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ABSTRACT: A sample dredged from a guyot on Nasca Ridge during the Scripps Institution of Oceanography expedition DOWNWIND to the southeastern Pacific contains fossil hermatypic corals indicative of post-Oligocene shallow tropical bottom conditions and a unique modern fauna. The four echinoids from this fauna represent genera which had not been recognized previously in the southeastern Pacific area. They include *Stereocidaris nascaensis*, new species; *Salenia scrippsae* Zullo and Allison, 1964 (described from this sample in an earlier paper); *Echinocyamus incertus* H. L. Clark, 1914; and a new genus and species of the family Asterostomatidae, *Scrippsechinus fisheri*, new genus, new species.

1. This is the fourth in a series of papers resulting from the Scripps Institution of Oceanography DOWNWIND Expedition, on the fauna of a guyot on Nasca Ridge (Hubbs, 1959; Zullo *et al.*, 1964; Zullo and Newman, 1964).

Introduction

The accelerating rate of oceanographic exploration which is evident in the massive array of literature published during the past two decades has produced many fundamental contributions to a comprehensive knowledge of the oceanology, geology, and biology of the submerged, or major, part of the earth's surface. Yet, great areas remain sparsely sampled and scarcely known. Oceanic areas of the southeastern Pacific are especially neglected. Bottom samples, other than sediment cores (Menard, 1964, fig. 13), have been taken from widely separated spots and leave much that is unknown.

A gross ignorance of the southeastern Pacific benthos inhabiting seamounts and guyots off the west coast of South America is suggested by the disproportionately large contribution to a knowledge of living Echinodermata made by the contents of a single dredge haul. Four echinoid species recovered by the University of California Scripps Institution of Oceanography expedition DOWNWIND are taxonomic and biogeographic novelties: they represent new or meagerly understood species belonging to higher taxa previously known only in areas remote from the southeastern part of the Pacific Ocean.

One of the species, *Salenia scrippsae* Zullo and Allison, 1964, has been described elsewhere (Zullo, Kaar, Durham, and Allison, 1964), *Stereocidaris nascaensis*, new species, represents a small group of *Stereocidaris* species, otherwise known only in Japanese waters, whose large globiferous pedicellariae bear a solitary end tooth. The third new species, *Scrippsechinus fisheri*, new genus and new species, is a member of the enigmatic family Asterostomatidae and is the only known member of the Order Spatangoida possessing adapically a considerable number of uniserial ambulacral plates. A fourth species, the clypeasteroid *Echinocyamus incertus* H. L. Clark, 1914, is recorded for the first time in the eastern Pacific.

The four species, represented by numerous specimens, were taken in a biological dredge sample, HD-73 (= University of California Museum of Paleontology locality B-6555) obtained by the Research Vessel *Horizon* on 26 January 1958, as that vessel participated in the 1957-1958 DOWNWIND cruise of the International Geophysical Year (Fisher, 1958). Reference to that sample henceforth will appear as "HD-73."

Location

Dredge sample HD-73 was taken from one of the many unnamed guyots between Isla de Pascua (Easter Island) and the South American mainland. The sampled guyot, called "Shoal Guyot" in an earlier publication (Zullo, Kaar, Durham, and Allison, 1964), is located near the juncture of Nasca Ridge with the Easter Island Fracture Zone (Menard, 1964), approximately 1540 kilometers distant from the coast of Chile and 550 kilometers N. 80° W.

from Isla San Felix. Its coordinates include longitude 85° 25' W. and latitude 25° 44' S., the reported location of HD-73. The breadth of the guyot where crossed by the ship is approximately 16 kilometers with a flat upper surface at a minimum depth of 210 meters. Slightly elevated edges of the guyot, with approximate summit depths of 205 meters on the southwestern side (the side approached by the R. V. *Horizon* during its dredging run) and 210 meters on the northeastern side, suggest a rimmed feature. Sample HD-73 was recovered from the central part of the guyot surface, inside of the elevated edges. The length of the dredging run was approximately 3 kilometers, at depths ranging from 227 meters to about 210 meters.

A second sample, HD-72, was dredged earlier during the same day from another Nasca Ridge prominence located a few kilometers to the northeast of the guyot from which HD-73 was recovered. Coordinates of HD-72 are longitude 85° 14' W. and latitude 25° 31' S. Depths recorded during the dredging run range from about 950 meters to 870 meters, possibly representing the southern flank of a northward shoaling feature. Notes concerning the fossils from that sample are presented in the preliminary expedition report (Fisher, 1958).

January water temperatures at 200 meters in the vicinity of both sample localities are indicated as near 14° C. by interpolation of data from nearest hydrographic casts (Fisher, 1958). Surface temperatures are near 22° C.

Contents of HD-73

Sample HD-73 was reported at the time of its recovery to consist of "50-100 lbs." of shell debris including "...hundreds of live pelecypods, limas, a few pectens, large gastropods, brachiopods, and gorgonians." Noted also were "...a few pieces of coral and much calcareous rock." (Fisher, 1958). No sediment sample was taken but gut contents of specimens of one of the echinoid species, described below, provide clues to the nature of modern sediments on and around the guyot. Neither sample HD-73 nor HD-72 contained volcanic rocks. The organic contents of HD-73 are listed on table 1.

Echinoids from HD-73 are preserved in the type collection of the University of California Museum of Paleontology, Berkeley (type numbers are given with descriptions of individual species). Some of the coralline algae and the coral debris are stored in the general collections (as locality B-6555) of the same institution. Additional calcareous debris is held by the University of California Scripps Institution of Oceanography at La Jolla. Types of the barnacles (Zullo and Newman, 1964) are in type collections of the University of California Museum of Paleontology and the United States National Museum. Other crustaceans and echinoderms are stored in collections of the University of Southern California, Allan Hancock Foundation, Los Angeles. A fish incidentally captured in the HD-73 rock dredge sample (Hubbs,

1959) is in the ichthyological collections of Scripps Institution of Oceanography. The present location of sorted mollusks from this sample is unknown.

Fossils

Indurated corals, coralline algae, and part of the mollusk shell debris of HD-73 probably represent a fossil reef assemblage. The recorded dredging depth (between 227 and 210 meters) and the local minimum "rim" depth of the guyot (205 meters) exceed the known living range of comparable modern reef faunas, but the contents of the sample, as well as the physiography of the feature, offer unmistakable evidence of a drowned island or bank, possibly an atoll.

The most abundantly represented coral genera, identified by Durham as *Leptoseris, Pocillopora,* and *Porites,* are not known to live together at depths greater than 40 meters (Clipperton Island), although *Leptoseris* and *Porites* have depth ranges which extend downward to at least 110 meters and 55 meters, respectively (Wells, 1954). A few specimens of a fourth genus, *Stylophora,* exhibit a relatively fresh appearance which suggests that they are younger than the rest of the coral assemblage. Possibly *Stylophora* still lives in the area on an unrecorded though unlikely shallow prominence on the guyot surface. Possibly this occurrence represents a greater depth than has been recorded for the genus (45 meters) or for other hermatypic corals (?155 meters). Cool water temperatures at depths comparable to that of the guyot's surface suggest that the last alternative is least likely, if *Stylophora* still lives there.

An additional hermatypic coral genus occurs on an adjacent Nasca Ridge prominence in Sample HD-72. That genus is *Plesiastrea* [*Plesiastrea* sp., *cf. P. versipora* (Lamarck, 1816)] which was reported by J. W. Wells (Fisher, 1958) to occur with *Porites* and *Stylophora* [*S. pistillata* (Esper, 1797)]. *Plesiastrea* does not occur in the material examined by us.

Diverse states of preservation exhibited by corals from sample HD-73 suggest that they are not all of the same age. Indeed, some, such as *Stylophora,* may still live on the guyot. A more careful analysis of the precise identity of these corals will be required before a decision can be reached concerning their significance as evidence for the earliest occurrence of shallow water in that area and thus as evidence of the history of Nasca Ridge.

The reported identity of corals from HD-72 is more revealing. *Stylophora pistillata* (Esper, 1797) ranges from Middle Miocene to Recent in the Indo-Pacific (Wells, 1964). The genus *Plesiastrea* is not known to occur in rocks older than Miocene anywhere. Manganese nodules bearing late Tertiary calcareous ooze are reported in a dredge sample from Nasca Ridge (Fisher, 1958), but neither the criteria for this age determination nor the exact location of the sample is presented in the preliminary expedition report.

TABLE 1. *The contents of HD-73* (Taxa represented by living specimens or interpreted as modern unless indicated otherwise)

ALGAE:	Unidentified coralline algae (? fossil)	
FORAMINIFERS:	*Homotrema.*	
	Sedimentary gut contents of *Scrippsechinus fisheri*, new genus and new species, consists mostly of planktonic species.	
CORALS:	*Stylophora* (? fossil) [HD-72 specimens identified as *Stylophora pistillata* (Esper, 1797)]	
	Pocillopora (fossil)	
	Leptoseris (fossil)	
	Porites (fossil)	
BRYOZOANS:	Not identified	
ANNELID WORMS:	Encrusting calcareous tubes not identified (living?)	
MOLLUSKS:	*Turbonilla (Strioturbonilla)*	*Glycymeris* (? living)
	Xenophora (? living)	*Ctena* (?living)
	Colus	*Acesta*
	Pteropods in gut contents of *Scrippsechinus fisheri*, new genus and new species	
	Arcopsis (? living)	
CIRRIPEDIA:	*Megalasma (Megalasma) elegans* Newman, 1964	
	Heteralepas mystacophora Newman, 1964	
	Verruca (Verruca) scrippsae Zullo, 1964	
	Balanus (Solidobalanus) nascanus Zullo, 1964	
DECAPODA:	Unidentified	
ECHINOIDEA:	*Salenia scrippsae* Zullo and Allison, 1964	
	Stereocidaris nascaensis, new species	
	Echinocyamus incertus Clark, 1914 (from gut contents of *Scrippsechinus fisheri*, new genus and new species	
	Scrippsechinus fisheri, new genus and new species	
PISCES:	*Pterygotrigla picta* (Gunther, 1880)	

MODERN FAUNA

The modern fauna sampled by HD-73 consists of both living and nonliving specimens. A great abundance of fresh shells of certain species is interpreted as evidence that those species still live in the area, although no living specimens happened to have been taken.

Foraminiferida: Adherent tests of the genus *Homotrema* appear to represent the only foraminifers which might have been living when taken in the dredge haul. Tests of foraminifers, almost entirely planktonic, which are the major part of the gut contents of the new asterostomatid echinoid described below, also must represent largely species now living on the bottom and in the overlying water column.

Bryozoa: Delicate bryozoans encrusting some of the shell debris of HD-73 certainly represent the living fauna of that area. They have not been identified.

Annelida: Calcareous tubes of unidentified serpulid worms are attached to many shell surfaces.

Mollusca: Living specimens of the gastropods *Turbonilla (Strioturbonilla)* and *Colus* and of the bivalve *Acesta* are recorded in the notes of Allison taken during the preliminary sorting of HD-73. Disassociated valves of *Acesta* are noted as abundant. Non-living mollusks recorded at that time include a few specimens each of *Xenophora*, *Arcopsis*, and *Glycymeris*. Numerous pteropods are associated with the planktonic foraminifers of the echinoid gut contents.

Crustacea: The recently described barnacle fauna of HD-73 (Zullo and Newman, 1964) consists of four species belonging to three suborders. The suborder Lepadomorpha includes *Megalasma (Megalasma) elegans* Newman, 1964, and *Heteralepas mystacophora* Newman, 1964, of this sample. The suborders Verrucomorpha and Balanomorpha are represented respectively by *Verruca (Verruca) scrippsae* Zullo, 1964, and *Balanus (Solidobalanus) nascanus* Zullo, 1964. Closest relatives of these species are distributed generally in the Indo-Pacific province. The study of decapod crustaceans of HD-73 has not yet been completed.

Echinoidea: The class Echinoidea is represented in HD-73 by specimens of the recently described *Salenia scrippsae* Zullo and Allison, 1964, and numerous specimens of *Echinocyamus incertus* Clark, 1914, a new species of *Stereocidaris*, and a new species placed in a new genus, *Scrippsechinus*, assigned to the family Asterostomatidae. None of these genera previously has been recorded validly from modern faunas of the eastern Pacific *(Echinocyamus terminalis* Grant and Hertlein, 1938, from Guadalupe Island off northwestern Mexico, is a small representative of the clypeasteroid genus *Dendraster).* All (12) of the Nasca Ridge *Echinocyamus* specimens came from the gut contents of specimens of *Scrippsechinus fisheri*, new genus and new species. None was found in the calcareous debris of comparable size taken in the same dredge haul.

Pisces: HD-73 yielded a single triglid fish (Hubbs, 1959) identified as *Pterygotrigla picta* (Günther, 1880). According to Hubbs, that species is known from Isla Juan Fernández, located south of Nasca Ridge, and from the New Zealand and Australian area.

History of Guyot and Relationships of Faunas

A truncated upper surface, apparently composed entirely of calcareous rock, and fossil hermatypic corals dredged from the central part of that sur-

face indicate past shallow marine conditions over the Nasca Ridge guyot sampled by HD-73. Well's identifications of *Stylophora pistillata* (Esper, 1797) and *Plesiastrea* among hermatypic corals of HD-72 further indicate that such shallow-water conditions have existed in the area at least once since the Oligocene Epoch. Fossil and modern faunal elements of HD-73, furthermore, suggest that a series of shallow-water "stepping stones" once linked Nasca Ridge with the far western Pacific, probably by way of Easter Island and drowned features of the Easter Island Fracture Zone.

The 205-230 meter depths recorded on the upper surface of the sampled guyot exceed the depth at which marine erosion could have been effective during lowered Pleistocene sea levels (100-150 meters below the present sea level) and are below the maximum depth at which reef building processes might effectively produce such a feature (15-25 meters for modern reefs and atolls). A combined affect of both factors (maximum depth 175 meters) is both insufficient and unlikely.

Two possible explanations for the present depth of the guyot's upper surface remain. A volume of water displaced by rising of existing oceanic ridges and rises, just one of the factors which might have altered the capacity of ocean basis through the Cenozoic Period, has been calculated as sufficient to produce a 200 meter elevation of sea level (Menard, 1964). The validity of this possible explanation can be tested by a precise comparison of the age of shallow-water fossils on the guyot with times of general inundation of oceanic islands and structurally stable border areas, but the details of these chronologic relationships are not known now. Such an explanation, if valid, can account for this, the shallowest of several identified and questionably identified Nasca Ridge guyots. Flat tops of other guyots, at approximately 320 and 400 meters (Fisher, 1958) are at depths exceeding the theoretical limits of such a mechanism for late Cenozoic sea level rise. Subsidence of once emergent or shallowly submergent islands or banks is, therefore the most likely explanation for the guyots of Nasca Ridge, including the one from which the sample discussed here (HD-73) was taken. Determination of the extent and time of that subsidence will require the sampling of others of the probably related guyots of Nasca Ridge.

Biogeographic relationships of taxa thus far recognized in the fossil and modern contents of HD-73, and reported in the contents of a related sample HD-72, are clearly with western Pacific areas. Many of the organisms have known living depth ranges restricted to shallow water, in some cases seemingly shallower than that from which they were dredged alive in HD-73. The trans-Pacific dispersal of these elements must have taken place at a time (post-Oligocene) when other islands and banks existed in intermediate areas. A poorly known line of seamounts extending westward from Nasca Ridge to near the southeastern edge of the Tuamotu Archipelago

(Fisher, 1958), and including Easter and Sala y Gomez islands, presents a possible drowned dispersal route along which "stepping stones" might once have been available for successive colonization and radiation of depth restricted organisms. The high incidence of endemism in what is known of the modern Easter Island marine fauna and the uniqueness of certain living elements of HD-73, such as the echinoids described here, suggest that such a dispersal route is no longer available for many organisms.

Problems concerning the geologic history of the sampled Nasca Ridge guyot and the biogeographic history of its faunas will be resolved with precision only when the entire southeastern Pacific area is better understood. The availability of a critical and widely applicable chronologic system, such as that which may be available in the Upper Cenozoic succession of planktonic foraminifers, will provide a necessary perspective in the attainment of these goals. The completion of studies of already available dredged samples and of additional samples taken at locations determined to be critical promise provocative and rewarding reviews of these problems in the future.

FIGURE 1. *Stereocidaris nascaensis*, new species; aboral view of holotype UCMP 36587, locality B-6555 (×.94).

FIGURE 2. *Stereocidaris nascaensis*, new species; oral view of holotype UCMP 36587, locality B-6555 (×.94).

FIGURE 3. *Stereocidaris nascaensis*, new species; aboral view of paratype UCMP 36588, locality B-6555 (×.94).

FIGURE 4. *Stereocidaris nascaensis*, new species; oral view of paratype UCMP 36588, locality B-6555 (×.94).

FIGURE 5. *Echinocyamus incertus* H. L. Clark, 1914; oral view of hypotype UCMP 36579, locality B-6555 (×7.0).

FIGURE 6. *Echinocyamus incertus* H. L. Clark, 1914; aboral view of hypotype UCMP 36579, locality B-6555 (×7.0).

FIGURE 7. *Echinocyamus incertus* H. L. Clark, 1914; oral view of hypotype UCMP 36580, locality B-6555 (×7.0).

FIGURE 8. *Echinocyamus incertus* H. L. Clark, 1914; aboral view of hypotype UCMP 36580, locality B-6555 (×7.0).

FIGURE 9. *Echinocyamus incertus* H. L. Clark, 1914; oral view of hypotype UCMP 36581, locality B-6555 (×7.0).

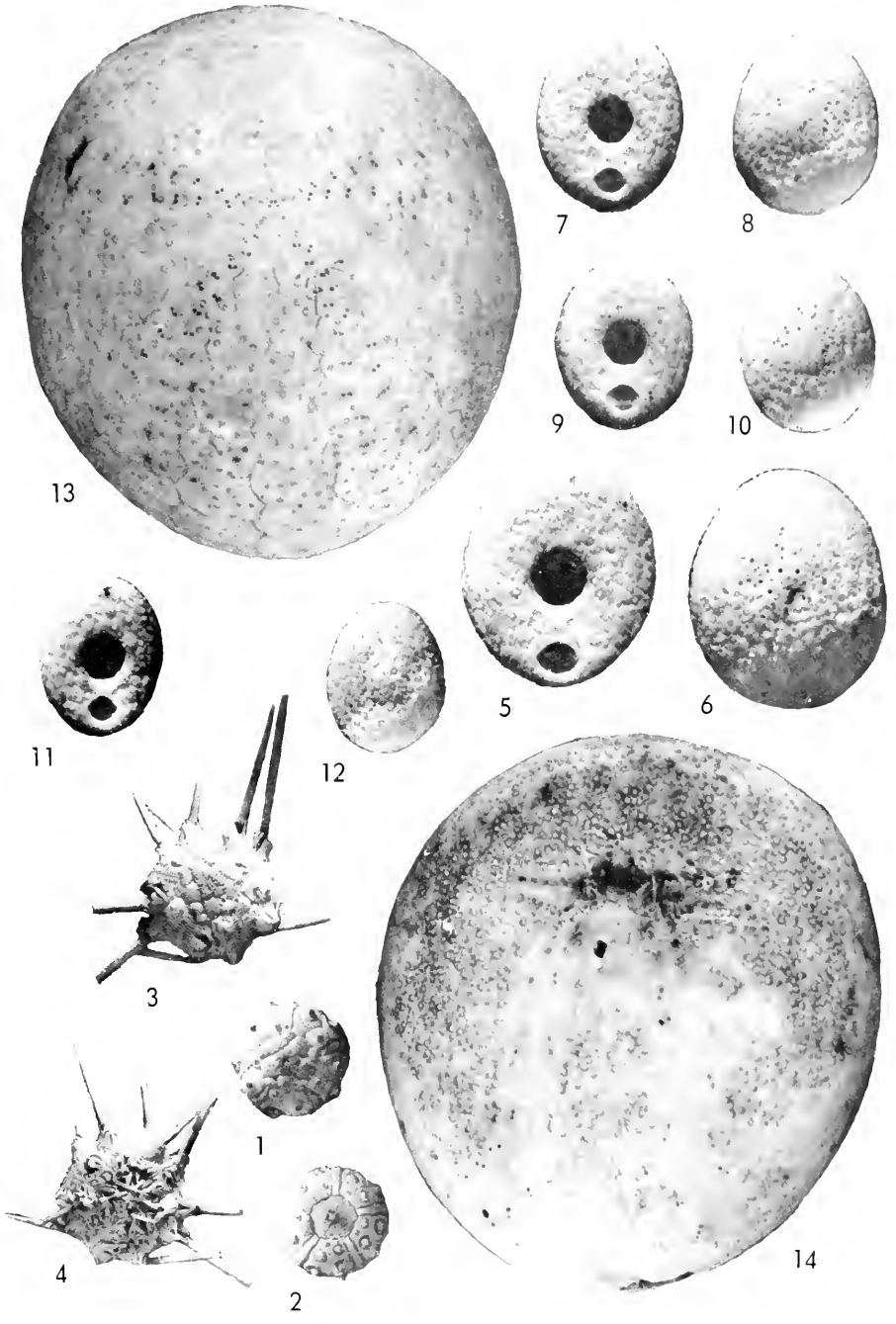
FIGURE 10. *Echinocyamus incertus* H. L. Clark, 1914; aboral view of hypotype UCMP 36581, locality B-6555 (×7.0).

FIGURE 11. *Echinocyamus incertus* H. L. Clark, 1914; oral view of hypotype UCMP 36582, locality B-6555 (×7.0).

FIGURE 12. *Echinocyamus incertus* H. L. Clark, 1914; aboral view of hypotype UCMP 36582, locality B-6555 (×7.0).

FIGURE 13. *Scrippsechinus fisheri*, new genus and new species; aboral view of paratype UCMP 36578, locality B-6555 (×1.3).

FIGURE 14. *Scrippsechinus fisheri*, new genus and new species; oral view of paratype UCMP 36578, locality B-6555 (×1.3).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Systematic descriptions

Class ECHINOIDEA Leske, 1778

Subclass PERISCHOECHINOIDEA McCoy, 1849

Order CIDAROIDA Claus, 1880

Family Cidaridae Gray, 1825

Subfamily Stereocidarinae Lambert, 1900

Genus **Stereocidaris** Pomel, 1883

Stereocidaris nascaensis Allison, Durham, and Mintz, new species.

(Figures 1-4; 15-20.)

Diagnosis. *Stereocidaris* with very large peristome; each ambulacral plate with obliquely oriented pore pairs bordered by interporiferous tubercle triad of large inner tubercle, slightly smaller marginal tubercle, and much smaller interposed miliary tubercle; globiferous pedicellariae including common small form with end tooth and rare large form with widely gaping distal tip.

Description. Test small, depressed (diameter 1.6 × height), with flat oral surface and slightly convex aboral surface.

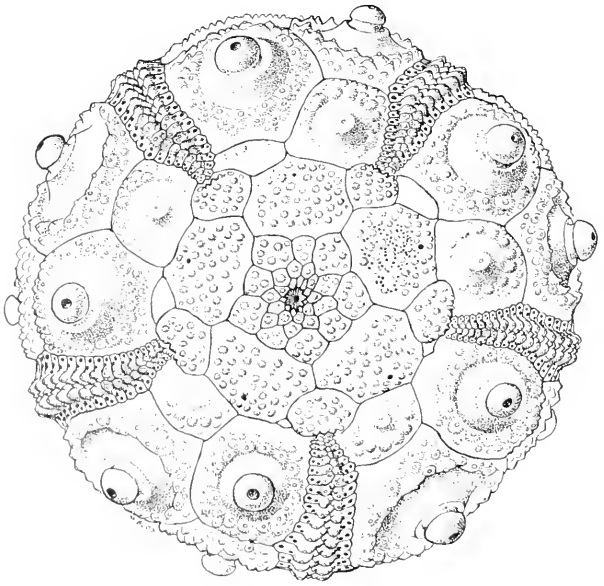
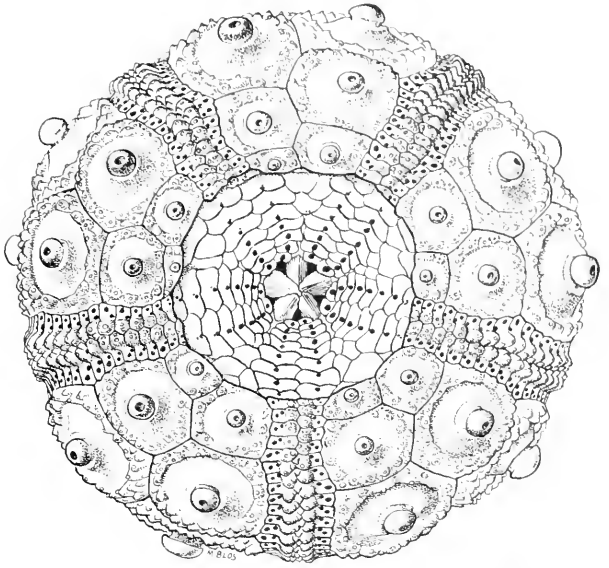


Figure 15. *Stereocidaris nascaensis*, new species; aboral (apical) view of [illegible] UCMP 36587, locality B-6555 (×4.0).



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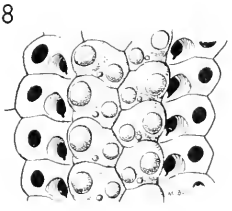

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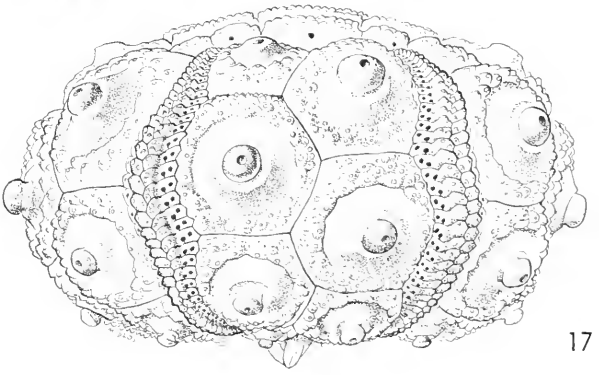

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FIGURE 16. *Stereocidaris nascaensis*, new species; oral view of holotype UCMP 36587, locality B-6555 (×4.0).

FIGURE 17. *Stereocidaris nascaensis*, new species; lateral view of holotype UCMP 36587, locality B-6555 (×4.0).

FIGURE 18. *Stereocidaris nascaensis*, new species; ambulacral plates at ambitus of holotype UCMP 36587, locality B-6555 (×10.0).

Ambulacra sinuate, 1/3 width of interambulacra at ambitus; interporiferous areas 1/2 width of ambulacra, with 3 rows of tubercles consisting of large inner tubercles, slightly smaller marginal tubercle, and much smaller miliary tubercle between (fig. 18); pores of equal size, widely separated in pairs oriented obliquely to suture (fig. 18); neuropores present.

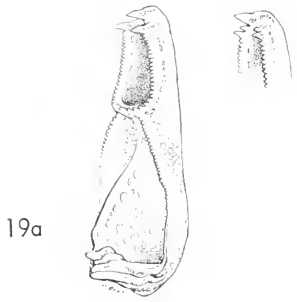

FIGURE 19. *Stereocidaris nascaensis*, new species; small globiferous pedicellariae, holotype UCMP 36587a (figure 19a), and holotype UCMP 36587b (figure 19b), locality B-6555 (× 235.0)

FIGURE 20. *Stereocidaris nascaensis*, new species; rare form of large globiferous pedicellaria, holotype UCMP 36587c, locality B-6555 (× 150.0).

Interambulacra of 4-5 plates per column, higher than wide adapically, with raised horizontal sutures adapically (figs. 1, 15); tubercles non-crenulate, surrounded by deep and widely separated areoles; scrobicular tubercles slightly larger than secondary tubercles, secondary tubercles smallest near plate margins (figs. 15, 16, 17).

Apical system inflated, with diameter 1/2 ambital diameter; ocular plates all exsert; genital plates broader than high, with very small genital pores; all apical system plates covered by numerous, small, rudimentary tubercles (fig. 15).

Peristome prominent, with diameter slightly more than 1/3 ambital diameter (35-40 per cent), covered by numerous small plates (fig. 16).

Primary spines large, length possibly two times greater than test diameter, cylindrical, slightly tapered distally; surface delicately sculptured by 10 or 11 longitudinal knobby ridges formed by rows of closely spaced nodes (figs. 3, 4).

Scrobicular spines spatulate, closely arranged around bases of primary spines; secondary marginal and ambulacral spines about 1/3 to 1/2 major scrobicular spines in size, not so distinctly flattened; central oral spines slender, densely arranged over peristomal area; apical spines small, short, spatulate.

Pedicellariae of globiferous forms only; small pedicellariae with distinct end tooth (fig. 19a-b); larger forms with very weak end tooth; rare form of large globiferous pedicellariae with widely expanded opening continuous to distal extremity of valve (fig. 20).

Color of alcohol-preserved specimens faded; probably buff with purplish bases of primary spines.

DISTRIBUTION. Nasca Ridge, 210-227 meters (HD-73).

DIMENSIONS OF TYPES (UNIVERSITY OF CALIFORNIA MUSEUM OF PALEONTOLOGY).

Holotype UCMP 36587 (figs. 1, 2, 15-20). Test with spines removed: height 10.9 mm., diameter 17.3 mm., peristome diameter 6.9 mm.

Paratype UCMP 36588 (figs. 3, 4). Test with spines in place: height 13.0 mm., diameter 19.5 mm.

Holotype UCMP 36587a (fig. 19a). Valve of small globiferous pedicellaria from holotype (UCMP 36587): length .16 mm.

Holotype UCMP 36587b (fig. 19b). Valve of small globiferous pedicellaria from holotype (UCMP 36587): length .19mm.

Holotype UCMP 36587c (fig. 20). Valve of rare form of large globiferous pedicellaria from holotype UCMP 36587): length .41 mm.

REMARKS. The new Nasca Ridge species is assigned to the genus *Stereocidaris* on the basis of the following features: rudimentary apical primary tubercles; incised aboral interambulacral sutures; widely separated scrobiculae on adjacent interambulacral plates; sinuate ambulacra.

The genus *Stereocidaris* has a stratigraphic record extending into the Cretaceous System and is represented by many species in modern seas. Almost all of the living species are restricted to the Indo-Pacific area; no living examples of *Stereocidaris* have been reported previously from eastern Pacific areas.

Most species of *Stereocidaris* have globiferous pedicellariae lacking the end tooth which occurs on small pedicellariae of *S. nascaensis*, new species. Two exceptional species, sharing these pedicellariae characteristics with *S. nascaensis*, new species, are *S. sceptriferoides* (Doderlein, 1887) and *S. japonica* (Doderlein, 1885) which live off Japan at depths from 70 to 700 meters (Mortensen, 1928, pp. 225-284). *Stereocidaris nascaensis* can be distinguished from these species by its characteristic ambulacral tubercle pattern, very large peristome, and peculiar large globiferous pedicellariae.

Subclass EUECHINOIDEA Bronn, 1860

Superorder ECHINACEA Claus, 1876

Order SALENIOIDA Delage and Hérouard, 1903

Family Salenidae Agassiz, 1838

Subfamily Saleninae Agassiz, 1838

Genus **Salenia** Gray, 1835

Salenia scrippsae Zullo and Allison, 1964.

Salenia scrippsae Zullo and Allison, 1964, pp. 339-343, pl. 56, figs. 1-4, text figs. 3-4.

Diagnosis. Living *Salenia* with partially bigeminate ambulacral plates, complexly sculptured apical system, and tricolour banded primary interambulacral spines which are longitudinally ribbed but not verticillate.

Distribution. Nasca Ridge (HD-73).

The specimens of this species, known only from HD-73, have been described separately (Zullo, *et al.*, 1964). These specimens are catalogued in the type collection of the University of California Museum of Paleontology as UCMP 30756 through 30763.

Superorder GNATHOSTOMATA Zittel, 1879

Order CLYPEASTEROIDA A. Agassiz, 1873

Suborder Laganina Mortensen, 1948

Family Fibulariidae Gray, 1855

Genus **Echinocyamus** Van Phelsum, 1774

Echinocyamus incertus H. L. Clark, 1914.

(Figures 5-12.)

Fibularia australis A. Agassiz and H. L. Clark, 1907, p. 247, (not *Fibularia australis* Desmoulins, 1835; not *Fibularia australis* Benham, 1911).
Echinocyamus incertus H. L. Clark, 1914, p. 64, pl. 128, figs. 1-3.
Fibularia incerta Lambert and Thiéry, 1925, p. 577.
Echinocyamus incertus H. L. Clark; Mortensen, 1948, pp. 193-194.

Diagnosis. Small, elongate-oval, moderately arched *Echinocyamus* with meagerly developed, non-convergent, ambulacral pore series limited to central aboral surface, and with ocular pores much smaller than genital pores.

Distribution. Hawaiian Islands, 20-360 meters, and Nasca Ridge, 210-227 meters (HD-73).

Dimensions and ambulacral pore development of types (University of California Museum of Paleontology)

Hypotype UCMP 36579 (figs. 5, 6). Test without spines: length 4.2 mm., width 3.6 mm., height 1.7 mm., width of periproct 0.8 mm.; 9 pores in ambulacrum III (2 pairs on each side partially developed).

Hypotype UCMP 36580 (figs. 7, 8). Test without spines: length 3.2 mm., width 2.6 mm., height 1.3 mm., width of periproct 0.6 mm.; 4 pores in ambulacrum III (1 pair on each side).

Hypotype UCMP 36581 (figs. 9, 10). Test without spines: length 3.0 mm., width 2.5 mm., height 1.2 mm., width of periproct 0.5 mm., 4 pores in ambulacrum III (1 pair fully developed on each side), additional pores not completely developed.

Hypotype UCMP 36582 (figs. 11, 12). Test without spines: length 2.7 mm., width 2.5 mm., height 1.1 mm., width of periproct 0.4 mm.; 3 pores in ambulacrum III (1 partially developed pore on each side), several partially developed pores.

Remarks. *Echinocyamus incertus* is represented in the Nasca Ridge sample (HD-73) by 6 nearly complete specimens, four of which are designated as hypotypes (UCMP 36579, 36580, 36581, and 36582), and by fragments of 5 others. All were obtained in the gut contents of specimens of *Scrippsechinus fisheri*, new genus and new species.

Clark had only a single specimen with dimensions as follows: length 6 mm., width nearly 5 mm., height nearly 2 mm., width of peristome 1.2 mm., width of periproct 0.6 mm., anterior petal with four pore pairs on each side. Mortensen (1948, pp. 193-194) reported 3 specimens, the largest of which is 3 mm. long.

The Nasca Ridge specimens are slightly more arched on the upper surface than the holotype and have a slight lateral angularity to the periproct not apparent in the Hawaiian material. Tuberculation and number of pore pairs appear to vary with size as would be expected from the information available on the Hawaiian representatives of the species (H. L. Clark, 1914, p. 64, pl. 128, figs. 1-3; Mortensen, 1948, pp. 193-194).

This species has been previously reported only from the Hawaiian Islands and at depths of 20 to 360 meters.

Superorder ATELOSTOMATA Zittel, 1879

Order SPATANGOIDA Claus, 1876

Family Asterostomatidae Pictet, 1897

(=Paleopneustidae Agassiz, 1904; Antillasterinae Lambert and Thiéry, 1924; Palaeopneustidae Mortensen, 1950)

Genus **Scrippsechinus** Allison, Durham, and Mintz, new genus

Diagnosis. Inflated, apetalous, ovoid to slightly elongate, asterostomatid lacking fascioles, and with fused genital plates, 4 genital pores, numerous uniserial ambulacral plates near apical system; ambulacral pores paired, except near peristome, in paired ambulacra, minute single pores in frontal ambulacrum.

Type species. *Scrippsechinus fisheri*, new species.

Discussion. The unique features exhibited by *Scrippsechinus fisheri*, known only from Nasca Ridge (HD-73), require that it be distinguished as a new monotypic genus. These features are described and their relationships discussed following treatment of that species.

The generic name, *Scrippsechinus*, acknowledges the contributions of the Scripps Institution of Oceanography to the knowledge of the southeastern Pacific area from which this echinoid was collected.

Scrippsechinus fisheri Allison, Durham, and Mintz, new species.

(Figures 13-14; 21-32.)

Diagnosis. As for the genus.

Description. Test large, thin-shelled, semi-globose, ovoid to slightly elongate in outline (table 2; figs. 13, 14, 21, 22); anterior end without frontal depression; posterior end not truncated except in immediate area of periproct (fig. 23).

Ambulacral plates large, with height about ½ height of adjacent interambulacral plates; arranged adapically in irregular uniserial columns in-

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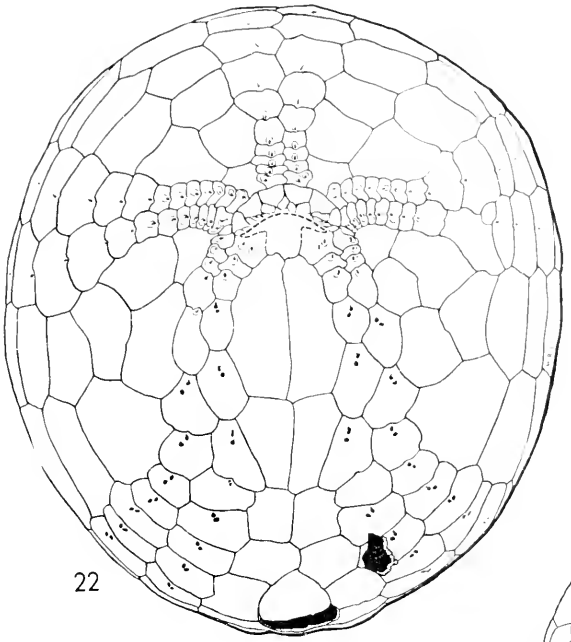
Figure 21. *Scrippsechinus fisheri*, new genus and new species; aboral view of holotype UCMP 36575, locality B-6555 (×1.25).

Figure 22. *Scrippsechinus fisheri*, new genus and new species; oral view of paratype UCMP 36572, locality B-6555 (×1.25).

Figure 23. *Scrippsechinus fisheri*, new genus and new species; lateral view of holotype UCMP 36575, locality B-6555 (×1.25).

Figure 24. *Scrippsechinus fisheri*, new genus and new species; peristome of paratype UCMP 36573, locality B-6555 (×3.0).

Figure 25. *Scrippsechinus fisheri*, new genus and new species; periproct of paratype UCMP 36573, locality B-6555 (×4.2).



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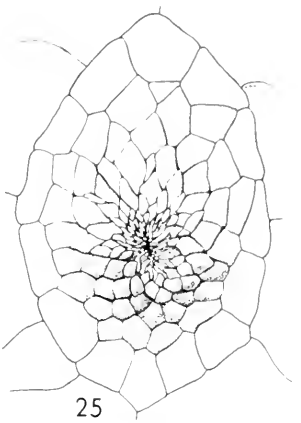

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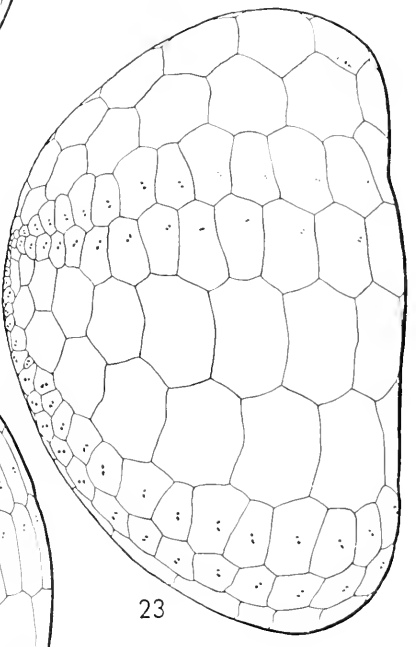

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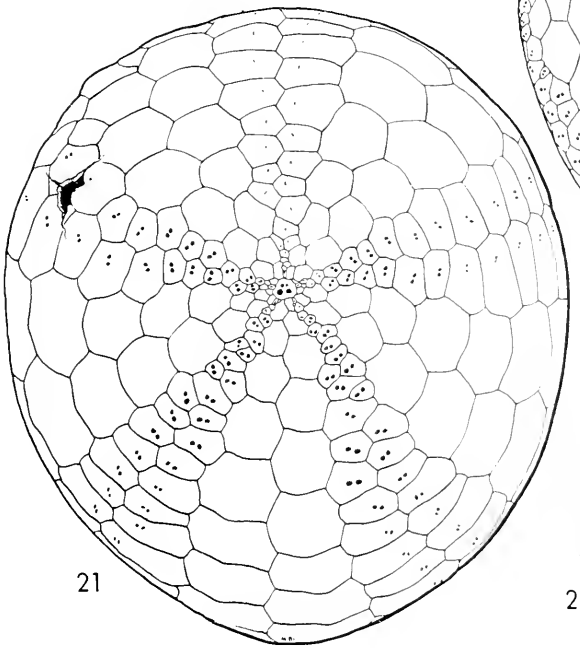


21

24

cluding rare intervening biserial plates (figs. 21, 26), with as many as 15 plates between last paired plates and ocular plate in posterior ambulacra, 11 in anterior paired ambulacra, and 13 in frontal ambulacrum (table 3); ambulacral plates depressed and crowded near peristome forming phyllodes (fig. 22); bivium "naked" on oral surface.

Ambulacral pores not distributed in petals; each pair generally located slightly below middle of plate; pores single and minute in frontal ambulacrum (fig. 21), double and non-conjugate in paired ambulacra except near peristome where they are single (fig. 22).

Podia simple, penicillate on phyllodes.

Interambulacra entirely amphiplacous; plastron amphisternous (fig. 8).

Labrum short and labiate; peristome lunate (fig. 22), depressed; peristomial plates large anteriorly, progressively smaller towards mouth opening (fig. 24).

Apical system ethmolytic (fig. 26), located slightly anterior to test center (fig. 21); genital plates fused, with 4 genital pores; ocular plates distinct (fig. 26); interior of apical system bearing typical "apical apophyse" (Devries, 1960) (fig. 27).

Periproct elongate (fig. 25), low on posterior surface of test, visible on oral side (fig. 22); covered by numerous small plates.

Tubercles weak, perforate, crenulate.

Primary spines moderately long, straight to strongly curved (in peristomial region), tips pointed or asymmetrically spatulate (on plastron) (fig. 28); secondary spines straight to moderately curved (fig. 29).

Fascioles not evident, except for faint ridge which may indicate incipient or obliterated subanal fasciole.

Pedicellariae represented by tridentate and triphyllous forms only, no globiferous or ophicephalous forms; tridentate pedicellariae three-jawed (most common) or four-jawed, both types with long and short forms, both with sculptured surface of ridges and pits and of densely arranged perforations (fig. 30, 31); triphyllous pedicellariae with distinctly serrate blade and base bearing pores which vary in number, shape, and distribution; basal surface of triphyllous pedicellariae either flat or with slight protuberence (fig. 32).

Sphaeridia numerous, on short stalks; distributed along ambulacra to at least sixth pair of post-basicoronal plates.

Color of alcohol preserved specimens, light brown or slightly pinkish.

Distribution. Nasca Ridge, 270-460 meters (HD-73).

Dimensions of types. Dimensions and plate counts are given in table 2 and table 3 for the following specimens: Holotype UCMP 36575 (figs. 21, 23, 26). Paratypes UCMP 36571, 36572 (figs. 22, 27), 36573 (figs. 24, 25), 36574, 36576, 36577, and 36578; British Museum specimen, as yet unnum-

bered; U. S. National Museum specimen, as yet unnumbered; and California Academy of Sciences specimen, as yet unnumbered.

TABLE 2. *Dimensions of the type specimens of* Scrippsechinus fisheri *new species.*

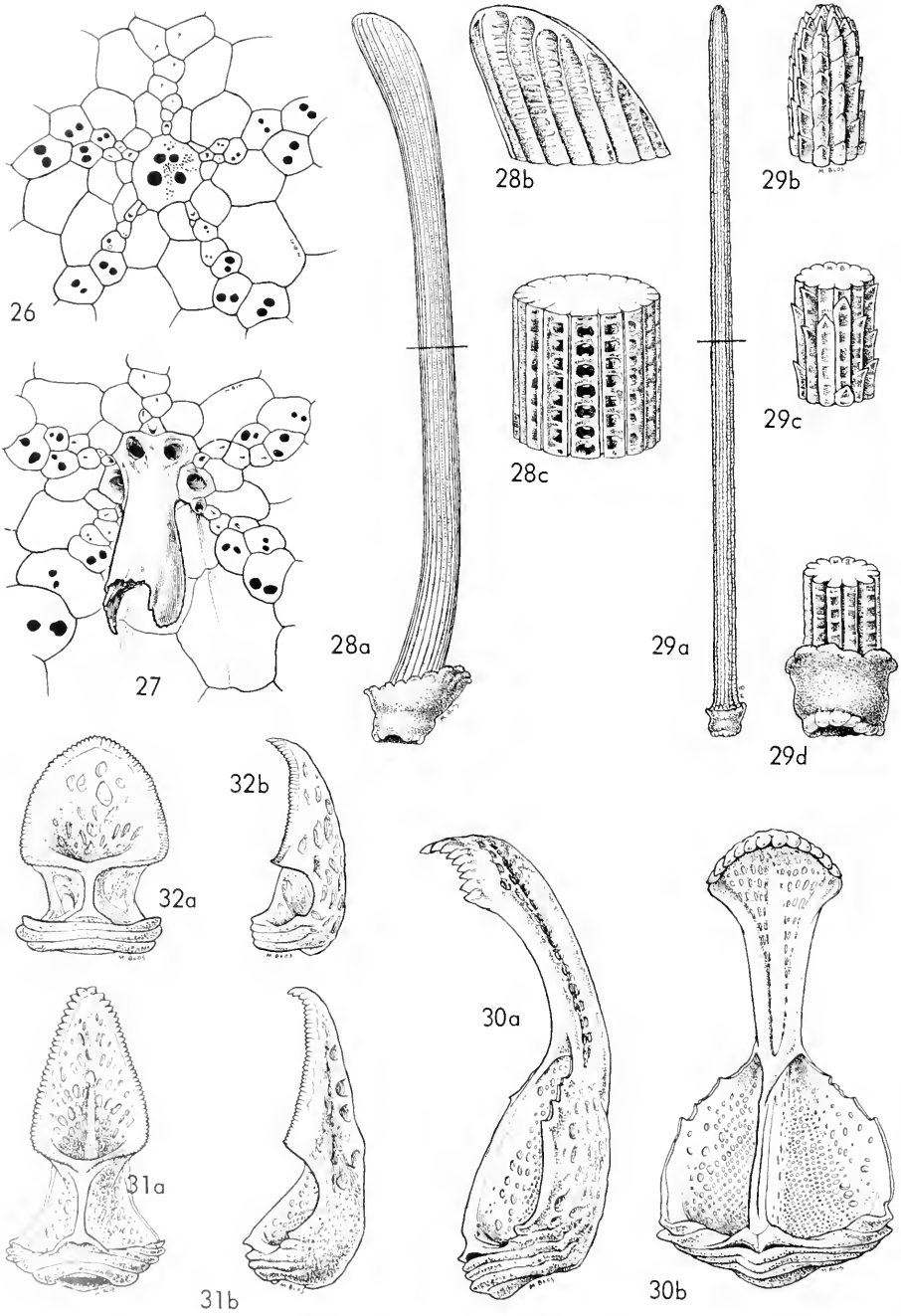
	UCMP								CAS	USNM	BMNH
	36571	36572	36573	36574	36575	36576	36577	36578			
Length (mm.)	54	65	69	72	66	66	59	60	59	59	66
Maximum width (mm.)	52	57	60	62	59	58	50	53	52	51	58
Maximum height (mm.)	37	43	46	46	42	49	38	43	40	42	40

REMARKS. *Scrippsechinus* is assigned to the spatangoid family Asterostomatidae (=Paleopneustidae) because of the amphisternous plastron, compact ethmolytic apical system, differentiated primary spines, non-petaloid ambulacra, and lack of fascioles.

Scrippsechinus differs from all other known asterostomatids, except *Palaeotropus*, by the possession of uniserial ambulacra near the apical system. *Palaeotropus*, however, has far fewer plates in its ambulacra between the first uniserial plate and the ocular plate. Also, in *Palaeotropus*, once uniserial plates appear, there is no reversion to biserial plates adapically as in *Scrippsechinus*. In *Palaeotropus*, ambulacrum I has 5 uniserial plates, ambulacrum II has 1, ambulacrum III has 4, ambulacrum IV has 2, and ambulacrum V has 6 (Mortensen, 1950, p. 295, fig. 205b). In contrast, the number of plates between the first uniserial plate and the ocular plate in *Scrippsechinus fisheri* (table 3) varies in ambulacrum I from 8 to 15, in ambulacrum II from 4 to 10, in ambulacrum III from 5 to 11, in ambulacrum IV from 6 to

TABLE 3. *Number of plates between first uniserial plate and ocular plate (includes some biserial plates) in type specimens of* Scrippsechinus fisheri, *new species.*

	UCMP								CAS	USNM	BMNH
Ambulacrum	36571	36572	36573	36574	36575	36576	36577	36578			
I	11	15	13	10	11	8	?	PRESERVED IN ALCOHOL	?14	8	8
II	7	10	?	8	4	10	?		8	9	5
III	11	11	13	9	8	8	?		10	5	7
IV	9	10	9	6	7	11	?		?	8	7
V	11	15	13	12	11	?13	?		14	11	5


26
27
28a
28b
28c
29a
29b
29c
29d
32a
32b
31a
31b
30a
30b

11, and in ambulacrum V from 5 to 15. In addition, *Palaeotropus* has only two genital pores, a well developed subanal fasciole, a periproct high on the subvertical posterior end, thorny primary spines, and 5 types of pedicellariae.

The completely nonpetaloid nature of the ambulacra would place *Scrippsechinus* in Lambert's subfamily Palaeotropinae to which Mortensen referred the genera *Palaeobrissus, Paleotrema, Palaeotropus,* and *Peripatagus*. *Palaeobrissus* is the only one of these genera whose ambulacra bear double pores aborally as in *Scrippsechinus*. *Palaeobrissus*, however, lacks adapical uniserial ambulacra and has a well developed subanal fasciole. Mortensen also doubtfully refers the genera *Cleistechinus* and *Enichester* to the Palaeotropinae. Both of these genera have double pores aborally, but *Cleistechinus* bears a well developed subanal fasciole and two genital pores, while *Enichaster* is a small, depressed form with sub-petaloid ambulacra.

There is no clear trace of a subanal fasciole in *Scrippsechinus*, although a faint ridge is present in the position where a fasciole might be expected. The ridge may indicate an incipient or obliterated fasciole. However, there are no adproctal elongations of the ambulacral plates in the vi-

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FIGURE 26. *Scrippsechinus fisheri*, new genus and new species; exterior view of apical area of holotype UCMP 36575, locality B-6555 (×4.0).

FIGURE 27. *Scrippsechinus fisheri*, new genus and new species; interior view of apical area showing "apical apophyse" of paratype UCMP 36572, locality B-6555 (×5.0).

FIGURE 28. *Scrippsechinus fisheri*, new genus and new species; primary spine, paratype UCMP 36573a, from oral side of ambulacrum V of paratype UCMP 36573, locality B-6555; 28a, entire spine (×20.0); 28b, tip of spine (×87.5); 28c, center of spine (×88.0).

FIGURE 29. *Scrippsechinus fisheri*, new genus and new species; secondary spine, paratype UCMP 36573b, from oral side of ambulacrum I of paratype UCMP 36573, locality B-6555; 29a, entire spine (×35.0); 29b, tip of spine (×133.0); 29c, center of spine (×133.0); 29d, base of spine (×133.0).

FIGURE 30. *Scrippsechinus fisheri*, new genus and new species; large tridentate pedicellaria valve, paratype UCMP 36573c, from oral side of ambulacrum I of paratype UCMP 36573, locality B-6555; 30a, inner surface (×123.0); 30b, lateral view (×123.0).

FIGURE 31. *Scrippsechinus fisheri*, new genus and new species; small tridentate pedicellaria valve, paratype UCMP 36573d, from oral side of ambulacrum I of paratype UCMP 36573, locality B-6555; 31a, inner surface (×205.0); 31b, lateral view (×205.0).

FIGURE 32. *Scrippsechinus fisheri*, new genus and new species; triphyllous pedicellaria valve, paratype UCMP 36573e, from aboral side of interambulacrum V of paratype UCMP 36573, locality B-6-555; 32a, inner surface (×468.0); 32b, lateral view (×468.0).

cinity of the periproct as in *Linopneustes*. Mortensen (1950, p. 211, fig. 158) interpreted these elongations with their enclosed pores as indicative of the presence of a subanal fasciole in the young.

This species is named in honor of Dr. Robert L. Fisher of Scripps Institution of Oceanography, Expedition Leader during the time that sample HD-73 was taken.

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