

A New Species of *Clypeaster* (Echinodermata, Echinoidea)
from San Felix Island, with a Key to the Recent
Species of the Eastern Pacific Ocean¹

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ABSTRACT: *Clypeaster isolatus* sp. nov. is described from 61 specimens taken off San Felix Island. It is distinguished by its concave oral side, moderately high test (23 to 36 percent of the test length), broad paired petals, primary spines without a hyaline point, short, stout aboral primary spines and three to six primary tubercles on the ridge between the pore pairs. Data on test morphology are given for use in analysis of intraspecific variation. The new species is most closely related to *C. australasiae* from southeastern Australia. This affinity to the Australian fauna supports the theory of west-wind-drift dispersal.

THE GENUS *Clypeaster* Lamarck, 1801, was known until now in the eastern Pacific only from Baja California to Ecuador and the Galápagos Islands, at depths ranging from intertidal to about 200 meters. In 1965 an undescribed *Clypeaster* was collected by the R.V. *Anton Bruun* off the coast of San Felix Island (Lat. 26°S, Long. 80°W). This new species, the sixth extant species of *Clypeaster* known from the eastern Pacific, extends the range of the genus 20° of latitude to the south in the eastern Pacific. A key is provided below to show the differences between these species.

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METHODS AND MATERIALS

Nineteen characters of taxonomic significance were examined statistically for the new species to evaluate intraspecific variation. Measurements were taken with vernier calipers to the nearest 0.1 mm. Test length (TL) is the greatest distance from the anterior ambitus to the posterior ambitus in a plane parallel to the plane of symmetry. Test width (TW) is the greatest distance from one lateral ambitus to the other in a plane perpendicular to the plane of symmetry. Test height (TH) is the greatest height of the specimen lying on a flat surface. Petal length (PL) in petals I and II (Loven's system) is measured along the axis of the perradial suture of the petal from the center of the apex to an imaginary line connecting the most distal pore pair of each pore pair series. The length of petal III is measured along the perradial suture from the center of the apex to an imaginary line perpendicular to the axis of the perradial suture and passing through the most distal pore pair in the III *a* series. Outside petal width (OPW) is the maximum distance between the outer pores of both pore series in a plane perpendicular to the axis of the perradial suture. The distance to the ambitus (DA) was measured from the center of the apex to the ambitus at the perradial suture, half way between the oral and aboral side. Maximum inside petal width (MIPW) is the maximum distance between the inner pores of each pore pair series in

a plane perpendicular to the perradial suture. Distal petal width (DPW) is the distance between the inner pore of the most distal pore pair in both pore series.

Specimens with genital pores are regarded as adults and specimens without genital pores are regarded as juveniles.

Terminology follows that of Durham (1966). Mean percentages are given in parentheses.

Clypeaster isolatus sp. nov. (family Clypeasteridae L. Agassiz, 1835; genus *Clypeaster* Lamarck, 1801)

Figs. 1(A-E), 2, and 3; Table 1

Material Examined

Examined were 60 adults, 27.4 to 56.6 mm TL and 1 juvenile, 25.4 mm TL, from R.V. *Anton Bruun*, Cruise 12, Station MV-65-IV-37, off San Felix Island, Lat. 26°16' S, Long. 80°06' W, 75 meters, 40-foot otter trawl, December 7, 1965.

Diagnosis

Test height from 23 to 36 percent of the test length; oral side concave; large triphyllous pedicellariae with the blade twice as long as wide; maximum number of primary tubercles on the ridge between the pore pairs three to six; petal III open distally 50 to 97 percent; primary spines without a hyaline point.

Description

The aboral outline of the test is elliptical to pentagonal with the test width ranging from 83 to 91 percent of the test length with a mean of 87.6 percent. Test moderately high ranging from 23 to 36 percent of the test length with a mean of 30.5 percent. The aboral side of the test rises rather uniformly from the ambitus to the apex. The oral side is moderately concave, gradually sloping from the margin of the test to the mouth. Internal skeleton includes five clusters of three to five pillars. A cluster occurs in each interambulacrum half way between the apex and the ambitus. A few poorly developed isolated lamellae are present at the ambitus.

Petal I is the longest petal in two-thirds of the specimens examined, its length is 29 to 38 (33.8) percent of the TL. The pore series at

the distal end of the petal converge somewhat but remain distinctly open. The degree of openness (DPW/MIPW) ranges from 35 to 91 (61.3) percent. The length of petal I ranges from 55 to 67 (60.7) percent of the DA. Outside petal width (OPW) ranges from 53 to 68 (60.7) percent PL.

Petal II is the shortest petal in all the specimens examined, its length ranges from 26 to 34 (29.7) percent of the TL. Outside petal width ranges from 52 to 71 (62.8) percent of the PL. The length of petal II ranges from 54 to 68 (60.1) percent of the DA. The pore series converges more in petal II than in either petals I or III. The degree of openness ranges from 20 to 72 (49.0) percent.

Petal III is the longest petal in one-third of the specimens examined, its length ranges from 28 to 38 (33.2) percent of the TL. Outside petal width ranges from 50 to 71 (61.2) percent of the PL. The length of petal III ranges from 52 to 68 (60.0) percent of the DA. The pore series converge somewhat, but in all but one specimen remain more open than in petals I and II. The degree of openness ranges from 49 to 97 (78.0) percent.

The maximum number of primary tubercles on the ridge between the pore pairs ranges from three to six at the widest part of the petal. The number of pore pairs increases with an increase in petal length (a 7-mm petal III has about 24 pore pairs, while one 15 mm long has about 32 pore pairs).

The primary tubercles on the aboral side are uniformly distributed. The concentration of tubercles on a specimen 44.5 mm TL is 75 to 80/cm². The diameter of the areoles on the aboral side of the test is relatively constant on any one specimen. The primary tubercles on the oral side are smaller and more numerous near the ambulacral groove than those on the interambulacral plates. The diameter of the areoles on the interambulacral plates is twice that of the areoles near the ambulacral groove.

The periproct is rounded to somewhat irregular and is displaced approximately its own diameter from the ambitus.

The large primary spines from around the mouth (Fig. 1A) are slightly curved and the axial cavity is filled with a mesh work. In cross section, there are 16 to 18 ridges per spine on

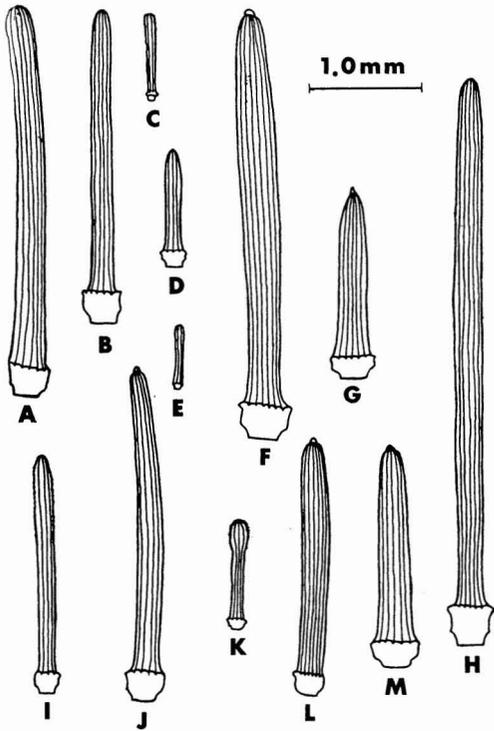


FIG. 1. Spines. A-E, *Clypeaster isolatus* (holotype), 57 mm TL (test length): A, large primary from around the mouth (16-18 ridges); B, oral primary (11-13 ridges); C, oral miliary (6-8 ridges); D, aboral primary (8-10 ridges); E, aboral miliary (5-6 ridges). F-G, *C. ocburus* (holotype), 92 mm TL: F, oral primary (18-19 ridges); G, aboral primary (14-16 ridges). H-I, *C. europacificus*, 128 mm TL: H, oral primary (15-17 ridges); I, aboral primary (11-12 ridges). J-K, *C. rotundus*, 129 mm TL: J, oral primary (11-12 ridges); K, aboral primary (9-11 ridges). L-M, *C. speciosus*, 124 mm TL: L, oral primary (16-18 ridges); M, aboral primary (14-15 ridges).

the holotype. The number of ridges per spine increases with an increase in test length. The smaller oral primary spines (Fig. 1 B) are hollow, straight, and have 11 to 13 ridges per spine on the holotype. The miliary spines of the oral side (Fig. 1 C) are claviform and have six to eight ridges per spine on the holotype. The primary spines of the aboral side (Fig. 1 D) are hollow and only one-half to one-third as long as the primary spines of the oral side. They are slightly enlarged distally and terminate in a rounded point. The aboral primaries of the holotype have 8 to 10 ridges. The miliary spines of

the aboral side (Fig. 1 E) are about two-thirds as long as the oral miliary spines. The aboral miliaries of the holotype have five to six ridges per spine.

The tridentate pedicellariae (Fig. 2 A, B) are of two main types. One type has a distally widened spatulate blade while the other type has a thinner blade with irregular edges. The three different valves of an opihcephalous pedi-

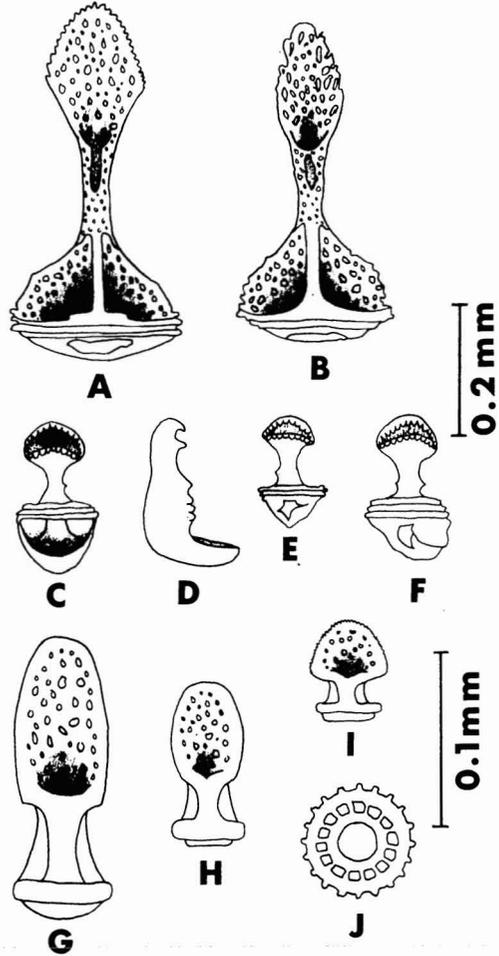


FIG. 2. Valves of the pedicellariae and sucking disk of the locomotory tube feet of *Clypeaster isolatus* (holotype). A-B (upper scale), large tridentate pedicellaria from around the mouth; C-F (upper scale), three valves of an opihcephalous pedicellaria (D is side view of C); G (lower scale), large oral triphylloous pedicellaria; H (lower scale), small oral triphylloous pedicellaria; I (lower scale), aboral triphylloous pedicellaria; J (lower scale), skeletal support of a sucking disk of a locomotory tube foot.

cellaria are shown in Fig. 2 C-F. This type occurs over the entire test but is most abundant around the margin. The triphyllous pedicellariae of the oral side (Fig. 2 G, H) have elongated blades. On the aboral side, this type of pedicellaria (Fig. 2 I) is considerably smaller with blades less elongate than on the oral side.

The skeletal support of the sucking disk from a locomotory tube foot of the holotype is shown in Fig. 2 J. It has a single circular series of 14 holes with 20 radiating prominences on the perimeter. The thickness of the sucking disk is about 15 percent of its diameter.

No live specimens were observed. Specimens preserved in 70 percent ethyl alcohol for 4 years are generally tan. A few specimens are either brown or cream colored.

The most reliable characters for species definition are TW/TL, TH/TL, PL/TL, and PL/DA (Table 1). OPW/PL exhibits more intra-specific variability but can be used as a supplement to the above characters. DPW/MIPW is quite variable and has no taxonomic significance in this species.

Holotype

The holotype (Fig. 3) is deposited in the United States National Museum, Washington, D.C., number E11361, and is 56.6 mm long,

49.9 mm wide, and 17.4 mm high. Paratypes are deposited in the United States National Museum; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; British Museum (Natural History), London; and Australian Museum, Sydney.

Type Locality

The type locality is found off San Felix Island, Lat. 26°16' S, Long. 80°06' W, in 75 meters of water.

Taxonomic Affinities

Clypeaster isolatus differs from other eastern Pacific Ocean species of *Clypeaster* as shown in the key below.

KEY TO THE SPECIES OF *Clypeaster* IN THE EASTERN PACIFIC OCEAN

- 1 a. Periproct marginal, in a distinct notch at the posterior edge of the test; petal III more than 90 percent open (see text) *C. europacificus* H. L. Clark
Fig. 1 H-I; Fig. 4 E
- 1 b. Periproct located on the oral side, generally its own diameter removed from the ambitus; petal III generally less than 90 percent open 2

TABLE 1
RATIOS FOR *Clypeaster isolatus*

CHARACTER		MEAN (percent)	STANDARD DEVIATION (percent)	RANGE (percent)
TW/TL		87.6	1.78	83-91
TH/TL		30.5	2.44	23-36
PL/TL	Petal I	33.8	1.90	29-38
	Petal II	29.7	1.79	26-34
	Petal III	33.2	2.20	28-38
OPW/PL	Petal I	60.7	4.24	53-68
	Petal II	62.8	4.26	52-71
	Petal III	61.2	4.60	50-71
PL/DA	Petal I	61.0	2.82	55-67
	Petal II	60.1	3.12	54-68
	Petal III	60.0	3.55	52-68
DPW/MIPW	Petal I	61.3	12.58	35-91
	Petal II	49.0	13.39	20-72
	Petal III	78.0	9.28	50-97

NOTE: TW, test width; TL, test length; TH, test height; PL, petal length; OPW, outside petal width; DA, distance from apex to the ambitus; DPW, distal petal width; MIPW, maximum inside petal width. Sixty-one observations were made.

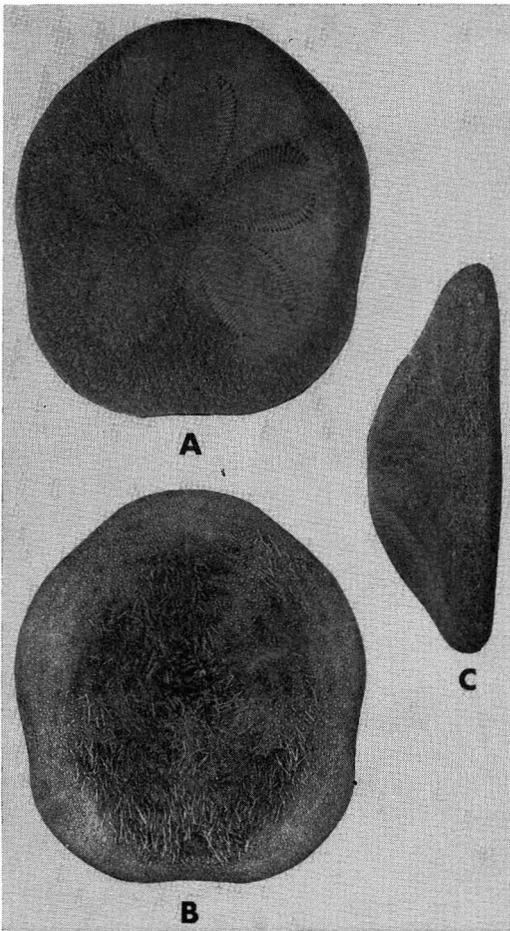


FIG. 3. *Clypeaster isolatus* sp. nov. (holotype). A, aboral surface; B, oral surface; C, lateral aspect.

- 2 a. Test greatly elongated; test width less than 82 percent of the test length *C. elongata* H. L. Clark
- 2 b. Test not greatly elongated; test width greater than 82 percent of the test length 3
- 3 a. Primary spines on the aboral side of the test claviform; more than eight primary tubercles on the ridge between the pore pairs; a type of tridentate pedicellaria present with the distal portion of the blade concave on the outer part *C. rotundus* A. Agassiz Fig. 1 J-K; Fig. 4 A-C
- 3 b. Primary spines on the aboral side not claviform; less than eight primary tu-

- bercles on the ridge between the pore pairs; no tridentate pedicellaria present with the distal portion of the blade concave on the outer side 4
- 4 a. Oral side concave, gradually sloping from the oral margin of the test to the mouth; primary spines do not terminate distally in a hyaline point *C. isolatus* sp. nov.
- 4 b. Oral side flat except where it is sharply concave directly around the mouth; primary spines terminate distally in a hyaline point 5
- 5 a. Primary spines of the oral side of uniform length; axial cavity of the large primary spines in the depression around the mouth is hollow *C. speciosus* Verrill Fig. 1 L-M; Fig. 4 F
- 5 b. Primary spines of the oral side longer in the interambulacral areas than in the ambulacral areas; axial cavity of the large primary spines in the depression around the mouth is filled with an irregular meshwork *C. ochrus* H. L. Clark Fig. 1 F-G; Fig. 4 D

Based on the general morphology of the test and pedicellariae, the closest relative of *C. isolatus* appears to be *C. australasiae*, a species from southeastern Australia. The new species differs from *C. australasiae* by having primary spines without a hyaline point, shorter and stouter aboral primary spines, broader paired petals, and oral miliary spines without an expanded distal portion.

Existing descriptions of *C. australasiae* (Clark, 1914; Mortensen, 1948) are based on large specimens of 100- to 150-mm test length. Since numerous morphological characters in this genus have been shown to vary considerably with size (Serafy, 1970), similarly sized specimens of each species were compared. Regression analysis was not used due to the small size range of the *C. isolatus* specimens.

Genital pores develop in *C. isolatus* at a test length of approximately 26 mm and in *C. australasiae* at a test length of approximately 30 mm. The fact that the latter species attains a size of 150 mm TL may indicate that *C. isolatus*

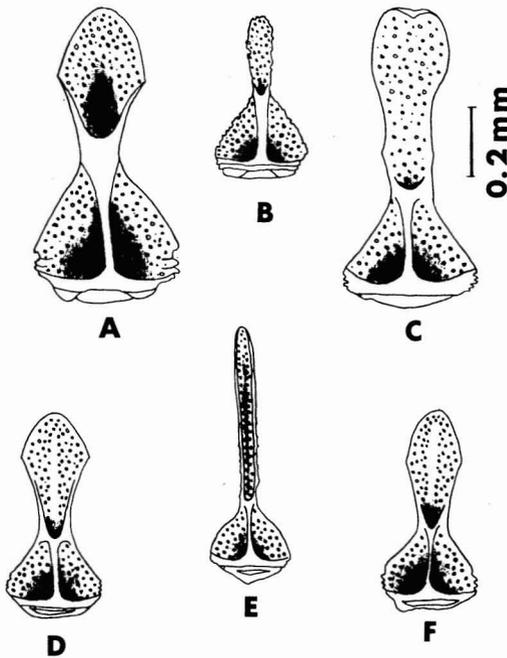


FIG. 4. Valves of tridentate pedicellaria from around mouth. A-C, *Clypeaster rotundus*; D, *Clypeaster ochrus*; E, *Clypeaster europacificus*; F, *Clypeaster speciosus*.

attains a considerably larger size than the largest known specimen of 56.6-mm test length.

The affinity of *C. isolatus* to the Australian *Clypeaster* fauna can be explained by the generally west-to-east-moving surface currents between Australia and San Felix Island. This is in accord with the west-wind-drift dispersal theory proposed by Fell (1962) for echinoderms in the Southern Hemisphere. Although he emphasized rafting as the primary means of dispersal, Fell (1967) later concluded that west-wind-drift plays a significant role in larval dis-

persion. Clypeasteroids would be restricted to the latter method by virtue of their life habits.

The entire genus occurs in relatively shallow, warm water. The cold Peru Current moving northward along the coasts of Chile and Peru could serve as a barrier to prevent the Central American congener species from extending their ranges southward along the coasts of Peru and Chile and to isolate the San Felix *Clypeaster* from the mainland of Chile.

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