals (V and I) short, slightly curved, length 24% L, width 9.0% L, in groove; 58 porepairs.

PERISTOME.—Not preserved, very anterior, just posterior to anterior groove.

PERIPROCT.—High on vertical posterior truncation, height 14% L, width 10% L.

FASCIOLAS.—Not preserved.

OCCURRENCE.—Late Cretaceous, “Concepción de Montalvo” farm, Rodas, Las Villas Province, Cuba.

REMARKS.—The holotype is too poorly preserved to permit generic identification. As pres-

ence or absence of fascioles is not known this species cannot be referred with any certainty to a genus. It resembles *Hemiaster herrerae* (Lambert and Sánchez Roig) except that the posterior petals in *H.?* *gonzalezmunoz* appear to be more divergent. The holotype is too poorly preserved to permit comparison with other species.

***Hemiaster* (*Trachyaster*) *herrerae* (Lambert
and Sánchez Roig), new combination**

PLATE 7: FIGURES 4–8; PLATE 8: FIGURE 1

Opissaster herrerae Lambert and Sánchez Roig in Sánchez Roig, 1926:126, pl. 40: figs. 1, 2, pl. 41: fig. 3; 1949:244.

MATERIAL.—The holotype and two other specimens referred to this species are in the Sánchez Roig Collection. The holotype (SRC 4857) is well preserved, except the exterior is weathered and abraded, obscuring the tuberculation and most of the fasciole.

A second topotypic specimen (SRC 4290) in the collection is not used in the following description because it may not be conspecific. The test is higher, its apical system less posterior, and the plates in the dorsal portion of ambulacrum III are higher. It is too poorly preserved for specific identification. The third specimen is also not conspecific with the holotype. Its apical system is much more anterior, and its ambulacrum III is narrower. The petals are shallower and the posterior is not highly inflated.

SHAPE AND SIZE.—Length 38 mm, width 97% L, height 64% L; greatest width central to slightly anterior, greatest height posterior.

APICAL SYSTEM.—Four genital pores (Plate 8: figure 1), ethmolytic, located posterior to center at distance from anterior margin to center of genital pores equal to 46% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove midway between apical system and margin 7.8% L, width 15% L; depth of groove at margin 7.0% L. Porepairs enlarged and in peripodia adapically (Plate 7: figure 8) high prominence separating pore of pair; 80 porepairs in this region; porepairs in single row

with inner pore of pair less elongated than outer. First enlarged porepair in plate 6; pores paired throughout ambulacrum which has 90 plates.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin; length 42% L, greatest width near extremity, 11% L, in deep groove with depth 6.5% L; petal flexuous. Pores conjugate, inner pore of pair larger than outer; interporiferous zone wider than single poriferous zone; 72 porepairs in petal; first petaloid porepair in plate 16; total of 102 plates in ambulacrum. Pores paired beyond petals.

Posterior petals (V and I) short, extending one-half distance from apical system to margin, length 26% L, width 9.4% L, in groove with depth 47% L; petal straight. Interporiferous zone equal in width to single poriferous zone; 50 porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 14% L; width of opening 16% L; height unknown. Phyllodes with pores paired in peripodia; 12 in ambulacra II and IV, 5 in III, number uncertain in V or I.

PERIPROCT.—Located high on posterior, opening higher than wide, height 14% L, width 11% L.

FASCIOLAS.—Peripetalous fasciole not curving into interambulacra, widest where it crosses ambulacrum III; fasciole crosses ambulacra II or IV on plate 15, III on plates 4 and 5.

ORAL PLATE ARRANGEMENT.—Labrum not preserved, rest of sutures not clear.

OCCURRENCE.—In the original description of this species, the age was given as Miocene. In Sánchez Roig (1949:245) it is recorded as Late Cretaceous, as it is by Brodermann (1949:325). On the label of the holotype, the age is written as Oligocene. The presence of double pores in the ambulacra beyond the petals indicates that the Cretaceous age is probably correct. Most spatangoids after the Eocene have single pores beyond the petals (Kier, 1974:28). Jesús del Monte, Tamarindo, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Hemiaster herrerae* differs from *Hemiaster madrugensis* Weisbord also from the Late Cretaceous of Cuba in having a more posterior apical system, more flexuous

anterior petals and apparently a wider anterior ambulacrum. Its test is probably lower than in *Hemiaster siboneyensis* Weisbord, also from the Late Cretaceous of Cuba; but the holotype of that species is badly distorted and its original shape is unknown. The anterior ambulacrum in *H. herrerae* is similar in the amount of its depression to *H. gonzalezmunoz* Sánchez Roig. The species may be similar but the holotype of *H. gonzalezmunoz* is so poorly preserved that comparison is not possible. *H. herrerae* is unlike any *Hemiaster* from North America.

REMARKS.—Lambert and Sánchez Roig placed this species in *Opissaster* probably because they believed that the anterior genital pores were microscopic. Cleaning of the specimen shows that these pores are large. This species seems better assigned to *Hemiaster* (*Trachyaster*). Although Fischer (1966:U559) states that this subgenus is confined to the Tertiary, many of the species of *Hemiaster* from the Late Cretaceous, such as *Hemiaster texanus* Roemer, have the ethmolytic apical system that characterizes this subgenus.

UNRECOGNIZABLE SPECIES OF *Hemiaster*

Hemiaster antillensis Cotteau

Hemiaster antillensis Cotteau, 1881:31, pl. 3: figs. 1–4.—Jackson, 1922:73.

Trachyaster antillensis (Cotteau).—Sánchez Roig, 1949:243.

The holotype has been lost.

OCCURRENCE.—Cotteau provisionally referred this species to the Eocene, but Sánchez Roig considered the species to be Late Cretaceous. Cienfuegos, Las Villas Province, Cuba.

Hemiaster dewalquei Cotteau

Hemiaster dewalquei Cotteau, 1881:30, pl. 2: figs. 7–9; 1897:75, pl. 3: figs. 7–9.—Jackson, 1922:73.

Hemiaster (*Integraster*) *dewalquei* Cotteau.—Sánchez Roig, 1949:239.

The holotype of this species is no longer at Liège, Belgium (Georges Ubaghs, Université de Liège, 1982, personal communication) and no specimens are in the Sánchez Roig Collection.

OCCURRENCE.—Eocene(?) of Cienfuegos, Las

Villas Province, Cuba, but Brodermann (1949:323) considers it Cretaceous.

Hemiaster globulosus Sánchez Roig

Hemiaster (Integraster) globulosus Sánchez Roig, 1949:240, 241, pl. 42: figs. 11, 13.

OCCURRENCE.—Oligocene-Miocene, "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

REMARKS.—One specimen (SRC 4196) is labelled as the type; but it clearly is not. The holotype was only 33 mm long according to Sánchez Roig, whereas this specimen is twice as large. It is clearly not conspecific with the holotype figured by Sánchez Roig. Its peristome is far more anterior. Sánchez Roig's illustrations are too poor to permit comparison of this species with other species of the genus.

Hemiaster (Trachyaster) minutus Sánchez Roig

Trachyaster minutus Sánchez Roig, 1949:241, pl. 42: figs. 6–8.

The holotype is lost and Sánchez Roig's illustrations are too poor to permit comparison with other species.

OCCURRENCE.—Late Cretaceous, sugarhouse of Central dos Hermanos, Santa Clara (now Las Villas) Province, Cuba.

Hemiaster (Trachyaster) simpaticus Sánchez Roig

Trachyaster simpaticus Sánchez Roig, 1949:242, pl. 42: figs. 3–5.

The holotype is lost and Sánchez Roig's illustrations are too poor for comparison with other species.

OCCURRENCE.—Late Cretaceous, "Simpatía" farm, at limit of Damuji, Cienfuegos, Santa Clara (now Las Villas) Province, Cuba.

Family PALEOPNEUSTIDAE A. Agassiz, 1904

Genus *Pericosmus* L. Agassiz, 1847

Test generally moderately large, broad, with flattened ventral surface, domed dorsal surface; apical system ethmolytic with three genital pores,

no pore in genital plate 2; anterior ambulacrum III with microscopic pores in most species; petals depressed, of approximately equal length, with occluded plates at ends, plates beyond petals with single pores; peripetalous and marginal fascioles present; sternum narrow; in some species first plate of interambulacrum 1 followed by single plate.

HABITAT.—No living *Pericosmus* has been seen in its habitat, so we can only suggest how they live and how the fossil species may have lived. All of the living species, according to Mortensen (1951:167), have in their periproctal region large subanal tubefeet with disks. These are the funnel-building tubefeet described by Smith (1980:51). Their presence indicates that the echinoids maintained a sanitary drain and therefore presumably lived at least partially buried. Two of the nine living species have enlarged peripodia in the dorsal portion of the anterior ambulacrum, and the tubefeet possess disks (Mortensen, 1951:166). Again, according to Smith (1980:51) this kind of tubefoot is used for funnel building. These species presumably live completely buried and maintain a funnel to the substrate-water interface. The absence of a deep anterior groove, deep petals, and a subanal fasciole suggest that they probably live not very deeply buried and not in very fine sediments. The seven other living species lack these funnel-building tubefeet in their anterior ambulacrum and could not maintain a funnel. Presumably they live with just the top of their tests covered with sediment.

The fossil specimens from Cuba are generally badly weathered. It is not possible to determine the exact nature of the pores in the anterior ambulacrum. In most of them the pores are very small, with slight size difference between pores on the dorsal side and pores at the margin. Furthermore, they are not close together. According to Smith (1980:77), there is a pronounced change in size of the pores if funnel-building tubefeet are present; the pores are often close together. It can be assumed that most of these fossil species could not build a funnel. The presence of larger subanal porepairs indicates they could maintain a sanitary drain. It is probable that they lived buried

with the dorsal part of the test slightly covered.

On the basis of our knowledge of the occurrence of the living species of *Pericosmus*, it can be suggested that the Cuban fossil species probably lived in tropical waters in depths over 100 m. Eight of the nine living species of this genus live in tropical waters; the ninth is subtropical. Most live at depths of 200–500 m with the shallowest occurring at 18–70 m.

COMPARISON WITH OTHER SPECIES OUTSIDE OF CUBA.—Only two species of *Pericosmus* are known outside of Cuba in the Western Hemisphere: *P. stehlini* Jeannet from the middle Miocene of Venezuela and *P. israelskyi* Durham from the Miocene of Costa Rica. *Pericosmus stehlini* is very similar to *P. camagueyanus* from the Oligocene-Miocene of Cuba. The holotype of *P. stehlini* has a more anterior apical system and the tips of its petals appear to be wider. These differences are slight, and the species may be synonyms. *P. israelskyi* is quite different from all the Cuban species having a larger test with deeper petals.

REMARKS.—Chesher (1968:159) showed the great similarity between *Pericosmus* and a group of genera including *Paleopneustes*. He reestablished for them the family Paleopneustidae, which he stated included genera having similarly shaped tests with domed dorsal surfaces and flattened ventral surfaces, apical systems with only three genital pores, phyllodes with double pores, some occluded plates at the ends of the petals and in interambulacrum 1 the first plate followed by a single plate. This more natural classification was later used by Henderson (1975) in his monograph on New Zealand spatangoids, and is followed herein.

In some of the Cuban species of *Pericosmus* (such as *P. valenzuelai* Sánchez Roig), the first two plates of interambulacrum 1 are not single but have the normal arrangement of a pair of plates following the first plate. In *Pericosmus blanquiazalensis* Sánchez Roig, the first two plates are single. Unfortunately, the plate sutures are not visible on most of the Cuban species. It is therefore not possible to determine whether there is an evolutionary trend in this character.

Not all the species of *Pericosmus* have phyllodes

with double pores. Mortensen (1951) shows single pores in *P. akabanus* Mortensen, *P. cordatus* Mortensen, *P. keiensis* Mortensen, *P. tenuis* Mortensen, *P. melanostomus* Mortensen, *P. oblongus* Mortensen, and *P. mauritanus* Mortensen. He shows double pores only in *P. bidens* Mortensen (1951, fig. 91a). I have seen only one specimen of a living *Pericosmus*: *P. akabanus*. Its pores beyond the petals and in the phyllodes are definitely single. The phyllodal pores give the first impression of being double because of a ridge dividing the peripodia, but actually only one pore is present. Only on well-preserved fossils is it possible to determine whether the pores are double or single. On badly weathered specimens, the larger pore of a pore-pair may be so enlarged as to include the smaller second pore, obscuring the fact that two pores were originally present.

Pericosmus is common in Cuba occurring in the Eocene, Oligocene-Miocene, and Miocene. Four species have been described from the Eocene. One of them, *P. cubanus* Palmer, has never been figured and its type specimen is lost. The other three are very similar and herein are considered synonymous; *P. atolladosae* (Sánchez Roig), *P. rojasi* Sánchez Roig, and *P. zanolettii* Sánchez Roig.

Five species of *Pericosmus* were described by Sánchez Roig or Lambert from the Oligocene-Miocene but one of them, *Pericosmus delgadoi*, is herein referred to *Schizaster*. Two species that Sánchez Roig considered to belong to *Mauritanaster* (*M. marroquinensis* Sánchez Roig and *M. depressus* Sánchez Roig) are herein referred to *Pericosmus*. Sánchez Roig's *Linthia aguayoi* and *Antilaster mortenseni* are also referred to *Pericosmus*. These eight species are all very similar and all of them may be synonymous. Because only one specimen is known of each of these species, the variation within a species is not known. It is therefore difficult to evaluate the significance of differences between the type specimens.

Pericosmus giganteus Sánchez Roig, *Mauritanaster marroquinensis* Sánchez Roig, and *M. depressus* Sánchez Roig are considered synonyms of *Pericosmus aguayoi*. *Pericosmus blanquiazalensis* Sánchez Roig, *P. mortenseni* (Sánchez Roig), and *P. camagueyanus* Sánchez Roig are maintained as separate species;

TABLE 2.—Disposition herein of Cuban species of *Pericosmus*
(*M.* = genus *Mauritanaster*)

Disposition	Miocene	Oligocene-Miocene	Eocene
Recognized species (synonyms)	<i>P. aguayoi</i> (? <i>P. artemisae</i>) (<i>P. valenzuelai</i>)	<i>P. aguayoi</i> (<i>M. depressus</i>) (<i>M. marroquinensis</i>) (<i>P. giganteus</i>) <i>P. blanquizalensis</i> <i>P. camagueyanus</i> <i>P. mortenseni</i>	<i>P. atolladosae</i> (<i>P. rojasi</i>) (<i>P. zanolettii</i>)
Unrecognizable species	<i>P. roigi</i>		<i>P. cubanus</i>
Referred to other genera		<i>P. delgadoi</i> [to <i>Schizaster</i>]	

but they are very similar to each other and to *P. aguayoi*. No specimens are available of *P. roigi* Lambert so its affinities are not known. Although Sánchez Roig (1949:246) considered this species to be late Oligocene, Brönnimann and Rigassi (1963:466) place it in the Miocene. Sánchez Roig's two Miocene species, *Pericosmus artemisae* and *P. valenzuelai*, are considered herein as syn-

onyms of *P. aguayoi*.
A summary of the present status of the Cuban species of *Pericosmus* is presented in Table 2. The following key may be useful, but it must be stressed that the differences between some of the species is slight. The significance of the differences is uncertain. I can see no evolutionary trends within the Cuban species.

Key to Cuban Species of *Pericosmus*

- 1. Petals short, length less than 39% L 2
 Petals long, length more than 39% L 4
- 2. Petals slightly depressed, slight anterior groove
 ***P. mortenseni*** (Sánchez Roig), new combination
 Petals more depressed, distinct anterior groove 3
- 3. Apical system anterior, petals slightly curved
 ***P. atolladosae*** (Sánchez Roig)
 Apical system central, petals straight
 ***P. blanquizalensis*** Sánchez Roig
- 4. Apical system central ***P. camagueyanus*** Sánchez Roig
 Apical system anterior ***P. aguayoi*** (Sánchez Roig)

***Pericosmus aguayoi* (Sánchez Roig),
new combination**

FIGURES 4–6; PLATES 9, 10, 11: FIGURES 1–6

Mauritanaster marroquinensis Sánchez Roig, 1953a:61, pl. 14: 2
figs.
Pericosmus valenzuelai Sánchez Roig, 1953c:167, pl. 10: fig. 5.
? *Pericosmus artemisae* Sánchez Roig, 1953c:168, pl. 11: fig. 1.

Linthia aguayoi Sánchez Roig, 1949:265, pl. 48: figs. 1, 2.
Mauritanaster depressus Sánchez Roig, 1949:228, pl. 33: fig. 1.
Pericosmus giganteus Sánchez Roig, 1952c:21, pl. 13: fig. 1; pl.
14: fig. 1.

MATERIAL.—Only one specimen, the holotype (SRC 4268), is in the Sánchez Roig Collection. The test is almost complete, not distorted, but

badly weathered with most of the tuberculation eradicated. Only short traces of the fascioles are preserved.

SHAPE AND SIZE.—Length 78 mm, width 99% L, height 60% L, with greatest height at apical system, greatest width anterior of center.

APICAL SYSTEM.—Slightly anterior of center, distance from anterior margin to center of system 36% L; ethmolytic, number of genital pores not clear.

AMBULACRA.—Anterior ambulacrum III not petaloid; in groove deepening adorally, depth at margin 6.6% L. Pores minute.

Anterior petals (II and IV) extending over two-thirds distance from apical system to margin, length 42% L, greatest width 7.0% L, in slight groove with depth 2.3% L; petals curving very slightly anteriorly. Interporiferous zone slightly narrower than single poriferous zone; pores slightly conjugate, outer pore of pair more elongate than inner; 80 petaloid porepairs; not known in which plate first petaloid porepair occurs. Last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plates beyond petal.

Posterior petals (V and I) only very slightly shorter than anterior, extending three-fifths distance from apical system to margin, length 40% L; width 7.7% L, depth of groove 1.1% L. Petals curving anteriorly. Last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal. Pores single in phyllodes but with ridge dividing peripodia. Two or three larger subanal porepairs on posterior margin in ambulacra V and I.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 17% L, width 15% L, height not more than 3.6% L. Peristome depressed in ventral surface of test.

PERIPROCT.—Inframarginal, on overhanging posterior truncation (Plate 10: figures 2, 4); opening with height 13% L, width 14% L.

FASCIOLAS.—Short tracks present of both peripetalous and marginal fascioles; marginal fasciole crossing plate 4 in ambulacrum III.

ORAL PLATE ARRANGEMENT.—Labrum high, height 11% L; rest of plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, holotype of *P. aguayoi* and *M. depressus*, "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba; holotype of *P. giganteus*, "Pedro Hernandez" farm, Tamarindo, Morón, Camagüey Province, Cuba; holotype of *M. marroquiniensis*, "Blanquizal" farm of the estate of Campañoni, Marroquín district, Morón, Camagüey Province, Cuba. Miocene, lectotype of *P. valenzuelai* and ?*P. artemisae*, "Sunset" farm (formerly "Gerona") on highway between Cayajabos and Artemisa, Pinar del Rio Province, Cuba.

REMARKS.—This species is clearly a *Pericosmus*. Not only are its shape and petal arrangement typical of this genus, but it has the minute pores in ambulacrum III, occluded plates at the end of its petals, and marginal fasciole so characteristic of *Pericosmus*.

Sánchez Roig's holotype of *Mauritanaster depressus* is from the same locality as the holotype of *P. aguayoi* and appears to be conspecific. Superficially they appear to differ in that the test in *M. depressus* is lower, the apical system more posterior, and no fascioles are visible. However, I believe that postmortem compression flattened the test and shifted the apical system posteriorly. Weathering removed the fascioles. The specimens are similar in the length, width, and arrangement of their petals. An anterior petal in *M. depressus* has 70 porepairs as opposed to 80 in *P. aguayoi*; but the test in *P. aguayoi* is larger and more petaloid porepairs should be present. Both specimens have three genital pores and plates occluded at the end of their petals.

Likewise, *Pericosmus giganteus* Sánchez Roig, also from the Oligocene-Miocene of Cuba, appears to be a synonym of *P. aguayoi*. Their type specimens have tests with similar marginal outlines, similarly situated apical systems and peristomes, and petals of similar length and arrangement. They only differ in test heights; the test is lower in *P. giganteus*. However, as shown by McNamara and Philip (in press), the test can be relatively lower in larger specimens within a species in *Pericosmus*. Although the holotype of *P. giganteus* has $2\frac{1}{2}$ plates occluded at the end of petal and the holotype of *P. aguayoi*, only $1\frac{1}{2}$, this difference is

probably not significant. I have not been able to determine the variability of this character in *Pericosmus* because of the lack of specimens, but Chesher (1968:129) has found in a closely allied genus, *Paleopneustes*, that the number of occluded plates varies within a species.

The holotype of *Mauritanaster marroquinensis* Sánchez Roig is indistinguishable from the holotype of *P. giganteus*, which occurs in the Oligocene-Miocene of the same region. Presumably because of the absence of fascioles, Sánchez Roig considered it to be a *Mauritanaster* and did not compare it to his *P. giganteus*, which he had described earlier. Because the specimen is so badly weathered, no fascioles are visible.

The Miocene *Pericosmus valenzuelai* Sánchez Roig appears to be a synonym of *P. aguayoi*. Their petals are similar in shape and length. The anterior petals in the holotype of *P. aguayoi* appear to be deeper and narrower, but this is due to post-mortem compression. Their apical systems are in the same position and the marginal outline of their tests are similar. The lectotype of *P. valenzuelai* is much lower than the holotype of *P. aguayoi* but only slightly lower than the type specimen of *P. giganteus*, a species considered herein to be a synonym of *P. aguayoi*. The lectotype is very similar in general appearance to the holotype of *P. marroquinensis*, another species considered a synonym of *P. aguayoi*.

Sánchez Roig's *Pericosmus artemisae* is from the same locality as *P. valenzuelai*. Its holotype and only known specimen has been lost. Sánchez Roig's photograph of it is very poor, but I can see no characters that distinguish it from *P. valenzuelai*. The shape of the test and arrangement of the petals are similar. However, because of uncertainty of other specific characters, I only provisionally place it in synonymy with *P. valenzuelai* under *P. aguayoi*.

SYNONYMS

Pericosmus giganteus Sánchez Roig

FIGURE 4; PLATE 9

MATERIAL.—The holotype (SRC 4130), which is the only known specimen previously referred to

this species, is moderately well preserved although slightly distorted and badly weathered.

SHAPE AND SIZE.—Length 91 mm, width 94% L, height 44% L, with greatest width anterior of center, location of greatest height uncertain because of damage to test. The adoral surface is depressed anterior and lateral to the peristome.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of system 40% L. Although much of the apical system is missing, no pore is present in genital plate 2.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove very shallow adapically but deepening crossing margin where depth 3.3% L. Pores in adapical region very small. Number of plates not discernible.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin, length 39% L, greatest width 8.3% L, in groove with depth 2.6% L. Petals curving slightly anteriorly, interporiferous zones narrower than single poriferous zone; pores slightly conjugate, outer pore of pair more elongate than inner; 80 petaloid

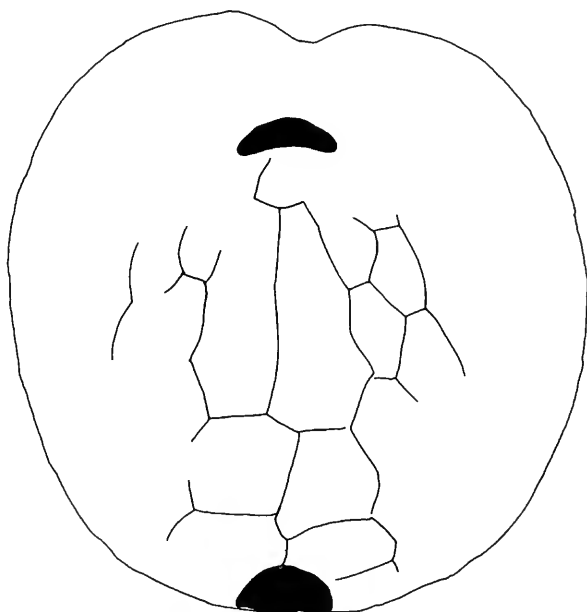


FIGURE 4.—*Pericosmus aguayoi* (Sánchez Roig), ventral view of the holotype of *Pericosmus giganteus* Sánchez Roig (= *P. aguayoi*) SRC 4130, $\times 0.9$.

porepairs; not clear in which plate first petaloid porepairs occur. Last $2\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

Posterior petals (V and I) of approximately same length as anterior, extending less than two-thirds distance from apical system to margin, length (est.) 40% L, width 8.0% L, depth of groove 1.6% L. Petals straight; number of petaloid porepairs unknown. Last $2\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 16% L, opening wider than high, width 17% L, height 4.6% L.

PERIPROCT.—Located on overhanging truncation, visible from ventral side, wider than high, width 19% L, height 12% L; located within interambulacral plates 4–6.

FASCIOLAE.—Test too weathered to show them but presumably both a peripetalous and marginal fasciole were present originally.

ORAL PLATE ARRANGEMENT.—Labrum extending posteriorly to one-third of height of second ambulacral plate; length 11% L. Plastron long (Figure 4) composed of four plates: two sternal plates 37% L in length, combined width 29% L; two episternal plates shorter 20% L, combined width 30% L. Sternal plates bordered by ambulacral plates 2–5.

OCCURRENCE.—Oligocene-Miocene, "Pedro Hernandez" farm, Tamarindo, Morón, Camagüey Province, Cuba.

Mauritanaster depressus Sánchez Roig

FIGURE 5; PLATE 10; FIGURES 5, 6

MATERIAL.—The holotype (SRC 4139), which is the only known specimen, is very poorly preserved. The ventral surface is absent; the test is very badly weathered, fractured, and distorted by postmortem compression.

SHAPE AND SIZE.—Length 68.5 mm, width (est.) 92% L; height not possible to determine because of postmortem distortion.

APICAL SYSTEM.—Central, located at distance

from anterior margin to center of genital pores equal to 48% L. Ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates; only three genital pores, no pore in genital plate 2.

AMBULACRA.—Anterior ambulacrum III in deep groove at margin with depth estimated at 5.7% L; porepairs small in adapical region but no further details visible because of fracturing. Anterior petals (II and IV) extending slightly more than two-thirds distance from apical system to margin; length 44% L, width 7.7% L, in groove with depth 4.5% L. Petals curving slightly anteriorly. Interporiferous zone width of single poriferous zone. Pores conjugate, outer pore more elongated than inner; 70 porepairs in petal; $\frac{1}{2}$ plate occluded in each poriferous zone (Figure 5) at end of petal.

Posterior petals (V and I) straight; length unknown, width estimated at 10% L, in groove. Number of petaloid porepairs unknown because of absence of end of petals.

PERISTOME.—Not preserved.

PERIPROCT.—Not preserved but on posterior overhanging truncation; inframarginal.

ORAL PLATE ARRANGEMENT.—Not preserved.

FASCIOLAE.—None visible, but test so badly weathered that they would not have been preserved if originally present.

OCCURRENCE.—Oligocene-Miocene, "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

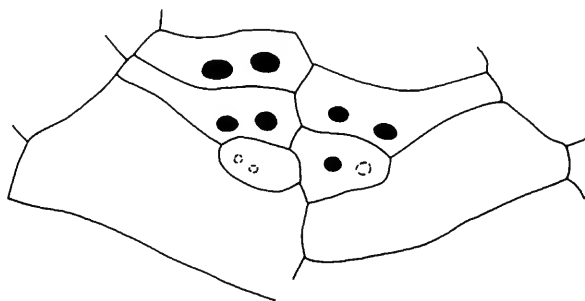


FIGURE 5.—*Pericosmus aguayoi* (Sánchez Roig), plate arrangement at end of petal IV of the holotype of *Mauritanaster depressus* Sánchez Roig (= *P. aguayoi*), SRC 4139, $\times 8$.

Mauritanaster marroquinensis Sánchez Roig

PLATE 11: FIGURES 1-3

MATERIAL.—Only one specimen, the holotype (SRC 4357), in the Sánchez Roig Collection. This specimen is the one figured by Sánchez Roig (1953a, pl. 14) in the original description. It is very poorly preserved being badly weathered, not showing the fascioles or the plate sutures, and lacking its posterior. The ventral surface has been compressed.

SHAPE AND SIZE.—Length can only be estimated, 87.0 mm; width 79.0 mm (est. 90% L); height (est.) 49% L with the greatest height just posterior to the apical system. Ventral surface depressed anterior and lateral to the peristome.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of system 32-mm (est. 37% L); no details of system visible.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove very shallow adapically but deepening crossing margin where depth 3.1 mm (est. 3.6% L). Nature of pores in dorsal region not discernible but apparently very small; number of plates not clear; width of ambulacrum at margin 8.9 mm (est. 10.2% L).

Anterior petals (II and IV) extending over two-thirds distance from apical system to margin, length 39.4 mm (est. 45% L), greatest width 7.8 mm (est. 9.0% L), in groove with depth 2.4 mm, (est. 2.9% L). Petals curving slightly anteriorly; interporiferous zone narrower than single poriferous zone; pores slightly conjugate, outer pore of pair more elongate than inner; 82 petaloid porepairs; not known in which plate first petaloid porepair occurs. Last 2½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

Posterior petals (V and I) only very slightly longer than anterior, extending two-thirds distance from apical system to margin, length 41.7 mm (est. 48% L); width 8.0 mm (est. 9.2% L); depth of groove 2.3 mm (est. 2.6% L). Petals straight; 86 petaloid porepairs. Last 2½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 16.0 mm (est. 18% L); width 16.9 mm (est. 19% L); height not known.

PERIPROCT.—Not preserved.

FASCIOLES.—None preserved but test too weathered to show them if they had been originally present.

ORAL PLATE ARRANGEMENT.—Sutures not clear.

OCCURRENCE.—Oligocene-Miocene, “Blanquizal” farm of the estate of Campanioni, Marroquín district, Morón, Camagüey Province, Cuba; “Las Cuevas” farm of Pedro Pozo, Marroquín district, Morón, Camagüey Province, Cuba.

Pericosmus valenzuelai Sánchez Roig

FIGURE 6; PLATE 11: FIGURES 4-6

MATERIAL.—One specimen, the lectotype (SRC 4021) (Sánchez Roig, 1953c: 167, pl. 10: fig. 5) is herein designated. The second cotype is missing. The lectotype is nearly complete except for the lack of part of the posterior. The test is very weathered resulting in the loss of the fascioles and the enhancing of the plate sutures.

SHAPE AND SIZE.—Length 62.8 mm, width 66.2 mm (105% L), height 23.8 mm (38% L); greatest height anterior to apical system; adoral surface flat.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2; ethmolytic (Figure 6A); located anterior of center at distance from anterior margin to center of genital pores equal to 34% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove deepest at margin of test where depth equal to 4.1% L. Character of pores not clear because of weathering of test; 42 plates.

Anterior petals (II and IV) long, extending almost to margin; length 42% L. Petals straight, depressed in groove, depth 3.5% L; petals narrow with greatest width 9.7% L. Porepairs with outer pore slit-like; 74 petaloid porepairs; interporiferous zone at its greatest width slightly less wide than single poriferous zone. First petaloid porepair in plate 13; total of 98 plates in ambulacra

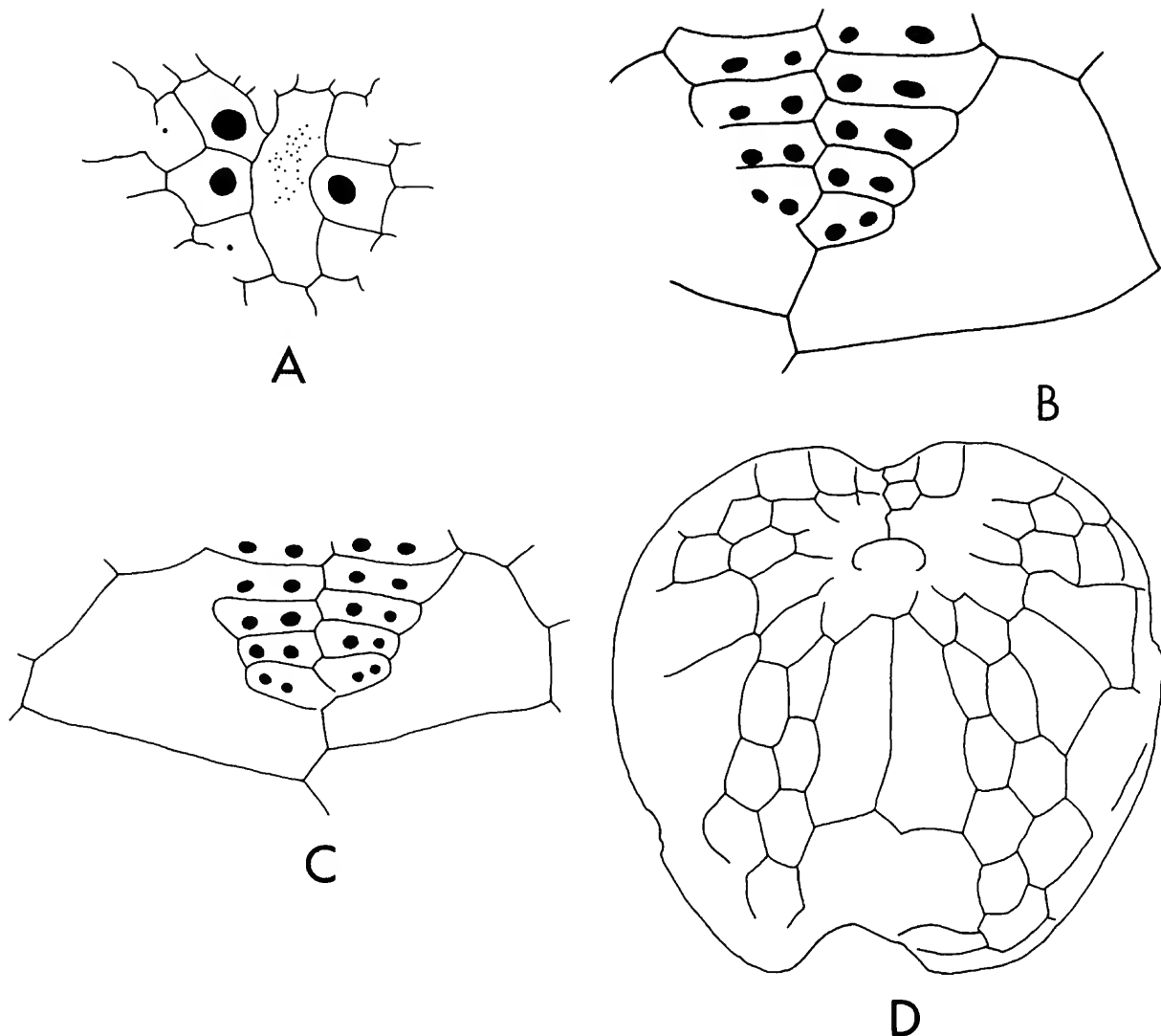


FIGURE 6.—*Pericosmus aguayoi* (Sánchez Roig), views of the holotype of *Pericosmus valenzuelai* Sánchez Roig (= *P. aguayoi*), SRC 4021: A, apical view, $\times 10$; B, end of petal I, $\times 10$; C, end of petal II, $\times 10$; D, ventral view, $\times 1.2$.

II or IV. Last $3\frac{1}{2}$ plates in single poriferous zone of petal occluded (Figure 6c).

Posterior petals (V and I) approximately same length as anterior, extending two-thirds distance from apical system to posterior margin, length 42% L, width 91% L. Petals straight, depressed in groove with depth 3.9% L, 74 petaloid porepairs, first petaloid porepairs in plate 17; total of 106 plates in ambulacrum. Last $3\frac{1}{2}$ plates in

single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal (Figure 6b).

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 16% L, opening wider than high, width 15% L, height not known.

PERIPROCT.—Unknown, test destroyed in this region.

FASCIOLES.—Only short tract of peripetalous fasciole visible; marginal not visible presumably because test is badly weathered. Sánchez Roig (1949:168) reports both to be well preserved on cotype, which is now missing. Peripetalous fasciole would cross ambulacra II or IV on plates 11 or 12; ambulacra V or I on plates 15 or 16.

ORAL PLATE ARRANGEMENT.—Labrum not preserved; plastron long (Figure 6D), composed of 4 plates: 2 sternal plates 40% L in length, combined width 33% L; 2 episternal plates shorter, 22% L, combined width 37% L. Sternal plates bordered by ambulacral plates 2(?)–5; episternal pair, by ambulacral plates 5–7. In interambulacrum 1, first plate followed by pair of plates although plate 2b nearly extends across interambulacrum (Figure 6D).

OCCURRENCE.—Miocene, “Sunset” farm (formerly “Gerona”) on highway between Cayajabos and Artemisa, Pinar del Rio Province, Cuba.

***Pericosmus atolladosae* (Sánchez Roig),
new combination**

FIGURES 7, 8; PLATE 11: FIGURES 7–9; PLATE 12:
FIGURES 1–8

Linthia atolladosae Sánchez Roig, 1951:59, pl. 34: figs. 1, 2.

Pericosmus rojasi Sánchez Roig, 1951:60, pl. 36: figs. 2, 3.

Pericosmus zanolettii Sánchez Roig, 1953c:169, pl. 11: fig. 2.

MATERIAL.—The holotype (SRC 4190), which is figured, is the only specimen. It is nearly complete, not distorted, but badly weathered with most of the tuberculation absent.

SHAPE AND SIZE.—Length 64.0 mm, width 61 mm (96% L), height 35 mm (55% L), with greatest width anterior, greatest height anterior of apical system.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2, ethmolytic; located slightly anterior of center at distance from anterior margin to center of genital pores equal to 38% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove deepest at margin of test where depth equal to 6.3% L. Porepairs in dorsal portion of anterior ambulacrum larger than at ambitus,

in peripodia with small node separating pores of pair; pores obliquely situated with inner pore of pair anterior to outer.

Anterior petals (II and IV) short, extending less than two-thirds distance from apical system to margin; length 37% L. Petals slightly curved (convex anteriorly), depressed in groove of depth 1.9% L; petals narrow with greatest width 8.0% L. Pores of pair conjugate with outer pores slit-like; 64 petaloid porepairs; interporiferous zone narrow, slightly more than one-half width of single poriferous zone; slight groove running length of petal in middle of interporiferous zone. Not possible to determine in which plate first petaloid porepairs occur.

Posterior petals (V and I) slightly shorter than anterior; length 33% L. Petals straight to very slightly curved posteriorly, depressed in shallow groove with depth 2.3% L, 56 (est.) petaloid porepairs. Last 3 plates in single poriferous zone of petals occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 17% L, opening wider than high, width 14% L, height 5.0% L.

PERIPROCT.—Situated on overhanging posterior truncation, opening visible from below, wider than high, width 21% L, height 13% L. Truncation depressed below periproct.

FASCIOLES.—Only part of peripetalous fasciole visible because of weathering of test. Marginal fasciole narrow, encircling test above margin. Not clear which plates bear fascioles because of obscuring of plate sutures.

ORAL PLATE ARRANGEMENT.—Labrum with height equal to 9.1% L; rest of plate sutures not clear.

OCCURRENCE.—Eocene, type specimens of *P. atolladosae* and *P. rojasi*, “Atolladosa” farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba; late Eocene, type specimen of *P. zanolettii*, Loma “Los Constantinos,” “La Ventura” farm, Marroquin district, Moron, Camagüey Province, Cuba.

REMARKS.—This species clearly is a *Pericosmus*. Not only is its shape and petal arrangement

similar to this genus; but it has a marginal fasciole, three genital pores, minute pores in ambulacrum III, and its distal petaloid plates are occluded, features typical of *Pericosmus*.

Pericosmus atolladosae is very similar and probably conspecific with *Pericosmus rojasi* Sánchez Roig from the same locality. The holotypes have equally depressed, short petals with interporiferous zones of similar width. The apical system is anteriorly situated, and peristome and periproct are in the same relative positions. The difference in the height of their tests is probably not significant.

Likewise, *Pericosmus zanolettii* Sánchez Roig also from the Eocene of Cuba appears to be a synonym of *P. atolladosae*. The petals are indistinguishable and the differences in the shape of their tests probably fall well within the range of variation in a species of *Pericosmus*.

SYNONYMS

Pericosmus rojasi Sánchez Roig

FIGURE 7; PLATE 12: FIGURES 1-4

MATERIAL.—The holotype (SRC 4300) is the only specimen known of this species. It is very poorly preserved, being fractured, badly weathered, and abraded.

SHAPE AND SIZE.—Length 52.5 mm, width 49.2 mm (94% L), height 35.4 mm (67% L); test very high with greatest height posterior to apical system, greatest width anterior. Posterior truncation overhanging, sides smoothly rounded.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2; ethmolytic; located anterior of center at distance from anterior margin to center of genital pores equal to 34% L.

AMBULACRA.—Anterior ambulacrum III not petaloid; lying in groove from apical system to peristome, groove very shallow near apical system, deepest at margin of test depth equal to 4.2% L. Peripodia very slightly developed; number of plates not clear.

Anterior petals (II and IV) extending less than two-thirds distance from apical system to margin;

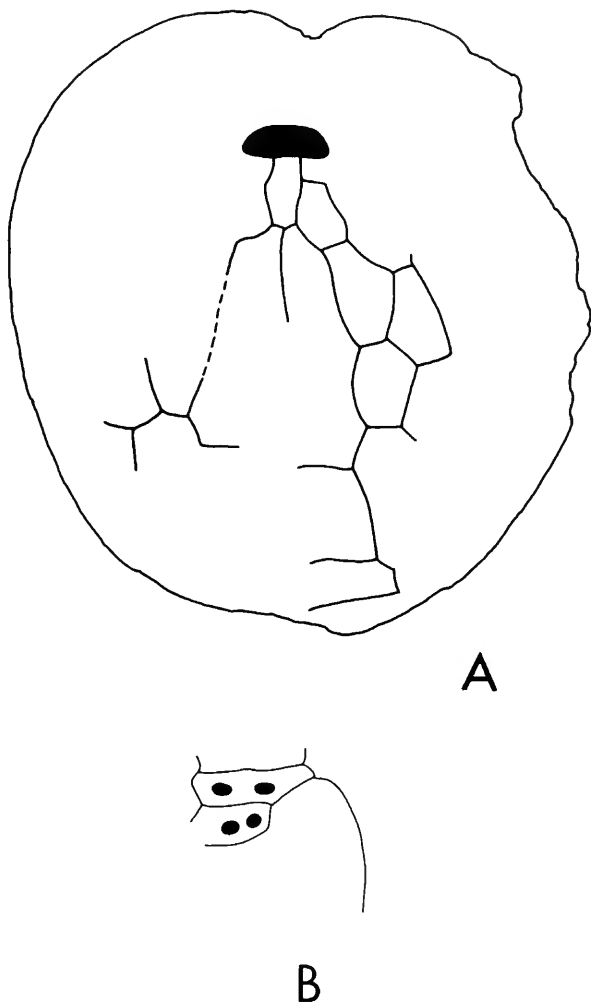


FIGURE 7.—*Pericosmus atolladosae* (Sánchez Roig), views of the holotype of *Pericosmus rojasi* Sánchez Roig (= *P. atolladosae*), SRC 4300: A, ventral view, $\times 1.5$; B, end of petal I, $\times 8$.

length 31% L, greatest width 8.4% L. Petals straight, in shallow groove, depth 2.1% L. Pore-pairs slightly conjugate with outer pore slit-like; 52 petaloid pores; interporiferous zone narrower than poriferous.

Posterior petals (V and I) approximately same length as anterior, extending one-half distance from apical system to margin, length 28% L, greatest width 7.4% L. Petals straight in very shallow groove, 50 petaloid porepairs. Last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded

(Figure 7B), enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 15% L; opening wider than high, width 14% L, height 5.7% L.

PERIPROCT.—Located on overhanging truncation, visible from ventral side; wider than high, width 17% L, height 11% L.

FASCIOLES.—Not preserved.

ORAL PLATE ARRANGEMENT.—Labrum (Figure 7A) extending posteriorly to posterior one-third of height of second ambulacral plate; length 12% L. Plastron long (Figure 7A), composed of 4 plates: 2 sternal plates 39% L in length, combined width 27% L; 2 episternal plates, shorter, 18% L (est.), combined width 29% L. Sternal plates bordered by ambulacral plates 2–5, episternal pair by ambulacral plates 5–7. Not clear whether first 2 plates of interambulacrum 1 are single.

OCCURRENCE.—Eocene, “Atolladosa” farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

Pericosmus zanolettii Sánchez Roig

FIGURE 8; PLATE 12: FIGURES 5–8

MATERIAL.—Only one specimen (SRC 4239) is present in the Sánchez Roig Collection although Sánchez Roig mentions two cotypes in his original description. This specimen is figured in his description and is herein selected as the lectotype (Sánchez Roig, 1953c, pl. 11: fig 2). It is moderately well preserved and although weathered still retains traces of the fascioles.

SHAPE AND SIZE.—Length 56.0 mm, width 52.8 mm (94% L), height 26.0 mm (46% L). Greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2; anterior, located at distance from anterior margin to center of genital pores equal to 37% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove very shallow near apical system, deepest at margin of test where depth equal to 3.8% L; 48 plates.

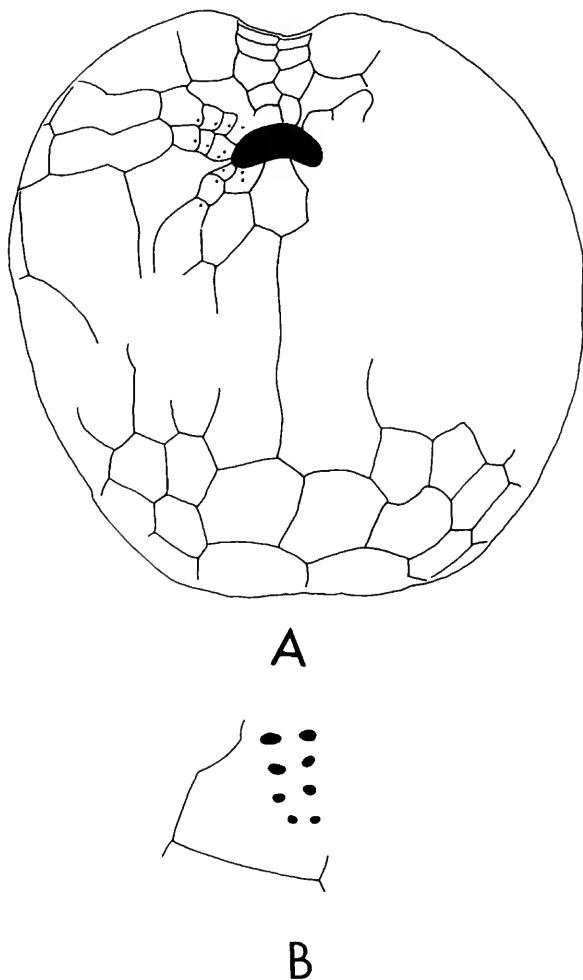


FIGURE 8.—*Pericosmus atolladosae* (Sánchez Roig), lectotype of *Pericosmus zanolettii* Sánchez Roig (= *P. atolladosae*), SRC 4239: A, ventral view, $\times 1.5$; B, end of petal I, $\times 6$.

Anterior petals (II and IV) extending two-thirds distance to margin; length 38% L, width 8.2% L. Petals curve anteriorly, depressed in deep groove, depth 3.2% L. Outer pore of pair slit-like; 66 petaloid porepairs, interporiferous zones slightly narrower than poriferous. First petaloid porepair in plate 14; total of 92 plates in ambulacrum.

Posterior petals (V and I) shorter than anterior, extending one-half distance from apical system to margin; length 32% L, width 8.9% L. Petals curving posteriorly, depressed in groove with depth 2.7% L; 56 petaloid porepairs, first petaloid

porepair in plate 18; total of 90 plates in ambulacrum. Last $2\frac{1}{2}$ to $3\frac{1}{2}$ plates in single poriferous zone of petal occluded (Figure 8B), enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 18% L, opening wider than high, width 15% L, height 4.8% L.

PERIPROCT.—Located on overhanging truncation, slightly visible from ventral side; wider than high, width 18% L, height 11% L, located within interambulacral plates 4–8.

FASCIIOLES.—Peripetalous fasciole narrow, curving slightly into interambulacra 4, 5, 1; crossing ambulacra II or IV on plate 13, V or I on plate 16 or 17; crossing interambulacra 4 or 1 on plates 11, 12. Marginal fasciole narrow passing around test adapical of margin and below periproct; crossing ambulacra II or IV on plates 8, 9; V or I on 10, 11; crossing interambulacra 4 or 1 on plates 4, 5; interambulacrum 5 on plates 4, 5.

ORAL PLATE ARRANGEMENT.—Labrum (Figure 8A) extending posteriorly to anterior two-thirds of height of second ambulacral plate, length 13% L. Plastron long (Figure 8A) composed of 4 plates: 2 sternal plates, 42% L in length, combined width 29% L (est.); 2 episternal plates shorter, 17% L, combined width 30% L. Sternal plates bordered by ambulacral plates 2–5, episternal pair by plates 4, 5. First plate of interambulacra in contact with peristome.

OCCURRENCE.—Late Eocene, Loma “Los Constantinos,” “La Ventura” farm, Marroquín district, Morón, Camagüey Province, Cuba.

***Pericosmus blanquizalensis* Sánchez Roig**

FIGURE 9; PLATE 12: FIGURES 9–11

Pericosmus blanquizalensis Sánchez Roig, 1952c:21, pl 13:fig. 2.

MATERIAL.—One specimen: the holotype and figured specimen (SRC 4106). The specimen is slightly crushed with part of the left side and posterior missing.

SHAPE AND SIZE.—Length 60 mm, width 59 mm (97% L), height (est.) 24 mm (40% L), with greatest height posterior of apical system. Ventral surface elevated at posterior of plastron.

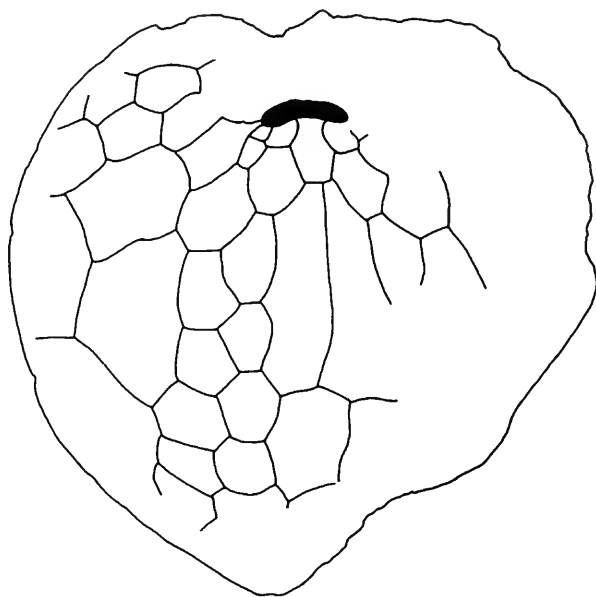


FIGURE 9.—*Pericosmus blanquizalensis* Sánchez Roig, ventral view of the holotype, SRC 4106, $\times 1.4$.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2, ethmolytic; located slightly posterior of center at distance from anterior margin to center of genital pores equal to 42% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove deepest at margin of test where depth equal to 3.8% L. Character of pores not clear because of weathering of test; 50 plates.

Anterior petals (II and IV) short, extending slightly more than over one-half distance from apical system to margin; length 31% L. Petals straight, depressed in groove with depth 1.8% L; petals narrow with greatest width 6.1% L. Pores conjugate with outer pore slit-like; 66 petaloid porepairs; interporiferous zone narrow, approximately one-half width of single poriferous zone; groove running length of petal in middle of interporiferous zone. First petaloid porepair in plate 14 or 15; total of 92–94 plates in ambulacrum II or IV.

Posterior petals (V or I) slightly shorter than anterior petals; length 31% L. Petals straight, depressed in shallow groove with depth 1.3% L, 64 petaloid porepairs, first petaloid porepair in plate 18 or 19; total of 100–102 plates in ambu-

lacrum. Last $2\frac{1}{2}$ plates in single poriferous zone of petals occluded, enclosed by first ambulacral plate beyond petal.

Pores paired beyond petals. Phyllodes with porepairs in well-developed peripodia with high ridge separating pores, 4 in ambulacrum III, 6 in II or IV, number uncertain in posterior ambulacra.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 12% L (est.), opening wider than high, width 15% L, height 4.8% L (est.).

PERIPROCT.—Unknown, test destroyed in this region.

ORAL PLATE ARRANGEMENT.—Labrum (Figure 9) extending posteriorly to anterior one-third of height of second ambulacral plate; length 10% L. Plastron long (Figure 9) composed of 4 plates: 2 sternal plates 37% L in length, combined width 23% L; 2 episternal plates shorter, 19% L, combined width 27% L (est.). Sternal plates bordered by ambulacral plates 2–5, episternal by ambulacral plates 5–7. First and second plate of interambulacrum 1 not paired, second plate extending across interambulacrum.

OCCURRENCE.—Oligocene-Miocene, “Blanquizar” farm, Tamarindo district, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar and may be conspecific with *Pericosmus mortenseni* (Sánchez Roig) from the same locality. It differs in having more depressed petals and a deeper anterior groove, but these differences may be due to postmortem distortion. It differs from *Pericosmus camagueyanus* Sánchez Roig, also from the Oligocene-Miocene, by having narrower, deeper, and longer petals and a narrower labrum.

***Pericosmus camagueyanus* Sánchez Roig**

FIGURE 10; PLATE 13; FIGURES 1–4

Pericosmus camagueyanus Sánchez Roig, 1949:246, pl. 38: figs. 1, 2.

MATERIAL.—There are 4 specimens in the Sánchez Roig Collection labelled as belonging to this

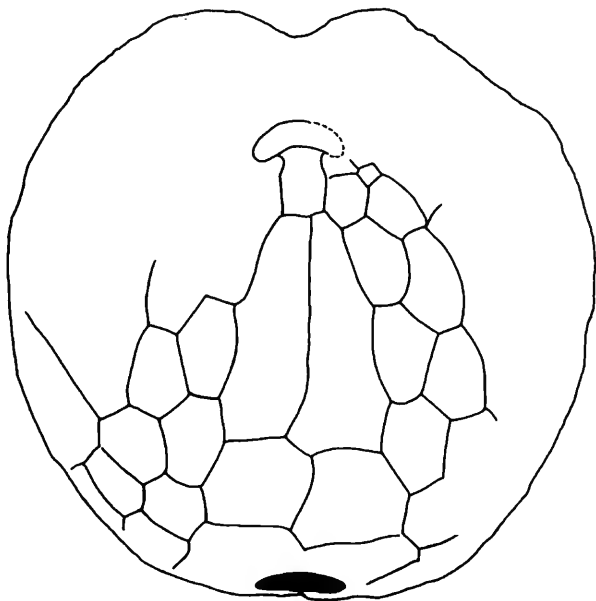


FIGURE 10.—*Pericosmus camagueyanus* Sánchez Roig, ventral view of the lectotype, SRC 4202, $\times 1.5$.

species. One of them (SRC 4202) is labelled as a type and is from the type-locality. It is herein designated as the lectotype. The specimen figured in the original description is missing. The following description is based on the lectotype and not on the other specimens, because they do not appear to be conspecific with it.

SHAPE AND SIZE.—Length 69 mm, width 65 mm (95% L), height 29 mm (42% L), greatest width and height anterior to center; ventral surface flat, margin sharp.

APICAL SYSTEM.—No genital pore in genital plate 2; present in genital 1 and 3, but genital 4 absent due to fracturing of test but presumably this genital had a pore; ethmolytic; located slightly anterior of center at distance from anterior margin to center of genital pores equal to 46% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove very slight near apical system, deepest at margin of test where depth equal to 4.4% L. Peripodia very slightly developed; number of plates not clear.

Anterior petals (II and IV) extending two-thirds distance to margin; length 39% L; width 9.1% L. Petals curving slightly anteriorly, slightly depressed in groove, depth 1.3% L. Porepairs slightly conjugate with outer pore only slightly more elongated than inner; 68 petaloid porepairs; interporiferous zone narrower than poriferous with greatest width near apical system, tapering distally. First petaloid porepair in plate 13; total of 92 plates in ambulacra II or IV.

Posterior petals (V and I) slightly longer than anterior extending slightly less than two-thirds distance from apical system to margin; length 40% L, width 9% L. Petals curving very slightly posteriorly, depressed in slight groove with depth 1.0% L, 74 petaloid porepairs, first petaloid porepair in plate 15; total of 102 plates in ambulacrum. Last $3\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 15% L, opening wider than high, width 17% L, height 4.8% L.

PERIPROCT.—Located on overhanging truncation, visible from ventral side; wider than high, width 17% L, height 8.7% L; located within interambulacral plates 4, 5 and perhaps 6.

FASCIOLAS.—Peripetalous fascioles narrow, curving sharply into interambulacra 1, 4, 5; crossing ambulacra II or IV on plate 12, V or I on plate 14; not clear on which interambulacral plates. Marginal fascioles narrow, passing along margin of test and below periproct; crossing ambulacra II or IV on plate 8; ambulacra V or I on plate 9; interambulacrum V on plates 4, 5.

ORAL PLATE ARRANGEMENT.—Labrum (Figure 10) extending posteriorly to posterior one-third of height of second ambulacral plate; length 12% L. Plastron long (Figure 10) composed of 4 plates: 2 sternal plates, 40% L in length, combined width 28% L; 2 episternal plates shorter, 19% L, combined width 34% L. Sternal plates bordered by ambulacral plates 2–5, episternal by ambulacral plates 5, 6. Not clear whether first 2 plates of interambulacrum are single.

OCCURRENCE.—Oligocene-Miocene, lectotype,

12 km NE of Jatibonico, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Pericosmus camagueyanus* is very similar to and may be conspecific with *Pericosmus aguayoi* (Sánchez Roig) also from the Cuban Oligocene-Miocene. Their petals are of similar length and arrangement. The anterior petals in the holotype of *P. aguayoi* appear to be more depressed, but this is the result of postmortem distortion.

Likewise, the ventral side of test in *P. camagueyanus* is partially depressed by this distortion. The apical system is more central in *P. camagueyanus*. For this reason I do not synonymize the 2 species although this difference may fall within the range of variation within a species of *Pericosmus*. *Pericosmus camagueyanus* is very similar to *P. blanzai* Sánchez Roig also from the Oligocene-Miocene of Cuba and differs only in the shape of its test with its greatest height anterior instead of posterior and its wider, shallower, and longer petals.

Pericosmus camagueyanus differs from the Miocene Cuban *P. valenzuelai* Sánchez Roig in having its apical system central not anterior and in having its petals in much shallower grooves.

Pericosmus mortenseni (Sánchez Roig), new combination

FIGURE 11; PLATE 13: FIGURES 5–7

Antillaster mortenseni Sánchez Roig, 1952c:20, pl. 14: figs. 2, 3.

MATERIAL.—The holotype (SRC 4185) is moderately well preserved with the test only slightly distorted but weathered, so that much of the tuberculation including most of the fascioles are eroded away.

SHAPE AND SIZE.—Length 68 mm, width 94% L, height 37% L; greatest width anterior, greatest height at apical system; ventral surface flattened to depressed.

APICAL SYSTEM.—Three genital pores, no pore in genital plate 2, ethmolytic; located slightly anterior of center at distance from anterior margin to center of genital pores equal to 35% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove where crossing margin;

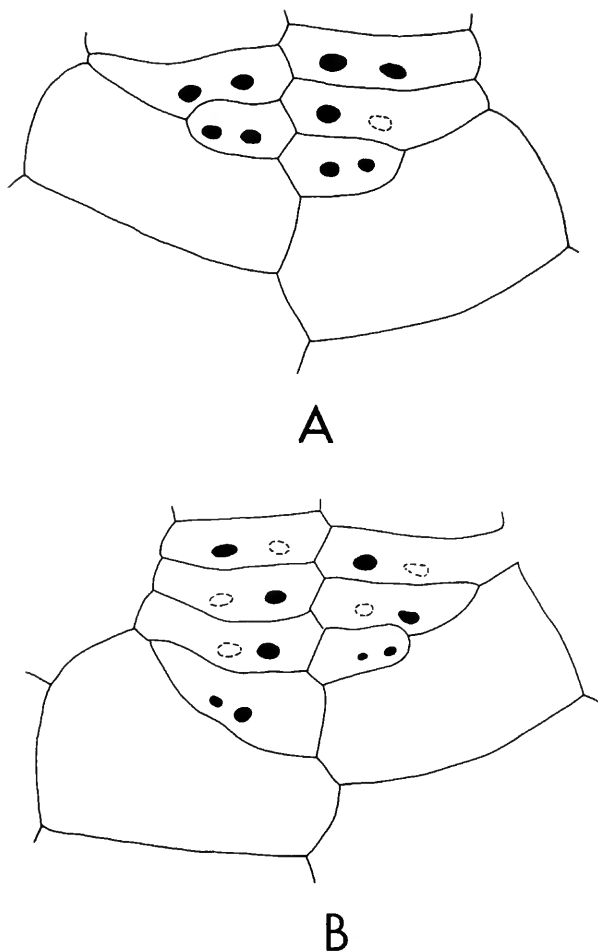


FIGURE 11.—*Pericosmus mortenseni* (Sánchez Roig), holotype, SRC 4185: A, end of petal II, $\times 10$; B, petal IV, $\times 10$.

pores in dorsal region very small, nature of peripodia not clear; 50 plates in ambulacrum.

Anterior petals (II and IV) short, extending slightly more than one-half distance from apical system to margin, length 29% L, width 8.1% L; straight to curving very slightly anteriorly, slightly depressed; interporiferous zone approximately same width as poriferous. Pores conjugate with outer pore more elongate than inner; 60 petaloid porepairs; first petaloid porepair in plate 14 or 15; total of 73–74 plates in ambulacrum. Ambulacrum II with last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacrum beyond petal (Figure 11A); am-

bulacrum IV with $1\frac{1}{2}$ in anterior poriferous zone, $2\frac{1}{2}$ in posterior poriferous zone occluded (Figure 11B).

Posterior petals (V and I) approximately same length as anterior petals; length 31% L, width 8.5% L, curving very slightly posteriorly; very slightly depressed; 64 petaloid porepairs; number of occluded plates not clear. Presence or absence of subanal pores not clear because of poor preservation.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 15% L; opening wider than high; width 16% L, height uncertain.

PERIPROCT.—Located high on steeply inclined posterior truncation; visible from below; dimensions of opening unknown; wider than high.

FASCIOLES.—Peripetalous fasciole eroded away; only short track of marginal fasciole preserved.

ORAL PLATE ARRANGEMENT.—Most of plastron missing; sutures not clear in interambulacrum 1.

OCCURRENCE.—Oligocene-Miocene, “Blanquizal” farm, Tamarindo, Morón, Camagüey Province, Cuba. Specimens SRC 4759 and SRC 4760 from “La Fortuna de Federico Pozo”, Marroquín, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Pericosmus blanquizalensis* Sánchez Roig from the same locality. The two holotypes have the same shape, the petals are of similar length, width, and arrangement, and the peristome is in similar position in both. The petals in *P. blanquizalensis* are more depressed and the anterior groove is deeper but these differences may be due to postmortem distortion. The more posterior position of the apical system in *P. blanquizalensis* may also be caused by distortion. *P. mortenseni* differs from *P. camagueyanus* Sánchez Roig and *P. aguayoi* Sánchez Roig, both from the Oligocene-Miocene, in its shorter petals, which do not extend so near to the margin of the test.

REMARKS.—Sánchez Roig probably referred this species to *Antillaster* because he thought it lacked fascioles and had 4 genital pores. Its marginal fasciole, 3 genital pores, and occluded plates at the end of its petals are characters typical of *Pericosmus*.

There are 2 specimens in the Sánchez Roig Collection (SRC 4759 and 4760), which Sánchez Roig labelled (but never described) as representing a new species. They are similar in their dimensions and number of petaloid porepairs to the holotype of *P. mortenseni* and in no significant character do they differ.

UNRECOGNIZABLE SPECIES OF *Pericosmus*

Pericosmus cubanus Palmer

Pericosmus cubanus Palmer in Sánchez Roig, 1949:248.

The type specimen has been lost and this species has never been figured.

OCCURRENCE.—Late Eocene, "Junquito" farm, 200 m E of San Antonio on the road from Maraguan, Camagüey Province, Cuba.

Pericosmus roigi Lemoine

Hemipatagus hoffmani—Sánchez Roig, 1920:5, fig. 24 [not Goldfuss, 1826].

Meoma roigi Lemoine, 1921:121.

Pericosmus roigi.—Lambert in Lambert and Thiéry, 1925 [1909–1925]:513.—Sánchez Roig, 1926:128, pl. 41: figs. 4, 5; 1949:245, pl. 38: figs. 3, 4.

The holotype and only known specimen is lost. Sánchez Roig's photograph is so poor and the holotype was so poorly preserved that it is not possible to determine the affinities of this species.

OCCURRENCE.—Miocene, railroad station at Ceiba, railroad from Marianao, Habana Province, Cuba. Although Sánchez Roig (1949:246) and Brodermann (1949:325) consider this locality to be late Oligocene, Brönnimann and Rigassi (1963:466) state that the Cojimar Formation outcrops here. They date this formation as Miocene on the basis of foraminifera.

Family SCHIZASTERIDAE Lambert, 1905

Genus *Schizaster* L. Agassiz, 1836

Test with faint or deep anterior notch, ambulacrum III not petaloid with enlarged porepairs apically. Anterior petals longer than posterior,

all petals depressed; single pores beyond petals. Apical system with 2 or 4 genital pores, ethmolytic. Both peripetalous and latero-anal fascioles present.

HABITAT.—These species of *Schizaster* no doubt lived buried in the sediment. The modern species, *Schizaster doederleini* (Chesher) has been reported (Kier, 1975:14) to live buried to a depth of 20–100 mm in mud. The fossil species share with this living species the following features, all of which indicate a burrowing habit: funnel-building tubefeet in the anterior ambulacrum (as indicated by presence of enlarged porepairs), depressed anterior ambulacrum and depressed well-developed petals, and presence of peripetalous and latero-anal fascioles. The thin tests and large plastrons also suggest a subsurface habitat. Modern species live in tropical to temperate waters from shallow depths to 900 m.

EVOLUTION.—The sixteen recognizable species of *Schizaster* from Cuba range from the Eocene through the Miocene. Although there are no obvious evolutionary trends, *S. bathypetalus* Arnold and Clark from the Eocene, *S. cartagensis* (Sánchez Roig) from the Oligocene-Miocene, and *S. delgadoi* (Sánchez Roig) from the Miocene all share large tests with deeply depressed petals. The Eocene *S. llagunoi* Lambert and Sánchez Roig and *S. santanae* Sánchez Roig are similar in size of test, position of apical system, and large number of enlarged porepairs in ambulacrum III to the late Oligocene-early Miocene *S. munozi* Sánchez Roig and the three species may be related. The Eocene *S. subcylindricus* Cotteau and *S. camagueyensis* Weisbord are obviously closely related and appear to be ancestral to the Miocene *S. fernandezi* Sánchez Roig; all share a posterior apical system, very short posterior petals, curved anterior petals, and few enlarged porepairs in ambulacrum III. The rest of the species appear to have no near relatives in Cuba or elsewhere.

COMPARISON WITH OTHER SPECIES OUTSIDE OF CUBA.—Three of the species of *Schizaster* from Cuba are found elsewhere. *S. gerthi* Pijpers occurs in both Cuba and Bonaire, *S. bathypetalus* Arnold and Clark occurs in Cuba and Jamaica, and *S. subcylindricus* Cotteau occurs in Cuba, Jamaica,

and St. Bartholomew. *Schizaster munozi* Sánchez Roig from the late Oligocene or early Miocene of Cuba is very similar to *S. americanus* Clark from the Oligocene (Vicksburg) of southeastern United States. It is also quite similar to *S. clevei* Cotteau from the Miocene of Anguilla. *S. subcylindricus* Cotteau is like *S. beckeri* Cooke from the late Eocene Ocala Limestone of Florida. The other Cuban species of *Schizaster* are distinctive with no close relatives.

REMARKS.—Generally the genus *Paraster* or subgenus *Schizaster* (*Paraster*) has been used for species having 4 genital pores. Lambert and Thiéry (1909–1925:522) did not consider the number of genital pores of generic significance believing that the number varied within the same species. Although I have never seen any variation in the number of genital pores within a species (including hundreds of specimens of the living *Paraster doederleini* Chesher and many of the Cuban species), McNamara and Philip (1980:49) report this variation in some of their Australian species. Unfortunately the number of genital pores is uncertain (Henderson, 1975:14) in *Schizaster studeri* Agassiz, the type-species of the genus. McNamara and Philip (1980:49), however, define the subgenus *Paraster* on other characters. In their view, *Paraster* comprises species which differ from typical species of *Schizaster* in having a more shallow ambulacrum III, a more circular test, a less posteriorly situated apical system, and anterior petals that are straighter and that diverge more strongly. I have tried unsuccessfully to use their system for the Cuban species. Although some species fall readily into *S.* (*Paraster*) or *S.* (*Schizaster*), others have characters of both subgenera. For example, *Schizaster bathypetalus* Arnold and Clark has the deep anterior groove and curved anterior petals of a *S.* (*Schizaster*) and also has the central apical system of a *S.* (*Paraster*). *S. cartagensis* Sánchez Roig has the deep anterior groove of a *S.* (*Schizaster*) but also has the central apical system of a *S.* (*Paraster*). *Schizaster subcylindricus* Cotteau has the posterior apical system of a *S.* (*Schizaster*) and has the shallow anterior groove of a *S.* (*Paraster*). Furthermore, the num-

ber of genital pores does not correlate with any other particular character. Therefore, in this paper, I abandon any effort to use the subgenus *Paraster* and refer all the species to *Schizaster*.

Thirty-seven species from Cuba have been referred to *Paraster* or *Schizaster*. Sixteen are recognized herein. The type specimens of ten species are lost or are too poorly preserved to permit recognition of their specific characters. One species is transferred to another genus and 8 species are considered to be synonyms. These species are listed in Table 3, except *S. parkinsoni*. Cotteau (1875:6; 1897:84) referred some Cuban specimens to *Schizaster parkinsoni* DeFrance, previously known from Europe. He did not illustrate any of the Cuban specimens and they are no longer in his collection, so it is not possible to confirm this occurrence.

***Schizaster bathypetalus* Arnold and Clark**

FIGURES 12, 13; PLATES 14, 15

Schizaster bathypetalus Arnold and Clark, 1927:58, 60, pl. 12: figs. 1–4.

Schizaster gigas Sánchez Roig, 1953a:66, pl. 20.

Schizaster pentagonalis Sánchez Roig, 1953a:65, pl. 19.

OCCURRENCE.—Eocene, in the Spring Mount Region, S and W towards Seven Rivers, St. James Parish, Jamaica. Middle to late Eocene, Loma Caoba, San Diego de Los Baños, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from *Schizaster subcylindricus* Cotteau, which occurs with it at Loma Caoba by its far larger test, more central apical system with 4 genital pores, longer posterior petals and anterior petals that curve in an opposite direction. It differs from *S. gerthi* Pijpers also from Loma Caoba by its larger test, more divergent and longer posterior petals and more curved anterior petals.

REMARKS.—I cannot distinguish *S. gigas* (Eocene of Cuba) from *S. bathypetalus* (Eocene of Jamaica). I have compared the Cuban specimens with the type specimen of the Jamaican species and they differ in no significant features. The

TABLE 3.—Disposition of Cuban species of *Schizaster*
(*P.* = genus *Paraster*)

Disposition	Miocene ¹	Oligocene-Miocene	Eocene
Recognized species (synonyms)	<i>S. delgadoi</i> <i>S. fernandezi</i>	<i>S. cartagensis</i> <i>S. egozcuei</i> <i>S. munozi</i> (<i>P. orientalis</i>) (<i>P. ischopi</i>) (<i>S. guirensis</i>) (<i>S. riveroi</i>) (<i>S. salutis</i>) <i>S. rojasi</i> <i>S. sanctamariae</i>	<i>S. bathypetalus</i> (<i>S. gigas</i>) (<i>S. pentagonalis</i>) <i>S. camagueyensis</i> <i>S. cubitabellae</i> <i>S. formelli</i> <i>S. gerthi</i> (<i>P. clarki</i>) <i>S. llagunoi</i> <i>S. nuevitasensis</i> <i>S. santanae</i> <i>S. subcylindricus</i>
Unrecognizable species	<i>S. cojimarensis</i> <i>S. cubensis</i> ² <i>S. habanensis</i> <i>S. sierrai</i> ³	<i>S. moronensis</i>	<i>S. alcaldei</i> <i>S. caobaense</i> <i>S. pastelilloensis</i> <i>S. pinarensis</i> <i>S. sandiegensis</i>
Referred to other genera	<i>S. vedadoensis</i> (= <i>Migliorinia habanensis</i>)		

¹ Unless otherwise noted. ² Pliocene ? ³ Pleistocene.

holotype (Plate 15: figure 2) of *S. bathypetalus* has longer posterior paired petals than the lectotype (Plate 14: figure 6) of *S. gigas*, but this difference is due to the smaller size of the holotype. Among the Cuban specimens, the smaller specimens have relatively longer posterior petals than the larger specimens. For example, a specimen 73 mm long has posterior petals 26% L; whereas, in a specimen 64 mm long the petals are 30% L. Likewise, the holotype of *S. bathypetalus* is 58 mm long with posterior petals 34% L; and the larger paratype is 72 mm long, with petals only 28% L.

I have exposed the petals and apical system in the paratype of *S. bathypetalus* (Plate 15: figure 1). The apical system has 4 genital pores. The anterior ambulacrum has 76 enlarged porepairs; petal II, 78 porepairs; and petal I, 56. The first petaloid porepair is in plate 18 or 19 in ambulacrum I, not discernible in other ambulacra.

S. pentagonalis Sánchez Roig, from the same locality as *S. gigas*, appears to be indistinguishable

from *S. gigas* and *S. bathypetalus*. Sánchez Roig distinguished *S. pentagonalis* from *S. gigas* by its higher test and narrower anterior groove. However, Sánchez Roig's (1953, pl. 19) figured specimen was badly distorted and it was not possible to determine its original height. The height of the neotype of *S. pentagonalis* is very similar to that of the specimen of *S. gigas*. Likewise, there is no significant difference in the width of the anterior groove in the 2 species: a specimen of *S. pentagonalis* has a groove with a width 15% L and *S. gigas* has a groove 13% L.

SYNONYMS

Schizaster gigas Sánchez Roig

FIGURE 12; PLATE 14: FIGURE 6; PLATE 15: FIGURES 3–7

MATERIAL.—Sánchez Roig's figured specimen is no longer in the collection, and neither is a smaller cotype mentioned in his description. Two

topotypic specimens identified by him are present, one of which is labelled as a cotype. This specimen (SRC 4946) is herein designated the lectotype. The description below is based on the following specimens, one (SRC 5001, Plate 15: figures 5–7) collected by Albear, Formell, and Kier at the type-locality, 3 topotypes in the USNM collections (Plate 15: figure 3) and one specimen, ANSP 16653 (Plate 15: figure 4), in the Palmer Collection at the Academy of Natural Sciences of Philadelphia. The lectotype is highly weathered, with the adoral posterior region broken away. The other specimen in the collection, the Palmer specimen, and one of the USNM specimens, have highly weathered but undistorted tests.

SHAPE AND SIZE.—Test large, high with greatest height posterior, greatest width anterior, length 61 to 70 mm, width 94 to 109% L, greatest height 69 to 81% L. Posterior truncation nearly vertical, very high, anterior sloping steeply.

APICAL SYSTEM.—Central to slightly posterior, ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates; 4 genital pores (Figure 12).

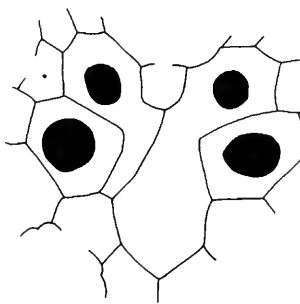


FIGURE 12.—*Schizaster bathypetalus* Arnold and Clark, apical system of a topotype of *Schizaster gigas* Sánchez Roig (= *S. bathypetalus*), USNM 341150, $\times 18$.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very deep groove extending from apical system to peristome; groove deepest and widest midway between apical system and test margin where width 13 to 18% L, depth 11 to 12% L; sides of groove nearly vertical. Pores paired only in adapical region where pores enlarged in peripodia with node separating pores of pair; enlarged porepairs present from apical system to approximately two-thirds distance to margin; porepairs in single row. First enlarged pores

in plate 7, 84 enlarged porepairs in lectotype 63 mm long.

Anterior petals (II and IV) flexuous, curved convexly to anterior, extending two-thirds distance from apical system to margin, length 44 to 50% L, greatest width 7.7 to 10% L; in deep groove with greatest depth 5.2 to 7.4% L. Pores strongly conjugated, 78 petaloid porepairs in lectotype 63.3 mm long, 60 in specimen 60 mm long; interporiferous zone approximately same width as single poriferous zone; pores single beyond petals. Not possible to determine which plate bears first petaloid porepair.

Posterior petals (V and I) short, straight, extending slightly more than one-half distance from apical system to margin; length 24 to 31% L, width 8.1 to 9.2% L, depth of groove 4.4 to 6.0% L; 54 petaloid porepairs in lectotype 63.3 mm long, 46 in specimen 60 mm long.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 12 to 19% L, opening wider than high, width 21 to 25% L, height 3.5 to 5.1% L.

PERIPROCT.—Located high on nearly vertical posterior truncation, opening higher than wide.

FASCIOLES.—Peripetalous fasciole very wide where passing around extremities of petals, deeply indented in interambulacra. Latero-anal fasciole passing in deep lobe below periproct.

ORAL PLATE ARRANGEMENT.—Labrum short, length 7.6% L; sternal plates very long, 61% L, greatest combined width of both sternal plates 38% L. First plate in interambulacrum 2 followed by pair of plates.

OCCURRENCE.—Middle to late Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Schizaster pentagonalis Sánchez Roig

FIGURE 13: PLATE 14: FIGURES 1–5

MATERIAL.—Both the figured specimen and cotype, for which the dimensions are given by Sánchez Roig, are lost. One topotypic specimen (SRC 4762) identified by Sánchez Roig remains in the Sánchez Roig Collection and it is herein

described. The specimen is slightly compressed but its tuberculation is well enough preserved to show the fascioles.

SHAPE AND SIZE.—Test very large, length 87.0 mm (est.), width 90 mm (104% L), height 62 mm (72% L); greatest height posterior.

APICAL SYSTEM.—Ethmolytic, genital plate 2 extending posteriorly and separating posterior ocular plates; apparently 4 genital pores but test fractured in apical region covering part of system. Anterior, at distance from anterior margin to center of genital pores 34% L.

AMBULACRA.—Ambulacrum III not petaloid, in very deep groove extending from apical system to peristome; groove deepest and widest midway between apical system and margin where width 15% L, depth 12% L; sides of groove nearly vertical. Pores paired only in adapical region where pores enlarged in peripodia (Plate 14: figure 5) with node separating pores of pair; outer pore of pair more elongated than inner. Enlarged porepairs present from apical system to approximately two-thirds distance to margin; porepairs in single row; 88 porepairs in area with enlarged porepairs.

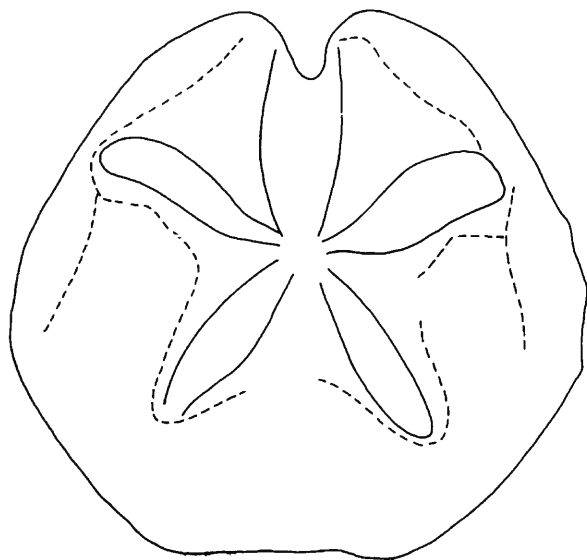


FIGURE 13.—*Schizaster bathypetalus* Arnold and Clark, dorsal view of a topotype of *Schizaster pentagonalis* Sánchez Roig (= *S. bathypetalus*), SRC 4762, $\times 0.9$.

Anterior petals (II and IV) flexuous, curved convexly to anterior, extending slightly more than two-thirds distance from apical system to margin, length 46% L, greatest width 8.4% L, in deep groove with greatest depth 7.6% L. Pores strongly conjugated, 90 petaloid porepairs; interporiferous zone approximately same width as single poriferous zone; pores single beyond petals; first petaloid porepair in plate 10 or 11.

Posterior petals (V and I) short, straight, extending approximately one-half distance from apical system to margin; length 30% L, width 9.3% L, depth of groove 5.3% L; 64 porepairs. Not possible to determine which plate bears first petaloid porepair.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 22% L, opening wider than high, width 23% L, height (est.) 3.6% L. Phyllodes with well-developed peripodia (Plate 14: figure 4), single pore with high node adapical to pore; pit behind node giving appearance of second spore but in most ambulacral plates pit does not penetrate test; in peripodia figured on Plate 14: figure 4, second pore appears to pass under node to join main pore; on weathered specimens only single pore present; 8–10 phyllodal pores in ambulacrum II, 3–4 in III, 4–6 in I.

PERIPROCT.—Located high on posterior truncation but area in region of periproct broken away and size and nature of opening not known.

FASCIOLES.—Peripetalous fasciole very wide where passing around extremities of petals, deeply indented in interambulacra (Figure 13), angular; crossing plate 10 in ambulacrum II. Latero-anal fasciole passing in deep lobe below periproct.

ORAL PLATE ARRANGEMENT.—Plate arrangement not discernible.

OCCURRENCE.—Middle Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

***Schizaster camagueyensis* (Weisbord),
new combination**

PLATE 16: FIGURES 1–3

Paraster camagueyensis Weisbord, 1934:68, pl. 7: figs. 9–11.—
Sánchez Roig, 1949:287.

The holotype (PRI 3831) is in the Paleontological Research Institution. I have nothing to add to Weisbord's detailed description except the following dimensions of the holotype, which include 56 porepairs in petal IV and 32 in petal V:

Character	mm	% L
Length	22	
Width	19	89
Height	16	74
Distance apical system from anterior	15	68
Width of peristome	4.3	19
Height of peristome	1.0	4.5
Distance peristome from anterior	3.4	15
Length petal IV	9.0	40
Length petal V	3.5	16
Width petal IV	2.6	12
Width petal V	2.3	10

OCCURRENCE.—Late Eocene, poorly bedded to lenticular white marks, 4 km ENE of Loma Calisto, from cut along railroad between Nuevitas and Pastelillo, about 2 km SE of Nuevitas railroad station; E of Arroyo Blanco, 150 m, in road to Majagua; Grua Guruqu, 5 km N of C. Lugareno; deep cut N of Grua 9, Ramal Juan Criollo, 0.2 km SE of Arroyo Blanco on road to Majagua, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *S. subcylindricus* from the Eocene of Jamaica and Cuba, differing only in having its apical system slightly more posterior and its petals slightly more depressed.

***Schizaster cartagensis* (Sánchez Roig),
new combination**

PLATE 16: FIGURES 4–7

Paraster cartagensis Sánchez Roig, 1949, pl. 44: figs. 7, 8; 1952c:28.

MATERIAL.—The only specimen known is the holotype (SRC 4219). This specimen is badly weathered with only part of its fascioles preserved. The test is not distorted, but the posterior is broken away.

SHAPE AND SIZE.—Length 65 mm, width 94% L, height 66% L. Greatest width central, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic, central, at distance from anterior margin to center of genital pores equal to 49% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove midway between apical system and margin 7.3% L, at margin 4.9% L. Enlarged pores adapically with porepairs in peripodia, inner pore of pair anterior to outer, 44 porepairs in this region.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin, length 39% L, width 9.0% L; depressed in groove with depth 5.2% L. Petals curve slightly anteriorly; interporiferous zones slightly narrower than single poriferous zone; 68 porepairs in petal; first petaloid porepair in plate 13; 92 plates in ambulacrum.

Posterior petals (V and I) extending one-half distance from apical system to margin, length 28% L, width 6.5% L, depressed in groove with depth 4.3% L. Interporiferous zone narrower than single poriferous zone; 52 porepairs. Nature of phyllodes not clear.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 19% L; width of opening 18% L, height unknown.

PERIPROCT.—Not preserved.

FASCIOLES.—Only short portions of both fascioles preserved. Peripetalous fasciole widest where passing around anterior petals; deeply indented in interambulacra 4 and 1. Latero-anal fasciole very narrow in interambulacra 4 and 1.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, SSE of Cartagena, 1 km N side of railroad, Las Villas Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species with its large test and long petals most resembles *Schizaster bathypetalus* Arnold and Clark from the Eocene of Cuba and Jamaica. It differs in having a much narrower anterior ambulacrum with far fewer porepairs and in having narrower petals with anterior petals straighter. It differs

from *Schizaster delgadoi* (Sánchez Roig) also from the Oligocene-Miocene of Cuba in its central apical system and straighter anterior petals.

***Schizaster cubitabellae* (Weisbord)**

PLATE 17: FIGURES 1-3

Paraster cubitabellae Weisbord, 1934:72, pl. 7: figs. 15, 16.—
Sánchez Roig, 1949:285.

I have studied the holotype (PRI 3833), which is the only known specimen, and have nothing to add to Weisbord's long description except the following dimensions:

Character	mm	% L
Length	28.0 (est.)	
Width	26±	93
Height	22±	80
Distance apical system from anterior	13	48
Length petal II	10	37
Width petal II	3.8	13
Length petal I	4.9	17
Width petal I	3.6 (est.)	12

There are 52 porepairs in petal II, 32 in petal I; and the first porepair in petal II occurs in plate 11. The number of genital pores is not known (only small part of apical system is preserved in the holotype).

OCCURRENCE.—Late Eocene, from cut along the railroad between Nuevitas and Pastelillo, about 2 km SE of Nuevitas railroad station, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Schizaster subcylindricus* Cotteau also from the Eocene of Cuba and may be conspecific, but too little is known of *S. cubitabellae* to be certain.

***Schizaster delgadoi* (Sánchez Roig), new combination**

FIGURE 14; PLATE 17: FIGURES 4-6

Pericosmus delgadoi Sánchez Roig, 1953a:65, pl. 16: fig. 2.

MATERIAL.—The only specimen, the holotype (SRC 4211), is flattened (postmortem), with most of ventral posterior part of test missing.

SHAPE AND SIZE.—Length 94.5 mm, width 88.9 mm (94% L); height indeterminate; greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Posterior, distance from anterior margin to center of system equal to 56% L; ethmolytic; number of genital pores not discernible.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very deep groove with depth of 3.3% L midway between apical system and anterior margin. Enlarged porepairs adapically with porepairs in peripodia, inner pore of pair anterior to outer, region of ambulacrum with enlarged porepairs extending slightly more than one-half distance from apical system to anterior margin; 50 porepairs in this region.

Anterior petals (II and IV) extending three-fifths distance from apical system to margin, length 35% L, greatest width 6.8% L, in very deep groove with depth 5.6% L. Interporiferous zone slightly wider than single poriferous zone; pores conjugate, 60 porepairs in petal; not discernible

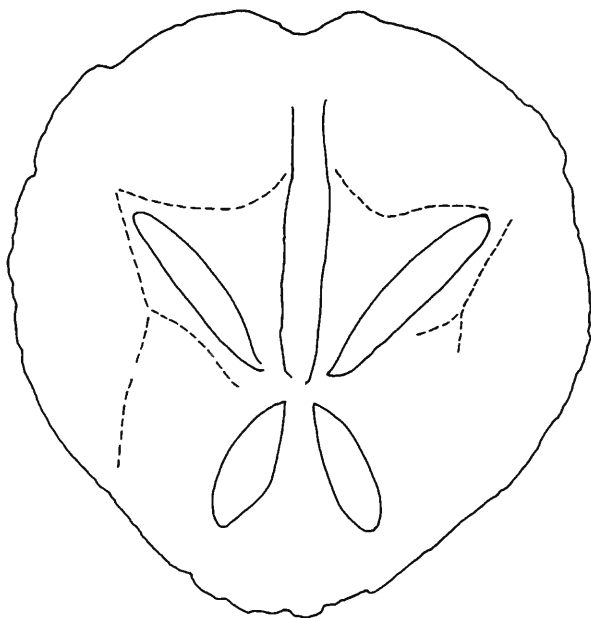


FIGURE 14.—*Schizaster delgadoi* (Sánchez Roig), dorsal view showing position of the fascioles (dashed lines) of the holotype, SRC 4211, $\times 0.9$.

which plate bears first porepair. Petals curving convexly to anterior.

Posterior petals (V and I) short, length 22% L, straight, in deep groove with depth 5.1% L; width 8.3% L. Interporiferous zone slightly wider than poriferous; 46 porepairs in petal.

PERISTOME.—Test crushed around peristome but peristome was situated very near anterior margin, with pronounced lip with flange along rim.

PERIPROCT.—Not preserved.

FASCIOLAE.—Traces (Figure 14) preserved of peripetalous and latero-anal fasciole. Peripetalous angular, deeply indented in interambulacra 4 and 1, slightly indented in 2 and 3. Latero-anal fasciole narrow, extending from peripetalous fasciole at midlength of petals II and IV.

ORAL PLATE ARRANGEMENT.—Not discernible.

OCCURRENCE.—Late Oligocene, according to Sánchez Roig but Albear (1980, personal communication) considers this locality early to middle Miocene, "Cervantes" farm, San José de las Lajas, Habana Province, Cuba.

REMARKS.—Sánchez Roig referred this species to *Pericosmus* because he thought it had a marginal fasciole. However, a latero-anal fasciole is present not a marginal fasciole. Furthermore, the distal-most plates in the petals are not occluded and the porepairs in ambulacrum III are very large, not minute as in *Pericosmus*. This species clearly belongs in the family Schizasteridae, and it is probably a *Schizaster*.

COMPARISON WITH OTHER SPECIES.—This species resembles *Schizaster bathypetalus* Arnold and Clark from the Eocene of Cuba and Jamaica in its large size, but it differs in having a much more posteriorly situated apical system and narrower anterior ambulacrum and petals. It differs from *Schizaster cartagensis* (Sánchez Roig) in its more posterior apical system.

***Schizaster egozcuei* Lambert**

PLATE 18: FIGURES 1-4

Schizaster egozcuei Lambert in Lambert and Thiéry, 1925 [1909-1925]:527.—Sánchez Roig, 1926:132; 1949:275.

MATERIAL.—Only one specimen (SRC 4234) of this species is known. It is topotypic; and although it is labelled as the type, it does not have the dimensions of the specimens described by Cotteau. The specimen is very poorly preserved with most of the test absent, and the test is partially crushed.

SHAPE AND SIZE.—Test large, length 55 mm, wide with width 98% L, height 57% L (but crushed). Greatest width anterior to center, greatest height posterior.

APICAL SYSTEM.—Posterior to center, located at distance from anterior margin to center of system equal to 56% L; number of pores not clear.

AMBULACRA.—Anterior ambulacrum III not petaloid in very wide and deep groove adapically, greatest width 13% L; adapical area of enlarged porepairs extending three-fourths distance from apical system to anterior margin.

Anterior petals (II and IV), extending two-thirds distance from apical system to margin, length 35% L, width 10% L; flexuous, curving outwards distally. Number of porepairs not discernible.

Posterior petals (V and I) extending more than one-half distance from apical system to margin, length 21% L, width 10% L; curving slightly outward distally.

PERISTOME.—Anterior, no further details known because of crushing of test.

PERIPROCT.—Located high on overhanging posterior truncation, visible from below.

FASCIOLAE.—Not preserved because most of test broken away.

OCCURRENCE.—Oligocene-Miocene, Cienfuegos, Santa Clara (now Las Villas) Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species resembles *Schizaster delgadoi* Sánchez Roig from the Miocene of Cuba, but it is easily distinguished by its wider anterior ambulacrum and less divergent anterior petals. It is very similar to *Schizaster munozi* Sánchez Roig also from the Oligocene-Miocene of Cuba and may be conspecific. However, the topotype is so poorly preserved,

Schizaster scillae.—Cotteau, 1897:82, pl. 26: figs. 4, 5, pl. 27: figs. 4-6.—Jackson, 1922:81. [Not *Schizaster scillae* Agassiz, 1847.]

being mainly an internal mold, that it is not possible to be certain of many of its specific characters.

REMARKS.—This species was described by Lambert for specimens that Cotteau had attributed to *Schizaster scillae* Agassiz. Lambert believed Cotteau's specimens were not conspecific with the type specimen of Agassiz's species.

***Schizaster fernandezi* Sánchez Roig**

PLATE 18: FIGURES 5–11

Schizaster (Schizaster) fernandezi Sánchez Roig, 1952c:25, pl. 9: fig. 3.

MATERIAL.—Three specimens are in the Sánchez Roig Collection. The following description is based on the holotype and figured specimen (SRC 4148) and a topotype (SRC 4147). The holotype is moderately well preserved with part of the fascioles intact, but most of the ventral surface of the test posterior to the peristome is missing. The topotype has more of the fascioles preserved but also lacks much of the ventral side of the test. The dimensions of the holotype are given first below.

SHAPE AND SIZE.—Length 26, 28 mm; width 25 mm (94% L), 24 mm (87% L); height 19 mm (73% L), 19 mm (69% L). Greatest width and height posterior to center.

APICAL SYSTEM.—Four genital pores, anterior pores much smaller than posterior; ethmolytic; located posterior to center at distance from anterior margin to center of genital pores equal to 62, 56% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove at margin 4.2 and 2.5% L. Pores paired only in adapical region where pores enlarged in well-developed peripodia with ridge separating pores of a pair with approximately 28 porepairs in this region; porepairs in single row with inner pore of porepair more elongated than outer.

Anterior petals (II and IV) extending approximately two-thirds distance from apical system to margin; length 38 and 34% L, greatest width 13 and 13% L. Petal curved convexly with petal

widening sharply just distal to midlength. Porepairs near apical system in anterior poriferous zone much smaller than opposite porepairs in posterior poriferous zone. Petals depressed in groove with depth 4.6 and 3.9% L; 46 and 40 porepairs; pores conjugate. Interporiferous zone at greatest width narrower than single poriferous zone. First petaloid porepair in plate 12 of holotype. Pores single beyond petals.

Posterior petals (V and I) very short, extending less than one-half distance from apical system to margin; length 17 and 18% L, width 9.1 and 9.0% L. Petals straight, depressed in groove 2.7 and 2.5% L; 24 and 24 porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 19 and 20% L; opening wider than high with width 24 and 20% L.

PERIPROCT.—Located high on posterior truncation; opening higher than wide with height 23 and (est.) 20% L.

FASCIOLES.—Peripetalous fasciole wide, with width just posterior to petal II 2.3 and 2.2% L, curving sharply into interambulacra 1 and 4 but extending anteriorly in anterior lobe where crossing ambulacrum III. Fasciole crossing ambulacrum II or IV on plate 10 or 11. Latero-anal fasciole only preserved in short tracts.

ORAL PLATE ARRANGEMENT.—Plates not preserved.

OCCURRENCE.—Miocene, "Las Cuevas" estate, Km 186 on highway from Pinar del Rio to Guane, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species resembles in its shape and arrangement of petals *Schizaster subcylindricus* Cotteau and *Schizaster camagueyensis* Weisbord both from the Eocene of Cuba. It differs in having 4 instead of 2 genital pores. Furthermore, its peristome is more posterior and its apical system more anterior.

***Schizaster formelli*, new species**

PLATE 24

MATERIAL.—The holotype (ANSP 16675a) and paratype (ANSP 16675b) are moderately well preserved with tests slightly distorted and fas-

cioles preserved. The first dimensions given below are of the holotype.

SHAPE AND SIZE.—Length 23 and 20 mm, width 96 and 99% L, height 76 and 81% L; greatest width anterior to center, greatest height posterior.

APICAL SYSTEM.—Central, located at distance from center of genital pores to anterior margin equal to 42 and 46% L. Four genital pores, ethmolytic; posterior genital pores much larger than anterior.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very deep groove particularly dorsally; greatest depth 8.8 and 9.3% L; 32 porepairs in adapical region in holotype, 28 in paratype.

Anterior petals (II and IV) extending slightly more than one-half distance from apical system to margin; length 32 and 33% L; greatest width 14 and 15% L; 44 porepairs in petal in holotype; 40 in paratype. Interporiferous zones slightly narrower than poriferous zone; petals flexuous; petals deeply depressed. First petaloid porepair in plate 6.

Posterior petals (V and I) straight, short, extending one-third distance from apical system to margin, length 21 and 19% L, width 11 and 12% L; 30 porepairs in holotype; 28 in paratype.

PERISTOME.—Anterior, distance from anterior edge of opening to anterior margin 23 and 25% L; width 18 and 21% L; height 6.3 and 6.3% L.

PERIPROCT.—High on vertical posterior truncation, higher than wide.

FASCIOLAS.—Peripetalous fasciole wide, widest in anterior paired interambulacra; deeply inserted in posterior paired interambulacra. Latero-anal fasciole extending in deep lobe below periproct.

OCCURRENCE.—Eocene, Palmer loc. 687a, 15 mi (24 km) E of Camagüey on Maraguan road from Guanabanito River, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Schizaster formelli* is easily distinguished from the other Cuban species of this genus. It differs from *Schizaster santanae* Sánchez Roig (also from the Eocene of Cuba) in its broader anterior ambulacrum, its

greater posterior width and its broader, shorter petals. It differs from *Schizaster llagunoi* Lambert and Sánchez Roig in its shorter, broader petals and few enlarged porepairs in ambulacrum III.

Schizaster gerthi Pijpers

PLATE 19

Schizaster gerthi Pijpers, 1933:96, fig. 157, pl. 1: fig. 19, pl. 2: figs. 10–12.

Paraster clarki [sic] Sánchez Roig, 1949, pl. 44: figs. 6, 9; 1952c:28, 29.

I am unable to distinguish Sánchez Roig's *Paraster clarki* from this species from the late Eocene of Bonaire. I was able to compare Cuban specimens with 5 paratypes of the Bonaire species very kindly loaned to me from the University of Utrecht. They are alike in all characters including the number of pores in the petals and anterior ambulacrum, position of the apical system and peristome, shape of the test, and depression of the petals. A photograph of one of the paratypes of *S. gerthi* is on Plate 19: figure 6.

OCCURRENCE.—Eocene, Loma Caoba, 5 km S of San Diego de los Baños, Pinar del Rio Province, Cuba; late Eocene, SE of Seroe Montagne, W. Bonaire.

COMPARISON WITH OTHER SPECIES.—This species is distinguished from *Schizaster subcylindricus* Cotteau, which occurs with it at Loma Caoba, by its central apical system with 4 genital pores and its more divergent and flexuous petals. It differs from *Schizaster bathypetalus* Arnold and Clark by its smaller test, less flexuous anterior petals, and less divergent, shorter posterior petals.

SYNONYM

Paraster clarki Sánchez Roig, emendation

PLATE 19: FIGURES 1–5, 7, 8

MATERIAL.—No specimens of this species are present in the Sánchez Roig Collection, but there are 4 topotypic specimens in the USNM collections of the National Museum of Natural History, and 2 in the collections of the Academy of Nat-

ural Sciences of Philadelphia, which appear to belong to this species.

SHAPE AND SIZE.—Length 28 to 38 mm (mean 35 mm), width 87 to 93% L (mean 90); height 63 to 77% L (mean 68). Greatest width central, greatest height posterior.

APICAL SYSTEM.—Central, located at distance from anterior margin to center of genital pores equal to 43 to 46% L (mean 45). Four genital pores, anterior pores much smaller than posterior, ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III (Plate 19: figure 7) not petaloid, enlarged porepairs adapically extending to two-thirds distance from apical system to anterior margin; 38 enlarged porepairs in specimen 38 mm long; inner pore of pair anterior to outer; in deep depression adapically, depth 6.7 to 9.3% L (mean 7.7); at margin only slight groove; first porepair in plate 6.

Anterior petals (II and IV) flexuous, with greatest width distal; extending two-thirds distance from apical system to margin, length 37 to 39% L (mean 38), greatest width 12 to 14% L (mean 13); depressed in groove with depth 4.5 to 6.6% L (mean 5.9). Interporiferous zone narrower than single poriferous zone; pores conjugate, 56 porepairs in petal of specimen 38 mm long; first petaloid porepair in plate 12.

Posterior petals (V and I) extending less than one-half distance from apical system to margin, length 21 to 24% L (mean 22), width 8.5 to 11% L (mean 9.8); curving slightly posteriorly; 42 porepairs in specimen 38 mm long; depressed in groove 2.6 to 5.4% L (mean 4.4). Interporiferous zone slightly narrower than single poriferous zone. First petaloid porepair in plate 18.

Phyllodes with well-developed peripodia with large single pore; ridge-like node behind pore (Plate 19: figure 8), pit on other side of node where second pore would have been; 9 phyllodal pores in ambulacrum II, 5 in I, number uncertain in III.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 17 to 22% L (mean 19). Opening with

width 19 to 26% L (mean 22), height 6.3 to 9.3% L (mean 8).

PERIPROCT.—Located high on tall vertical posterior truncation, on neotype height 18% L, width 12% L. Occurring between interambulacral plates 5–9.

FASCIOLES.—Peripetalous fasciole sharply indented in posterior paired interambulacra, not indented in others, crossing ambulacrum III on plate 5, ambulacra II or IV on plate 11, ambulacra V or I on plate 17. Latero-anal fasciole passing in lobe below periproct at distance equal to height of periproct.

ORAL PLATE ARRANGEMENT.—Labrum low, height 9% L, extending posteriorly two-thirds height of first ambulacral plate. Sternal plates long, length 61% L, width 38% L. In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Eocene, Loma Caoba, 5 km S of San Diego de Los Baños, Pinar del Rio Province, Cuba.

REMARKS.—The spelling of the species name is emended to agree with the name of Herbert L. Clark, for whom the species was named.

Schizaster llagunoi Lambert and Sánchez Roig

FIGURE 15; PLATE 20: FIGURES 1–4

Schizaster llagunoi Lambert and Sánchez Roig in Sánchez Roig, 1949:274.

MATERIAL.—Two specimens are in the Sánchez Roig Collection. One specimen (SRC 4217) is labelled as type and is from the type-locality. It is herein designated the lectotype (no specimens were figured in the original description) and the following description is based on it. The lectotype is moderately well preserved. Although the test is weathered, portions of the fascioles are preserved.

SHAPE AND SIZE.—Length 52 mm, width 50 mm (96% L), height 38 mm (73% L). Greatest width central, greatest height posterior to center with posterior interambulacrum sharply elevated and test sloping anteriorly to margin.

APICAL SYSTEM.—Four genital pores (Figure 15A), ethmolytic, located slightly anterior of cen-

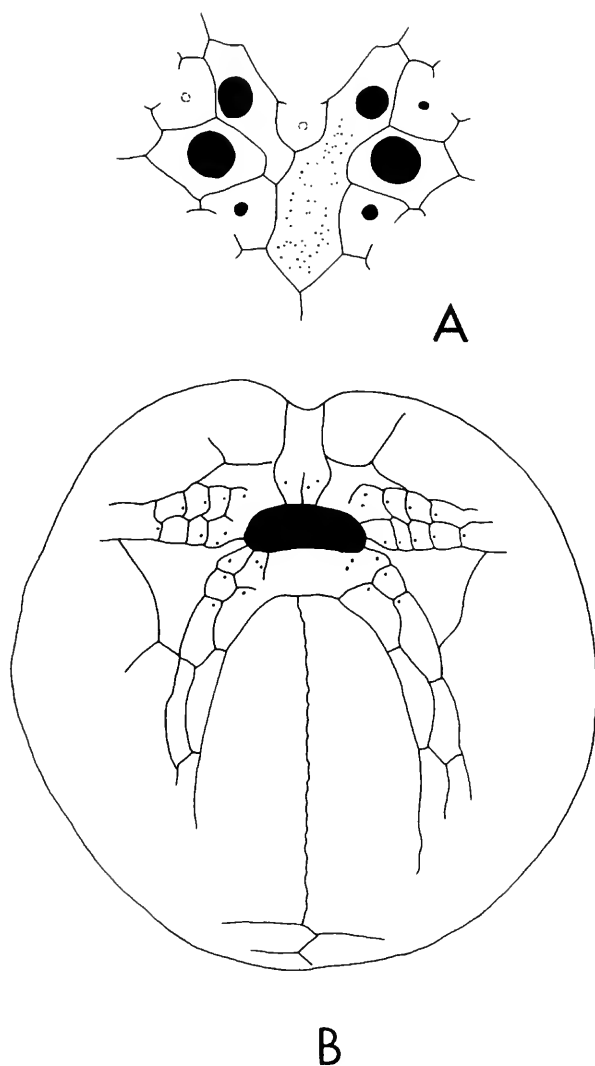


FIGURE 15.—*Schizaster llagunoi* Lambert and Sánchez Roig, lectotype, SRC 4217; A, apical view, $\times 12$; B, ventral view, $\times 1.6$.

ter at distance from anterior margin to center of genital pores equal to 45% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove at margin 3.8% L. Pores paired and enlarged only in adapical region, approximately 56 porepairs in this area, porepairs in single row, inner pore more elongate than outer. First enlarged pores in plate 6, plates near

peristome very high (Figure 15B); 66 plates in ambulacrum.

Anterior petals (II and IV) short, extending less than two-thirds distance from apical system to margin, length 35% L, width 12% L, depth 3.1% L. Petals curved convexly to anterior, depressed in groove; pores conjugate, pores of pair equally elongated transversely, 62 porepairs. Interporiferous zone at greatest width equal to width of poriferous zone. First petaloid porepair in plates 12, 13; total of 86 plates in ambulacrum. Pores single beyond petals.

Posterior petals (V and I) short, extending less than one-half distance from apical system to margin, length 21% L, width 8.2% L. Petals curving posteriorly, depressed in groove with depth 3.2% L; 46 porepairs, first porepair in plate 20; total of 84 plates in ambulacrum.

Phyllodes single pored, 3 pores in ambulacrum III, 10 in II or IV, 6 in V or I.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 18% L, opening wider than high, with width 19% L, height 7.3% L.

PERIPROCT.—Located high on slightly overhanging posterior truncation. Opening higher than wide with height 17% L, width 11% L; located between interambulacral plates 5–8.

FASCIOLES.—Peripetalous fasciole wide, maximum width 2.1% L, angular, curving sharply into interambulacra, 1, 4, 5; position on anterior interambulacra not known. Fasciole crosses ambulacra II or IV on plates 11, 12, ambulacra V or I on plate 19, interambulacra 1 and 4 on plates 5–8, interambulacrum on plate 12. Latero-anal fasciole passes below periproct, approximately as wide as peripetalous fasciole; crosses ambulacrum V or I on plate 11, interambulacrum 5 on plates 5 and 6.

ORAL PLATE ARRANGEMENT.—Labrum broad, short, length 9.4% L (est.), extending back to posterior edge of first adjacent ambulacral plate. Plastron broad (Figure 15B), sternal plates with combined length 52% L, width 35% L; bordered by ambulacral plates 2–7. First plate of interambulacra in contact with peristome (Figure 15B).

In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—According to Brodermann (1949:328) middle Eocene and late Oligocene, estate of Doña Juana, Santiago de las Vegas, Habana Province, Cuba. Lambert and Sánchez Roig in Sánchez Roig (1949:276) state that the species occurs at Palmer's localities 2889, 2891. According to Palmer (1948:160) these localities are 2.9 km E of San Antonio de las Vegas, Habana Province, Cuba, and are middle Eocene.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Schizaster munozi* Sánchez Roig from the late Oligocene or early Miocene of Cuba and differs only in possessing a more inflated area behind the apical system and less divergent posterior petals. It is possible that these differences were caused by postmortem compression of the lectotype of *S. llagunoi*. *S. llagunoi* closely resembles *Schizaster santanae* Sánchez Roig, also from the Eocene of Cuba, but it is definitely a different species. Its anterior ambulacrum is wider and it has many more enlarged porepairs, there being 56 in the lectotype of *S. llagunoi* and only 42 in the lectotype of *S. santanae*.

Schizaster munozi Sánchez Roig

FIGURES 16–18; PLATE 20: FIGURES 5–8; PLATES 21, 22;
PLATE 23: FIGURE 1

Schizaster munozi Sánchez Roig, 1949:277, pl. 43: figs. 1–3.
Schizaster salutis Sánchez Roig, 1949:278, pl. 45: figs. 3, 4.
Schizaster guirensis Sánchez Roig, 1949:278, pl. 43: figs. 4, 5.
Paraster orientalis Sánchez Roig, 1949:289, pl. 46: figs. 2, 3.
Paraster tschopi Palmer in Sánchez Roig, 1949:290, pl. 46: fig. 1.
Schizaster (Aplospalangus) riveroi Sánchez Roig, 1952a:27, pl. 15: figs. 4, 5.

MATERIAL.—Only one specimen in the collection is referred to this species, the holotype (SRC 4224). Although the specimen is highly weathered and the apical area is missing, the test is not distorted. It is figured on Plate 22: figures 1–3.

SHAPE AND SIZE.—Length 61 mm, width 57 mm (93% L), height 39 mm (65% L). Greatest width central to slightly anterior, greatest height

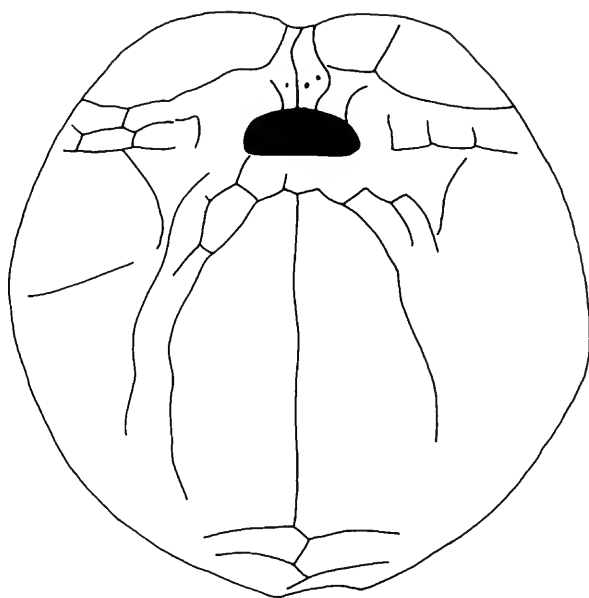


FIGURE 16.—*Schizaster munozi* Sánchez Roig, ventral view of the holotype, SRC 4224, $\times 1.4$.

posterior to center with test sloping anteriorly to margin.

APICAL SYSTEM.—Absent from holotype but situated slightly posterior to center.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove deepest adapically where depth 6.1% L, groove at margin 3.3% L; greatest width of groove midway from apical system to margin where width 13% L. Pores paired only in adapical region where pores enlarged in peripodia with node separating pores of pair; inner pore more elongate than outer; enlarged pores present from apical system to approximately two-thirds distance to margin; porepairs in single row. First enlarged porepair in plate 6, plates near peristome very high.

Anterior petals (II and IV) short, extending less than two-thirds distance from apical system to margin, length 35% L (est.), width 11% L. Petals curved convexly to anterior, depressed in groove; pores strongly conjugate, outer pore of pair slightly more elongated transversely than inner. Interporiferous zone at greatest width slightly

narrower than single poriferous zone. First petaloid porepair in plate 12 or 13. Pores single beyond petals.

Posterior petals (V and I) short, extending less than one-half distance from apical system to margin, length 21% L (est.), width 8.7% L. Petals straight or curving very slightly posteriorly, depressed in groove with depth 3.9% L; 44 porepairs (est.).

Phyllodes single pored, 3 pores in ambulacrum III, 8 in II or IV, number not discernible in V or I.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 14% L, opening wider than high, with width 19% L.

PERIPROCT.—Located high on slightly overhanging posterior truncation. Opening higher than wide with height 21% L (est.), width 13% L; located between interambulacral plates 5–9.

FASCIOLAS.—Peripetalous fasciole wide, greatest width where passing around petal V, I where width 3.8% L, angular, curving sharply into interambulacra 1, 4; anteriorly across 2 and 3, straight across 5. Crosses ambulacrum III on plate 4 or 5, ambulacrum II or IV on plates 9, 10. Latero-anal fasciole destroyed by weathering.

ORAL PLATE ARRANGEMENT.—Labrum broad, short, length 5.6% L (est.), extending back to posterior two-thirds of first ambulacral plate (Figure 16). Plastron broad, sternal plates with combined width 40% L, length 55% L; bordered by ambulacral plates 1–5. First interambulacral plates in contact with peristome; in interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Late Oligocene–early Miocene, quarry near Cabezas, Matanzas Province, Cuba. The lectotype of *S. salutis* is from the early Miocene, Lastra estate, La Salud, Habana Province, Cuba. The lectotype of *S. guirensis* is from the early Miocene, estate of María Teresa, Km 40–41, on highway from San Antonio de los Baños to Guira, Habana Province, Cuba. The holotype of *S. riveroi* is from the early Miocene at a quarry on the outskirts of Cardenas, Matanzas Province, Cuba. The lectotype of *S. orientalis* is from the late

Oligocene–early Miocene, roadcut in Central Highway, Km 753.5 E of Habana, 18.5 km W of Holguín, Oriente Province, Cuba. The holotype of *S. tschopi* is from the Oligocene–Miocene, Km 202 United Railroad, 0.5 km S of Km 213 on Central highway, 23 km E of Colon church, Matanzas Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Schizaster americanus* (Clark) from the Oligocene (Vicksburg) of southeastern United States. Although the anterior ambulacrum in the holotype of *S. americanus* is narrower than in *S. munozi*, this specimen is much smaller than the holotype of the Cuban species. In larger specimens of *S. americanus*, the width of this ambulacrum is similar to the Cuban species. There appear to be more enlarged porepairs in the anterior ambulacrum of *S. munozi* with 46 in a specimen of *S. munozi* 33.3 mm long as opposed to only 36 in the holotype of *S. americanus* which is 36 mm long.

I cannot distinguish *Schizaster munozi* from *S. clevei* Cotteau from the Miocene Anguilla Formation of Anguilla. I have examined the holotype of *S. clevei* in the USNM collections and there are no differences. However, the holotype is crushed and I hesitate for this reason to synonymize formally the two species. *Schizaster loveni* Cotteau, also from the Anguilla Formation of Anguilla, is very similar to *S. munozi* differing only in having shorter posterior petals. If more specimens were available of the 2 species from Anguilla, it might be seen that only one species was present with the length of the posterior petals being quite variable.

Schizaster munozi differs from *S. llagunoi* Sánchez Roig only in its less inflated region posterior to the apical system and more divergent petals. It is possible that these differences are not real but were caused by postmortem compression of the lectotype of *S. llagunoi*.

REMARKS.—This species is indistinguishable from *Schizaster salutis* Sánchez Roig from the early Miocene. In all characters the two species are similar including length, curvature, and depth of the petals, width and depth of the anterior ambulacrum, shape and position of the peristome

and periproct, and oral plate arrangement. Although the test is lower in the lectotype of *S. salutis* than the holotype of *S. munozi*, it has been depressed by postmortem compression. *Schizaster salutis* is considered herein a synonym of *S. munozi*.

Schizaster munozi is likewise indistinguishable from *Schizaster riveroi* Sánchez Roig from the Miocene of Cuba. In no way do the species differ and *S. riveroi* is, therefore, considered a synonym of *S. munozi*.

I cannot distinguish the lectotype of *Paraster orientalis* (Sánchez Roig) from *S. munozi*. Its petals and anterior ambulacrum are identical and the tests have similar shapes. Although the apical system appears to be more posterior, this is probably due to postmortem distortion. The test of the lectotype is partially crushed with the dorsal surface shifted posteriorly. *P. orientalis* is herein considered a synonym of *S. munozi*.

Paraster tschopi Palmer from the Oligocene or Miocene of Cuba also appears to be a synonym of *S. munozi*. The peristome of the holotype of *P. tschopi* appears to be lower but this is due to postmortem distortion of its test. I can see no other significant differences between them.

S. munozi is likewise very similar to *Schizaster guirensis* Sánchez Roig from the early Miocene. The lectotype of *S. guirensis* differs from the holotype of *S. munozi* only in its greater size. *S. guirensis* is herein considered a synonym of *S. munozi*.

SYNONYMS

Paraster orientalis Sánchez Roig

FIGURE 17; PLATE 22: FIGURES 7-9

MATERIAL.—One specimen in the Sánchez Roig Collection. This specimen (SRC 4254) is labelled the type and is figured by Sánchez Roig (1949, pl. 46: fig. 2). It is herein selected as the lectotype. The other specimen figured by Sánchez Roig (1949, pl. 46: fig. 3) is missing. The lectotype is very poorly preserved, being flattened and fractured.

SHAPE AND SIZE.—Length 33 mm, width 32 mm (98% L), height 49% L, but test crushed.

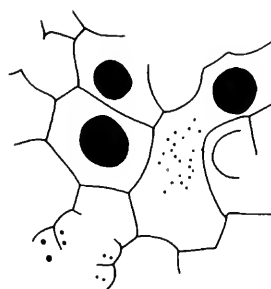


FIGURE 17.—*Schizaster munozi* Sánchez Roig, apical system of the lectotype of *Paraster orientalis* Sánchez Roig (= *S. munozi*), SRC 4254, $\times 7$.

Greatest width anterior to center.

APICAL SYSTEM.—Four genital pores (Figure 17), ethmolytic, located posterior to center at distance from anterior margin to center of genital pores equal to 59% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove greatest midway between apical system and margin where depth 6.9% L, at margin groove shallow, only 3.3% L. Groove wide, with greatest width one-third distance from apical system to anterior margin, width 15% L. Pores enlarged in adapical area situated in well-developed peripodia with ridge separating pores of a pair; 46 porepairs in this region.

Anterior petals (II and IV) extending three-fifths distance from apical system to margin; length 38% L, greatest width near extremity of petal where 11% L. Petals flexuous, depressed in groove of depth 4.8% L. Pores conjugate with 52 porepairs in petal; porepairs in anterior poriferous zone near apical system much smaller than in posterior. Interporiferous zone narrower than poriferous. Not possible to determine number of plate with first petaloid porepair.

Posterior petals (V and I) short, length 22% L; slightly flexuous, depressed in groove with depth 3.0% L; 42 porepairs in petal.

PERISTOME.—Anterior wide (width 25% L), opening low but not measurable because of postmortem distortion of test.

PERIPROCT.—Located high on posterior truncation but dimensions unknown because of poor preservation.

FASCIOLAS.—Peripetalous fasciole prominent, of variable width, where passing around anterior

petals very wide with width 6.9% L, narrowing down to a width 2.1% L in interambulacra 4 and 1; curving sharply into interambulacra 4 and 1 extending anteriorly crossing ambulacrum III. Latero-anal fasciole passing around posterior at distance below periproct equal to 12% L.

ORAL PLATE ARRANGEMENT.—Sutures of labrum not clear. Sternal plates long, length estimated 58% L, greatest combined width of both plates 41% L. In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Oligocene–Miocene, roadcut in Central Highway, Km 753.5 E of Habana, 18.5 km W of Holguín, Oriente Province, Cuba.

Paraster tschopi Palmer

PLATE 21: FIGURES 1–4

MATERIAL.—Only one specimen, the holotype (SRC 4255), is in the Sánchez Roig Collection. This specimen is very well preserved showing clearly the tuberculation and fascioles. It is slightly crushed resulting in distortion around the periproct and peristome. A topotype is in the MCZ (4040). The first dimension given below is of the holotype.

SHAPE AND SIZE.—Length 58 and 56 mm; width 59 mm (101% L), 52 mm (94% L); height 35 mm (60% L), 35 mm (61% L). Greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic, central, located at distance from anterior margin to center of genital pores equal to 50 and 56% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, deepest adapically where greatest depth 5.8 and 10% L, greatest width 11 and 11% L.

Pores greatly enlarged adapically where situated in well-developed peripodia, pores of pair separated by ridge; 50 and 46 porepairs in this region; porepairs in single row with inner pore of pair situated anterior to outer, more elongated; first enlarged porepair in plates 7 and 8.

Anterior petals (II and IV) extending approximately three-fifths distance from apical system

to margin; length 38 and 36% L, greatest width near extremity of petal, 8.9 and 10% L, depth 5.3 and 7.0% L; petals slightly flexuous. Interporiferous zone almost as wide as single poriferous zone; pores conjugate, 58 and 72 porepairs in petal; first porepair in plate 13 or 14.

Posterior petals (V and I) very short, extending less than one-half distance from apical system to margin; length 21 and 20% L, width 7.9 and 9.0% L, depth 3.8 and 3.8% L; 46 and 46 porepairs in petal.

Phyllodes with well-developed peripodia with high node behind each single pore and pit where second pore would have been; in topotype 10 pores in phyllode II, 3 in III, 5–6 in V.

PERISTOME.—Anterior, located on topotype at distance from anterior margin to anterior edge of peristome equal to 23% L. Opening on topotype with width 15% L and height 6% L.

PERIPROCT.—Located high on overhanging posterior truncation, opening with width (est.) 8.7% L, height (est.) 13% L.

FASCIOLES.—Peripetalous fasciole with greatest width where passing around anterior petals, width 4.5% L; curving sharply into interambulacra 4 and 1; slightly indented in 5, curving anteriorly around ambulacrum III. Crossing ambulacra II and IV on plates 12 and 13, ambulacrum III on plate 5. Latero-anal fascioles passing in deep lobe below periproct at distance from lower edge of periproct 17% L.

ORAL PLATE ARRANGEMENT.—Labrum with length 12% L; sternal plates with length 59% L; width 37% L.

OCCURRENCE.—Oligocene–Miocene, Palmer locality 1553, Km 202 United Railroad, 0.5 km S of Km 213 on Central Highway, 23 km E of Colon church, Matanzas Province, Cuba.

Schizaster guirensis Sánchez Roig

PLATE 23: FIGURE 1

MATERIAL.—The specimen (SRC 4251), figured by Sánchez Roig (1949, pl. 43: fig. 5), is herein selected as the lectotype. The dorsal sur-

face is well preserved although slightly distorted by postmortem compression. The ventral surface is badly fractured with the peristome largely destroyed.

SHAPE AND SIZE.—Length 77 mm, width 70 mm (91% L), height 42 mm (55% L).

APICAL SYSTEM.—Posterior, distance of apical system from anterior margin equal to 56% L. The posterior position may be due to postmortem distortion. Four genital pores, ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in wide deep groove; many enlarged porepairs adapically, 84 porepairs, region with enlarged porepairs with length equal to 41% L, width 13% L, depth at midlength 7% L; depth of notch at anterior margin 2.4% L.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin, length 34% L, width 9.4% L, flexuous; depressed in deep groove with greatest depth 4.1% L; pores strongly conjugate, outer pore of pair slightly more elongated transversely than inner. Interporiferous zone at greatest width slightly narrower than single poriferous zone; 74 porepairs. Pores single beyond petals.

Posterior petals (V and I) short, extending slightly more than one-half distance from apical system to margin, petals curving slightly posteriorly; length 25% L, width 9.2% L; depressed in groove with depth 3.5% L.

PERISTOME.—Anterior, distance from anterior edge of opening to anterior margin 17% L. No other details preserved.

PERIPROCT.—Located high on slightly overhanging posterior truncation. Opening higher than wide with height 11% L, width 8.8% L.

FASCIOLAE.—Peripetalous fasciole wide, greatest width where passing around petal V, I; angular, curving sharply into interambulacra 1 and 4. Latero-anal fasciole narrower.

ORAL PLATE ARRANGEMENT.—Not discernible.

OCCURRENCE.—Early Miocene, María Teresa farm, Km 40–41, on highway from San Antonio de los Baños to Guira, Habana Province, Cuba.

Schizaster riveroi Sánchez Roig

FIGURE 18: PLATE 21: FIGURES 5–8

MATERIAL.—Only one specimen known, the holotype (SCR 4194). It is moderately well preserved with much of the tuberculation preserved although weathering has removed part of the test. The specimen is slightly depressed on the left side of the test.

SHAPE AND SIZE.—Length 57 mm, width 52 mm (92% L), height 38 mm (66% L); greatest width anterior, greatest height posterior. Elevated node on interambulacral plates above margin.

APICAL SYSTEM.—Four genital pores, apical system broad, ethmolytic, central, located at distance from anterior margin to center of genital pores equal to 50% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove extending from apical system to peristome, deepest midway between apical system and margin where depth 11% L, width 12% L. Pores greatly enlarged adapically but nature of pores obscured by heavy weathering. There appear to be four columns of plates in adapical region; this is probably an artifact of weathering.

Anterior petals (II and IV) short, extending slightly more than one-half distance from apical system to margin, length 33% L, width 11% L, in deep groove 4.9% L. Petals flexuous, 58 petaloid porepairs, pores conjugate, interporiferous zone as wide as poriferous.

Posterior petals (V and I) straight, short, length 16% L, width 8.2% L. Number of petaloid porepairs not clear because of heavy weathering. Petals depressed in groove with depth 3.8% L. Not possible to determine number of plates between end of petals and peristome. Phyllodes not clear.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 14% L, opening labiate, wider than high, width 19% L, height 5.9% L.

PERIPROCT.—Located slightly higher than mid-height of overhanging posterior truncation. Opening higher than wide, height 11% L, width

8.0% L; located between plates 5–8.

FASCIOLES.—Peripetalous fasciole very wide, especially as it passes around extremities of petals; width at end of petal II 5.7% L, petal I 4.4% L;

curving sharply into interambulacra (Figure 18), anteriorly around ambulacrum III. Latero-anal fasciole narrow band passing in deep lobe below periproct. Width of fasciole in interambulacrum 4, 1, 1.0% L; distance from lower edge of periproct to fasciole 14% L. Not clear on which plates fascioles occur.

ORAL PLATE ARRANGEMENT.—Labrum short, length 8.9% L; sternal plates long with height 58% L, combined width 41% L.

OCCURRENCE.—Early Miocene, quarry on outskirts of Cardenas, Matanzas Province, Cuba.

Schizaster salutis Sánchez Roig

PLATE 22: FIGURES 4–6

MATERIAL.—The one specimen (SRC 4187), figured by Sánchez Roig (1949, pl. 45: fig. 4), is herein selected as the lectotype. This specimen is moderately well preserved with the tuberculation present, but the petals are partially removed by weathering.

SHAPE AND SIZE.—Test 55 mm long, width 50 mm (92% L), height 32 mm (59% L). Dorsal surface sloping anteriorly.

APICAL SYSTEM.—Central, 4 genital pores, ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in wide deep groove; many enlarged porepairs, length of region with enlarged porepair 36% L, width 13% L.

Anterior petals (II and IV) extending slightly more than two-thirds distance to margin, length 33% L, width 9.8% L, flexuous, depressed in deep groove; pores strongly conjugate, outer pore of pair slightly more elongated transversely than inner. Interporiferous zone at greatest width slightly narrower than single poriferous zone. Pores single beyond petals. Not possible to determine number of plate with first petaloid porepair.

Posterior petals (V and I) short, extending slightly more than one-half distance from apical system to margin, length 23% L, width 8.1% L, depressed in groove. Phyllodes with well-developed peripodia with large node behind each sin-

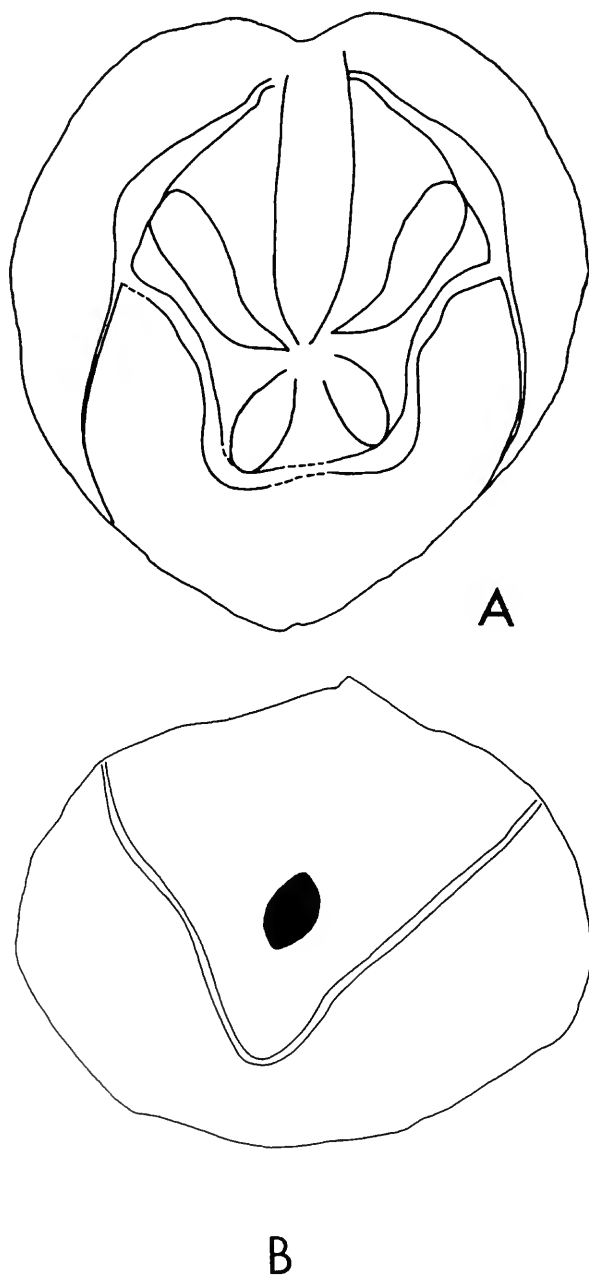


FIGURE 18.—*Schizaster munozi* Sánchez Roig, holotype, of *Schizaster riveroi* Sánchez Roig (= *S. munozi*), SRC 4194: A, dorsal view, $\times 1.5$; B, rear view, $\times 1.5$.

gle pore with pit in position where second pore would have been.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 19% L; width of opening 20% L, height 6.0% L.

PERIPROCT.—Located high on overhanging posterior truncation, height 13% L, width 11% L.

FASCIOLES.—Peripetalous fasciole wide, reaching greatest width as it passes around petals; angular, curving sharply into interambulacra 4 and 1. Latero-anal fasciole narrower, passing below periproct.

ORAL PLATE ARRANGEMENT.—Labrum not preserved. Sternal plates long, 58% L, width 38% L. In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Early Miocene, Lastra farm, La Salud, Habana Province, Cuba.

***Schizaster nuevitasensis* (Weisbord), new combination**

PLATE 23: FIGURES 2-5

Paraster nuevitasensis Weisbord, 1934:67, pl. 7: figs. 7, 8.—
Sánchez Roig, 1949:283.

MATERIAL.—I have nothing to add to Weisbord's description except to note that there are 50 porepairs in petal II, 34 in I, and 40 enlarged porepairs in ambulacrum III.

Phyllodes with well-developed peripodia; well-preserved peripodia having a high ridge-like node behind pore with a pit on side opposite pore (Plate 23: figure 5); 9 peripodia in ambulacrum II, 5 in I. Ventral tubercles well preserved: illustrated on Plate 23: figure 5.

OCCURRENCE.—Late Eocene, Weisbord's loc. 714, from lenticular marls between Nuevitas and Pastelillo along railroad cut, about 2 km SE of Nuevitas railroad station, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—The holotype and only known specimen is badly crushed, making it difficult to compare with other species. It appears to differ from *Schizaster camagueyensis* (Weisbord) (which occurs at the same locality with it) in having fewer porepairs in its petals.

The holotype of *S. nuevitasensis* is 39 mm long, whereas the holotype of *S. camagueyensis* is only 22 mm long, but both have approximately the same number of petaloid porepairs.

***Schizaster rojasi* Sánchez Roig**

FIGURE 19: PLATE 25: FIGURES 1-4

Schizaster (*Aplospatangus*) *rojasi* Sánchez Roig, 1952c:25, pl. 15: figs. 1-3.

MATERIAL.—Specimen SRC 4186, figured in the original description, is herein selected as the lectotype. It is well preserved with its test only slightly distorted (in the posterior region).

SHAPE AND SIZE.—Length 52 mm, width 97% L, height 52% L; greatest width anterior, greatest height posterior; margin sharp.

APICAL SYSTEM.—Posterior, located at distance from anterior margin to center of genital pores equal to 59% L; 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep, wide groove, greatest width 18% L, greatest depth adapically 6.7% L, depth of groove at margin 5.1% L; adapical area of

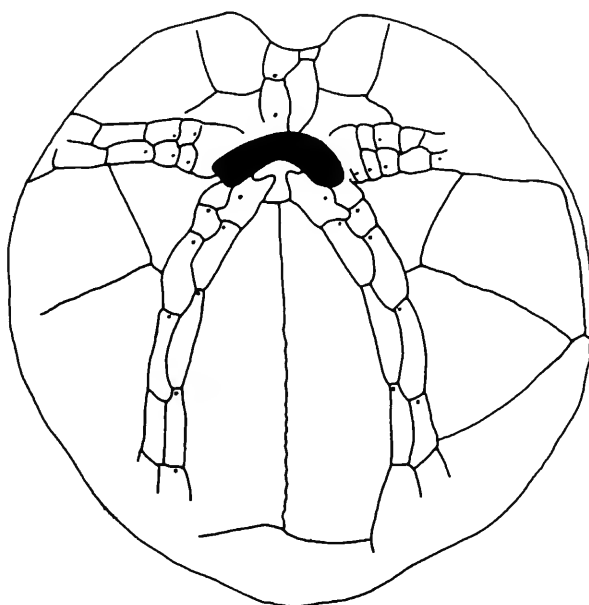


FIGURE 19.—*Schizaster rojasi* Sánchez Roig, ventral view of the lectotype, SRC 4186, $\times 1.6$.

enlarged porepairs extending more than two-thirds distance from apical system to margin; 70 porepairs in this region; first enlarged porepair in plate 7 or 8.

Anterior petals (II and IV) extending slightly less than two-thirds distance from apical system to margin, petals flexuous curving outwards distally, length 39% L, width 8.6% L, depressed in groove with greatest depth 3.6% L; interporiferous zone only slightly narrower than single poriferous zone; 74 petaloid conjugate porepairs, first petaloid pore in plate 12; 96 plates in ambulacrum.

Posterior petals (V and I) very short, curving slightly inward, length 19% L, width 7.7% L, depth 3.6% L; interporiferous zone slightly narrower than single poriferous zone; 42 petaloid porepairs; first petaloid porepair in plate 19; 78 plates in ambulacrum.

Phyllodes composed of well-developed peripodia with single large pore; each pore has ridge-like node behind with pit on other side where second pore would have been; 10 phyllodal pores in ambulacrum II, 5 in I, 3 perhaps 4 in III.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of opening 20% L; width 21% L, height 4.6% L.

PERIPROCT.—Located high on overhanging posterior truncation, visible from below; between interambulacral plates 6–9.

FASCIOLAS.—Peripetalous fasciole sharply indented in posterior paired interambulacra, crossing ambulacrum III on plate 4 or 5. Latero-anal fasciole largely eroded away.

ORAL PLATE ARRANGEMENT.—Labrum (Figure 19) low, height 8.5% L, extending posteriorly one-half height of first adjacent ambulacral plate. Sternal plates high and wide, height 58% L, width 34% L; bordered by ambulacral plates 1–6. In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Oligocene-Miocene, “Blanquital” farm, Cuatro Caminos, Marroquín, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is most similar to *Schizaster egozcuei* Lambert

also from the late Oligocene-early Miocene of Cuba having a similar marginal outline but differs in its more divergent anterior petals and shorter posterior petals. It differs from *S. munozi* also from the Oligocene-Miocene of Cuba in having a wider anterior ambulacrum; but in most of its other characters the two species are similar. This species may be a synonym of *S. munozi*, but more specimens must be studied.

Schizaster sanctamariae Sánchez Roig

PLATE 25: FIGURES 5–8

Schizaster sanctamariae Sánchez Roig, 1949:272, pl. 44: figs. 4, 5.

MATERIAL.—The holotype (SRC 4161) is moderately well preserved showing the shape of the test. Plate sutures not clear on most of test.

SHAPE AND SIZE.—Length 30 mm, width 26 mm (87% L), height 20 mm (67% L). Greatest width anterior of center, greatest height posterior.

APICAL SYSTEM.—Four genital pores, anterior pores much smaller than posterior, ethmolytic, located slightly anterior of center; distance from anterior margin to center of genital pores equal to 48% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep groove from apical system to peristome, depth of groove at margin 5.3% L. Pores paired only in adapical region where pores enlarged in large peripodia with approximately 38 porepairs; inner pore of pair elongated, outer circular. Adapically, ambulacrum widest near midlength between apical system and anterior margin.

Anterior petals (II and IV) extending almost two-thirds distance between apical system and margin, length 34% L, greatest width 13% L; deeply depressed in groove with depth 5.0% L. Petal curved convexly to anterior, pores of pair equally elongated transversely, 48 porepairs. Interporiferous zone at greatest width slightly narrower than single poriferous zone. Not possible to determine number of plates between end of petals and peristome.

Posterior petal (V and I) short, extending one-half distance from apical system to margin, length 24% L, width 11% L. Petals straight, depressed in groove with depth 4.3% L; 34 porepairs.

Phyllodes with single pores, 3 pores in ambulacrum III, 7 or 8 in II or IV, 6 in V or I. Peripodia with large ridge-like node behind pore; pit on other side of node giving impression of second pore.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 14% L, opening wider than high with width 21% L, height 8.6% L.

PERIPROCT.—Located high on nearly vertical posterior truncation. Opening higher than wide with height 19% L (est.), width 13% L.

FASCIOLAS.—Only short tracts of fascioles preserved on test. Peripetalous fasciole narrow, curving sharply into interambulacra 4, 1 not visible elsewhere. Latero-anal fasciole narrow, passing below periproct.

ORAL PLATE ARRANGEMENT.—Labrum broad, short, length 7.6% L, extended back to posterior one-third of first ambulacral plate. Plastron broad, width 38% L, length indeterminate.

OCCURRENCE.—According to Brodermann (1949:328), this species is from the Oligocene-Miocene; 1.75 mi (2.8 km) N of Santa Maria del Rosario, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from most of the other Cuban species of this genus by its narrower test.

Schizaster santanae Sánchez Roig

FIGURE 20; PLATE 26

Schizaster santanae Sánchez Roig, 1949:281, pl. 45: figs. 5–7.

MATERIAL.—Two specimens were figured by Sánchez Roig. Specimen SRC 4266 (his figures 6, 7) is herein designated the lectotype. The other specimen is no longer in the collection. The lectotype is moderately well preserved showing portions of the fascioles.

SHAPE AND SIZE.—Length 42.0 mm, width 41 mm (98% L), height 29 mm (70% L). Greatest

width anterior to center, greatest height posterior of apical system with posterior interambulacrum sharply inflated and test sloping anteriorly to margin.

APICAL SYSTEM.—Four genital pores (Figure 20), ethmolytic, located slightly anterior to center at distance from anterior margin to center of genital pores equal to 42% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome; groove at greatest width 11% L, depth at margin 2.6% L. Pores paired only in adapical region where the 42 porepairs are enlarged; peripodia well developed with large protuberance separating pores of pair; porepairs in single row. First enlarged pores in plate 6 or 7, plates near peristome very high; 54 or 56 plates in ambulacrum.

Anterior petals (II or IV) short, extending less than two-thirds distance from apical system to margin, length 30% L. Greatest width 11% L, narrowing sharply adapically; petals curving slightly anteriorly, depressed in groove of depth 3.3% L. Pores strongly conjugate, pores of pair equally elongated transversely, 50 porepairs, interporiferous zone at greatest width near end of petal, width less than width of poriferous zone. First petaloid porepair in plate 11 or 12; total of 77 plates in ambulacrum. Pores single beyond petals.

Posterior petals (V and I) short, extending approximately one-third distance from apical system to margin, length 21% L, width 8.3% L; in groove with depth 3.3% L. Petals curve slightly posteriorly; 40 porepairs; number of plate with first petaloid porepairs not discernible.

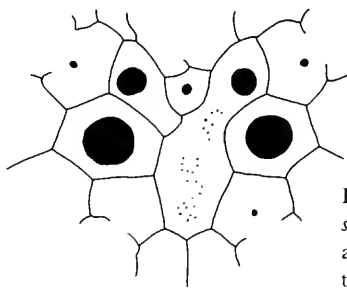


FIGURE 20.—*Schizaster santanae* Sánchez Roig, apical system of the lectotype, SRC 4266, $\times 14$.

Phyllodes single pored, 3 pores in ambulacrum III, 10 in II or IV, 6 in V or I; peripodia large with single large pore with big, thick ridge-like node behind pore, small pit on other side of node where second pore would be.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 19% L, opening wider than high, width 17% L.

PERIPROCT.—Located high on slightly overhanging posterior truncation. Opening higher than wide with height 14% L, width 11% L.

FASCIOLAS.—Peripetalous fasciole narrow, curving sharply into interambulacra 4 and 1, not discernible on rest of test; crossing ambulacra II or IV on plate 10 or 11, not clear in other ambulacra or interambulacra. Latero-anal fasciole narrow, only small portion preserved.

ORAL PLATE ARRANGEMENT.—Labrum broad and short, length 14% L. Sternal plates long, length estimated at 58% L. In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—According to Brodermann (1949:328), this species is from the middle to late Eocene, "Santa Ana" estate, Ciego de Avila, Majagua district, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species strongly resembles *Schizaster llagunoi* Lambert and Sánchez Roig from the middle Eocene of Cuba but is definitely a different species. *S. santanae* has a narrower anterior ambulacrum with only 42 enlarged porepairs in its lectotype as opposed to 56 in the lectotype of *S. llagunoi*. It also resembles *Schizaster munozi* Sánchez Roig but likewise differs in its narrower anterior ambulacrum with far fewer enlarged porepairs.

Schizaster subcylindricus Cotteau

FIGURE 21; PLATES 27, 28; FIGURES 1-4

Schizaster subcylindricus Cotteau, 1875:31, pl. 5: figs. 14-17.—

Guppy, 1882:197.—Jackson, 1922:78, pl. 13: fig. 10, pl. 14: figs. 1, 2.—Sánchez Roig, 1949:281.

Schizaster brachypetalus Arnold and Clark, 1927:59, pl. 11: figs. 14-16.

In the USNM collections, there are many specimens that are indistinguishable from the type

specimens of this species known previously from St. Bartholomew. Likewise, I have compared the type specimen of *S. subcylindricus* and the Cuban specimens to the type specimens of *Schizaster brachypetalus* Arnold and Clark from the Eocene of Jamaica and they are all indistinguishable. The type specimens of both species are illustrated herein on Plate 27: figures 1, 2, and Plate 28:

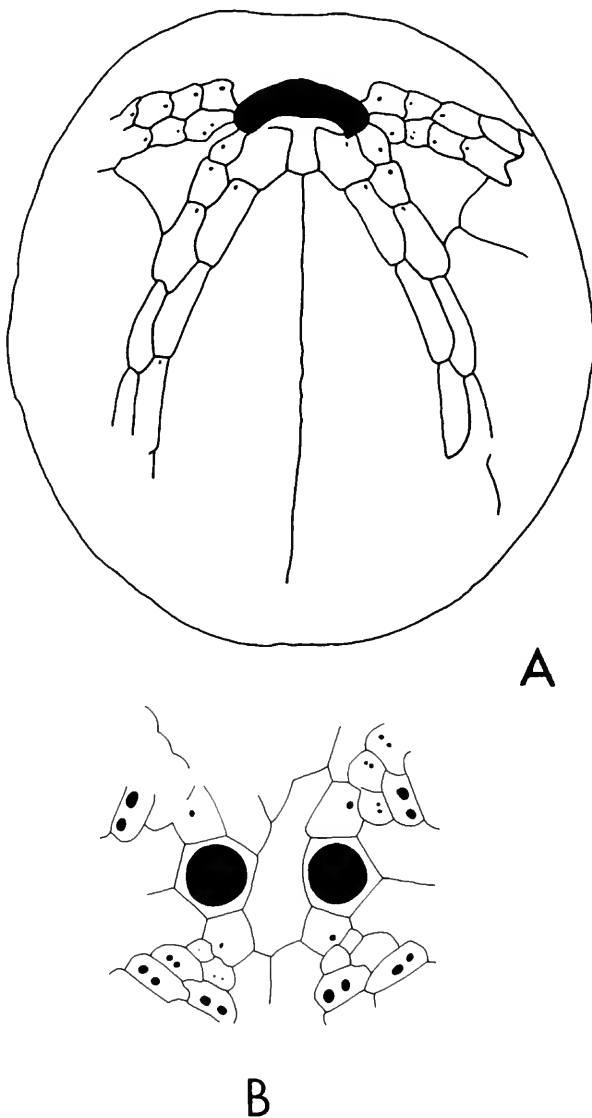


FIGURE 21.—*Schizaster subcylindricus* Cotteau, USNM 563308, Eocene, Loma Caoba, 5 km S of San Diego de Los Baños, Pinar del Rio Province: A, ventral view, $\times 3.5$; B, apical view, $\times 14$.

figures 1–4. The following description is based on 38 specimens from the same Cuban locality. The specimens have undistorted tests, but most of them are badly weathered obscuring the tuberculation.

SHAPE AND SIZE.—Length 18 to 34 mm (mean 28 mm), width 88 to 98% L (mean 93%); height 70 to 82% L (mean 76%), greatest width central, greatest height posterior.

APICAL SYSTEM.—Posterior, located at distance from anterior margin to center of genital pores equal to 48 to 62% L (mean 55%); 2 genital pores, ethmolytic (Figure 21B) with genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep groove adapically, slight groove at margin. Porepairs enlarged adapically, 32 porepairs in specimen 26 mm long, 34 in specimen 32 mm long, porepairs in well-developed peripodia with high ridge separating each pore, inner pore of pair more anterior and more elongate; first enlarged porepair in plate 6.

Anterior petals (II and IV) flexuous, long, wide, extending more than two-thirds distance from apical system to margin, length 34 to 43% L (mean 39%); greatest width 11 to 16% L (mean 13%); interporiferous zone one-half width poriferous zone. Poriferous zone at greatest width 5.7 to 8.1% L (mean 6.7%), both pores of pair slit-like, 48 porepairs in petal of specimen 20 mm long, 60 in specimen 32 mm long. Porepairs in anterior poriferous zones smaller adapically than in posterior zones. Petal depressed in groove with depth 2.7 to 5.6% L (mean 4.3%). First petaloid porepair in plate 11.

Posterior petals (V and I) short, straight, length 15 to 22% L (mean 19%); width 8.1 to 12% L (mean 10%); depressed in groove with depth 1.2 to 4.3% L (mean 2.7%); interporiferous zone slightly more than one-half width of poriferous zone; 28 porepairs in petal in specimen 20 mm long, 38 in specimen 32 mm long.

PERISTOME.—Anterior, distance from anterior edge of opening to anterior margin equal to 10 to 20% L (mean 15%); width of opening 17 to 23% L (mean 20%).

PERIPROCT.—Located high on overhanging posterior truncation, slightly visible from below; opening higher than wide.

FASCIOLES.—Peripetalous fasciole slightly indented in posterior paired interambulacra, passing straight across posterior interambulacrum, passing far anteriorly and low around anterior margin; crossing plate 4 in ambulacrum III. Latero-anal fasciole passing in deep lobe below periproct at distance below periproct greater than height of periproct.

ORAL PLATE ARRANGEMENT.—Labrum long (Figure 21A); on specimen 33 mm long, labrum 5.5 mm long (16% L); first 2 plates of plastron 16.1 mm long (49% L), width 12.8 mm long (39% L).

OCCURRENCE.—Eocene, St. Bartholomew Limestone, St. Bartholomew; middle to late Eocene, Loma Caoba, 5 km S of San Diego de los Baños; Km 186 on railroad to Guane, Pinar del Rio Province, Cuba. *Schizaster brachypetalus* is known from the Eocene of Jamaica near Abingdon, SW of Green Harbour, Hanover Parish, and from St. James Parish.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Schizaster camagueyensis* Weisbord also from the Eocene of Cuba. It differs only in having its apical system less posteriorly situated and in having less depressed petals. The two species may be synonyms but too few specimens are known of *S. camagueyensis* to be able to know the variation within the species.

Schizaster subcylindricus is very similar and obviously closely related to *Ditremaster beckeri* (Cooke) from the late Eocene Ocala Limestone of Florida. They only differ in that the anterior petals in *S. subcylindricus* are slightly shorter and the apical system more anterior. These petals in *D. beckeri* have a length equal to 48% L as opposed to 34–41% L (mean 37.5%) in *S. subcylindricus*. *Ditremaster beckeri* should be referred to *Schizaster*. Its latero-anal fasciole is distinct, whereas, no latero-anal fasciole is present in *Ditremaster*. *Schizaster subcylindricus* differs from *S. antillarum* Cotteau also from the Eocene of St. Bartholomew in having its apical system more posterior, a narrower test, and its peristome more anterior.

REMARKS.—On one specimen the second plate in interambulacrum 2 is single, not paired (Figure 21A). The plate arrangement in interambulacrum 2 is visible on 4 other specimens and in all of them a pair of plates follows the first plate. In one of them, however, only a small portion of a second plate is in contact with the first plate.

UNRECOGNIZABLE SPECIES OF *Schizaster*

Schizaster alcaldei Sánchez Roig

Schizaster alcaldei Sánchez Roig, 1949:273; 1951:64, pl. 39: figs. 10, 11.

OCCURRENCE.—Late Eocene, central Soledad, Cienfuegos, Santa Clara (now Las Villas) Province, Cuba.

REMARKS.—The holotype is lost and there are no topotypic specimens well enough preserved to permit redescription of this species. Sánchez Roig's illustrations are too poor to permit comparison of this species with other species of this genus.

Schizaster caobaense Sánchez Roig

Schizaster caobaense Sánchez Roig, 1949:273, pl. 44: fig. 2.

MATERIAL.—Although 12 specimens labelled as belonging to this species are in the Sánchez Roig Collection, none are the type and most do not belong to *Schizaster*. Sánchez Roig's illustration shows a specimen with its petals filled with matrix. He gives no side or bottom views. Too little is known of this species to determine its affinities.

OCCURRENCE.—Eocene, Caraballo quarry, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Schizaster cojimarensis Sánchez Roig

Schizaster cojimarensis Sánchez Roig, 1949:270, pl. 44: figs. 1, 3.

MATERIAL.—No specimens of this species are in the Sánchez Roig Collection; therefore, it is not possible to redscribe it. Sánchez Roig's illustra-

tions are too poor to permit comparison of this species with other species of the genus.

OCCURRENCE.—Miocene, "La Noria" farm, Cojimar, Habana Province, Cuba. Although Sánchez Roig (1949:270) and Brodermann (1949:327) consider this locality to be late Oligocene, Brönnimann and Rigassi (1963:466) state that the Cojimar Formation outcrops here. They date it as Miocene on the basis of foraminifera. Albear (1981, personal communication) agrees with this latter date.

Schizaster cubensis d'Orbigny

PLATE 28: FIGURE 5

Schizaster cubensis d'Orbigny in Agassiz and Desor, 1847:22.—Sagra, 1855: pl. 8: figs. 4, 6.—Gray, 1855:61.—Michelin, 1855:759.—Sánchez Roig, 1949:280.

Hemiasaster cubensis (d'Orbigny).—Cotteau, 1881:41, pl. 4: figs. 1–3; 1897:73, pl. 25: figs. 1–3.—Jackson, 1922:73.

I have studied fragments of the holotype (MNHN 11934) in the Muséum National d'Histoire Naturelle and can see traces of a latero-anal fasciole, indicating that this species should be referred to *Schizaster*. The fragments are too incomplete to permit a redescription of this species.

OCCURRENCE.—Pliocene or Recent from Cuba according to Cotteau. The specimen is so well preserved that I doubt if it is older, although Sánchez Roig reports this species from the early Miocene, Medina quarries, at Vedado, Habana Province, Cuba.

Schizaster habanensis Sánchez Roig

Schizaster habanensis Sánchez Roig, 1949:270, pl. 45: figs. 1, 2.

One specimen in the Sánchez Roig Collection is labelled as being this species, but it is not the type; neither is it topotypic. Sánchez Roig's illustrations do not show sufficient details to permit comparison of this species with others.

OCCURRENCE.—Miocene, National Home for the Aged, Casa Blanca, Habana Province, Cuba. Although Sánchez Roig (1949:271) and Brodermann (1949:327) consider this locality to be late

Oligocene, Brönnimann and Rigassi (1963:466) report that the Cojímar Formation outcrops there. They assign a Miocene age to this formation on the basis of foraminifera.

Schizaster moronensis Sánchez Roig

Schizaster moronensis Sánchez Roig, 1951:58, pl. 36: figs. 4, 5.

MATERIAL.—No specimens of this species are in the Sánchez Roig Collection; therefore, a redescription of this species is not possible. Sánchez Roig's illustrations show that the apical system is very posteriorly eccentric, with very short posterior petals, flexuous anterior petals, and very anterior peristome. It resembles *Schizaster camagueyensis* (Weisbord) from the late Eocene of Cuba, but *S. moronensis* appears to have narrower petals.

OCCURRENCE.—Oligocene-Miocene, "Las Cuevas" farm of Pedro del Pozo, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

Schizaster pastelilloensis (Weisbord),
new combination

PLATE 28: FIGURES 6–8

Paraster pastelilloensis Weisbord, 1934:70, pl. 7: figs. 12–14.—
Sánchez Roig, 1949:284.

The holotype (PRI 3832) is the only specimen known of this species. It is badly distorted and it is not possible to compare it to other species of this genus from Cuba.

OCCURRENCE.—Late Eocene, from cut along the railroad between Nuevitas and Pastelillo, about 2 km SE of Nuevitas railroad station, Camagüey Province, Cuba.

Schizaster pinarensis (Sánchez Roig),
new combination

Paraster pinarensis Sánchez Roig, 1953c: 173–174, pl. 12: figs. 3, 4.

MATERIAL.—The only specimen (SRC 4197) of this species in the Sánchez Roig Collection is labelled as the type (it carries the red dot usually

placed on type-specimens) and is from the type-locality. It is not the specimen figured by Sánchez Roig; it is far longer than Sánchez Roig's cotype. Its peristome is more posterior than the specimen figured by Sánchez Roig. It does not appear to be the same species. It is, therefore, not possible to know the characters of this species.

OCCURRENCE.—Middle-late Eocene, "La Caoba" farm, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Schizaster sandiegensis (Sánchez Roig),
new combination

Paraster sandiegensis Sánchez Roig, 1949:288–289; 1951, pl. 40: figs. 6, 7.

MATERIAL.—No specimens are present of this species in the Sánchez Roig Collection. Without seeing specimens, it is not possible to know the characters of this species. Sánchez Roig's illustrations are too poor to permit comparison of this species with others of this genus.

OCCURRENCE.—Eocene, Loma Caoba, 3 km S of San Diego de los Baños, E of the old road to the quarry, Pinar del Rio Province, Cuba.

Schizaster sierrai (Sánchez Roig),
new combination

Paraster sierrai Sánchez Roig, 1951:63, pl. 40: fig. 1

MATERIAL.—No specimens of this species are in the Sánchez Roig Collection. It is not possible to know the characters of this species.

OCCURRENCE.—Pleistocene, Buenaventura, between Jagüey Grande and Bahía de Cochinos, between Las Villas and Matanzas Provinces, Cuba.

Genus Agassizia L. Agassiz and Desor, 1847

Test small to medium size, high, plates thin; apical system ethmolytic with four genital pores; anterior ambulacrum and petals flush to slightly depressed, pores in anterior poriferous zones of petals smaller than in posterior; both peripetalous and latero-anal fascioles.

HABITAT.—The two living species of *Agassizia*

are restricted to tropical American seas at depths from littoral to 900 m. Nothing is known of their living habits except for the report by Lewis (1963:361) that *Agassizia excentrica* Agassiz appears to ingest loose bottom material at random. I opened a dead test of the Recent *Agassizia scrobiculata* Valenciennes. Its gut was packed with coarse shell fragments.

Species of *Agassizia* probably live buried in sand. Serafy (1979:90) reports that *A. excentrica* was collected on an algal sand bottom and specimens of *Agassizia scrobiculata* Valenciennes in the USNM collections were collected on sand. However, *Agassizia* probably lacks the ability to maintain a burrow in mud. The pores and peripodia in the dorsal part of the anterior ambulacrum are small, only slightly larger than those below the margin of the test, indicating a slight development in the funnel-building tubefeet (Smith, 1980) necessary for maintenance of a tunnel through mud to the surface. I have examined specimens of the Recent *A. scrobiculata* and note that although the tubefeet in the anterior ambulacrum have discs and rods, these tubefeet are small and there are few of them. They are largest near the margin. Their scarcity, small size, and slight development adaptically would make it difficult for this echinoid to maintain a long tunnel in mud. Furthermore, the fact that the ambulacra, including the petals, are not depressed in

deep grooves is further evidence that these echinoids lived in coarser sediments. Mud-living species (Kier, 1975), such as *Schizaster doederleini* (Chesher), *Moiria atropos* (Lamarck), and *Brissopsis elongata* Mortensen, have depressed petals and anterior ambulacra. They all have many well-developed funnel-building tubefeet.

EVOLUTION.—No clear evolutionary trends are apparent among the Cuban species of *Agassizia*, except that the Eocene species all have their apical system very posterior with short posterior petals; whereas, some of the later species, such as the late Oligocene-Miocene *Agassizia alveari* Sánchez Roig, have a central apical system and longer posterior petals.

COMPARISON WITH SPECIES OF *Agassizia* OUTSIDE OF CUBA.—Two of the Cuban species occur elsewhere. *A. clevei* is known from Anguilla, Puerto Rico, and southeastern United States. *A. inflata* has been found in St. Bartholomew, Jamaica, and North and South Carolina. *A. alveari* and *A. pinarensis* are distinct from any other species in the Western Hemisphere.

REMARKS.—Eleven species of *Agassizia* have been reported from Cuba. Four are recognized as valid herein (Table 4). Three are not recognizable because their type-specimens have been lost. Three are considered synonyms of *Agassizia clevei* Cotteau and two are synonyms of *Agassizia inflata* Jackson, not previously reported from Cuba.

TABLE 4.—Disposition herein of Cuban species of *Agassizia*

Disposition	Miocene	Oligocene-Miocene	Eocene-Miocene	Eocene
Recognized species (synonyms)	<i>A. pinarensis</i>	<i>A. alveari</i>	<i>A. clevei</i> (<i>A. avilensis</i>) (<i>A. camagueyana</i>) (<i>A. caribbeana</i>) (<i>A. floridana</i>) ¹ <i>A. inflata</i> ¹ (? <i>A. caobaensis</i>) (<i>A. egozcuei</i>) (<i>A. wilmingtonica</i>) ¹	
Unrecognizable species		<i>A. guanensis</i> <i>A. lamberti</i> ²		<i>A. flexuosa</i>

¹ Species not previously reported from Cuba. ² Age uncertain.

Agassizia is easily distinguished by the presence of smaller pores in the anterior poriferous zones of the anterior petals. Some workers, including Cooke (1959:75) and Fischer (1966:U574), use

Anisaster as a subgenus of *Agassizia* for those species in which some of the pores are not reduced in this anterior zone. This division is not used herein.

Key to Cuban Species of *Agassizia*

1. No large pores in anterior poriferous zones of anterior petals 2
 Some large pores in anterior poriferous zones of anterior petals 3
2. Central apical system ***A. pinarensis*** Sánchez Roig
 Posterior apical system ***A. clevei*** Cotteau
3. Short posterior petals ***A. inflata*** Jackson
 Long posterior petals ***A. alveari*** Sánchez Roig

Agassizia alveari Sánchez Roig

FIGURE 22; PLATE 33; FIGURES 6–9

Agassizia alveari Sánchez Roig, 1949:258, pl. 41: fig. 7

MATERIAL.—The specimen (SRC 4084) figured by Sánchez Roig is herein designated the lectotype. It is moderately well preserved with its test undistorted and the surface well enough preserved to show the fascioles. Two other topotypic specimens are used in the following description. A third topotype is in the MCZ (4118).

SHAPE AND SIZE.—Length 24 to 35 mm, width 83 to 92% L, height 74 to 77% L; greatest width central, greatest height anterior. Dorsal surface smoothly inflated.

APICAL SYSTEM.—Posterior, located at distance from anterior margin to center of genital pores equal to 48 to 54% L; 4 genital pores ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove, pores only slightly enlarged adapically, in very small peripodia; porepairs widely spaced, dorsal plates very high.

Anterior petals (II and IV) long, extending almost to margin, length 44 to 47% L, width 7.6 to 9% L; petals curving anteriorly; depressed in very slight groove. Pores greatly reduced in size in anterior poriferous zone, only distal 4 porepairs enlarged but still not as large as pores in poriferous zone; interporiferous zones no wider than single poriferous zone; outer pore of pair more

elongate than inner; 52 porepairs in specimen 24 mm long, 56 in specimen 29 mm long, 60 in specimen 35 mm long. Pores single beyond petals.

Posterior petals (V and I) straight, short, extending four-fifths distance from apical system to margin, length 40 to 42% L, width 8.5 to 10% L, depressed in slight groove. Adapically anterior poriferous zones with porepairs somewhat smaller than in posterior poriferous zones; 46 porepairs in specimen 24 mm long, 52 in specimen 29 mm long, 58 in specimen 35 mm long.

Phyllodes single pored with well-developed peripodia, number of pores not clear.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of opening 17 to 20% L, width 16 to 24% L, height 8.2 to 9.4% L.

PERIPROCT.—Marginal, slightly visible from below; opening wider than high, width 18 to 22% L.

FASCIOLES.—Peripetalous fasciole passing anteriorly inframarginally at great distance from anterior petals, then curving sharply adapically (Figure 22) in posteriorly paired interambulacra. Latero-anal fasciole passing posteriorly in deep lobe below periproct at distance slightly greater than height of periproct.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear but labrum appears to be short, plastron large.

OCCURRENCE.—Oligocene-Miocene, 42 km W of Ciego de Avila, 419.7 km on central highway, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This spe-

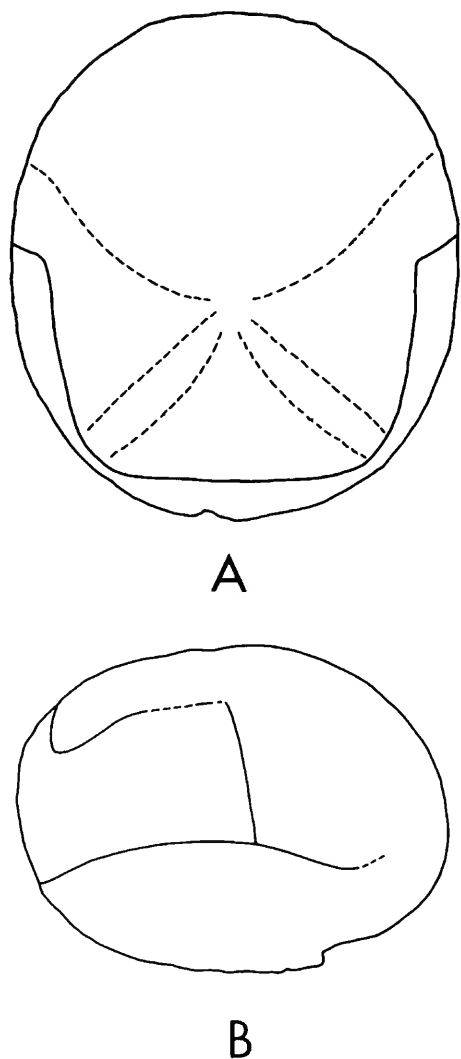


FIGURE 22.—*Agassizia alveari* Sánchez Roig, positions of the fascioles of the lectotype, SRC 4084, $\times 2$: A, ventral view; B, side view.

cies is easily distinguished from all other Cuban and most of the Western Hemisphere species of *Agassizia* by its very long posterior petals. It is found with *A. inflata* from which it is distinguished by its longer posterior petals and more central apical system. *Agassizia porifera* (Ravenel) from the Pleistocene of Florida and South Carolina has long posterior petals but differs from *A. alveari* in lacking large pores in the anterior poriferous zone of the anterior petals, in its wider and larger test, and more anterior apical system.

Agassizia clevei Cotteau

FIGURE 23; PLATES 29–31

Agassizia clevei Cotteau, 1875:33, pl. 6: figs. 2–8 [in part, not figs. 9, 10].—Jackson, 1922:71, pl. 12: figs. 5–7.—Sánchez Roig, 1949:256.—Gordon, 1963:640, fig. 1, pl. 80: figs. 1–3.
Agassizia floridana de Loriol, 1887:398, pl. 17: figs. 9–9f.—Cooke, 1942:44, pl. 3: figs. 1–4.—Fischer, 1951:73, pl. 6: figs. 3, 4.—Cooke, 1959:75, pl. 32: figs. 1–4.
Agassizia caribbeana Weisbord, 1934:238, pl. 8: figs. 1–6.
Agassizia avilensis Sánchez Roig, 1949:260, pl. 41: figs. 4–6, 8.
Agassizia camagueyana Weisbord, 1934:247, pl. 9: figs. 5, 6.—Sánchez Roig, 1949:253.

MATERIAL.—I have studied many specimens of *Agassizia floridana* de Loriol from the late Eocene of Florida and cannot distinguish them in any way from the types of *A. clevei* from the Miocene of Anguilla. The Cuban and Floridian specimens are identical in shape of the test, arrangement of petals, number of petaloid porepairs, absence of petaloid porepairs in the anterior poriferous zones of the anterior petals, position and shape of peristome, and position of the apical system. I searched for differences with particular care, since the Floridian specimens are late Eocene and the types of *A. clevei* are from the Miocene Anguilla Formation in Anguilla. Echinoids do not commonly have such a wide stratigraphic range.

The types of *A. clevei* and specimens from Florida previously referred to *A. floridana* are illustrated for comparison with each other on Plate 29: figures 6, 7, and Plate 31: figure 8.

I have examined the holotype (Plate 31: figures 1–3) and paratype (Plate 31: figures 4–6) of *Agassizia caribbeana* and agree with Cooke (1959:75) that it is a synonym of *A. floridana*. Weisbord's description (1934:238) is detailed and requires only the inclusion of the following statistics: holotype with length of 35 mm has 20 porepairs in posterior poriferous zone of anterior petal; 32 in both zones of posterior petal. Paratype 21 mm long with 18 porepairs in posterior poriferous zone of anterior petal; 26 in both zones of posterior petal.

Sánchez Roig's holotype (Plate 29: figures 4, 5) and topotype (Plate 29: figures 1–3) of *A. avilensis* are very similar to specimens of *A. floridana* from

the late Eocene, Crystal River Formation of Florida. The dimensions of the Cuban and Floridian specimens were placed on scattergrams. In the following characters the two species were inseparable: length, width, height of test, length of anterior petals, length of posterior petals, position of apical system, number of porepairs in the petals, and the position of the fascioles. They differ only in that the petals in the Cuban specimens are slightly wider. As there are only 2 Cuban specimens, it is not possible to know the significance of this difference. The 2 species are too similar to be differentiated on the basis of the evidence now available.

The holotype (Plate 31: figure 7) of *Agassizia camagueyana* Weisbord from the Oligocene-Miocene of Cuba appears to me to be only a flattened *A. clevei*.

Cooke (1959:75) considered *Agassizia inflata* Jackson and *Agassizia egozcuei* Lambert, from the Eocene St. Bartholomew Limestone of St. Bartholomew, to be synonyms of *Agassizia floridana*. I have seen the holotype of *A. inflata* (*A. egozcuei* is based on material conspecific with *A. inflata*). Although they are similar in many ways, *A. inflata* can be distinguished by its more anterior apical system and by possessing a few enlarged porepairs in the anterior poriferous zones of its anterior petals. In none of 17 specimens studied of *A. floridana* were any large porepairs present in the anterior poriferous zones.

Jackson (1937:233) referred 2 specimens from the Oligocene-Miocene of Mexico to *A. clevei*. These specimens have a few larger pores in the anterior poriferous zones of the anterior petals that are not found in *A. clevei*. These 2 specimens are very similar to *Agassizia inflata* Jackson.

OCCURRENCE.—The type specimens of *A. clevei* came from the Miocene Anguilla Formation of Anguilla. Sánchez Roig (1949:257) reports this species from "La Noria" farm, Cojímar, Habana Province, Cuba. According to Brönnimann and Rigassi (1963:466), this locality is in the Miocene Cojímar Formation. Gordon (1963:640) refers to this species' specimens from the Miocene of Puerto Rico.

Sánchez Roig's specimens of *A. avilensis* came

from the Oligocene-Miocene, Carretera Central, both sides, 425.5 km E of Habana, 36.1 km W of Ciego between Ciego de Avila and Jatibonico, Camagüey Province, Cuba.

Weisbord's specimens of *A. caribbeana* came from the late Eocene, Loma Calisto, and between Nuevitas and Pastelillo, Camagüey Province, Cuba. His holotype of *A. camagueyana* is from the Oligocene-Miocene at Km 440, central highway, between Jatibonico and Ciego de Avila, Camagüey Province, Cuba. The American specimens of *A. floridana* come from the late Eocene Ocala Limestone of Florida and Georgia (see Cooke, 1959:75, for detailed locality data).

One specimen (Plate 30: figures 5–7) of this species (MCZ 4124) is from Palmer's locality 1081, Oligocene-Miocene, in roadcuts at Arroyo la Palma, 8.2 km SE of bridge over Río Zaza or 12.8 km SE of Sancti Spiritus.

SYNONYM

Agassizia avilensis Sánchez Roig

FIGURE 23; PLATE 29: FIGURES 1–5, PLATE 30: FIGURES 1–4

MATERIAL.—Three specimens in the Sánchez Roig Collection are referred to this species. The holotype (SRC 4749) and only specimen figured by Sánchez Roig is beautifully preserved showing the fascioles and other surface detail. It is slightly compressed. A second topotypic specimen (SRC 4750) is also well preserved and shows the original shape of the test. A third specimen (SRC 4222), from Palmer's locality 1081, may belong to this species, but it is too poorly preserved to be identified with certainty. It is not used in this description. One topotype (4121) is in the MCZ (Plate 30: figures 1–4). The first dimension given below refers to the holotype; the second is for the topotype SRC 4750.

SHAPE AND SIZE.—Length 25 and 26 mm, width 22 and 24 mm (91 and 92% L); height of topotype 21 mm (83% L). Greatest width central, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic with genital plate 2 extending far beyond the posterior ocular plates. Apical system posterior of

center at distance from anterior margin to center of genital plates equal to 57 and 67% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, adapically in very shallow groove not extending to margin. Porepairs in adapical region only slightly enlarged, in peripodia, with pore-

pairs widely separated longitudinally from each other because of great height of plates; no clear demarcation between area with enlarged pores and area adoral with slightly smaller porepairs; 40 and 40 plates in ambulacrum.

Anterior petals (II and IV) extending more than two-thirds distance from apical system to margin, length 51 and 56% L; greatest width 9.3 and 8.9% L, curving in convex arc; depressed in very shallow groove. Porepairs of anterior poriferous zone greatly reduced in size, no large pores in anterior zone; porepairs of posterior poriferous zones not conjugate, outer pore of pair more elongate than inner; 44 and 48 porepairs in petal including anterior poriferous zone; first petaloid porepair in plate 13. Total of 68 plates in ambulacrum in holotype.

Posterior petals (V and I) very short, extending less than one-half distance from apical system to margin, length 23 and 28% L. Petals wide, 12 and 12% L, in shallow groove. Interporiferous zone narrow, less than one-half width of single poriferous zone. Petal straight with 26 and 32 porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 17 and 10% L; opening wider than high, width 25 and 25% L, height unknown.

PERIPROCT.—Located high on vertical posterior truncation, opening wider than high; on topotypic specimen width 22% L, height 15% L.

FASCIOLAS.—Peripetalous fasciole narrow, width 2.3% L, with 4 longitudinal rows of nodes; curving sharply into interambulacra 4 and 1, straight across interambulacrum 5; from ends of anterior plates, fascioles curve down to junction with latero-anal fasciole, anteriorly passing below margin, far distant from ends of anterior petals (Figure 23A, B); crossing ambulacrum III on plate 3 or 4, II or IV on 8. Latero-anal fasciole passing in deep lobe (Figure 23c) below periproct; at greatest width 1.9% L with 6 longitudinal rows of nodes.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear, but labrum appears to be very short; plas-tron very large.

OCCURRENCE.—Oligocene-Miocene, Carretera Central, both sides, 425.5 km E of Habana, 36.1

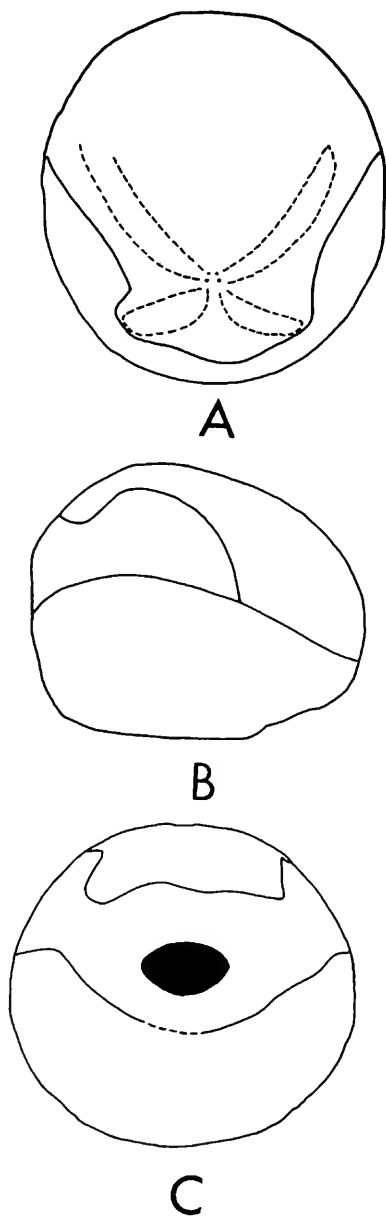


FIGURE 23.—*Agassizia clevei* Cotteau, topotype of *Agassizia avilensis* Sánchez Roig (= *A. clevei*), SRC 4750, $\times 2$: A, dorsal view; B, side view; C, rear view.

km W of Ciego between Ciego de Avila and Jatibonico, Camagüey Province, Cuba.

Agassizia inflata Jackson

PLATE 32

Agassizia clevei Cotteau, 1875:33 [part], pl. 6: figs. 9, 10 [not figs. 3–8].

Agassizia inflata Jackson, 1922:70, pl. 12: figs. 2–4.

Agassizia egozcuei Lambert in Lambert and Thiéry, 1925 [1909–1925]:596.

Agassizia wilmingtunica Cooke, 1942:46, pl. 5: figs. 9–13; 1959:76, pl. 32: figs. 10–13.—Kier, 1980:43, fig. 19, pl. 15: figs. 1–10.

?*Agassizia caobaensis* Sánchez Roig, 1953c:172, pl. 12: figs. 1, 2.

MATERIAL.—Fourteen Cuban specimens in the USNM collections are indistinguishable from the holotype of this species from St. Bartholomew and USNM specimens from Jamaica.

Likewise, no differences could be found from a comparison of the Cuban specimens and the type specimen of *A. inflata* with many specimens of *Agassizia wilmingtunica* Cooke from the middle Eocene of North and South Carolina. Scattergrams plotting the dimensions of all the major characters revealed no separation between the *A. inflata* specimens and those of *A. wilmingtunica* from North Carolina.

The type specimen of *Agassizia caobaensis* Sánchez Roig is not in the Sánchez Roig Collection. One cannot be certain of its specific characters, but all the specimens I have seen from its type-locality belong to *A. inflata*.

OCCURRENCE.—Eocene, St. Bartholomew Limestone, St. Bartholomew; Late Eocene, 3.5 km SE of San Diego de los Baños, Pinar del Rio Province, Cuba. Oligocene-Miocene, 43.1 km W of Ciego de Avila, Camagüey Province, Cuba. In the USNM collections of the Smithsonian are 4 specimens from Jamaica that are indistinguishable from the Cuban specimens. These specimens are labelled as having been collected by B.W. Arnold in Jamaica—no further stratigraphic or geographic data are given. *A. wilmingtunica* occurs in the middle Eocene Castle Hayne and Santee Limestones of North and South Carolina (see Kier, 1980:44 for localities).

COMPARISON WITH OTHER SPECIES.—*Agassizia inflata* is very similar to *A. clevei* from elsewhere in Cuba and from Anguilla, Puerto Rico, Mexico, Florida, and Georgia. *A. inflata* differs in having its apical system more anterior and in having a few enlarged petaloid pores in the anterior poriferous zones at the end of the anterior petals. No enlarged pores are present in *A. clevei*.

Agassizia regia Israelsky from Mexico differs in having its anterior petals curving more convexly and in having smaller pores in the anterior poriferous zones of the anterior petals.

Agassizia pinarensis Sánchez Roig

FIGURE 24; PLATE 33: FIGURES 1–5

Agassizia pinarensis Sánchez Roig, 1952c:22, pl. 6: figs. 6, 7.

MATERIAL.—The holotype (SRC 4160) and only known specimen is well preserved with its test not distorted and its tuberculation well preserved showing the fascioles.

SHAPE AND SIZE.—Length 22.8 mm, width 21.0 mm (92% L), height 19.1 mm (84% L). Greatest width and height central.

APICAL SYSTEM.—Four genital pores ethmolytic, centrally located at distance from anterior margin to center of genital pores equal to 41% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, adapically in very shallow groove; porepairs in dorsal region widely separated because of great height of plates; approximately 22 plates in dorsal region.

Anterior petals (II and IV) long, extending almost to margin, length 19% L; petal depressed in slight groove, petals narrow, greatest width 11% L, curving in convex arc. Porepairs of anterior poriferous zones greatly reduced in size, no large pores in anterior zone; porepairs of posterior poriferous zones not conjugate, outer pore of pair more elongate than inner; 46 porepairs in petal including anterior poriferous zone.

Posterior petals (V and I) very short, extending less than one-half distance from apical system to margin, length 32% L. Petals wide, width 12% L, in shallow groove. Interporiferous zone narrow, one-half width of single poriferous zone. Petals

straight with 30 porepairs. First petaloid porepair in plate 15; total of 58 plates in ambulacrum. Last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

Phyllodes with large peripodia, number of pores in each phyllode not clear.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 18% L; opening wider than high, width 22% L, height 8.8% L.

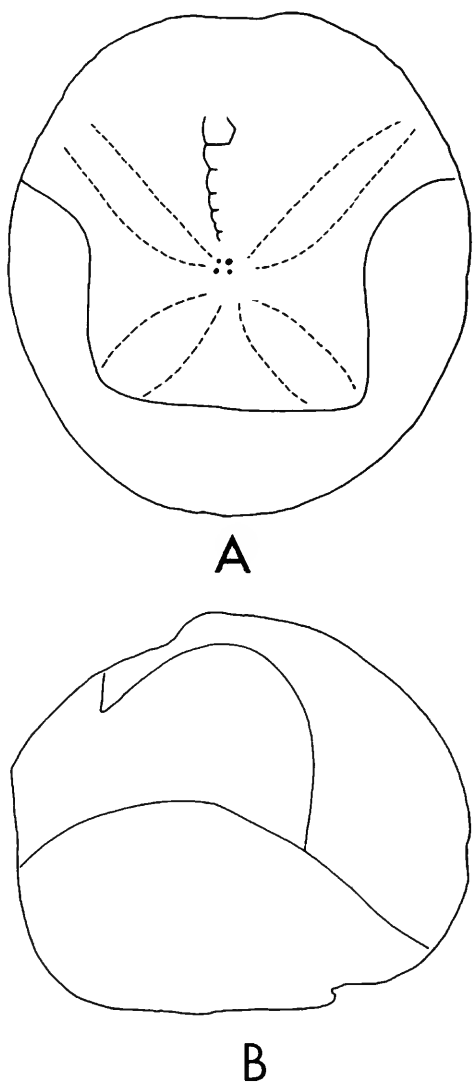


FIGURE 24.—*Agassizia pinarensis* Sánchez Roig, holotype, SRC 4160, $\times 3$: A, dorsal view; B, right side.

PERIPROCT.—Located high on posterior truncation; opening wider than high, width 22% L, height 15% L.

FASCIOLES.—Peripetalous fasciole (Figure 23) broad, width 2.6% L, curving sharply into interambulacra 4 and 1, straight across interambulacrum 5; from ends of anterior petals fasciole curves sharply adorally to junction with latero-anal fasciole; anteriorly fasciole curves adorally passing around anterior of test below margin (Figure 24B); crossing ambulacrum III on plate 3 or 4, II or IV on 7 or 8, V or I on 14. Latero-anal fasciole passing in deep lobe below periproct; crossing ambulacra V or I on plate 10.

ORAL PLATE ARRANGEMENT.—Labrum broad, short, length 6.6% L. Rest of plate sutures difficult to discern, but plastron appears to be large.

OCCURRENCE.—Miocene, extreme N of Consolación del Sur, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from *Agassizia clevei* Cotteau by its rounder, wider, higher test with its greatest height central rather than posterior and its steeper anterior surface. Furthermore, in *A. pinarensis* the apical system is central, whereas, in *A. clevei* it is very posteriorly situated. It is distinguished from *Agassizia inflata* by its more central apical system and absence of any enlarged petaloid pores in the anterior poriferous zones of the anterior petals. It differs from the Oligocene-Miocene Cuban species *Agassizia alveari* Sánchez Roig in having much shorter posterior petals and lacking enlarged pores in its anterior poriferous zones of its anterior petals. It is very similar in general appearance to *Agassizia mossomi* Cooke from the late Oligocene-early Miocene of southeastern United States but differs in having no enlarged pores in the anterior poriferous zones of the anterior petals.

UNRECOGNIZABLE SPECIES OF *Agassizia*

Agassizia flexuosa Sánchez Roig

Agassizia flexuosa Sánchez Roig, 1949:257, pl. 41: figs. 9, 10.

No specimens of this species are present in the Sánchez Roig Collection. From Sánchez Roig

figures this species appears to be very similar to *Agassizia clevei* Cotteau.

OCCURRENCE.—Eocene, “La Concepción” farm, Guadalupe district, Morón, Camagüey Province, Cuba.

Agassizia guanensis Sánchez Roig

Agassizia guanensis Sánchez Roig, 1951:62, pl. 39: figs. 4, 5.

OCCURRENCE.—Oligocene-Miocene, “Las Cuevas” farm, San Juan and Martínez, Pinar del Rio Province, Cuba. Sánchez Roig reports two paratypes from Km 186 at Guane, Pinar del Rio Province, Cuba.

REMARKS.—Only one specimen (SRC 4242) is labelled in the Sánchez Roig Collection as belonging to this species. However, this specimen belongs to a different species, *Caribbaster loveni* (Cotteau), for it has 2 genital pores and lacks the reduced porepairs in the anterior poriferous zones that are characteristic of *Agassizia*. No specimens are known of *Agassizia guanensis*.

Agassizia lamberti Palmer

Agassizia lamberti Palmer in Sánchez Roig, 1949:261, pl. 41: fig. 11.

No specimens of this species are present in the Sánchez Roig Collection. A specimen identified by Palmer as being this species is in the Academy of Natural Sciences of Philadelphia (ANSP 16611). This specimen is indistinguishable from *Agassizia clevei* Cotteau. However, this specimen is not from the type-locality, so I cannot assume it to be conspecific with the lost type specimen.

OCCURRENCE.—Late Eocene according to Palmer (in Sánchez Roig, 1949:261) but Oligocene according to Brodermann (1949:316), SE of Cartagena, 3 km on road to Lajas, Santa Clara (now Las Villas) Province, Cuba.

Genus *Aguayoaster* Sánchez Roig, 1952

Test small, highly inflated; apical system very anterior, ethmolytic with 4 genital pores; anterior paired petals transverse; peripetalous and latero-anal fascioles.

HABITAT.—Žítt (1981) described in detail his views of the mode of life of this genus. He suggests that its fascioles denoted a burrowing existence and that it maintained a respiratory funnel.

REMARKS.—Žítt (1981) has re-examined the type-species of this genus and has found a latero-anal fasciole, necessitating the transfer of the genus from the Brissidae (Fischer, 1966) to the Schizasteridae. Žítt also determined that Sánchez Roig’s *Prenaster nuevitasensis* belongs in this genus.

Aguayoaster aguayoi Sánchez Roig

Aguayoaster aguayoi Sánchez Roig, 1952b:11, pl. 8: figs. 3, 5–7.—Žítt, 1981:274, pls. 1, 2, pl. 3: figs. 1, 2, pl. 4.

Žítt has redescribed in careful detail this species and has extensively illustrated it.

OCCURRENCE.—Middle Eocene, Carabollos quarries, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Aguayoaster nuevitasensis (Sánchez Roig)

Prenaster nuevitasensis Sánchez Roig, 1949:252, pl. 42: figs. 1, 2.

Aguayoaster nuevitasensis (Sánchez Roig).—Žítt, 1981:279, pl. 3: figs. 3–6.

This species has been redescribed and re-illustrated by Žítt who suggests that it may be a synonym of *Aguayoaster aguayoi*.

OCCURRENCE.—Eocene, Loma de Calisto, Nuevitas, Camagüey Province, Cuba.

Genus *Caribbaster*, new genus

Test small, highly inflated; apical system ethmolytic with two genital pores; ambulacrum III not petaloid, pores enlarged dorsally in peripodia, petals straight, slightly depressed, anterior petals longer than posterior; peristome very eccentric anteriorly, periproct high on posterior truncation; labrum long, narrow, in interambulacrum 1 first plate followed by single plate; peripetalous and latero-anal fascioles.

TYPE-SPECIES.—*Caribbaster loveni* (Cotteau).

HABITAT.—*Caribbaster* has peripetalous and latero-anal fascioles and larger pores and peripodia dorsally in ambulacrum III indicating that fun-

nel-building tubefeet were present there. These characters suggest that this echinoid could live in a burrow. The small size of the peripodia in ambulacrum III and lack of an anterior groove and deeply depressed petals probably indicate that the echinoid could not live in fine sediment.

COMPARISON WITH OTHER GENERA.—In having both a peripetalous and latero-anal fasciole, this genus belongs to the Schizasteridae. It resembles *Prenaster*, but differs in having two instead of four genital pores.

REMARKS.—*Schizaster dyscritus* Arnold and Clark (1927:61) from the Eocene of Jamaica should be referred to *Caribbaster*. It has a peripetalous and latero-anal fasciole and has only two genital pores. Likewise, its petal arrangement and general appearance is very similar to *Caribbaster loveni* (Cotteau).

Caribbaster loveni (Cotteau), new combination

FIGURE 25; PLATE 34

Prenaster loveni Cotteau, 1875:34, pl. 6: figs. 11–15.—Jackson, 1922:72, pl. 12: figs. 8, 9.

Hypselaster perplexus Arnold and Clark, 1927:56, pl. 11: figs. 8–10.

Three Cuban specimens, one from the Academy of Natural Sciences of Philadelphia and two from the USNM Collections of the Smithsonian are similar in all respects to the holotype of *C. loveni* from St. Bartholomew in the USNM Collections and to the holotype from Jamaica of *Hypselaster perplexus* Arnold and Clark. These Cuban specimens are better preserved than the Jamaican and St. Bartholomew specimens and show fascioles not seen previously. Photographs (Plate 34: figures 5, 6) are included of the holotype of *C. loveni*. Cotteau (1875, pl. 6: fig. 12) shows 4 genital pores in his drawing of this specimen, but there are only 2. Photographs are also provided (Plate 34: figures 7–10) of the holotype of *Hypselaster perplexus* along with a drawing (Figure 25) of the ventral plate arrangement of another Jamaican specimen.

No specimens are present in the Sánchez Roig Collection of *Prenaster sanchezi* Lambert; but from

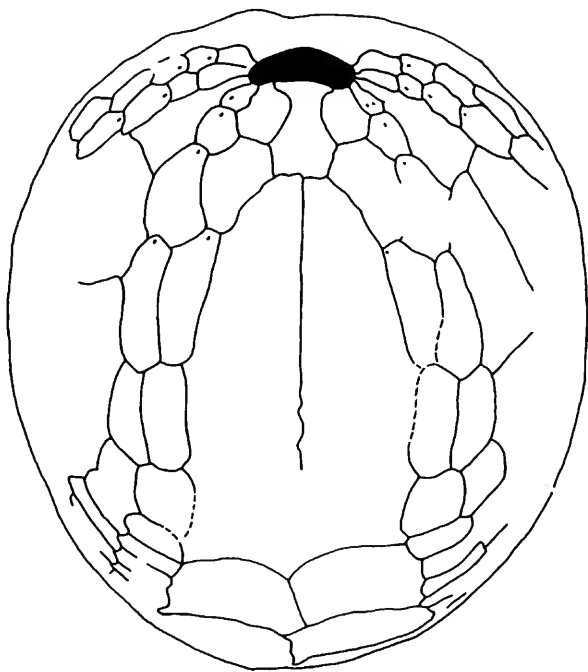


FIGURE 25.—*Caribbaster loveni* (Cotteau), ventral view of *Hypselaster perplexus* Arnold and Clark (= *C. loveni*), MCZ 3292 from Jamaica, $\times 5$.

the photographs in Sánchez Roig (1949, pl. 46: figs. 4–6), it appears to be similar to *Caribbaster loveni*.

The description below is based on the three Cuban specimens.

SHAPE AND SIZE.—Length 17 mm to 24 mm, width 88 to 91% L, height 77 to 82% L; test highly inflated, with smoothly rounded sides, steep anterior surface.

APICAL SYSTEM.—Central, center of system located at distance from anterior margin 42 to 45% L, ethmolytic with 2 genital pores, no pores in anterior genital plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very shallow groove, 46 plates in holotype 25 mm long; enlarged pores in dorsal portion of anterior ambulacrum in larger peripodia.

Anterior petals (II and IV) long, extending almost to margin, length 43 to 50% L, greatest width 15% L; width of interporiferous zones equal

to width of single poriferous zone; 52 porepairs in specimen 17 mm, 54 in specimen 18 mm, and 64 in specimen 25 mm long; first porepair in plate 12.

Posterior petals (V and I) extending more than one-half distance from apical system to margin, length 32 to 36% L, width 11 to 13% L; interporiferous zones of all petals slightly depressed forming a median groove in each petal.

Phyllodes very well developed with large peripodia, peripodia with high ridge dividing pores of peripodium, one pore much larger than other, in some peripodia only one pore; 12 peripodia in ambulacrum II, 4 in III, 8 in I.

PERISTOME.—Very anterior, distance from anterior edge of opening to anterior margin 11% L; opening small, width 16 to 18% L, height 8.5% L.

PERIPROCT.—High on posterior truncation, opening with height 16% L, width 13% L.

FASCIOLAS.—Peripetalous fasciole wide, slightly indented in interambulacra; only short traces of latero-anal fasciole preserved.

ORAL PLATE ARRANGEMENT.—Labrum long, length 21% L, extending posteriorly to anterior of third adjacent ambulacral plate. Length of sternal plates not clear; first plate of interambulacrum 1 followed by single plate.

OCCURRENCE—Late Eocene, E of Arroyo Blanco, 150 m, in road to Majagua, Camagüey Province, Cuba. A MCZ specimen is from Palmer locality 1003, Eocene, 2.1–2.2 mi (3.5 km) N of Carratera Central on road to San Diego de los Baños, Pinar del Rio Province, Cuba. Holotype of *Hypselaster perplexus* Arnold and Clark, Eocene, Spring Mount, St. James Parish, Jamaica. According to the 1958 geological map of Jamaica, this region lies in the middle Eocene Yellow Limestone. Eocene, St. Bartholomew Limestone, St. Bartholomew.

Specimen SRC 4242 in the Sánchez Roig Collection is labelled as the type specimen of *Agassizia guanensis* Sánchez Roig, but it is *Caribbaster loveni* (Cotteau). Its locality is from the Oligocene, "Las Cuevas" farm, San Juan and Martínez, Pinar del Rio Province, Cuba. This is the locality for the holotype of *Agassizia guanensis*, but *Caribbaster loveni* is only known from the Eocene. This specimen

probably came from another locality and was misplaced in the tray with *A. guanensis*.

The holotype of *Prenaster loveni* is from the Eocene of St. Bartholomew.

Genus *Lambertona* Sánchez Roig, 1953

Lambertona Sánchez Roig, 1953b:257.—Henderson, 1975:24.
Pericosmus (*Lambertona*) Fischer, 1966:U568.

Test large, low with deep anterior notch; apical system slightly posterior with 3 genital pores; anterior ambulacrum III not petaloid, deeply depressed, pores minute; petals narrow, deeply depressed, posterior petals much shorter than anterior; peristome very anterior, labiate with pronounced lip; peripetalous fasciole; labrum short not extending posteriorly beyond first adjacent ambulacral plate.

HABITAT.—Presumably species of *Lambertona* lived buried in fine sediment. The presence of the peripetalous fasciole and deeply depressed petals indicate a buried life habit. The large peripodia in the dorsal portion of the ambulacrum indicate presence of funnel-building tube feet. This fact combined with the presence of a marl matrix within the test of the holotype of *L. lamberti* suggest that this echinoid lived in fine sediment.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—*Lambertona lamberti* is very similar to the holotype of *Victoriaster jamaicensis* Arnold and Clark of unknown age in Jamaica. This specimen is a mold so the existence or lack of a latero-anal fasciole is unknown. Its short posterior petals and posteriorly situated apical system are features similar to *L. lamberti* and unlike *Victoriaster*. This species should be referred to *Lambertona*. It may be a synonym of *L. lamberti*, but its holotype shows too few specific characters to permit this determination.

Three species of *Lambertona* have been reported by Henderson from New Zealand. *Lambertona lyoni* (Hutton) from the Oligocene strongly resembles *L. lamberti* but differs in its more posterior apical system and more divergent posterior petals. *Lambertona perplexa* Henderson from the Miocene has

much shorter anterior petals, more divergent posterior petals, a more posteriorly situated apical system, and a deeper anterior notch. *Lambertona perdita* Henderson of uncertain age also has much shorter anterior petals and a deeper notch.

Henderson refers the Australian *Linthia moora-booleensis* Pritchard to *Lambertona*. McNamara (1982, personal communication) considers the species a synonym of *Victoriaster gigas*.

REMARKS.—Fischer (1966:U568) considered *Lambertona* and *Victoriaster* subgenera of *Pericosmus*, presumably because of the supposed presence of marginal fascioles in their type-species. However, McNamara and Philip (in press) report that the type-species of *Victoriaster*, *V. gigas* McCoy, has a latero-anal fasciole, not a marginal fasciole. They refer the genus to the Schizasteridae.

Henderson (1975:24) suggested that the "marginal" fasciole of the type-species of *Lambertona*, *L. lamberti*, was probably a remnant of a latero-anal fasciole and that *Lambertona* should, therefore, be referred to the Schizasteridae. He also noted that the 3 species of *Lambertona* from New Zealand lack a latero-anal fasciole.

I have studied the holotype and 2 beautifully preserved specimens of *L. lamberti* in the USNM Collections and in none of them is there any sign of latero-anal or marginal fascioles. The tuberculation is well preserved in all 3 specimens. If these fascioles had been present originally, they undoubtedly would be visible now. In spite of the absence of this fasciole, *Lambertona* should probably continue to be referred to the Schizasteridae. As pointed out by Henderson, *Lambertona* resembles the well-known schizasterid, *Brisaster*, which lacks a latero-anal fasciole in some adults. Furthermore, this genus strongly resembles *Victoriaster*, which has a latero-anal fasciole and is clearly a schizasterid. *Victoriaster* is confined to the Miocene; whereas, *Lambertona* is present in the Eocene-Miocene, suggesting that *Victoriaster* descended from *Lambertona* with the introduction of the latero-anal fasciole in the Oligocene.

Henderson (1975:64) suggested that *Lambertona* originated in the Pacific and that its presence in Cuba was due to its derivation from the west via the Central American seaway. However, the Cu-

ban species is early Eocene and the New Zealand species are Oligocene and Miocene indicating that *Lambertona* probably originated in the Caribbean. Likewise all the species of *Victoriaster*, a genus probably descended from *Lambertona*, are Miocene and Australian.

Lambertona lamberti (Sánchez Roig)

FIGURE 26; PLATES 35, 36

Victoriaster lamberti Sánchez Roig, 1924a:16, pl. 1: fig. 1, pl. 2: fig. 1; 1949:249, pl. 39: fig. 1, pl. 40: fig. 1.—Mortensen, 1951:170, fig. 81.

Lambertona lamberti (Sánchez Roig).—Sánchez Roig, 1953b:257, pls. 27, 28.—Fischer, 1966:U568, fig. 452-1a,b.—Henderson, 1975:24.

MATERIAL.—Sánchez Roig designated 3 different specimens as the holotype. The specimen figured in Sánchez Roig (1953b, pls. 27, 28) was not included in his original description and therefore cannot be considered as a primary type. The specimen whose ventral surface is figured in Sánchez Roig (1924a, pl. 2) is stated therein to be the holotype but is not the same specimen (although published as being the holotype) whose dorsal surface is figured in plate 1 of the same paper. That specimen (SRC 4959) is presently in the Sánchez Roig Collection and has no ventral surface. It is the only specimen of this species now in the Sánchez Roig Collection and is herein selected as the lectotype. This specimen, although lacking its ventral surface, is only slightly weathered and its tubercles and fasciole are well pre-

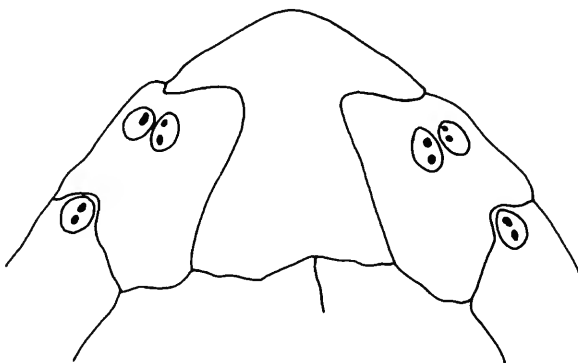


FIGURE 26.—*Lambertona lamberti* (Sánchez Roig) labrum of a paralectotype, USNM 352864, $\times 3$.

served. Two additional specimens are in the Smithsonian (USNM 352864, 352870), the latter of which is labelled as a cotype. Although these specimens lack their posterior portions, they are beautifully preserved, USNM 352864 still having many spines attached (Plate 36: figure 3).

SHAPE AND SIZE.—Length of lectotype 130 mm, width 136 mm, and height estimated at 35 mm. Greatest width anterior, greatest height posterior at apical system.

APICAL SYSTEM.—Central, located in lectotype at distance from anterior margin to center of genital pores equal to 55% L. On lectotype only left part of apical system preserved showing pores in genital plates 3 and 4; total number not known.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very deep groove with depth midway from apical system to margin estimated at 9.8% L, depth at margin estimated at 11% L. Porepairs largest adapical to fasciole; pores in peripodia, inner pore smaller, anterior to outer pore of pair; 52 plates in ambulacrum.

Anterior petals (II and IV) long, narrow, extending four-fifths distance from apical system to margin, length 47% L, width 3.5% L; petals curving slightly anteriorly; in groove with depth 3.6% L; width of interporiferous zone less than width of single poriferous zone; pores conjugate, 83 porepairs in petal. Pores beyond petals double.

Posterior petals (V and I) much shorter than anterior, extending one-half distance from apical system to margin, length 20% L, width 3.7% L; 54 porepairs in petal.

Phyllodes with porepairs in large peripodia (Plate 34: figure 2).

PERISTOME.—Very anterior, distance from anterior margin to anterior edge of peristome estimated at 18% L. Opening labiate with pronounced lip, width 9.2% L.

PERIPROCT.—Not visible on any specimens examined but according to Sánchez Roig (1949: 250) marginal, oval.

FASCIOLAS.—Peripetalous fasciole widest where crossing around end of anterior petals, angular course, indented in posterior paired interambulacra. No marginal or latero-anal fasciole.

TUBERCULATION AND SPINES.—No large tuber-

cles within peripetalous fasciole. Tubercles very small dorsally, larger on anterior margin; largest dorsally where mamelons eccentric anteriorly on large raised scrobicules. Ventral spines slim, length 10 mm (Pl. 35: fig. 3).

ORAL PLATE ARRANGEMENT.—Labrum (Figure 26) mushroom-shaped, height 8.8% L, width 9.0% L, followed by 2 large plastron plates, incomplete so dimensions not available. Labrum not extending posteriorly beyond first adjacent ambulacral plate.

OCCURRENCE.—Early Eocene, quarries of Tejar Consuelo, Cerro, Ciénaga, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar in its shape and petal arrangement to *Lambertona jamaicensis* (Arnold and Clark) of unknown age from Jamaica (but probably Eocene considering that most Jamaican fossil echinoids are this age). The Jamaican holotype and only known specimen is too poorly preserved to determine whether it is conspecific with the Cuban species.

REMARKS.—Sánchez Roig (1949:249) reported that preservation did not permit the observation of a marginal fasciole, but later (1953b:257) noted that the marginal fasciole was thin, sinuous, and incomplete. I have studied the holotype and 2 other beautifully preserved specimens, and in none of them is there any sign of a marginal or latero-anal fasciole. These specimens have their tuberculation well preserved; and had these fascioles been originally present, they would have been visible.

Genus *Linthia* Desor, 1853

Test commonly small, heart-shaped, anterior ambulacrum III not petaloid, depressed with groove at margin; apical system ethmolytic with 4 genital pores, petals of almost equal length; peripetalous fasciole sharply indented between petals, latero-anal fasciole present.

Eight species from Cuba have been referred to *Linthia*. Two, *Linthia aguayoi* Sánchez Roig and *Linthia atolladosae* Sánchez Roig, are referred to *Pericosmus*. *Linthia avilensis* Sánchez Roig probably

is not a *Linthia*. Its type is too poorly preserved for generic identification. The type specimens have been lost of *Linthia garciai* Sánchez Roig and *Linthia cretacica* Sánchez Roig. *Linthia alta* Sánchez Roig and *Linthia gonzalezmunozzi* Sánchez Roig are considered as synonyms of *Linthia brodermanni* Sánchez Roig. One new species, *Linthia monteroeae*, is described.

In summary two Cuban species of *Linthia* are recognized definitely. One of them, *L. brodermanni*, is very similar to *Linthia variabilis* Slocum from the late Cretaceous of Texas and southeastern United States.

HABITAT.—Species of *Linthia* probably lived buried in mud. The crowded and enlarged porepairs in the dorsal portion of ambulacrum III indicate the presence of funnel-building tubefeet necessary for living in a burrow in mud. The depressed petals, anterior groove, and fascioles are also indicative of the capability of living in fine sediment.

Linthia? avilensis Sánchez Roig

PLATE 40: FIGURES 5–7

Linthia avilensis Sánchez Roig, 1949:264; 1951:64, pl. 40: fig. 8.

MATERIAL.—The holotype (SRC 4158), which is the only known specimen is very poorly preserved. The test is badly weathered lacking all traces of the fascioles. Most of the apical system is absent and most of the posterior surface is broken away.

SHAPE AND SIZE.—Length 38.0 mm, width 96% L, height 68% L. Greatest height posterior to center, greatest width central to slightly posterior. Posterior truncation appears to be vertical to slightly overhanging.

APICAL SYSTEM.—Only the posterior part of the apical system is preserved showing the two posterior genital pores. Although Sánchez Roig (1949:264) reported 4 genital pores, it is not known whether the anterior genital plates were perforated (that part of the apical system is not preserved on the holotype). Apical system ethmolytic, located at distance from anterior margin

to center of genital pores equal to 56% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove extending from apical system to peristome, groove deepest adapically where width of groove 13% L. Pores largest in adapical portion, with first enlarged porepair in plate 6 or 7.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin; petals not of equal length (probably result of distortion), petal II with length 37% L, petal IV 38% L. Petals curving distally with greatest width, 13% L, near end of petal; in deep groove. Width of interporiferous zone less than width of single poriferous zone. Pores conjugate with 56 (est.) porepairs in petal.

Posterior petals (V and I) short, extending less than one-half distance from apical system to margin, length 18% L; straight, width 10% L. Interporiferous zone at widest almost as wide as single poriferous zone; 30 porepairs in petal. Not clear whether pores beyond petals are single or double.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 57% L, opening wider than high with width 23% L, height 7.9% L.

PERIPROCT.—Not preserved.

FASCIOLES.—Slight indentations distal to end of petal II indicate probable presence of peripetalous and perhaps a latero-anal fasciole.

ORAL PLATE ARRANGEMENTS.—Labrum short, broad, extending posteriorly two-thirds height of first adjacent ambulacral plate.

OCCURRENCE.—Late Cretaceous, “Maniadero” farm, 7.5 km, W Jicotea, Camagüey Province, Cuba.

REMARKS.—The generic identity of this species is uncertain because of insufficient knowledge about the presence of a latero-anal fasciole or the number of genital pores. It does not appear to be a *Linthia* because its anterior petals are more flexuous and its posterior petals are shorter than commonly found in this genus. It superficially resembles *Schizaster*. Its Cretaceous age is doubtful; the short posterior petals and the depth and shape of all petals suggest a later occurrence.

***Linthia brodermanni* Sánchez Roig**

FIGURES 27, 28; PLATES 37-39

Linthia brodermanni Sánchez Roig, 1949:263, pl. 49: figs. 2, 4.*Micraster elevatus* Sánchez Roig, 1949:218, pl. 47: figs. 4, 5.*Hemiaster lamberti* Sánchez Roig, 1949:238, pl. 35: figs. 7, 8.*Linthia alta* Sánchez Roig, 1949:266, pl. 49: figs. 3, 5.

Linthia gonzalezmunoz Sánchez Roig, 1952c:23, pl. 9: fig. 1.

MATERIAL.—Three specimens. SRC 4851 (Sánchez Roig, 1949, pl. 49: fig. 2) is herein designated the lectotype. It is very well preserved; whereas, the lectoparatype, SRC 4858 (Sánchez Roig, 1949, pl. 49: fig. 4), is fractured with part of the dorsal surface missing. The lectotype of *Hemiaster lamberti* (SRC 4864) (Sánchez Roig, 1949, pl. 35: fig. 7), herein designated, is fairly complete but badly weathered. The second cotype figured by Sánchez Roig (1949, pl. 35: fig. 8) is missing.

SHAPE AND SIZE.—Length 44 to 45 mm (mean 44.5 mm); greatest width anterior of center, width 97 to 99% L; height 50 to 59% L, greatest height posterior to center; posterior truncation nearly vertical; marginal outline slightly angular.

APICAL SYSTEM.—Four genital pores, ethmolytic (Figure 27A); located at distance from anterior margin to center of genital pores equal to 32 to 34% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, groove deepest at margin of test where depth equal to 5.0 to 7.7% L. Pores paired throughout entire length of all ambulacra. Pores largest in adapical portion of ambulacrum with 38 to 42 porepairs in this region; greatly reduced in size between this portion and the phyllode.

Anterior petals (II and IV) long, extending almost to margin; length 37 to 42% L, width 11 to 12% L. Petals straight to slightly curved, depressed in groove, depth 2.2 to 5.4% L; petals narrow with greatest width 11 to 12% L. Pores conjugate with outer pores slit-like; 60 porepairs in specimen 44.1 mm long; interporiferous zone at its greatest equal in width to single poriferous zone. First petaloid porepair in plate 14.

Posterior petals (V and I) short, extending slightly less than one-half distance from apical

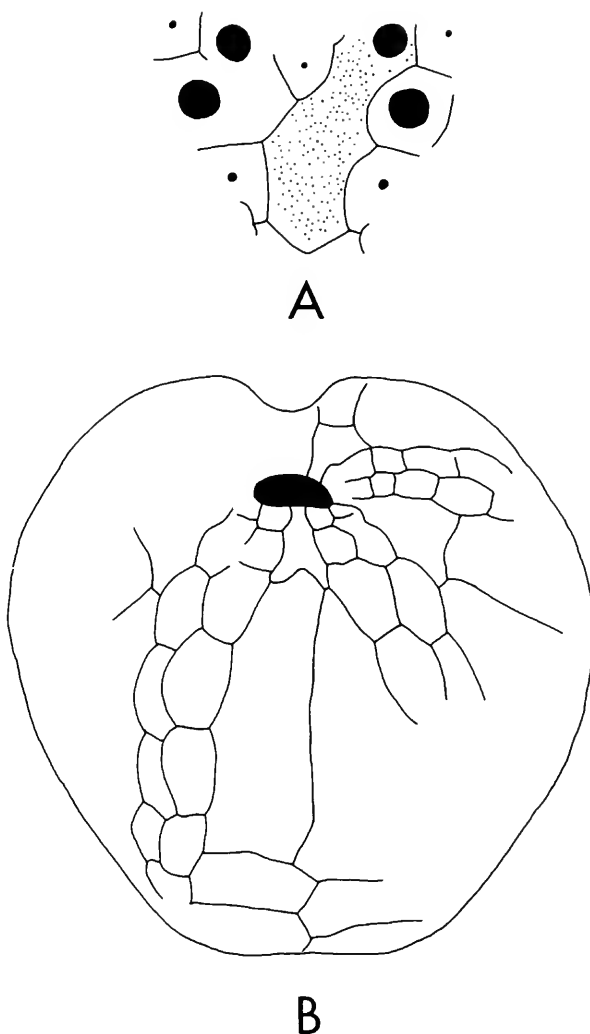


FIGURE 27.—*Linthia brodermanni* Sánchez Roig: A, apical system of the lectotype, SRC 4851, $\times 8$; B, ventral side of the lectotype of *Hemiaster lamberti* Sánchez Roig (= *L. brodermanni*), SRC 4864, $\times 2$.

system to posterior margin; length 27 to 28% L; width 10 to 12% L. Petals curving slightly towards midline; depressed in groove with depth 1.3 to 3.2% L; 52 porepairs in specimen 44 mm long.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 15 to 17% L, opening wider than high with width 11 to 15% L, height 6.0 to 6.8% L.

PERIPROCT.—Located high on nearly vertical truncation, slightly visible from above. Opening

higher than wide, height 12 to 14% L, width 9.3 to 11% L; occurs within plates 4–7.

FASCIOLAS.—Peripetalous fascioles narrow, curving sharply into interambulacra 1 and 4, but not into interambulacra 2 or 3. Fasciole crosses ambulacra II or IV on plates 12 or 13, ambulacra V or I on plates 17 or 18, position on interambulacra not clear. Lateroanal fasciole passes below periproct at distance from periproct equal to less than height of periproct; fasciole very narrow, only present on unweathered portions of test.

ORAL PLATE ARRANGEMENT.—Labrum extending posteriorly to two-thirds height of third ambulacral plate (Figure 27B); length of labrum 12 to 14% L. Two sternal plates long, 51 to 52% L; bordered by ambulacral plates 3–6. First plate of interambulacra 1, 2, 3, 4 extending to peristome. Phyllodes with 5 large porepairs in ambulacrum III, 10 or 11 in II or IV, 6 or 7 in V or I.

OCCURRENCE.—Late Cretaceous, lectotypes of *L. brodermanni* and *H. lamberti* and holotypes of *L. alta* and *Micraster elevatus* from west edge of Batey Dos Hermanos, in mulberry patch (Palmer loc. 1833), Las Villas Province, Cuba. Lectoparatype of *L. brodermanni* from fields ½ km of W of Central Manuelita, along cane railroad (Palmer loc. 1729), Las Villas Province, Cuba. Holotype of *L. gonzalezmunozzi*, provisionally referred to this species, from Late Cretaceous (Senonian) at Abra de Castellón, Cumanayagua, Las Villas Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Linthia brodermanni* resembles in general appearance *L. variabilis* Slocum from the late Cretaceous (Maestrichtian) of Texas and southeastern United States but differs in having narrower petals, narrower ambulacrum III, and a more anterior apical system.

L. brodermanni differs from *Linthia monteroeae*, new species, also from the Cretaceous of Cuba, in having a lower test, broader petals and a smaller peristome. It differs from *Linthia alabamensis* Clark from the Paleocene of Alabama in having a smaller test with its greater width and height more posterior and in having longer posterior petals.

REMARKS.—The lectotype (Plate 38: figures 4–6) of *Hemiaster lamberti* is indistinguishable from the types of *Linthia brodermanni*. It was collected at the same locality as the lectotype of *L. brodermanni*. Because its test is weathered, the latero-anal fasciole is not present. Presumably this is why Sánchez Roig placed it in *Hemiaster*.

Although the holotype of *Linthia alta* Sánchez Roig is much higher than the type specimens of *L. brodermanni*, it appears to be conspecific. It comes from the same locality as the types of *L. brodermanni* and is similar in all characters except its height and size. The petals are of similar length, width, and shape with similar number of porepairs relative to the size of the test. The labrum also extends back to two-thirds the height of the third adjacent ambulacral plate. The fascioles are similar in location and cross the same or almost the same ambulacral plates. The peristome is similar in position, size, and outline.

Linthia brodermanni is very similar to *Linthia gonzalezmunozzi* Sánchez Roig, also from the Cretaceous of Cuba, differing only in having a slightly shallower anterior notch and slightly narrower test. The species may be conspecific but not enough specimens are available to be able to know the significance of these minor differences. For this reason *L. gonzalezmunozzi* is only provisionally considered a synonym of *L. brodermanni*.

Micraster elevatus Sánchez Roig is from the same locality as *L. brodermanni* and is certainly a synonym. It is identical in all respects.

SYNONYMS

Linthia alta Sánchez Roig

FIGURE 28; PLATE 39: FIGURES 1–3

MATERIAL.—the holotype and only known specimen (SRC 4223) is moderately well preserved; the fascioles are visible. The test is slightly distorted, the right side being somewhat compressed. The posterior is broken away and most of the right oral side is absent.

SHAPE AND SIZE.—Length uncertain, approximately 60 mm, width 57 mm, height 43 mm (76%

W). Greatest width anterior to center, greatest height posterior to apical system.

APICAL SYSTEM.—Four genital pores, ethmolytic, located 18 mm from anterior margin, at distance equal to 32% W.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep groove from apical system to peristome, depth of groove at anterior margin 2.7 mm (4.7% W). Pores paired throughout length of ambulacrum with pores largest in adapical portion with approximately 52 porepairs between apical system and peripetalous fasciole; 8 porepairs between fasciole and peristome; 60 in ambulacrum.

Anterior petals (II and IV) long, extending almost to margin, length 28 mm (50% W). Petals straight, depressed in groove with greatest depth 1.4 mm (2.4% W), width 5.6 mm (9.8% W). Both outer and inner pore of pair slightly elongated transversely, not clear whether or not conjugate; 82 porepairs in petal. Interporiferous zone approximately same width as poriferous; 108 porepairs in ambulacrum.

Posterior petals (V and I) short, extending one-half distance from apical system to margin, length 20 mm (36% W). Petals straight, depressed in groove with depth 1.6 mm (2.8% W), width 5.4 mm (9.4% W), 64 porepairs.

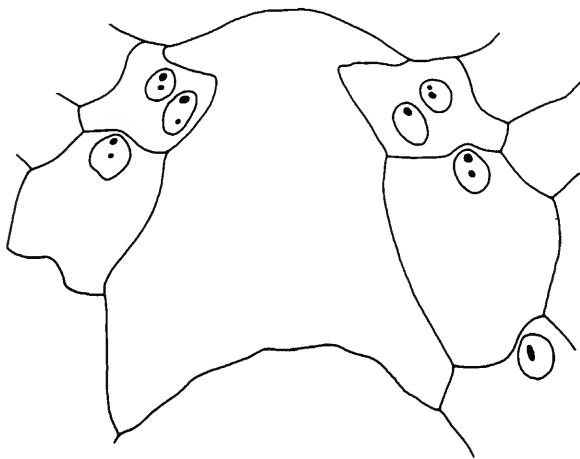


FIGURE 28.—*Linthia brodermanni* Sánchez Roig, labrum of holotype of *Linthia alta* Sánchez Roig (= *L. brodermanni*), SRC 4223, $\times 6$.

PERISTOME.—Located at distance from anterior margin to anterior edge of peristome equal to 10.0 mm (18% W). Width of opening 8.9 mm (16% W), height 4.0 mm (7.0% W). Phyllodes with 4 large peripodia in ambulacrum III, 12 in II, 7 or 8 in I.

PERIPROCT.—Not preserved.

FASCIOLES.—Peripetalous fascioles narrow, deeply re-entering interambulacra 1, 4, and 5; crossing ambulacra II or IV on plates 12 or 13, ambulacrum III on plates 4 or 5. Only short portion of latero-anal fasciole preserved.

ORAL PLATE ARRANGEMENT.—Labrum large, height 6.9 mm (12% W), extending posteriorly to two-thirds height of third adjacent ambulacral plate (Figure 28).

OCCURRENCE.—Late Cretaceous, W edge of Batey Dos Hermanos, in mulberry patch (Palmer loc. 1833), Las Villas Province, Cuba.

Linthia gonzalezmunoz Sánchez Roig

PLATE 39: FIGURES 4–7

MATERIAL.—The holotype is the only known specimen (SRC 4247) and is very poorly preserved. Much of the surface of the test is absent due to weathering. Most of the tuberculation is obliterated with only small portions of the fascioles present.

SHAPE AND SIZE.—Length 30 mm, width 31 mm (105% L), height 22 mm (73% L). Greatest width central, greatest height central, posterior to apical system. Posterior truncation slightly overhanging; marginal outline slightly angular.

APICAL SYSTEM.—Four genital pores, ethmolytic, located at distance from anterior margin to center of genital pores equal to 35% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove from apical system to peristome, depth of groove at midlength from apical system to margin 6.7% L, depth of groove at margin 9.7% L. Pores paired throughout length of ambulacrum with pores largest in adapical portion with approximately 40 porepairs in this region; greatly reduced in size between this portion and the phyllode.

Anterior petals (II and IV) long, extending slightly more than two-thirds distance from apical system to margin, length 42% L. Petals straight, depressed in groove with greatest depth nearer apical system, depth 3.7% L, width 10% L. Both outer and inner pore of porepair slit-like; 64 porepairs in petal. Interporiferous zone very slightly wider than poriferous zone.

Posterior petals (V and I) short, extending one-half distance between apical system and posterior margin, length 30% L, width 9.4% L. Petals straight, depressed in groove with depth 2.7% L; 44 porepairs.

PERISTOME.—Incompletely preserved, located at distance from anterior margin to anterior edge of peristome equal to 16% L, opening wider than high with width 22% L, height 9.7% L (est.).

PERIPROCT.—Located high on slightly overhanging posterior truncation. Opening higher than wide with height 20% L, width 12% L.

FASCIOLAS.—Only small portions of peripetalous and latero-anal fasciolas preserved. Because of poor preservation of test it is not possible to know which plates they cross.

ORAL PLATE ARRANGEMENT.—Unknown, most of plates absent.

OCCURRENCE.—Late Cretaceous (Senonian), Abra de Castellón, Cumanayagua, Las Villas Province, Cuba.

Micraster elevatus Sánchez Roig

PLATE 38: FIGURES 1–3

MATERIAL.—One specimen, the holotype (SRC 4256), which is well preserved except for absence of the front of the specimen. The test is not distorted and the tuberculation is preserved showing the fasciolas.

SHAPE AND SIZE.—Length unknown, width 62 mm, height 43 mm; greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Probably anterior, 4 genital pores, ethmolytic with genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid. Anterior petals (II and IV) straight in

groove; interporiferous zones approximately same width as single poriferous zones; pores conjugate. Petal extending almost to margin, length 33.5 mm, width 6.2 mm; 88 porepairs in petal. Posterior petals (V and I) short, extending slightly more than one-half distance from apical system to margin, length 24.0 mm, width 6.0 mm; 70 porepairs.

PERISTOME.—Absent.

PERIPROCT.—Located high on nearly vertical truncation, height of opening 7.1 mm, width 5.6 mm.

FASCIOLAS.—Peripetalous fasciolas narrow, curving sharply in posterior paired interambulacra. Latero-anal fasciolas passes below periproct at distance equal to slightly less than height of periproct.

OCCURRENCE.—Late Cretaceous, W edge of Bay of Dos Hermanos, Las Villas Province, Cuba.

Linthia monteroae, new species

PLATE 40: FIGURES 1–4

MATERIAL.—One specimen (ANSP 16656), moderately well preserved, not distorted and showing most of the features of its test.

SHAPE AND SIZE.—Length 56 mm, width 96% L, test very high with height 73% L. Greatest width anterior of center; greatest height posterior.

APICAL SYSTEM.—System slightly anterior of center; 4 genital pores, ethmolytic.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep, wide groove from apical system to peristome, depth at groove midway from apical system to margin 8.1% L, width 15% L; depth of groove at margin 7.3% L; 56 enlarged porepairs, first enlarged porepair in plate 7.

Anterior petals (II and IV) long, extending almost to margin, length 45% L, greatest width 9.8% L, petals curve convexly anteriorly; 70 porepairs in petals II, first porepair in plate 12 or 13. Posterior petals (V and I) short, extending approximately one-half distance from apical system to margin, length 31% L, greatest width 9.8% L; 62 porepairs in petal I. Interporiferous zones slightly wider than single poriferous zone.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 18% L, opening wider than high, crescent shaped, width 23% L, height 8.1% L.

PERIPROCT.—Located high on posterior truncation, which slopes forward making periproct slightly visible dorsally. Opening higher than wide, height 20% L, width 13% L.

FASCIOLAE.—Peripetalous fasciole deeply inserted between petals crossing plate 5 in ambulacrum III, plate 11 in ambulacrum II. Latero-anal fasciole passing in deep trough below periproct.

ORAL PLATE ARRANGEMENT.—Labrum very short, not extending posterior to first adjacent ambulacral plate.

OCCURRENCE.—Eocene (Palmer loc. 1085), E of Arroyo Blanco, 150 m, in road to Majagua, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species differs from *Linthia brodermanni* Sánchez Roig from the Cretaceous of Cuba in its higher test, with height 73% L as compared to 50–59% L in *L. brodermanni*, in its far wider peristome 23% L versus 11–15% L, and narrower petals with width 9.8% L versus 11–12% L.

UNRECOGNIZABLE SPECIES OF *Linthia*

Linthia cretatica Sánchez Roig

Linthia cretatica Sánchez Roig, 1949:264, pl. 47: figs. 1–3.

No specimens of this species are now in the Sánchez Roig Collection and I have been unable to find any elsewhere.

OCCURRENCE.—Late Cretaceous, approximately 3 mi (4.8 km) S of Santa Clara, Santa Clara (now Las Villas) Province?, Cuba.

Linthia garciai Sánchez Roig

Linthia garciai Sánchez Roig, 1952c:24, pl. 9: fig. 2.

No specimens of this species are now in the Sánchez Roig Collection and I have found none elsewhere.

OCCURRENCE.—Late Eocene, Báguanos, Holguín, Santiago de Cuba, Oriente Province, Cuba.

Genus *Prenaster* Desor, 1853

Test small, ovoid, inflated; apical system anterior, ethmolytic, with 4 genital pores; latero-anal and peripetalous fascioles present, the latter extending onto oral side anteriorly.

REMARKS.—Five specimens of *Prenaster* have been described, but no specimens are now known of three of them. Sánchez Roig's illustrations are too poor to permit their comparison with each other or with other species of this genus. The one species redescribed herein, *Prenaster parvus* Palmer, is distinct from the only other species, *Prenaster jeanneti* Pijpers, known from the Caribbean region. This genus has never been found in North America. Sánchez Roig's *Prenaster nuevitasensis* is transferred by Žižt (1981) to *Aguayoaster*.

HABITAT.—No species of this genus are alive today, but because this echinoid has peripetalous and latero-anal fascioles, large peripodia dorsally in ambulacrum III indicating presence of funnel-building tube feet, and depressed petals, it is reasonable to suggest that it lived buried in fine sediment.

Prenaster parvus Palmer

PLATE 41: FIGURES 1–5

Prenaster parvus Palmer in Sánchez Roig, 1949:251, pl. 42: fig. 12.

MATERIAL.—The holotype is no longer present in the Sánchez Roig Collection. The following description is based on 2 topotypic specimens at the Academy of Natural Sciences of Philadelphia. Both are moderately well preserved, with undistorted tests and with enough of the tuberculation preserved to show the position of the fascioles. Measurements for ANSP 16649 are noted first.

SHAPE AND SIZE.—Length 24 and 23 mm; width 87 and 87% L; height 74 and 73% L. Greatest height and width anterior.

APICAL SYSTEM.—Anterior, distance of system from anterior margin 19 and 18% L; 4 genital

pores, anterior pores much smaller than posterior; ethmolytic.

AMBULACRA.—Anterior ambulacrum II not petaloid, in shallow groove extending from apical system to peristome, greatest width 11 and 12% L; dorsally peripodia well developed with high ridge separating pores (Plate 41: figure 5).

Anterior petals (II and IV) extending almost to the margin, length 43 and 47% L, greatest width 11 and 12% L, highly divergent, forming arc of 180 degrees; interporiferous zones narrower than single poriferous zone; 58 porepairs in larger specimen, 54 in smaller. First petaloid porepair in plate 12.

Posterior petals (V and I) extending one-half distance from apical system to margin, length 44 and 43% L, greatest width 11 and 12% L; petals slightly divergent distally; 56 porepairs in larger specimen, 54 in smaller.

Phyllodes present but not preserved well enough to permit description.

PERISTOME.—Anterior, distance from anterior edge of peristome to anterior margin 19 and 18% L; width of opening 21 and 18% L, height 12 and 10% L.

PERIPROCT.—Supramarginal, opening large, higher than wide, height 25% L, width 16% L.

FASCIOLAS.—Peripetalous fasciole narrow, indented in interambulacra extending deeply around ambulacrum III onto ventral surface. Latero-anal fasciole narrower than peripetalous, passing posteriorly below periproct.

ORAL PLATE ARRANGEMENT.—Labrum, broad, short, length 5.6% L; sternal plates long, length 55% L, combined width 35% L; first plate of interambulacrum 2 followed by pair of plates.

OCCURRENCE.—Late Eocene (Palmer loc. 1085), E of Arroyo Blanco, 150 m, in road to Majagua, Camagüey Province, Cuba. Sánchez Roig (1949:252) cites the locality for the specimen he received from Palmer as San Diego de los Baños, 3 km from cross roads of central highway; quarries near Puente, Pinar del Rio Province, Cuba. I suspect that this locality may not be correct. Palmer's specimens are not from there, and I have not seen any specimens of this species

in a large collection of specimens from that locality.

COMPARISON WITH OTHER SPECIES.—I have compared this species with 4 specimens of *Prenaster jeanneti* Pijpers from the Eocene of Bonaire (Dutch West Indies). It is easily distinguished by its far more anterior peristome, less pointed anterior margin, and wider, more depressed petals. Photographs of the Bonaire species are included on Plate 41: figures 6–8.

UNRECOGNIZABLE SPECIES OF *Prenaster*

Prenaster clarki Sánchez Roig, emendation

Prenaster clarki [sic] Sánchez Roig, 1949:252, pl. 46: figs. 7, 8.

The type specimen is lost and no other specimens are known of this species. The original illustrations are so poor that it is not possible to compare this species with others of this genus.

OCCURRENCE.—Late Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Prenaster elongatus Sánchez Roig

Prenaster elongatus Sánchez Roig, 1949:250, pl. 50: figs. 3, 4.

The type specimen is lost and no other specimens are known of this species.

OCCURRENCE.—Brodermann (1949:326) states Cretaceous; Campos del Central Manuelita, ½ km SW of station, Santa Clara (now Las Villas) Province, Cuba. From Sánchez Roig's photographs, this species appears very similar to *Prenaster parvus* Sánchez Roig from the Eocene. This genus has never been found in rocks older than Eocene; and I, therefore, doubt this Cretaceous determination. Sánchez Roig considered the locality early Eocene.

Prenaster sanchezi Lambert

Prenaster sanchezi Lambert in Sánchez Roig, 1949:251, pl. 46: figs. 4–6.

The type specimen is lost and no other specimens are known. Sánchez Roig's illustrations are too poor to form the basis for a comparison of this species with other species of this genus.

OCCURRENCE.—Eocene, Loma de Calisto, Nuevitas, Camagüey Province, Cuba.

Suborder MICRASTERINA A.G. Fischer, 1966

Family MICRASTERIDAE Lambert, 1920

Genus *Habanaster* Lambert, 1924

Test small, high, apical system ethmophract with 2 or 3 genital pores; no petals, phyllodes present, peristome large, anterior, labrum long, plastron mesamphisternous; no peripetalous fasciole; subanal fasciole prominent.

Mortensen (1950:173) regarded *Habanaster* as incertae sedis because the structure of both the apical system and the plastron was unknown. Wagner and Durham (1966:U542) considered placement of the family as uncertain and placed the genus among the holasteroids. I have seen specimens showing clearly the apical system and plastron, and *Habanaster* definitely is a spatangoid. Its apical system is not elongate or disjunct and its plastron is amphisternous as typically spatangoid. As it has a subanal fasciole, *Habanaster* is here referred to the suborder Micrasterina and to the family Micrasteridae. It most resembles *Ovu-laster* in that both genera lack petals. Only one species of this genus is known and it is confined to Cuba.

HABITAT.—The well-developed subanal fasciole indicates that *Habanaster* could burrow, which is surprising considering the absence of petals. Presumably it could only burrow in well-aerated coarser sediments.

Habanaster sanchezi Lambert

FIGURE 29; PLATE 42

Habanaster sanchezi Lambert in Sánchez Roig, 1924a:12, pl. 5: figs. 1–4.—Lambert and Thiéry, 1909–1925:429, pl. 14: figs. 11–15.—Sánchez Roig, 1926:89, pl. 16: figs. 1–4; 1949:177.—Mortensen, 1950:172, figs. 135–137.

MATERIAL.—One topotypic specimen (SRC 4081) in the Sánchez Roig Collection is labelled the type and is herein designated as the lectotype. According to Sánchez Roig (1924a:13), cotypes were deposited in the United States National Museum Collection, the British Museum, and in the Lambert Collection in Paris. The following description is based on the lectotype, the paratype in the USNM collection, and 20 specimens collected in 1978 by Francisco de Albear, Kier, and Francisco Formell. The specimens are very well preserved. One specimen (MCZ 4079) is in the Museum of Comparative Zoology.

SHAPE AND SIZE.—Length 21 to 12 mm (mean 17); width 90% L (S.D. 2.67, C.V. 16.54, N. 17); height 83% L (S.D. 2.50, C.V. 16.88, N. 17). Greatest width anterior, greatest height posterior; oral surface smoothly rounded.

APICAL SYSTEM.—Slightly anterior of center, at distance from anterior margin in center of system 17% L (S.D. 0.84, C.V. 23.13, N. 17). Two or 3 genital pores, 15 specimens with pores in genital plates 1 and 3; 4 with pores in genital plates 1, 2, 3; no specimens with a pore in genital plate 4. Ethmophract (Figure 29b) with genital plate 2 not separating genital plates 4, 1.

AMBULACRA.—No petals but ambulacrum III differing from other ambulacra in having porepairs in slightly more depressed peripodia; porepairs undifferentiated except in phyllode where pores larger with more developed peripodia, 5 porepairs in phyllode; 28 porepairs in ambulacrum III in specimen 21 mm long.

Other ambulacra with no petals; porepairs not enlarged on dorsal surface, undifferentiated except for increase in size and presence in peripodia in phyllodes; 6 porepairs in phyllode in ambulacra II or IV; 4 in V or I; 28 plates in ambulacrum II or IV, 32 in V or I in specimen 20 mm long. Ambulacra V and I in contact apically separating first plate of interambulacrum 5 from apical system (Figure 29a).

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 20% L (S.D. 0.63, C.V. 17.99, N. 17); opening large, width 15% L (S.D. 0.34, C.V. 12.98, N. 17); height 11%

L (S.D. 0.24, C.V. 12.71, N. 17); slight rim around opening (Plate 42: figure 6).

PERIPROCT.—Located high on slight posterior truncation with slight sulcus below opening;

width 14% L (S.D. 0.44, C.V. 17.69, N. 17); height 13% L (S.D. 0.29, C.V. 12.61, N. 17); located between interambulacral plates 5b, 6b, 5a.

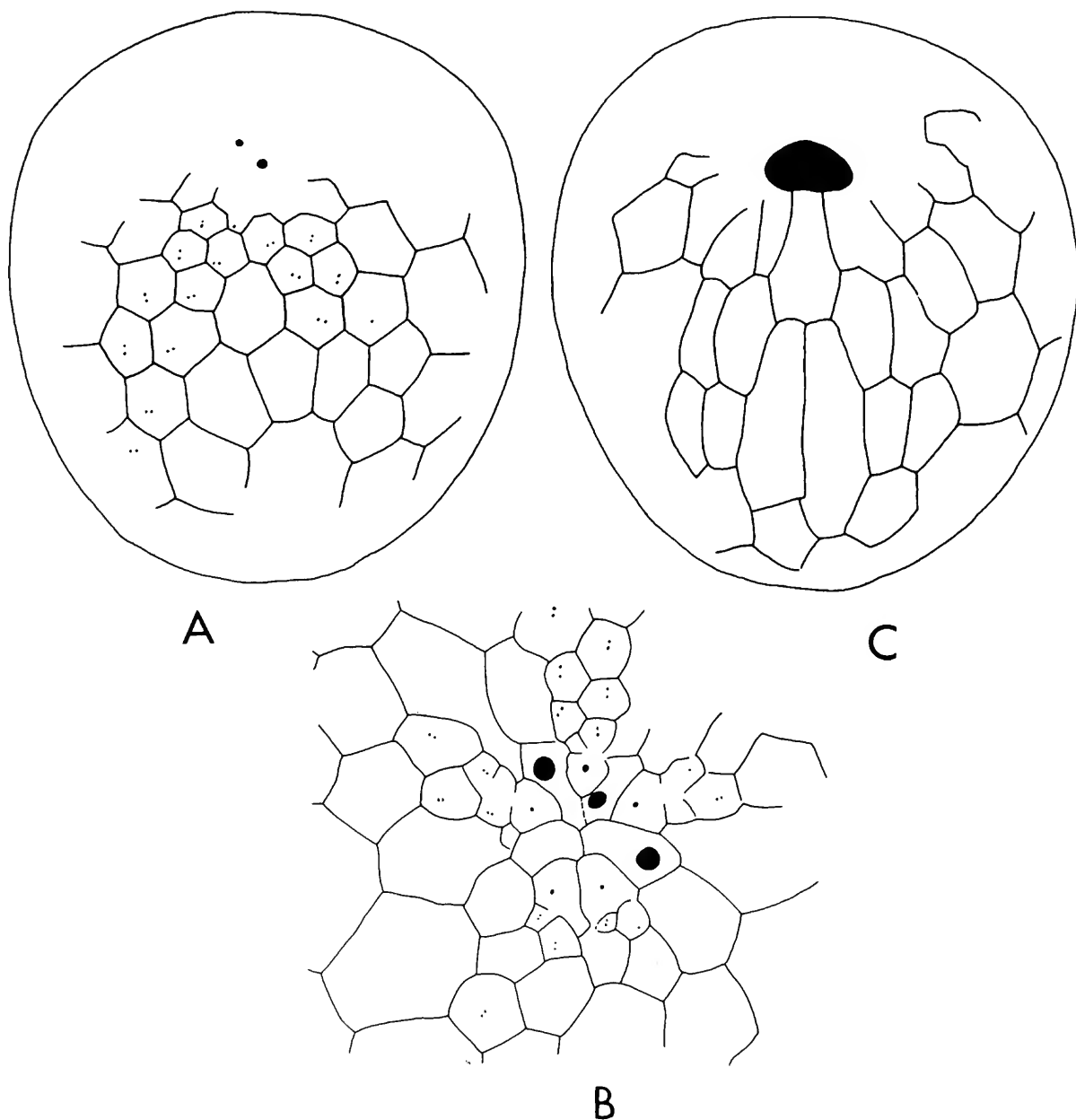


FIGURE 29.—*Habanaster sanchezi* Lambert: A, dorsal view of USNM 351802, Eocene, Mariel, quarry of Morro Cement Plant, at corner of workings, N end of N-S cliff, Pinar del Rio Province, $\times 4$; B, apical system of USNM 351803, $\times 22$; C, ventral view of USNM 351801, Eocene, Loma Entanto, $\times 4$.

FASCIOLAS.—No peripetalous fasciole. Subanal fasciole prominent, circular, width of area enclosed including width of fasciole, 30% L (S.D. 0.78, C.V. 14.62, N. 16); height 29% L (S.D. 0.75, C.V. 14.46, N. 15); width of fasciole 5.8% L (S.D. 0.18, C.V. 16.77, N. 16). Fasciole crossing interambulacrum 5 plates 3b, 4b, 2a, 3a, 4a; ambulacrum I plates 4a, 5a, ambulacrum V plates, 4b, 5b. Fasciole encloses 2 enlarged porepairs.

TUBERCULATION.—Tubercles on dorsal side very small, of equal size; tubercles on ventral side much larger, largest on anterior part of sternum, posterior part of labrum. Tubercles within area enclosed by subanal fasciole larger than in area surrounding fasciole (Plate 42: figure 2); tubercles perforate, crenulate. Pits common on ventral side, very deep in ambulacra V and I and anterior part of labrum (Plate 42: figure 6).

ORAL PLATE ARRANGEMENT.—Plastron mesamphisternous with sternal plates similar but succeeding plates alternating (Figure 29c); labrum long, length 22% L (S.D. 0.81, C.V. 20.45, N. 16), narrow extending posteriorly to first third of second adjacent ambulacral plate (Figure 29c). Sternum narrow with width 22% L (S.D. 0.71, C.V. 18.08, N. 16). First plate of paired interambulacra in contact with peristome.

OCCURRENCE.—Late Eocene, Brodermann (1949:322) considered this species to be early to middle Eocene, but it is found in the Jabaco Formation, which according to Bermúdez and Hoffstetter (1959:54) is late Eocene. Furthermore, the specimens I collected in 1978 were from yellow marls, which Francisco de Albear (1981, personal communication) placed in the late Eocene. Quarry of "Consuelo" tileworks, Cerro, Cienaga, Habana Province, Cuba; "Cuba y Cantera Grande," park on bank of Almendares River, Habana Province, Cuba; cut on W side of Avenida de los Presidentes near the University of Habana (Palmer loc. 941), Habana Province, Cuba; marls with numerous *Lepidocyclinas* and one *Pauropygus*, 4.65 km W of Guanajay on road to Mariel (Palmer loc. 1102), Pinar del Rio Province, Cuba; quarry of Morro Cement Plant, at corner of workings, N end of N-S cliff, Mariel, Pinar del Rio Province, Cuba; coarse lime gravel

with many foraminifera, Cayo Alto of Loma Guainabo, 6 km W of Yaguajay, Santa Clara (now Las Villas) Province, Cuba.

Family BRISSIDAE Gray, 1855

Genus *Brissus* Gray, 1825

Test elongate, no anterior groove or very shallow one; apical system anterior, ethmolytic, with 4 genital pores, anterior ambulacrum not petaloid, anterior petals transverse, petals depressed; peripetalous and subanal fascioles; labrum short, first plate of interambulacrum 1 followed by single plate.

HABITAT.—According to Mortensen (1951:507) *Brissus* lives buried in a coarse gravelly bottom. William M. Kier (1981, personal communication) reports finding *Brissus obesus* Verrill buried in coarse sand to gravel in the Gulf of California. As it has both peripetalous and subanal fascioles, it would be expected that *Brissus* could burrow. The absence of large pores and peripodia in the dorsal part of ambulacrum III indicates a lack of funnel-building tube feet. This lack probably means that *Brissus* cannot live in fine sediment. Modern species occur in shallow water in tropical to temperate areas.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—No other Eocene or Oligocene species of *Brissus* are known from the Western Hemisphere. *Brissus glenni* Cooke from the Pleistocene of South Carolina is easily distinguished from the Cuban species by its far larger test and deeper petals. *Brissus exiguus* Cotteau from the Miocene of Anguilla is based on two deformed specimens making it difficult to be certain of its specific characters. Its apical system is less anterior than in *B. cabrerai*, *B. durhami*, and *B. caobaense*. Its petals are narrower than those of *B. camagueyensis* and *B. minutus*.

REMARKS.—In *Brissus*, the first plate in interambulacrum 1 is apparently always followed by a single plate. This plate arrangement occurs in all the specimens of *Brissus* I have studied in which the plate arrangement was visible, including the living species *Brissus unicolor* (Leske), *Brissus latecarinatus* (Leske), *Brissus obesus* Verrill, and

Brissus gigas Fell. The same is true in the fossil species, *Brissus latidunensis* Clegg, from the Miocene and *Brissus minutus* (Sánchez Roig) from the Oligocene-Miocene. Lovén (1874, pl. 4: fig. 43) illustrated the arrangement in *Brissus scillae* Lovén (= *B. unicolor*).

Four Cuban species have been referred to *Brissus* and three others are transferred herein from other genera. The type specimen of *Brissus sagrae* Lambert in Lambert and Thiéry (1925 [1909–1925]:497) has been lost and the illustrations of this species are too poor to permit comparison with the other species of *Brissus* from Cuba. *Brissoides minutus* Sánchez Roig, *Crucibrissus cabrerai* Sánchez Roig, and *Sandiegoaster durhami* Sánchez Roig are referred to *Brissus*. Sánchez Roig (1949:235) reports a specimen of *Brissus brissus* (Leske) (= *B. unicolor*) from the Pleistocene of Cuba, but this specimen is no longer in the Sánchez Roig Collection.

Four of these species are from the Eocene. Only one other species of *Brissus* is known elsewhere from the Eocene, and that is *Brissus fabiani* Lambert from Italy. Probably *Brissus* originated in the Cuban region, later spreading around the world.

I suspect that not all of these fossil species are distinct. *Brissus caobaense* occurs at the same locality as *B. durhami*, and both species are very similar. Two species, *B. camagueyensis* and *B. minutus*, are based on small specimens and their differences from the other species may stem from their smaller size.

***Brissus cabrerai* (Sánchez Roig),
new combination**

FIGURE 30; PLATE 43: FIGURES 1–3

Crucibrissus cabrerai Sánchez Roig, 1953a:67, pls. 10, 13, 21.

MATERIAL.—Only one specimen is present in the collection, a cotype (SRC 4191). This specimen was figured by Sánchez Roig (1953a, pl. 21) and is herein selected as the lectotype. It is poorly preserved, being badly weathered with all the tubercles removed dorsally and with part of the posterior surface broken away.

SHAPE AND SIZE.—Test high with steep sides; length estimated 90 mm, width 80% L, height 56% L; greatest width anterior, greatest height posterior to apical system along inflated surface in posterior interambulacrum. Although posterior surface broken away in lectotype, the cotype figured by Sánchez Roig (1953a, pl. 13) has a pointed posterior margin.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of genital pores 17% L; ethmolytic, genital plate 2 extending posteriorly separating posterior ocular plates (Figure 30); 4 genital pores.

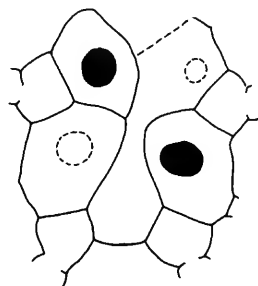


FIGURE 30.—*Brissus cabrerai* (Sánchez Roig), apical system of the lectotype, SCR 4191, $\times 23$.

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove; pores microscopic in dorsal region.

Anterior petals (II and IV) narrow, straight, widely divergent, almost flush with surface of test; length 40% L, width 5.9% L; interporiferous zones narrow, slightly less width of single poriferous zone. Test too weathered to permit determination whether or not pores conjugate; 84 pore-pairs in petal. Dorsally, pores smaller in anterior poriferous zone.

Posterior petals (V and I) narrow, diverging slightly from each other; length 46% L, width 5.1% L; 96 pore-pairs in petal.

PERISTOME.—Anterior, located at distance from margin to anterior edge of opening equal to 21% L; labiate, width 18% L, height 5.2% L.

PERIPROCT.—Not preserved on lectotype but located high on posterior truncation.

FASCIOLAS.—Peripetalous fasciole not preserved on lectotype; test too weathered dorsally. Short track of subanal fasciole present forming lobe below periproct.

ORAL PLATE ARRANGEMENT.—No sutures visible.

OCCURRENCE.—Late Eocene, Armadillo farm, Marroquín district, Camagüey Province, Cuba.

REMARKS.—Sánchez Roig referred this species to *Crucibrissus*, a genus in the family Hemiasteridae. He was not aware of the presence of a subanal fasciole. This species with its transversely oriented anterior petals appears to be a typical *Brissus*.

Among the Cuban species of *Brissus*, it resembles *B. durhami* Sánchez Roig, also from the Eocene, in its large test, but differs in its higher test, smaller pores in petals, and less anteriorly situated peristome.

***Brissus camagueyensis* Weisbord**

PLATE 43: FIGURES 4–6

Brissus camagueyensis Weisbord, 1934:76, pl. 9: figs. 1, 2.—Sánchez Roig, 1949:234.

Only one specimen is known of this species, which was carefully described by Weisbord. There are 52 porepairs in petal IV, 64 in petal V.

OCCURRENCE.—Late Eocene, in road cut at Loma Calisto, approximately 800 m SW of the S end of town of Neuvinas, on the road leading toward Belén, Camagüey Province, Cuba.

***Brissus caobaense* Sánchez Roig**

FIGURE 31; PLATE 44: FIGURES 1–4

Brissus caobaense Sánchez Roig, 1953c:163, pl. 7: fig. 5, pl. 8: figs. 1, 2.

MATERIAL.—Although the species was based on two cotypes, only one is still in the collection. This specimen (SRC 4726) was figured by Sánchez Roig (1953c, pl. 8: figs. 1, 2) and is selected here as the lectotype. This specimen is moderately well preserved, having an undistorted but highly weathered test with only portions of the fascioles preserved.

SHAPE AND SIZE.—Length 63 mm, width 52 mm (82% L), height 31 mm (49% L); greatest width central, greatest height posterior.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 20% L; 4 genital pores, ethmolytic.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very shallow groove from apical system to peristome; pores minute.

Anterior petals (II and IV) extending almost to margin, length 30% L, width 7.6% L transverse forming 180 degree angle; 62 petaloid porepairs.

Posterior petals (V and I) straight, extending three-fourths distance from apical system to margin, length 44% L, width 8.1% L; 80 petaloid porepairs.

Petals in groove with depth 2.9% L (petal II),

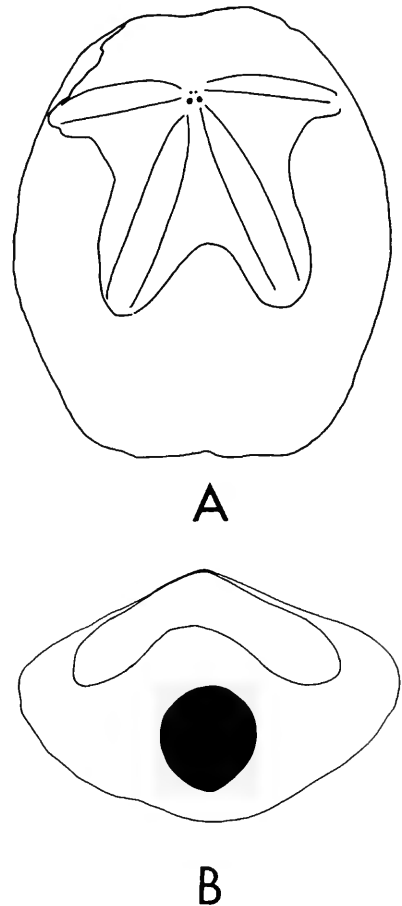


FIGURE 31.—*Brissus caobaense* Sánchez Roig, positions of the fascioles of the lectotype, SRC 4726, A, dorsal view; B, rear view.

1.9% L (petal I); interporiferous zones narrow, one-half width of single poriferous zone.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 19% L, opening large with width 21% L, height uncertain.

PERIPROCT.—Inframarginal, high on overhanging posterior truncation. Opening appears to be very large but may be enlarged by postmortem fracturing; height 20% L, width 20% L.

FASCIOLAS.—Peripetalous fasciole deeply indented (Figure 31A) in interambulacra 4, 5, and 1, passing anteriorly around ambulacrum III at margin, slightly indented in interambulacra 2, 3. Subanal fasciole broad with large lateral lobes (Figure 31B), width 48% L (estimated at 30 mm). Not possible to discern which plates crossed by fascioles.

ORAL PLATE ARRANGEMENT.—Labrum partially broken away; plastron long and narrow, combined plates with length 52% L, width 54% L (plastron 33 mm long, 19 mm wide).

OCCURRENCE.—Middle Eocene. Albear (1980, personal communication) considers this locality middle to late Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Brissus durhami* Sánchez Roig from the same locality. Although the lectotype of *B. caobaense* is smaller and narrower, these differences may reflect variation within individuals of the same species. I suspect that the two species are synonymous, but more specimens must be studied before a decision can be made.

Brissus caobaense differs from *B. camagueyensis* Weisbord from the Eocene of Camagüey Province. The lectotype of *B. caobaense* has a lower test, more depressed petals, a slight anterior groove, and a more anterior apical system. The species appear to be distinct but some of these differences may result from difference in size of the type specimens.

***Brissus durhami* (Sánchez Roig)**

PLATE 44: FIGURES 5–8

Sandiegoaster durhami Sánchez Roig, 1952b:12, pl. 5: fig. 2, pl. 6: fig. 2, pl. 7: fig. 2.

Brissus durhami.—Fischer, 1966:U582.

MATERIAL.—Only one specimen known, the holotype (SRC 4055), which has an undistorted but poorly preserved test. It is highly weathered and fractured.

SHAPE AND SIZE.—Length 80 mm, width 72 mm (91% L), height 43 mm (54% L). Greatest width central to slightly posterior, greatest height posterior.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 22% L; 4 genital pores, ethmolytic.

AMBULACRA.—Anterior ambulacrum III not petaloid, flush with test, no groove; pores minute.

Anterior petals (II and IV) transverse, subtending angle of 180°; extending two-thirds distance from apical system to margin, length 33% L. Petals narrow, width 5.6% L, with interporiferous zone narrower than poriferous; pores conjugate, outer pore slightly more elongate than inner, 62 porepairs in each petal. Plates in posterior poriferous zone wider than plates in anterior.

Posterior petals (V and I) slightly curved, extending slightly more than one-half distance from apical system to margin, length 47% L, width 6% L. Plates in anterior posterior poriferous zones slightly wider than plates in posterior; 72 porepairs in each petal. All petals slightly depressed.

FASCIOLAS.—Because of weathering, only short traces of the fascioles are present. Peripetalous fasciole indented in interambulacra 4 and 1, crossing ambulacrum III above margin. Subanal fasciole present but too little preserved to know shape of area circumscribed by it.

ORAL PLATE ARRANGEMENT.—Plate sutures obscured.

OCCURRENCE.—Middle to late Eocene; Albear (1980, personal communication) considers this locality middle to late Eocene, Caraballo quarry, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Brissus durhami* and *B. caobaense* Sánchez Roig occur together at the same locality and may be synonymous. *B. durhami* differs in having a narrower test with its width 72% L as opposed to 82% L in other species. This difference may be individual variation.

REMARKS.—Fischer (1966:U582) considered *Sandiegoaster*, of which *S. durhami* (= *Brissus dur-*

hami) is the type-species, a synonym of *Brissus*. I agree with Fischer for I can see no character in this species distinguishing it from *Brissus*.

***Brissus minutus* (Sánchez Roig),
new combination**

FIGURE 32; PLATE 45: FIGURES 1-3

Brissoides minutus Sánchez Roig, 1949:205.

Neopatagus minutus.—Sánchez Roig, 1953b:261.

MATERIAL.—Holotype (SRC 4954) and only known specimen well preserved with undistorted

test. Ornamentation removed by weathering.

SHAPE AND SIZE.—Length 24 mm, width 82% L, height 64% L; greatest width anterior, dorsal surface inflated with steep sides.

APICAL SYSTEM.—Anterior, ethmolytic (Figure 32c) with genital plate 2 extending posteriorly separating posterior ocular plates, 4 genital pores. System located at distance from anterior margin to center of genital pores equal to 24% L.

AMBULACRA.—Anterior ambulacrum III not petaloid; pores minute in dorsal region; 44 plates in ambulacrum.

Anterior petals (II and IV) short, length 31%

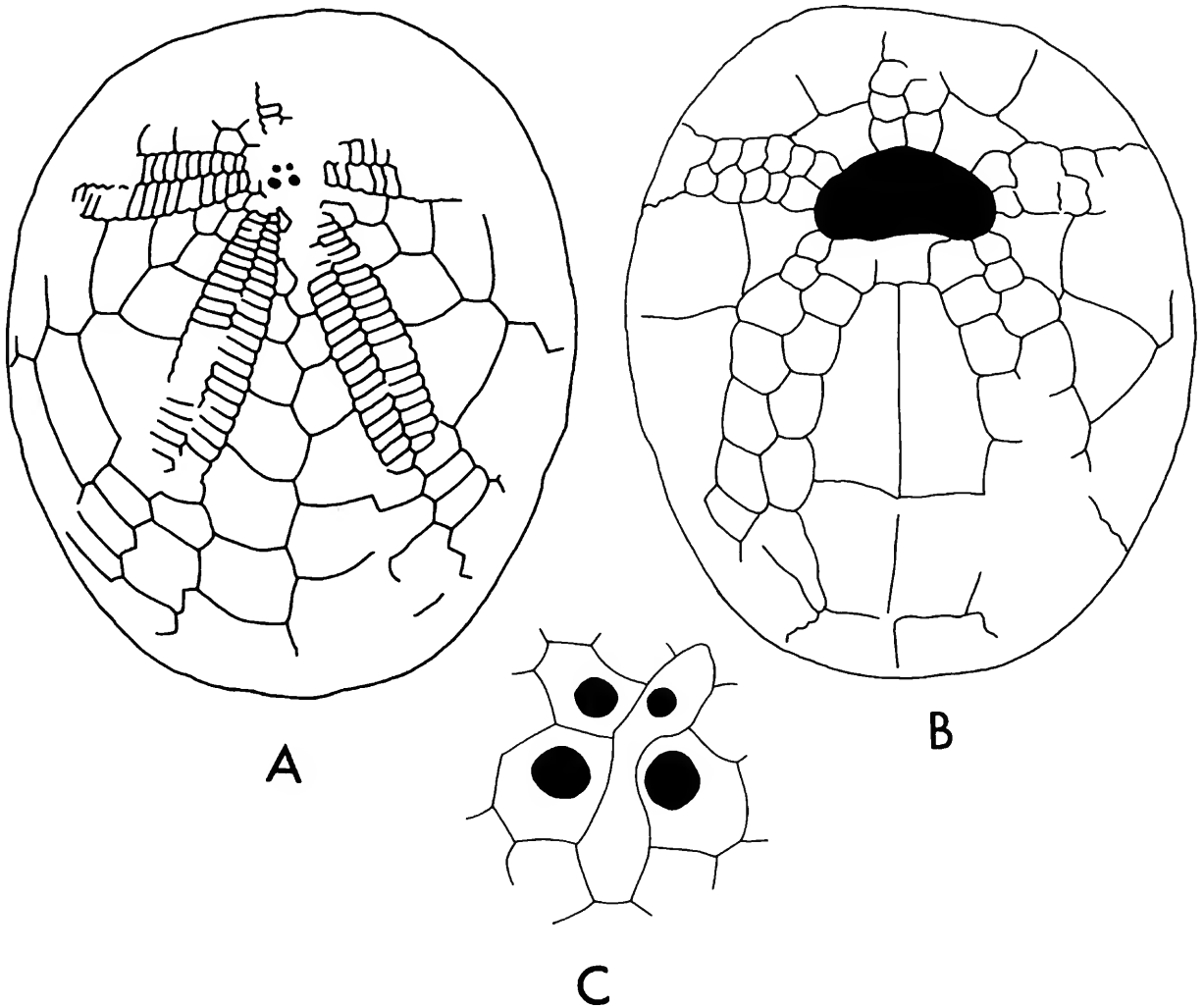


FIGURE 32.—*Brissus minutus* (Sánchez Roig), plate arrangement (many sutures are not visible) of the holotype, SRC 4954: A, dorsal view, $\times 4$; B, ventral view, $\times 4$; C, apical system, $\times 22$.

L, width 10% L; petals transverse, subtending angle of 180° . Interporiferous zones very narrow, almost one-half width of poriferous zone, pores conjugate; 36 petaloid porepairs, first petaloid porepair in plate 13.

Posterior petals (V and I) short, extending slightly more than one-half distance from apical system to margin; length 39% L, width 11% L; 44 petaloid porepairs; first petaloid porepair in plate 18. Last plate bearing petaloid porepair of outer poriferous (Va and Ib) occluded (Figure 32A).

PERISTOME.—Large, anterior, distance from anterior margin to anterior edge of opening equal to 21% L; width 26% L, height 13% L.

PERIPROCT.—Marginal, slightly visible from above, higher than wide, height 29% L, width 18% L; occurring between interambulacral plates 6–10.

FASCIOLAS.—Probably peripetalous and subanal present but removed by weathering.

TUBERCULATION.—No large tubercles dorsally.

ORAL PLATE ARRANGEMENT.—Labrum short, broad, length 7.1% L, width 13% L, extending posteriorly two-thirds height of first adjacent ambulacral plate (Figure 32B). First pair of plastron plates with height 32% L, combined width 25% L; second pair with height 20% L, combined width 28% L. In interambulacrum 1 first plate followed by single plate.

OCCURRENCE.—Oligocene-Miocene, "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Brissus minutus* has similar petals in size and arrangement to those of *B. camagueyensis* Weisbord from the late Eocene of Cuba. The test of *B. camagueyensis* seems to be thicker posteriorly, but this difference may only be the result of postmortem distortion.

Genus *Brissopsis* L. Agassiz, 1847

Test small to large, elongate; apical system ethmolytic, number of genital plates and pores variable; anterior ambulacrum depressed, forming notch at anterior margin, pores minute; petals of about equal size, depressed, confluent in some

species with porepairs reduced adapically where petals nearly meet; peristome anterior; periproct marginal; peripetalous, subanal fascioles, in some species anal branches; labrum short, episternal plates almost one-half length of sternal plates.

HABITAT.—These Cuban species of *Brissopsis* probably lived buried in fine sediment. Their morphological features would have enabled this mode of life: anterior ambulacrum with funnel-building tubefeet, depressed petals, and presence of a peripetalous and a subanal fasciole. The modern *Brissopsis elongata* Mortensen has been reported (Kier, 1975:16) alive buried deeply in mud. Modern species live in tropical and temperate seas at depths from 12–2980 m.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—Two species of this genus are recognized herein from Cuba. Both are easily distinguished from the three fossil United States species, one fossil Anguillan species, and one fossil Costa Rican species of *Brissopsis*.

Although Sánchez Roig (1949:223) reports *Brissopsis antillarum* Cotteau from Cuba, no specimens are present now in the Sánchez Roig Collection. I therefore cannot confirm this occurrence.

Brissopsis aguayoi Sánchez Roig

PLATE 45: FIGURES 4–7

Brissopsis aguayoi Sánchez Roig, 1952c:15, pl. 6: figs. 1, 2.

MATERIAL.—Only one specimen, the holotype (SRC 4720), is known. This specimen is poorly preserved, badly fractured and weathered but not distorted.

SHAPE AND SIZE.—Length 35 mm, width 31 mm (90% L), height 16 mm (45% L), with greatest width anterior of center, greatest height posterior of center.

APICAL SYSTEM.—Four genital pores, located at distance from anterior margin to center of genital pores, equal to 38% L; in deep trough with petals; plate sutures not visible.

AMBULACRA.—Anterior ambulacrum III, not petaloid, in groove; porepairs enlarged and in peripodia but number not clear.

Anterior petals (II and IV) very broad adapically, short, extending one-half distance from apical system to anterior margin, length 20% L. Anterior poriferous zone of petal with pores greatly reduced in size adapically; of the 17 porepairs in the anterior poriferous zone, the 9 distal porepairs are large, the 8 adapical porepairs are minute. This reduction does not occur in the posterior poriferous zone in which all the pores are large. Petals sharply curving with posterior poriferous zones joining anterior poriferous zones of posterior petals to form arc; 34 plates in petal.

Posterior petals (V and I) short, extending slightly more than one-half distance from apical system to margin, length 25% L. Posterior or inner porepairs of each petal greatly reduced in size adapically; 7 or 8 of distal porepairs large, 14 adapical porepairs minute; 42 plates in petal.

Petals deeply depressed with apical system; depth of groove at apical system 4.3% L. Pores single beyond petals.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 20% L. Opening wide, width 20% L, height 5.7% L.

PERIPROCT.—Located high on vertical posterior truncation; opening higher than wide, height 17% L, width 15% L.

FASCIOLAS.—Test too weathered to preserve peripetalous fascioles; short trace of subanal fasciole visible.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, "Las Cuevas de Pedro Pozo" farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from the other species of this genus known from Cuba, the Miocene *B. jimeno* Cotteau. It differs in its smaller, higher and wider test, shorter anterior petals, and more anterior apical system. It differs from *Brissopsis antillarum* Cotteau from the Miocene of Anguilla in its much shorter anterior petals. Likewise its shorter petals distinguish it from *Brissopsis steinhatchee* Cooke from the late Eocene of Florida.

Brissopsis aguayoi is much different from *Brissop-*

sis blaspiedi Grant and Hertlein from the Oligocene-Miocene of Mississippi. Its anterior petals are much shorter, more deeply depressed and its test is much wider. It differs from the Eocene specimens from Alabama that Cooke (1959:85) referred to *Brissopsis biarrizensis* Cotteau in its more anterior apical system, more depressed petals, and shorter and narrower anterior petals. *Brissopsis aguayoi* has a smaller test with much shorter petals than the unnamed specimen from the Miocene of Costa Rica that Durham (1961:484) referred to *Brissopsis*.

***Brissopsis jimeno* Cotteau**

PLATE 46: FIGURES 1, 2

Brissopsis jimeno Cotteau, 1875:6; 1881:33, pl. 3: figs. 5–9; 1897:79, pl. 24: figs. 5–9.—Jackson, 1922:81.—Jeannet, 1928:12, pl. 1: fig. 35.—Sánchez Roig, 1949:225.

MATERIAL.—I have studied the specimen in the Cotteau Collection at the Université Claude Bernard, Lyons, France, figured by Cotteau (1881, pl. 3: fig. 9). It is a mold of the interior of the test with only a few fragments of the original test present. It is herein selected as the lectotype.

SHAPE AND SIZE.—Test 84 mm long, width 76% L with greatest width anterior of center, height 30% L.

APICAL SYSTEM.—Central, located at distance from anterior margin to center of genital pores equal to 49% L; small, appears from mold to be ethmolytic with genital 2 extending far posteriorly, 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove extending from apical system to margin; 34 enlarged pores on dorsal surface. Anterior petals (II and IV) very curved, depressed in groove, short, length 27% L, width 6.8% L; interporiferous zone narrower than single poriferous zone; 50 porepairs in petal; porepairs greatly reduced in size adapically in anterior poriferous zones.

Posterior petals (V and I) confluent for two-thirds length of petals, sharing common groove; curving away from each other distally; short, length 22% L, width at end of petal 5.5% L; 46

porepairs in petal; porepairs greatly reduced in size adapically where petals confluent.

PERISTOME.—Anterior, distance from anterior edge of peristome to anterior margin 21% L; width of opening 16% L, height 6.4% L.

PERIPROCT.—Inframarginal, on overhanging posterior truncation; more details not discernible because of poor preservation.

FASCIOLAE.—Not preserved.

ORAL PLATE ARRANGEMENTS.—Labrum with length 7% L; sternal plates, first plates of plastron, with length estimated at 38% L, combined width 31% L; episternal plates, second plates of plastron, width length 16% L, combined width 31%.

OCCURRENCE.—Miocene, Cienfuegos, San Martin, Santa Clara (now Las Villas) Province, Cuba. Early or middle Miocene, Delhitrace-Silverstream, Trinidad.

COMPARISON WITH OTHER SPECIES.—This species differs from *Brissopsis aguayoi* Sánchez Roig from the Oligocene-Miocene of Cuba in its larger, lower, and longer anterior petals with length 27% L versus 20% in *B. aguayoi*. It is distinguished from *Brissopsis antillarum* Cotteau from the Miocene Anguilla Formation of Anguilla by its shorter petals. Its anterior petals extend little over one-half the distance from the apical system to the margin, but in *B. antillarum* these petals extend two-thirds this distance. Furthermore, the test in *B. jimeno* is larger, more elongate, and lower. *Brissopsis jimeno* has a much lower test and less divergent and more curved petals than the specimen from the Miocene of Costa Rica that Durham (1961:484) referred to *Brissopsis* as a new but unnamed species. *Brissopsis jimeno* is easily distinguished from *Brissopsis steinhatchee* Cooke from the late Eocene of Florida. It differs in its much less divergent anterior petals, which are longer than the posterior petals. In the Floridian species, the posterior petals are longer than the anterior. In addition, the apical system is central, and the test is larger and lower in *B. jimeno*. *Brissopsis jimeno* differs from the Eocene specimens of Alabama that Cooke (1959:85) referred to *Brissopsis biarritzensis* Cotteau in its much larger, lower test and narrower petals. The Cuban species has much shorter petals and a larger test than the Mississi-

pian *Brissopsis blanpiedi* Grant and Hertlein from the middle Oligocene.

Genus *Cyclaster* Cotteau, 1856

Palmeraster Sánchez Roig, 1949:268.

Test small, heart-shaped; apical system ethmophract, 3 genital pores, no pore in genital plate 2; anterior ambulacrum III not petaloid, petals short, closed; peripetalous and subanal fascioles present labrum long, narrow.

HABITAT.—Species of this genus probably live buried in fine sediment. The presence of a subanal and a peripetalous fasciole would provide the circulation necessary in a burrow. The porepairs are larger and in well-developed peripodia in the dorsal portion of the anterior ambulacrum indicating that these echinoids had funnel-building tube feet so necessary for the maintenance of a burrow in fine sediment. Although no modern species has been seen in its habitat, Baker (1969:269) reports that the living *Cyclaster regalis* Baker was collected in sandy mud. The genus is confined today to tropical seas. *C. regalis* was collected in 115 to 260 fm.

REMARKS.—The type-species of *Palmeraster* appears to be a synonym of the type-species of *Cyclaster*. *Palmeraster* is, therefore, herein considered a synonym of *Cyclaster*. Six species of these genera have been described from Cuba. No specimens are available of one of them, *Palmeraster herrera* Sánchez Roig. *Palmeraster palmeri* Sánchez Roig, *Palmeraster zanolettii* Sánchez Roig, *Palmeraster herrera* Sánchez Roig and *Cylaster brodermanni* Sánchez Roig are herein considered synonyms of *Cyclaster drewryensis* Cooke.

Cyclaster drewryensis Cooke occurs also in the early Oligocene of Alabama. *Cyclaster sterea* Arnold and Clark from Jamaica is based on too poor a specimen for comparison with the Cuban species.

Cyclaster drewryensis Cooke

FIGURE 33; PLATE 46: FIGURES 3–6; PLATE 47

Cyclaster drewryensis Cooke, 1942:50, pl. 3: figs. 9–11; 1959:68, pl. 28: figs. 1–4.

Cyclaster brodermanni Sánchez Roig, 1949:221, pl. 35: figs. 1, 2.

Palmeraster palmeri Sánchez Roig, 1949:269, pl. 31: figs. 2–4.—Mortensen, 1950:354, figs. 251a–c.—Fischer, 1966: U555, fig. 437–1c.

Palmeraster zanolettii Sánchez Roig, 1952b:17, pl. 5: figs. 3, 4.

?*Palmeraster herrerae* Sánchez Roig, 1952b:17, pl. 1: figs. 2, 3.

OCCURRENCE.—Late Eocene, type specimens of *Cyclaster brodermanni* from Palmer loc. 1640, deep cut N of Grúa 9, Ramal Juan Criollo, Camagüey Province, Cuba. Other specimens collected by Palmer and not in the USNM are from Palmer loc. 1670, just NW of switch in Ciego Caballo, Central Jatibonico, Santa Clara (now Las Villas) Province, Cuba; Palmer locs. 1431, 1433, S slope of Loma La Quinta, 0.2 km SE of Arroyo Blanco on road to Majagua, Camagüey Province, Cuba; Palmer loc. 1655, E of switch on Ramal Valle, 2 km or 1 km W of Valle 1, Camagüey Province, Cuba; Palmer loc. 1086, Loma La Quinta, E of Arroyo Blanco on road to Majagua, Camagüey Province, Cuba.

Specimens of *Palmeraster palmeri* from late Eocene, Finca Concepción, Morón, Camagüey Province, Cuba.

Specimens of *Palmeraster zanolettii* from late Eocene, Armadillo farm, corral Marroquín, Marroquín district, Morón, Camagüey Province, Cuba.

The holotype of *Palmeraster herrerae* from the late Eocene at “La Rabona” farm, Tamarindo district, Morón, Camagüey Province, Cuba.

The type specimens of *C. drewryensis* from early Oligocene, Red Bluff clay, Drewry and Whatley, Alabama.

REMARKS.—I cannot see any significant difference between the American specimens of this species and the Cuban specimens that have been referred to *Cyclaster brodermanni*. All the specimens have tests of similar shape and petals of similar length with a similar number of porepairs. Although the apical system of the holotype of *C. drewryensis* is more posterior than in the Cuban specimens, that of the other American specimens (i.e., the paratype (USNM 154148) and figured

specimen (USNM 559882)) is as equally anterior as in the Cuban specimens. Perhaps, if a large number of specimens were available, significant differences might be apparent between the Cuban and American specimens; none are apparent now.

Photographs of a paratype of *C. drewryensis*, not figured before, are on Plate 46: figures 5, 6.

Sánchez Roig's *Palmeraster palmeri* appears to be a synonym of *C. brodermanni*. Unfortunately, the type specimens of *P. palmeri* are lost but 6 topotypic specimens are present in the University of California, Museum of Paleontology (UCB A8394a). One of these is illustrated on Figure 33; Plate 47: figures 1–4. These specimens are indistinguishable specifically from a specimen of *C. brodermanni* (ANSP 16651) and from Sánchez Roig's photographs and description of *P. palmeri*. They all share an ethmophract apical system with 3 genital pores, identically shaped tests, ambulacrum III with few enlarged pores, short straight petals, a very long labrum extending back to the posterior part of the third adjacent ambulacral plate and identically positioned and shaped peristomes and periprocts. Sánchez Roig reported the absence of any fascioles but his specimens were probably too weathered to show them. They are barely discernible on the specimens I have studied from his type-locality of *P. palmeri*. The petals are shorter in a specimen of *Cyclaster brodermanni* than in a specimen of *Palmeraster palmeri*, but this is presumably due to the much smaller size of the *C. brodermanni* specimen.

Because *P. palmeri* is the type-species of *Palmeraster* Sánchez Roig (1949), that genus becomes a junior synonym of *Cyclaster* Cotteau, 1856.

Palmeraster zanoletti Sánchez Roig is indistinguishable from *C. brodermanni*. Although the type specimen is lost, 2 topotypic specimens in the USNM collections are similar in all respects to *C. brodermanni*.

Although no specimens are available of *Palmeraster herrerae* Sánchez Roig (also from the late Eocene of Cuba), Sánchez Roig's illustrations show a specimen very similar to *C. brodermanni*. *P. herrerae* is provisionally considered a synonym, of *C. brodermanni* and *C. drewryensis*.

SYNONYMS

Cyclaster brodermanni Sánchez Roig

PLATE 46: FIGURES 3–6

MATERIAL.—The type specimen is lost. Two extremely well-preserved specimens from the type-locality that clearly belong to this species are in the Palmer Collection at the Academy of Natural Sciences of Philadelphia (ANSP 16651a, b). The following description is based on these two specimens. (Five topotypic specimens (4063) are also at the MCZ.)

SHAPE AND SIZE.—Length 25 and 26 mm, width 90 and 92% L; height 71 and 72% L. Greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 34 and 34% L. Three large genital pores, no pore in genital plate 2; ethmophract.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very shallow groove from apical system to peristome. Pores paired throughout all ambulacra. Pores enlarged in only short section of ambulacrum III, with length extending approximately one-third to one-half distance from apical system to margin; 20 to 22 porepairs in region with enlarged porepairs; 40 plates in ambulacrum.

Anterior petals (II and IV) straight, short, extending one-half distance from apical system to margin, length 26 and 27% L; width 13 and 12% L. Interporiferous zones slightly narrower than single poriferous zones; pores conjugate; 36 and 40 petaloid porepairs; first petaloid porepair to plate 15 or 16. Double pores in ambulacra beyond petals.

Posterior petals (V and I) straight, approximately same length as anterior, length 26 and 29% L, extending less than one-half distance from apical system to margin; width 12 and 12% L; 38 and 46 petaloid porepairs. Both pair of petals depressed in slight grooves.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 17 and 16% L, opening wider than high; width 12 and 12% L; height 4.4 and 3.5% L.

PERIPROCT.—Located high on nearly vertical posterior truncation. Opening higher than wide, height 12 and 13% L, width 10 and 10% L. Enclosed by interambulacral plates 6–8.

FASCIOLAS.—Peripetalous fasciole a broad band sharply indented in interambulacra 4 and 1, slightly indented in interambulacrum 5, fasciole incomplete anterior of anterior petals (II and IV) passing only partially into interambulacra 2, 3; no fasciole near to or crossing ambulacrum III. The absence of this fasciole is not because it has been removed by weathering. The test in ANSP 16651a is extremely well preserved and the tuberculation is present in this anterior region, but no fasciole is present. Four other crushed topotypic specimens (in the MCZ and not used in this description) have this region well preserved and no fasciole is visible here on them.

Subanal fasciole a broad band circumscribing a bilobed area with width 39 and 36% L, situated very ventral from periproct; distance from ventral edge of periproct to fasciole 23 and 20% L.

ORAL PLATE ARRANGEMENT.—Labrum very long, length 21 and 23% L, extending to posterior of second adjoining ambulacral plate. Rest of oral plate sutures not clear on topotypic specimens.

OCCURRENCE.—Late Eocene, type specimens from Palmer loc. 1640, deep cut N of Grua 9, Ramal Juan Criollo, Camagüey Province, Cuba. Other specimens collected by Palmer and not in the USNM Collections are from Palmer loc. 1670, just NW of switch to Cieto Caballo, Central Jatibonico, Santa Clara (now Las Villas) Province, Cuba; Palmer locs. 1431 and 1433, S slope of Loma La Quinta, 0.2 km SE of Arroyo Blanco on road to Majagua, Camagüey Province, Cuba; Palmer loc. 1655, E of switch on Ramal Valle, 2 km or 1 km W of Valle 1, Camagüey Province, Cuba; Palmer loc. 1086, Loma La Quinta, E of Arroyo Blanco on road of Majagua, Camagüey Province, Cuba.

Palmeraster palmeri Sánchez Roig

FIGURE 33; PLATE 47: FIGURES 1–4

MATERIAL.—The type specimens have been lost; but 6 topotypic specimens identified by Sán-

chez Roig are in the Museum of Paleontology, University of California. One of them (UCB-A8394a) is described here. It is well preserved with no postmortem distortion, but weathering has removed all trace of the fascioles. The other specimens are poorly preserved and are not used in this description.

SHAPE AND SIZE.—Length 33.0 mm, width 30 mm (91% L), height 23 mm (70% L). Greatest width anterior, greatest height posterior; sides steep, smoothly rounded.

APICAL SYSTEM.—Anterior, located 11.7 mm, from anterior margin to center of genital pores, 36% L. Three large genital pores, no pore in

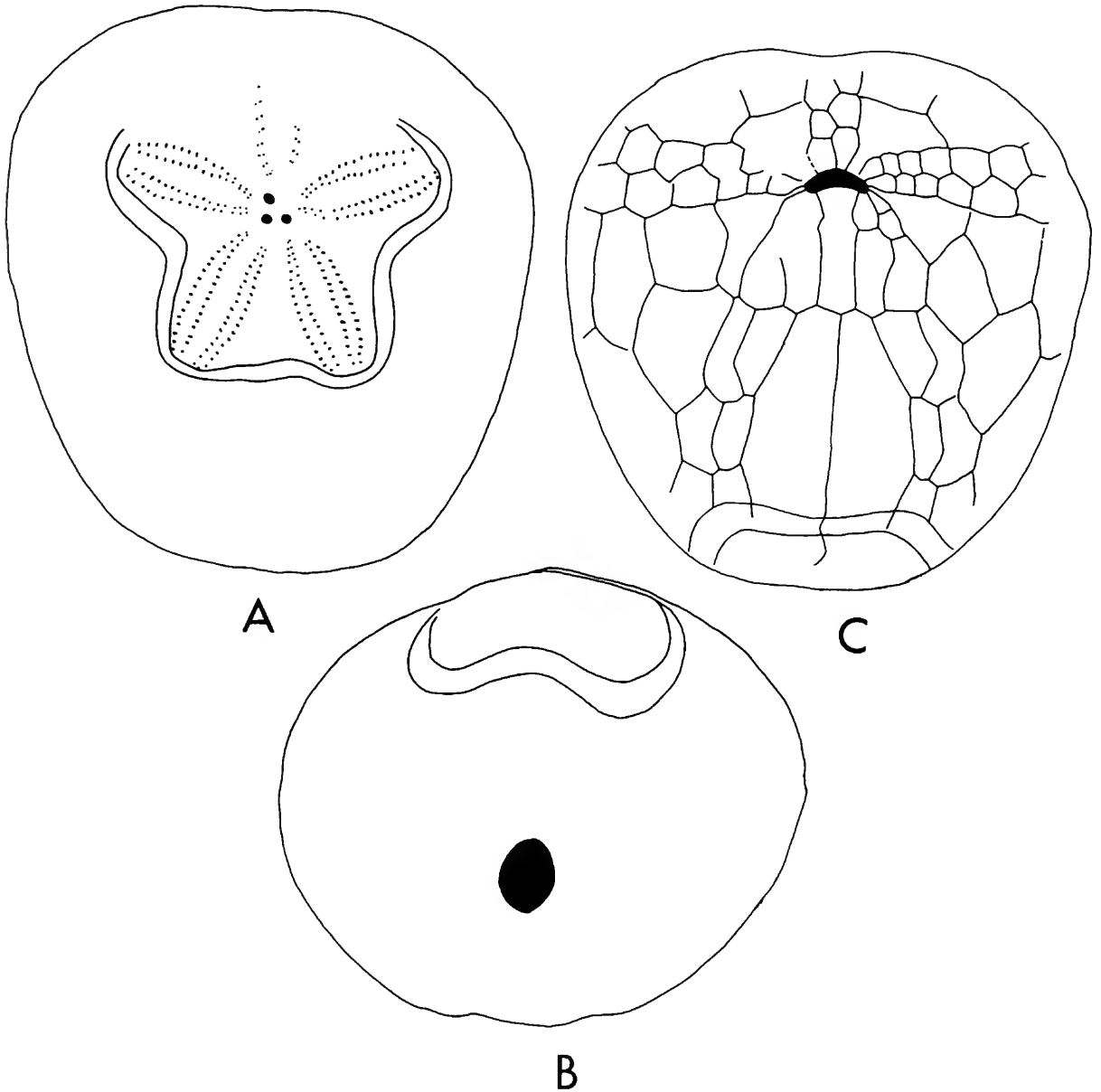


FIGURE 33.—*Cyclaster drewryensis* Cooke, topotype of *Palmeraster palmeri* Sánchez Roig (= *C. drewryensis*), UCB A8394a, $\times 4$: A, dorsal view; B, rear view; C, ventral view.

genital plate 2; ethmophract.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very shallow groove from apical system to peristome. Pores paired throughout all ambulacra. Pores enlarged in only short section of ambulacrum III with length approximately one-third distance from apical system to margin; 24 porepairs in region with enlarged porepairs; 54 plates in ambulacrum.

Anterior petals (II and IV) straight, short, extending almost two-thirds distance from apical system to margin, length 9.5 mm (29% L), width 2.9 mm (8.8% L). Interporiferous zones approximately same width as single poriferous zone; pore conjugate; 52 petaloid porepairs; first petaloid porepair in plate 16. Double pores in all ambulacra beyond petals.

Posterior petals (V and I) straight, approximately same length as anterior, length 9.0 mm (27% L), extending approximately one-half distance from apical system to margin; width 3.0 mm (9.1% L); 50 petaloid porepairs. Both pair of petals depressed in slight groove.

PERISTOME.—Very anterior, located at distance from anterior margin to anterior edge of peristome equal to 5.5 mm (17% L); opening wider than high; width 3.4 mm (10% L).

PERIPROCT.—Located high on nearly vertical posterior truncation. Opening higher than wide, height 3.4 mm (10% L), width 3.1 mm (9.4% L).

FASCIOLAE.—Not preserved.

ORAL PLATE ARRANGEMENT.—Labrum very long, length 7.8 mm (24% L). Rest of plate sutures not clear.

OCCURRENCE.—Late Eocene, Finca Concepción, Morón, Camagüey Province, Cuba.

Cyclaster sanchezi Lambert

PLATE 48: FIGURES 1–4

Cyclaster sanchezi Lambert in Sánchez Roig, 1926:113, pl. 38: figs. 1, 2; 1949:218.

MATERIAL.—The holotype is lost. The one specimen in the collection (SRC 5452) is herein described. This specimen is only slightly distorted with most of its test intact. Seventeen other spec-

imens are in the USNM Collections, but they are crushed.

SHAPE AND SIZE.—Length 37 mm, width 106% L, height 60% L. Greatest width anterior to center.

APICAL SYSTEM.—Anterior of center, distance from anterior margin to center of genital pores equal to 33% L. Ethmophractic with 3 genital pores; no pore in genital plate 2.

AMBULACRA.—Anterior ambulacrum III not petaloid; dorsal region with enlarged pores short, extending approximately one-third distance from apical system to anterior margin; 28 enlarged porepairs (Plate 48: figure 4) in this region; first enlarged porepair in plate 11; total of 48 plates in ambulacrum.

Anterior petals (II and IV) and curving slightly anteriorly, depressed in groove with depth 2.1% L, extending slightly more than one-half distance from apical system to margin; length 30% L, width 9.4% L. Interporiferous zone as wide as single poriferous zone; pores conjugate; 58 porepairs in petal.

Posterior petals (V and I) straight, extending less than one-half distance from apical system to margin; depressed in groove with depth 2.4% L; length 31% L, width 9.4% L; 64 porepairs in each petal. Plates beyond petals with porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of opening equal to 20% L; opening small, width 13% L, height 6.4% L.

PERIPROCT.—High on posterior truncation, wider than high.

FASCIOLAE.—Peripetalous fasciole broad, indented in paired interambulacra. Subanal fasciole broad, circumscribing a broad area, bilobed.

TUBERCULATION.—No large tubercles confined within peripetalous fasciole.

ORAL PLATE ARRANGEMENT.—Labrum very narrow, length 20% L.

OCCURRENCE.—Late Eocene, Finca Turibacoa, Majagua district, Ciego de Avila, Morón, Camagüey Province; Sievra Maraguan; 1 km E of San Antonio on Maraguan road, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Cyclaster*

sanchezi is clearly congeneric with *C. drewryensis*, also from the late Eocene of Cuba. Both species have ethmophract apical systems with 3 genital pores, narrow short petals, short regions in the anterior ambulacrum with enlarged porepairs, and small peristome. *C. sanchezi* differs in having a larger, lower test and a less anterior peristome.

Genus *Eupatagus* L. Agassiz, 1847

Herreraster Sánchez Roig, 1951:52.

Zanolettiaster Sánchez Roig, 1952c:14.

Neopatagus Sánchez Roig, 1953b:258.

Test generally large, low, anterior ambulacrum with minute porepairs, petals large, broad, closed, apical system ethmolytic with 4 genital pores usually close together, large primary tubercles enclosed within peripetalous fasciole, both peripetalous and subanal fasciole present.

HABITAT.—The living habits of the modern species of *Eupatagus* have not been described. Probably the echinoids live buried in sand. Presence of fascioles indicate a burrowing habit, but the small pores in the dorsal portion of ambulacrum III indicate a lack of funnel-building tube-feet. Therefore, it is doubtful that *Eupatagus* could bury in fine sediment. The living habits are known of a genus very similar to *Eupatagus*, namely *Plagiobrissus*. *P. grandis* (Gmelin) lives (Kier and Grant, 1965:37) buried in sand and builds no tunnel to the sediment-water interface.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—Most of the Cuban specimens of *Eupatagus* can be referred to *E. cubensis* (Cotteau), *E. clevei* (Cotteu), or *E. alatus* Arnold and Clark. *E. cubensis* is unlike any other species of this genus in the Western Hemisphere. Its large, very low test with many large tubercles within the peripetalous fasciole easily distinguishes it from all other species from this region. This difference is not surprising considering that no other species of *Eupatagus* is known from the Miocene of the Western Hemisphere. (*Eupatagus depressus* Jackson from the Miocene of Puerto Rico is herein considered a synonym of *E. cubensis*.) The genus was very common to the Eocene, with approximately 64 species reported from all over the world. It later became

more restricted with only 17 species in the Oligocene and only 14 in the Miocene. Only 5 species are known today, and all are in the Indo-West Pacific.

Although Sánchez Roig (1949:201) reports *Eupatagus antillarum* (Cotteau) from Cuba, I have found no specimen from Cuba of that species.

Eupatagus clevei occurs in the Oligocene-Miocene of Cuba and the Eocene of Panama, St. Bartholomew, Florida, Jamaica, and Curacao. It is characterized by its long, wide petals and small tubercles within the peripetalous fasciole.

Eupatagus alatus is common in the Eocene of Cuba and Jamaica and is quite similar to *E. clevei* differing only in having shorter posterior petals and interporiferous zones, which are usually more constricted at the ends of the petals.

Specimens are rare of *E. sanchezi* (Lambert), *E. turibacoensis* Sánchez Roig, *E. santanae* Sánchez Roig, and *E. siboneyensis* Weisbord. *E. sanchezi* bears very little resemblance to any other species in the Western Hemisphere because of the few large, deeply scrobiculated primary tubercles within its peripetalous fasciole. *E. turibacoensis* and *E. santanae* are very similar to *E. clevei* and *E. alatus*. *E. siboneyensis* is much narrower than any other *Eupatagus* in the Western Hemisphere.

REMARKS.—*Herreraster* is herein considered a subjective synonym of *Eupatagus*. Although the holotype of *Herreraster* is lost, a topotypic specimen identified by Sánchez Roig as belonging to this species is indistinguishable from *Eupatagus clevei* (Cotteau), which occurs at a nearby locality. *E. clevei* is clearly a *Eupatagus* having the large test, broad petals, subanal and peripetalous fascioles, and larger tubercles within the fasciole typical of this genus.

Zanolettiaster was considered by Fischer (1966: U586) a synonym of *Eupatagus*. Its type-species, *Z. herrerae* Sánchez Roig, is herein considered a synonym of *E. clevei*.

Sánchez Roig (1953b:258) erected a new genus *Neopatagus* for some species previously referred to *Eupatagus*, with type-species *Eupatagus cubensis* (Cotteau). I can see no differences that could distinguish generically this species (redescribed below) from the type-species of *Eupatagus*.

TABLE 5.—Disposition herein of Cuban species of *Eupatagus*

Disposition	Miocene	Oligocene-Miocene	Eocene
Recognized species (Synonyms)	<i>E. cubensis</i> (? <i>Brissoides</i> <i>brevipetalum</i>) (? <i>B. elongatum</i>) (? <i>B. herrerae</i>) (? <i>B. lajasensis</i>) (? <i>B. lamberti</i>) (? <i>B. laucesi</i>) (? <i>B. mayor</i>) (? <i>B. munozi</i>) (? <i>B. planus</i>) (? <i>B. zanolettii</i>) ² (? <i>Maretia estenozi</i>) <i>E. sanchezi</i> (? <i>E. habanensis</i>)	<i>E. clevei</i> ^{1,4} (? <i>E. brevipetalum</i>) (<i>E. grandiflorus</i>) ⁴ (? <i>E. herrerae</i>) (? <i>E. rojasi</i>) (? <i>E. zanolettii</i>) (? <i>E. venturillae</i>) (? <i>Herreraster herrerae</i>) (? <i>Lajanaster guevarai</i>) (? <i>L. venturillae</i>) (? <i>Megapatacus franciscanus</i>) (? <i>Zanolettia</i> <i>herrerai</i>) <i>E. santanae</i>	<i>E. alatus</i> ⁴ (? <i>E. brodermanni</i>) (? <i>E. caobaense</i>) (? <i>E. casanovai</i>) (? <i>E. pinarensis</i>) <i>E. siboneyensis</i> <i>E. turibacoensis</i> (? <i>E. calistoides</i>) (? <i>Megapatacus turibacoensis</i>)
Unrecognizable species		<i>Brissoides camagueyanus</i> <i>B. minutus</i> <i>B. palmeri</i> <i>B. santanae</i> <i>E. avilensis</i> <i>E. depressus</i> ³ <i>Lajanaster hernandezi</i>	<i>Brissoides stefaninii</i>

¹ Some specimens from the Eocene. ² Oligocene-Miocene. ³ Preoccupied. ⁴ This taxon not previously reported from Cuba.

Although 41 species (Table 5) described from Cuba can be referred to *Eupatagus*, I can recognize only 7. Eight of the 41 are unrecognizable because the type specimens were not available to me (lost or on loan) and Sánchez Roig's illustrations of them are not adequate for comparison with other species. These include:

Brissoides camagueyanus Sánchez Roig (1949:206, pl. 25: fig. 1).

Brissoides minutus Sánchez Roig (1949:205).

Brissoides palmeri Sánchez Roig (1949:205, pl. 25: figs. 4, 5).

Brissoides santanae Sánchez Roig (1949:210, pl. 25: figs. 2, 3; not *Eupatagus santanae* Sánchez Roig, 1951:47, pl. 37: fig. 2).

Brissoides stefaninii Lambert and Sánchez Roig (1949:207, pl. 23: fig. 1).

Eupatagus avilensis Sánchez Roig (1951:45, pl. 33: figs. 2, 3).

Lajanaster hernandezi Sánchez Roig (1949:195,

pl. 23: figs. 2, 3). (The specimen labelled as the type in the collection is not the specimen figured by Sánchez Roig; it does not have the same dimensions; its petals are far wider than those in Sánchez Roig's illustration. For this reason I cannot redescribe this species. This particular species appears from Sánchez Roig's figures to be a *Eupatagus*; its petals are too wide for *Lajanaster*).

Twenty-eight of the species are considered herein as probable synonyms. Most of the type specimens are badly weathered and many distorted by postmortem compression. This alteration has caused them to differ, not only in their shape but also in the character of their petals and other features. The pores of a petaloid porepair diverge from each other as they pass inward through the test. Therefore, in a more heavily weathered specimen the pores of a pair will be farther apart than in a less-weathered specimen of the same species. This difference makes the

petals appear very different suggesting that the specimens may not be conspecific. Furthermore, Sánchez Roig had very few specimens of most of these species and could not be aware of the amount of variation that can occur within one species of *Eupatagus*.

Many of the species occur at the same locality, 11 from "Cervantes" farm at San José de las Lajas and 7 from "La Venturilla" farm at Realengo, Charco Hondo. It is unlikely that so many species would occur at the same locality unless the deposition of the sediment occurred over a

long period of time permitting the evolution of so many species.

It is not possible to be certain of the status of most of the assignments of these species. The type specimens are poorly preserved. Many are lost or not available for study, and none were collected from measured sections so that the relative ages of most of them are not known. Therefore, most of my assignments are provisional, and only if more specimens become available can the uncertainties be resolved.

Key to Cuban Species of *Eupatagus*

1. Large tubercles in deep scrobicules within peripetalous fascioles 2
 Small tubercles not in deep scrobicules within peripetalous fascioles ... 3
2. Few tubercles *E. sanchezi* (Lambert), new combination
 Many tubercles *E. cubensis* (Cotteau)
3. Test wide, width greater than 73% L 4
 Test narrow, width less than 73% L *E. siboneyensis* Weisbord
4. Test large with long, wide petals, posterior extending almost to margin
 with greatest width of interporiferous zones near end of petals
 *E. clevei* (Cotteau)
 Test of moderate size with posterior petals not reaching margin, interpori-
 ferous zones constricted at ends of petals 5
5. Porepairs in same poriferous zone close together
 *E. turibacoensis* Sánchez Roig and *E. santanae* Sánchez Roig
 Porepairs in same poriferous zone more widely separated
 *E. alatus* Arnold and Clark

Eupatagus alatus Arnold and Clark

FIGURE 34; PLATE 54; PLATE 55: FIGURES 1, 2

Eupatagus alatus Arnold and Clark, 1927:63, pl. 13: figs. 4-7; 1934:155.

?*Eupatagus caobaense* Sánchez Roig, 1952c:13, pl. 6:fig. 10.

?*Eupatagus brodermanni* Sánchez Roig, 1953c:159, pl. 9: figs. 1, 4.

?*Eupatagus casanovai* Sánchez Roig, 1953c:159, pl. 9: figs. 2, 3.

?*Eupatagus (Spatangomorpha) pinarensis* Sánchez Roig, 1953c:157, pl. 7: figs. 3, 4.

MATERIAL.—Sánchez Roig described 4 species (see above) of *Eupatagus* from the same locality. The type specimens of these species are not avail-

able, but from a study of Sánchez Roig's illustrations and examination of 24 specimens of *Eupatagus* in the USNM Collections from the type-locality, these 4 species appear to be synonyms of *E. alatus* from the Eocene of Jamaica.

Many of the specimens are badly weathered and distorted. Because of these differences in preservation, some specimens superficially appear to belong to different species. The shape of their tests differ as a result of postmortem distortion. Highly weathered specimens have the petaloid pores greatly enlarged making the petals appear to be dissimilar. Because the pores diverge from each other as they pass into the test, specimens which are more weathered have the pores of a

pair more widely separated than do less-weathered specimens. The number of pores in the petals relative to the length of the test, the length of the petals relative to each other and number of plates beyond the petals are similar in all the specimens, suggesting that they are all conspecific.

I have compared the Cuban specimens with 19 Jamaican specimens of *E. alatus* in the USNM

Collections and with the holotype and many paratypes at the MCZ and can see no significant differences. A photograph of a Jamaican specimen is included (Plate 55: figs. 1, 2) for comparison with the Cuban specimens. The description below is based on the Cuban specimens.

SHAPE AND SIZE.—Test large, length 38 to 75 mm (mean 56 mm); width 77 to 93% L (mean

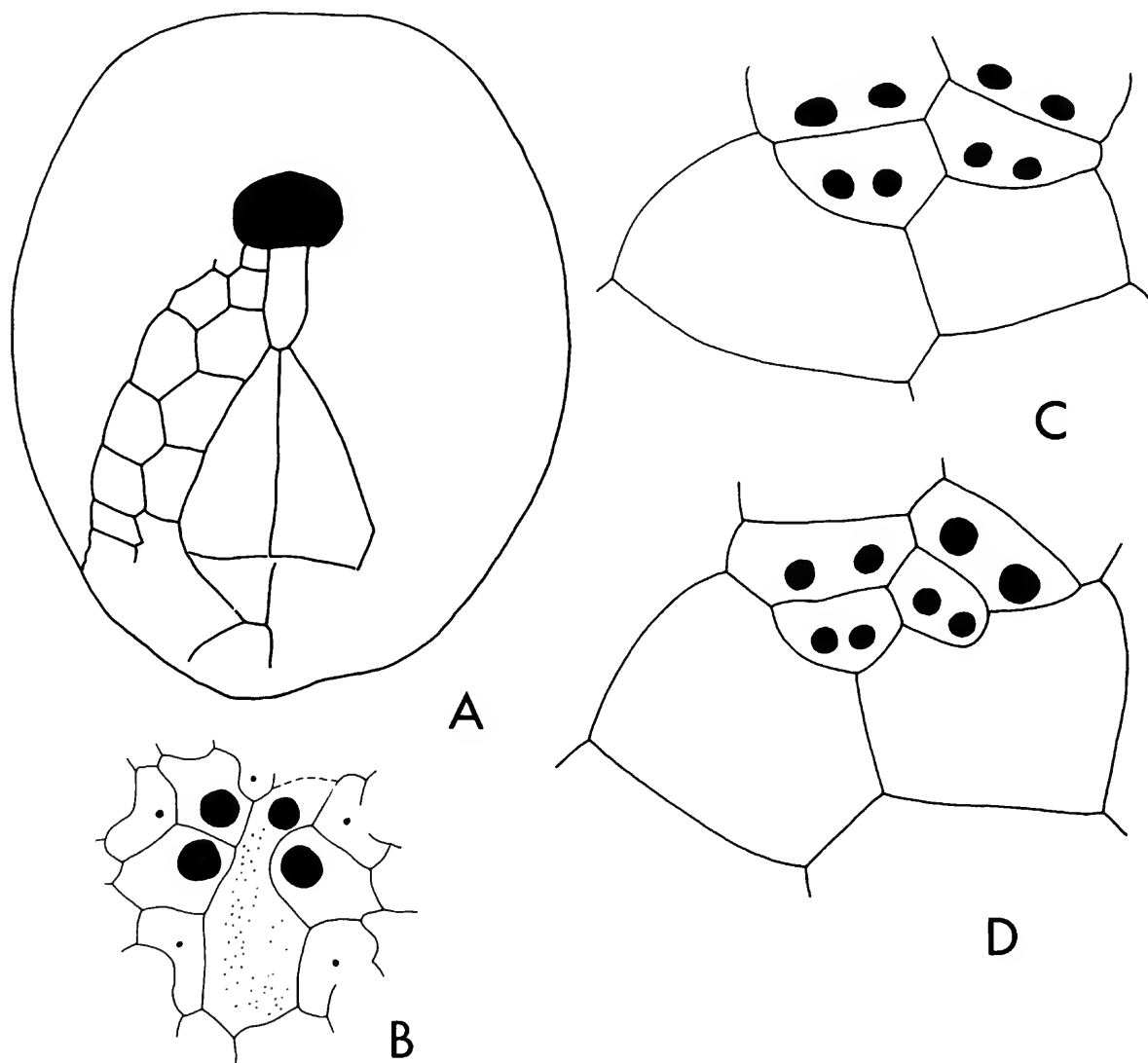


FIGURE 34.—*Eupatagus alatus* Arnold and Clark, Eocene, Loma Caoba, San Diego de los Baños, Pinar del Río Province: A, ventral plate arrangement of USNM 341263, $\times 2$; B, apical system of USNM 341256, $\times 12$; C, plate arrangement at end of petal I of USNM 341262, $\times 15$; D, petal II of USNM 341262, $\times 15$.

83); with greatest width central; height 43 to 56% L (mean 51); greatest height posterior; slight anterior groove.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of apical system equal to 24 to 36% L (mean 28); 4 genital pores (Figure 34B, Plate 54: figure 6), ethmolytic with genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum not petaloid, pores small, nonconjugate anisopores (as defined by Smith, 1980:62) having the inner pore of pair anterior, slit-like, outer pore round with prominence separating them. According to Smith (1980:64) the tubefoot that extended through this kind of porepair was sensory in function; 64 plates in ambulacrum III of specimen 67 mm long.

Anterior petals (II and IV) long, extending almost to margin, length 29 to 45% L (mean 34); petals wide with width 12 to 15% L (mean 13); interporiferous zones wide, width 3.9 to 7.2% L (mean 5.0); poriferous zones narrow, width 3.5 to 4.4% L (mean 3.9); petals closing distally. Five specimens show sutures of plates at end of petal; two (Figure 34c) have 1½ plates of anterior poriferous zone occluded, enclosed by first ambulacral plate beyond petal; other three with last plate not occluded in posterior poriferous zones; four specimens with 1½ plates occluded, one with no occluded plate. Specimen 37 mm long with 52 petaloid porepairs, 48 mm long with 54; 65 mm long with 64; 76 mm long with 66; first porepair in petal II or IV in plates 13, 14, or 15.

Posterior petals (V and I) extending less than two-thirds distance from apical system to margin; length 32 to 48% L (mean 39); petals wide with width 11 to 15% L (mean 12); interporiferous zones wide, width 3.7 to 6.9% L (mean 4.7); poriferous zones narrow, width 3.7 to 4.5% L (mean 4.0); petals closing distally. Five specimens show sutures of plates at end of petals (Figure 34c); four have 2½ plates of anterior poriferous zone occluded, enclosed by first ambulacral plate beyond petal, one with 1½ plates occluded; in posterior poriferous zones 4 specimens have 1½ plates occluded, one has 2½. Specimen 37 mm long with 58 petaloid porepairs, 44 mm long with

60, 65 mm long with 68, 76 mm long with 68. In none of the specimens is it possible to determine the number of plates beyond the petals.

All petals flush with surface of test; pores strongly conjugate with deep furrow joining pores (Plate 54: figure 7); outer pore more elongate than inner.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 18 to 26% L (mean 23); width 13 to 17% L (mean 16); height 8.2 to 13% L (mean 11).

PERIPROCT.—Well preserved on 2 specimens; high on posterior truncation, sloping slightly so that periproct slightly visible from above; opening higher than wide, height 16 to 21% L (mean 18); width 10 to 15% L (mean 13).

FASCIOLAS.—Peripetalous fasciole passing around petals, not indented in interambulacra, width approximately 0.8% L, crossing ambulacra II or IV on plates 12, 13, or 14; not clear on what other plates.

Subanal fasciole circumscribing broad shield with dorsal tract passing below lower edge of periproct approximately one-half distance from lower edge to ventral side of test; width of shield approximately 37% L, height 21% L.

TUBERCULATION.—Large, irregularly arranged tubercles confined within peripetalous fasciole in all interambulacra (Plate 54: figure 7).

ORAL PLATE ARRANGEMENT.—Most of plate arrangement not visible on any specimens; labrum (Figure 34A) long, narrow, length approximately 15% L, width 7% L; extending posteriorly to middle of third adjacent ambulacral plate. Plastron (Figure 34A) composed of 4 plates: 2 sternal plates measurable in only one specimen, length 29% L, combined width 28% L; 2 poststernal plates much smaller, length 12% L, greatest combined width 23% L.

OCCURRENCE.—Middle to late Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba; Eocene, W of Springfield towards Seven Rivers, St. James Parish, Jamaica. One specimen from Camagüey Province in the USNM Collections was collected by Palmer and appears to belong to this species. It is from Palmer loc. 1640, late Eocene, deep cut N of Grua 9,

Ramal Juan Criollo, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *E. turibacoensis* Sánchez Roig from the late Eocene of Camagüey Province. It differs only in having a blunter anterior surface and in having the porepairs in the same poriferous zone appear to be closer together. These differences may or may not be systematically significant; only one specimen is available of *E. turibacoensis*.

Eupatagus alatus differs from the lectotype (designated by Cooke, 1959:90) of *E. antillarum* (Cotteau) (Plate 61: figures 1, 2) from the Eocene of St. Bartholomew in having a broader test with wider petals and a much higher peristome. It differs from the late Eocene Floridian specimens that Cooke referred to *E. antillarum* (which belong to a different species, *Eupatagus mooreanus* Pilsbry) in having shorter posterior petals, a less-pointed posterior and blunter anterior surface.

Eupatagus clevei (Cotteau) from St. Bartholomew, Panama, Jamaica, Curacao, and Florida differs from *E. alatus* in its much narrower test, wider petals and lower peristome.

E. alatus is distinguished from *Eupatagus carolinensis* Clark from the middle Eocene, Castle Hayne Limestone of North Carolina by its wider petals, more divergent anterior petals, smaller peristome, and smaller tubercles within the peripetalous fasciole. It differs from *Eupatagus wilsoni* Kier also from the Castle Hayne in having its apical system much more anterior, more petaloid porepairs, generally wider test, and larger tubercles within the peripetalous fasciole.

Eupatagus clevei (Cotteau)

PLATE 61: FIGURES 3–6; PLATES 62–66

Euspatangus clevei Cotteau, 1875:44, pl. 8: figs. 1–4.

Euspatangus grandiflorus Cotteau, 1875:45, pl. 8: figs. 5, 6.

Eupatagus clevei (Cotteau).—Guppy, 1882:199.—Jackson, 1922:90, pl. 16: figs. 1, 2.—Cooke, 1948:92, pl. 22: fig. 9.—Fischer, 1951:83, fig. 18, pl. 7: figs. 1–3.—Cooke, 1959:89, pl. 41: figs. 6–8; 1961:26, pl. 10: figs. 2–5.—Zachos and Shaak, 1978:921, pl. 1: fig. 1.

Eupatagus grandiflorus (Cotteau).—Jackson, 1922:89, pl. 15: figs. 5, 6.—Molengraaff, 1929:72, pl. 24: figs. 1, 2, pl. 25:

fig. 1.—Arnold and Clark, 1934:156.—Cooke, 1959:89.—Zachos and Shaak, 1978:921.

Brissoides grandiflorus (Cotteau).—Sánchez Roig, 1949:208.

?*Eupatagus* (*Gymnopatagus*) *venturillae* Sánchez Roig, 1951:43, pl. 26: figs. 1, 2.

?*Eupatagus* (*Gymnopatagus*) *rojasi* Sánchez Roig, 1951:42, pl. 34: fig. 3.

?*Eupatagus* (*Gymnopatagus*) *zanolletti* Sánchez Roig, 1951:43, pl. 32: fig. 3 [not *Brissoides zanolletti* Sánchez Roig, 1952c:12, pl. 7: figs. 1, 2].

Lajanaster guevarai Sánchez Roig, 1951:53, pl. 24: figs. 2–4.

?*Eupatagus* (*Plagiobrissus*) *herrerai* Sánchez Roig, 1951:46, pl. 25: figs. 1, 2 [not *Herreraster herrerai* Sánchez Roig, 1951:53, pls. 30, 31; not *Brissoides herrerai* Sánchez Roig, 1924:82, pl. 10: figs. 1, 2].

?*Eupatagus* (*Gymnopatagus*) *brevipetalum* Sánchez Roig, 1951:44, pl. 33: fig. 1, pl. 38: fig. 1 [not *Brissoides brevipetalum* Sánchez Roig, 1924a: 84, pl. 11: figs. 1, 2.

?*Herreraster herrerai* Sánchez Roig, 1951:53, pls. 30, 31 [not *Brissoides herrerai* Sánchez Roig, 1982a:58, pl. 10: figs. 1, 2; not *Eupatagus herrerai* Sánchez Roig, 1951:46, pl. 25: figs. 1, 2.

?*Lajanaster venturillae* Sánchez Roig, 1951:54, pl. 25: figs. 3, 4.

?*Zanollettiaster herrerai* Sánchez Roig, 1952c:15, pl. 8: figs. 1, 2, pl. 9: fig. 4.

?*Megapatagus franciscanus* Sánchez Roig, 1953a:59, pl. 11: 2 figs.

?*Eupatagus ingens* Zachos, 1968:161, fig. 1.—Zachos and Shaak, 1978:921, pl. 1: figs. 2–4.

MATERIAL.—Many species have been erected for specimens that differ only slightly from each other; all appear conspecific with *E. clevei*. Most of the differences are the result of postmortem distortion, or they are phenotypic variations, which are expected to occur in specimens of the same species. Guppy (1882:192), Cooke (1948:93; 1959:89) and Zachos and Shaak (1978:921) consider *E. grandiflorus* (Cotteau) and *E. clevei* (Cotteau) to be synonymous. Both come from the Eocene of St. Bartholomew.

Sánchez Roig erected many new species of *Eupatagus* for specimens that appear conspecific with each other and *E. clevei*. They are all from the same locality and include *E. venturillae* (Plate 62: figures 1, 2), *E. brevipetalum* (Plate 62: figures 3–6), *E. herrerai* (Plate 65: figures 1–4), *E. zanolletti* (Plate 66: figures 4–6), *Lajanaster venturillae* (Plate 65: figures 5, 6; Plate 66: figures 1, 2), *L. guevarai* and *Zanollettiaster herrerai* (Plate 61: figures 5, 6). *E. rojasi* Sánchez Roig (Plate 64: figures 3–5) is

found near this locality. Its apical system is more central than in the holotype of *E. clevei*, but this appears to only be due to postmortem distortion. The two species are similar in having long, broad petals. The holotype of *E. zanoletti* Sánchez Roig is lost, but a topotypic specimen (Plate 66: figures 4–6) referred to this species by Sánchez Roig is indistinguishable from *E. clevei*.

The holotype of *Megapatagus franciscanus* Sánchez Roig (Plate 63) is also very similar to *E. clevei*.

Although the holotype of *Herreraster herrerae* Sánchez Roig is lost, a topotypic specimen (Plate 64: figures 1, 2) has the same long, wide petals so typical of *E. clevei*.

Eupatagus ingens Zachos from the Eocene of Florida also appears to be a synonym of *E. clevei*.

Eupatagus hildae Hawkins from Jamaica is probably synonymous with *E. clevei*. Both species have a large test with long, wide petals and the same general appearance. As only one specimen is known of *E. hildae* and its age is uncertain, I am unwilling to synonymize it with *E. clevei*.

The St. Bartholomew, American, and Jamaican specimens referred to *E. clevei* are Eocene; whereas, the Cuban specimens come from the Oligocene-Miocene. It is unusual for a spatangoid species to have such a long stratigraphic range. Perhaps, if better material was available, specific distinctions might be apparent between the Cuban and Eocene specimens. I cannot separate them now.

OCCURRENCE.—Types of *E. clevei* and *E. grandiflorus* from Eocene of St. Bartholomew. *E. clevei* has also been reported from Jamaica, Curacao, and from the late Eocene, USGS loc. 16889, Madden Airfield, 15 mi (24 km) N of central part of Panama City; Rio Tonosí, 300 ft (91.4 m) below the mouth of Quebrada Guerita (USGS 8289), Panama. *E. ingens* is from the late Eocene Ocala Limestone in Florida. The type specimens of *Eupatagus brevipetalu*, *E. herrerae*, *E. venturillae*, *E. zanoletti*, *Lajanaster venturillae*, *L. guevarai*, and *Zanolettiaster herrerae* came from beds referred to the Oligocene (Oligocene-Miocene herein) at “La Venturilla” farm, Realengo, Charco Hondo, Mo-

rón, Camagüey Province, Cuba. The type of *Eupatagus rojasi* came from “Las Cabezadas” farm, Corral Naranjo, 12 km E of Marroquín, Morón, Camagüey Province. *Herreraster herrerae* came from “Las Cuevas” farm, Realengo, Charco Hondo, Ranchuelo district, Morón, Camagüey Province. The holotype of *Megapatagus franciscanus* is from “San Francisco de la Rosa” farm, Guadalupe district, Morón, Camagüey Province, Cuba. All of these localities were considered by Sánchez Roig to be Oligocene but are herein considered Oligocene-Miocene.

One poorly preserved specimen (ANSP 16638) in the Palmer Collection in the Academy of Natural Sciences of Philadelphia, probably belongs to the species. It is from Palmer locality no. 1476, riprap along Nuevitas beach, about Km 73 on railroad to Pastelillo (taken from cut at Km 74), Camagüey Province, Cuba. Palmer assigned a late Eocene age to this locality.

COMPARISON WITH OTHER SPECIES.—*E. clevei* resembles in many characters *Eupatagus turibacoensis* Sánchez Roig from the late Eocene of Cuba. Both species have large tests with the anterior ambulacrum flush or in a very slight groove; long, wide petals with wide interporiferous zones, and peristomes of similar outline and position. The holotype of *E. turibacoensis* has its petals slightly constricted near their extremities, whereas in *E. clevei* they are narrower and less constricted. However, the holotype of *Megapatagus turibacoensis* Sánchez Roig, which occurs with the lectotype of *E. turibacoensis* and is herein considered a probable synonym of it, has petals indistinguishable from *E. clevei*. Obviously, *E. clevei* and *E. turibacoensis* are very closely related and may be synonymous.

REMARKS.—Of the Cuban specimens that I have seen and consider to belong to this species, none are well-enough preserved to show the nature of the tubercles within the peripetalous fasciole. They are visible, however, on specimens from the late Eocene of Panama that Cooke (1948:92) referred to *Eupatagus clevei* (Cotteau). One of the Panamanian specimens is crushed but has its tuberculation extremely well preserved (Plate 66: figure 3). The tubercles within the

fasciole are only slightly larger than those outside and are not sunken in deep scrobicules.

SYNONYMS

?Eupatagus brevipetalum Sánchez Roig

PLATE 62: FIGURES 3–6

MATERIAL.—Only one specimen (SRC 4094), present in the Sánchez Roig Collection. This specimen was figured by Sánchez Roig (1951, pl. 33: fig. 1) and is the one he used for dimensions. It is herein selected as the lectotype. His second figured specimen has been lost.

The lectotype is very poorly preserved. The dorsal surface is very badly weathered with most of the tubercles absent and no trace of the fascioles. The adoral surface was covered with matrix and was not seen by Sánchez Roig. The test has been distorted by postmortem compression with the upper left side depressed.

SHAPE AND SIZE.—Length 77 mm, width 85% L, height 49% L; greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Absent.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove; porepairs very small in adapical region.

Anterior petals (II and IV) extending four-fifths distance from apical system to margin; length 39% L, greatest width 19% L, interporiferous zone very wide, greatest width 9.6% L; petals flush with rest of surface of test except for slight depression of poriferous zones. Pores conjugate; where pores not altered and enlarged by weathering, outer pore of pair more elongate than inner; 56 petaloid porepairs.

Posterior petals (V and I) extending two-thirds distance from apical system to margin, length 41% L, greatest width 6.5% L, greatest width of interporiferous zone 9.9% L. Not possible to determine number of petaloid porepairs because of fracturing of test. Last 2½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from

anterior margin to anterior edge of peristome equal to 21% L. Width of opening 15% L, height 7.4% L.

PERIPROCT.—Located slightly below midpoint of slightly overhanging posterior truncation; higher than wide, height 15% L, width 11% L.

FASCIOLAS.—Not preserved.

ORAL PLATE ARRANGEMENT.—Sutures not visible.

OCCURRENCE.—Oligocene-Miocene, “La Venturilla” farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

?Eupatagus herrerae Sánchez Roig

PLATE 65: FIGURES 1–4

MATERIAL.—Only one specimen is known, the holotype (SRC 4060). This specimen is complete but heavily weathered, eradicating the tuberculation. The test is compressed to the left as viewed from above.

SHAPE AND SIZE.—Length 84.0 mm, width 67.9 mm (81% L), height 41.6 mm (50% L). Greatest width and height anterior; test smoothly inflated.

APICAL SYSTEM.—Four genital pores, ethmolytic with madreporite extending far beyond posterior ocular plates. Apical system anterior of center at distance from anterior margin to center of genital pores equal to 36% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, flush adapically, slightly depressed from margin to peristome. Ambulacrum very narrow adapically, nature of pores and number of plates not known because of weathering.

Anterior petals (II and IV) long, extending almost to margin, length 42% L. Petals wide, 15% L with wide interporiferous zone, 6.9% L; petals flush with rest of surface of test. Poriferous zones narrow, conjugate, outer pore of pair slightly more elongate than inner; porepairs in first adapical 4 or 5 plates of anterior poriferous zone smaller than opposite porepairs in posterior zone; 76 petaloid porepairs.

Posterior petals (V and I) long, extending almost to margin, length 48% L. Petals wide, 14% L with wide interporiferous zone, 6.3% L; petals flush with test. Adapically, pores closer together

in posterior poriferous zones; 82 petaloid porepairs.

PERISTOME.—Anterior, located medially on vertical posterior truncation; opening large, height 8.0% L, width 16% L.

PERIPROCT.—Marginal, located on nearly vertical posterior truncation; height 17% L, width 11% L (Plate 65: figure 4).

FASCIOLES.—Peripetalous and subanal fasciole present but most of tract not preserved.

ORAL PLATE ARRANGEMENT.—Labrum long; length 12% L; rest of plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, old sugar house of "La Venturilla" farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

Eupatagus rojasi Sánchez Roig

PLATE 64: FIGURES 3–5

MATERIAL.—The holotype (SRC 4056) and only known specimen is very poorly preserved. The test is crushed and badly weathered with the tubercles eroded away and the peristome covered.

SHAPE AND SIZE.—Length 116 mm, width (est.) 85% L, height (est.) 50% L. Greatest width anterior, greatest height at apical system.

APICAL SYSTEM.—Because of distortion of the test, position of apical system uncertain. It is central on the specimen but was probably anterior originally before postmortem crushing. Ethmolytic, number of genital pores not discernible.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove, pores very small in adapical region, not markedly differentiated from pores on margin; width of ambulacrum at margin 7.4% L.

Anterior petals (II and IV) extending to margin, length 56% L, interporiferous zone very wide, width 7.5% L, greatest width of petal 16% L, petals flush with test. Poriferous zones narrow, 4.3% L, pores conjugate, outer pore of pair larger and more elongate than inner; adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone; 98 petaloid porepairs.

Posterior petals (V and I) extending almost to margin, length 53% L, greatest width 17% L,

petals flush; interporiferous zone with width 7.8% L. Poriferous zones narrow, 4.3% L; 96 petaloid porepairs. Last 2½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Covered by hard matrix.

PERIPROCT.—Position obscured by crushing, apparently large, higher than wide, height 14% L.

FASCIOLES.—Not discernible.

ORAL PLATE ARRANGEMENT.—Covered.

OCCURRENCE.—Oligocene-Miocene, "Las Cabezas," Coral Naranjo, 12 km E of Marroquín, Morón, Camagüey Province, Cuba.

?Eupatagus venturillae Sánchez Roig

PLATE 62: FIGURES 1, 2

MATERIAL.—Two specimens were used by Sánchez Roig in his original description. I suspect that they both did not come from the "Concepción" farm as stated by Sánchez Roig. One of the specimens (SRC 4027) is very similar in its color and matrix to specimens from "La Venturilla" farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba. Because Sánchez Roig named the species *E. venturillae*, I suspect that this specimen came from there. In every other case in which he used that trivial name, the species has been from that locality. The other specimen is more yellow in color and may be from "Concepción" farm. In order to avoid basing the species on specimens from two localities, I herein select specimen 4027 (Sánchez Roig, 1951, pl. 26: fig. 1), which I believe is from "La Venturilla," as the lectotype; the other specimen (4704) is not included in the following description.

SHAPE AND SIZE.—Length 99 mm, width 82% L, height 48% L. Greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic, madreporite extending posteriorly separating posterior ocular plates; located anterior of center at distance from anterior margin to center of genital pores equal to 37% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove at margin, pores very small in adapical region, not markedly differentiated from pores on margin of test; at margin width of ambulacrum 5.7% L.

Anterior petals (II and IV) long, extending to margin; length 47% L, greatest width 16% L, interporiferous zones very wide, greatest width 7.8% L, petals flush with test. Poriferous zones narrow 4.7% L; pores conjugate, outer pore of pair larger and more elongated than inner; adapical porepairs and plates in anterior poriferous zone slightly smaller than in posterior poriferous zone; 84 petaloid porepairs.

Posterior petals (V and I) extending almost to margin, length 53% L, greatest width 15% L, interporiferous zone very wide, greatest width 7.0% L, petals flush. Poriferous zone narrow 4.6% L; 90 petaloid porepairs.

PERISTOME.—Not preserved.

PERIPROCT.—Not preserved.

FASCIOLAS.—Not preserved, but both peripetalous and subanal fasciolas preserved on other specimens referable to this species.

TUBERCULATION.—Specimen too weathered to determine presence of larger tubercles within peripetalous fasciolas.

ORAL PLATE ARRANGEMENT.—Not preserved.

OCCURRENCE.—Oligocene-Miocene, "La Venturillae" farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

?Lajanaster venturillae Sánchez Roig

FIGURE 35; PLATE 65: FIGURES 5, 6;
PLATE 66: FIGURES 1, 2

MATERIAL.—One of the two cotypes (SRC 4136) is present. This specimen was figured by Sánchez Roig (1951, pl. 25: fig. 4) and is herein selected as the lectotype. The specimen is badly weathered with most of the tuberculation eroded away.

SHAPE AND SIZE.—Length 74 mm, width 82% L, height 48% L; greatest width anterior of center, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic with madreporite (Figure 35A) extending posteriorly separating posterior ocular plates. Apical system anterior of center at distance from anterior margin to center of genital pores equal to 30% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove at margin, pores very small in adapical region, not markedly differentiated from pores on margin of test, 76 plates in ambulacrum.

Anterior petals (II and IV) extending almost to margin, length 40% L; petals very wide, greatest width 18% L, closed distally. Interporiferous zone very wide, at greatest width 8.8% L; petals flush with test except for slightly depressed poriferous zones. Poriferous zones narrow, 4.2% L, pores strongly conjugate with deep groove joining pores of pair, outer pore slightly more elongate than inner. Adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone; 74 petaloid porepairs in petal.

Posterior petals (V and I) extending less than two-thirds distance from apical system to margin, length 44% L; greatest width 17% L; interporiferous zone very wide, greatest width 8.0% L; poriferous zones narrow, 4.4% L; 76 petaloid porepairs. Last 2½ plates in inside poriferous zones (Vb and Ia) occluded (Figure 35B); enclosed by first ambulacral plate beyond petal; last plates of petal of outside poriferous zones (Va and Ib) not occluded.

PERISTOME.—Large, width 18% L, height 8.4% L; anterior located at distance from anterior margin to anterior edge of peristome equal to 25% L.

PERIPROCT.—Located on posterior truncation tilting so opening slightly visible from above. Opening large, higher than wide but area damaged so that dimensions not known.

FASCIOLAS.—Peripetalous fasciolas not preserved; subanal fasciolas circumscribing shield-shaped area below periproct.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, old sugar house of "Venturilla" far, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba.

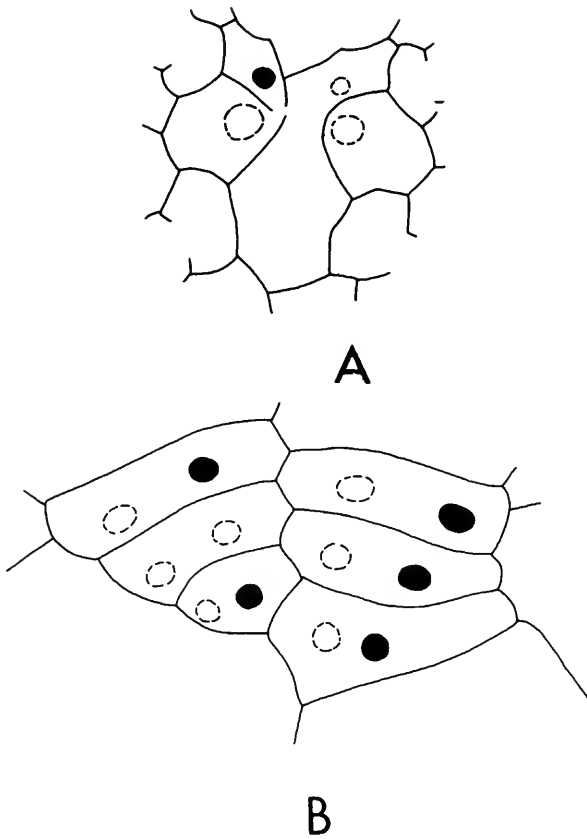


FIGURE 35.—*Eupatagus clevei* (Cotteau), lectotype of *Lajaster venturillae* Sánchez Roig (= *E. clevei*), SRC 4136, $\times 10$: A, apical system; B, plate arrangement at end of petal I.

Megapatagus franciscanus Sánchez Roig

PLATE 63

MATERIAL.—Only one specimen known, the holotype (SRC 4473). This specimen is not distorted but is highly weathered, lacking tubercles and obscuring the fascioles. Peristome filled with matrix, test broken around periproct.

SHAPE AND SIZE.—Length 127 mm, width 102 mm (80% L), height 62 mm (49% L); greatest width and height anterior.

APICAL SYSTEM.—Four genital pores, ethmolytic with madreporite extending far posterior of posterior ocular plates, anterior at distance from anterior margin to center of genital pores equal to 38% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very faint groove, pores very small adapically, not markedly differentiated from pores on margin of test; greatest width of ambulacrum 0.65% L.

Anterior petals (II and IV) extending to margin, flush, length 50% L, greatest width 15% L. Interporiferous zone very wide, greatest width 9.2% L; poriferous zone narrow 2.9% L, pores conjugate, outer pore more elongate than inner; adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone; 96 petaloid porepairs.

Posterior petals (V and I) extending almost to margin, length 56% L, greatest width 15% L, interporiferous zone very wide 8.7% L, poriferous zone narrow, 3.1% L; 110 petaloid porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 27% L. Peristome filled with matrix, but width estimated to be 13% L, height 6% L.

PERIPROCT.—Fractured obscuring opening; on slightly overhanging posterior truncation; height of opening estimated at 17% L, width 13% L.

FASCIOLES.—Obscured by weathering.

ORAL PLATE ARRANGEMENT.—Sutures not clear due to fracturing of test.

OCCURRENCE.—Oligocene-Miocene, “San Francisco de la Rosa” farm, Guadalupe district, Morón, Camagüey Province, Cuba.

REMARKS.—Sánchez Roig (1953a:58) erected a new genus, *Megapatagus*, with this species as the type-species. Fischer (1966:U586) considers it to be a synonym of *Eupatagus*. I can see no characters distinguishing the two genera.

Eupatagus cubensis (Cotteau)

PLATE 55: FIGURES 3–5; PLATES 56, 57

Breynia cubensis Cotteau, 1875:7; 1881:43, pl. 4: figs. 4–6; 1897:87, pl. 25: figs. 4–6.

Brissoides cubensis (Cotteau).—Lambert, 1915:17.—Sánchez Roig, 1926:109; 1949:200.

Eupatagus depressus Jackson, 1922:93, pl. 16, fig. 7 [not *Megapatagus depressus* Sánchez Roig, 1953a:60].

Eupatagus cubensis (Cotteau).—Jackson, 1922:94.

- ?*Brissoides lamberti* Sánchez Roig, 1924b:79, pl. 12, fig. 1.—Lambert in Lambert and Thiéry, 1924 [1909–1925]:451.
- ?*Brissoides munozi* Lambert in Sánchez Roig, 1924b:80, pl. 8: figs. 1, 2.—Lambert in Lambert and Thiéry, 1924 [1909–1925]:451.—Sánchez Roig, 1926:103, pl. 28: figs. 1, 2, pl. 29: figs. 1, 2, pl. 30: fig. 1; 1949:197.
- ?*Brissoides munozi* Lambert, sub. sp. *minor* Sánchez Roig, 1924b:82, pl. 9, figs. 1, 2.
- ?*Brissoides herrerae* Sánchez Roig, 1924b:82, pl. 10: figs. 1, 2.—Lambert in Lambert and Thiéry, 1924 [1909–1925]:451.—Sánchez Roig, 1926:104, pl. 32: figs. 1, 2, pl. 33: fig. 1. [Not *Eupatagus herrerae* Sánchez Roig, 1951:46, pl. 25, figs. 1, 2.]
- ?*Brissoides brevipetalum* Sánchez Roig, 1924b:84, pl. 11: figs. 1, 2; 1926:106, pl. 34: fig. 1, pl. 35: fig. 1. [Not *Eupatagus brevipetalum* Sánchez Roig, 1951:44, pl. 33: fig. 1, pl. 38: fig. 1.]
- ?*Brissoides elongatum* Sánchez Roig, 1924b:86, pl. 13: figs. 1, 2.—Lambert in Lambert and Thiéry, 1924 [1909–1925]:451.—Sánchez Roig, 1926:107, pl. 36: fig. 1.
- ?*Brissoides planus* Sánchez Roig, 1924b:87, pl. 14: fig. 1.—Lambert in Lambert and Thiéry, 1924 [1909–1925]:451.
- ?*Brissoides luacesi* Sánchez Roig, 1924b:79.
- ?*Brissoides mayor* Lambert in Sánchez Roig, 1924b:91; 1926:108.
- ?*Marelia estenozii* Sánchez Roig, 1926:111, pl. 37: figs. 1, 2; 1949:215.
- ?*Brissoides lajasensis* Sánchez Roig, 1949:203, pl. 24: fig. 1.
- ?*Brissoides zanolettii* Sánchez Roig, 1952c:12, pl. 7: figs. 1, 2 [not *Eupatagus zanoletti* Sánchez Roig, 1951:43, pl. 32: fig. 3].
- Neopatagus cubensis* (Cotteau).—Sánchez Roig, 1953b:259.

MATERIAL.—This description is based on the holotype in the Cotteau Collection at the Université Claude Bernard, Lyons, France. The specimen is moderately well preserved, although the peristome and periproct are broken away and the test is too weathered to show the fascioles.

SHAPE AND SIZE.—Length 87 mm, width 80% L, height 27% L; greatest width anterior of center. Test flattened by postmortem distortion.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of pores equal to 35% L; no further details visible.

AMBULACRA.—Anterior ambulacrum III not petaloid; pores minute adapically; not in groove where crossing margin.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin, length 29% L, very wide, width 12% L with greatest width one-third distance from apical sys-

tem to end of petal. Interporiferous zone wide, at greatest width 6.7% L; poriferous zones at greatest width 2.8% L. Porepairs in anterior poriferous zones adapically smaller than in posterior poriferous zones of same petal; pores conjugate, 62 petaloid porepairs in petal. No plates occluded at end of petals.

Posterior petals (V and I) of length slightly more than one-half distance from apical system to margin, length 35% L, width 13% L. Interporiferous zones at greatest width 7.4% L; poriferous zones 3.2% L; pores strongly conjugate, 66 porepairs in petal. Last 2½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Not preserved.

PERIPROCT.—Not preserved.

FASCIOLES.—Not preserved.

TUBERCULATION.—Large primary tubercles confined within peripetalous fasciole, 13 tubercles in interambulacrum 2, 23 in interambulacrum 1, apparently none in interambulacrum 5.

ORAL PLATE ARRANGEMENT.—Most of oral surface not preserved.

OCCURRENCE.—Cotteau reports *E. cubensis* from the Eocene, Matanzas of Cuba; but Sánchez Roig records it from the Miocene at “Cervantes” farm, San José de las Lajas, Habana Province, Cuba. All the other species provisionally considered synonyms (except *Eupatagus depressus* and *Brissoides zanolettii*) are from “Cervantes” farm. *E. depressus* is from the Miocene, Ponce Limestone at a high bluff, 2 km SW of Juana Diaz, Puerto Rico. *B. zanolettii* is from the Oligocene-Miocene, El Blanquizar, Tamarindo district, Morón, Camagüey Province, Cuba.

A well-preserved specimen of *E. cubensis* (MCZ 4044) is from Palmer’s locality 1660, which he considered to be Oligocene-Miocene. It is from a long cut S of switch on Ramal Valle, Central Jatibonico, cane railroad, Camagüey Province, Cuba. It is illustrated on Plate 56: figures 3–5.

REMARKS.—There is no evidence of an internal fasciole, and for this reason the species cannot be referred to *Breynia*. Although the fascioles are not visible on the holotype, the presence of an internal fasciole would be indicated by an abrupt change

in the size of the petaloid porepairs adapically.

Eleven species of *Eupatagus* (*Brissoides*) have been reported from the "Cervantes" farm at San José de las Lajas. Most of these species were based on only one or two specimens each, and most of these specimens were not available to me for study. However, from a study of Sánchez Roig's illustrations and the few specimens available, I suspect that all of these species are synonyms of *E. cubensis*. Although they differ in such characters as length and width of petals and in the dimensions of the test, these differences probably fall within the range of variation to be expected within one species. This suggestion could be tested only if a large number of specimens could be collected in place in a measured section at the type-locality. Unfortunately, specimens are now rare at this locality.

Sánchez Roig himself doubted the validity of some of these species. He did not mention *Eupatagus lamberti* (Sánchez Roig), *Eupatagus planus* (Sánchez Roig), or *Eupatagus elongatum* (Sánchez Roig) in his compilation of the echinoids of Cuba (1949). Lambert (in Lambert and Thiéry, 1924 [1909–1925]:451) had earlier considered *E. lamberti* as a variety of *E. herrerae* (Sánchez Roig) and the other two species as varieties of *E. munozi* (Lambert). I have studied two specimens of *E. munozi* and cannot distinguish them from *E. cubensis*. Both species occur at the same locality. Their petals are indistinguishable, of approximately the same length, with similar numbers of porepairs, similar width of interporiferous and poriferous zones, and similar lanceolate shape. Their apical systems are similarly situated and the large tubercles within the peripetalous fasciole are of similar number, location, and size with both species lacking these tubercles in interambulacrum 5. Finally, both species have very low, large tests.

Although the petals of *Eupatagus estenozii* (Sánchez Roig) are longer and narrower than those in the type specimens of *E. cubensis*, both species share a low test, anterior position of apical system, and lack of primary tubercles in the posterior interambulacrum. The significance of the difference in the length of petals is doubtful because of

the great variation in petal length and width among all the species of *Eupatagus* at this one locality. A posterior petal in *E. estenozii* is 46% L, in *E. lamberti* (Sánchez Roig) 42% L, *E. herrerae* (Sánchez Roig) 40% L, *E. lajasensis* (Sánchez Roig) 39% L, *E. planus* (Sánchez Roig) and *E. cubensis* (Cotteau) 34% L, *E. munozi* (Lambert) 33–37% L, *E. elongatum* (Sánchez Roig) 33% L, and *E. brevipetalum* (Sánchez Roig) 31% L. (The length of the petals in *E. luacesi* (Sánchez Roig) and *E. mayor* (Lambert) cannot be determined because Sánchez Roig did not illustrate these species.) The presence of specimens with petal length and width grading between the two extremes convinces me that the type specimens of all these species may be conspecific, and I provisionally consider them to be synonyms of *E. cubensis*.

I have not seen any specimens of *Eupatagus zanolettii* (Sánchez Roig) from the Oligocene-Miocene of Camagüey Province; but from a study of Sánchez Roig's (1952c, pl. 7: figs. 1, 2) illustrations, it appears to be a synonym of *E. cubensis*.

Jackson's *Eupatagus depressus* from Puerto Rico is indistinguishable from *E. cubensis* and is herein considered a synonym. A new photograph of the holotype in the American Museum of Natural History is included in Plate 56: figure 5. Although Jackson said the Puerto Rican specimen was from the Oligocene, the label with the specimen says it is from the Ponce Limestone, which according to Gordon (1963:628) is Miocene.

SYNONYMS

?*Brissoides munozi* Lambert

PLATE 57: FIGURES 1–4

MATERIAL.—The holotype is not in the Sánchez Roig Collection. The following description is based on one specimen (SRC 5497) in the Sánchez Roig Collection and one (USNM 352863) in the Smithsonian figured by Sánchez Roig (1926c, pl. 30: fig. 1). Both are badly weathered with fascioles obscured. The first measurement is of SRC 5497.

SHAPE AND SIZE.—Test large, length 99 and 109 mm; width 85 and 88% L, very low; height

23 and 19% L. Although both specimens are slightly depressed by postmortem compression, the tests appear to have been originally very low.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of genital pores 37 and 39% L, ethmolytic, with genital plate 2 extending far posteriorly separating posterior ocular plates; 4 genital pores.

AMBULACRA.—Anterior ambulacrum III depressed in slight trough extending from apical system to anterior margin; not petaloid, porepairs minute, not possible to count plates.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin, length 32 and 30% L, petals wide, width 13 and 13% L with greatest width nearer apical system; poriferous zone with width 3.6 and 3.2% L, interporiferous zones with greatest width 6.9 and 6.9% L; porepairs minute adapically in anterior poriferous zones; 64 porepairs in petal in each specimen.

Posterior petals (V and I), longer than anterior, extending two-thirds distance from apical system to margin, length 37 and 33% L, width 13 and 12% L; poriferous zone with width 3.3 and 3.5% L, interporiferous zones with greatest width 6.4 and 5.6% L; 72–76 porepairs in petal.

PERISTOME.—Anterior, located at distance from anterior edge of opening to anterior margin equal to 26 and 24 percent L. Opening small, width 11% L, height not clear.

PERIPROCT.—Marginal, no further details visible.

FASCIOLAS.—Not preserved.

TUBERCULATION.—Very large, deeply scrobiculated tubercles confined between petals in paired interambulacra; 28–31 tubercles in interambulacra 1 or 4, 17–20 in interambulacra 2 or 3.

ORAL PLATE ARRANGEMENT.—Entire length of labrum not preserved on either specimen but estimated on USNM 352863 to equal 19% L. No other plate sutures visible.

OCCURRENCE.—Miocene, holotype from San Antonio de Cabezas, Matanzas; “Cervantes” farm, San José de las Lajas, Habana Province, Cuba.

?Maretia estenozi Sánchez Roig

PLATE 55: FIGURE 5; PLATE 56: FIGURES 1, 2

MATERIAL.—Only one specimen is in the Sánchez Roig Collection (SRC 5491). This specimen is illustrated by Sánchez Roig (1926c, pl. 37: fig. 1) and is the holotype. Although the dorsal surface is well preserved, the ventral surface is almost entirely missing.

SHAPE AND SIZE.—Length (est.) 97 mm, width 82% L, height 24% L; test very low, slightly flattened because of postmortem compression.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 33% L, ethmolytic with genital plate 2 extending posteriorly separating posterior ocular plates; 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove but on flattened surface; pores microscopic, character not clear.

Anterior petals (II and IV) transverse, long, extending almost to margin, length 37% L, greatest width adapical, 12% L. Interporiferous zone at greatest width 5.4% L; poriferous zone with width 3.0% L, pores of both anterior and posterior poriferous zones greatly reduced in size; pores deeply conjugate; 74 porepairs in petal.

Posterior petals (V and I) longer than anterior, length 46% L, greatest width 11% L; interporiferous zones with width 5.5% L, poriferous zone 3.4% L; 94 porepairs.

PERISTOME.—Not preserved.

PERIPROCT.—Not preserved.

FASCIOLAS.—Narrow peripetalous fascioles passing around extremities of petals, not indented in interambulacra. Subanal fasciole not present on holotype due to absence of region where it could occur, but Sánchez Roig reports its presence in cotype.

TUBERCULATION.—Large tubercles in sunken scrobicules confined within peripetalous fascioles in paired interambulacra; absent in interambulacrum 5. Tubercles arranged in single row on each plate; 38 in interambulacrum 2, 47 in interambulacrum 1.

OCCURRENCE.—Although Brodermann (1949: 324) considered this species late Oligocene, Al-

bear (1980, personal communication) considers the type-locality to be early to middle Miocene, "Cervantes" farm, San José de las Lajas, Habana Province, Cuba.

REMARKS.—This species must be referred to *Eupatagus* because of the presence of a peripetalous fasciole, not present on *Maretia*.

***Eupatagus sanchezi* (Lambert),
new combination**

PLATE 58: FIGURES 1–3

Brissoides sanchezi Lambert in Sánchez Roig, 1949:211, pl. 24: figs. 2, 3.

?*Brissoides habanensis* Sánchez Roig, 1949:204, pl. 23: fig. 4.

Neopatagus sanchezi (Lambert).—Sánchez Roig, 1953b:261.

MATERIAL.—Only one specimen known, the holotype (SRC 4765). This specimen is poorly preserved being badly distorted by postmortem compression. The peristomial area is broken away.

SHAPE AND SIZE.—Length 31 mm, width 80% L, height uncertain. Greatest width anterior, greatest height posterior at sharply inflated plas-tron.

APICAL SYSTEM.—Anterior, distance of apical system from anterior margin equal to 35% L; no further details visible.

AMBULACRA.—Anterior ambulacrum III not petaloid, adapical pores minute, slight groove at margin, but because of postmortem distortion not possible to measure depth.

Anterior petals (II and IV) with length estimated at 26% L, greatest width 9.6% L; interporiferous widest adapically with width 3.8% L; much narrower near end of petal; 32 porepairs estimated in petals; porepairs more widely separated from each other in same poriferous zone near end of petal than apically (Plate 58: figure 1). Pores conjugate, outer pore of pair more elongate and more adoral to inner.

Posterior petals (V and I) with length estimated at 31% L, width 12% L; interporiferous with greatest width 5.1% L; 44 porepairs. Posterior petals less constricted in width at their extremities than anterior petals.

PERISTOME.—Anterior, no further details visible.

PERIPROCT.—Large, higher than wide, on posterior truncation probably overhanging, but test distorted and shape of truncation not certain.

FASCIOLAS.—Peripetalous fasciole, narrow band not indented in interambulacra. Subanal fasciole circumscribing shield-shaped area below periproct with width 27% L, height 21% L. 10 enlarged porepairs enclosed by fasciole.

TUBERCULATION.—Very large scrobiculated tubercles confined within peripetalous fasciole in paired interambulacra; 4 in anterior paired interambulacrum, 5 or 6 in posterior paired interambulacrum; largest tubercle with scrobicule with diameter of 2 mm (6.4% L).

OCCURRENCE.—Miocene, "La Noria" farm, Cojimar, Habana Province, Cuba. Although Sánchez Roig (1949:211) and Brodermann (1949:318) considered this species late Oligocene, Brönnimann and Rigassi (1963:466) report that the Cojimar Formation occurs at this locality. They date this formation as Miocene on the basis of foraminifera. The holotype of *Eupatagus habanensis* (Sánchez Roig) is from quarries on Rte. 23, left side of bridge, Vedado, Habana Province, Cuba. Sánchez Roig (1949:204) and Brodermann (1949:317) date this species as late Oligocene, but it is probably Miocene. *Migliorinia habanensis* (Sánchez Roig) occurs with the holotype of *Eupatagus habanensis* but has also been found at Rio Cojimar and at quarries at the entrance of Cojimar in beds Brönnimann and Rigassi consider to be Cojimar Formation. Furthermore, according to Albear (1981, personal communication) all the formations that Brodermann (1949, chart) attributes to the late Oligocene are now considered to be early Miocene.

REMARKS.—I suspect that *Eupatagus habanensis* (Sánchez Roig), known also from beds that Sánchez Roig refers to the late Oligocene of Habana Province, is a synonym of *E. sanchezi*. Both species have pointed posterior margins, petals of similar size and shape, and large primary tubercles in deeply sunken scrobicules within their peripetalous fascioles. Sánchez Roig's figured specimen of *E. habanensis*, is much larger than the holotype of

E. sanchezi and as expected, has more numerous scrobiculate primary tubercles. Regrettably no specimens of *E. habanensis* were available for study.

COMPARISON WITH OTHER SPECIES.—The test of the holotype is so badly distorted that it is difficult to compare it to other species, but the shape of its petals resemble those of *Eupatagus antillarum* (Cotteau) from the Eocene of St. Bartholomew. It differs in having far fewer, large tubercles dorsally. In *E. antillarum* there are at least 18 in interambulacrum 1 but only 5 in *E. sanchezi*.

E. sanchezi is likewise easily distinguished from all other species of *Eupatagus*, except *E. habanensis*, from Cuba by these very large tubercles with their deeply sunken scrobicules.

Eupatagus santanae Sánchez Roig

PLATE 58: FIGURES 4–7

Eupatagus (*Plagiobrissus*) *santanae* Sánchez Roig, 1951:47, pl. 37: fig. 2 [not *Brissoides santanae* Sánchez Roig, 1949:210, pl. 25: figs. 2, 3].

MATERIAL.—Only one specimen (SRC 4306) known (figured by Sánchez Roig and herein designated the lectotype. The cotype is no longer in the Sánchez Roig Collection. The lectotype is an undistorted test, badly weathered, with the peristomial and periproctal regions broken away.

SHAPE AND SIZE.—Length 76 mm, width 81% L, height 48% L; greatest width central, greatest height posterior.

APICAL SYSTEM.—Four genital pores, ethmolytic, with madreporite extending posteriorly far beyond posterior ocular plates. Apical system anterior of center at distance from anterior margin to center of genital pores equal to 32% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove, porepairs in adapical region very small, not markedly differentiated from porepairs on margin of test; pores of pair arranged vertically.

Anterior petals (II and IV) extending two-thirds distance from apical system to margin; length 38% L, greatest width 12% L, interporifer-

ous zone very wide, greatest width 4.7% L; petals flush with rest of surface of test. Poriferous zones narrow, 3.3% L, pores conjugate, outer pore of pair slightly more elongated than inner; adapical porepairs in anterior poriferous zones smaller than in posterior poriferous zone; 68 petaloid porepairs.

Posterior petals (V and I) extending two-thirds distance from apical system to margin, length 42% L, width 11% L, width of interporiferous zone 4.6% L, width of poriferous zone 3.4% L; 68 petaloid porepairs. Last 1½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Not preserved.

PERIPROCT.—On posterior truncation tilting slightly so that periproct would have been slightly visible from above; all except bottom edge of opening absent due to fracturing of test.

FASCIOLES.—Eradicated by weathering.

TUBERCULATION.—Large tubercles present adapically in paired interambulacra.

ORAL PLATE ARRANGEMENT.—Most of labrum missing; rest of plate suture of plastron not clear.

OCCURRENCE.—Oligocene-Miocene, “Santa Inés” farm, Guadalupe district, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Eupatagus santanae* is very similar and may be a synonym of *E. turibacoensis* Sánchez Roig from the late Eocene of Cuba. Both species have tests of similar shape, long flexuous petals that are constricted at their extremities, and apical systems in similar positions. The petals of the lectotype of *E. santanae* are narrower than those in the holotype of *E. turibacoensis*, but with only one specimen available of *E. santanae*, it is not possible to know the significance of this difference. Furthermore, the peristome is absent in the lectotype of *E. santanae*, making it impossible to compare its position and shape with that in *E. turibacoensis*.

If *Brissoides santanae* Sánchez Roig, 1949, is a *Eupatagus* (its type specimen is not available to me), then it will have priority over *Eupatagus santanae* Sánchez Roig, 1951. A new name would have to be assigned to the 1951 species.

***Eupatagus siboneyensis* Weisbord**

PLATE 59: FIGURES 1-3

Eupatagus siboneyensis Weisbord, 1934:78, pl. 8: figs. 7, 8.

I have nothing to add to Weisbord's description. Only two specimens are known and both are only fragments.

OCCURRENCE.—Late Eocene, road cut at Loma Calisto, approximately 800 m SW of the S end of the town of Nuevitas, on the road leading toward Belén, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—Although very little is known of this species because of the fragmental nature of the two known specimens, it is easily distinguished from all the other Cuban species of *Eupatagus* by its very narrow test. Its petals also appear to have narrower interporiferous zones.

***Eupatagus turibacoensis* Sánchez Roig**

FIGURE 36; PLATE 59: FIGURES 4-7; PLATE 60

Eupatagus turibacoensis Sánchez Roig, 1953c:157, pl. 8: figs. 3, 4.*?Megapatagus turibacoensis* Sánchez Roig, 1953a:61, pl. 13: 2 figs.*?Eupatagus calistoides* Sánchez Roig, 1953c:160, pl. 6: fig. 8.

MATERIAL.—The holotype (SRC 4050) and only specimen referred to this species by Sánchez Roig is moderately well preserved with an undistorted test. The upper surface is badly weathered obscuring the tuberculation.

SHAPE AND SIZE.—Length 79 mm, width 81% L, height 51% L. Greatest width central, greatest height posterior due to inflation of plastron.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of apical system equal to 24% L; 4 genital pores, ethmolytic (Figure 36A) with genital plate 2 extending far posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, flush, not in groove. Porepairs minute adapically; part of area broken away making count of plates not possible.

Anterior petals (II and IV) extending almost

to margin, length 39% L, greatest width 14% L; interporiferous zone very wide, greatest width 7.1% L, petals flush with rest of surface of test. Poriferous zone narrow 3.7% L, pores conjugate, outer pore of pair slightly more elongate than

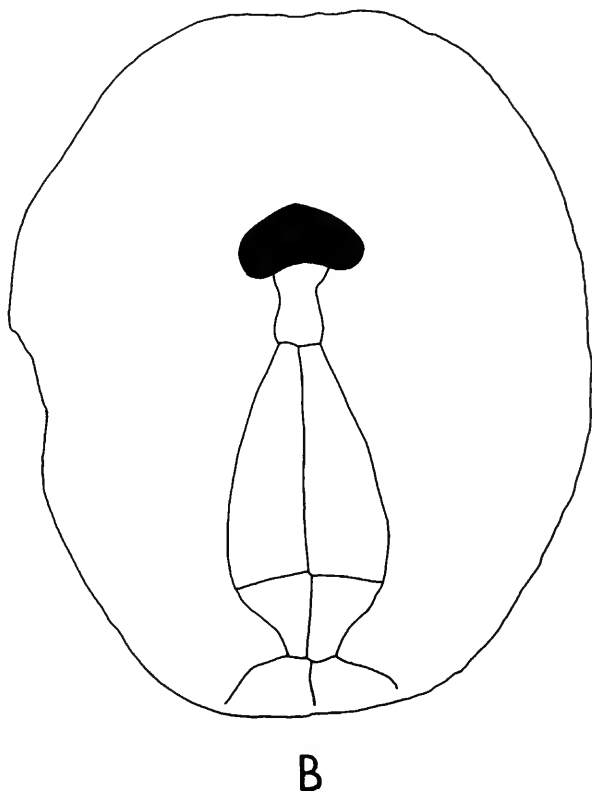
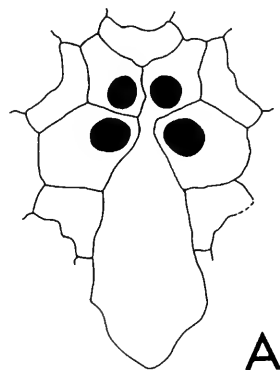


FIGURE 36.—*Eupatagus turibacoensis* Sánchez Roig, holotype, SRC 4050; A, apical system, B, plastron $\times 1.25$.

inner; adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone; 66 petaloid porepairs; first petaloid pore in plate 15 or 16.

Posterior petals (V and I) extending two-thirds distance from apical system to margin, length 44% L; greatest width 13% L, petals flush. Poriferous zones narrow, 3.7% L; interporiferous zones wide, width 6.9% L; 72 petaloid porepairs. Last $1\frac{1}{2}$ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 24% L. Opening very large, wider than high, width 16% L, height 9.4% L. Phyllodes with 10 pores in ambulacrum III, 13 in IV, 10 or 11 in V.

PERIPROCT.—Located near middle of posterior truncation, opening with height 18% L, width 11% L; enclosed by interambulacral plates 5–8.

FASCIOLAS.—Most of peripetalous fasciole removed by weathering. Subanal fasciole enclosing area with width 37% L, height 22% L, crossing interambulacral plates 3, 5, and perhaps 4, ambulacral plates 7–11.

ORAL PLATE ARRANGEMENT.—Labrum long, length 10% L, extending posteriorly to anterior one-third of third adjacent ambulacral plate. Plastron long, composed of 2 pairs of plates; anterior pair with combined height 33% L, width 22% L; posterior pair with height 13% L, width 19% L, narrowing sharply posteriorly (Figure 36B).

OCCURRENCE.—Late Eocene, “Turibacoa” farm, Marroquín, Morón, Camagüey Province, Cuba. Holotype of *Megapatagus turibacoensis* from same locality. Holotype of *Eupatagus calistoides* from Eocene, in highway cut, Loma Calisto, Nuevitas, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Eupatagus alatus* Arnold and Clark from the Eocene of Jamaica and the middle to late Eocene of Cuba. The holotype of *E. turibacoensis* differs from specimens of *E. alatus* in having a less blunt anterior surface; the porepairs

in the same poriferous zone in the petals appear to be further apart. These differences are slight and the species may be synonymous; but with only one specimen available of *E. turibacoensis*, it is not possible to know the significance of these differences.

E. turibacoensis resembles *E. clevei* (Cotteau), which is also found in the Oligocene-Miocene of Cuba differing primarily in having the petals in the holotype of *E. clevei* wider and more constricted at their extremities (compare Plate 59: figure 4 with Plate 61: figure 3). However, the petals in the holotype of *Megapatagus turibacoensis* Sánchez Roig (Plate 60: figure 4), herein considered a probable synonym of *E. turibacoensis*, are similar to those in *E. clevei*. These two species must have been closely related.

REMARKS.—I cannot distinguish this species from *E. calistoides* Sánchez Roig, also from the late Eocene of Camagüey Province, Cuba. The two species have similarly shaped tests, apical system in the same position, petals of similar shape and size with the first petaloid porepairs in plate 15 or 16, and peristome of same outline and position. In both species the last $1\frac{1}{2}$ plates in the posterior petals are occluded.

Likewise, *Megapatagus turibacoensis* Sánchez Roig, whose type specimen (SRC 4173) comes from the same locality as *E. turibacoensis*, appears to be a synonym. It differs only in having a larger, higher test with longer, wider petals; however, considering the variation known to be present in large populations of this genus, these differences may not be significant.

SYNONYMS

?Eupatagus calistoides Sánchez Roig

PLATE 60: FIGURES 1–3

MATERIAL.—The holotype (SRC 4774) is moderately well preserved showing the original shape of the test; but the region circumscribed by the subanal fasciole is missing.

SHAPE AND SIZE.—Length 47 mm, width 39 mm (83% L), height 22 mm (47% L). Greatest

width central, greatest height anterior but upper surface is nearly level, not sloping.

APICAL SYSTEM.—Four genital pores, ethmolytic with madreporite extending far beyond the posterior ocular plates. Apical system anterior of center at distance from anterior margin to center of genital pores equal to 28% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove, pores very small in adapical region, not markedly differentiated from pores on margin of test; approximately 72 plates in ambulacrum.

Anterior petals (II and IV) extending almost to margin, length 35% L, greatest width 12% L, interporiferous zone very wide, greatest width 5.3% L, petals flush with rest of surface of test. Poriferous zones narrow, 3.8% L, pores conjugate, outer pore of pair slightly more elongated than inner; adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone; 50 petaloid porepairs. First petaloid porepairs in plate 16, total of 80 plates in ambulacrum.

Posterior petals (V and I) extending two-thirds distance from apical system to margin, length 41% L; greatest width 12% L, interporiferous zone very wide, greatest width 4.9% L, petals flush. Poriferous zones narrow, 3.8% L; 60 petaloid porepairs. Last 1½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 25% L. Opening very large, wider than high, width 17% L, height 11% L.

PERIPROCT.—Located high on posterior truncation tilting so opening visible from above. Area fractured, but opening estimated as being height 17% L, width 11% L.

FASCIOLAS.—Peripetalous and subanal fascioles present, but most of tracts not preserved. Larger tubercles confined within peripetalous fasciole.

ORAL PLATE ARRANGEMENT.—Labrum with length 13% L; rest of plate sutures not clear.

OCCURRENCE.—Late Eocene, "Turibacoa" farm, Marroquín, Morón, Camagüey Province, Cuba.

?Megapatagus turibacoensis Sánchez Roig

PLATE 60: FIGURES 4–6

MATERIAL.—Only one specimen known, the holotype (SRC 4173), which is poorly preserved, badly weathered, with large part of the test broken away.

SHAPE AND SIZE.—Length (est.) 85 mm, width 90% L, height 58% L, greatest width slightly anterior.

APICAL SYSTEM.—Anterior, exact position not clear because of distortion of test; plate sutures not clear.

AMBULACRA.—Anterior ambulacrum III not petaloid; porepairs minute adapically; part of area broken away making count of plates not possible.

Anterior petals (II and IV) extending to margin, length 48% L, greatest width 18% L; interporiferous zone very wide, greatest width 10% L; petals flush with rest of surface of test; poriferous zones narrow, 4.0% L; adapical porepairs in anterior poriferous zone smaller than in posterior poriferous zone, 82 petaloid porepairs.

Posterior petals (V and I) extending more than two-thirds distance from apical system to margin, length 55% L, greatest width 11% L, petals flush. Poriferous zones narrow, 4.4% L; 96 petaloid porepairs.

PERISTOME.—Large; no other details because of fracturing around peristome.

PERIPROCT.—Marginal, but no other details available.

FASCIOLAS.—Because of weathering of test, only short portions of peripetalous and subanal fascioles preserved.

ORAL PLATE ARRANGEMENT.—Labrum with length 9.2% L, extending posteriorly to anterior one-third of third adjacent ambulacral plate. Plastron long, composed of 2 pairs of plates; anterior pair with combined height 39% L, width 23% L, posterior pair much smaller but dimensions not clear.

OCCURRENCE.—Late Eocene, "Turibacoa" farm, Marroquín, Morón, Camagüey Province, Cuba.

UNRECOGNIZABLE SPECIES OF *Eupatagus*

Eupatagus depressus (Sánchez Roig), preoccupied

PLATE 67

Megapatagus depressus Sánchez Roig, 1953a:60, pl. 12 [not
Eupatagus depressus Jackson, 1922].

MATERIAL.—Only the holotype (SRC 4476) is known. It is a very badly weathered specimen with all trace of fascioles and most of the dorsal tubercles absent. The test is distorted with the left side compressed. The test is slightly depressed by postmortem compression but probably not more than 5 to 10 mm. The posterior is broken away and the peristome filled with matrix. The plate sutures are not clear.

This specimen is very similar to *Eupatagus clevei* (Cotteau) but differs in having the anterior poriferous zone of its petals less curved anteriorly. Its apical system is more central, but this may be due to postmortem distortion of the test. The species are probably distinct. Unfortunately, the binomen *Eupatagus depressus* (Sánchez Roig, 1953) is preoccupied by *Eupatagus depressus* Jackson, 1922. In order to maintain Sánchez Roig's species, it would be necessary to supply a new species name. Because the type specimen is so poorly preserved, it does not seem advisable to take this step.

OCCURRENCE.—Oligocene-Miocene, "El Regalo" farm, Charco Hondo, Marroquín district, Morón, Camagüey Province, Cuba.

Genus *Fernandezaster* Sánchez Roig, 1952

Test large, flattened, ambulacrum III not petaloid, posterior petals confluent, occupying single groove adapically, periproct marginal; both peripetalous and subanal fascioles present.

REMARKS.—This genus belongs in the Brissidae because it has both a peripetalous and subanal fasciole. It is similar to *Brissopsis* and *Metalia* in having its posterior petals confluent proximally and diverging greatly distally. It differs from *Brissopsis* in having an extremely wide test. It differs from *Metalia* in apparently having a

broader area enclosed by the subanal fasciole. Only the type-species is known and the genus is not known outside of Cuba.

HABITAT.—Presence of fascioles and depressed petals indicate that this genus lived buried. Because of the poor preservation of the holotype and only known specimen, nothing is known of the pores in the anterior ambulacrum. Therefore, we do not know whether or not *Fernandezaster* had funnel-building tube feet, permitting it to live buried in fine sediment.

***Fernandezaster mortenseni* Sánchez Roig**

PLATE 52: FIGURES 4–5; PLATE 53: FIGURES 1, 2

Fernandezaster mortenseni Sánchez Roig, 1952c:18, pl. 10: figs. 1, 2.—Fischer, 1966:U588, fig. 476–2.

MATERIAL.—Only one specimen, the holotype (SRC 4240), is known of this species. This specimen is very poorly preserved with most of the test missing. None of the test is present ventrally and only a small part of the ambulacra and interambulacra 5 and 1 are present dorsally. The apical system, periproct, and peristome are absent. The test is extremely thin.

SHAPE AND SIZE.—Length 112 mm, width (est.) 104% L, height 40% L; test very broad with greatest width central. Marginal outline very angular, almost hexangular.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to apical system equal to 32% L; no other details visible.

AMBULACRA.—Anterior ambulacrum III in deep groove, not petaloid. The holes through the test, which look like inner pores, are not pores but are places where the test is especially thin and has weathered away.

Anterior petals (II and IV) straight, length 36% L, width 8.1% L, in deep groove of depth 3.8% L; pores very large, inner pore of pair round, outer elongated transversely.

Posterior petals (V and I) parallel and close together adapically and then turning sharply away from each other distally. Length 38% L, width 7.5% L; adapically for almost first half of length of petal, pores of ambulacra Vb and Ib

much smaller than pores of outer poriferous zone of same petal; 66 ± 4 porepairs in each petal.

PERISTOME.—Anterior, estimated distance of anterior edge of opening from anterior margin equal to 15% L. Peristome appears to have been labiate with width estimated at 7.5% L, height 13% L.

PERIPROCT.—Marginal, opening very large, apparently higher than wide but only partially preserved.

FASCIOLAE.—Peripetalous fasciole very narrow, width 0.04% L, deeply indented in interambulacra. Subanal fasciole narrow, only short tract preserved; area enclosed by fasciole extremely wide.

TUBERCULATION.—Test covered by very small tubercles.

OCCURRENCE.—Oligocene-Miocene, in well on "Balbín" farm, San Pedro Bauta, Habana Province, Cuba.

Genus *Hernandezaster* Sánchez Roig, 1949

Test large, elongate, no anterior groove, apical system with 4 genital pores, ethmolytic, anterior ambulacrum not petaloid, porepairs very small dorsally, petals depressed, narrow; periproct inframarginal; probably both peripetalous and subanal fascioles.

HABITAT.—Presumably this echinoid lived buried in coarse sediment. It lacks funnel-building tubefeet in the anterior ambulacrum as indicated by the lack of crowding of the pores in that region. Without these it probably could not have burrowed in fine sediment.

REMARKS.—Only one badly weathered specimen is known of this genus, and it is not possible to know which fascioles were present. Sánchez Roig (1949:212) stated that he observed part of a peripetalous fasciole. I suspect it was present originally, but I could find no trace of it on the specimen. Fascioles are very important in the classification of spatangoids and it is not possible to assign with certainty this genus to a family without knowledge of the nature of the fascioles. Mortensen (1950:405) stated that Sánchez Roig informed him that the apical system was ethmo-

phract with the madreporite not extending beyond the posterior genital plates. However, the apical system is definitely ethmolytic with the madreporite not only separating the posterior genital plates but also the posterior ocular plates (Figure 37). If we could be certain that no subanal fasciole was present, then this species could be referred with some certainty to the Hemiasteridae as was done by Mortensen (1950:405) and Fischer (1966:U559). However, it is possible that a subanal fasciole was present and in that case this genus would be referred to the Brissidae. I agree with Sánchez Roig in believing that its strongest affinities are with genera of this family.

Hernandezaster hernandezi Sánchez Roig

FIGURE 37; PLATE 68: FIGURES 1-4

Hernandezaster hernandezi Sánchez Roig, 1949:212, pl. 33: figs. 3-5.—Mortensen, 1950:405, fig. 303a-c, pl. 2: fig. 5.—Fischer, 1966:U559, fig. 444-1.

MATERIAL.—Only one specimen known, the holotype (SRC 4075). This specimen has an undistorted test but is badly weathered with all the fine tuberculation removed.

SHAPE AND SIZE.—Length 64 mm, width 54 mm (85% L), height 34 mm (53% L). Greatest width central, greatest height posterior. Anterior margin rounded, posterior pointed.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 38% L; 4 genital pores, ethmolytic with genital plate 2 extending posteriorly separating posterior genital and ocular plates (Figure 37).

AMBULACRA.—Anterior ambulacrum III not petaloid, not in groove; porepairs minute dorsally; 50 plates.

Anterior petals (II and IV) long, extending almost to margin, length 38% L, width 8.9% L; petals curving slightly anteriorly subtending arc nearly 180 degrees; interporiferous zones narrow, narrower than single poriferous zones; porepairs conjugate, outer pores more elongate than inner; 66 petaloid porepairs; first petaloid porepair in plate 16 or 17. Petals in groove with depth 2.3% L.

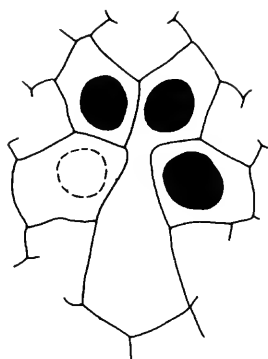


FIGURE 37.—*Hernandezaster hernandezi* Sánchez Roig, apical system of the holotype, SRC 4075, $\times 22$.

Posterior petals (V and I) two-thirds distance from apical system to margin, length 40% L; width 8.3% L, depth of groove 3.1% L. Petals straight to slightly curving anteriorly distally; 76 petaloid porepairs.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 14% L, opening wide, width 24% L; height 6.2% L but part of labrum appears to be broken away.

PERIPROCT.—Inframarginal, on overhanging truncation. Test around periproct fractured but opening appears to have been higher than wide, height 18% L, width 12% L.

FASCIOLAS.—Not discernible presumably because of weathering of test.

ORAL PLATE ARRANGEMENT.—Sutures not clear but plastron appears to have been very broad.

OCCURRENCE.—Miocene, “Santa Ana” farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba. Although Sánchez Roig considered this locality late Oligocene, Albear (1980, personal communication) dates it as Miocene.

Genus *Lajanaster* Lambert and Sánchez Roig, 1924

Test large, apical system ethmolytic with 4 genital pores, anterior ambulacrum not petaloid, in very slight groove, pores minute petals narrow, inflated along interporiferous zones; large tubercles at anterior margin of paired petals; peripetalous and subanal fascioles present.

REMARKS.—Five species have been referred to

this genus, but only one, *Lajanaster jacksoni* Lambert and Sánchez Roig, is recognizable herein. None occur outside Cuba. No specimens in the Sánchez Roig Collection are of *Lajanaster guevarai* Sánchez Roig and none are known elsewhere. The illustrations of this species by Sánchez Roig are not very clear, but the petals are much wider than in the type-species of *Lajanaster*. This species appears to be a *Eupatagus*.

Lajanaster venturillae Sánchez Roig is herein considered a synonym of *Eupatagus venturillae* Sánchez Roig.

Lajanaster hernandezi Sánchez Roig appears also to be a *Eupatagus*, but the type specimen of this species has been lost. The specimen in the Sánchez Roig Collection labelled as the type specimen (SRC 4095) is not the specimen figured by Sánchez Roig. Its petals are far wider. It appears to be a *Eupatagus venturillae* Sánchez Roig.

No specimens are available of *Lajanaster rojasi* Sánchez Roig; but from Sánchez Roig’s (1953a, pl. 10, upper figure) illustration, it can be seen that its petals are narrower as in the type-species of *Lajanaster*.

HABITAT.—Species of this genus, having both peripetalous and subanal fascioles, could surely burrow but probably only in coarser sediment. The small pores in the dorsal portion of the anterior ambulacrum indicate that funnel-building tubefeet, necessary for echinoids burrowing in fine sediment were absent.

Lajanaster jacksoni Lambert and Sánchez Roig

PLATE 52: FIGURE 6; PLATE 53: FIGURES 3, 4

Lajanaster jacksoni Lambert and Sánchez Roig in Lambert and Thiéry, 1924 [1909–1925]:449.—Sánchez Roig, 1926:100, pl. 23: fig. 1, pl. 24: fig. 1, pl. 25: fig. 1, pl. 26: figs. 1, 2, pl. 27: figs. 1, 2; 1949:193, pls. 26, 27.—Mortensen, 1951, fig. 262.—Fischer, 1966, figs. 478–3a,b.

MATERIAL.—No specimens of this species are in the Sánchez Roig Collection, but one topotypic specimen identified on its label by Sánchez Roig is in the Smithsonian. This specimen (USNM 352866) is moderately well preserved, although partially flattened and with part of the ventral surface fractured. Two specimens from Cama-

güey Province are in the Museum of Comparative Zoology, Harvard MCZ 4117, 4129).

SHAPE AND SIZE.—Length 115 mm, width 84% L, test very low, height 24% L; greatest width central, greatest height posterior at plastron. Interambulacra inflated slightly along midline forming slight ridge.

APICAL SYSTEM.—Anterior, distance from anterior margin to anterior edge 42% L; 4 genital pores, ethmolytic with genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove adapically; adapical pores minute, not possible to count pores.

Anterior petals (II and IV) long, extending two-thirds distance from apical system to margin, length 31% L, width 8.7% L, maximum width of interporiferous zone near midlength of petal 3.2% L; poriferous zone with width 1.7% L, of equal length; 64 porepairs in petal.

Posterior petals (V and I) long, slightly longer than anterior petals, extending more than two-thirds distance to margin, length 40% L, width 9.6% L, greatest width of interporiferous zone 3.1% L, greatest width of poriferous zone 1.7% L; 76 petaloid porepairs in each petal. Petals inflated along interporiferous zones, with poriferous zones slightly depressed, pores strongly conjugate, outer pore slightly elongate.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 27% L; width 15% L, height 6.6% L.

PERIPROCT.—Not preserved but according to Lambert and Sánchez Roig in Sánchez Roig (1926:100) circular, marginal, and visible from below.

FASCIOLAS.—Only short portions of peripetalous fasciole visible on this specimen. Lambert and Sánchez Roig in Sánchez Roig (1926:101) report a subanal fasciole.

TUBERCULATION.—Large tubercles confined within peripetalous fasciole immediately anterior to anterior poriferous petals in paired interambulacra.

ORAL PLATE ARRANGEMENT.—Suturs not visible but plastron very narrow (Sánchez Roig, 1949, pl. 27).

OCCURRENCE.—Miocene, "Cervantes" farm, San José de las Lajas, Habana Province; Oligocene-Miocene, Palmer loc. 1660, long cut S of Y-switch on Ramal Valle, Central Jatibonico cane railroad, Camagüey Province, Cuba.

UNRECOGNIZABLE SPECIES OF *Lajanaster*

Lajanaster hernandezi Sánchez Roig

Lajanaster hernandezi Sánchez Roig, 1949:195, pl. 23: figs. 2, 3.

The type specimen has been lost.

OCCURRENCE.—Late Oligocene but Albear (1980, personal communication) considers this locality to be Miocene. "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

Lajanaster rojasi Sánchez Roig

Lajanaster rojasi Sánchez Roig, 1953a:58, pl. 10 [part].

No specimens are known of this species.

OCCURRENCE.—Oligocene-Miocene, "Blanquizar" farm, Marroquín district, Morón, Camagüey Province, Cuba.

Genus *Macropneustes* L. Agassiz, 1847

Test large, low, broad, with anterior groove; paired petals long; large tubercles confined within peripetalous fasciole; peristome large; subanal fasciole present.

This genus is difficult to distinguish from *Eupatagus*. The petals are generally narrower and a distinct anterior groove is present in *Macropneustes*. The subgenus, *Deakia*, is distinguished from *Macropneustes* (*Macropneustes*) by its lower test and shorter petals.

Three species of this genus have been reported from Cuba: *Macropneustes* (*M.*) *brodermanni* Sánchez Roig, *Macropneustes* (*M.*) *cubensis* Cotteau, and *Macropneustes* (*Deakia*) *armadilloensis* Sánchez Roig. Only one of these is referred definitely to *Macropneustes*: *M.* (*D.*) *armadilloensis*. *M. brodermanni* is referred to *Meoma*. The holotype of *M. cubensis*

is in the Cotteau Collection but is too poorly preserved to be generically identified with certainty.

Metalia palmeri Sánchez Roig is tentatively referred to *Macropneustes* (*Macropneustes*).

HABITAT.—The presence of both a subanal and peripetalous fasciole indicates that this genus could burrow. The absence of large pores dorsally in ambulacrum III suggests an absence of funnel-building tubefeet and probably means that this genus could not maintain a burrow in fine sediment. It resembles *Spatangus*, which Nichols (1959:353) reports lives in shell gravel.

***Macropneustes* (*Deakia*) *armadilloensis*
Sánchez Roig, new combination,
new status**

PLATE 49: FIGURES 5, 6; PLATE 50: FIGURES 1–3

Deakia armadilloensis Sánchez Roig, 1953c, pl. 10: figs. 1, 2.

MATERIAL.—Two specimens are present in the collection. The first specimen (SRC 4263) figured by Sánchez Roig (1953c, pl. 10: fig. 1) is herein selected as the lectotype. The second specimen (SRC 4262) is topotypic and probably is a paratype. The other specimen figured by Sánchez Roig (1953c, pl. 10: fig. 2) is no longer in the collection. The lectotype is flattened by postmortem depression and is badly weathered with the sutures, especially ventrally, greatly enlarged. The second specimen is also badly weathered with most of the ventral surface absent, but it is only slightly distorted. The first dimension in the following description is of the lectotype.

SHAPE AND SIZE.—Length 55 and 43 mm; width 91 and 96% L; height of lectotype 32% L but specimen flattened after death, height of SRC 4262 is 39% L. Greatest width anterior, greatest height posterior.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of pores 27 and 31% L. Four genital pores, very close together, ethmolytic with genital plate 2 extending posteriorly separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid with very small pores in dorsal region;

flush with test except for slight depression where crossing margin of test.

Anterior petals (II and IV) short, extending slightly more than one-half distance from apical system to margin, length 22 and 27% L; petals with greatest width near apical system where width 8.2 and 9.6% L. Poriferous zones wide with pores conjugate, outer pore elongated; 36 and 36 porepairs in petal; dorsal pores in anterior poriferous zone greatly reduced in size relative to porepairs in dorsal posterior poriferous zone. No plates occluded at end of petals.

Posterior petals (V and I) slightly longer than anterior, extending less than one-half distance from apical system to margin of test, length 29 and 29% L; greatest width 8.4 and 8.0% L; 46 and 40 porepairs in petal. No occluded plates at end of petals.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome 18 and 23% L. Opening wider than high, width 16 and 15% L, height 6.6 and 5.7% L. Phyllodes with pores in large peripodia; 7 in phyllode of ambulacrum II of specimen SRC 4262.

PERIPROCT.—Only partially preserved on lectotype, marginal.

FASCIOLES.—Only traces of peripetalous and subanal fascioles preserved. Peripetalous fasciole narrow, not indented in interambulacra.

TUBERCULATION.—Large tubercles with very large scrobicules confined within peripetalous fasciole in posterior region of paired interambulacra. Four to 6 large tubercles in posterior interambulacra; 2 in each anterior interambulacrum. Single row of secondary tubercles parallel to transverse suture between petaloid porepairs; 6 to 8 pores in each row at widest part of poriferous zone. Ventrally, many large tubercles with large scrobicules with eccentric mamelons.

ORAL PLATE ARRANGMENT.—Labrum of length 10% L, width 6.4% L; sternal plates of length 44% L, width (est.) 30% L. First plate in interambulacrum 1 followed by pair of plates.

OCCURRENCE.—Late Eocene, “Armadillo” farm, Marroquín, Morón, Camagüey Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This spe-

cies is a typical brissid, having both a peripetalous and subanal fasciole, large tubercles confined within the peripetalous fasciole, and an ethmolytic apical system with the genital pores very close together as common in many brissids. Its short petals and broad, low test are quite similar to the type-species of the subgenus *Deakia*. *Macropneustes* (*D.*) *armadilloensis* is the only species of this subgenus known from the Western Hemisphere.

***Macropneustes?* (*Macropneustes*) *cubensis* Cotteau**

PLATE 49: FIGURE 4

Macropneustes cubensis Cotteau, 1875:6; 1876:130; 1881:48, pl. 4: fig. 7.—Egozcue y Cía in Cotteau, 1897:91, pl. 23: figs. 1–4, pl. 25: fig. 7.—Sánchez Roig, 1924a:41.—Cooke, 1959:83, 84.

Eupatagus cubensis (Cotteau).—Jackson, 1922:94.

Mauritanaster cubensis (Cotteau).—Sánchez Roig, 1926:118; 1949:227.—Mortensen, 1951:551.

I have seen the holotype of this species in the Cotteau Collection. It is too poorly preserved for generic identification. The specimen is very badly weathered; the presence or absence of fascioles is uncertain.

It is possible that two species are represented. The name *Asterostoma castroi* was applied by Egozcue to a specimen exhibited in the Universal Exposition of Paris. Cotteau (1875:6) later described *Macropneustes cubensis* for this species. Egozcue y Cía (in Cotteau 1897:91) discussed the situation and reported no difference between his specimen of *Asterostoma castroi* and the species described by Cotteau (1875:6). Lambert (1924a:42) disagreed, claiming that two species were represented and resurrected *Asterostoma castroi* with Egozcue as the author. However, as pointed out by Cooke (1959:84), *Asterostoma castroi* Egozcue is a manuscript name.

It is not clear whether 2 species are represented. The differences pointed out by Lambert between the 2 species may result only from differences in the preservation of the few specimens known.

Cooke considered the Cuban species to be a synonym of *Macropneustes mortoni* (Conrad, 1850)

from the Eocene of southeastern United States, but they appear to be quite distinct. *M. mortoni* has two fascioles, whereas none are visible on the Cuban species. Furthermore, the American species has 4 genital pores and wider interporiferous zones. Only 3 genital pores are present in the 2 specimens of *M. cubensis* where the apical system is preserved.

OCCURRENCE.—Miocene, St. Martin; “Cervantes” farm, San José de las Lajas, Habana Province, Cuba.

***Macropneustes?* (*Macropneustes*) *palmeri* (Sánchez Roig), new combination**

FIGURE 38; PLATE 48: FIGURES 5, 6, 7; PLATE 49: FIGURES 1–3

Metalia palmeri Sánchez Roig, 1953c:166 [new name for *Antillaster cartagensis* Sánchez Roig, 1949:188, pl. 22: fig. 2; not *Metalia cartagensis* Sánchez Roig, 1949:232].

MATERIAL.—Two cotypes in Sánchez Roig Collection. Specimen (SRC 4032) figured by Sánchez Roig (1949, pl. 22: fig. 2) is herein selected as the lectotype. It is poorly preserved, being badly weathered with the peristomial and posterior surface destroyed. The test is distorted with the right side depressed and the front compressed making the anterior surface steeper than original. The paralectotype (SRC 4031) is also badly weathered with most of its dorsal surface absent and the ventral surface badly fractured. The test, however, is undistorted showing the original shape.

SHAPE AND SIZE.—Paralectotype 77 mm long, width 94% L, height 42% L; test low and broad with greatest width central, greatest height anterior. Lectotype estimated to have been 71 mm long.

APICAL SYSTEM.—Anterior, located on paralectotype at distance from anterior margin to center of genital pores equal to 31% L. Plates of apical system absent on both specimens.

AMBULACRA.—Anterior ambulacrum III not petaloid; in slight groove where crossing anterior margin; pores in dorsal region very small; 54 plates in ambulacrum in lectotype.

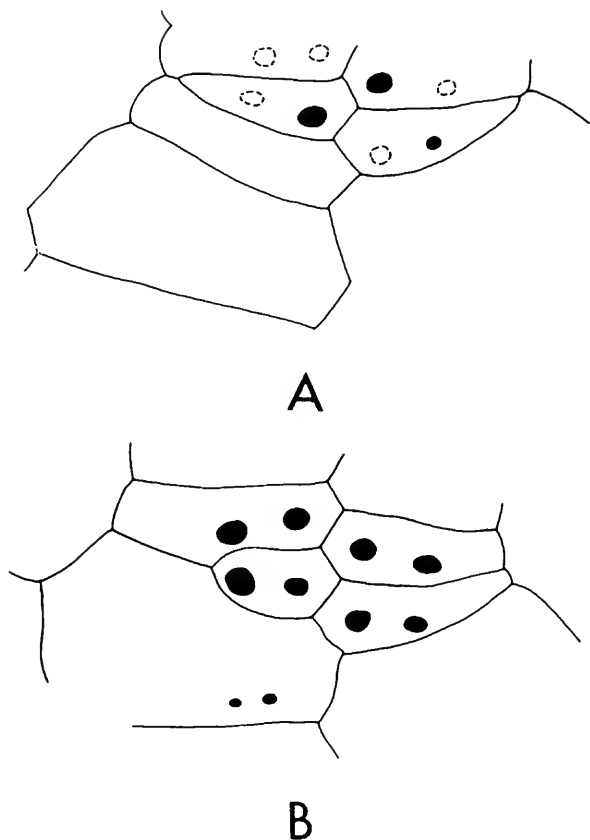


FIGURE 38.—*Macropneustes?* (*Macropneustes*) *palmeri* (Sánchez Roig): A, plate arrangement at end of petal IV of the lectotype, SRC 4032, $\times 8$; B, plate arrangement at end of petal V of paralectotype, SRC 4031, $\times 8$.

Anterior petals (II and IV) curving anteriorly, length 34% L in lectotype, 30% L in paralectotype, width 9.7 and 11% L; interporiferous zones narrower than poriferous. Dorsally, pores in anterior poriferous zones smaller than in posterior zones; 44 petaloid porepairs in lectotype. No plates occluded at end of petal in lectotype, one plate occluded in both zones of petal IV (Figure 38A).

Posterior petals (V and I) divergent, short, extending slightly more than one-half distance from apical system to margin; length in lectotype 39% L, width 11% L. Interporiferous zone narrower than single poriferous zone; 52 petaloid porepairs in lectotype. One plate occluded at end

of each petal in zone Va and Ia (Figure 38B) of lectotype. End of posterior petals not preserved in paralectotype.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 18% L; width of opening 13% L in paralectotype.

PERIPROCT.—Absent.

FASCIOLES.—No traces of peripetalous fasciole preserved; probably originally present but removed by weathering. Only short track of subanal fasciole present; most of posterior surface broken away on both specimens.

TUBERCULATION.—Larger tubercles present in paired interambulacra presumably confined within peripetalous fasciole.

ORAL PLATE ARRANGEMENT.—Labrum absent; rest of plate sutures not clear.

OCCURRENCE.—Oligocene-Miocene, SSE of Cartagena, 1 km N side of railroad, Las Villas Province, Cuba.

REMARKS.—It is not possible to know with certainty the genus to which this species belongs. Too many important morphological characters are unknown because of the poor preservation of the types. According to Mortensen (1951:532), *Metalia* is distinguished from *Brissus* by its narrower shield-shaped region enclosed by the subanal fasciole. Unfortunately the shape of this region is not clear on the types. In the type-species of *Metalia*, no large tubercles are confined within the peripetalous fasciole; but in this Cuban species large tubercles are present in the anterior and posterior paired interambulacra. Of all the genera of the Brissidae having large tubercles within the peripetalous fasciole, this species with its broad shape and narrow petals most resembles *Macropneustes*.

Genus *Meoma* Gray, 1851

Test large, apical system ethmolytic with 4 genital pores, anterior ambulacrum in notch at margin, not petaloid, pores minute; petals narrow, sunken; periproct marginal to inframarginal; tubercles within peripetalous fasciole slightly larger; peripetalous fasciole deeply in-

dented between petals, subanal fasciole bilobed; labrum short, not extending posteriorly past first adjoining ambulacral plates; sternal plates broad, episternal plates large, about one-half length of sternal plates.

HABITAT.—Modern species of *Meoma* live buried in sand in tropical seas at a depth from 5 to 200 m. These echinoids randomly ingest and pack their intestines with sediment. They probably cannot burrow in fine sediment. Their fascioles are poorly developed, and they lack funnel-building tubefeet in the anterior ambulacrum and around the periproct.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—Two Cuban species can be referred with some certainty to *Meoma*: *Meoma antiqua* Arnold and Clark and *Meoma antillarum* (Cotteau). Sánchez Roig's *Meoma caobaensis*, from the middle Eocene of Cuba appears to be a synonym of *Meoma antiqua* Arnold and Clark, previously known from the middle Eocene of Jamaica. *M. antillarum* of uncertain age from Cuba and perhaps from the Eocene of St. Bartholomew appears to be quite distinct from the other Cuban and Caribbean species of this genus.

Meoma? *brodermanni* (Sánchez Roig) and *Meoma?* *gomezmazae* (Sánchez Roig) are very similar to each other but are based on internal molds showing too few characters to permit certain generic identification. Both Cotteau (1875:40) and Sánchez Roig (1949:231) report Cuban specimens of *Meoma clevei* (Cotteau); but they never illustrated these specimens and none are available in the present collection. Therefore, it is not possible to confirm the presence of this Anguillan species in Cuba.

REMARKS.—The systematics of this genus have been reviewed by Chesher (1970).

***Meoma antillarum* (Cotteau)**

PLATE 51

Peripneustes antillarum Cotteau, 1875:7, 39, pl. 7: figs. 1–3.—Cooke, 1959:83.

Macropneustes antillarum (Cotteau).—Guppy, 1882:198.—Cotteau, 1897:95, pl. 29: figs. 1–3.—Jackson, 1922:85, pl. 15: fig. 1.

Schizobrissus antillarum (Cotteau).—Lambert in Lambert and Thiéry, 1924 [1909–1925]:494.—Sánchez Roig, 1949:229.

Meoma antillarum (Cotteau).—Chesher, 1970:755–758.

MATERIAL.—Two cotypes are available. The Cuban specimen in the Cotteau Collection at the Université Claude Bernard, Lyons, France, figured by Cotteau (1875, pl. 7: figs. 1–3) is herein selected as the lectotype. The other cotype is from the Eocene of St. Bartholomew and was originally in Cleve's collection, later in Guppy's and now is housed in the Smithsonian (USNM 214150). This specimen was figured by Jackson (1922, pl. 15: fig. 1). Later, Lambert (in Lambert and Thiéry, 1924 [1909–1925]:494) decided that this specimen was not conspecific with Cotteau's (1875, pl. 7: figs. 1–3) figured specimen of *Peripneustes antillarum*. Lambert made the cotype from the Eocene of St. Bartholomew the holotype of his new species, *Schizobrissus jacksoni*. The specimen is so badly weathered and crushed that it is not possible to determine whether or not it is conspecific with the lectotype of *P. antillarum*. Sánchez Roig (1949:230) credited *S. jacksoni* to Sánchez Roig and Lambert in Sánchez Roig (1949:230) stating that the type was a specimen from the Pleistocene of Habana. This action is not valid because Lambert (in Sánchez Roig, 1926:121) did not include this specimen in his description.

Fischer (1966:U594) stated that *P. antillarum* was the type-species of *Peripneustes* by original designation. I can see no designation of type-species in Cotteau's description. Cooke (1959:83) designated *Peripneustes clevei* Cotteau as the type-species.

Lambert (in Lambert and Thiéry, 1924 [1909–1925]:494) considered *Peripneustes* a synonym of *Schizobrissus* as did Fischer (1966:U594). Chesher (1970:755) pointed out that the holotype of the type-species of *Schizobrissus*, *S. cruciatus* (Agassiz), is so poorly preserved that it is not possible to be certain of its family. For this reason he thought it incorrect to synonymize *Schizobrissus* with *Meoma*. He referred *P. antillarum* to *Meoma*.

The lectotype is moderately well preserved although part of the test is missing, and the test is

somewhat distorted. The following description is based on this specimen.

SHAPE AND SIZE.—Test 112 mm long, width 84% L, greatest width slightly posterior of center; greatest height 48% L, anterior to center at apical system.

APICAL SYSTEM.—Anterior, distance from anterior margin 35% L, ethmolytic, number of genital pores not clear but Cotteau (1875, pl. 7: fig. 3) shows 4 in his figure.

AMBULACRA.—Anterior ambulacrum III not petaloid, depressed in deep groove. Anterior petals (II and IV) long, extending almost to margin, length 44% L, width 7.3% L, curving anteriorly distally. Interporiferous zone very narrow, approximately one-half width of single poriferous zone; 84 porepairs in petal.

Posterior petals (V and I) long, narrow, straight, extending four-fifths distance from apical system to margin, length 51% L, width 7.3% L; 88 porepairs in petal.

PERISTOME.—Anterior, distance from anterior edge of peristome to anterior margin 18% L; width estimated at 19% L, height 3.8% L. Details of phyllodes not clear.

PERIPROCT.—Not preserved.

FASCIOLAS.—Peripetalous fasciole very narrow, width 1.4% L, very angular in course around petals. Only anterior portion of subanal fasciole visible, very narrow, width 0.9% L, enclosing a large area; because of poor preservation, not possible to know if fasciole complete.

ORAL PLATE ARRANGEMENT.—Not discernible.

OCCURRENCE.—The lectotype is reported from the Cuban Eocene with no further locality data. Cotteau (1897:96) reports the species from Matanzas, Cuba. Sánchez Roig reports a specimen from the late Oligocene (now considered Miocene by Brönnimann and Rigassi, 1963:466) at "La Noria" farm, Cojimar, Habana Province, Cuba; but this specimen is no longer in the Sánchez Roig Collection.

COMPARISON WITH OTHER SPECIES.—This species differs from *Meoma brodermanni* (Sánchez Roig) of uncertain age from Cuba in having its anterior petals curving anteriorly distally, whereas they

are straight in *M. brodermanni*. Furthermore, the petals in *M. antillarum* are narrower (a width of approximately 10% L as opposed to 7.3% L) and longer (particularly the posterior ones whose length is equal to 51% L in *M. antillarum* versus 43% L in *M. brodermanni*).

Cooke (1959:83) considered *M. antillarum* as probably being the same species as *Meoma cleveii* (Cotteau) from the Anguillan Miocene. Jackson (1922:85) and Chesher (1970:756) maintained them as separate species. I have compared the type specimens of both species; they appear to be quite distinct. *M. antillarum* has a much larger and wider test, which is more abruptly inflated at its apical system, and a much narrower peristome, which is situated much more anteriorly.

M. antillarum is very similar in its general appearance and petal arrangement to the living *Meoma frangibilis* Chesher from the Bay of Panama. It differs in having a less anterior apical system, straighter posterior petals, and less rounded anterior margin. It also resembles the living *Meoma ventricosa* (Lamarck) from Bermuda to Colombia, South America—in particular some of the more elongate specimens figured by Chesher (1970, fig. 4g, f). It differs in having a deeper anterior notch, more asymmetrical test, and less rounded anterior margin. Chesher (1970:758) suggested that the Recent species of *Meoma* was probably derived from *M. antillarum*.

***Meoma antiqua* Arnold and Clark**

Meoma antiqua Arnold and Clark, 1927:70, pl. 15: fig. 2.

?*Meoma caobaensis* Sánchez Roig, 1952c:16, pl. 11: figs. 2, 3.

OCCURRENCE.—Debris at base of vertical cliffs, visible as one approaches from the Claremont Road, near Lucky Hill, St. Mary Parish, Jamaica. According to the 1958 geological map of Jamaica, Lucky Hill occurs in the middle Eocene Yellow Limestone. Middle Eocene, Loma Caoba, quarries of Caraballo, San Diego de los Baños, Pinar del Rio Province, Cuba.

Remarks.—The holotype and only known specimen of *Meoma caobaensis* is lost; but from

Sánchez Roig's photographs, this species appears to be a synonym of the Jamaican *Meoma antiqua*. Its elongate test and petal arrangement are identical.

***Meoma? brodermanni* (Sánchez Roig),
new combination**

PLATE 50: FIGURES 4–6

Macropneustes brodermanni Sánchez Roig, 1953a:62, pls. 15, 16.

MATERIAL.—Only one specimen known, the holotype (SRC 4121). This specimen is a mold of the interior with none of the original test preserved.

SHAPE AND SIZE.—Length 107.5 mm, width 91% L, height 49% L; greatest width anterior, greatest height anterior at apical system.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 30% L. No other details preserved.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep groove crossing ambitus with depth 4.3% L. Anterior petals (II and IV) straight, extending almost to margin, length 39% L, width 10% L; interporiferous zone appears to be slightly narrower than single poriferous zone. Petals depressed in groove with depth 4.3% L.

Posterior petals (V and I) straight, extending two-thirds distance from apical system to margin, length 43% L, width 9.7% L; interporiferous zone narrower than single poriferous zone. Petals depressed in groove with depth 3.3% L.

PERISTOME.—Very eccentric anteriorly, distance from anterior margin to anterior edge of peristome 10% L; width estimated at 19% L.

PERIPROCT.—Inframarginal, located high on overhanging posterior truncation; opening large, higher than wide, height estimated 17% L, width estimated 13% L.

FASCIOLES.—Not preserved.

ORAL PLATE ARRANGEMENT.—Labrum not preserved; impression of plates of plastron suggests that first pair of plastron plates (sternal) with length estimated at 47% L, combined width estimated at 37% L; second pair (episternal) with

length estimated at 16% L, combined width estimated at 37% L.

OCCURRENCE.—Age and locality uncertain, perhaps Casa Rabelo, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—*Meoma brodermanni* is very similar to *Meoma? gomezmazae* (Sánchez Roig) from the Oligocene-Miocene of Cuba. Both species are known only from internal molds so many specific characters are not known. The apical system appears to be slightly more anterior in *M. brodermanni*; the test, slightly more depressed posterior to the apical system and the anterior groove, deeper at the margin. However, all these differences may be due to postmortem distortion of the test. The species may be synonymous; but with so many specific characters not preserved, I hesitate to synonymize them.

M. brodermanni is easily distinguished from *Meoma antiqua* Arnold and Clark from the middle Eocene of Cuba and Eocene of Jamaica by its much broader test. It is distinguished from *Meoma clevei* (Cotteau) from the Miocene of Anguilla by its much larger and broader test, wider petals, and wider, more anterior peristome. It differs from *M. antillarum* from the Eocene of Cuba in its shorter, straighter, and wider petals.

REMARKS.—Because the only known specimen of this species is an internal mold, none of the external features of the plates are preserved. Therefore, nothing is known about the fascioles, tuberculation, or apical system. It is not possible to be certain of its generic affinities, but it appears to be a *Meoma* not *Macropneustes*. Chesher (1970:756) distinguishes *Meoma* from *Macropneustes* by the depressed petals and indented fascioles found in the former genus. Although nothing is known of the fascioles in this species, its petals are very depressed.

***Meoma clevei* (Cotteau)**

Peripneustes clevei Cotteau, 1875:40, pl. 7: figs. 4–7.—Cooke, 1959:83.

Macropneustes clevei (Cotteau).—Guppy, 1882:198.—Cotteau, 1897:93, pl. 28: figs. 1–4.

Schizobrissus clevei (Cotteau).—Sánchez Roig, 1949:231.
Meoma clevei (Cotteau).—Chesher, 1970:755, figs. 9a–c.

It is not certain that this species occurred in Cuba. Cotteau (1897:94) reported an internal mold of the species from the Cuban Miocene, but it has never been figured or described. Likewise, Sánchez Roig referred to this species a specimen from the Oligocene (now considered Miocene) of Cuba. The specimen is no longer in the Sánchez Roig Collection and was never illustrated by him.

OCCURRENCE.—Miocene of Cuba and Anguilla. Sánchez Roig's specimen came from "La Noria" farm, Cojímar, Habana Province, Cuba.

***Meoma? gomezmazae* (Sánchez Roig),
 new combination**

PLATE 52: FIGURES 1–3

Macropneustes gomezmazae Sánchez Roig, 1953a: 63, pl. 17.

MATERIAL.—The holotype and only known specimen (SRC 4101) is an internal mold. Therefore, none of the features of the external surface of the test are preserved.

SHAPE AND SIZE.—Length 99.0 mm, width 86% L, height 48% L; greatest height and width central.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove at margin. Anterior petals (II and IV) straight, extending almost to margin, length estimated at 37% L, width 9.7% L; interporiferous zones narrower than single poriferous zone. Petals depressed in groove with depth 2.9% L.

Posterior petals (V and I) straight, extending two-thirds distance from apical system to margin; length 36% L, width 9.7% L. Petals depressed in groove with depth 24% L.

PERISTOME.—Anterior distance from anterior margin to anterior edge of peristome 14% L, width estimated at 18% L.

PERIPROCT.—Inframarginal, on overhanging posterior truncation; height greater than width, height estimated at 16% L, width estimated at 13% L.

FASCIOLAS.—Not preserved.

ORAL PLATE ARRANGEMENT.—Labrum unknown. Sternal plates with length estimated at 46% L, combined width 36% L; episternal with length 15% L, combined width 40% L.

OCCURRENCE.—Oligocene-Miocene, Matanzas, Matanzas Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Meoma brodermanni* (Sánchez Roig) and the two species may be synonymous. *M. gomezmazae* differs from *M. brodermanni* in having a shallower anterior groove, more posterior apical system, and in being more inflated posterior to the apical system. These differences may be due to postmortem distortion.

REMARKS.—As the only known specimen of this species in an internal mold and nothing is known of the external features of the test, it is not possible to be certain of its generic affinities. Its depressed petals indicate that it should be referred to *Meoma* not *Macropneustes*.

Genus *Metalia* Gray, 1855

***Metalia cartagensis* Sánchez Roig**

Metalia cartagensis Sánchez Roig, 1949:232.

The type specimen is lost and no other specimens are known. The species has never been figured.

OCCURRENCE.—Oligocene-Miocene, S of Cartagena at 1 km on N side of railroad, Las Villas Province, Cuba.

Genus *Migliorinia* Checchia-Rispoli, 1942

Test small, low, apical system ethmolytic with 4 genital pores, petals flush with narrow interporiferous zones; peripetalous and subanal fascioles present; periproct supramarginal, no larger tubercles within peripetalous fasciole.

HABITAT.—*Migliorinia* presumably lived buried in sand or coarser sediment. It lacked funnel-building tubefeet as indicated by the lack of larger pores in the dorsal portion of its anterior ambulacrum. These tubefeet are essential for an echinoid to live in a burrow in fine sediment.

REMARKS.—Only two species are known of this genus—the type-species from the middle Eocene of Somaliland and the Miocene *M. habanensis* (Sánchez Roig) from Cuba.

***Migliorinia habanensis* (Sánchez Roig)**

PLATE 68: FIGURES 5–7

Brissoma habanensis Sánchez Roig, 1949:224, pl. 35: figs. 3, 4.
Schizaster vedadoensis Sánchez Roig, 1949:270, pl. 45: fig. 8.

MATERIAL.—Only one specimen (SRC 4773) is referable to this species in the Sánchez Roig Collection. It is not the specimen originally figured by Sánchez Roig, but it is a cotype that is now selected as the lectotype. The specimen is moderately well preserved but is crushed.

SHAPE AND SIZE.—Length 21 mm, width 92% L, height indeterminate because of postmortem crushing; greatest width central.

APICAL SYSTEM.—Anterior, distance from anterior margin to center of genital pores equal to 39% L. Ethmolytic, with genital plate 2 separating posterior ocular plates; 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, pores minute adapically in very faint groove at margin.

Anterior petals (II and IV) extending three-fourths distance from apical system to margin; length 31% L, wide, width 15% L; adapically pores of anterior poriferous reduced in size. Interporiferous zones width of single poriferous zone, pores conjugate, 30 porepairs in petal. Petals flush, not depressed in groove.

Posterior petals (V and I) approximately same length as anterior, extending two-thirds distance from apical system to margin, length 32% L; pore in zones Vb and Ia greatly reduced in size adapically; 30 porepairs in petal.

PERISTOME.—Anterior, distance of anterior margin from anterior edge of opening equal to 30% L, opening large, width 23% L, height 14% L.

PERIPROCT.—Inframarginal, but present position may be due to postmortem distortion; opening large, higher than wide.

FASCIOLAS.—Peripetalous fasciole broad,

deeply indented in paired interambulacra. Only portions of subanal fasciole preserved.

TUBERCULATION.—No large tubercles confined within peripetalous fasciole.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear.

OCCURRENCE.—Miocene, quarries at 23 Vedado, left of the bridge, Habana Province, Cuba. Although Sánchez Roig (1949:225) considered the type-locality to be late Oligocene, the species has been collected at Rio Cojimar and quarries at the entrance of Cojimar. These localities are considered to be in the Miocene Cojimar Formation by Brönnimann and Rigassi (1963:466).

REMARKS.—Sánchez Roig referred this species to *Brissoma*, a genus which Mortensen (1951:374) considered a subjective synonym of *Brissopsis*. The type-species of *Brissoma* is very similar to the type-species of *Brissopsis* and is certainly not generically distinct.

This Cuban species differs from *Brissopsis* in having flush petals. Of all the genera of brissids, it seems to have the greatest affinities with *Migliorinia*. It differs from the type-species, *M. migiurtina* Checchia-Rispoli from the Eocene of Somaliland in having broader petals.

The holotype (SRC 4208) of *Schizaster vedadoensis* Sánchez Roig is a very badly preserved specimen with its test crushed. However, its petals are identical to those in *M. habanensis* and it comes from the same locality. Without doubt it belongs to this species. It is too poorly preserved to permit description, but it is figured on Plate 68: figure 8.

Genus *Rojasia* Sánchez Roig, 1951

Large, low test with deep anterior groove; narrow, depressed, long petals; peripetalous fasciole.

HABITAT.—Presumably this echinoid lived buried in coarse sediment. It lacked funnel-building tube feet in the anterior ambulacrum as indicated by the small pores there. Without these tube feet it is unlikely that it could maintain a burrow in mud.

REMARKS.—Nothing is known of the nature of the peristome, oral plate arrangement, periproct

or presence of a subanal fasciole. Therefore, it cannot be referred to a family with any certainty. As noted by Sánchez Roig and by Fischer (1966:U604), this genus resembles *Schizobrissus*. Only one species is known of this genus.

Rojasia rojasi Sánchez Roig

PLATE 69

Rojasia rojasi Sánchez Roig, 1951:58, pl. 35, pl. 36: fig. 1.

MATERIAL.—Only one specimen, the holotype (SRC 3623), is known. The dorsal surface is well preserved but the ventral surface is completely absent.

SHAPE AND SIZE.—Length 177 mm, width 94% L, height 40% L; greatest width anterior, greatest height anterior; test depressed greatly posterior to apical system; no evidence that depression due to postmortem compression.

APICAL SYSTEM.—Anterior, located at distance from anterior margin equal to 36% L. Nature of apical system not clear. Although Sánchez Roig states that there are 4 genital pores, it is not clear on the holotype.

AMBULACRA.—Anterior ambulacrum III not petaloid, in deep groove, at margin groove with depth 9.4% L; porepairs small adapically.

Anterior petals (II and IV) curving anteriorly, long, extending four-fifths distance from apical system to margin, length 42% L, narrow, width 4.5% L, depressed in deep groove; interporiferous zone narrower than single poriferous zone, pores conjugate; 104 porepairs in petal.

Posterior petals (V and I) longer than anterior, curving anteriorly, length 45% L, width 4.5% L; 100 porepairs in petal.

PERISTOME.—Unknown.

PERIPROCT.—Unknown.

FASCIOLAS.—Peripetalous fasciole distinct; indented in paired interambulacra.

ORAL PLATE ARRANGEMENT.—Unknown.

OCCURRENCE.—Eocene, "El Maja" farm, Ma-

jagua district, Ciego de Avila, Camagüey Province, Cuba.

Suborder ASTEROSTOMATINA A.G. Fischer, 1966

Family ASTEROSTOMATIDAE Pictet, 1857

Genus *Asterostoma* L. Agassiz, 1847

Test large; apical system ethmolytic, with 4 genital pores; petals long, open, anterior petals transverse, no occluded plates at ends of petals; anterior ambulacrum not petaloid, with minute pores; ventrally ambulacra in deep grooves, with phyllodal pores not concentrated around peristome; periproct marginal to inframarginal, opening higher than wide; no fascioles; plastron amphisternous, slightly developed; in interambulacrum 2 first plate followed by pair of plates.

HABITAT.—Presumably *Asterostoma* lived exposed on the sea floor. It lacked suckered tubefeet on its upper surface, which could have held detritus over the top of its test. It probably had short, slender spines, sparsely distributed over the dorsal surface but more common on the ventral side. Its tubercles are small, widely separated dorsally but more crowded ventrally. Its lack of fascioles suggests that *Asterostoma* could not burrow. Probably, it lived in deeper, dark water. I know of no modern irregular echinoid that lives uncovered in the shallow lighted part of the sea.

Asterostoma probably fed by passing food particles to its mouth with its phyllodal tubefeet, which were present along the length of the ventral ambulacra. Many of these tubefeet, as suggested by the small size of the pores, were probably too short to extend to the mouth. In order to reach the mouth, the particles must have been passed from tubefoot to tubefoot.

DISTRIBUTION.—Six Cuban species have been referred to *Asterostoma*, but only two are recognizable: *A. excentricum* Agassiz and *A. subcircularis*. *A. dickersoni* Sánchez Roig and *A. irregularis* Sánchez Roig occur at the same locality with *A. excentricum*

and are herein considered synonyms.

The holotype of *Asterostoma jimenoi* Cotteau from the Eocene or Miocene of Cuba has been lost. This species has been made the type-species of *Prosostoma* Pomel but too little is known of it to determine its affinities. It appears to be similar to *Antillaster*. Cotteau's *Asterostoma cubense* is an *Antillaster*.

COMPARISON WITH SPECIES OUTSIDE OF CUBA.—*Asterostoma* is known only in Cuba and Jamaica. *A. excentricum* is present in Jamaica. *A. pawsoni*, new species, from the Eocene of Jamaica is easily distinguished from the Cuban species.

REMARKS.—Mortensen (1950:33) originally placed *Asterostoma* in his suborder Protosternata because he was misled by Cotteau's erroneous illustration showing a lack of a labrum and plastron. Later Mortensen (1951:563) learned that the type-species, *Asterostoma excentricum* Agassiz, had a labrum and an amphisternous plastron. He then referred the genus to the Paleopneustidae and rejected the family Asterostomatidae. Fischer (1966:U614) resurrected the family and created a new suborder, Asterostomatina, as a polyphyletic assemblage of spatangoids that had lost their petals or had them slightly developed, had no fascioles, or only traces of them, and lacked differentiation of spines in some genera. He considered them derived from highly specialized ancestors. Cheshier (1968:159) removed two of the genera, *Paleopneustes* and *Plesiozonus*, and placed them in the family *Paleopneustidae*.

Asterostoma is so distinct from all the other genera in Fischer's concept of Asterostomatidae that I believe it must be maintained in a separate family. It differs from the genera Cheshier (1968:159) and Henderson (1975:53) included in the Palaeopneustidae in having 4 genital pores, no occluded plates at the ends of its petals, and a pair of plates following the first plate in interambulacrum 2. It differs from the Paleopneustidae and all the other genera that Fischer referred to the Asterostomatidae in having a less developed plastron, its ventral ambulacra in grooves, and in having no concentration of large phyllodal pores around its peristome. On first impression,

Asterostoma appears to have no phyllodes. However, they are much longer than typical in other spatangoids and their pores are smaller. Instead of consisting of a few larger pores concentrated around the peristome, the phyllodes in *Asterostoma* include almost all the ventral ambulacra extending from the peristome to the margin. Their pores are quite small but are larger than those in the ambulacral plates between the petals and the phyllodes. They have peripodia typical of a phyllodal pore in a spatangoid but they are smaller.

Asterostoma excentricum L. Agassiz

FIGURE 39; PLATES 70-75; PLATE 76: FIGURE 1

Asterostoma excentricum L. Agassiz in Agassiz and Desor, 1847:168.—d'Orbigny, 1856:280, pls. 906-908.—Desor, 1858:196, pl. 37: figs. 1, 2.—Cotteau, 1871:183.—Duncan, 1889:202.—Egozcue y Cía in Cotteau, 1897:65, pl. 20: figs. 1, 2.—Jackson, 1922:67.—Sánchez Roig, 1924a:31; 1926:91.—Arnold and Clark, 1927:46, pls. 7, 8.—Sánchez Roig 1949:178-180, pl. 29: fig. 1, pl. 30: fig. 1.—Mortensen, 1950:36, figs. 35a-c; 1951:563, fig. 285.—Fischer, 1966, fig. 502-1a-c.

Asterostoma dickersoni Sánchez Roig, 1949:180, pl. 31: fig. 1, pl. 32: fig. 1.

Asterostoma irregularis Sánchez Roig, 1952b:7, pls. 2, 3.

MATERIAL.—The type specimen was in the zoology collections of the Muséum National d'Histoire Naturelle in Paris, but Dr. Jean Roman (1981, personal correspondence) believes that it is probably lost. The following description is based on eight specimens in the USNM Collections and the dimensions are of specimen ANSP 16684 in the Academy of Natural Sciences in Philadelphia. All the specimens, except one, are badly weathered with most of the ornamentation removed. The ventral plate arrangement is clear (Figure 39) on specimen UCB-A8396.

SHAPE AND SIZE.—Test very large, length (est.) 160 mm, width 138 mm (87% L), height (est.) 74 mm (46% L); greatest width anterior of center, greatest height central, posterior to apical system.

APICAL SYSTEM.—Anterior, distance from center of genital pores to anterior margin 26% L; ethmolytic with 4 genital pores (Plate 76: figure 1), genital plate 2 extending far posteriorly be-

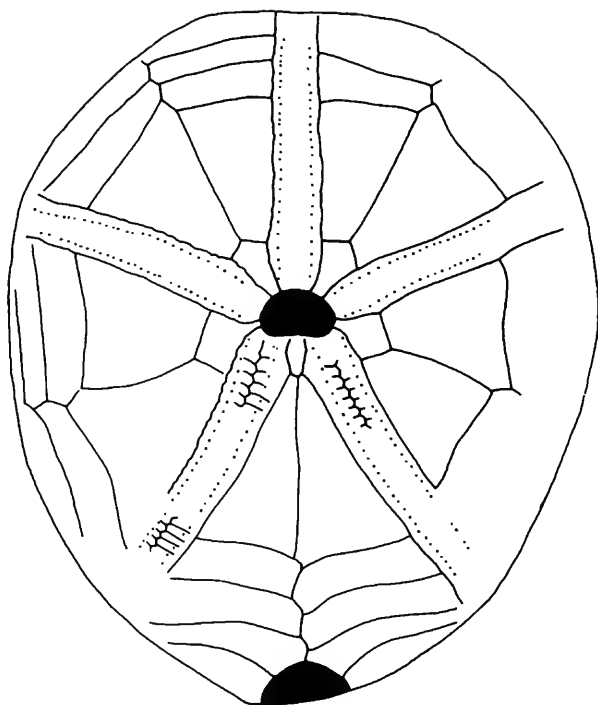


FIGURE 39.—*Asterostoma excentricum* Agassiz, ventral view of A8396, University of California, Berkeley, Museum of Paleontology, $\times 0.6$.

tween posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, flush with test from apical system to margin becoming depressed in groove on ventral side of test; adapically pores minute, pores paired for less than one-half distance from apical system to anterior margin, single for rest of length of ambulacrum to peristome.

Anterior petals (II and IV) very long, extending to margin, length 44% L, greatest width at two-thirds distance from apical system to end of petal, width 12% L; greatest width of interporiferous zone 5.9% L. Porepairs with outer pore more elongate than inner; 112 porepairs in petal; first petaloid porepair in plate 43 (45 in specimen UC-A8396). Petals very divergent, transverse flush with surface of test.

Posterior petals (V and I) very long, extending to margin, length 71% L, greatest width 14% L, open; interporiferous zone with greatest width 7.2% L; 164 porepairs in petal; first petaloid

porepair in plate 40 (40 in specimen UC-A8396).

Ventrally, all ambulacra depressed in deep groove, which widens toward peristome, greatest depth 2.3% L. No occluded plates at end of petals. Ambulacral plates beyond petals at margin with minute single pores; pores increasing in size ventrally where each pore (Plate 72: figure 4) has small neural canal on adoral side of pore surrounded by oblong peripodial area. These phyllodal pores extend from near margin to peristome becoming more widely separated from each other nearing peristome; 62 phyllodal pores in ambulacrum II, 22 smaller pores (probably for sensory tubefeet) between phyllode and end of petal; 56 phyllodal pores in I, 22 smaller; number in ambulacrum III not clear.

PERISTOME.—Central, distance from anterior edge of peristome to anterior margin of test 44% L; width of opening 11% L, height 6% L; peristome with steep sides.

PERIPROCT.—Inframarginal, opening very large, not preserved on specimen ANSP 16684 but present on specimen UC-A8396 (157 mm long) where height of opening is 11% L and width 12% L. Enclosed by interambulacral plates 5–8.

FASCIOLAE.—None present. One specimen with tubercles well preserved where fasciolas would have been preserved if originally present.

TUBERCULATION.—Tubercles very small, crenulate, and perforate; sparse dorsally where approximately 14 in 100 sq. mm area; tubercles on plastron no larger than on other interambulacra.

ORAL PLATE ARRANGEMENT.—Not clear on specimen ANSP 16684 but most sutures visible on specimen UC-A8396 (Figure 39). Labrum small, length 5.3% L, extending back to second adjoining ambulacral plate. Next interambulacral plates paired, length 28% L, combined width 30% L; next interambulacral plate not distinguishable in width from succeeding plates.

OCCURRENCE.—Eocene, Caraballo quarry, Loma Caoba, 5 km S of San Diego de los Baños, Pinar del Rio Province, Cuba. Eocene, hillsides above the Yallahs River, St. Thomas, in the Lucky Hill region in St. Mary and in the Spring Mount region, St. James, Jamaica.

REMARKS.—*Asterostoma irregularis* Sánchez Roig

and *Asterostoma dickersoni* Sánchez Roig occur at the same locality with *A. excentricum*. They all appear to be synonyms. The holotype of *A. dickersoni* (Plates 73, 74) is indistinguishable from *A. excentricum* in the length and width of its test, position of the apical system and peristome, length and arrangement of its petals, and position of its periproct. Although its test is lower than is common in *A. excentricum*, this difference probably falls within the range of variation of a species. Likewise, the holotype of *A. irregularis* (Plate 75) appears similar in all respects differing only in having a blunter anterior margin, an apparent result of postmortem distortion.

A. excentricum differs from *A. subcircularis* Sánchez Roig, also from the same locality, in having a more elongate, higher test with more anterior apical system. The first petaloid pores in ambulacrum II occur in plates 40–45 in *A. excentricum*, but in plate 35 in *A. subcircularis*, and in ambulacrum I in plate 40 as opposed to plate 36 in *A. subcircularis*. Finally the episternal plates are much lower in *A. excentricum*. In spite of these differences, these two species are very similar.

SYNONYMS

Asterostoma dickersoni Sánchez Roig

PLATES 73, 74

MATERIAL.—One specimen, the holotype (SRC 4957), is moderately well preserved with undistorted test. The peristome is filled with hard matrix.

SHAPE AND SIZE.—Length 165 mm, width 86% L, height 35% L; greatest width anterior to center, greatest height central. Posterior truncation slightly overhanging.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 31% L. Ethmolytic with genital plate 2 separating posterior ocular plates, 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove at margin, deeply depressed adorally like other ambulacra. Pores only slightly larger dorsally, changing from dou-

ble to single pores above margin but exact position of change not clear; greatest width 13.4 mm. Porepairs near center of plate, inner pore anterior and larger.

Anterior petals (II and IV) long, extending almost to margin, open, transverse, flush with rest of surface of test, length 52% L, width 10% L. Interporiferous area wide, width 6.1% L, width of poriferous zone 3.0% L. Pores conjugate, outer pore more elongate than inner; 122 porepairs in petal; not possible to determine in which plate occurs first petaloid porepair.

Posterior petals (V and I) long, extending to margin, length 65% L, width 11% L; width of interporiferous zone 6.4% L, poriferous zone 2.7% L; 156 porepairs in petal.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of opening equal to 41% L; no other details visible.

PERIPROCT.—Marginal to inframarginal, height of opening 9.7% L, width 11% L.

FASCIOLES.—None.

OCCURRENCE.—Middle Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Asterostoma irregularis Sánchez Roig

PLATE 75

MATERIAL.—One specimen, the holotype (SRC 4296), is moderately well preserved, although the test is fractured, the peristome is covered with matrix, and the apical system is missing. Test undistorted except for compression of anterior.

SHAPE AND SIZE.—Length 140 mm, width 91% L, height 56% L; greatest width anterior, greatest height central, posterior of apical system.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to estimated location of center of genital pores equal to 27% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very shallow groove dorsally, slight groove at margin, deep ventrally like other ambulacra. Pores double dorsally, single at margin and ventrally; position of change from double to single pore dorsal of margin but exact location not clear. Dorsally pore in each plate in anterior

position of plate nearer medial suture; ventrally pore more posterior nearer outer suture.

Anterior petals (II and IV) transverse, open, flush with test, extending to margin, length 57% L, greatest width 10% L. Interporiferous zone approximately twice width of single poriferous zone, width 5.3% L; width of poriferous zone 2.6% L; ~110 porepairs in petal; pores conjugate, outer pore of pair more elongate than inner. Not possible to determine in which plate the petaloid pores first occur.

Posterior petals (V and I) long, extending to margin, length 83% L, width 12% L, width of interporiferous zone 6.1% L, width of poriferous zone 2.9% L. Petal with 158 ± 3 porepairs.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of opening equal to 41% L.

PERIPROCT.—Marginal to inframarginal, slightly visible from below; opening higher than wide, height 13% L, width 10% L.

FASCIOLES.—None.

ORAL PLATE ARRANGEMENT.—Plate sutures not clear.

OCCURRENCE.—Middle Eocene, Caraballo quarry, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

Asterostoma pawsoni, new species

FIGURE 40; PLATE 78

Asterostoma excentricum. Arnold and Clark [part], 1927:46, 47 [not plates 7 or 8 which illustrate *Asterostoma excentricum* Agassiz].

MATERIAL.—Six specimens in the USNM Collections. Many of these specimens are very well preserved, having undistorted tests slightly weathered and showing details of tubercles and peripodia. The holotype is USNM 301378a; figured paratypes are USNM 301378b, 301378c.

SHAPE AND SIZE.—Test of moderate size, length 87.5 to 71.3 mm (mean 80 mm), width 82 to 73% L (S.D. 3.09, C.V. 5.08, N. 6), greatest width anterior to center; greatest height 59 to 50% L (S.D. 5.01, C.V. 11.27, N. 6), anterior at apical system or slightly posterior to apical system.

APICAL SYSTEM.—Anterior, distance from center of genital pores to anterior margin 32 to 28% L (S.D. 2.34, C.V. 9.76, N. 6); ethmolytic with 4 genital pores (Figure 40B), genital plate 2 extending far posteriorly between posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not

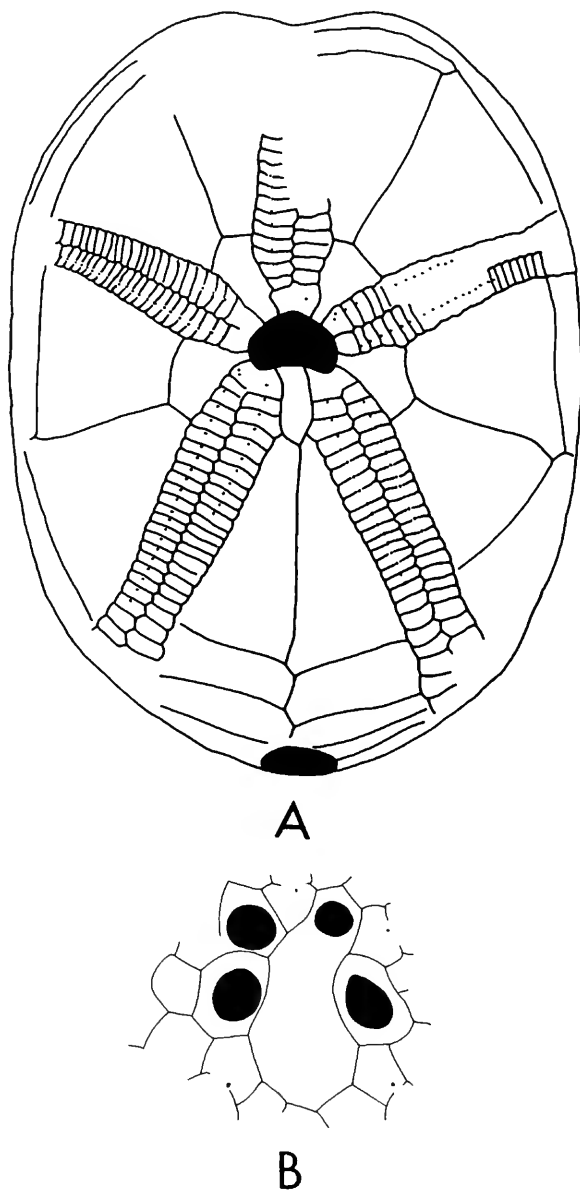


FIGURE 40.—*Asterostoma pawsoni*, new species: A, ventral view of the holotype, USNM 301378a, $\times 1.5$; B, apical view of paratype, USNM 301378b, $\times 8$.

petaloid, flush with test adapically but becoming depressed in slight groove at margin; adapically porepairs minute, double pores extending to approximately one-half distance from apical system to margin with 32 porepairs in specimen 88 mm long, 74 single pores including phyllode, total of 106 plates.

Anterior petals (II and IV) long, flush, transverse, subtending arc of 180 degrees, extending two-thirds distance to margin, length 45 to 38% L (S.D. 4.34, C.V. 12.84, N. 6), greatest width 15 to 13% L (S.D. 0.96, C.V. 8.53, N. 6), near end of petals; interporiferous zone wide, twice width of poriferous zone, width 6.5 to 5.1% L (S.D. 0.44, C.V. 9.30, N. 6); poriferous zone with greatest width 4.2 to 3.8% L (S.D. 0.35, C.V. 10.52, N. 6), zones narrowing distally; outer pore of pair more elongate than inner; in anterior poriferous zones outer pores oblique (Plate 78: figure 1); 74 petaloid porepairs in specimen 73 mm long, 86 in specimen 84 mm long, first petaloid porepair in plates 35–38.

Posterior petals (V and I) very long, extending almost to margin, open, flush, length 70 to 61% L (S.D. 4.76, C.V. 8.95, N. 6), greatest width 18 to 15% L (S.D. 0.76, C.V. 6.06, N. 6), greatest width three-fourths distance from apical system to end of petal; interporiferous zone wide, twice width of poriferous zone, width 8.4 to 6.1% L (S.D. 0.35, C.V. 6.35, N. 6); poriferous zone with greatest width 4.6 to 3.9% L (S.D. 0.34, C.V. 9.99, N. 6), zones narrowing distally; outer pore of pair more elongate than inner; 110 petaloid porepairs in specimen 73 mm long, 116 in specimen 84 mm long, first petaloid porepair in plates 30–34.

Ventrally, all ambulacra depressed in deep grooves, which widen towards peristome. No occluded plates at end of petals. Ambulacral plates beyond petals with minute single pores increasing in size in phyllode; phyllodes very long, extending almost to margin, widening gradually towards peristome but becoming more widely separated from each other nearing peristome (Plate 78: figure 6). Each phyllodal pore with neural canal on adoral side of pore, surrounded by oblong peripodial area (Plate 78: figure 5); 50 phyllodal pores in ambulacrum II, 42 in I, 32 in III; exact

count difficult because of gradual transition from phyllodal pore to smaller pores between phyllode and end of petal.

PERISTOME.—Slightly anterior, distance from anterior edge of peristome to anterior margin of test 38 to 33% L (S.D. 3.37, C.V. 11.72, N. 6). Subpentagonal, width 14 to 9% L (S.D. 0.90, C.V. 9.81, N. 6); height 7.9 to 6.3% L.

PERIPROCT.—Inframarginal, visible from below, height greater than width, height 14 to 13% L (S.D. 0.43, C.V. 3.87, N. 5), width 12 to 11% L (S.D. 0.51, C.V. 5.48, N. 4). Enclosed by interambulacral plates 4–8.

FASCIOLES.—None present. Some specimens so well preserved that their absence cannot be due to removal by weathering.

TUBERCULATION.—Tubercles very small, crenulate, perforate, sparse dorsally, slightly larger and more crowded ventrally. Tubercles on plastron not larger than on other interambulacra.

ORAL PLATE ARRANGEMENT.—Labrum long, narrow, length 11 to 7.5% L (S.D. 1.65, C.V. 22.65, N. 4) extending back to third adjacent ambulacral plate. Sternal plates in interambulacrum 5 not larger than corresponding plates in other interambulacra; height 32 to 29% L (S.D. 1.05, C.V. 4.28, N. 3). Episternal plates much lower with height 15 to 11% L (S.D. 1.32, C.V. 11.80, N. 4) not conspicuously higher than succeeding plates (Figure 40A). In interambulacrum 2 first plate followed by pair of plates.

OCCURRENCE.—Eocene, hillsides above the Yallahs River, St. Thomas, in the Lucky Hill region in St. Mary, and in the Spring Mount region, St. James, Jamaica. Although Arnold and Clark (1927) did not know the age of these localities, they occur in the Eocene Yellow Limestone.

REMARKS.—Arnold and Clark (1927:47) noted a gap in the size of specimens that they referred to *Asterostoma excentricum* Agassiz but saw no reason to group them into separate species. However, there are significant differences between the smaller and larger specimens and some of these differences are not size related. The larger specimens are obviously *Asterostoma excentricum* and are indistinguishable from Cuban specimens. A new species is erected here for the smaller specimens;

it differs from *A. excentricum* in having a smaller, more elongate test, its first petaloid porepairs in ambulacrum II in plates 35–38 versus 40–45 in *A. excentricum*, and in plates 30–34 in ambulacrum I versus 40. This latter difference is significant because it is not age- or size-related. The first petaloid plate is introduced early in the growth of an echinoid, and, because new plates are added at the apical system, the number of plates between the end of the petal and the peristome remains constant throughout the life of the echinoid, regardless of its ultimate size. Furthermore, the labrum in *A. pawsoni*, new species, is longer with a length 11 to 7.5% L as compared to 5.3% L in *A. excentricum*; and it extends posteriorly to the third adjacent ambulacral plate instead of the second.

A. pawsoni, new species, differs from *Asterostoma subcircularis* Sánchez Roig from the Eocene of Cuba in its more elongate test and far higher sternal plates (compare Figures 40 and 41).

***Asterostoma subcircularis* Sánchez Roig**

FIGURE 41; PLATE 76; FIGURES 2, 3; PLATE 77

Asterostoma sub-circularis Sánchez Roig, 1952c:19, pl. 2: figs. 1, 2; pl. 11: fig. 1.

MATERIAL.—The holotype and only known specimen (SRC 4010) is moderately well preserved with the test only slightly distorted. The anterior appears to be slightly compressed.

SHAPE AND SIZE.—Length 109 mm, width 90% L, height 55% L; greatest width anterior of center, greatest height central, posterior to apical system. Dorsal surface highly inflated with steep sides; ventral surface slightly depressed.

APICAL SYSTEM.—Anterior, distance from apical system to anterior margin equal to 36% L but probably originally greater before postmortem distortion. Ethmolytic, with genital plate 2 extending posteriorly between posterior ocular plates (Figure 41A); 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove dorsally and at margin, deepening ventrally. Pores minute, not significantly larger in dorsal region. Greatest width of

ambulacrum slightly above margin where width 9.6% L. Pores paired only adapically becoming single high above margin; 140 plates in ambulacrum.

Anterior petals (II and IV) long, broad, open, only slightly depressed; extending almost to margin, curving distally anteriorly; length 53% L, width 12% L. Interporiferous zone at greatest

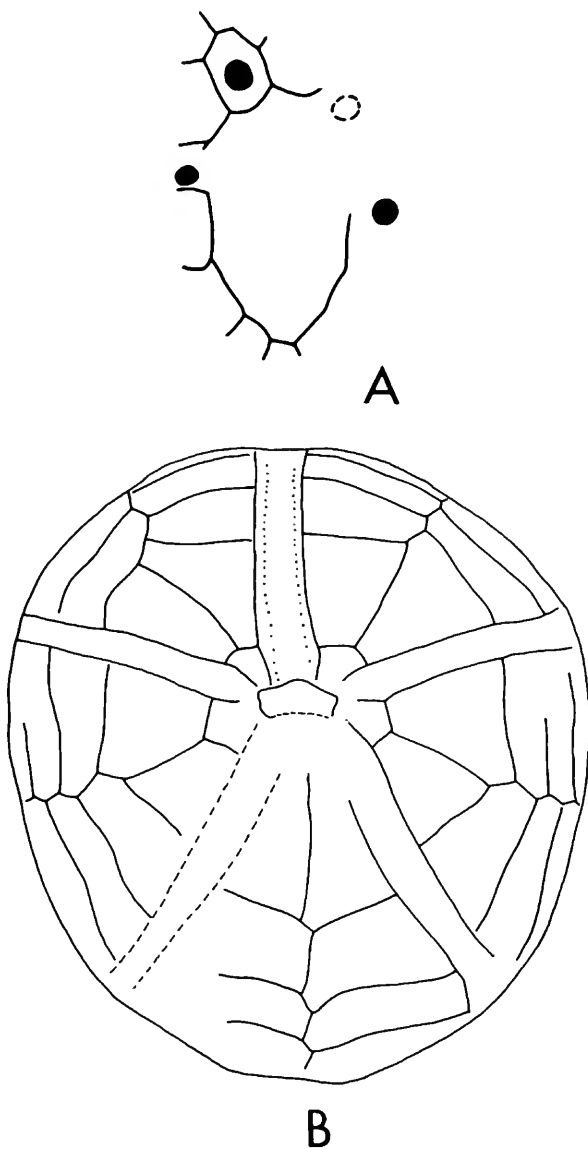


FIGURE 41.—*Asterostoma subcircularis* Sánchez Roig, holotype, SRC 4010: A, apical system, $\times 6$; B, ventral view, $\times 0.8$.

width near midlength, width almost twice width of single poriferous zone, width 5.2% L. Poriferous zone with greatest width 4.3 L outer pore more elongate than inner, conjugate; 98 porepairs in petal. No plates occluded at end of petal. First petaloid porepair in plate 35.

Posterior petals (V and I) long, extending almost to margin; length 72% L, greatest width 15% L. Interporiferous zones wide, greatest width 7.3% L, greatest width of poriferous zone 4.5% L; 130 porepairs in petal. No plate occluded at end of petal. First petaloid porepair in plate 36.

Ventrally, all ambulacra depressed in deep grooves, which widen towards peristome except in ambulacra II and IV where distortion of test obscures widening. No occluded plates at end of petals. Ambulacral plates beyond petals at margin with minute single pores; pores increasing in size ventrally where each pore (where preserved) has small neural canal in adoral side of pore surrounded by oblong peripodial area. These phyllodal pores extend from near margin to peristome becoming more widely separated from each other nearing peristome; 60 phyllodal pores in ambulacrum II, 8 smaller pores (probably for sensory tubefeet) between phyllode and end of petal; 50 phyllodal pores in I, 20 smaller.

PERISTOME.—Anterior, located at distance from anterior edge of opening to anterior margin equal to 27% L. Opening subpentagonal, wider than high, width 13% L, height 5.8% L. Opening depressed with vertical sides.

PERIPROCT.—Marginal, slightly visible from below, opening very large, higher than wide, height 12% L, width 11% L; located within interambulacral plates 5–10.

FASCIOLES.—None.

TUBERCULATION.—Test covered by small tubercles of approximately same size; more crowded on ventral side where evenly distributed.

ORAL PLATE ARRANGEMENT.—Length of labrum not clear; first 2 plates of plastron (Figure 41) with height estimated at 26% L, combined width 26% L. Next pair of plates lower than first, greatest height 14% L, but higher than next pair with greatest height 8% L. First plate in paired

interambulacra large, followed by 2 large paired plates.

OCCURRENCE.—Middle Eocene, Loma Caoba, San Diego de los Baños, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Asterostoma excentricum* Agassiz, which occurs with it. Its petals are indistinguishable and its periproct occurs within the same interambulacral plates. It differs in that its test is rounder and higher than *A. excentricum* and its apical system is more central. In *A. excentricum* the apical system is located at a distance from the anterior margin equal to 26% L; whereas, in *A. subcircularis* it is 36% L. Furthermore, the first petaloid pores in ambulacrum II occur in plates 40–45 in *A. excentricum*, but in plate 35 in *A. subcircularis*; in ambulacrum I in plate 40 (in 3 specimens where the count could be made) but plate 36 in *A. subcircularis*. Finally, the episternal plates in *A. excentricum* are much lower, 6% L, than in *A. subcircularis*, 14% L. These differences may fall within the range of variation within a species; but with so few specimens available, it is not possible to know. Therefore, it seems best to maintain *A. subcircularis* as a separate species.

Genus *Antillaster* Lambert, 1909

Test large, low to high; apical system ethmolytic with 3 or 4 genital pores; petals long, wide, open, flush with test, or very slightly depressed; anterior ambulacrum with small pores, in slight groove or flush with test; some plates occluded at ends of petals; peristome large; periproct large, inframarginal; tubercles small, no fascioles; plastron mesamphisternous with large labrum, narrow sternal plates, large episternal plates; in some species first plate in interambulacrum 1 followed by single plate.

HABITAT.—These species of *Antillaster* probably lived on the top of the substrate. They lack the features normally found in burrowing spatangoids. No funnel building tubefeet were present in the anterior ambulacrum as indicated by their minute pores, which do not change in size mar-

ginally, and by the fact that this ambulacrum is flush, not in a groove. Smith (1980:77) has shown that sensory tubefeet occur in this kind of ambulacrum. Likewise, no large pores are present in the anal region, indicating a lack of subanal tubefeet that could have maintained a sanitary drain if the echinoid lived in a burrow. Furthermore, no fascioles are present. Finally many of the species have very high tests, a character commonly associated with nonburrowing species.

No species of the genus are alive today, but *Paleopneustes* is very similar. *Paleopneustes cristatus* A. Agassiz has been seen alive from a submarine (Messing, 1981, personal communication) living on top of the substrate with its test not covered with sediment. Chesher (1968:134) suggests that the Recent *Paleopneustes tholoformis* Chesher could not burrow as indicated by its high test and the large number of live, unbroken specimens captured by surface trawls.

Species of *Antillaster* probably passed organic material and sediment into their mouths with their well-developed penicillate phyllodal tubefeet. The large peripodia in their phyllodes with pronounced ridges indicate the presence of these tubefeet. Specimens of the Recent *Paleopneustes cristatus* Agassiz tightly pack their intestines with bottom material (Lewis, 1963:362).

Antillaster presumably lived in fairly deep, tropical water. All living species of the Paleopneustidae occur in depths of 70–800 m (Henderson, 1975:53). Only two species live today north of the tropics in the northwestern Pacific. Henderson suggests that this distribution pattern results from the warming effect of the Kuroshia Current, which sweeps north from the tropics and sustains a warm-water fauna where the two species live.

EVOLUTION.—The earliest Cuban species referred to *Antillaster* are *A. arnoldi* Clark from the Eocene and possibly Oligocene-Miocene and *A. albeari*, new species, from the middle or late Eocene. They have low, elongate tests with 4 genital pores and a normal plate arrangement in interambulacrum 1. Later species, such as *A. fernandezi* (Sánchez Roig), *A. cubensis* (Cotteau), and *A. lamberti* Jeannet from the late Oligocene

or Miocene have much higher, wider tests, with only 3 genital pores and interambulacrum 1 with the first plate followed by a single plate. Probably the Recent species of *Paleopneustes* are descended from species like *A. lamberti* Jeannet. They share the high test, 3 genital pores, and second single plate in interambulacrum 1.

COMPARISON WITH OTHER SPECIES OUTSIDE CUBA.—The genus *Antillaster* is confined to the Caribbean and northeastern South America. It has never been found in North America. *Antillaster lamberti* Jeannet is found in the Miocene of Venezuela and the Oligocene-Miocene of Cuba. *Antillaster arnoldi* Clark is from the Eocene(?) of Jamaica and the Eocene or Oligocene-Miocene of Cuba. *Antillaster bonairensis* Pijpers from the late Eocene of Bonaire (Dutch West Indies) resembles most *A. arnoldi* Clark but differs in having a more anterior apical system, more pointed posterior margin, and higher test. *Antillaster vaughani* (Jackson) occurs in the Oligocene-Miocene of Antigua, Mexico, and Cuba.

One specimen of *Antillaster* is in the USNM Collections from the Miocene at Falcón, Venezuela. It resembles very much *Antillaster lamberti* Jeannet in its large, high test and wide petals but differs in having shorter, broader petals (Figure 42; Plate 87: figure 4).

As pointed out by Sánchez Roig (1926:97), *Eupatagus elegans* Jackson (1922:94) should be referred to *Antillaster*. This species, from the Miocene of Puerto Rico, lacks the fascioles typical of *Eupatagus*. Tuberculation on the holotype is extremely well preserved, but there are no signs of any fascioles. Furthermore, the tubercles are not larger within the area that would have been circumscribed by a peripetalous fasciole. Its petals are similar to those found in *Antillaster*, and it has the large labrum typical of that genus. Photographs of the holotype and a paratype of this species are on Plate 79.

Although Sánchez Roig (1949:182) reports *A. elegans* from the Oligocene of Cuba, I found no specimens in the Sánchez Roig Collection that I could be certain belonged to that species.

REMARKS.—Sánchez Roig's *Pseudoasterostoma* is

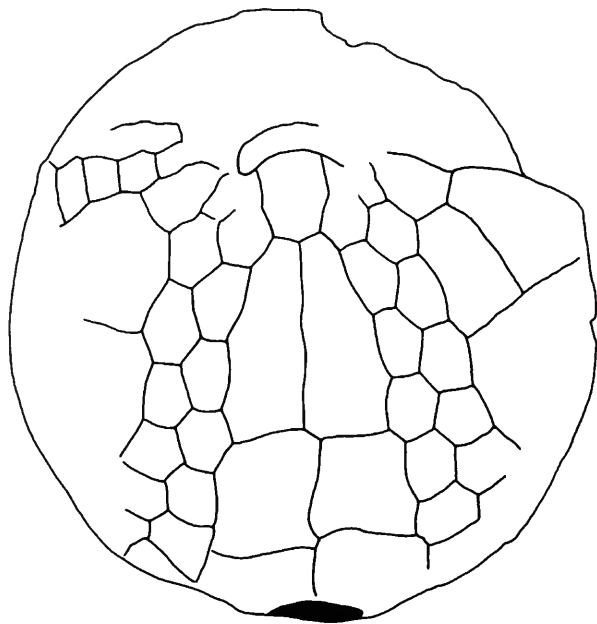


FIGURE 42.—*Antillaster* sp., ventral view of USNM 341261, Miocene, Falcón, Venezuela, $\times 0.75$.

an objective synonym of *Antillaster*. Both genera have the same type-species.

Henderson (1975:52) noted the similarity between *Antillaster* and *Paleopneustes* and considered *Antillaster* to be a subgenus of *Paleopneustes*. He noted that they differ only in that the pores of a porepair in *Antillaster* are dissimilar with the outer pore much more elongate than the inner. Although the genera are very similar, this difference is very strongly developed in the type-species of *Antillaster* and seems to warrant generic differentiation.

The species that have been referred to *Antillaster* fall into two groups. One group includes all those species having a large, very high, steeply sided test, with a flat ventral surface and very wide petals. This group includes the type-species *A. cubensis* (Cotteau), *A. lamberti* Jeannet, *A. bonairensis* Pijpers, and *A. fernandesi* Sánchez Roig. The apical system and oral plate arrangement are not known in *A. cubensis* and *A. bonairensis*; but in *A. lamberti* and *A. fernandesi*, only 3 genital pores are present and the first plate in interambulacrum 1

is followed by a single plate.

The second group includes all those species with generally lower tests, often more elongate, with more rounded ventral surfaces and narrower petals. This group includes *A. vughani* (Jackson), *A. sanchezi* Lambert, *A. arnoldi* Clark, *A. estenozzi* Sánchez Roig, and *A. albeari*, new species. In three of these species, *A. vughani*, *A. albeari*, and *A. arnoldi*, the apical system is preserved; there are four genital pores. In two species, the oral plates are known and the first plate of interambulacrum 1 is followed by a pair of plates.

I do not separate these two groups as subgenera because of the existence of some transitional species, such as *A. bonairensis*, which could be placed in either group. Furthermore, it is not known whether all the species in the second group have four genital pores and the normal plate arrangement in interambulacrum 1 of a pair of plates following the first plate.

Apparently, in *Antillaster* some plates are always occluded at the ends of the petals. This occlusion occurs in all species in which the plate sutures are visible, including *A. arnoldi* Clark, *A. vughani* (Jackson), *A. lamberti* Jeannet, *A. fernandesi* Sánchez Roig, and *A. sanchezi* Lambert.

Although genera of the Paleopneustidae are supposed to have double pores in their phyllodes (Chesher, 1968:159; Henderson, 1975:51), the pores are single in all the species of *Antillaster* in which the specimens are well-enough preserved to permit determination (see *A. lamberti*, p. 138).

Seventeen species have been described from Cuba, but only six are recognizable. Many of these 17 species appears to be synonyms. *A. depressus* Sánchez Roig, *A. expansus* Sánchez Roig, *A. guevarai* Sánchez Roig, and *A. herrerae* Sánchez Roig are considered synonyms of *A. vughani* Jackson. The Cuban species are from the Oligocene-Miocene of Camagüey and are all very similar in appearance.

A. habanensis (Sánchez Roig) is considered herein to be a synonym of *A. lamberti* Jeannet from Venezuela. Likewise, *A. jaumei* Sánchez Roig and *A. fernandesi* Sánchez Roig are too similar to be specifically separated. *A. arnoldi* Clark from

TABLE 6.—Disposition herein of Cuban species of *Antillaster*

Disposition	Miocene	Oligocene-Miocene	Eocene-Miocene	Eocene
Recognized species (Synonyms)	<i>A. cubensis</i> <i>A. sanchezi</i> (<i>A. flexuosus</i>)	<i>A. fernandezi</i> (<i>A. jaumei</i>) <i>A. lamberti</i> (<i>A. habanensis</i>) <i>A. voughani</i> (<i>A. depressus</i>) (<i>A. expansus</i>) (<i>A. guevarai</i>) (<i>A. herrerae</i>)	<i>A. arnoldi</i> (<i>A. rojasi</i>)	<i>A. albeari</i> ²
Unrecognizable species	<i>A. estenozzi</i>	<i>A. cartagensis</i> <i>A. giganteus</i>		
Referred to other genera		<i>A. brachypetalus</i> [to ? <i>Macropneustes</i>] <i>A. mortenseni</i> [to <i>Pericosmus</i>]		

¹ From Jamaica. ² New species.

Jamaica and *A. rojasi* Sánchez Roig are indistinguishable, as are *A. flexuosus* Sánchez Roig and *A. sanchezi* Lambert whose type specimens are from the same locality.

Three species, *A. estenozzi* Sánchez Roig, *A. cartagensis* Sánchez Roig, and *A. giganteus* were very poorly illustrated and their types are lost. No

suggestion can be made of their relationships with the other species. *A. mortenseni* Sánchez Roig has fascioles and is referred to *Pericosmus*, and *A. brachypetalus* Sánchez Roig is probably a *Macropneustes*. These assignments are summarized in Table 6, and the recognizable species are keyed below. One new species is described.

Key to Cuban Species of *Antillaster*

- 1. Test high, 3 genital pores, broad petals 2
Test low, 4 genital pores, petals narrow to broad 4
- 2. Interporiferous zones of petals narrow, equal in width to single poriferous zone **A. fernandezi** (Sánchez Roig), new combination
Interporiferous zones wide, twice width of single poriferous zone 3
- 3. Petals extending to margin **A. cubensis** (Cotteau)
Petals shorter, not reaching margin **A. lamberti** Jeannet
- 4. Test elongate, petals broad 5
Test wide, petals narrow 6
- 5. Poriferous zones flush **A. arnoldi** Clark
Poriferous zones depressed **A. albeari**, new species
- 6. Apical system anterior, anterior petals very divergent, almost 180 degrees **A. voughani** (Jackson), new combination
Apical system central, anterior petals not transverse **A. sanchezi** Lambert

***Antillaster albeari*, new species**

PLATES 80, 81

DIAGNOSIS.—Species characterized by large, wide, low test with depressed poriferous zones and slightly inflated interambulacra.

MATERIAL.—One very well-preserved specimen with no distortion in shape of test. Plate sutures not visible. Specimen ANSP 16631, Academy of Natural Sciences of Philadelphia.

SHAPE AND SIZE.—Length 137 mm, width 88% L, greatest width anterior; height 47% L, with greatest height posterior to center. Anterior notch well developed; margin smoothly rounded; ventral side not flat with peristome slightly depressed.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 30% L. Ethmolytic, with genital plate 2 extending posteriorly separating posterior ocular plates, 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, in groove extending from apical system and deepening to peristome; depth of notch at margin 2.2% L. Pores not enlarged dorsally, no large peripodia, presumably dorsal tubefeet were sensory.

Anterior petals (II and IV) long, extending to margin, curving very slightly anteriorly; length 49% L, width 11% L; very divergent, subtending an angle of nearly 180 degrees; posterior poriferous zones curving more anteriorly at end of petal than anterior poriferous zones. Interporiferous zones very wide, at greatest width nearly 3 times width of single poriferous zone, width 6.7% L. Poriferous zones depressed below general surface level of test, greatest width 2.8% L; pores strongly conjugate with deep furrow joining pores, with inner pore of pair slightly elongated transversely, outer pore greatly elongated; 134 porepairs in petal. Not possible to determine number of plate bearing first petaloid porepair.

Posterior petals (V and I) very long, extending to margin, straight, length 61% L, width 12% L. Interporiferous zones more than twice width of poriferous, narrowing slightly distally, greatest width 6.7% L. Poriferous zones with width 3.1% L; 158 porepairs in petal.

Plate sutures not clear; hence presence or absence of occluded plates at ends of petals not known. Pores beyond petals single.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 30% L. Opening large, width 15% L, height 4.5% L, labiate. Phyllodes well developed, pores single, 12 pores in ambulacrum III, 20 in II, 10–11 in I.

PERIPROCT.—Opening on very slightly overhanging truncation, not visible from above or below; higher than wide, height 13% L, width 9.9% L.

FASCIOLES.—None.

ORAL PLATE ARRANGEMENT.—Plate sutures not visible.

OCCURRENCE.—Middle to late Eocene, Palmer loc. 1003, N of Carretera Central, 2.1–2.2 mi (3.5 km), on road to San Diego de los Baños, Pinar del Rio Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species resembles most *Antillaster arnoldi* Clark from the Eocene? of Jamaica and possibly Oligocene-Miocene of Cuba. It differs in having a wider test with depressed poriferous zones and inflated interambulacral areas. In *A. arnoldi* the petals are flush with the general surface of the test and the interambulacra are not inflated.

Antillaster albeari also resembles *A. bonairensis* Pijpers from the late Eocene of Bonaire. The Cuban species differs in having a lower, wider test with a more vertically truncated posterior margin and petals with depressed poriferous zones.

***Antillaster arnoldi* Clark**

FIGURE 43; PLATE 82

Antillaster arnoldi Clark in Arnold and Clark, 1927:62, pl. 15: fig. 3, pls. 16, 17.—Sánchez Roig, 1949:186.

Antillaster rojasi Sánchez Roig, 1951:50, pl. 37: fig. 1, pl. 38: fig. 2.

The holotype of *A. rojasi* is virtually indistinguishable specifically from the holotype of *A. arnoldi* from Jamaica. Sánchez Roig noted the similarity between the two species but separated

them on the basis of the lower test and shorter and less distinct petals in *A. rojasi*. The test is lower, but this difference probably falls within the range of variation expected within a species. I do not see any difference between the species in the length of the petals or their distinctness.

OCCURRENCE.—Eocene, near Spring Mount, W of Springfield road, St. James Parish, Jamaica. Oligocene-Miocene, holotype of *A. rojasi* Sánchez Roig, "La Venturilla" farm, Realengo, Charco Hondo, Morón, Camagüey Province, Cuba. Sánchez Roig (1949:187) reports a specimen of *A. arnoldi* from the late Oligocene from "Santa Ana" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba. I have not seen this specimen.

SYNONYM

Antillaster rojasi Sánchez Roig

FIGURE 43; PLATE 82

MATERIAL.—One specimen, the holotype (SRC 4133), is very badly weathered and much of the test is broken away.

SHAPE AND SIZE.—Length 110 mm, width 79% L, height 51% L; greatest width anterior, greatest height central, posterior to apical system.

APICAL SYSTEM.—Four genital pores, ethmolytic, anterior of center at distance from anterior margin to center of genital pores equal to 29% L.

AMBULACRA.—Anterior ambulacrum III not petaloid, in slight groove; nature of adapical pores obscured by weathering and fracturing of test.

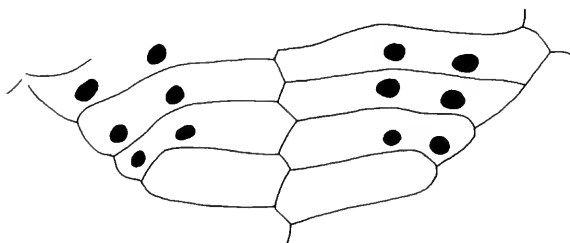


FIGURE 43.—*Antillaster arnoldi* Clark, end of petal I showing occluded plates in the holotype of *Antillaster rojasi* Sánchez Roig (= *A. arnoldi*), SRC 4133, $\times 4.5$.

Anterior petals (II and IV) extending to margin, length 49% L, greatest width near end of petal 14% L. Petals straight to very slightly curving anteriorly, flush with test; open, with interporiferous zone increasing in width distally with greatest width 6.0% L. Poriferous zone with greatest width two-thirds distance from apical system to end of petal where width 4.8% L; pores conjugate, outer pore elongate than inner; 98 petaloid porepairs. Test too weathered and fractured to permit determination of presence or absence of occluded plates.

Posterior petals (V and I) very long, extending to margin, length 64% L, width (est.) 14% L with greatest width near end of petal. Petals straight, flush, open with interporiferous zone increasing in width distally with greatest width 4.9% L. Poriferous zone with greatest width two-thirds distance from apical system to end of petal where width 4.7% L, zone narrowing sharply at end of petal; 134 petaloid porepairs. Last $3\frac{1}{2}$ plates in single poriferous zone of petal occluded (Figure 43), enclosed by first ambulacral plate beyond petal.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 26% L; opening deeply depressed, wider than high, width 13% L, height 5.4% L; lip large, pointed.

PERIPROCT.—Posterior region broken away.

FASCIOLAS.—None visible but test so badly weathered that they would not have been preserved had they been present originally.

ORAL PLATE ARRANGEMENT.—Sutures of labrum and plastron not clear. In interambulacrum 1 first plate followed by pair of plates.

OCCURRENCE.—Oligocene-Miocene, "La Venturilla" farm, Realengo Charco Hondo, Morón, Camagüey Province, Cuba.

Antillaster cubensis (Cotteau)

Asterostoma cubensis Cotteau, 1870:272; 1871:181, pl. 16: figs. 2–4, pl. 17: figs. 2–4; 1875:6, 46; 1881:27; 1897:67, pl. 21: figs. 1, 2.—Jackson, 1922:67.—Sánchez Roig, 1924a:32.
Antillaster cubensis (Cotteau).—Lambert in Lambert and Thiéry, 1924 [1909–1925]:440.—Lambert in Sánchez Roig, 1924a:43; 1926:92; 1949:185.—Mortensen, 1950, fig. 180.—Fischer, 1966, figs. 503, 504–4a, b.

Archaeopneustes cubensis (Cotteau).—Gregory, 1892:167.

Pseudoasterostoma cubensis (Cotteau).—Sánchez Roig, 1952b:5, pl. 1: fig. 1.

The holotype of this species is no longer in the Cotteau Collection.

OCCURRENCE.—Miocene, Matanza; "Cervantes" farm, San José de las Lajas, Habana Province, Cuba. I have studied the two specimens Cotteau (1875:46) reported from the Eocene of St. Bartholomew, but they cannot be referred with any certainty to this species or even to *Antillaster*. They are small fragments too badly weathered for identification.

***Antillaster fernandezi* (Sánchez Roig),
new combination**

PLATE 83

Pseudoasterostoma fernandezi Sánchez Roig, 1952b:6, pl. 6: fig. 1.

Antillaster jaumei Sánchez Roig, 1953a:64, pl. 15: fig. 2.

MATERIAL.—Only one specimen in collection, the holotype (SRC 4107). This specimen lacks its left side and posterior, most of its peristome, and oral surface. It is compressed and has been cut in two.

SHAPE AND SIZE.—Test 105 mm long, width (est.) 90–95 mm (86–91% L), height 60–65 mm (57–62% L); greatest height posterior to center. Oral surface flat.

APICAL SYSTEM.—Anterior of center, at distance from anterior margin to center of genital pores 32% L. Ethmolytic with narrow genital plate 2; 3 genital pores, no pore visible in genital plate 2.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove. Pores very small except in phyllodes where in peripodia. Width of ambulacrum midway between apical system and margin 10% L.

Anterior petals (II and IV) extending one-third distance from apical system to margin, length 50% L, greatest width 13% L. Petals straight, flush with test except for very shallow, narrow groove along middle of interporiferous zone; interporiferous zone at greatest width approxi-

mately same width as single poriferous zone, greatest width 3.0% L. Pores slightly conjugate with outer pore more elongate transversely than inner. Petal with 84 porepairs. Last 1½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

Posterior petals (V and I) extending one-third distance from apical system to margin, length 58% L, greatest width 12% L; petals straight; 92 porepairs.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome estimated at 22% L; no other features of peristome visible.

PERIPROCT.—Not preserved.

FASCIOLAS.—None.

ORAL PLATE ARRANGEMENT.—Most of oral surface absent.

OCCURRENCE.—Oligocene-Miocene, well in San Pedro, Habana Province, Cuba. The holotype of *Antillaster jaumei* Sánchez Roig is from the early Miocene, Somorrostro quarries, Habana, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from *Antillaster lamberti* Jeannet also from the late Oligocene-Miocene of Cuba (and Eocene? of Jamaica) by its much narrower petals with narrower interporiferous zones. The interporiferous zones in *A. fernandezi* are equal in width to a single poriferous zone; whereas in *A. lamberti*, they are twice the width of a poriferous zone.

REMARKS.—I can see no significant difference between the holotypes of *A. fernandezi* and *A. jaumei* (Sánchez Roig). Both are large, high specimens with broad petals of similar shape and length; both have only 3 genital pores.

SYNONYM

Antillaster jaumei Sánchez Roig

PLATE 83: FIGURES 3–5

MATERIAL.—There are only 2 specimens in the Sánchez Roig Collection, the holotype, and a second specimen that is crushed, not topotypic, and not used in this description. The holotype (SRC 4505) is badly weathered with little more

than one-half of the specimen preserved. The adoral surface is missing and the test is distorted, with the right anterior region depressed.

SHAPE AND SIZE.—Test estimated to be 110 mm long with width 100% L, height 64% L.

APICAL SYSTEM.—Position probably slightly anterior of center, at distance from anterior margin to center of genital pores 41% L (est.). Three genital pores, no pore in genital plate 2, ethmolytic with genital plate 2 extending far posteriorly (Plate 83: figure 4) separating posterior ocular plates.

AMBULACRA.—Anterior ambulacrum III not petaloid, in very slight groove. Dorsal region with double pores appears to be very short, less than 15 mm long, but test too weathered to be certain; near apical system porepairs near anterior edge of each plate. Greatest width of ambulacrum 12 mm.

Petals flush with surface of test, long, extending to margin (as viewed from above), wide and open distally with interporiferous zones equal to width of single poriferous zone; pores slightly conjugate, outer pore slightly more elongate than inner.

Anterior petals (II and IV) straight to slightly curving anteriorly, length 56% L, width 10% L, with 96 porepairs. Length of posterior petal unknown.

PERISTOME.—Not preserved.

PERIPROCT.—Not preserved.

FASCIOLAS.—None visible.

ORAL PLATE ARRANGEMENT.—Not preserved.

OCCURRENCE.—Early Miocene, Somorostro quarries, Habana, Habana Province, Cuba.

Antillaster lamberti Jeannet

FIGURE 44; PLATES 88, 89; PLATE 90: FIGURE 1

Antillaster lamberti Jeannet, 1928:36, pl. 4: figs. 14, 15.—Cooke, 1961:24, pl. 11: figs. 1, 2.—Henderson, 1975:52, fig. 11f.

Pseudoasterostoma habanensis Sánchez Roig, 1952b:6, pl. 5: fig. 1.

I have studied 4 specimens of this species from the late Miocene of Venezuela and have found no features that distinguish it from the holotype of *Antillaster habanensis* (Sánchez Roig) from Cuba.

Although the poriferous zones in the holotype of *A. lamberti* appear to be narrower than in the holotype of *A. habanensis*, this is probably only because the holotype of *A. lamberti* is more weathered. One of the specimens referred to *A. lamberti* by Cooke (1961:24), whose petals are well preserved, has poriferous zones as wide as in the holotype of *A. habanensis* (compare Plate 89: figure 1 to Plate 90: figure 1). Cooke's specimens came from rocks of the same age and region in Venezuela as the holotype of *A. lamberti* and are conspecific with it.

Henderson (1975:52, fig. 11f) observed that interambulacrum 1 in *A. lamberti* has its first plate followed by a single, unpaired plate. A similar plate arrangement is evident in one of the USNM specimens (USNM 362351) of this species, but a second specimen (USNM 638639) has two plates following the first.

Although the presence of double pores in the phyllode is considered a family character of the Paleopneustidae, the phyllodal pores in *A. lamberti* are definitely single. Cooke's figured specimen (USNM 638639) of this species has its phyllodes well preserved. The peripodia are very well developed with a single pore occurring in the adoral portion of each peripodia.

A strongly sculptured ridge occupies a large part of the peripodia. The shape of this ridge is difficult to describe in words but is well illustrated on Plate 87: figure 4 in a specimen of *Antillaster* sp. from the Miocene of Venezuela.

OCCURRENCE.—Miocene, La Vela beds, which according to Cooke (1961:24) and Eames and Savage (1975:363) are late Miocene. Sabanas Altas, Falcón (type, fide Jeannet), Venezuela. La Vigía, 10 km SW of Pueblo Nuevo, Paraguaná district, Falcón (Creole Petroleum Co. 7824), Venezuela. Cerro La Luz near Quebrada Larga, 3 km W of Pueblo Nuevo (Mene Grande Petroleum Co. B-6295), Venezuela. Oligocene-Miocene, holotype of *A. habanensis*, on margin of deep cut along hill approximately 1 mi (1.6 km) E of Casa Blanca, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *Antillaster fernandesi* Sánchez Roig and *A. jaumei* Sánchez Roig from Cuba in

having 3 genital pores and a large, very high test. It differs in having much wider interporiferous zones.

SYNONYM

Antillaster habanensis (Sánchez Roig)

FIGURE 44; PLATES 88, 89

MATERIAL.—Only one specimen, the holotype (SRC 4114), is known. This specimen is badly distorted by compression along the anteroposterior axis causing the apical system and the apical portions of the anterior petals to be pushed under the apical portions of the posterior petals. Furthermore, the area around the peristome is absent.

SHAPE AND SIZE.—Test estimated to have been approximately 120 mm long, width 108 mm (90% L) (est.); height 80 mm (67% L). Oral surface flat.

APICAL SYSTEM.—Absent, probably slightly anterior of center.

AMBULACRA.—Anterior ambulacrum III not petaloid; in very slight groove. Pores very small throughout dorsal portion of ambulacrum; pores paired, arranged parallel to length of ambulacrum; 48 plates. Width of ambulacrum midway between apical system to peristome 13% L.

Anterior petals (II and IV) extending four-fifths distance from apical system to margin; length 56% L; greatest width 16% L. Petals curving anteriorly, flush with test except for very slight groove running down middle of interporiferous zone; interporiferous zone at greatest width almost twice width of single poriferous zone, greatest width 6.1% L. Pores conjugate with outer pore greatly elongated transversely, almost slit-like. Last 1½ plates in single poriferous zone of petal occluded, enclosed by first ambulacral plate beyond petal.

Posterior petals (V and I) extending almost four-fifths distance from apical system to margin; length 59% L; greatest width 17% L; petals straight. Interporiferous zone at greatest width almost twice width of single poriferous zone,

greatest width 7.0% L; 102 porepairs in petal. Last 2½ plates in single poriferous zone of petal occluded (Figure 44B), enclosed by first ambulacral plate beyond petal.

PERISTOME.—Absent.

PERIPROCT.—Marginal on tilted truncation; width 14% L, height 12% L. Anterior edge of opening in interambulacral plate 4.

FASCIOLES.—None.

ORAL PLATE ARRANGEMENT.—Labrum destroyed, plastron mesamphisternous (Figure 44A).

OCCURRENCE.—Oligocene-Miocene, on margin of deep cut along hill approximately 1 mi (1.6 km) E of Casa Blanca, Habana Province, Cuba.

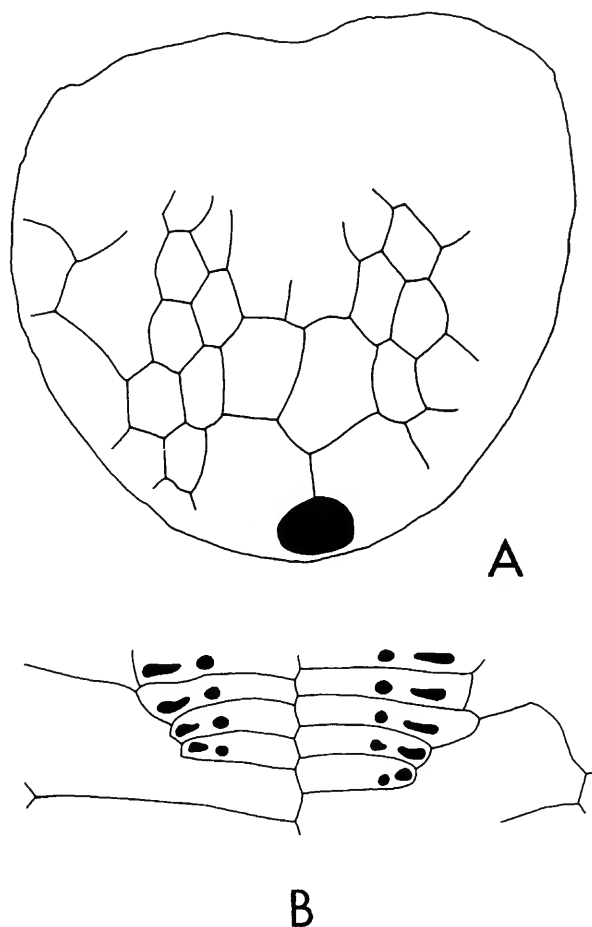


FIGURE 44.—*Antillaster lamberti* Jeannet, holotype of *Antillaster habanensis* (Sánchez Roig) (= *A. lamberti*), SRC 4114: A, ventral view, $\times 0.75$; B, end of petal V, $\times 4$.

***Antillaster sanchezi* Lambert**

PLATE 90: FIGURES 2–4

Mauritanaster cubensis—Sánchez Roig, 1924a, pl. 7 [not *Mauritanaster cubensis* Cotteau, 1875].

Antillaster sanchezi Lambert in Lambert and Thiéry, 1924 [1909–1925]:440.—Sánchez Roig, 1926:96, pl. 17: fig. 2, pl. 18: figs. 1, 2; 1949:184.

Antillaster flexuosus Lambert in Lambert and Thiéry, 1924 [1909–1925]:440.—Lambert in Sánchez Roig, 1924a:43; 1926:95, pl. 19: figs. 1, 2, pl. 20: figs. 1, 2, pl. 21: figs. 1, 2; 1949:183.

Antillaster castroi. Lambert in Sánchez Roig, 1924a:43, pl. 6: figs. 1, 2 [not *Antillaster castroi* Egozcue y Cía (name on label) in Cotteau, 1897:92, pl. 23].

MATERIAL.—The holotype is lost. Although topotypic specimens are in the Sánchez Roig Collection, they are too poorly preserved to permit writing a description of the species. One specimen (SRC 4511) has $3\frac{1}{2}$ plates occluded at the end of petal IV in the posterior poriferous zone (IVb) and in petal I $2\frac{1}{2}$ in poriferous zone Ia, $3\frac{1}{2}$ in Ib.

OCCURRENCE.—Although Sánchez Roig (1949:185) considered the type-locality of both *A. sanchezi* and *A. flexuosus* to be late Oligocene, Albear (1980, personal communication) places it in the early to middle Miocene. “Cervantes” farm, San José de las Lajas, Habana Province, Cuba.

COMPARISON WITH OTHER SPECIES.—This species is very similar to *A. vughani* (Jackson) from the Oligocene-Miocene of Cuba, Mexico, and Antigua in having a low test with narrow petals but appears to differ in having less divergent anterior petals and a more central apical system.

REMARKS.—This species is very similar to *Antillaster flexuosus* Lambert, which occurs at the same locality. Although the type specimens of both species are lost, Sánchez Roig's (1926) illustrations show them to have petals very similar in shape, length, and angle of divergence. Their apical systems appear to be similarly situated; their tests appear to have the same shape. They are herein considered synonyms.

SYNONYM

Antillaster flexuosus Lambert

The holotype and figured specimens are lost. Two specimens referred to this species are in the

Sánchez Roig Collection, but are too poorly preserved to classify on a specific level.

OCCURRENCE.—Although Sánchez Roig considered the type-locality to be late Oligocene, Albear (1980, personal communication) places it in the early or middle Miocene. “Cervantes” farm, San José de las Lajas, Habana Province, Cuba.

***Antillaster vughani* (Jackson),
new combination**

PLATES 84–86; PLATE 87: FIGURES 1–3

Eupatagus vughani Jackson, 1922:96, pl. 17: fig. 2, pl. 18: figs. 1, 2.

Eupatagus mexicanus Jackson, 1937:234, pl. 14, pl. 15: fig. 1.

Antillaster herrerae Sánchez Roig, 1951:49, pls. 27, 28.

Antillaster depressus Sánchez Roig, 1951:51, pl. 29.

Antillaster expansus Sánchez Roig, 1953a:63, pl. 18.

Antillaster guevarai Sánchez Roig, 1952b:9, pl. 4:figs. 1, 2.

I have studied specimens of *Eupatagus vughani* Jackson from the Oligocene-Miocene of Antigua, *Eupatagus mexicanus* Jackson from the Oligocene-Miocene of Mexico, *Antillaster herrerae* Sánchez Roig, *Antillaster depressus* Sánchez Roig, *Antillaster expansus* Sánchez Roig and *Antillaster guevarai* Sánchez Roig from the Oligocene-Miocene of Cuba and cannot distinguish them from each other.

The specimens labelled “*Antillaster giganteus* Sánchez Roig” in the Sánchez Roig Collection, also from the Oligocene-Miocene of Cuba, appear to be conspecific with *A. vughani*. However, because Sánchez Roig never figured *A. giganteus* and because these specimens are not topotypic, their identity cannot be verified.

The type specimens of *A. vughani* are not well enough preserved to show the presence of any fascioles. The holotype of *A. mexicanus* shows its tuberculation and no fascioles are present. Their absence confirms that these species should be referred to *Antillaster* not *Eupatagus*.

OCCURRENCE.—All are Oligocene-Miocene. Holotype of *A. vughani*, Antigua Formation, bluff on N side of Willoughby Bay, Antigua. Holotype of *A. mexicanus*, Meson Formation, S end of Cerro La Puerta, Hacienda Santa Fé, Topila, Canton Ozuluama, Veracruz, Mexico. Holotype of *A. herrerae*, “Santa Clara” farm, Loma La Calera,

Marroquín district, Morón, Camagüey Province, Cuba. A non-type specimen in the Sánchez Roig Collection is from "Ajocicado" farm, Chamban, Camagüey Province, Cuba. The topotype of *A. depressus* is from approximately 3 mi (4.8 km) SE of Arroyo Blanco, "Pantano Verde" farm, Camagüey Province, Cuba. The holotype of *A. guevarai* is from Loma Mendoza, Marroquín, Morón, Camagüey Province, Cuba. The topotypic specimen studied was from "El Maja" farm, Majaqua district, Ciego de Avila, Camagüey Province, Cuba.

SYNONYMS

Antillaster depressus Sánchez Roig

PLATE 85

MATERIAL.—The specimen labelled as the type is not the one figured by Sánchez Roig in his original description. The holotype is lost and a topotype (SRC 4501) is herein described. This specimen is slightly depressed anterior to the apical system. The ventral surface is fractured and the test is weathered.

SHAPE AND SIZE.—Test very large, length 144 mm, width 91% L, height 30% L. Posterior truncation overhanging making periproct visible from below. Greatest height is at apical system. Test may have been originally higher before postmortem distortion.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 35% L. Ethmolytic with genital plate 2 extending far posteriorly separating posterior ocular plates; 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid; porepairs in adapical region very small. Anterior petals (II and IV) long, extending to margin, length 40% L, width 8.3% L, open, curving anteriorly. Interporiferous zones at greatest width 1½ times width of single poriferous zone; pores conjugate, outer pore of pair elongated transversely; 96 porepairs in petal.

Posterior petals (V and I) long, extending to margin, length 54% L, greatest width 9.0% L. Interporiferous zone almost twice width single

poriferous zone; 122 porepairs in petal.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 27% L. Opening large, width 17% L, height 7.4% L. Phyllodes not clear because of poor preservation.

PERIPROCT.—Located on overhang of posterior margin, visible from below; width estimated at 11% L, height 13% L.

FASCIOLES.—None visible.

ORAL PLATE ARRANGEMENT.—Not discernible.

OCCURRENCE.—Oligocene-Miocene, approximately 3 mi (4.8 km) SE of Arroyo Blanco, "Pantano Verde" farm, Camagüey Province, Cuba.

Antillaster expansus Sánchez Roig

PLATE 86

MATERIAL.—The holotype is not in the Sánchez Roig Collection. One specimen (SRC 4480), labelled as the type, is not the specimen figured by Sánchez Roig. It is topotypic but is too poorly preserved to permit its selection as the neotype. Most of its adoral surface is absent, the periproctal region is broken away, and the apical region is badly fractured obscuring the character of the system.

OCCURRENCE.—Oligocene-Miocene, "El Maja" farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba.

Antillaster guevarai Sánchez Roig

FIGURE 45; PLATE 87: FIGURES 1-3

MATERIAL.—The holotype (SRC 4509) is a moderately well-preserved specimen with an undistorted test. The test is heavily weathered, the plate sutures enlarged, and most of the tubercles eroded away. Four other specimens are in the collection. They are either poorly preserved or not from type-locality and are not used in the following description.

SHAPE AND SIZE.—Test 87 mm long, width 90% L, height 39% L. Greatest width central, greatest height anterior.

APICAL SYSTEM.—Anterior, at distance from anterior margin to center of genital pores equal

to 30% L; ethymolytic with genital plate 2 extending far posteriorly separating posterior ocular plates (Figure 45D); 4 genital pores.

AMBULACRA.—Anterior ambulacrum III not petaloid, flush with test; pores in adapical region not markedly larger than at margin; width of ambulacrum at margin 7.9% L; 72 plates.

Anterior petals (II and IV) extending almost to margin, very divergent, curving slightly anteriorly, flush, length 41% L, width 9.9% L. Interporiferous zones narrow, equal in width to poriferous zones; pores conjugate, outer pore more elongate than inner; petal with 66 porepairs; first petaloid porepair in plate 21. No plates occluded at end of petal.

Posterior petals (V and I) extending four-fifths distance from apical system to margin, length 49% L, width 11% L; 84 porepairs in petal. Occlusion of plates at end of petal variable: in petal V, poriferous zone Va with $1\frac{1}{2}$ plates occluded, none in poriferous zone Vb (Figure 45B); in petal I $1\frac{1}{2}$ plates are occluded in zone Ia, none in Ib (Figure 45C). Pores beyond petals and in phyllodes appear to be single; but because of enlargement of pores by weathering, it is not possible to be certain.

PERISTOME.—Anterior, distance from anterior margin to anterior edge of peristome 23% L; opening large, width 19% L, height 6.6% L. Phyllodes large, apparently single pored, 17 pores in ambulacrum III, 25 in IV, 12 in V.

PERIPROCT.—Nor preserved.

FASCIOLAS.—None visible.

ORAL PLATE ARRANGEMENT.—Labrum large, length 9.5% L, width 11% L, extending back to third adjacent ambulacral plate. Plastron (Figure 45A) composed of 4 plates; first pair with (combined) length 33% L, width 29% L; second pair smaller with combined length 13% L, width 24% L. Interambulacrum 1 with first plate followed by pair of plates (Fig. 45A).

OCCURRENCE.—Oligocene-Miocene, Loma Mendoza, Marroquín, Morón, Camagüey Province, Cuba.

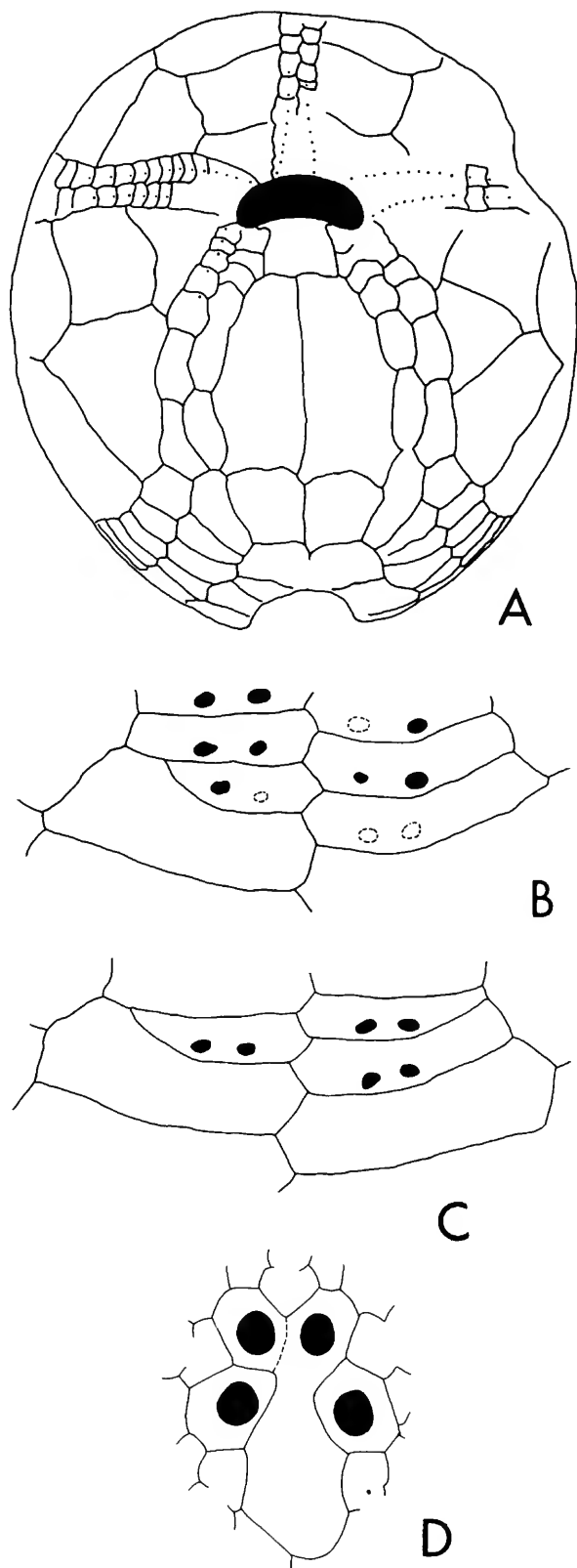


FIGURE 45.—*Antillaster vauhani* (Jackson), holotype of *Antillaster guevarai* Sánchez Roig (= *A. vauhani*), SRC 4509: A, ventral view, $\times 1$; B, end of petal V, $\times 6$; C, petal I, $\times 6$; D, apical system of SRC 4509, $\times 9$.

Antillaster herrerae Sánchez Roig

PLATE 84

MATERIAL.—The holotype (SRC 4469) has an undistorted test, which is weathered enough to reveal plate sutures.

SHAPE AND SIZE.—Length 126 mm, width 92% L, height 51% L; greatest width slightly anterior of center, greatest height posterior of apical system. Posterior truncation overhanging.

APICAL SYSTEM.—Anterior, located at distance from anterior margin to center of genital pores equal to 35% L. Ethmolytic, with genital plate 2 extending posteriorly between posterior ocular plates, 4 genital pores, with anterior pores closer together than posterior.

AMBULACRA.—Anterior ambulacrum III not petaloid, in faint groove from apical system to peristome; groove deepest at peristome. Adapical portion of ambulacrum covered with matrix; pores single adorally. Petals flush except for very slightly depressed poriferous zones; outer pore slightly more elongated than inner, slightly conjugate, open distally; petals extending almost to margin; pores decreasing in size at end of petals (Plate 84: figure 3).

Anterior petals (II and IV) curving slightly anteriorly, with length 50% L, greatest width 8.9% L, greatest width of interporiferous zone 4.5% L, poriferous zone 2.6% L.

Posterior petals (V and I) with length 60% L, greatest width 9.1% L, greatest width interporiferous zone 4.4% L, poriferous zone 2.9% L. Petal II with ~94 porepairs, petal V with ~112.

PERISTOME.—Anterior, located at distance from anterior margin to anterior edge of peristome equal to 21% L. Opening large, width 19% L, height 7.5% L; labiate. Phyllodes of ambulacra II and IV curved (Plate 84: figure 2); single pores in peripodia, 17 in ambulacrum III, 24 (est.) in IV, number in V not clear.

PERIPROCT.—On overhanging posterior truncation, slightly visible from below; width estimated at 17% L, height uncertain. Opening in plates 3–8.

FASCIOLAS.—None visible.

ORAL PLATE ARRANGEMENT.—Labrum large,

broad, width 13% L, height 11% L; extending posteriorly to middle of third or fourth (not clear which) adjacent ambulacral plate. Plastron composed of 4 plates, anterior 2 largest with length 29% L; posterior with length (est.) 17% L. Character of plates in interambulacrum 1 not clear on holotype; but on another specimen of this species, the first plate in interambulacrum 1 is followed by a pair of plates.

OCCURRENCE.—Oligocene-Miocene. "Santa Clara" farm, Loma La Calera, Marroquín district, Morón, Camagüey Province, Cuba. A non-type specimen in the Sánchez Roig Collection is from "Ajocicado" farm, Chamban, Camagüey Province, Cuba.

UNRECOGNIZABLE SPECIES OF *Antillaster**Antillaster cartagensis* Sánchez Roig

Antillaster cartagensis Sánchez Roig, 1949:188, pl. 22: fig. 2.

The holotype and only known specimen is lost.

OCCURRENCE.—Oligocene-Miocene, 1 km N of railroad SSE of Cartagena, Las Villas Province, Cuba.

Antillaster estenozi Sánchez Roig

Antillaster estenozi Sánchez Roig, 1949:189, pl. 22: fig. 1.

The holotype and only known specimen is lost. Sánchez Roig's illustration is not adequate to permit comparison of this species with others.

OCCURRENCE.—Although Sánchez Roig considered the type-locality to be late Oligocene, Albear (1980, personal communication) places it in the early or middle Miocene. "Cervantes" farm, San José de las Lajas, Habana Province, Cuba.

Antillaster giganteus Sánchez Roig

Antillaster giganteus Sánchez Roig, 1951:48.

The specimen labelled as the type (SRC 4868) does not correspond in its dimensions to those given by Sánchez Roig; neither is it from the type-locality. Because Sánchez Roig never figured

it, I cannot be certain that the specimens in the Sánchez Roig Collection belong to this species and therefore cannot redescribe the species.

OCCURRENCE.—Oligocene-Miocene, holotype from “Las Mercedes” farm, Majagua district, Ciego de Avila, Camagüey Province, Cuba. Other specimens in the Sánchez Roig Collection are from “El Maja” farm, Corral Concepción, Ciego de Avila, Camagüey Province, Cuba.

Genus *Moronaster* Sánchez Roig, 1952

Unfortunately no specimens of the two species that Sánchez Roig referred to this genus are available. These species were based on badly weathered specimens, and there is no way of knowing whether or not they had fascioles. The validity of the genus cannot be determined. From Sánchez Roig illustrations, the species appear to belong to either *Pericosmus* or *Antillaster*.

Moronaster moronensis Sánchez Roig

Moronaster moronensis Sánchez Roig, 1952b:14, pl. 9: figs. 1, 2.

No specimens of this species are now in the Sánchez Roig Collection or are known elsewhere.

OCCURRENCE.—Eocene, “Armadillo” farm, Marroquín district, Camagüey Province, Cuba.

Moronaster santanae Sánchez Roig

Brissolampas santanae Sánchez Roig, 1949:190, pl. 22: figs. 3, 4.

Moronaster santanae—Sánchez Roig, 1952b:15.

No specimens of this species are now in the Sánchez Roig Collection or are known elsewhere.

OCCURRENCE.—Eocene, “Santa Ana” farm, Marroquín district, Morón, Camagüey Province, Cuba.

Incertae Sedis

Genus *Brissopatagus* Cotteau 1863

Brissopatagus? rojasi Sánchez Roig

Brissopatagus rojasi Sánchez Roig, 1953c:164, pl. 9: figs. 5, 6.

The type specimen is no longer in the Sánchez Roig Collection and the other specimens are too poorly preserved to permit redescription of this species.

OCCURRENCE.—Late Eocene, Concepción Corral, Guadalupe district, Morón; “Armadillo” farm, Marroquín; “Santa Ana”, Marroquín, Morón, Camagüey Province, Cuba.

REMARKS.—Not enough is known of this species to be certain of its generic assignment. It lacks the large depressions in front of the anterior petals typical of *Brissopatagus* according to Henderson and Fell (1969:14).

Literature Cited

- Agassiz, L., and P. Desor
1847. Catalogue raisonné des espèces, des genres et des familles d'Echinines. *Annales des Sciences Naturelles, Zoologie* (Paris), series 3, 7:129-168; 8:4-35, 355-380, plates 15, 16.
- Arnold, B.W., and H.L. Clark
1927. Jamaican Fossil Echini, with Descriptions of New Species of Cainozoic Echinoidea by H.L. Hawkins. *Memoirs of the Museum of Comparative Zoology* (Harvard), 50(1):1-84, figures 1-3, plates 1-22.
1934. Some Additional Fossil Echini from Jamaica. *Memoirs of the Museum of Comparative Zoology* (Harvard), 54(2):139-156, plates 1-5.
- Baker, A.N.
1969. Two New Heart-Urchins, Including a New Species of *Cyclaster*, from New Zealand Waters (Echinoidea, Spatangoida). *Records of the Dominion Museum*, 6(16):265-273, figures 1-22, plates 1,2.
- Bather, F.A.
1934. *Chelonechinus* n.g., a Neogene Urechid. *Bulletin of the Geological Society of America*, 45(5):799-874, figures 1-18, plates 108-110.
- Bermúdez, P.J.
1961. Las formaciones geológicas de Cuba. *Geologia Cubana*, 1:1-177, figure 1.
- Bermúdez, P.J., and R. Hoffstetter
1959[1960]. Cuba et îles adjacentes. In R. Hoffstetter, editor, *Lexique Stratigraphique International*, volume 5 (Amérique Latine), fascicle 2c, 140 pages, 1 map. Paris: Centre National de la Recherche Scientifique.
- Brodermann, J.
1949. Significación estratigráfica de los Equinodermos fósiles cubanos. In M. Sánchez Roig, Los equinodermos fósiles de Cuba. *Paleontologia Cubana*, 1:305-330, 3 unnumbered tables.
- Brönnimann, P., and D. Rigassi
1963. Contribution to the Geology and Paleontology of the Area of the City of La Habana, Cuba, and Its Surroundings. *Eclogae Geologicae Helvetiae*, 56(1):193-480, figures 1-75, plates 1-26.
- Chesher, R.H.
1968. The Systematics of Sympatric Species in West Indian Spatangoids: A Revision of the Genera *Brissopsis*, *Plethotaenia*, *Paleopneustes*, and *Saviniaster*. *Studies in Tropical Oceanography* (Institute of Marine Sciences, University of Miami), 7:1-168, figures 1-25, plates 1-35.
1970. Evolution in the Genus *Meoma* (Echinoidea: Spatangoida) and a Description of a New Species from Panama. *Bulletin of Marine Science*, 20(3):731-761, figures 1-9.
- Conrad, T.A.
1850. Descriptions of One New Cretaceous and Seven New Eocene Fossils. *Proceedings of the Academy of Natural Sciences of Philadelphia*, series 2, 2:39-41, illustrations.
- Cooke, C.W.
1942. Cenozoic Irregular Echinoids of Eastern United States. *Journal of Paleontology*, 16(1):1-62, plates 1-8.
1948. Eocene Echinoids from Panama. *Journal of Paleontology*, 22(1):91-93, plate 22.
1959. Cenozoic Echinoids of Eastern United States. *United States Geological Survey Professional Paper*, 321:1-106, plates 1-43.
1961. Cenozoic and Cretaceous Echinoids from Trinidad and Venezuela. *Smithsonian Miscellaneous Collections*, 142(4):1-35, plates 1-14.
- Cortázar, D. De
1880. Descripción de un nuevo equinodermo de la Isla de Cuba, *Encope ciae* n. sp. *Comisión del Mapa Geológico de España, Boletín*, 7:227-232, plates G, H.
- Cotteau, G.H.
1870. Sur le genre *Asterostoma*, de la famille des Echinocorydées. *Comptes Rendus des Séances de l'Académie des Sciences*, 70:271-273.
1871. II: Notice sur le genre *Asterostoma*. *Société Géologique de France, Mémoire*, (2)9(2):177-184, plates 16, 17.
1875. Description des Echinides Tertiaires des îles St. Barthélemy et Anguilla. *Kongliga Svenska Vetenskaps-Akademiens Handlingar*, 13(6):1-47, plates 1-8.
1876. Echinides tertiaires des îles Saint-Barthélemy et d'Anguilla. *Bulletin de la Société Géologique de France*, (3)5:126-130.
1881. Description des échinides fossiles de l'île de Cuba. *Annales de la Société Géologique de Belgique*, 9(Mémoire 4):1-49, plates 1-4.
1897. Descripción de los equinoides fósiles de la Isla de Cuba por M.G. Cotteau, adicionada por D. Justo Egozcue y Cía. *Boletín de la Comisión del Mapa Geológico de España*, 22:1-99, plates 1-29.
- de Loriol, P.
1887. Notes pour servir à l'étude des Echinodermes. *Recheil Zoologie Suisse*, series 7, 1(4)365-407, plates 15-18.

- Desor, P.J.E.
1858. *Synopsis des échinides fossiles*. 490 pages, 44 plates. Paris & Wiesbaden.
- Dickerson, R.E., and W.S.W. Kew
1917. The Fauna of a Medial Tertiary Formation and the Associated Horizons of Northeastern Mexico. *Proceedings of the California Academy of Sciences*, series 4, 7(5):125–156, plates 17–26a.
- d'Orbigny, A.D.
1856. Echinodermes. In *Paléontologie Française*, series 1 (Terrains Crétacés), 6: 598 pages, plates 801–1006. [Completed by G. Cotteau.]
- Duncan, P.M.
1889. A Revision of the Genera and Great Groups of the Echinoidea. *Journal of the Linnean Society of London, Zoology*, 23(141):1–311.
- Durham, J.W.
1961. Miocene Echinoids from the Valle Central, Costa Rica. *Journal of Paleontology*, 35(3):480–488, figures 1, 2, plates 67, 68.
- Eames, F.E., F.T. Banner, W.H. Blow, and W.J. Clarke
1962. *Fundamentals of Mid-Tertiary Stratigraphical Correlation*. 163 pages, 17 plates. Cambridge, England: Cambridge University Press.
- Eames, F.E., and R.J.G. Savage
1975. The Sequence of Tertiary Faunas. In A.M. Davies, *Tertiary Faunas, A Text-Book for Oilfield Palaeontologists and Students of Geology*, volume 2, 447 pages, 34 figures, 4 tables. New York: American Elsevier.
- Fischer, A.G.
1951. The Echinoid Fauna of the Inglis Member, Moodys Branch Formation. *Florida Geological Survey, Geological Bulletin*, 34(2):49–101, figures 1–18, plates 1–7.
1966. Spatangoids. In R.C. Moore editor, *Treatise on Invertebrate Paleontology*, part U (Echinodermata 3), 2:U543–U628, figures 427–514. New York: Geological Society of America, Inc.
- Goldfuss, A.
1826. *Petrefacta [Germaniae:] Musei Universitatis Regiae Borussicae Rhenanae Bonnensis nec non Hoeninghusiani Crefeldensis*, 1(1):1–76, plates 1–25.
- Gordon, W.
1963. Middle Tertiary Echinoids of Puerto Rico. *Journal of Paleontology*, 37(3):628–642, figures 1–4, plates 79–81, table 1.
- Gray, J.E.
1855. *Catalogue of the Recent Echinida or Sea-Eggs in the British Museum, Part I: Echinida Irregularia*. iv + 69 pages, plates 1–6. London.
- Gregory, J.W.
1892. *Archaeopneustes abruptus*, a New Genus and Species of Echinoid from the Oceanic Series in Barbados. *Quarterly Journal of the Geological Society of London*, 48:163–169, plate 4.
- Guppy, R.
1882. On the Fossil Echinodermata of the West Indies. *Proceedings of the Scientific Association of Trinidad*, 2(4):193–199. [Reprint 1921, *Bulletin of American Paleontology*, 8(35):103–109.]
- Henderson, R.A.
1975. Cenozoic Spatangoid Echinoids from New Zealand. *New Zealand Geological Survey, Paleontological Bulletin*, 46:1–129, figures 1–17, plates 1–18.
- Henderson, R.A., and H. Fell
1969. *Taimanawa*, a New Genus of Brissid Echinoids from the Tertiary and Recent Indo-West Pacific with a Review of the Related Genera of *Brissopatagus* and *Gillechinus*. *Breviora*, 320:1–29, figures 1–3, plates 1–5.
- Jackson, R.T.
1918. Fossil Echini of the Panama Canal Zone and Costa Rica. *United States National Museum Bulletin*, 103:103–116, figures 1–3, plates 46–52.
1922. Fossil Echini of the West Indies. *Contributions to the Geology and Paleontology of the West Indies*, 306:1–103, figures 1–6, plates 1–18. Carnegie Institution of Washington.
1937. Mexican Fossil Echini. *Proceedings of the United States National Museum*, 84(3015):227–237, plates 12–15.
- Jeannet, A.
1928. Contribution à l'étude des Échinides Tertiaires de la Trinité et du Vénézuëla. *Mémoires de la Société Paléontologique Suisse*, 48:1–49, figures 1–12, plates 1–6.
- Kier, P.M.
1974. Evolutionary Trends and Their Functional Significance in the Post-Paleozoic Echinoids. *Journal of Paleontology*, 48(2) (Mémor 5):1–96, figures 1–78, table 1, chart 1.
1975. The Echinoids of Carrie Bow Cay, Belize. *Smithsonian Contributions to Zoology*, 206: 45 pages, 8 figures, 12 plates, 2 tables.
1980. The Echinoids of the Middle Eocene Warley Hill Formation, Santee Limestone, and Castle Hayne Limestone of North and South Carolina. *Smithsonian Contributions to Paleobiology*, 39: 102 pages, 26 figures, 22 plates.
- Kier, P.M., and R.E. Grant
1965. Echinoid Distribution and Habits, Key Largo Coral Reef Preserve, Florida. *Smithsonian Miscellaneous Collections*, 149(6):1–68, figures 1–15, plates 1–16.
- Lambert, J.M.
1915. Echinides néogènes des Antilles anglaises. *Société et Académie d'Agriculture, Sciences, Artes et Belles Lettres, Département de l'Aube, Mémoire*, 79:17–33, plate 3.
1922. Nouvelles observations sur quelques Echinides néogènes de l'île d'Anguilla. *The Annals and Magazine of Natural History*, series 9, 9:587–596, plate 9.

1928. Sur deux Echinides fossiles de Cuba. *Bulletin de la Société Géologique de France*, series 4, 28:19–21, figures 1, 2.
1932. Note sur le groupe des *Oligopygus*, la nouvelle famille des Haimeidae, et sur quelques Echinides fossiles de Cuba. *Bulletin de la Société Géologique de France*, series 5, 1(1931):289–304, 3 figures, plate 17.
- Lambert, J.M., and P. Thiéry
1909–1925. *Essai de nomenclature raisonnée des Echinides*. 607 pages, 15 plates. Chaumont: Librairie L. Ferrière.
- Lemoine, J.
1921. Abstract 314 Roig, Esqualidos del Mioceno y Plioceno de la Habana. *Revue de Géologie et des Sciences Connexes* (Liege), 2:121.
- Lewis, J.B.
1963. The Food of Some Deep-Water Echinoids from Barbados. *Bulletin of Marine Science of the Gulf and Caribbean*, 12/13(2):360–363.
- Lovén, S.
1874. Études sur les Echinoidées. *Kongliga Svenska Vetenskaps-Akademiens Handlingar*, new series, 11(7): 91 pages, 53 plates.
- McNamara, K.J., and G.M. Philip
1980. Australian Tertiary Schizasterid Echinoids. *Alcheringa*, 4:47–65, figures 1–9.
- In press. Large Fossil Spatangoid Echinoids from the Tertiary of Australia. *Palaeontographica*.
- Michelin, H.
1855. Sur les oursins vivants et fossiles des Antilles et du Golfe du Mexique. *Bulletin de la Société Géologique de France*, series 2, 12:756–759.
- Molengraaf, G.J.H.
1929. Beschrijving van de Echiniden uit het Boven-Eoceen van Curacao. In J.H. Gerard, *Geologie en Geohydrologie van het eiland Curacao*, pages 72–83, plates 24–28, maps. Delft: Drukkerij J. Waltman, Jr.
- Mortensen, T.
1950. Spatangoida. In T. Mortensen, *A Monograph of the Echinoidea*, 5(1): 432 pages, 315 figures, 25 plates. Copenhagen: C.A. Reitzel.
1951. Spatangoida. In T. Mortensen, *A Monograph of the Echinoidea*, 5(2): 593 pages, 286 figures, 64 plates. Copenhagen: C.A. Reitzel.
- Nichols, D.
1959. Changes in the Chalk Heart-Urchin *Micraster* Interpreted in Relation to Living Forms. *Philosophical Transactions of the Royal Society of London*, B(693)242:347–437, 46 figures, plate 9.
- Palmer, R.H.
1948. List of Palmer Cuban Fossil Localities. *Bulletins of American Paleontology*, 31(128):1–458, 2 maps.
- Parra, A.
1787. *Descripción de diferentes piezas de historia natural, las mas del ramo marítimo*. 195 pages, 75 plates. Havana.
- Pijpers, P.
1933. Geology and Palaeontology of Bonaire (D.W.I.). *Geographische en Geologische Mededeelingen* (Utrecht), 8:1–103, figures 1–157, plates 1, 2.
- Randazzo, A., and H. Saroop
1976. Sedimentology and Paleocology of Middle and Upper Eocene Carbonate Shoreline Sequences, Crystal River, Florida, U.S.A. *Sedimentary Geology*, 15:259–291, figures 1–12.
- Sagra, R. de la
1855. *Historia Física Política y Natural de la Cuba*. Volume 8 (Atlas de Zoología), part 2 (Paléontología).
- Sánchez Roig, M.
1920. Escualidos del Mioceno y Plioceno de la Habana. *Boletín de Minas*, 6:1–16, 27 figures, 12 plates.
- 1924a. Revision de los Equinidos fosiles cubanos. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 6:6–50, plates 1–7.
- 1924b. Neuvas especies de equinidos fosiles Cubanos. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 6:75–92, plates 8–14.
1926. Contribucion a la Paleontologia Cubana: Los Equinodermos Fósiles de Cuba, *Boletín de Minas*, 10:1–179, plates 1–43.
1949. Los equinodermos fosiles de Cuba. *Paleontologia Cubana*, 1:1–330, plates 1–50.
1951. Faunula de Equinodermos fosiles del Terciario, del termino municipal de Moron, Provincia de Camagüey. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 20(2):37–64, plates 23–40.
- 1952a. El genero *Cubanaster* (Equinidos fosiles irregulares). *Torreia*, 16:3–8, plates 1–3.
- 1952b. Nuevos generos y especies de Equinoideos fosiles Cubanos. *Torreia*, 17:1–18, plates 1–9.
- 1952c. Neuvos generos y especies de equinodermos fosiles Cubanos. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 21(1):1–30, plates 1–15.
- 1952d. Paleontologia Cubana: Revision de los Equinodermos Fosiles del Grupo Cassiduloida. *Memoria de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 21(1):47–57, plates 16–17.
- 1952e. Revision de los Clypeasteridos Cubanos. *Revista de Agricultura* (Habana), pages 118–155, plates 1–16.
- 1953a. Algunos Equinoideos fósiles Cubanos. *Revista de Agricultura* (Habana), pages 53–67, plates 1–21.
- 1953b. Dos nuevos generos de Equinoideos cubanos: *Lambertona* y *Neopatagus*. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 21(3):257–262, plates 27–29.

- 1953c. Neuvos equinodos fosiles de Cuba. *Anales de la Academis de Ciencias Medicas, Fisicas y Naturales de la Habana*, 91(2):135-176, plates 1-12.
- Serafy, D.K.
1979. Echinoids (Echinodermata:Echinoidea). *Memoirs of the Hourglass Cruises*, 5(3):1-120, figures 1-47, tables 1-30.
- Smith, A.B.
1980. The Structure, Function, and Evolution of Tube Feet and Ambulacral Pores in Irregular Echinoids. *Paleontology*, 23(1):39-83, figures 1-15, plates 1-6.
- Stephenson, D.C.
1963. The Spines and Diffuse Fascioles of the Cretaceous Echinoid *Echinocorys scutata* Leske. *Paleontology*, 6:458-470, 6 figures.
- Van den Bold, W.A.
1965. Middle Tertiary Ostracoda from Northwestern Puerto Rico. *Micropaleontology*, 11(4):381-414, figure 1, plates 1-7, tables 1-5.
- Wagner, C.D., and J.W. Durham
1966. Holasteroids. In R.C. Moore, editor, *Treatise on Invertebrate Paleontology*, part U (Echinodermata 3), 2:U523-U543, figures 414-426. New York: Geological Society of America, Inc.
- Weisbord, N.
1934. Some Cretaceous and Tertiary Echinoids from Cuba. *Bulletins of American Paleontology*, 20 (70C):165-270, plates 1-9.
- Zachos, L.
1968. A New Echinoid from the Ocala Limestone. *Quarterly Journal of the Florida Academy of Sciences*, 31(3):161-164, figure 1.
- Zachos, L., and G. Shaak
1978. Stratigraphic Significance of the Tertiary Echinoid *Eupatagus ingens* Zachos. *Journal of Paleontology*, 52(4):921-927, figures 1-6, plate 1, table 1.
- Žitt, J.
1981. *Aguayoaster* Sánchez Roig (Echinoidea) from Cuba. *Casopsis pro Mineralogii a Geologii*, 26(3):273-284, figures 1-3, plates 1-4.