

Some Cretaceous Echinoids from the Americas

By C. WYTHE COOKE

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

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*Descriptions and illustrations of some
Lower and Upper Cretaceous echinoids
from Colombia, Ecuador, Mexico, and the
United States*



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SOME CRETACEOUS ECHINOIDS FROM THE AMERICAS

By C. WYTHE COOKE

ABSTRACT

Thirty species of echinoids from Colombia, Ecuador, Mexico, and the United States, and one additional type species, *Heteraster oblongus* (Brongniart), are herein described and illustrated. Of the 19 genera represented, *Boletechinus* is formally described for the first time. *Echinopygus* d'Orbigny is accepted as a subgenus under *Pygurus*, and *Washitaster* Lambert as a subgenus of *Enallaster*. New species are: *Stereocidaris hudspethensis*, *Pedinopsis texana*, *Orthopsis casanovai*, *Boletechinus mcglameryae*, *Holactypus* (*Caenholactypus*) *nanus*, *Arnaudaster colombianus*, *Faujasia rancheriana*, *Pygurus* (*Echinopygus*) *jagüeyanus*, *Hardouinia clypeus*, *Heteraster cesarensis*, *Epiaster dartoni*, and *Epiaster renfroae*. New combinations include: *Stereocidaris hemigranulosus* (Shumard) [*Cidaris*], *Faujasia geometrica* (Morton) [*Clypeaster*], *Pygurus* (*Echinopygus*) *chelonium* (Cooke) [*Faujasia*] *Phyllobrissus angustatus* (Clark) [*Echinobrissus*], *Toxaster colombianus* (Lea) [*Spatangus*], *Enallaster riovistae* (Adkins) [*Hemias*], and *Epiaster washitae* (Lambert) [*Macraster*].

This report makes the record of the American Cretaceous echinoids current and the stratigraphic and geographic records of the new forms available for use in correlation and phylogenetic studies.

INTRODUCTION

Previous papers (Cooke, 1946, 1953) described the Early Cretaceous echinoids from the Comanche series, chiefly from Texas, and Late Cretaceous echinoids from the United States, including some from Texas. A principal objective of this report is to augment our knowledge of these faunas by describing some additions. However, descriptions of comparable material from other areas in the Americas are also included and some errors have been corrected.

A formal description of the genus *Boletechinus* and its type species, named in a key to the genera of American Upper Cretaceous Echinoidea (Cooke, 1953, p. 4), are included. The American species of *Holactypus*, *Heteraster*, and *Enallaster* are also reviewed.

The initials USGS followed by a serial number indicates an entry in the register of Mesozoic localities of the Paleontology and Stratigraphy Branch of the United States Geological Survey. The initials USNM indicate United States National Museum catalog numbers.

The new species from Colombia were discovered in a collection of Colombian echinoids belonging to the Museum of Paleontology of the University of California at Berkeley, which was sent to me for study by J. Wyatt Durham. This collection includes specimens from several localities. The largest single lot (S 91), from the Department of Santander, consists of several hundred individuals that apparently represent *Toxaster colombianus* (Lea), commonly called *Toxaster roulini* Agassiz, the age of which was reported to be Lower Cretaceous, Hauterivian(?) As no other echinoids were associated with this species, there is no means of checking the age assignment.

The most diversified echinoid fauna in this collection came from a group of localities in the Rancheria Valley about 10 kilometers north of Fonseca in the Department of Magdalena. These lots (C 14025-14027, C 14160, C 14161, and C 14164), collected from a series of sandy marls and thin-bedded limestones containing also the ammonites *Venezoliceras* sp. and *Pervinqueria* sp., were referred to the late Albian. The echinoids include the following species:

Tetragramma malbosii (Agassiz)
Holactypus (*Caenholactypus*) *planatus* Roemer
Holactypus (*Caenholactypus*) *castilloi* Cotteau
Arnaudaster colombianus Cooke, n. sp.
Faujasia rancheriana Cooke, n. sp.
Phyllobrissus angustatus (Clark)
Pygurus (*Echinopygus*) *jagüeyanus* Cooke, n. sp.
Enallaster (*Washitaster*) *bravoensis* Böse

The late Albian age of these lots appears to be confirmed by the occurrence in them of several species characteristic of the Washita group of the Comanche series of Texas, notably *Holactypus castilloi* and *Enallaster bravoensis*. The presence of *Phyllobrissus angustatus*, occurring elsewhere near the top of the Washita group in the Buda limestone (early Cenomanian), suggests that these Colombian echinoids are of late Washita age or that more than one zone is represented among them.

With these Colombian echinoids was one lot (A 7134) of five well-preserved specimens of *Hemiaster texanus* Roemer from the upper part of the Napo series of the Oriente of Ecuador. No age was assigned to this lot, but the species is found in Texas in the Austin chalk, Anacacho limestone, and Taylor marl, of Late Cretaceous (Senonian) age.

Among the results of this study is the recording in Colombia of new species of *Arnaudaster* and *Pygurus*, genera heretofore unknown in the Americas.

Thanks are due to J. Wyatt Durham for the opportunity to study the Colombian collection; to Miss Winnie McGlamery, of the Geological Survey of Alabama for the loan of the type and paratype of *Boletechinus mcglameryae* and of two specimens of *Hardouinia clypeus*; and to Richard L. Casanova, of the Paleontological Research Laboratories at Statesville, N. C., for the gift of the types of *Holactypus nanus*, *Orthopsis casanovai*, and *Heteraster cesarensis*. The names of the species described and illustrated, their geologic age, and their occurrence are enumerated in the following list:

Cidaridae:

Stereocidaris hudspeithensis Cooke, n. sp. Early Cretaceous (late Albian or early Cenomanian), Washita group in Texas.

Saleniidae:

Salenia hondoensis Cooke. Late Cretaceous (middle Senonian, Campanian), Anacacho limestone in Texas.

Pedinidae:

Dumbea symmetrica Cragin. Early Cretaceous (late Albian), Washita group in Texas and Mexico.

Pedinopsis texana Cooke, n. sp. Early Cretaceous (late Albian), Washita group in Texas.

Pseudodiadematidae:

Tetragramma malbosii (Agassiz). Early Cretaceous (late Neocomian to late Albian), France, Colombia, and Texas (Fredericksburg group).

Tetragramma bösei Jones. Early Cretaceous (Vraconian?), in Mexico.

Orthopsidae:

Orthopsis casanovai Cooke, n. sp. Late Cretaceous (Campanian), Anacacho limestone in Texas.

Temnopleuridae:

Boletechinus mcglameryae Cooke n. sp. Late Cretaceous (late Maestrichtian), Prairie Bluff chalk in Alabama.

Holactypidae:

Holactypus (*Caenholactypus*) *planatus* Roemer. Early Cretaceous (Albian), Trinity and Fredericksburg groups in Texas and Colombia.

Holactypus (*Caenholactypus*) *castilloi* Cotteau. Early Cretaceous (late Albian), Washita group in Texas, Mexico, and Colombia.

Holactypus (*Caenholactypus*) *transpecosensis* Cragin. Early Cretaceous (late Albian), Washita group in Texas and Mexico.

Holactypus (*Caenholactypus*) *nanus* Cooke, n. sp. Early Cretaceous (late Albian), Washita group, Pawpaw formation, in Texas.

Cassidulidae:

Arnaudaster colombianus Cooke, n. sp. Early Cretaceous (late Albian), in Colombia.

Faujasia rancheriana Cooke, n. sp. Early Cretaceous (late Albian), in Colombia.

Phyllobrissus angustatus (Clark). Early Cretaceous (late Albian) or Late Cretaceous (early Cenomanian), Buda limestone in Texas and Colombia.

Pygurus (*Echinopygus*) *jagüeyanus* Cooke, n. sp. Early Cretaceous (late Albian), in Colombia.

Hardouinia clypeus Cooke, n. sp. Late Cretaceous (Santonian), Tombigbee sand member of Eutaw formation in Alabama.

Toxasteridae:

Toxaster colombianus (Lea). Early Cretaceous (Hauterivian-Valanginian?), in Colombia.

Heteraster oblongus (Brongniart). Early Cretaceous (Neocomian, Urgonian), in France.

Heteraster cesarensis Cooke, n. sp. Early Cretaceous (late Neocomian?), Villeta group in Colombia.

Enallaster obliquatus Clark. Early Cretaceous (early Albian), Trinity group, Glen Rose limestone in Texas.

Enallaster mexicanus Cotteau. Early Cretaceous (middle Albian), Fredericksburg group in Mexico and Texas.

Enallaster (*Washitaster*) *riovistae* (Adkins). Early Cretaceous (late Albian), Washita group in Texas.

Enallaster riovistae wenoensis Adkins. Early Cretaceous (late Albian), Washita group, Weno clay and Main Street limestone in Texas.

Enallaster (*Washitaster*) *longisulcus* Adkins and Winton. Early Cretaceous (late Albian), Washita group, Fort Worth limestone in Texas.

Enallaster (*Washitaster*) *inflatus* Cragin. Early Cretaceous (late Albian), Washita group, Grayson marl (early Cenomanian) in Texas.

Enallaster (*Washitaster*) *bravoensis* Böse. Early Cretaceous (late Albian), Washita group, Georgetown limestone, in Mexico, Colombia, and Texas.

Holasteridae:

Holaster simplex Shumard. Early Cretaceous (late Albian), Washita group in Oklahoma and Texas; Indidura formation in Mexico.

Hemiasteridae:

Epiaster dartoni Cooke, n. sp. Early Cretaceous (Aptian?) in Texas and Mexico.

Epiaster renfroae Cooke, n. sp. Early Cretaceous (late Albian), Washita group, Weno clay in Texas.

Hemiaster texanus Roemer. Late Cretaceous (Senonian), Austin chalk, Anacacho limestone, and Taylor marl in Texas; Napo series in Ecuador.

SYSTEMATIC DESCRIPTIONS

Genus STEREOCIDARIS Pomel

Dorocidaris (*Stereocidaris*) Pomel, 1883, Classification méthodique et genera des échinides, p. 110.

Stereocidaris Pomel. Mortensen, 1928, Monograph of the Echinoidea, v. 1, p. 225. Includes synonymy.

Type species, *Cidaris cretosa* Mantell from the Upper White Chalk of England, designated by Lambert and Thierry (1909, p. 31). It has been illustrated by Cotteau (1861-67, p. 276, pl. 1067), and by Wright (1864-

82, p. 57, pl. 8, figs. 2, 4-6) under the name *Cidaris subvesiculosa* d'Orbigny. These figures show a large, persistent apical system including five perforated genital plates and exsert ocular plates; narrow, somewhat flexuous, ribbonlike ambulacra; wide interambulacra with large plates and conspicuous sutures, each plate has one large perforated, smooth tubercle except the plates near the apex, which have rudimentary tubercles or none. The miliary spaces are filled with homogeneous granules.

Stereocidaris has many features of *Cidaris* but differs in the persistence of the apical system and in the obsolescence of the tubercles on the upper plates. Whether it should be considered as a subgenus under *Cidaris*, as was suggested by Cooke (1953, p. 5), or as a genus is debatable.

***Stereocidaris hudspeithensis* Cooke, n. sp.**

Plate 18, figures 1-4

Test large, oblate-spheroidal. Apical system moderately large, with five perforated genital plates and five nearly insert ocular plates, all covered by large warts and granules. Periproct pentagonal, large, central within the apical system. Ambulacra narrow, ribbonlike, strongly sinuous; poriferous zones half as wide as the interporiferous; pores conjugate, oblique; interporiferous zones having one large, elongated wart and one outer granule on each plate. Interambulacra having five tiers of coronal plates separated by conspicuous sutures, each plate has one large smooth, central perforated tubercle except the highest tier, on which the large plates have one small tubercle without areole and the small plates have none; miliary spaces covered with close-set rounded warts and with rows of granules along the sutures. Peristome circular, nearly one-third the horizontal diameter. Teeth strong. Spines cylindrical, fluted.

Horizontal diameter 88 mm; height 58 mm; diameter of apical system 28.5 mm; diameter of peristome 36 mm.

Occurrence.—Texas: Hudspeth County 1.5 miles north of Roundtop Mountain, Triple Hill quadrangle (type, USNM 104828, Mrs. L. P. Jones). Small arroyo flowing north from Sierra Blanca Mountains into Arroyo Balluco, about three-fourths of a mile from mouth of arroyo, 3 miles north of Sierra Blanca Peak and about 11¼ miles N. 50° W. of railroad station (USNM 104607, J. B. Carson).

Geologic horizon.—Washita group, of late Albian or early Cenomanian age.

Type.—USNM 104828.

Comparisons.—The type of *Stereocidaris hudspeithensis* is about twice as large as *Stereocidaris cretosa* (Mantell) as illustrated by Cotteau (1861-67, p. 276, pl. 1067), its decoration is coarser, with more warts and fewer granules. The ambulacra are more flexuous. The new species has heretofore been misidentified as *Cidaris hemigranulosus* Shumard (Clark, 1915, p. 84, pl. 10, figs. 1a-g; pl. 11, figs. 1a-b), which also is probably a *Stereocidaris*

but which (as interpreted by Clark) has a much smaller peristome, somewhat smaller and more numerous plates, and somewhat finer sculpture.

Remarks.—The type is one of two fine specimens presented to the National Museum by Mrs. L. P. Jones of Sierra Blanca, Tex., through Earl Ingerson. The spine (pl. 18, fig. 4) is one of several that accompanied a somewhat smaller test also obtained by Mr. Ingerson from J. B. Carson of Sierra Blanca.

Genus *SALENIA* Gray

***Salenia hondoensis* Cooke**

Plate 19, figure 7

Salenia hondoensis Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 6, pl. 1, figs. 3, 4.

The specimen illustrated, which was contributed by R. L. Casanova, is somewhat larger than the type and has more punctae along the sutures of the apical system. This difference, presumably, is an individual variation.

Occurrence.—Texas: Bluff on Sabinal River 2 miles north of Sabinal, Uvalde County (Paleont. Research Lab. loc. 127).

Geologic horizon.—Upper Cretaceous, Anacacho limestone, of middle Senonian (Campanian) age.

Type.—USNM 108366.

Figured specimen.—USNM 108693.

Genus *DUMBLEA* Cragin

Dumblea Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 149.

Dumblea Cragin. Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 207; 1925, fasc. 8, p. 566.

Dumblea Cragin. Mortensen, 1940, Monograph of the Echinoidea, v. 3, pt. 1, p. 134.

Type species, *Dumblea symmetrica* Cragin. Generic characters are its subspherical shape; small, subcircular apical system with projecting points, three exsert ocular plates, two insert; and central periproct. It differs from *Pedinopsis* in the shape and arrangement of the compound ambulacral plates, which are much lower and contain only three pairs of pores instead of six. It is similar to *Micropedina* but differs in the arrangement of its pore pairs, which are biserial instead of in inclined groups of three and are more spread out near the peristome. Judgment is suspended as to whether this is a specific or a generic difference.

The type species was transferred to *Pedinopsis* by Clark (1915, p. 64), and also by Cooke (1946, 1953). Lambert (1927, p. 267) considered it as a synonym of *Micropedina olisiponensis* (Forbes, 1850, p. 195, pl. 25, fig. 1; de Loriol, 1887, p. 62, pl. 10, figs. 3-6).

***Dumblea symmetrica* Cragin**

Plate 18, figures 5-7

Dumblea symmetrica Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 150, pl. 24, fig. 12; pl. 25, figs. 4-7; pl. 27, fig. 1.

Pedinopsis symmetrica (Cragin). Clark, 1915, U. S. Geol. Survey Mon. 54, p. 64, pl. 23, figs. 1 a-h.

Micropedina olisiponensis (Forbes). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 267.

Micropedina symmetrica (Cragin). Adkins, Tex. Univ. Bull. 2838, p. 276.

Dumblea symmetrica Cragin. Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 457, pl. 62, figs. 17-20.

Dumblea symmetrica Cragin. Mortensen, 1940, Monograph of the Echinoidea, v. 3, pt. 1, p. 134, figs. 80-81 (after Clark, 1915).

Pedinopsis symmetrica (Cragin). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 211, pl. 31, figs. 20-21.

Test subglobular, flattened or concave around the peristome. Apical system having a large, swollen madreporite; one or two posterior ocular plates insert; periproct slightly excentric. Ambulacra regularly expanding, about half as wide as the interambulacra; poriferous zones biserial, somewhat disarranged below the ambitus, slightly expanding near the peristome; compound plates short and wide, including one primary and two demiplates, each with one pair of pores, the arrangement of the platelets variable. Interambulacral plates short, wide, straight, about $1\frac{1}{2}$ times as high as the ambulacral plates. Tubercles small, perforated, minutely crenulated, the perforations and crenulations not commonly preserved. Peristome small, little more than one-quarter of the diameter, strongly notched.

Diameter of largest specimen from USGS 21074 45 mm; height 30 mm; diameter of peristome, 13.8 mm.

Occurrence.—Texas: Sierra Blanca Mountains (types, Streeruwitz and Wyschetzki, *vide* Cragin). Between Sierra Blanca Peak and Little Blanca Mountain, Triple Hill quadrangle, Hudspeth County (USGS 21074, J. F. Smith and C. C. Albritton; USGS 1914, T. W. Stanton). South of Pecos River 10 miles south of McCamey, Upton County (USGS 14314, N. H. Darton). Five miles west of Kent (USGS 1938, T. W. Stanton). Six miles east of Kent (USGS 14251, T. W. Stanton and W. P. Popenoe). Fifteen miles north of Hovey (USGS 14620, N. H. Darton). Latitude, $29^{\circ}52'$; longitude, $103^{\circ}8'$, near center of Hood Springs quadrangle (USGS 13891, N. H. Darton). San Martin Mountain, Reeves County, 2 miles northeast of San Martin, Kent quadrangle (USGS 3647, G. B. Richardson). North of 3000 block on Bomar Avenue, Fort Worth (USGS 22352, W 1 Renfro coll.). Northeast of the O. B. Leonard farm (old Alta Vista dairy) 5 miles north of Fort Worth (USGS 22359, W 8 Renfro coll.). West of Glengarden Country Club, Fort Worth (USGS 22364, W 13 Renfro coll.). Five miles east of downtown Fort Worth (USGS 19691, W 2 Renfro coll.).

Mexico: South side of Rio Grande 4 miles west of El Paso, Tex., between the railway bridge and the Initial Monument (USGS 1689, E. A. Mearns).

Geologic horizon.—Lower Cretaceous, Washita group, Georgetown limestone in southwest Texas, Weno clay near Fort Worth, of late Albian age.

Type.—Geological Survey of Texas at Austin (*vide* Clark).

Figured specimen.—USNM 108713.

Genus PEDINOPSIS Cotteau

Pedinopsis Cotteau, 1863, Congrès sci. France Mém., sess. 28, v. 3, p. 176.

Pedinopsis Cotteau. Cotteau, 1864, Paléontologie française, Terrain crétacé, sér. 1, v. 7, p. 527; 1867, p. 826.

Pedinopsis Cotteau. Wright, 1870, British fossil Echinodermata from the Cretaceous formations, p. 113.

Pedinopsis Cotteau. Pomel, 1883, Classification méthodique et genera des échinides, p. 103.

Pedinopsis Cotteau. Duncan, 1889, Linnean Soc. London Jour., Zoology, v. 23, p. 68.

Pedinopsis Cotteau. Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 190.

Pedinopsis Cotteau. Mortensen, 1935, Monograph of the Echinoidea, v. 2, p. 451.

Pedinopsis Cotteau. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 211.

Pedinopsis Cotteau. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 7.

Type species, *Pedinopsis meridanensis* Cotteau (1863, p. 177; 1861-67, p. 528, pls. 1125-1126), from the Neocomian of France, by monotypy. Cotteau's figures show this species to be subhemispherical or subconical, with a flattened base and rounded margin. Apical scar is rather small and nearly circular. Its rather narrow ambulacra have double rows of pore pairs that are somewhat expanded at the peristome. The compound ambulacral plates are as high as wide, and each has six pairs of pores. Interambulacral plates are wide, very low, and nearly straight. Each is decorated with several perforated, weakly crenulated tubercles, whose arrangement is dominantly in longitudinal rows. Peristome is small, little more than one-quarter the diameter, circular, and very weakly notched.

Pedinopsis was placed next to *Tetragramma* in the family Pseudodiadematidae by Mortensen (1935, p. 451) because the arrangement of the ambulacral pores is similar; but the two genera are probably not closely related, for *Tetragramma* has a much larger and plainly pentagonal apical scar, and its shape is discoidal.

Dumblea Cragin has lower compound ambulacral plates containing only three pairs of pores, and the arrangement of the tubercles is dominantly transverse.

Pedinopsis texana Cooke, n. sp.

Plate 19, figures 1-8

Test hemispherical, with rounded margin. Apical scar small, nearly circular. Ambulacra evenly expanding, nearly half as wide as the interambulacra; poriferous zones biserial throughout, the pore pairs alternating in location, tending to be disarranged at the peristome; compound plates half as high as wide, each with six pairs of pores in partial plates. Interambulacral plates much wider than high, straight. Peristome circular, weakly notched, about one-quarter of the diameter. Tubercles crenulated, perforated; small, slightly larger below the margin than elsewhere; arranged in radial rows, two rows adjacent to the poriferous zones on the ambulacra, six rows on the

interambulacra, somewhat smaller tubercles intercalated. Intermediate areas granular.

Horizontal diameter of holotype 61 mm; height 40 mm; diameter of peristome 16 mm.

Occurrence.—Texas: Road cut north of Glengarden Country Club swimming pool, Fort Worth (type, USGS 22270, Mst 11 Renfro coll.). Fort Worth-Crowley road south of Texas Christian University, 8 miles southwest of Fort Worth (paratype A, USGS 22265, Mst 4 Renfro coll.). Cobbs Park, old Cobbs brick pit south of Maddox Avenue on Cobbs Park Drive, Fort Worth (paratype B, USGS 22246, PP 1 Renfro coll.). Blum-Rio Vista road 1.3 miles southwest of Rio Vista (USGS 22255, PP 10A Renfro coll.). State Highway 171, 1¼ miles east of Godley (USGS 22378, W 32 Renfro coll.).

Geologic horizon.—Lower Cretaceous, Washita group, Main Street limestone, Pawpaw formation, and Weno clay, of late Albian age.

Types.—Holotype USNM 108714, from the Main Street limestone at USGS 22270. Paratype A USNM 108715, from the Main Street limestone at USGS 22265. Paratype B, USNM 108716, from the Pawpaw formation at USGS 22246.

Comparisons.—*Pedinopsis texana* resembles in general features Cotteau's figures of *Pedinopsis meridanensis* but seems to have smaller tubercles above the margin. It is much larger than the figures of *Pedinopsis yarboroughi* Ikins (1940, p. 14, pl. 1, figs. 3a-c) and *P. engerrandi* Ikins (1940, p. 14, pl. 1, figs. 2a-c), both from near the bottom of the Walnut clay of the Fredericksburg group in Travis County, Tex. These specimens have more rows of tubercles, whose alinement seems to be dominantly transverse rather than radial.

Genus **TETRAGRAMMA** Agassiz

Tetragramma Agassiz, 1838, Monographies d'échinodermes, Mon. 1, p. 4.

Tetragramma Agassiz. Agassiz, 1840, Allg. Schweizer. Gesell. Neue Denkschr., Band 4, pt. 2, p. 24.

Tetragramma Agassiz. Agassiz, 1840, Catalogus systematicus eotyporum Echinodermatum, p. 9, 18.

Diadema (*Tetragramma*) Agassiz. Agassiz and Desor, 1847, Catalogue raisonnée des échinodermes, p. 46.

Tetragramma Agassiz. Pomel, 1883, Classification méthodique et genera des échinides, p. 104.

Diplopodia (*Tetragramma*) Agassiz. Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 187.

Tetragramma Agassiz. Lambert, 1927, Mus. Ciencias Nat. Barcelona Mem., ser. geol., v. 1, no. 1, p. 25.

Tetragramma Agassiz. Mortensen, 1935, Monograph of the Echinoidea, v. 2, p. 448.

Diplopodia (*Tetragramma*) Agassiz. Ikins, 1940, Bull. Am. Paleontology, v. 25, no. 90, p. 56.

Tetragramma Agassiz. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 206.

Type species, *Cidarites variolaris* A. Brongniart, designated by Agassiz (1840, p. 25). As figured by Cotteau (1861-67, p. 488, pls. 1117-1120), *Tetragramma variolare* has a large pentagonal apical scar; a double row of pore pairs on the upper side, a single, somewhat uneven row on the lower side, not conspicuously multiplied at the peristome; two vertical rows of primary tubercles in each ambulacrum; and a nearly circular,

weakly incised peristome about one-third the total diameter.

The number of vertical rows of tubercles in the interambulacra of *Tetragramma* generally increases with the size of the individual. Small specimens commonly have only four, larger ones may have eight or more rows.

Tetragramma malbosii (Agassiz)

Plate 20, figures 6-8

?*Echinus boliviarii* d'Orbigny, 1842, Coquilles et échinodermes fossiles de Colombie, p. 61, pl. 6, figs. 11-13.

?*Echinus boliviarii* d'Orbigny. D'Orbigny, 1842, Voyage dans l'Amérique Méridionale, v. 3, pt. 4, p. 95, pl. 21, figs. 11-13.

Diadema malbosii Agassiz, 1847, in Agassiz and Desor, Catalogue raisonnée des échinodermes, p. 46.

Diplopodia malbosii (Agassiz). Desor, 1858, Synopsis des échinides fossiles, p. 78, pl. 12, figs. 12-14.

Pseudodiadema malbosii (Agassiz). Cotteau, 1863, Paléontologie française, Terrain crétacé, sér. 1, v. 7, p. 448, pls. 1106-1107.

?*Pseudodiadema malbosii* (Agassiz). Wright, 1868, British fossil Echinodermata from the Cretaceous formations, v. 1, p. 91, pl. 20, figs. 1a-f.

Diplopodia malbosii (Agassiz). Cotteau, 1890, Soc. géol. France Bull., sér. 3, v. 18, p. 294.

Diplopodia texanum (Roemer). Clark, 1893, U. S. Geol. Survey Bull. 97, p. 48, pl. 15, figs. 1a-f; pl. 16, figs. 1a-d.

Diplopodia taffi Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 148, pl. 46, fig. 3.

Diplopodia taffi Cragin. De Loriol, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, p. 56, pl. 4 (7), figs. 14-14b.

Tetragramma malbosii, (Agassiz). Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 188.

Diplopodia taffi Cragin. Clark, 1915, U. S. Geol. Survey Mon. 54, p. 58, pl. 20, figs. 2a-e.

Cyphosoma texanum (Roemer). Clark, 1915, U. S. Geol. Survey Mon. 54, p. 60, pl. 21, figs. 1a-e (not figs. 1f-g).

Tetragramma malbosii (Agassiz). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 266.

Tetragramma taffi (Cragin). Adkins, 1928, Tex. Univ. Bull. 2838, p. 274.

Tetragramma malbosii (Cotteau). Mortensen, 1935, Monograph of the Echinoidea, v. 2, p. 449, fig. 254f (after Cotteau, 1863).

?*Echinus boliviarii* d'Orbigny? Botero A., 1936, Escuela nac. de Minas [de Colombia] Anales, no. 35, p. 14, 52, (fig.) no. 3, fig. 2.

Tetragramma malbosii (Agassiz). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 207.

Horizontal outline subpentagonal, disc-shaped, having flattened upper surface, rounded margin, concave around the peristome. Apical scar large, pentagonal, occupying about one-third the diameter, with slightly protruding points. Poriferous zones double above, single below, changing at the margin. Median part of the interambulacra from the points of the apical system to the margin bare, depressed. Primary tubercles perforate, crenulate, two vertical rows in

each ambulacrum, four in each interambulacrum, the number of rows increasing with the size. Miliary tubercles and fine granulation covering all but the bare median areas. Peristome circular, deeply notched, about one-third the total diameter.

Diameter of figured specimen 37.2 mm; height 14 mm.

Occurrence.—France: La Clape (Aude); Opoul (Pyrenees-Orientales) (*vide* Cotteau). Ramade near Marbonne (Aude) (USNM 28853).

Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena (locs. C 14025, C 14025D (figured specimen), C 14027, C 14160).

Texas: North San Gabriel River 3 miles above Georgetown, Williamson County (type of *Diplopodia taffi* Cragin). Other localities in Texas are listed by Cooke (1946, p. 207).

Geologic horizon.—Lower Cretaceous, Albian.

Type.—Museum at Neuchâtel, Switzerland, T 63 (*vide* Desor). Figured specimen from Colombia USNM 108695.

Comparisons.—The upper side of this species closely resembles *Tetragramma streeruwitzi* (Cragin) (Cooke, 1946, p. 208, pl. 31, fig. 23), but the lower side has only four rows of tubercles in the interambulacrum, whereas *T. streeruwitzi* of the same size has eight or more.

Remarks.—The preceding description is based on the figured specimen from Colombia. This agrees well with Cotteau's description and figures of the type of *Tetragramma malbosii*, which he assigns to the late Neocomian of France, with which *Diplopodia taffi* Cragin, from Texas, has been identified (Lambert, 1927, p. 266). Whether it is the same as *Echinus bolivarii* d'Orbigny, the type of which came from Zapatoya, Province of Socorro, Colombia, must await the comparison of authentic specimens of that species, for d'Orbigny's figures of it appear to be in part synthetic.

Tetragramma bösei Jones

Plate 20, figures 4, 5

Pseudodiadema (*Diplopodia*) *texanum* (Roemer). Böse, 1910, Inst. Geol. Mexico Bol. 25, p. 157, pl. 34, figs. 4–8; pl. 36, figs. 1–2.

Tetragramma bösei Jones, 1938, Geol. Soc. America Bull., v. 49, no. 1, p. 130, pl. 12, figs. 6–7.

Horizontal outline subpentagonal; upper surface nearly flat, with slight depressions extending from the points of the apical scar; margin evenly rounded; lower surface rounded, depressed at the peristome. Apical scar pentagonal, longer than wide, width about one-third the horizontal diameter. Ambulacra about half as wide as interambulacra; poriferous zones biserial above the margin, uniserial below. Peristome about one-third the total diameter. Tubercles perforated, crenulated, set on large bases; two rows on each ambulacrum, four on each interambulacrum.

Horizontal diameter (length) 31 mm; (width) 30 mm; height 13.4 mm.

Occurrence.—Mexico: Sierra de Santa Ana, Coahuila, float just northwest of Fossil Hill (Jones J 50). Cerro de las Conchas, Arivechi, Sonora (*vide* Böse).

Geologic horizon.—Cretaceous, Indidura formation, member unknown; Vraconian (*vide* Böse).

Type.—University of Michigan 16623, on loan to the U. S. National Museum.

Comparisons.—In shape and decoration this species seems to be similar to *Tetragramma variolare* (Brongniart) from the Cenomanian of France, although its apical scar is narrower—a feature that may be the result of distortion. The differences from *T. malbosii* other than the distorted scar are not obvious. It may prove to be a synonym of either of these species.

Removal of some of the matrix reveals the apical scar and part of the peristome, which were covered when the type, a unique specimen, was described by Jones.

Genus *ORTHOPSIS* Cotteau

Orthopsis Cotteau, 1863, Paléontologie française, Terrain crétacé, sér. 1, v. 7, p. 374; 1864, p. 550.

Orthopsis Cotteau. De Loriol, 1873, Échinologie helvétique, pt. 2, Période crétacé, p. 135.

Orthopsis Cotteau. Pomel, 1883, Classification méthodique et genera des échinides, p. 100.

Orthopsis Cotteau. Cotteau, 1885, Paléontologie française, Terrain jurassique, sér. 1, v. 10, p. 875.

Orthopsis Cotteau. Duncan, 1889, Linnean Soc. London Jour., Zoology, v. 25, p. 80.

Orthopsis Cotteau. Lambert and Thiéry, 1910, Nomenclature raisonnée des échinides, fasc. 3, p. 199; 1925, fasc. 8, p. 566.

Orthopsis Cotteau. Smiser, 1933, Jour. Paleontology, v. 7, no. 2, p. 140.

Orthopsis Cotteau. Serra, 1934, R. accad. Lincei, Cl. sci. fis., mat., e nat., Atti, Anno 331, ser. 6, Rend., v. 20, fasc. 1–2, p. 51.

Orthopsis Cotteau. Mortensen, 1943, Monograph of the Echinoidea, v. 3, pt. 2, p. 10.

Orthopsis Cotteau. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 214.

Type species, *Cidarites miliaris* d'Archiac, designated by Cotteau (1861–67, p. 563). Cotteau (1861–67, p. 558, pl. 1131) has illustrated under this name several specimens from the Turonian and Senonian having peristomes of different sizes and possibly representing two or more different species. The decoration of all is similar to that of *Orthopsis casanovai* Cooke, n. sp., which is of Senonian age.

Orthopsis casanovai Cooke, n. sp.

Plate 20, figures 1–3

Horizontal outline subcircular, slightly depressed in the interambulacra; upper surface low arched; margin rounded; lower surface concave around the peristome. Apical system pentagonal, with pointed genital pores, a large swollen madreporite, and ocular plates all exsert. Peristome nearly central, large. Ambulacra narrow, regularly expanding, less than half as wide as the interambulacra; poriferous zones uniserial, the row somewhat uneven in the outer half of the upper surface; plates simple; tubercles in two even rows, each tubercle covering two plates, separated by one plate decorated with two granules. Interambulacra wide; each plate

having one primary tubercle in the middle, the tubercles forming two straight rows extending from the apical system to the peristome; additional rows of tubercles are intercalated toward the margin, totaling six or eight rows at the margin; intermediate spaces granular. Larger tubercles perforated; some of the smallest seem to be imperforate; mamelons small, round; cones smooth, high. Peristome subcircular, more than one-third the horizontal diameter; moderately notched.

Horizontal diameter 38 mm; height 16 mm; diameter of peristome 14 mm.

Occurrence.—Texas: Bluff on Sabinal River 2 miles north of Sabinal, Uvalde County (Paleont. Research Lab. loc. 127).

Geologic horizon.—Upper Cretaceous, Anacacho limestone, of Campanian age.

Type.—USNM 108694.

Comparisons.—The peristome of this species is proportionately much smaller than that of *Orthopsis charltoni* (Cragin) (Cooke, 1946, p. 214, pl. 31, figs. 6, 7). It is nearly the same size as that of the species illustrated by Cotteau (1861–67, pl. 1131, figs. 7–9) under the name of *Orthopsis miliaris* from the limestone of Royan, but that species is a little taller.

Remarks.—This species is named in honor of R. L. Casanova, director of the Paleontological Research Laboratories at Statesville, N. C.

Genus BOLETECHINUS Cooke

Boletechinus Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 4 (key to genera).

Type species, *Boletechinus mcglameryae* Cooke, n. sp. Small dome-shaped, base rounded. Apical system pentagonal, the three anterior ocular plates plainly exsert, the two posterior oculars broadly insert, the posterior genital plate produced into a point. Ambulacra evenly expanding to the ambitus; poriferous zones straight, apparently trigeminate throughout, zygopores oblique. Peristome medium sized, circular, weakly notched. Periproct within the apical system. Tubercles imperforate, crenulate, two rows in each area, those above the ambitus minute, those on and below it much larger. Surface coarsely granular, sutures between the plates depressed.

The imperforate, crenulate tubercles might place this genus among the Phymosomatidae as accepted by Mortensen (1928–51, v. 2, p. 456), among which it bears some resemblance to *Orthocyphus* Arnaud, whose apical system, however, is completely dicyclic. The coarse surface and indented sutures probably indicate relationship with the Temnopleuridae, although the large basal tubercles suggest some of the primitive Arbaciidae.

The generic name is derived from *Boletus*, a mushroom.

Although the preceding is the first formal description of *Boletechinus*, the genus was named in a key to genera, which enumerates some of its distinctive features and validates the name as of July 1953.

Boletechinus mcglameryae Cooke, n. sp.

Plate 28, figures 11–16, text figure 4.

Test small, hemispherical, base rounded. Apical system pentagonal, the three anterior ocular plates plainly exsert, the two posterior oculars widely insert, causing the periproct to be slightly elongated longitudinally, the posterior genital plate produced into a point, the madreporite conspicuously swollen. Ambulacra evenly expanding to the ambitus, plates apparently trigeminate throughout, poriferous zones straight, uniserial, zygopores oblique. Interambulacra nearly twice as wide as the ambulacra. Tubercles imperforate, crenulate; large, with conspicuous areolas on and below the ambitus, very small and inconspicuous above it. Peristome nearly one-third the horizontal diameter, circular, weakly notched.

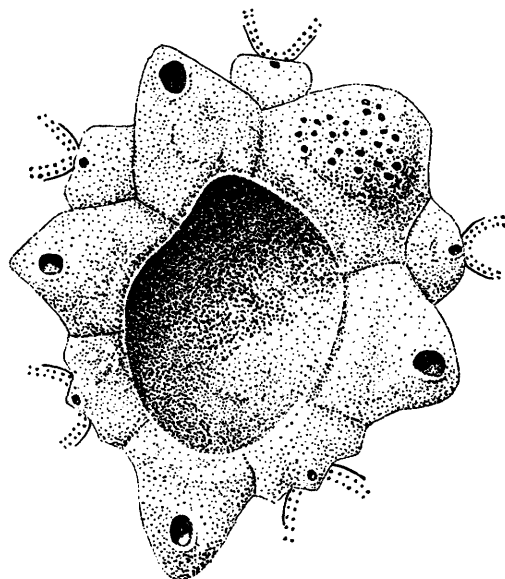


FIGURE 4.—*Boletechinus mcglameryae* Cooke, n. sp.

Diameter of holotype 8.7 mm; height 4.9 mm; diameter of peristome 2.5 mm.

Occurrence.—Alabama: Near Industrial School 2 miles north of Livingston, Sumter County, on U. S. Highway 11 at the junction with State Highway 132 (Ala. Geol. Survey, W. McGlamery). Sumter County, 11.3 miles southwest of Epes in NW¼NW¼ sec. 2, T. 19 N., R. 2 W. (USGS 18636, L. W. Stephenson and W. H. Monroe).

Geologic horizon.—Upper Cretaceous, Prairie Bluff chalk of late Maestrichtian age.

Type.—Type and four paratypes Alabama Museum of Natural History, University, Alabama. Figured paratype USNM 108689.

Remarks.—This species is named in honor of the collector, Miss Winnie McGlamery of the Geological Survey of Alabama.

Genus POROSOMA Cotteau

Porosoma Cotteau. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 6. Includes synonymy and description.

In a key to the genera of American Upper Cretaceous echinoids (Cooke, 1953, p. 4) *Porosoma* was inad-

vertently tabulated under "Tubercles perforate." It should have been placed under "Tubercles imperforate" next to *Rachiosoma*, from which it can be distinguished by its smaller, mainly dicyclic apical system.

Genus **HOLECTYPUS** Desor

Subgenus **Caenholectypus** Pomel

- Holectypus* (*Coenholectypus*) Pomel, 1883, Classification méthodique et genera des échinides, p. 75. [Typographical error for *Caenholectypus*.]
Caenholectypus Pomel, 1883, Classification méthodique et genera des échinides, p. 125.
Holectypus (*Coenholectypus*) Pomel. Hawkins, 1912, Zool. Soc. London Proc. 1912, pt. 3, p. 450.
Holectypus Desor (part). Lambert, 1931, Soc. géol. France Bull., sér. 5, v. 1, p. 302.
Holectypus Desor (part). Lambert and Thiéry, 1914, Nomenclature raisonnée des échinides, fasc. 4, p. 279.
Holectypus (*Coenholectypus*) Pomel. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 216.
Caenholectypus Pomel. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 1, p. 30.

Type species of *Caenholectypus*, *Discoidea macropyga* Agassiz, first species, designated by Hawkins (1912, p. 450). This species, as figured by Cotteau (1861-67, p. 44, pl. 1014, figs. 1-14; pl. 1015, figs. 1-4) has five genital pores, whereas typical *Holectypus* has only four. This difference, which was pointed out by Guéranger in 1859, is the only criterion commonly recognized for distinction between *Holectypus* (*Holectypus*) (type species *Echinites depressus* Leske) and *Holectypus* (*Caenholectypus*). Typical *Holectypus* is said (Mortensen, 1928-51, v. 4, p. 27) to be restricted to the Jurassic and Lower Cretaceous (Neocomian), whereas *Caenholectypus* is younger, chiefly from the Lower Cretaceous.

Specific distinctions in *Caenholectypus* are based primarily on the size and location of the periproct and on the size and shape of the peristome.

***Holectypus* (*Caenholectypus*) *planatus* Roemer**

Plate 21, figures 1-3

- Holectypus planatus* Roemer, 1849, Texas, p. 393.
Holectypus planatus Roemer. Roemer, 1852, Kreidebildungen von Texas, p. 84, pl. 10, figs. 2a-g.
Holectypus planus Giebel, 1853, Naturwiss. Ver. Halle Jahresber. 1852, p. 373.
Holectypus planatus Roemer. Conrad, 1857, U. S. Mexican Boundary Survey Rept., v. 1, pt. 2, p. 145, pl. 1, figs. 4a-f.
Holectypus planatus Roemer. Desor, 1858, Synopsis des échinides fossiles, p. 174.
Holectypus cenomanensis Guéranger, 1859, in Cotteau and Triger, Échinides du Département de la Sarthe, p. 173, pl. 30, figs. 5-10.
Holectypus cenomanensis Guéranger. Cotteau, 1861, Paléontologie française, Terrain crétacé, sér. 1, v. 7, p. 53, pl. 1016, figs. 8-13.
Holectypus planatus Roemer. Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 159.
Holectypus planatus Roemer. Clark, 1893, U. S. Geol. Survey Bull. 97, p. 58, pl. 23, figs. 2a-f.

- Holectypus planatus* Roemer (part). Clark, 1915, U. S. Geol. Survey Mon. 54, p. 65, pl. 25, figs. 2a-f (type of *H. engerrandi* Lambert). Not pl. 26, figs. 1a-e (type of *H. charltoni* Cragin=*H. castilloi* Cotteau).
Holectypus planatus Roemer. Adkins and Winton, 1920, Tex. Univ. Bull. 1945, p. 50, pl. 9, fig. 2.
Holectypus planatus Roemer. Winton, 1925, Tex. Univ. Bull. 2544, p. 48, pl. 13, fig. 6.
Holectypus planatus Roemer. Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 268.
Holectypus engerrandi Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 269.
Holectypus planatus Roemer. Adkins, 1928, Tex. Univ. Bull. 2838, p. 282, pl. 8, fig. 5; pl. 14, fig. 6.
Holectypus planus Giebel. Adkins, 1928, Tex. Univ. Bull. 2838, p. 282.
Holectypus cf. *planus* Giebel. Adkins, 1928, Tex. Univ. Bull. 2838, pl. 3, fig. 2.
Holectypus engerrandi Lambert. Adkins, 1928, Tex. Univ. Bull. 2838, p. 281.
Holectypus planatus Roemer. Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 460, pl. 62, figs. 8, 9, 11.
Holectypus engerrandi Lambert. Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 460, pl. 62, figs. 21-24.
Holectypus adkinsi Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 461, pl. 62, figs. 12-15.
Holectypus (*Coenholectypus*) *planatus* Roemer. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 217, pl. 32, fig. 13.

Horizontal outline subpentagonal to circular, subconical to dome shaped, margin broadly rounded, base flattish, concave around the peristome. Apical system with five perforated genital plates and a large central madreporite. Ambulacra half as wide as the interambulacra; poriferous zones narrow, straight, continuous; pore pairs transverse on upper surface, becoming increasingly oblique near the peristome. Peristome nearly one-third the horizontal diameter, somewhat wider than long, strongly notched. Periproct large, extending from near the margin to near the peristome, pointed at both ends. Tubercles arranged in concentric rows; small and inconspicuous on upper surface, much larger underneath; perforated.

Length 35 mm; width 35.4 mm; height 17 mm; width of peristome 10.4 mm.

Occurrence.—Texas: Near Fredericksburg, and San Saba Valley 15 miles below the old Spanish forts (*vide* Roemer). Wolf Creek about 9 miles northeast of Kerrville on road from Fredericksburg (USGS 1558, R. T. Hill, T. W. Vaughan, and T. W. Stanton). For additional localities in Texas see Cooke (1946, p. 217).

Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena (locs. C 14025, C 14025C-E).

Geologic horizon.—Lower Cretaceous: Fredericksburg group, Comanche Peak limestone; Trinity group, Glen Rose limestone; of middle and early Albian ages. Late Albian in Colombia.

Figured specimens.—USNM 103886, 108719.

Remarks.—The preceding description is based on two individuals from USGS 1558, the smaller of which closely resembles Roemer's figure of the species. *Holectypus planatus* differs from

all other American species of the genus in the great size of its periproct. In this feature it resembles *H. macropyga* (Agassiz), whose periproct is not pointed but rounded at the back.

***Holactypus* (*Caenholactypus*) *castilloi* Cotteau**

Plate 21, figures 7–10

Holactypus castilloi Cotteau, 1890, Soc. géol. France Bull., sér. 3, v. 18, p. 295, pl. 1, figs. 1–8.

Holactypus charltoni Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 158, pl. 24, figs. 8, 9.

Holactypus planatus Roemer (part). Clark, 1915, U. S. Geol. Survey Mon. 54, p. 65, pl. 26, figs. 1a–e. These figures represent the same specimen as Cragin's figures of *H. charltoni*. Not pl. 25, figs. 2–4.

Holactypus limitis Böse. Adkins and Winton, 1920, Tex. Univ. Bull. 1945, p. 51, pl. 9, figs. 1, 3.

Holactypus limitis Böse. Winton, 1925, Tex. Univ. Bull. 2544, p. 60, pl. 13, fig. 7.

Holactypus castilloi Cotteau. Adkins, 1928, Tex. Univ. Bull. 2838, p. 282.

Holactypus charltoni Cragin. Adkins, 1928, Tex. Univ. Bull. 2838, p. 282, pl. 8, fig. 8.

Holactypus limitis Böse. Adkins, 1928, Tex. Univ. Bull. 2838, p. 282, pl. 8, fig. 7; pl. 14, fig. 7 (after Winton, 1925, pl. 13, fig. 7).

Holactypus (*Caenholactypus*) *castilloi* Cotteau. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 218, pl. 32, fig. 15.

Subpentagonal to circular, low-arched above, concave below. Apical system central; ocular plates about as large as the genitals, inserted against the large central madreporite; five perforated genital plates. Ambulacra straight, about one-third as large as the interambulacra; poriferous zones continuous, narrow, pore pairs slightly oblique on top, more strongly on bottom; pores separated by a high partition. Peristome central, small, nearly circular or subpentagonal, strongly notched. Periproct about as long as the diameter of the peristome, occupying less than one-third the space between the peristome and the margin, closer to the margin than to the peristome. Tubercles arranged in concentric circles; small on upper surface, much larger, perforated, and crenulated on lower surface. Spines slender, longitudinally ribbed.

Length of large individual 65 mm; width 65 mm, height 25 mm; diameter of peristome 9.5 mm; length of periproct 10.8 mm.

Occurrence.—Mexico: Jalpa, Jalisco (type, *fide* Cotteau).

Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena. About 46 meters stratigraphically below locality C 14025 (loc. C 14164).

Texas: Rio Grande near Del Rio, Val Verde County (USGS 13976, W. G. Kane). Road cut along west side of Meadowbrook Country Club, 0.25 mile north of clubhouse, Fort Worth, Tarrant County (A. R. Loeblich, Jr.). Underpass of Santa Fe Railway south of Cleburne on Cleburne-Hillsboro road, Johnson County (H. T. and A. R. Loeblich). Other localities listed by Cooke (1946, p. 218).

Geologic horizon.—Washita group, Main Street limestone,

Weno limestone, and equivalents of late Albian age.

Figured specimens.—USNM 108717, 108718.

Comparisons.—The peristome of *Holactypus castilloi* is smaller than that of *H. transpecosensis* Cragin, and the periproct is nearer the margin; in other respects the two species are quite similar. The peristome is smaller and more nearly circular than that of *H. planatus* Roemer, the periproct is very much smaller, the ambulacra are narrower, and the individuals are larger.

***Holactypus* (*Caenholactypus*) *transpecosensis* Cragin**

Plate 21, figures 4–6)

Holactypus transpecosensis Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 160, pl. 27, figs. 3–5.

Holactypus transpecosensis Cragin. Lambert, 1903, Revue critique paléozoologie, Année 7, no. 4, p. 218.

Holactypus limitis Böse, 1910, Inst. geol. Mexico Bol. 25, p. 159, pl. 36, figs. 3–6; pl. 37, figs. 1–8; pl. 38, figs. 1–2.

Holactypus planatus Roemer (part.) Clark, 1915, U. S. Geol. Survey Mon. 54, p. 65, not figures.

Holactypus transpecosensis Cragin. Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 269.

Holactypus transpecosensis Cragin. Adkins, 1928, Tex. Univ. Bull. 2838, p. 281, 282.

Holactypus transpecosensis Cragin. Smiser, 1933, Jour. Paleontology, v. 7, no. 2, p. 147, 148.

Holactypus (*Caenholactypus*) *transpecosensis* Cragin. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 218, pl. 32, fig. 14.

Subpentagonal to circular, low dome-shaped to conical, margin rounded. Apical system central, with five perforated genital plates and five large ocular plates inserted against the large central madreporite. Ambulacra narrow, one-third as wide as the interambulacra, with narrow, straight, continuous poriferous zones; pore pairs very oblique near the peristome. Peristome central, circular, moderately notched, about one-fifth the total diameter. Periproct midway between the peristome and the margin, of variable size, inner end commonly somewhat rounded. Tubercles small on upper surface, much larger, crenulated, and with areoles on lower surface, arranged in concentric lines.

Length of figured specimen 52.5 mm; width 54 mm; height 29 mm; diameter of peristome 10.7 mm; length of periproct 10 mm.

Occurrence.—Texas: Sierra Blanca Mountains (type, *fide* Cragin). Pass between North and South Peaks of Sierra Blanca Mountains (figured specimen, USGS 1914, T. W. Stanton). Additional localities in Texas are listed by Cooke (1946, p. 218).

Mexico: Cerro Muleros, above the Initial Monument, 5 or 6 kilometers northwest of Ciudad Juarez, Chihuahua (type of *H. limitis*, *fide* Böse).

Geologic horizon.—Washita group of late Albian age.

Comparisons.—In shape and size *Holactypus transpecosensis* closely resembles *H. castilloi* Cotteau, but the peristome is larger and the periproct is commonly farther from the margin and larger. The periproct is much smaller than that of *H. planatus* Roemer.

Figured specimen.—USNM 103887.

Holectypus (Caenholectypus) nanus Cooke, n. sp.

Plate 27, figures 13-19

Test small, rarely exceeding 10 mm in diameter; horizontal outline circular to subpentagonal; upper surface moderately tumid; lower surface slightly concave around the peristome; ambitus rounded. Apical system having five genital pores. Poriferous zones uniserial, straight, continuous; zygopores oblique. Peristome central, rather small, moderately notched. Periproct large, submarginal, barely visible from above, well separated from the peristome. Tubercles small, far apart, arranged in vertical rows, two rows in each area. Spines short, acicular.

Horizontal diameter of holotype 5.9 mm; height 3.1 mm; diameter of peristome 1.5 mm.

Occurrence.—Texas: Hillside exposure on the old Burleson road about one-half mile north of the Glengarden Country Club, Fort Worth, Tarrant County. Cobbs brick pit, Cobbs Park, south of Maddux Avenue on Cobbs Park Drive (USGS 22246, Renfro coll. PP 1).

Geologic horizon.—Lower Cretaceous, Washita group, Pawpaw formation of late Albian age.

Type.—USNM 108610. Three cotypes.

Comparisons.—Of American species *Holectypus nanus* most closely resembles *Holectypus (Caenholectypus) planatus* Roemer, but is much smaller. The periproct is farther from the peristome and is turned obliquely upward so that it indents the ambitus. The decoration is quite different, there being fewer tubercles, which are arranged in vertical rows, not transversely as in *H. planatus*. This arrangement suggests that of *Discholectypus meslei* (Gauthier) (Cotteau, Peron, and Gauthier, 1876-84, fasc. 3, p. 84, pl. 8, figs. 1-4; Mortensen, 1928-51, v. 4, pt. 1, p. 32, figs. 192-0), which is very much larger, has a proportionately much smaller periproct, and differs in other respects.

Holectypus nanus is represented by several individuals, all small and all covered with a ferruginous coating, which obscures some details of structure.

Genus ARNAUDASTER Lambert

Arnaudaster Lambert, 1920, Soc. acad. d'agriculture, des sciences, arts et belles-lettres du département de l'Aube Mém., v. 83-84, p. 152, 167. (*Fide* Neave.)

Arnaudaster Lambert. Lambert and Thiéry, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 353.

Arnaudaster Lambert. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 1, p. 157.

Type species, *Arnaudaster gauthieri* Lambert, from the Cenomanian of France, by monotypy. Lambert's figures, as copied by Mortensen (1948, p. 157, figs. 131 a-d), show this species as a plump ovate form with rather short, open petals having unequal poriferous zones, a weak floscelle, and a terminal periproct on a depressed area. No other species have heretofore been assigned to *Arnaudaster*.

Arnaudaster colombianus Cooke, n. sp.

Plate 22, figures 1-9

Test rather large; horizontal outline ovate, wider behind than in front; upper surface low-arched; lower surface slightly concave around the peristome; margin broadly rounded. Apical system nearly central, with four unevenly spaced genital pores and a large central madreporite, which extends to a point behind the genital pores. Petals long, rather narrow, open distally, extending nearly to the margin; poriferous zones nearly the same length, narrower than the interporiferous; pores conjugate, inner pores circular; outer pores appearing diagonally elongate but nearly circular when corroded. Peristome pentagonal, nearly equilateral. Bourrelets very weak; phyllodes nearly flush, straight-sided. Periproct inframarginal, longitudinally oval, sloping backward, on a depressed area that barely indents the margin. Tubercles moderately large, little larger on lower surface than elsewhere.

Length 43.2 mm; width 38 mm; height 18.4 mm.

Occurrence.—Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena. Collected through a stratigraphic range of about 30 meters on a hill east of Quebrada Jagüey near the point where the quebrada opens into the valley (locs. C 14025, C 14026 B-E, C 14160, C 14161, type).

Geologic horizon.—Late Albian.

Types.—Holotype, Museum of Paleontology, University of California at Berkeley. Figured paratypes USNM 108696, 108697.

Comparison.—*Arnaudaster colombianus* may be distinguished from *A. gauthieri* by its much longer petals and nearly equal poriferous zones.

Genus FAUJASIA d'Orbigny

Faujasia d'Orbigny, 1856, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 290, 314.

Faujasia d'Orbigny. Cooke 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 13. Includes complete synonymy.

Type species *Pygurus apicalis* Desor, designated by Lambert and Thiéry (1909-25, p. 373). Cooke (1953, p. 14) referred to this genus *Faujasia chelonium* Cooke, basing his generic identification entirely on the literature. With the discovery of the species here described, which seems to fit the characters of *Faujasia* much better, it becomes apparent that the generic assignment was wrong. The margin of "*F*" *chelonium* is much more acute than that of any known species of *Faujasia*, its bourrelets are of a different type, and its posterior truncations are more angular. The species should probably be transferred to *Pygurus*, becoming *Pygurus (Echinopygus) chelonium* (Cooke).

Clypeaster geometricus Morton, which was transferred to *Pygurus* by d'Orbigny and to *Pygurostoma* by Cooke

(1953, p. 14, pl. 4, figs. 15-20), is here reassigned to *Faujasia*, the name becoming *Faujasia geometrica* (Morton).

Faujasia rancheriana Cooke, n. sp.

Plate 23, figures 10-14

Horizontal outline ovate, wider behind than in front; upper surface inflated; lower surface slightly concave; margin rounded. Apical system slightly anterior, having four genital pores and a large central madreporite. Ambulacra petaloid; petals lanceolate, nearly closed distally, extending two-thirds the way to the margin; poriferous zones rather wide; pores conjugate, inner row circular, outer row elongate, pairs oblique. Peristome slightly anterior, star-shaped; bourrelets round, conspicuous; phyllodes nearly flush. Sternal area granular, narrow. Tubercles scrobiculated.

Length 40 mm; width 36 mm; height 19 mm.

Occurrence.—Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. from San Juan de Cesar, Department of Magdalena. Collected through a stratigraphic range of about 20 meters on a hill east of Quebrada Jagüey near the point where the quebrada opens into the valley (locs. C 14025, C 14025B, and C 14025D).

Geologic horizon.—Late Albian.

Types.—Holotype, Museum of Paleontology, University of California at Berkeley. Paratypes, USNM 108700.

Comparisons.—*Faujasia rancheriana* has somewhat longer petals than *F. apicalis* (Desor), and is less conical. Horizontal outline is intermediate between that of *F. faujasi* d'Orbigny and *F. delauneyi* d'Orbigny. These three species are figured by d'Orbigny (1854-60, p. 315-319, pls. 922-924).

Genus *PHYLLOBRISUS* Cotteau

Phyllobrissus Cotteau, 1860, Soc. sci. hist. et nat. Yonne Bull., v. 13, p. 434.

Porobrissus Lambert, 1916, Revue critique de paléozoologie, v. 20, p. 169.

Nucleopygus (*Porobrissus*) Lambert. Lambert and Thiéry, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 437.

Porobrissus Lambert. Adkins, 1928, Tex. Univ. Bull. 2838, p. 284.

Phyllobrissus Cotteau. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 17. Includes additional synonymy.

Type species *Catopygus gressleyi* Agassiz, from the Neocomian of France, designated by Savin (1903).

Porobrissus, with *Echinobrissus angustatus* Clark as its type by monotypy, was based on imperfect drawings made for Clark before the matrix had been removed. Subsequent cleaning reveals features quite different from those attributed to it by the artist. These seem to ally it with *Phyllobrissus*, although the apical system is still somewhat obscure.

Phyllobrissus angustatus (Clark)

Plate 23, figures 1-4

Echinobrissus angustatus Clark, 1915, U. S. Geol. Survey Mon. 54, p. 69, pl. 27, figs. 2a-c.

Echinobrissus angustatus Clark. Whitney, 1916, Bull. Am. Paleontology, v. 5, no. 26, p. 98 (14), pl. 21 (7), figs. 6-9; pl. 23 (9), fig. 4.

Porobrissus angustatus (Clark). Lambert, 1916, Revue critique de paléozoologie, v. 20, no. 4, p. 169.

Nucleopygus (*Porobrissus*) *angustatus* (Clark). Lambert and Thiéry, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 348.

Clypeopygus angustatus (Clark). Lambert and Thiéry, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 348.

Porobrissus angustatus (Clark). Adkins, 1928, Tex. Univ. Bull. 2838, p. 284.

Clypeopygus angustatus (Clark). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 222, pl. 31, figs. 1-12.

Porobrissus angustatus (Clark). Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 1, p. 186, 187, text fig. 166 (after Clark).

Test small, shovel-shaped, wider behind than in front; upper surface inflated in front, sloping backward; lower surface concave around the peristome; margin rounded. Apical system at the anterior third, with four genital pores and apparently a large central madreporite. Petals rather short, nearly equal in length, open at the tips; poriferous zones equaling the interporiferous zones in width; pores small, round or oval. Peristome anterior but farther back than the apical system; slightly wider than long, suboval; phyllodes straight; bourrelets very weak. Periproct supramarginal, elliptical, twice as long as wide, deeply sunken in a rounded sulcus, which barely indents the margin and extends more than halfway to the apical system. Tubercles closely scattered, deeply pitted.

Length of type 15.5 mm; width 14.2 mm; height 9.4 mm.

Occurrence.—Texas: Shoal Creek near Austin (type).

Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena (loc. C 14025D).

Geologic horizon.—Buda limestone, of early Cenomanian age (type); late Albian in Colombia.

Type.—USNM 103701. Figured specimen from Colombia USNM 108699.

Comparisons.—This species appears to have the essential generic features of *Phyllobrissus gressleyi* but is narrower in front and the periproct is farther forward. It is smaller than *Phyllobrissus cubensis* (Weisbord) (Cooke, 1953, p. 17, pl. 5, figs. 11-14) and narrower in front, but the periproct occupies nearly the same location.

Remarks.—*Echinobrissus angustatus* Clark was transferred to *Nucleopygus* by Lambert and Thiéry, and that assignment was accepted by Mortensen, who considered *Porobrissus* a synonym of *Nucleopygus*. However, *Nucleopygus minor* Agassiz, the type species of *Nucleopygus*, appears to have a large, flush periproct, quite different from this species. Lambert and Thiéry also assigned it to *Clypeopygus*, but *Clypeopygus paultrei* is a large, flattish species with an angular V-shaped anal sulcus, curved phyllodes, and stronger bourrelets.

The genital pores of the specimen from Colombia (pl. 23, figs. 1-4) are farther apart than those of the type, from Texas. However, this seems to be a variable feature, for Whitney's figures (1916, pl. 7, figs. 7, 8) show some variation in the spacing of the pores.

Genus **PYGURUS** Agassiz

Pygurus Agassiz, 1839, Allg. Schweizer. Gesell. Neue Denkschr. Band 3, Art. 3, p. 68, 100.

Pygurus Agassiz. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 1, p. 132. Includes complete synonymy.

Type species, *Echinolampas montmollini* Agassiz, first species, designated by Savin (1903, p. 140). As figured by Agassiz (1839, p. 69, pl. 11, figs. 1-3) and by d'Orbigny (1854-60, p. 305, pls. 916-917) this species is subquadrate, conical, with an anterior depression and rather short open petals. The peristomial region appears to have rather low, rounded bourrelets and rather shallow phyllodes. Periproct is longitudinally oval and occupies a depressed area near the margin of the oral surface.

Two American species, *Clypeaster geometricus* Morton from New Jersey and *Laganum? colombianum* d'Orbigny from Colombia, were referred to *Pygurus* by Agassiz and Desor (1847, p. 105, 141), but both of these species probably represent different genera. *Clypeaster geometricus* was transferred to *Pygurostoma* by Cooke (1953, p. 14), but it is probably a *Faujasia*. Little is known about *Laganum? colombianum*, but d'Orbigny (1854-60, p. 311, pl. 920, fig. 1) thought that it is not a *Pygurus*. The species here described as *Pygurus* (*Echinopygus*) *jagüeyanus* appears to be the only known representative of the genus in South America, but *Pygurus* (*Echinopygus*) *chelonium* (Cooke, 1953, p. 14, pl. 4, figs. 11-14) occurs in the late Maestrichtian Escondido formation of Texas.

Subgenus **ECHINOPYGUS** d'Orbigny

Pygurus (*Echinopygus*) d'Orbigny, 1856, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 303.

Echinopygus d'Orbigny. Lambert and Thiéry, 1921, Nomenclature raisonnée des échinides, fasc. 5, p. 354.

Type species, *Clypeaster oriformis* var. 2 Lamarck, which Desor (1855-58, p. 311) and Wright (1864-82, p. 258, pl. 58, figs. 1a-h) identify as *Echinonauus lampas* De la Beche (1824, p. 42, pl. 3, figs. 3-5), designated by Lambert and Thiéry (1921, p. 355). This species as figured by d'Orbigny (1854-60, p. 311, pl. 919) is longer than wide, lacks an anterior depression, and is produced behind. The phyllodes appear to be deeper and the bourrelets stronger than those of *Pygurus montmollini*, and the upper surface is more evenly rounded. The periproct is transversely oval, having no flat or concave area surrounding it. These differences may be of sufficient importance to justify the

retention of *Echinopygus* as a subgenus under *Pygurus*, as it was originally proposed.

Pygurus (*Echinopygus*) *jagüeyanus* Cooke, n. sp.

Plate 23, figures 5-9

Horizontal outline subovate, widest behind the center, slightly produced behind. Upper surface broadly convex, steeper in front than behind. Lower surface concave. Apical system slightly anterior, with four genital pores and a large central madreporite. Ambulacra petaloid; petals lanceolate, closed apically, slightly open distally, extending almost to the margin; pores conjugate, inner pores circular, outer pores elongate; interporiferous zones much wider than the poriferous. Peristome slightly anterior, directly under the apical system. Bourrelets very conspicuous, high, flat, spear shaped, hollow. Phyllodes halberd-shaped, bordered by a double row of circular pores, the pairs staggered medially; concave, deeply depressed near the peristome, from which they are separated by a wall. Periproct transversely oval, inframarginal, not visible from above. Tubercles small on upper surface, much larger on lower surface.

Length 56 mm; width 48 mm; height 19.5 mm.

Occurrence.—Colombia: Rancheria Valley about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena. Collected through a stratigraphic range of about 30 meters on a hill east of Quebrada Jagüey near the point where the quebrada opens out into the valley (locs. C 14025, C 14025B-E).

Geologic horizon.—Late Albian. In a series of sandy marls and thin-bedded limestones containing *Venezolicerias* sp. and *Pervinquieria* sp.

Types.—Holotype, Museum of Paleontology, University of California at Berkeley. Figured paratype, USNM 108698.

Comparisons.—The peristomial region is similar to that of *Pygurus rostratus* Agassiz as figured by d'Orbigny (1854-60, p. 304, pl. 915), but the ambitus is more evenly rounded and the periproct more nearly terminal. The posterior end is less produced than that of *Pygurus lampas* (De la Beche).

Genus **HARDOUINIA** Haime

Hardouinia Haime. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 19. Includes synonymy and full discussion.

Hardouinia clypeus Cooke, n. sp.

Plate 25, figures 1-5

Test small, shield-shaped, rounded in front, sides nearly parallel, posterolateral margins truncate; upper surface rising to a low, pointed dome; lower surface concave around the peristome; margins acutely rounded. Apical system central or slightly posterior; four genital pores surrounding a large central madreporite. Strongly petaloid; anterior petal much the longest, extending nearly to the margin; paired petals nearly equal, extending halfway to the margin; petals nearly

closed; inner pores oval, outer pores elongated; interporiferous zones not wider than the poriferous. Peristome posteriorly eccentric; phyllodes subtriangular, longer than wide; bourrelets strong, pointed, protruding into the opening. Periproct supramarginal, behind the ends of the petals, oval or circular, sunken in a tube, which opens into a sulcus that extends to the margin. Tubercles very small and close together on upper surface, much larger and sunken on lower surface.

Length 28.8 mm; width 26.1 mm; height 18.2 mm.

Occurrence.—Alabama: Catoma Creek, Montgomery County, 0.9 mile northeast of Mount Moriah Church, in the NW¼ sec. 32, T. 16 N., R. 17 E. (USGS 17010, L. W. Stephenson, C. W. Cooke, and A. C. Munyan; Ala. Mus. Nat. History, W. McGlamery; Ala. Geol. Survey, Gunter Glass).

Geologic horizon.—Upper Cretaceous, Tombigbee sand member of Eutaw formation, of Santonian age.

Type.—USNM 108720, from USGS 17010. One paratype each in USNM 108721, Alabama Museum of Natural History, and Geological Survey of Alabama.

Comparisons.—This species is associated with *Hardouinia bassleri* (Twitchell), from which it can be distinguished by the sharper margin, posterolateral truncations, shorter paired petals, and narrower interporiferous zones. In shape it most nearly resembles *Hardouinia mortonsi emmonsii* (Stephenson); but the phyllodes are longer, have a double row of lateral pores, a staggered inner row of pores, and lack deep pits; the periproct is oval rather than circular; and the petals are narrower and unequal in length. *Hardouinia clypeus* is much rarer than *H. bassleri*; only four specimens have been found.

Genus TOXASTER Agassiz

?*Echinospatagus* Meuschen, 1778, Mus. Gronovianum, p. 92 (fide Neave).

Toxaster Agassiz, 1840, Catalogus eotyporum Echinodermatum fossilium, p. 15.

Toxaster Agassiz. Agassiz and Desor, 1847, Catalogue raisonné des Échinodermes (reprint), p. 131.

Echinospatagus Breynius. D'Orbigny, 1854, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 30; 1855, p. 149, 151.

Toxaster Agassiz. Desor, 1858, Synopsis des échinides fossiles, p. 350.

Echinospatagus Breynius. De Loriol, 1873, Échinologie helvétique, pt. 2, p. 340.

Echinospatagus Breynius. Wright, 1874, 1878, British fossil Echinodermata from the Cretaceous formations, v. 1, p. 192, 280.

Toxaster Agassiz. Pomel, 1883, Classification méthodique et genera des échinides, p. 43.

Echinospatagus Breynius. Duncan, 1889, Linnean Soc. Jour., Zoology, v. 23, p. 219.

Toxaster Agassiz. Savin, 1903, Soc. hist. nat. Savoie Bull., sér. 2, v. 8, p. 81.

Toxaster Agassiz. Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 435.

Toxaster Agassiz. Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 340. Includes additional synonymy.

Type species, *Holaster complanatus* Agassiz = *Spatangus retusus* Lamarck, from the Hauterivian, designated by Pomel (1883, p. 44). This species has been

figured by d'Orbigny (1854–60, p. 155, pl. 840) under the name *Echinospatagus cordiformis* Breynius. It is characterized by open petals with elongated pores, the outer rows longer than the inner and the anterior zones of the paired petals somewhat narrower than the posterior zones. The anterior ambulacrum is slightly depressed; the other petals are nearly flush. The peristome is subpentagonal, without lips, and the elongated periproct lies near the top of a terminal depressed area. The species has no fascioles.

The legal name of this genus, whether *Toxaster* or *Echinospatagus*, depends upon the identity of the latter as described by Meuschen in the Museum Gronovianum, which book I have not seen. D'Orbigny and later writers who have revived *Echinospatagus* attribute it to Breynius, who was pre-Linnean.

Toxaster colombianus (Lea)

Plate 24, figures 9–12

Spatangus colombianus Lea, 1841 Am. Philos. Soc. Trans., ser. 2, v. 7, p. 257, pl. 9, fig. 11.

Toxaster roulini Agassiz, 1847, in Agassiz and Desor, Catalogue raisonné des Echinodermes (reprint), p. 131.

Echinospatagus roulini (Agassiz). D'Orbigny, 1855, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 163, pl. 843, figs. 1–8.

Toxaster roulini Agassiz and Desor. Desor, 1858, Synopsis des échinides fossiles, p. 356.

Toxaster roulini Agassiz. Gerhardt, 1897, Neues Jahrbuch Beilage Band 11, p. 189, fig. 17a-f; p. 192, figs. 18a-d.

Toxaster (*Miotoxaster*) *roulini* Agassiz. Lambert, 1920, Soc. sci. hist. et nat. Yonne, Année 1919, v. 73, pt. 2, p. 18 (124).

Heteraster colombianus (Lea). Lambert, 1920, Soc. sci. hist. et nat. Yonne Année 1919, p. 25 (131).

Toxaster (*Miotoxaster*) *roulini* Agassiz. Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 436.

Heteraster colombianus (Lea). Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 438.

Toxaster roulini Agassiz. Noeth, 1938, Estudios geol. y paleont. sobre Cordillera Oriental de Colombia, pt. 3, Rep. Colombia, Dept. minas y petroleos, p. 123, pl. 24, figs. 1–5.

Toxaster roulini Agassiz? Beurlen, 1938, Estudios geol. y paleont. sobre Cordillera Oriental de Columbia, pt. 3, Rep. Columbia, Dept. mines y petrleos, p. 132.

Toxaster (*Miotoxaster*) *roulini* Agassiz. Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 342, fig. 232 (after d'Orbigny).

Test medium-sized, length ranging from 20 mm or less to 45 mm or more; horizontal outline ovate-cordate, upper surface strongly inflated; lower surface slightly convex; anterior ambulacrum having a deep, narrow depression extending from the apical system to the peristome; posterior end sloping steeply downward and backward. Apical system well behind the center; four genital pores nearly equally spaced, the posterior pair tending to be a little closer than the anterior pair and the plates in contact with each other; posterior ocular plates in contact. Anterior ambula-

crum subpetaloid, the pores of the petals resembling chevrons, the outer pores transversely elongated, the inner pores shorter and sloping forward. Anterior paired petals curving forward near the apex, curving outward near the outer ends, which are wide open; extending nearly to the margin; pores transversely elongated, anterior zone narrower than the other. Posterior petals much shorter, widely spreading at an angle approximating 105° , slightly curved backward, open at the outer ends; pores transversely elongated, posterior zone the wider. Peristome near the anterior end, subcircular, without lips. Periproct subcircular or bilunate, small, high up on the posterior truncation, generally visible from above. Tubercles small, in shallow circular depressions, rather sparsely scattered.

Length of figured specimen 35 mm; width 29.5 mm; height 19 mm.

Occurrence.—Colombia: Road from Bogotá to Popayan between Tocaima and La Messa (type, *vide* Lea). Northwest part of the Department of Santander, near Río Sogomosa 1.6 and 2 kilometers above the highway bridge near El Tablazo on the road from Bucaramanga to Barranca Bermeja (locs. C 170 and S 91). Department of Santander 1–2 kilometers east of Zapatoca (*vide* Gerhardt). Northwest part of the Department of Boyacá, on the Arcabuco-Barbosa Highway near Km 56.5, where the road crosses a high black limestone ridge (this area is northeast of the town of Chiquinquirá) (loc. C 789). Northwest part of the Department of Boyacá, in the area between Leiva and Arcabuco at Las Hojitas on the Gachantiva trail about 10.5 kilometers north of Leiva (loc. C 922). Northwest part of the Department of Tolima, on the south bank of Quebrada Cobre 3.75 kilometers S. 11° W. of Payandé (loc. C 185).

Geologic horizon.—Localities S 91, C 170, C 789, and C 922 have been referred to the Lower Cretaceous Hauterivian-Valanginian (?), but C 185 is reported as Albian. Gerhardt reports the species from the Aptian, although other fossils listed by him from the same locality suggest Hauterivian.

Type.—According to Lea the type was in his own cabinet; it could not be found at the Academy of Natural Sciences of Philadelphia, where his Claiborne collections are. The type of *Toxaster roulini*, from South America, is in the museum at Neuchâtel, Switzerland, no. 25 M. 42b (*vide* Agassiz).

Figured specimen.—USNM 108702.

Remarks.—The collections examined include a great profusion of individuals, mostly from locality S 91, but many of them are defective or partly embedded in very hard dark gray limestone. There is considerable variation in the relative proportions of the specimens, some being narrower than others. According to Gerhardt the ratio of the width to the length in the normal form is 0.88; in the elongated variety it is 0.8.

Toxaster colombianus superficially resembles *Enallaster mexicanus* but can readily be distinguished by the uniform pores of its anterior ambulacrum and by the position of its posterior genital plates, which are in contact, whereas those of *Enallaster* are separated by the madreporite. *T. colombianus* is proportionately narrower than *T. complanatus* (Agassiz), and the inner pores of its anterior ambulacrum are more oblique.

Genus HETERASTER d'Orbigny

Heteraster d'Orbigny, 1855, *Paléontologie française, Terrain crétacé*, sér. 1, v. 6, p. 175.

Toxaster Agassiz (part). Desor, 1858, *Synopsis des échinides fossiles*, p. 355.

Heteraster d'Orbigny. De Loriol, 1873, *Échinologie helvétique*, pt. 2, *Période crétacé*, p. 354.

Heteraster d'Orbigny. Pomel, 1883, *Classification méthodique et genera des échinides*, p. 44.

Heteraster d'Orbigny (part). Lambert and Thiéry, 1924, *Nomenclature raisonnée des échinides*, fasc. 6, p. 437.

Heteraster d'Orbigny (part). Mortensen, 1950, *Monograph of the Echinoidea*, v. 5, pt. 1, p. 346.

Type species, *Spatangus oblongus* (Brongniart).

Heteraster is regarded by Lambert, Mortensen, and others as a senior synonym of *Enallaster* d'Orbigny, but typical *Heteraster* differs from the American species of *Enallaster* as follows: (1) The posterior genital plates are more broadly in contact; in *Enallaster* they are almost separated by the madreporite. (2) All the inner pores of the anterior ambulacrum are round or oval and are arranged in a straight line; in *Enallaster* the inner pores of the long pairs are elongated and extend inward beyond the short pairs, whose median spaces fall in a straight line with the median spaces of the long pairs. (3) The posterior paired petals are flexuous and more widely spreading, and their anterior poriferous zones are much narrower than the posterior; in *Enallaster* the posterior petals are nearly straight and less widely spreading, and the anterior poriferous zones are as wide or nearly as wide as the posterior.

These differences, which are readily recognizable, may be important enough to justify the retention of *Heteraster* and *Enallaster* as separate genera or at least subgenera. Moreover, the two occupy different geologic zones. *Heteraster* is the older, both *H. oblongus* and *H. couloni* (Agassiz) occurring in the late Neocomian, whereas *Enallaster* occupies younger Lower Cretaceous strata, chiefly Albian.

Heteraster oblongus (Brongniart)

Plate 24, figure 5

Spatangus oblongus Brongniart, 1821, *Annales des Mines*, v. 6 p. 555, pl. 7, figs. A–C.

Toxaster oblongus (Brongniart). Agassiz, and Desor, 1847, *Catalogue raisonné des échinides*, p. 131.

Heteraster oblongus (Brongniart). D'Orbigny, 1855, *Paléontologie française, Terrain crétacé*, sér. 1, v. 6, p. 176, pl. 847.

Toxaster (*Heteraster*) *oblongus* (Brongniart). Desor, 1858, *Synopsis des échinides fossiles*, p. 355, pl. 40, figs. 8–9.

Heteraster oblongus (de Luc) d'Orbigny. Cotteau, Peron, and Gauthier, 1876, *Échinides fossiles de l'Algérie*, fasc. 3, p. 20.

Heteraster oblongus (ae Luc). De Loriol, 1873, *Échinologie helvétique*, pt. 2, *Période crétacé*, p. 355, pl. 29, figs. 8a–d.

Enallaster oblongus (Brongniart). Savin, 1903, *Soc. hist. nat. Savoie Bull.*, sér. 2, v. 8, p. 239 (list).

Heteraster oblongus (Brongniart). Mortensen, 1950, *Monograph of the Echinoidea*, v. 5, pt. 1, p. 347, figs. 237, 238 (after d'Orbigny).

Test rather straight sided, greatest width far forward, steeply truncated behind, anterior sulcus shallow,

Apical system rather far back; posterior genital plates in broad contact. Anterior petal long; colon-shaped pore pairs separated by two or three exclamation-point-like pores, all the inner pores in a straight line. Anterior paired petals long, bent forward near the apex, outward at the tips; anterior poriferous zones narrow, nearly straight, pores punctiform, pore pairs spaced like those of posterior zones; posterior poriferous zones much wider, inner pores oval, outer pores elongated. Posterior petals much shorter, wide, spreading at an angle approximating 120° ; anterior poriferous zones narrow, pores punctiform; interporiferous zones wide; posterior poriferous zones wide, inner pores punctiform, outer pores elongated. Peristome rather small, far forward, subcircular. Periproct rather large, bilunate, on the posterior truncation, visible from above.

Length of figured specimen 28.2 mm; width 23.5 mm; height 15 mm.

Occurrence.—Southeastern France: Somaye, Département Isère (figured specimen).

Geologic horizon.—Lower Cretaceous, Neocomian, Urgonian (*fide* d'Orbigny).

Figured specimen.—USNM 19590.

Remarks.—This well-known European species, type of the genus, is figured to show the generic features.

***Heteraster cesarensis* Cooke, n. sp.**

Plate 24, figures 1-4

Test emarginate in front, vertically truncate behind, widest in front of the center, about half as high as long; highest at the apical center, sloping very gently to the posterior truncation, more steeply forward; anterior furrow rather shallow. Apical system posterior; four genital plates, the perforations forming a rectangle slightly longer than wide; posterior genital plates joined behind, partly enclosing the madreporite. Pores of the anterior petal are like exclamation points and colons, the inner pores are round or oval and nearly aligned, the outer pores commonly alternating two longs and a short, the more distal of the two long pores slightly oblique. Anterior paired petals twice as long as the posterior pair, curved forward near the apex, outward at the tips; anterior poriferous zone narrow, pores small, round or oval, spaced equally with those of the posterior zone; inner pores of posterior zone oval, outer pores much elongated; interporiferous zone wider than posterior poriferous zone. Posterior paired petals diverging at an angle approximating 95° ; anterior poriferous zones much narrower than the posterior zones, pores oval; inner pores of the posterior zone oval, outer pores much elongated. Peristome near the anterior quarter, subcircular. Periproct bilunate, large, near the top of the posterior truncation.

Length 38 mm; width 36.3 mm; height 19 mm.

Occurrence.—Colombia: Cesar Valley, Department of Magdalena.

Geologic horizon.—Lower Cretaceous, Villeta group, probably late Neocomian.

Type.—USNM 108704, Paratypes USNM 108723. Gift from the Paleontological Research Laboratories through R. L. Casanova.

Comparisons.—The proportions of *Heteraster cesarensis* are similar to those of *Enallaster obliquatus* Clark, but the greatest width is farther forward. The sides taper back more rapidly and the apical center is farther back than in *Heteraster oblongus* (Brongniart). The species is proportionately shorter than *Heteraster couloni* (Agassiz). The inner pores of the colonlike pairs of the anterior petal are less perfectly aligned with the other inner pores than in those two species of *Heteraster*; they are slightly offset outward but less so than in species of *Enallaster*.

Genus ENALLASTER d'Orbigny

Enallaster d'Orbigny, 1854, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 181.

Enallaster d'Orbigny. Desor, 1858, Synopsis des échinides fossiles, p. 357.

Enallaster d'Orbigny. De Loriol, 1873, Échinologie helvétique, pt. 2, Échinides crétacé, p. 359.

Enallaster d'Orbigny. Wright, 1878, British fossil Echinodermata, v. 1, pt. 8, p. 288.

Enallaster d'Orbigny. Pomel, 1883, Classification méthodique et genera des échinides, p. 44.

Enallaster d'Orbigny. De Loriol, 1884, Recueil zool. suisse, v. 1, p. 622.

Enallaster d'Orbigny (part). Duncan, 1898, Linnean Soc. London Jour., Zoology, v. 23, p. 220.

Enallaster d'Orbigny. Savin, 1903, Soc. hist. nat. Savoie Bull., sér. 2, v. 8, p. 84.

Heteraster d'Orbigny (part). Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 437.

Heteraster d'Orbigny (part). Adkins, 1928, Tex. Univ. Bull. 2838, p. 287.

Enallaster d'Orbigny. Ikins, 1940, Bull. Am. Paleontology, v. 25, no. 90, p. 58 (10).

Enallaster d'Orbigny. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 230.

Heteraster d'Orbigny (part). Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 346.

Type species, *Hemipneustes greenovii* Forbes (1852, pl. 5), from the greensand of Blackdown in Devonshire, England. As figured by Forbes and d'Orbigny (1854-60, p. 183, pl. 849 after Forbes), the anterior petal lies in a deep, wide depression that extends to the peristome. This anterior petal has chevron-shaped pores alternating with small circular pores in narrow pairs. The anterior poriferous zones of all the paired petals are narrower than the posterior zones and contain small round pores; the pores of the posterior zones are elongated. The posterior genital plates are not in contact but are separated by the madreporite. The posterior ocular plates are in contact. The anterior paired petals are represented as bending forward near the apex but not outward near their tips. The peristome is well forward and is without lips. The periproct lies near the top of a gently sloping posterior truncation. It is visible from above.

The most significant difference between *Enallaster*, *Toxaster*, and *Heteraster* is found in the arrangement of the pores of the anterior petal. In *Enallaster* the pores are of two kinds—pairs of round or oval pores and pairs of elongated pores, of which the outer pore is the longer, the pairs alternating with more or less regularity and alined along the middle spaces of the pairs. In *Toxaster* the pore pairs are alike, generally chevron shaped, and evenly alined. In *Heteraster* the inner pores are round and evenly alined, but the outer pores are slitlike, long and short pores alternating irregularly.

The American species of *Enallaster* have frequently been lumped into the species *Enallaster texanus* (Roemer), which has been supposed to range throughout the Comanche series. The identity of this species is uncertain because the type is not accessible. Presumably the type came from either the Trinity group or the Fredericksburg group, both of which crop out in the vicinity of Fredericksburg, Tex., the type locality. *Enallaster texanus* is here tentatively identified as the Trinity species later named *Enallaster obliquatus* Clark because Roemer's figure shows it to be a flatter form than the Fredericksburg species, *Enallaster mexicanus* Cotteau. The common species in the Washita group, *Enallaster bravoensis* Böse, differs from both of these species in having narrow, branching fascioles, which place it in the subgenus *Washitaster*.

When the state of preservation is such that they can be accurately identified, the species of *Enallaster* make good horizon markers. *Enallaster obliquatus* seems to be restricted to the Trinity group, *E. mexicanus* to the Fredericksburg group, and all the known species of *Washitaster* to the Washita group. The principal distinguishing characteristics are mentioned in the key to the species.

Key to the American species of Enallaster

Without fascioles:

Test depressed, broader in front (Trinity group)

Enallaster obliquatus

Test inflated, narrower in front (Fredericksburg group)

E. mexicanus

Having narrow multiple fascioles (Washita group). Subgenus *Washitaster*:

Odd petal having irregularly alternating long and short pore pairs without conspicuous beads

Upper surface strongly inflated, lower surface moderately inflated.....*E. (Washitaster) inflatus*

Upper surface moderately inflated, lower surface nearly flat
E. (Washitaster) bravoensis

Odd petal having conspicuous beads, short pores predominating

Test wider, apical system farther forward

Few if any long pores in odd petal

E. (Washitaster) riivistae

Variable number of long pores in odd petal

E. riivistae wenoensis

Test narrower, apical system farther back

E. (Washitaster) longisulcus

Enallaster obliquatus Clark

Plate 25, figures 7-13

?*Toxaster texanus* Roemer, 1849, Texas, p. 393.

?*Toxaster texanus* Roemer. Roemer, 1852, Kreidebildungen von Texas, p. 85, pl. 10, figs. 3a-c.

?*Enallaster texanus* (Roemer). D'Orbigny, 1853, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 184, pl. 850, figs. 1-7. Misspelling for *texanus*.

?*Toxaster texanus* Roemer. Conrad, 1857, United States and Mexican Boundary Survey Rept., v. 1, pt. 2, p. 145, pl. 1, figs. 2a-c.

?*Enallaster texanus* (Roemer). Desor, 1858, Synopsis des échinides fossiles, p. 358.

?*Heteraster texanus* (Roemer). Shumard, 1860, Acad. Sci. St. Louis Trans., v. 1, p. 585.

Enallaster obliquatus Clark, 1893, U. S. Geol. Survey Bull. 97, p. 79, pl. 40, figs. 1a-1.

Enallaster obliquatus Clark. Clark, 1915, U. S. Geol. Survey Mon. 54, p. 87, pl. 40, figs. 1a-1.

Heteraster obliquatus (Clark). Lambert, 1920, Soc. hist. et nat. Yonne Bull., v. 73 (Année 1919), p. 130.

?*Heteraster texanus* (Roemer). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 270.

Heteraster obliquatus (Clark). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 270.

?*Heteraster obliquatus* (Clark). Smiser, 1936, Jour. Paleontology, v. 10, no. 3, p. 468, pl. 64, fig. 25.

?*Enallaster texanus* (Roemer). Ikins, 1940, Bull. Am. Paleontology, v. 25, no. 90, pl. 4 (7), figs. 1a-b.

Enallaster texanus (Roemer) (part). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 231, pl. 33, figs. 9-12.

Test cordate, widest in front of the midline, posterolateral outline convex, emarginate in front, weakly truncated behind. Upper surface highest behind the apical system, sloping gently forward, more steeply behind, with a broad, shallow, anterior sulcus extending from the apex to the peristome. Lower surface nearly flat. Apical system posterior, somewhat variable in location; four genital plates, the posterior pair nearly separated by the madreporite. Anterior petal having regularly alternating long and short pairs of pores, the short pores divided by a small bead. Anterior paired petals very slightly sunken, slightly flexuous; the anterior poriferous zones nearly straight, pores oval; posterior poriferous zones more flexuous, inner pores slightly elongated, outer pores much longer; interporiferous zones nearly as wide as the posterior poriferous zones. Posterior petals shorter, flush, lanceolate, the outer pores somewhat longer than the inner, diverging at an angle approximating 90°. Peristome subcircular or wider than long, near the anterior fourth. Periproct transversely oval, well up on a weak truncation. Plastron dotted with close-set tubercles; tubercles perforated, crenulated, largest on the anterior interambulacra. A broad finely granular band surrounds the petals; covered with widely spaced tubercles; no distinct fascioles.

Length of holotype 49 mm; width 46.3 mm, height 28.6 mm. Most specimens are much lower.

Occurrence.—Texas: Mount Bonnell near Austin (USNM 12237, type, George Stolley). In Bandera County 10.5 miles southwest of Boerne, Kendall County (USGS 18388, Ralph Imlay). Cranes Mill-New Braunfels road about 3 miles south of Guadalupe River, 222.5 feet above the bridge (USGS 18384, Ralph Imlay). Wimberley-Dripping Springs road 2.5 miles south of Lone Man Mountain, Hays County (USGS 18400, Ralph Imlay). About 9 miles northeast of Bandera on Langford Ranch, Bandera County (USGS 18386, Ralph Imlay). Ridge east of mouth of Mayfield Canyon about 3 miles east of Indian Hot Springs, Hudspeth County (USGS 18382, J. B. Reeside, Jr., and Ralph Imlay). Presidio County 3.2 miles southwest of Shafter (USGS 16897, W. E. Cartwright). Cut on the Kerre Creek road about 0.25 mile south of hill 112 on the Leon Springs Military Reservation near Leon Springs, Bexar County (USGS 8736, Alexander Deussen). Road 3.4 miles north of bridge over Guadalupe River at Cranes Mill (USGS 11867, T. W. Stanton and F. L. Whitney). Road to D'Hanis 2.5 miles southeast of Utopia (USGS 13635, N. H. Darton and T. W. Stanton). East of Marathon, 1.5 miles south of highway (USGS 13623, T. W. Stanton and N. H. Darton). Bank of Cibolo River about 2.5 miles west of Bulverde road crossing, northern part of Bexar County (USGS 10200, O. B. Hopkins). Callahan County 5 miles north-northeast of Cross Plains (USGS 14716, N. H. Darton). Road to New Braunfels 2.5 miles east of Cranes Mill (USGS 11869, T. W. Stanton and F. L. Whitney). One mile north of Twin Buttes, 8 miles west of San Angelo (USGS 11857, T. W. Stanton and J. A. Udden). Hays County 0.25 mile west of Jacobs Well (USGS 19721, A. N. Sayre). Smith Creek, 7 mile post, Travis County (USGS, R. T. Hill 57). Turtle Creek, Kerr County (USGS 10483, C. Habecker).

Geologic horizon.—Comanche series, Trinity group, Glen Rose limestone, of early Albian age.

Type.—USNM 12237, from Mount Bonnell, near Austin, Tex. Figured specimen USNM 108710, from USGS 18384. The type of *Enallaster texanus* may be in the Geological Institute at Bonn, Germany (Adkins, 1920, p. 37).

Comparisons.—*Enallaster obliquatus* is commonly flatter and more nearly spade shaped than *E. mexicanus* from the Fredericksburg group or *E. bravoensis* from the Washita group. It differs further from *E. bravoensis* in the lack of fascioles. The type is unusually obese for the species.

Remarks.—Although this species is provisionally identified as *Enallaster texanus* Roemer 1849, the younger name *E. obliquatus* 1893 is retained because of the uncertainty and because *E. texanus* is commonly supposed to be the Fredericksburg species. However, Roemer's figures depict *E. texanus* as lower than *E. mexicanus*, agreeing in this respect with *E. obliquatus*. *E. texanus* is commonly reported as from the Fredericksburg group because Fredericksburg is its type locality, but Fredericksburg is built on the Trinity group.

Enallaster mexicanus Cotteau

Plate 26, figures 1–8

Enallaster mexicanus Cotteau. 1890, Soc. géol. France Bull., sér. 3, v. 18, p. 296, pl. 2, figs. 1–8.

Enallaster texanus (Roemer) (part). Clark, 1893, U. S. Geol. Survey Bull. 97, p. 78, pl. 39, figs. 2a–g.

Enallaster texanus (Roemer) (part). Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 151.

Enallaster texanus (Roemer). Hill and Vaughan, 1898, U. S. Geol. Survey Ann. Rept. 18, pt. 2, pl. 53, figs. 4a–b. After Clark, 1893.

Enallaster texanus (Roemer). De Loriol, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, pl. 4 (7), figs. 5–5b, 6, 6a.

Enallaster cf. mexicanus Cotteau. Böse, 1910, Inst. geol. Mexico Bol. 25, p. 165, pl. 39, figs. 9, 11; pl. 40, figs. 4, 5; pl. 41, fig. 1.

Enallaster texanus (Roemer) (part). Clark, 1915, U. S. Geol. Survey Mon. 54, p. 86, pl. 39, figs. 2a–g. After Clark, 1893. Type of *Heteraster adkinsi* Lambert.

Enallaster texanus (Roemer) (part). Adkins and Winton, 1920, Tex. Univ. Bull. 1856, p. 55, pl. 9, figs. 12, 13.

Heteraster texanus (Roemer). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 270.

Heteraster adkinsi Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 270.

Heteraster texanus (Roemer) (part). Adkins, 1928, Tex. Univ. Bull. 2838, p. 289, pl. 3, fig. 1.

Heteraster mexicanus (Cotteau). Adkins, 1928, Tex. Univ. Bull. 2838, p. 292, pl. 8, fig. 2.

Heteraster mexicanus (Cotteau). Smiser, 1926, Jour. Paleontology, v. 10, no. 6, p. 468, pl. 64, figs. 19–21.

Enallaster texanus (Roemer). Ikins, 1940, Bull. Am. Paleontology, v. 25, no. 90, p. 12 (60), pl. 4 (7), figs. 1a–b.

Enallaster texanus (Roemer) (part). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 231.

The following is a free translation of Cotteau's original description.

Rather large, oval, elongate, notched in front, vertically truncate behind; upper face swollen, highest near the apical center, obliquely sloping in the anterior region, not carinate behind; lower face almost flat, depressed around the mouth, slightly arched in the posterior interambulacral area. Apical system very excentric behind. Anterior furrow wide, quite deep, extending from the apex to the peristome. Each poriferous zone in the odd ambulacrum is composed first, near the summit, of 8 or 10 pairs of small, narrow, similar pores; then the pairs of pores become farther apart and unequal, and a pair of long, narrow pores alternates with a similar but much shorter pair. In the long pairs the outer pore is much longer and more accentuated than the other; in the short pairs the contrary is true, the outer pore finer, narrower than the other, like a narrow slit and scarcely visible. The alternation is usual; sometimes, however, two pairs of long pores occur beside one of the others. Each pair of pores opens on a plate like the others and perfectly distinct on the specimen described.

Anterior paired ambulacra flush, subflexuous, approaching the odd ambulacrum, rounded at their start, slightly bent outward at their tips; the anterior poriferous zone is narrow, composed of very small rounded pores, rather close together, opening at the base of the plates, arranged in widely spaced and sometimes irregular pairs. The posterior zone is very wide, formed of unequal pores, the outer narrow, elongated, comma shaped, the inner more rounded, transversely oval. Eight pairs of pores of the posterior zone correspond to five pairs of pores of the anterior zone. Interporiferous zone very narrow, scarcely equal to half of the posterior poriferous zone, enlarging a little toward the extremity, which is open. Posterior ambulacral areas short, subflexuous, slightly diverging, subangular and almost closed at the end. Poriferous zones unequal, the anterior area a little narrower and composed, in the outer row, of pores less elongated.

Interporiferous zone very narrow, scarcely equal to half of the posterior poriferous zone. Tubercles quite large, scattered, widely scrobiculate, indistinct in our specimen. Peristome very eccentric in front, poorly preserved. Periproct rounded, subtransverse, placed at the top of the posterior truncation. Apical system well developed, furnished with four genital plates almost equally spaced; the madreporite somewhat elongated, reaching the center of the system but not extending beyond the two posterior genital plates, which touch each other at the base; ocular plates subpentagonal, angular, quite large, notably the two posterior plates. Height 25 mm; length 40 mm; width 38.5 mm.

Occurrence.—Mexico: Colima, Colima; Placeres de Guadalupe, Chihuahua (*vide* Cotteau).

Texas: Comanche peak limestone: Western edge of Menard (USGS 11758, T. W. Stanton and J. A. Udden). West side of Comanche Peak where road makes a right-angled turn, about 5 miles southeast of Granbury, Hood County (USGS 18569, Ralph Imlay). South fork of San Gabriel River north of bridge just west of Georgetown, Williamson County (USGS 11860, T. W. Stanton). Benbrook, 8 miles west of Fort Worth (USGS 1577, R. T. Hill and T. W. Stanton). Bachelor Peak, Llano-Burnet region, 20 feet below base (USGS 8299, Sidney Paige). Bosque County 2.5 miles south of Clifton (USGS 24501, R. T. Stark). Two miles north of Clifton (USNM accession 188539). Bluff near mouth of Steel Creek, Bosque County (USGS 2296, J. K. Prather). Hill 1.5 miles north of Fredericksburg (USGS 1560, T. W. Vaughan and T. W. Stanton). Outlier 0.25 mile north of east base of Castle Mountain, Upton County (USGS 13174, T. W. Stanton and W. B. Lang).

Goodland limestone: Nolands River 1 mile west of Blum (USGS 11823, T. W. Stanton). Tarrant County 2 miles west of Benbrook (USGS 19710, Renfro coll.). Bosque County 3 miles north of Walnut Springs (USGS 19711, Renfro coll.). Little Mineral Creek 4 miles south of Marshall and about 15 miles from Denison (USGS 1492, R. T. Hill and T. W. Stanton). West bank of Trinity River east of Lake Worth dam, Fort Worth (USGS 11758, T. W. Stanton).

Geologic horizon.—Comanche series, Fredericksburg group, of middle Albian age.

Type.—Unknown; perhaps in the École des Mines at Paris.

Figured specimens.—USNM 108706, 108707.

Remarks.—This species has commonly passed as *Enallaster texanus* (Roemer), whose name has been a catchall for American *Enallasters*. Because of the uncertainty as to the identity of Roemer's species, it seems preferable to refer the species from the Fredericksburg group to *E. mexicanus*, which has been well defined and figured, and of whose identity there seems to be no question.

Enallaster mexicanus is higher and narrower in front and broader behind than *E. obliquatus*, from the Trinity group. It is commonly higher than *E. bravoensis*, from the Washita group, and lacks the narrow, branching fascioles that are a distinctive feature of the subgenus *Washitaster*.

Subgenus WASHITASTER Lambert

Washitaster Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, fasc. 3-5, p. 271.

Washitaster Lambert. Adkins, 1928, Tex. Univ. Bull. 2838, p. 292.

Washitaster Lambert. Smiser, 1933, Jour. Paleontology, v. 7, no. 2, p. 157.

Enallaster d'Orbigny (part). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 230.

Washitaster Lambert. Mortensen, 1951, Monograph of the Echinoidea, v. 5, pt. 2, p. 202.

Type species, *Hemiaster riovistae* Adkins (1920, p. 115, pl. 6, fig. 4; pl. 8, figs. 2, 3, 5), from the Weno clay (late Albian) of Texas. The type of this species differs from typical *Enallaster* in having multiple narrow peripetalous fascioles within a broad granular band beset with tubercles. Moreover, the pores of its anterior ambulacrum are nearly circular, and each pair is divided by a conspicuous bead. This feature, however, is variable, for the three paratypes have a few pairs of elongated pores divided by a much smaller bead. In the type of *Enallaster wenoensis* Adkins, which is here regarded as a variant of *Washitaster riovistae*, from the same locality, there are still more pairs of elongated pores irregularly alternating with nearly circular pores. This specimen, also, has multiple fascioles and small beads. There are similar multiple fascioles on *Enallaster bravoensis* Böse from the Cenomanian at Cerro de Muleros, Mexico. This species has irregularly alternating elongated and circular pores in its anterior ambulacrum, but beads have not been noticed.

Enallaster (*Washitaster*) *riovistae* (Adkins)

Plate 26, figures 10-13

Hemiaster riovistae Adkins, 1920, Tex. Univ. Bull. 1856, p. 115, pl. 6, fig. 4; pl. 8, figs. 2, 3, 5.

Washitaster riovistae (Adkins). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 271, text fig. 2.

Washitaster riovistae (Adkins). Adkins, 1928, Tex. Univ. Bull. 2838, p. 293, pl. 19, fig. 2.

Enallaster texanus (Roemer) (part). Cooke, Jour. Paleontology, v. 20, no. 3, p. 231.

Washitaster riovistae (Adkins). Mortensen, 1951, Monograph of the Echinoidea, v. 5, pt. 2, p. 202, text figs. 99-100.

Horizontal outline cordate, longer than wide, widest at or in front of the midpoint, vertically truncated behind; highest point behind the apical center, steeply sloping to the truncation, gradually to the anterior end; anterior sulcus extending from the apical center to the peristome; lower surface gently rounded. Apical system near the posterior third, with four perforated genital plates, the pores rather close together and evenly spaced, the posterior plates nearly separated by the madreporite. Anterior petal having evenly spaced pairs of nearly round pores, each pair divided by a conspicuous bead; paratypes having a few pairs of more elongated pores on which the beads are much reduced or absent. Anterior paired petals long and flexuous, slightly depressed, bent forward near the apex, flaring outward distally; anterior poriferous zones very narrow, pores small, circular, pairs widely spaced; posterior zones much wider, with pore pairs closer together, inner pores slightly elongated, outer pores much

longer. Posterior petals much shorter, nearly flush, diverging at an angle approximating 100° , arrangement of pores similar to that of the anterior pair. Peristome slightly wider than long, deeply sunken. Periproct nearly circular, high up on the posterior truncation. Tubercles of varying sizes, the largest in the anterior interambulacra, a group of large tubercles with areoles occupying the ridges between the three anterior ambulacra. Three or more narrow, divaricating peripetalous or marginal fascioles occupy a broad band.

Length of holotype 27 mm; width 24 mm; height 14.4 mm. The paratypes are of approximately the same size.

Occurrence.—Texas: One mile southeast of Riovista, one-half mile east of the Waco road (type, Adkins loc. 720, coll. 328a). Northeast of Birdville, 0.3 mile west of State Highways 121 and 184 (USGS 19703, Renfro coll. W17). East end of White Lake dam, Fort Worth (USGS 19692, Renfro coll. W3). One-half mile east of Burleson (USGS 19685, Renfro coll. Grs. 4). Johnson Branch, south side of Cleburn-Godley road, northwest of Cleburne, Johnson County (USGS 18576, Ralph Imlay). 4.5 miles south of Cleburne (USGS 11825, T. W. Stanton). Hog Creek (USGS 3193, J. K. Prather).

Geologic horizon.—Washita group, Fort Worth limestone to Grayson marl, type from Weno clay, of late Albian age.

Type.—USNM, on temporary deposit by the Texas Bureau of Economic Geology.

Enallaster riovistae wenoensis Adkins

Plate 26, figures 14–17

Enallaster wenoensis Adkins, 1920, Tex. Univ. Bull. 1856, p. 112, pl. 5, fig. 3.

Heteraster wenoensis (Adkins). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 271.

Heteraster wenoensis (Adkins). Adkins, 1928, Tex. Univ. Bull. 2838, p. 291.

?Not *Heteraster wenoensis* (Adkins). Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 469, pl. 65, figs. 5–7. (= *Enallaster bravoensis* Böse.)

Enallaster texanus (Roemer) (part). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 231.

Differs from *Enallaster riovistae* in having a greater and variable number of elongated pores in its anterior petal and in the commonly smaller size of the beads separating the circular pores.

Length of holotype 25.3 mm; width 23.1 mm; height 14.6 mm.

Occurrence.—Texas: One mile southeast of Riovista, one-half mile east of the Waco road (type, Adkins loc. 720, coll. 327a). East end of White Lake dam, Fort Worth (USGS 19692, Renfro coll. W 3). Northeast of Birdville 0.3 mile west of State Highways 121 and 184 (USGS 19703, Renfro coll. W 17). The Haystacks, 3.8 miles northeast of the Magnolia refinery, Tarrant County (USGS 19697, Renfro coll. W 8). Roanoke-Haslet road 2.35 miles west by road from the railroad station at Roanoke (USGS 19698, Renfro coll. W 9). Fort Worth, 0.5 mile north of the Meadowbrook Country Club (USGS 19687, Renfro coll. Mst 1). Roanoke, Denton County, State Highway 114 west

of the underpass (USGS 18521, Ralph Imlay. Haltom farm near Birdville (USGS 19705, Renfro coll. W 23). Meadowbrook Drive, Oakland Boulevard, 1.5 miles northwest of the city fire hall, Fort Worth (USGS 19691, Renfro coll. W 2). Roanoke-Haslet road 2.35 miles west by road from the railroad station at Roanoke (USGS 19698, Renfro coll. W 9).

Geologic horizon.—Weno clay and Main Street limestone, of late Albian age.

Type.—USNM on temporary deposit by the Texas Bureau of Economic Geology.

Comparison.—This variety is similar to *Enallaster bravoensis* Böse but differs from it in the greater irregularity of the pores in the anterior petal.

Enallaster (Washitaster) longisulcus Adkins and Winton

Plate 26, figure 9

Enallaster longisulcus Adkins and Winton, 1920, Tex. Univ. Bull. 1945, p. 55, pl. 9, figs. 4, 8–10.

Washitaster longisulcus (Adkins and Winton). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 271.

Washitaster longisulcus (Adkins and Winton). Adkins, 1928, Tex. Univ. Bull. 2838, p. 293, pl. 13, fig. 6.

Enallaster longisulcus Adkins and Winton. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 232, pl. 33, figs. 5–6.

Like *Enallaster riovistae* in most features but proportionally narrower and having the apical system slightly farther back.

Length of holotype 26.1 mm; width 21.5 mm; height 13.1 mm.

Occurrence.—Texas: Cedar Creek branch of Nolands River 2 miles southeast of Blum, Johnson County (Tex. Bur. of Econ. Geology coll. 328a).

Geologic horizon.—Washita group, upper part of the Fort Worth limestone, of late Albian age.

Type.—Holotype and one paratype USNM on temporary deposit by the Texas Bureau of Economic Geology.

Comparison.—This species is evidently very closely related to *Enallaster riovistae*, of which it may be a variety. The only authentic specimens of this supposed species in the National Museum are the type and paratype. Other specimens recorded by Cooke (1946) appear to be *E. riovistae*.

Enallaster (Washitaster) inflatus Cragin

Plate 27, figures 1–4

Enallaster inflatus Cragin, 1893, Geol. Survey Ann. Rept. 4, pt. 2, p. 150, pl. 24, fig. 13.

Heteraster inflatus (Cragin). Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 438.

Heteraster inflatus (Cragin). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 270.

Heteraster inflatus (Cragin). Adkins, 1928, Tex. Univ. Bull. 2838, p. 298. Probably not pl. 8, fig. 1.

Heteraster inflatus (Cragin). Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 467, pl. 65, figs. 1–4.

Test subglobose, upper surface more strongly inflated than the lower, weakly emarginate in front, weakly truncated behind. Apical system slightly posterior; four genital plates, the posterior pair nearly separated by the madreporite. Anterior petal containing irregularly alternating pairs of long and short pores, the

long pores more numerous and the short pores divided by a flattened bead. Anterior paired petals slightly depressed, slightly flexuous, diverging at an angle approximating 90° ; anterior poriferous zone narrow, posterior poriferous zones wider; interporiferous zone as wide as the posterior poriferous zone. Posterior petals flush, nearly half as long as the anterior paired petals, biconvex, straight; poriferous zones alike, pores elongated; petals diverging at an angle approximating 90° . Peristome nearly round, at the anterior third. Periproct nearly round, at the top of a weak truncation. Tubercles rather small, the largest on the anterior half. Narrow branching peripetalous fascioles.

Length of figured specimen 27.7 mm; width 26.3 mm; height 19.7 mm.

Occurrence.—Texas: Denton Creek 1 mile east of Roanoke (*vide* Cragin). Choctaw Creek east of Denison on the Denison-Bonham road (*vide* Cragin). One-quarter mile north of Denton Creek 5 miles northeast of Roanoke (USGS 11752, T. W. Stanton). Grayson County 2 miles north of Pottsboro (USGS 1490, R. T. Hill and T. W. Stanton). Jennings road 1.5 miles north of Meadowbrook Drive, Handley (USGS 19684, Renfro coll. Grs 2).

Geologic horizon.—Grayson marl, of late Albian age.

Figured specimen.—USNM 108705, from USGS 11752.

Remarks.—The preceding description is based on the figured specimen, which corresponds closely in size and shape to the lateral profile given by Cragin, and which was collected from the same formation as the type and only 4 miles from the type locality. As here interpreted, *Enallaster inflatus* is more obese but otherwise similar to *E. bravoensis* Böse, which may prove to be a variety of it.

Enallaster (Washitaster) bravoensis Böse

Plate 27, figures 5–12

?*Enallaster sapperi* de Loriol, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, p. 47 (95), pl. 4 (7), figs. 4–4e.

?*Enallaster böhmi* de Loriol, 1904, Notes pour servir à l'étude des échinodermes, sér. 2, fasc. 2, p. 29 (97), pl. 4 (7), figs. 7–10.

Enallaster bravoensis Böse, 1910, Inst. geol. Mexico Bol. 25, p. 168, pl. 41, figs. 5–10; pl. 42, figs. 2–12; pl. 43, figs. 1–2, 6–7.

?*Enallaster bravoensis* Böse. Whitney, 1916, Bull. Am. Paleontology, v. 5, no. 26, p. 100 (6), pl. 20 (6), figs. 3–5.

Enallaster bravoensis Böse. Adkins and Winton, 1920, Tex. Univ. Bull. 1945, p. 58, pl. 9, fig. 11.

Not *Enallaster bravoensis* Böse. Adkins, 1920, Tex. Univ. Bull. 1856, p. 114, pl. 8, fig. 4. (? = *Enallaster inflatus* Cragin.)

Not *Heteraster bravoensis* (Böse). Lambert, Soc. geol. France Bull., sér. 4, v. 26, p. 270, (? = *Enallaster inflatus* Cragin.)

?*Heteraster böhmi* (de Loriol). Adkins, 1928, Tex. Univ. Bull. 2838, p. 290.

?*Heteraster sapperi* (de Loriol). Adkins, 1928, Tex. Univ. Bull. 2838, p. 290.

Heteraster bravoensis (Böse). Adkins, 1928, Tex. Univ. Bull. 2838, p. 291.

?Not *Heteraster bravoensis* (Böse). Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 467, pl. 64, figs. 22–24. (Probably *Enallaster mexicanus* Cotteau.)

Heteraster wenoensis (Adkins). Smiser, 1936, Jour. Paleontology, v. 10, no. 6, p. 469, pl. 65, figs. 5–7.

Hemiaster sp. Böse. Jones, 1938, Geol. Soc. America Bull., v. 49, no. 1, table 3.

Enallaster texanus (Roemer) (part). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 231. Not pl. 33, figs. 9–12. (= *Enallaster obliquatus* Clark.)

Medium-sized, commonly about 30 mm in length but reaching about 50. Horizontal outline cordate, widest at the anterior third; upper surface rather evenly inflated; lower surface flattish; anterior depression extending from the apical system to the peristome; steeply truncated behind. Apical system slightly behind the center; genital pores close together, evenly spaced; madreporite central, separating the posterior genital plates; posterior ocular plates in contact. Odd ambulacrum having 8 or 10 pairs of small, round pores nearest the apex; succeeding pairs alternating long and short, somewhat irregularly, two pairs of long pores at some places being adjacent; the outer pores of each series are longer than the inner pores; the long and short pairs are not aligned, but the long pairs extend beyond the short pairs in both directions. Anterior paired petals slightly depressed, open at the outer ends, extending about two-thirds the way to the margin; anterior poriferous zone nearly straight, composed of widely spaced pairs of small round pores; posterior zone convex near the apex, becoming parallel to the anterior zone distally, composed of more closely spaced pairs of elongated pores, the outer pores the longer. Posterior petals flush, much shorter, extending less than halfway to the margin, nearly straight, open at the outer ends, diverging at an angle approximating 90° . Peristome at the anterior fourth or fifth, nearly circular, slightly projecting behind. Periproct well up on the posterior truncation, slightly wider than high. Tubercles rather small, closest on the plastron. Petals surrounded by a broad granular band decorated with tubercles and several narrow branching fascioles.

Length of figured specimen from Cerro Muleros 29 mm; width 26.5 mm; height 14 mm.

Occurrence.—Mexico: Cerro Muleros 5 to 6 kilometers northwest of Ciudad Juarez, near the international boundary southwest of El Paso, Tex. (type, *vide* Böse; USGS 15979, N. H. Darton). South side of the Rio Grande 4 miles west of El Paso (USGS 1689, E. A. Mearns). Sierra de la Peña, Coahuila (Univ. Mich. 16688, T. S. Jones).

Colombia: Rancheria Valley, small hill east of Quebrada Jagüey about 10 kilometers due north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Department of Magdalena (locs. C 14025B–D, C 14161).

Texas: Rio Grande above El Paso near Initial Monument (USGS 298, 1943, 1944, T. W. Stanton). Rio Grande west of Mule Canyon (USGS 1843, 1854, T. W. Stanton). East of Mule Canyon, 25 miles south of Sierra Blanca station (USGS 1808, T. W. Stanton). East side of Black Mountain, Trans-Pecos (USGS 3609, G. B. Richardson). Pass between North and South Peaks of Sierra Blanca Mountains, Hudspeth County

(USGS 1813, 1914, T. W. Stanton; USGS 3577, E. H. Elder). Two miles west of Kent, Culberson County (USGS 1929, T. W. Stanton). Five miles west of Kent (USGS 1928, 1935-38, T. W. Stanton). Near water tank 8 miles west of Kent (USGS 1939, T. W. Stanton). One-quarter mile southwest of station at Kent (USGS 1932, T. W. Stanton). One mile east of station at Kent (USGS 1931, 1933, T. W. Stanton). Six miles east of Kent (USGS 14251, 14252, T. W. Stanton and W. P. Popenoe). Seven miles north of Kent (USGS 3645, G. B. Richardson). California Hill, Terlingua, Brewster County (USGS 2492, J. K. Prather). Three miles west of Boracho and 13 miles west of Kent (USGS 14255, 14256, 14258, T. W. Stanton and W. P. Popenoe). Bed 4 at University Mesa, 15 miles northeast of Fort Stockton, Pecos County (USGS 14217, T. W. Stanton and W. P. Popenoe).

Geologic horizon.—Lower Cretaceous, Washita group, Georgetown limestone and equivalents, of late Albian age.

Type.—Instituto Geológico de México. Figured specimens USNM 108701, 108708, 108709.

Comparisons.—The type of *Enallaster sapperi* de Loriol, from Honduras, is twice as large (length 64 mm) as the largest specimen of *E. bravoensis* mentioned by Böse (length 32.6 mm), but in other respects the two appear to be very similar. Some specimens from Texas and Colombia here referred to *E. bravoensis* are almost as large as *E. sapperi*. *Enallaster böhmi* de Loriol, also from Honduras, is much smaller (length 20 mm), but its figure is somewhat obscure.

Enallaster bravoensis is similar to *E. mexicanus* Cotteau from the Fredericksburg group but is commonly not quite so tall. The most distinctive difference is the occurrence of very narrow branching fascioles on the granular band of *E. bravoensis*. These multiple fascioles are lacking from *E. mexicanus* though the granular band is otherwise similar.

Enallaster inflatus Cragin is commonly more globular than *E. bravoensis* and appears to lack a granular band though it has multiple narrow fascioles. The short pores of its odd petal are separated by a bead, which feature has not been observed in *E. bravoensis*.

Remarks.—*Enallaster bravoensis* may prove to be a synonym or a varietal form of *E. inflatus* or, if not that, of *E. sapperi*.

Genus *HOLASTER* Agassiz

Holaster Agassiz, 1836, Soc. sci. nat. Neuchâtel Mém., v. 1, p. 183.

Holaster Agassiz. Cooke, 1942, Jour. Paleontology, v. 16, no. 1, p. 52.

Holaster Agassiz. Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 233.

Holaster Agassiz. Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 47. Includes additional synonymy.

Holaster Agassiz. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 26.

Type species, *Spatangus nodulosus* Goldfuss 1829 = *Holaster laevis* (Brongniart) 1822 from the Upper Greensand and Lower Chalk of England, designated by Savin (1905, p. 173). This is a small heart-shaped echinoid with a shallow frontal sulcus, rounded sides, strongly arched upper surface, slightly convex lower surface, somewhat rostrate above the terminal periproct. Its apical system is elongated. The pores of the paired ambulacra are transversely elongated, and the anterior poriferous zones are narrower than the posterior. The

peristome is transversely elliptical, and the periproct is longer than wide.

Holaster simplex Shumard

Plate 24, figures 6-8

Holaster simplex Shumard, 1853, Natural history of the Red River of Louisiana, Appendix E, p. 210.

Holaster simplex Shumard. Shumard, 1854, Marcy's exploration of the Red River of Louisiana, Appendix E, p. 184, pl. 3, fig. 2.

Holaster comanchesi Marcou, 1858, Geology of North America, p. 40, pl. 3, figs. 3a-c.

Holaster comanchesi Marcou. Desor, 1858, Synopsis des échinides fossiles, p. 449.

Holaster simplex Shumard. Desor, 1858, Synopsis des échinides fossiles, p. 450.

Holaster simplex Shumard. Clark, 1893, U. S. Geol. Survey Bull. 97, p. 76, pl. 38, figs. 1a-g; pl. 39, figs. 1a-d.

Holaster nanus Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 156, pl. 24, fig. 14; pl. 25, fig. 11.

Holaster simplex Shumard. Cragin, 1893, Tex. Geol. Survey Ann. Rept. 4, pt. 2, p. 157, pl. 25, fig. 13.

Holaster simplex Shumard. Clark, 1915, U. S. Geol. Survey Mon. 54, p. 85, pl. 34, figs. 3a-b; pl. 38, figs. 1a-j. Not pl. 39, figs. 1a-g = *Pseudananchys completa* (Cragin).

Holaster simplex Shumard. Adkins and Winton, 1920, Tex. Univ. Bull. 1945, p. 51, pl. 8, figs. 5-6; pl. 9, figs. 18-19.

Holaster simplex Shumard. Winton, 1925, Tex. Univ. Bull. 2544, p. 54, pl. 13, figs. 1-3.

Holaster simplex Shumard. Lambert, 1927, Soc. géol. France Bull. sér. 4, v. 26, p. 269.

Holaster nodulosus (Goldfuss). Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 269.

Holaster nanus Cragin. Lambert, 1927, Soc. géol. France Bull., sér. 4, v. 26, p. 269.

Holaster simplex Shumard. Adkins, 1928, Tex. Univ. Bull. 2838, p. 285, pl. 14, figs. 1, 3.

Holaster nanus Cragin. Adkins, 1928, Tex. Univ. Bull. 2838, p. 285.

Holaster nodulosus (Goldfuss). Adkins, 1928, Tex. Univ. Bull. 2838, p. 285.

Holaster nanus Cragin. Jones, 1938, Geol. Soc. America Bull., v. 49, no. 1, p. 134, pl. 13, figs. 11-16.

Holaster laevis (Brongniart). Cooke, 1946, Jour. Paleontology, v. 20, no. 3, p. 234, pl. 34, figs. 1-3.

Horizontal outline ovate, slightly emarginate in front; upper surface strongly convex, with nearly vertical sides and a shallow furrow in the anterior slope; lower surface nearly flat, ranging from slightly convex to slightly concave; margin acutely rounded; somewhat rostrate behind. Apical system slightly posterior, elongated. Anterior poriferous zones straight, slightly diverging, space between the pore pairs increasing distally; outer pores punctate; inner pores very slightly elongated, oblique. Anterior paired ambulacra curved forward; poriferous zones diverging, anterior zone the narrower; pores transversely elongated; posterior pores of posterior zone the longer. Anterior poriferous zones of posterior ambulacra nearly straight, diverging at an

angle of 90°; posterior zones concave laterally; pores like those of the anterior paired ambulacra. Peristome transversely oval; at the anterior fifth. Periproct terminal, well up on a depressed area, longer than wide, partly visible from below. Primary tubercles perforated, crenulated; widely scattered on upper surface; more abundant on lower surface but nearly confined to the interambulacral areas.

Length of figured specimen 45 mm; width 39 mm; height 28.5 mm. Other specimens range from 23 mm to 72 mm in length.

Occurrence.—Oklahoma: Fort Washita, Bryan County (type, *vide* Shumard). Bluff on small branch at road crossing one-third mile northeast of Missouri-Kansas-Texas Railroad Co. bridge 5½ miles north of Denison, Tex., in Bryan County, from lower 18 feet of section (USGS 9690, L. W. Stephenson, figured specimen).

Texas: Many localities, listed by Cooke (1946, p. 234).

Mexico: Sierra de Santa Ana, Coahuila (J 56-58, 68; K 65, 70, 134, *vide* Jones).

Geologic horizon.—Lower Cretaceous, Washita group, of late Albian age. Abundant in the Fort Worth and Weno. Members 2 and 3 of the Indidura formation in Mexico.

Figured specimen.—USNM 103884, from USGS 9690.

Remarks.—Young individuals of this species resemble Cragin's figure of *Holaster nanus*, which is therefore put in the synonymy. Slightly larger specimens were identified by Lambert as *Holaster nodulosus* (Goldfuss), which appears to be a junior synonym of *Holaster laevis* (Brongniart) (Cooke, 1946, p. 235). Comparison of this European species with *Holaster simplex* shows that *H. simplex* is proportionately longer, broader posteriorly, and attained a much larger size.

Genus EPIASTER d'Orbigny

Epiaster d'Orbigny, 1855, Paléontologie française, Terrain crétacé, sér. 1, v. 6, p. 149, 186.

Micraster Agassiz (part). Desor, 1858, Synopsis des échinides fossiles, p. 360.

Epiaster d'Orbigny. De Loriol, 1873, Échinologie helvétique, pt. 2, Période crétacé, p. 361.

Epiaster d'Orbigny. Pomel, 1883, Classification méthodique et genera des échinides, p. 43.

Epiaster d'Orbigny. Duncan, 1889, Linnean Soc. London Jour., Zoology, v. 23, p. 218.

Epiaster d'Orbigny. Lambert, 1895, Essai d'une monographie du genre *Micraster*, p. 157.

Epiaster d'Orbigny. Lambert and Thiéry, 1924, Nomenclature raisonnée des échinides, fasc. 6, p. 477.

Epiaster d'Orbigny. Adkins, 1928, Tex. Univ. Bull. 2838, p. 297.

Epiaster d'Orbigny. Smiser, 1935, Musée royal d'Histoire naturelle de Belgique Mém. 68, p. 79.

Epiaster d'Orbigny. Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 343.

Type species, *Spatangus crassissimus* DeFrance from the Cenomanian of France, designated by Lambert (1895, p. 156). Lambert and Thiéry, Adkins, and Mortensen cite *Micraster trigonalis* as the type species, but these designations are subsequent to 1895. *Epiaster crassissimus* has been figured by d'Orbigny (1855, p. 194, pl. 860), Smiser (1935, p. 79, pl. 7, figs. 6a-d), and Mortensen (1950, p. 345, fig. 235, after d'Orbigny).

D'Orbigny's figures show a rather large, tall, subtrigonal form, higher behind than in front, tapering to a narrow, sloping posterior truncation. Its petals are straight, slightly depressed, the posterior pair nearly as long as the anterior pair. The pores of the paired petals are transverse slits, all nearly the same length. The pores of the anterior petal are oval or comma shaped, the outer pores transverse, the inner oblique. The two posterior genital plates are in contact, as are the posterior oculars. The peristome is wider than long; it has a posterior lip. The periproct is longer than wide; it is visible from above. The species has no fascioles.

The lack of fascioles distinguishes *Epiaster* from *Micraster*, which has a subanal fasciole, and *Hemiaster*, which has a peripetalous fasciole. *Macraster* Roemer, which was referred to *Hemiaster* as a subgenus (Cooke, 1946, p. 227) is more closely related to *Epiaster*. Its posterior end is commonly overhanging as contrasted with the sloping end of *Epiaster*. It also may have a broad diffuse granular band but no distinct fasciole.

The following American species, some of which are commonly referred to *Macraster* or to *Hemiaster*, appear to represent *Epiaster*: *Epiaster electus* Cragin (not seen), *Epiaster whitei* Clark, *Macraster washitae* Lambert (Cooke, 1946, p. 229, pl. 33, figs. 1-4), *Epiaster renfroae* Cooke, n. sp. and *Epiaster mexicanus* Cooke, n. sp. Well preserved specimens of *E. whitei* and *E. washitae* have granular bands similar to that of *Macraster elegans* (Shumard) (Cooke, 1946, p. 227). This feature should be looked for on typical *Epiaster*, on which it has not been reported.

Epiaster dartoni Cooke, n. sp.

Plate 28, figures 1-10

Horizontal outline cordate, anterolateral margins evenly rounded, posterolateral margins nearly straight, widest at the anterior third, narrow behind; lateral profile highest behind the apical system, steeply convex in front, steeply truncated behind; upper surface strongly inflated, lower surface slightly convex. Apical system nearly central, with four equally spaced genital pores, posterior genital plates in contact behind the central madreporite, posterior ocular plates in contact. Anterior ambulacrum depressed throughout; pores of petaliferous part short, chevron-shaped, pores of each pair separated by a bead. Paired petals moderately depressed, the anterior pair somewhat longer than the posterior; anterior pair extending two-thirds the way to the margin, posterior pair halfway; pores transversely elongated, poriferous zones about as wide as the interporiferous. Peristome small, subpentagonal, far forward. Periproct elongated, pointed at both ends, well up on the posterior truncation, visible from above. Tubercles closely spaced on plastron, more widely

spaced elsewhere. Small granules occupying the spaces between the tubercles in a broad, ill-defined band surrounding the petals.

Lengths of cotypes 43 mm, 36.6 mm; widths 39.4 mm, 34.3 mm; heights 27 mm, 22.6 mm.

Occurrence.—New Mexico: Ridge south of Big Hatchet Mountain, Grant County, (USGS 10159, 10161, N. H. Darton).

Mexico.—Arroyo Palomas, a southern tributary of Arroyo la Zorra, near Rancho San Vicente, Coahuila (USGS 24511, Teodoro Diaz).

Geological horizon.—Lower Cretaceous, Aptian(?)

Types.—USNM 108722, two cotypes.

Figured specimen.—USNM 108711, from USGS 24511.

Comparisons.—This species differs from *Epiaster crassissimus* (Defrance) as figured by d'Orbigny in that the pores of its paired petals are longer, the interporiferous zones correspondingly narrower; and the posterior truncation is convex, not concave and produced behind. It closely resembles *Epiaster whitei* Clark (Cooke, 1946, p. 244, pl. 32, figs. 16, 17), but its posterior end is narrower, its posterolateral sides are straighter, and its posterior petals are a trifle shorter.

Remarks.—This species is named in honor of the collector, the late N. H. Darton.

***Epiaster renfroae* Cooke, n. sp.**

Plate 29, figures 1–4

Test rather small; horizontal outline subovate, with a shallow emargination in front, widest in front of the midpoint; highest behind, sloping gently forward, broadly rounded in front, not strongly rostrate behind; posterior truncation steeply sloping; lower surface gently convex. Apical system nearly central; four widely separated genital pores, the posterior pair a little farther apart; posterior genital plates nearly separated by the large central madreporite. All petals straight, slightly sunken; anterior pair extending about two-thirds the way to the margin, diverging at an angle approximating 110°; posterior pair extending about halfway to the margin, diverging at an angle approximating 66°. Pores of paired petals transversely elongated, space between pores of a pair very narrow; interporiferous zones equalling in width the poriferous zones; pores of anterior petal shorter, outer pores transverse, inner pores oblique. Peristome at or in front of the anterior third, broadly transversely oval, weakly lipped behind. Periproct higher than wide, pointed at both ends. Tubercles rather widely scattered, largest on the plastron, minutely perforated. A broad, faintly granular band surrounds the petals, but there is no fasciole.

Length of holotype 28.2 mm; width 26 mm; height 17 mm.

Occurrence.—Texas: North of 3000 block on Bomar Avenue, Fort Worth (USGS 22352, W 1 Renfro coll.).

Geologic horizon.—Lower Cretaceous, Washita group, Weno clay, of late Albian age.

Type.—USNM 108712.

Comparison.—This species closely resembles *Epiaster whitei* Clark (Cooke, 1946, p. 224, pl. 32, figs. 16–17) from the Goodland limestone of the Fredericksburg group; but its posterior petals are proportionately somewhat shorter, the spaces between the pores of the pore pairs of its paired petals are narrower, and it is higher behind and more steeply sloping in front than *E. whitei*.

Remarks.—Besides the type, there are 10 poorly preserved specimens from the same locality that are tentatively identified as *Epiaster renfroae*.

The species is named in honor of Mrs. Jesse H. Renfro of Fort Worth, Tex.

Genus HEMIASTER Desor

Hemiaster Desor. Mortensen, 1950, Monograph of the Echinoidea, v. 5, pt. 1, p. 378. Includes full synonymy.

Hemiaster Desor. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 30.

***Hemiaster texanus* Roemer**

Plate 29, figures 5–10

Hemiaster texanus Roemer, 1849, Texas, p. 393.

Hemiaster texanus Roemer. Cooke, 1953, U. S. Geol. Survey Prof. Paper 254-A, p. 33, pl. 13, figs. 1–4. Includes full synonymy and description.

Occurrence.—Texas: For list of localities see Cooke (1953, p. 34).

Ecuador: From the Oriente of Ecuador on the Rio Napo about 500 meters below Latas, 7 kilometers east of El Napo (loc. A7134).

Geological horizon.—In Texas from the Austin chalk, Anacacho limestone, and Taylor marl, of Senonian age. In Ecuador from the upper part of the Napo series, about 50 meters below the top of the series in a light-gray-yellow marly limestone.

Figured specimen.—From Ecuador, USNM 108703.

Remarks.—The largest of five individuals from Ecuador is figured. Its dimensions are: length 46 mm; width 43.2 mm; height 26.5 mm.

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		<i>Saleniidae</i>	88	<i>Heteraster</i>	105, 106
		<i>sapperi</i> , <i>Enallaster</i>	106, 107	<i>whitei</i> , <i>Epiaster</i>	108, 109
		<i>Heteraster</i>	106	Y	
		<i>simplex</i> , <i>Holaster</i>	88, 107, pl. 24	<i>yarboroughi</i> , <i>Pedinopsis</i>	91

PLATES 18–29

PLATE 18

[All figures natural size except as indicated on plate]

FIGURES 1-4. *Stereocidaris hudspethensis* Cooke, n. sp. (p. 89).

1-3, Top, side, and bottom of type, USNM 104828. From the Washita group 1.5 miles north of Roundtop Mountain, Hudspeth County, Tex.

4, Spine ($\times 2$), USNM 104607. From the Washita group 3 miles north of Sierra Blanca Peak, Hudspeth County, Tex.

5-7. *Dumblea symmetrica* Cragin (p. 89).

Side, bottom, and top of USNM 108713 ($\times 2$). From the Washita group at USGS 21074, between Sierra Blanca Peak and Little Blanca Mountain, Hudspeth County, Tex.



STEREOCIDARIS AND DUMBLEA



1

X 1



4

X 3



2

X 1



3

X 1



5

X 1



7

X 2



6

X 2

PLATE 19

[All figures natural size except as indicated on plate]

FIGURES 1-6. *Pedinopsis texana* Cooke, n. sp. (p. 90).

1-3, Bottom, top, and side of holotype, USNM 108714. From the Main Street limestone at USGS 22270, road cut north of Glengarden Country Club swimming pool, Fort Worth, Tex.

4, 5, Ambulacrum ($\times 3$) and top of paratype A, USNM 108715. From the Main Street limestone at USGS 22265, Crowley road south of Tex. Christian Univ., 8 miles southwest of Fort Worth, Tex.

6, Bottom of paratype B ($\times 2$). From the Pawpaw formation at USGS 22246, Cobbs old brick pit south of Maddox Avenue on Cobbs Park Drive, Fort Worth, Tex.

7. *Salenia hondoensis* Cooke (p. 89).

Top of USNM 108693 ($\times 2$). From the Anacacho limestone in a bluff on Sabinal River 2 miles north of Sabinal, Uvalde County, Tex.

PLATE 20

[All figures natural size except as indicated on plate]

FIGURES 1-3. *Orthopsis casanovai* Cooke, n. sp. (p. 92)

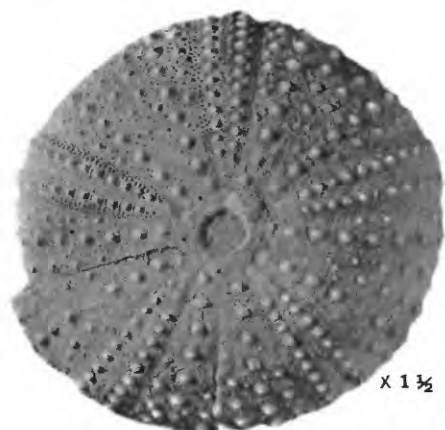
Top, bottom, and side of type, USNM 108694 ($\times 1\frac{1}{2}$). From the Anacacho limestone in bluff on Sabinal River 2 miles north of Sabinal, Uvalde County, Tex.

4, 5. *Tetragramma bösei* Jones (p. 92)

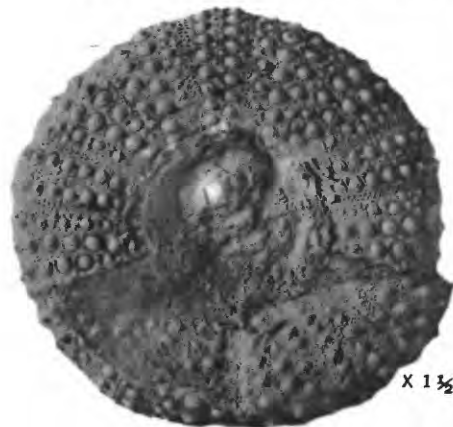
Top and bottom of type, Univ. Mich. 11623 ($\times 2$). From the Indidura formation, Sierra de Santa Ana, Coahuila, Mexico.

6-8. *Tetragramma malbosii* (Agassiz) (p. 91)

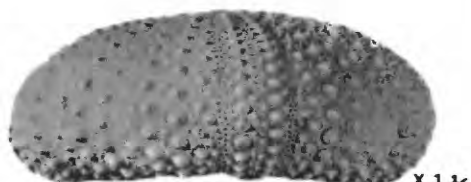
Top and bottom ($\times 2$) and side ($\times 1$) of USNM 108695, from C14025D, 10 kilometers north of Fonseca, Dept. Magdalena, Colombia.



1



2



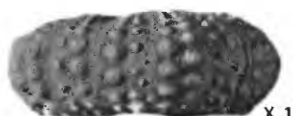
3



4



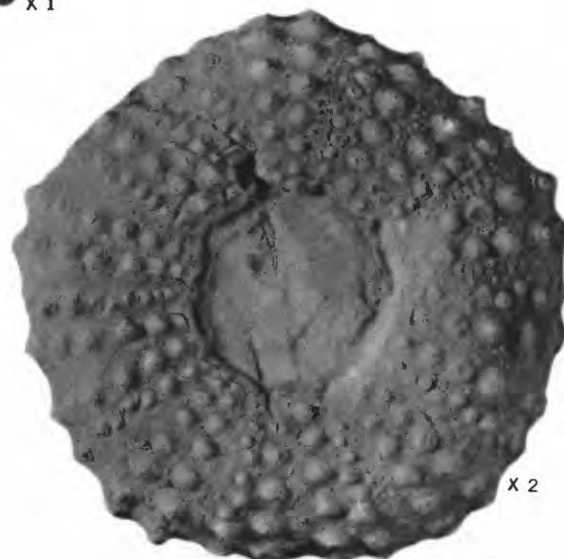
5



8

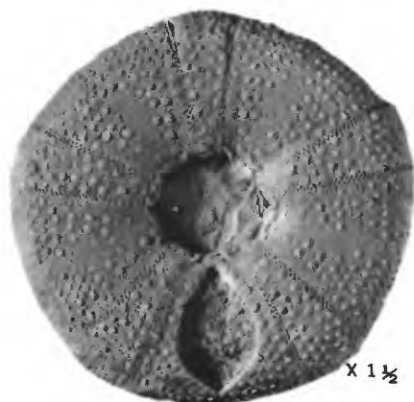


6



7

ORTHOPSIS AND TETRAGRAMMA



1



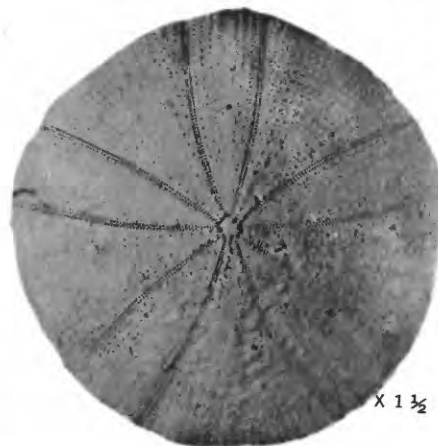
3

X 1



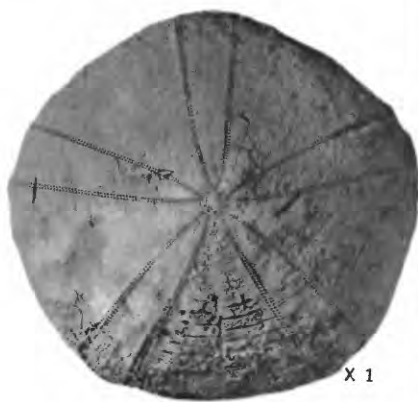
4

X 1



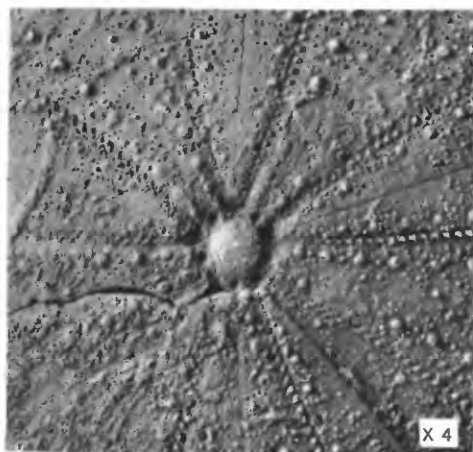
2

X 1 1/2



5

X 1



7

X 4



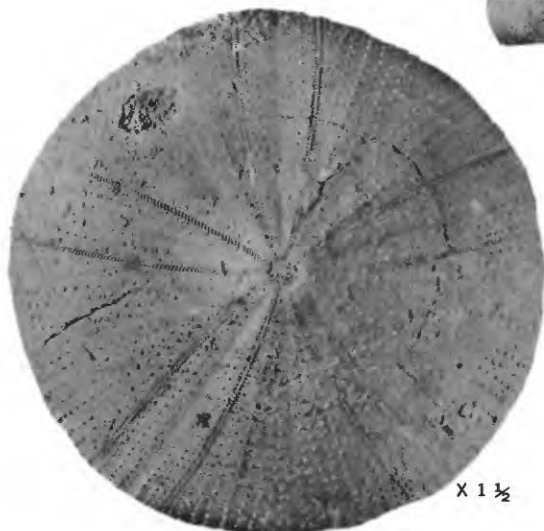
6

X 1



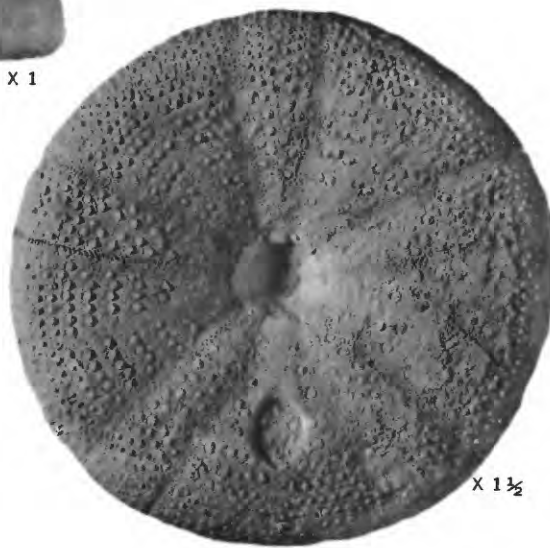
10

X 1



8

X 1 1/2



9

X 1 1/2

HOLECTYPUS (CAENHOLECTYPUS)

PLATE 21

[All figures natural size except as indicated on plate]

FIGURES 1-3. *Holectypus* (*Caenholectypus*) *planatus* Roemer (p. 94)

Bottom and top ($\times 1\frac{1}{2}$), and side of USNM 108179. From the Comanche Peak limestone at USGS 1558, west of creek about 9 miles northeast of Kerrville on road to Fredericksburg, Tex.

4-6. *Holectypus* (*Caenholectypus*) *transpecosensis* Cragin (p. 95)

Side, top, and bottom of USNM 103887. From the Washita group at USGS 1914, pass between North and South Peaks of Sierra Blanca Mountains, Hudspeth County, Tex.

7-10. *Holectypus* (*Caenholectypus*) *castilloi* Cotteau (p. 95)

7, Apical part of USNM 108717 ($\times 4$). From the top 50 feet of the Georgetown limestone at USGS 13976, Rio Grande near Del Rio, Valverde County, Tex.

8-10, Top and bottom ($\times 1\frac{1}{2}$) and side of USNM 108718. From the Main Street limestone from a road cut along the west side of Meadowbrook Country Club, one-quarter mile north of the clubhouse, in Fort Worth, Tex.

PLATE 22

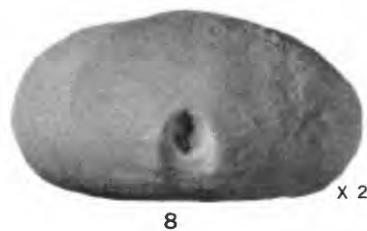
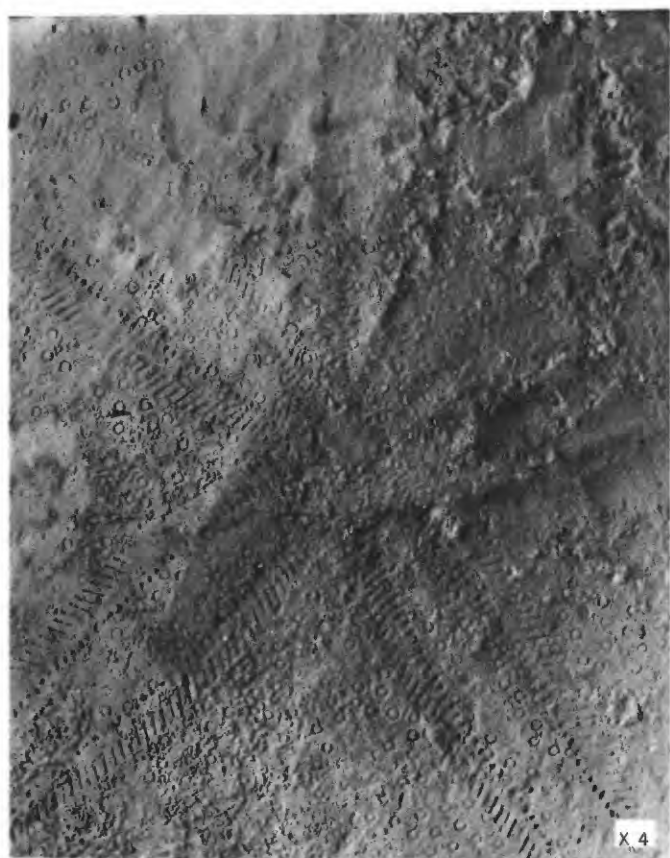
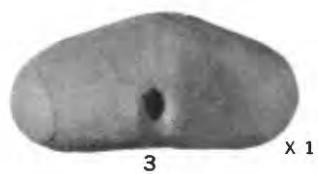
[All figures natural size except as indicated on plate]

FIGURES 1-9. *Arnaudaster colombianus* Cooke, n. sp. (p. 96)

1-5, Top, bottom, and size ($\times 1$), and apical region ($\times 4$) of holotype, Univ. Calif. From the late Albian at C 14161 Rancheria Valley, 10 kilometers north of Fonseca and 25 kilometers N. 67° E. of San Juan de Cesar, Dept. Magdalena, Colombia.

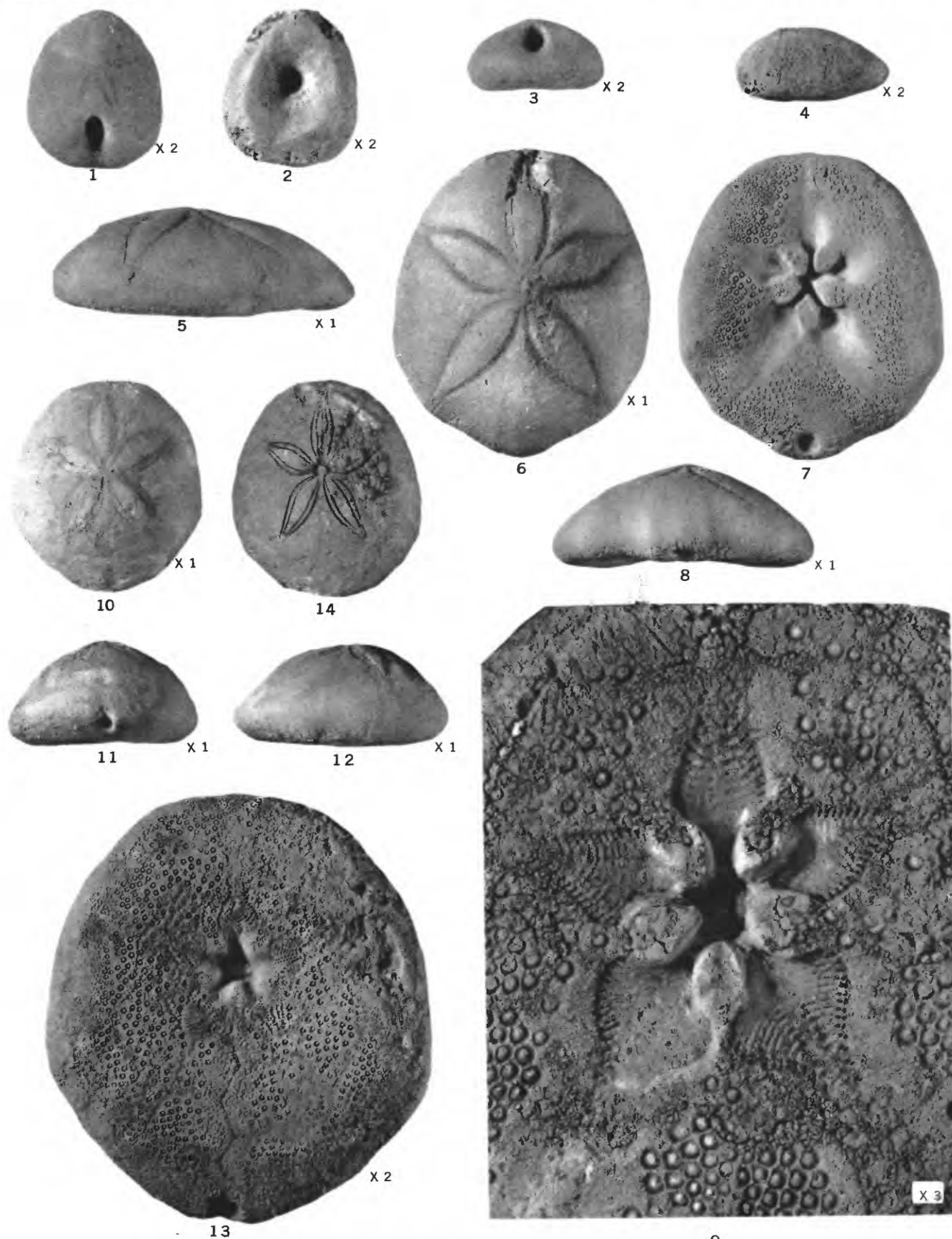
6, Top of paratype A, USNM 108696. From the late Albian at C 14025D, same vicinity as type.

7-9, Top, posterior end, and bottom of paratype B ($\times 2$), USNM 108697. From the late Albian at C 14025C, same vicinity as the type.



5

ARNAUDASTER



PHYLLOBRISUS, PYGURUS (ECHINOPYGUS), AND FAUJASIA

PLATE 23

[All figures natural size except as indicated on plate]

FIGURES 1-4. *Phyllobrissus angustatus* (Clark) (p. 97)

Top, bottom, posterior end, and left side of USNM 108699 ($\times 2$). From the late Albian at C14025D, Rancheria Valley, 10 kilometers north of Fonseca, Dept. Magdalena, Colombia.

5-9. *Pygurus (Echinopygus) jagüeyanus* Cooke, n. sp. (p. 98)

5-8, Left side, top, bottom, and posterior end of type, Univ. Calif.

9, Oral region of paratype, USNM 108698 ($\times 3$).

Both from the late Albian at C 14025, 10 kilometers north of Fonseca, Dept. Magdalena, Colombia.

10-14. *Faujasia rancheriana* Cooke, n. sp. (p. 97)

10-13, Top, posterior end, and right side ($\times 1$), and bottom ($\times 2$) of type, Univ. Calif. From the late Albian at C 14025B, 10 kilometers north of Fonseca, Dept. Magdalena, Colombia.

14, Top of paratype, USNM 108700. From the late Albian at C 14025, in the same vicinity as the type.

PLATE 24

[All figures natural size except as indicated on plate]

FIGURES 1-4. *Heteraster cesarensis* Cooke (p. 101)

Top ($\times 1\frac{1}{2}$), bottom, posterior end, and right side of type, USNM 108704. From the late Neocomian(?), Villeta group at C 8167, Cesar Valley, Dept. Magdalena, Colombia.

5. *Heteraster oblongus* (Brongniart) (p. 100)

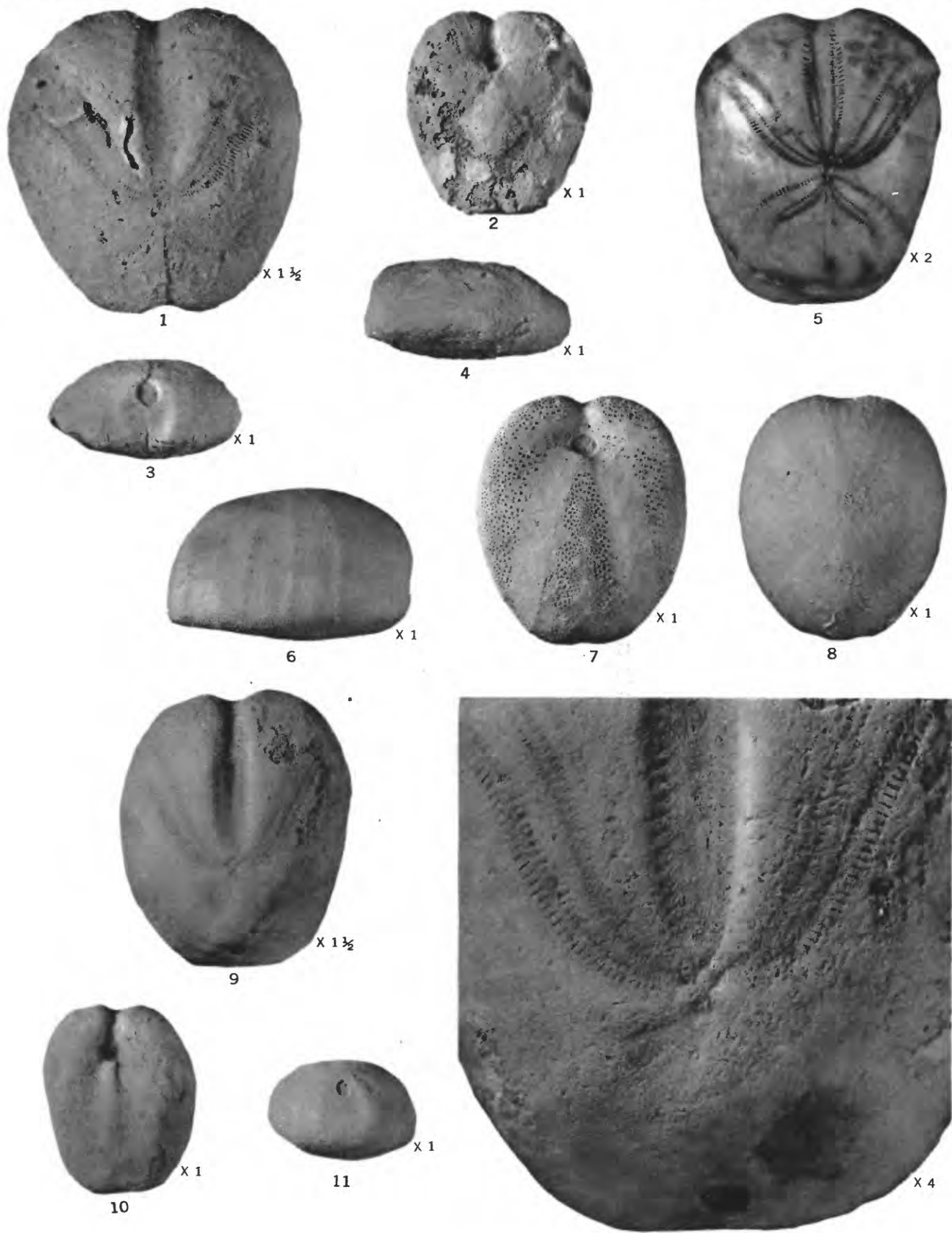
Top of USNM 19590. From the Neocomian (Urgonian) at Somaye, Dept. of Isère, France.

6-8. *Holaster simplex* Shumard (p. 107)

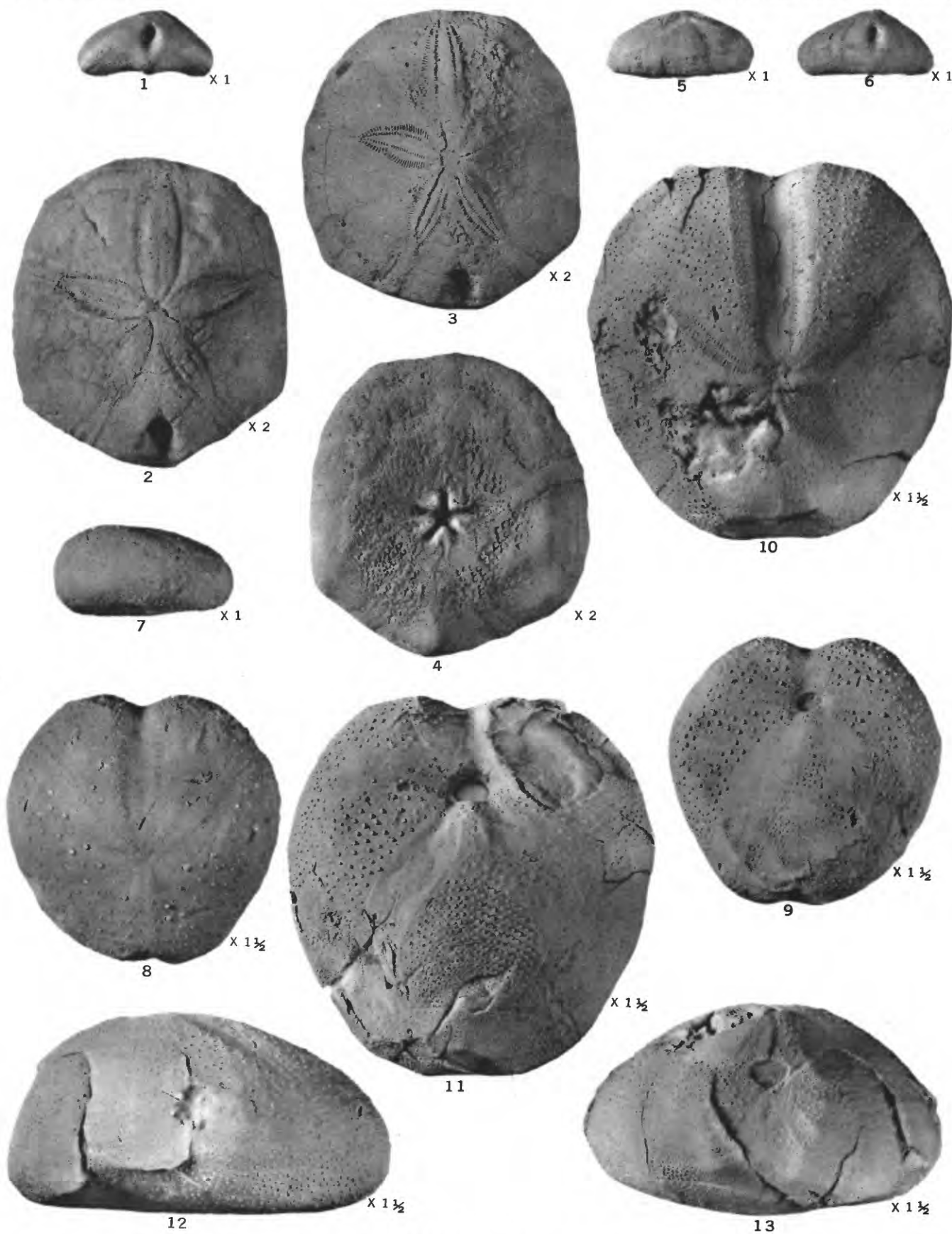
Left side, bottom, and top of USNM 103884, after Cooke (1946, pl. 34, figs. 1-3). From the Washita group at USGS 9690, in Oklahoma, 5.3 miles north of Denison, Tex.

9-12. *Toxaster colombianus* (Lea) (p. 99)

Top ($\times 1\frac{1}{2}$), bottom and posterior end ($\times 1$), and apical region ($\times 4$) of USNM 108702. From the Hauterivian-Valanginian(?) at S 91, near Rio Sogomosa at El Tablazo, Dept. Santander, Colombia.



HETERASTER, HOLASTER, AND TOXASTER



HARDOUINIA AND ENALLASTER

PLATE 25

[All figures natural size except as indicated on plate]

FIGURES 1-5. *Hardouinia clypeus* Cooke (p. 98)

1, 2, Posterior end ($\times 1$) and top ($\times 2$) of paratype, Ala. Geol. Survey. From the Tombigbee sand member of the Eutaw formation on Catoma Creek, Montgomery County, Ala.

3-6, Top and bottom ($\times 2$), left side and posterior end ($\times 1$) of type, USNM 108720. From the Tombigbee sand member of the Eutaw formation at USGS 17010, Catoma Creek, Montgomery County, Ala.

7-13. *Enallaster obliquatus* Clark (p. 102)

7-9, Right side ($\times 1$), top and bottom ($\times 1\frac{1}{2}$) of USNM 108710. From the Glen Rose limestone at USGS 18384, Cranes Mill-New Braunfels road about 3 miles south of Guadalupe River, Comal County, Tex.

10-13, Top, bottom, left side, and posterior end of type USNM 12237 ($\times 1\frac{1}{2}$). From the Trinity group at Mount Bonnell, near Austin, Tex.

PLATE 26

[All figures natural size except as indicated on plate]

FIGURES 1-8. *Enallaster mexicanus* Cotteau (p. 103)

1-4, Top, posterior end, right side, and bottom ($\times 1$) of USNM 108706.

5-8, Posterior end ($\times 1$), top and bottom ($\times 1\frac{1}{2}$), and left side ($\times 1$) of USNM 108707.

Both from the Comanche Peak limestone at USGS 24501, Bosque County, Tex., $2\frac{1}{2}$ miles south of Clifton.

9. *Enallaster (Washitaster) longisulcus* Adkins and Winton (p. 105)

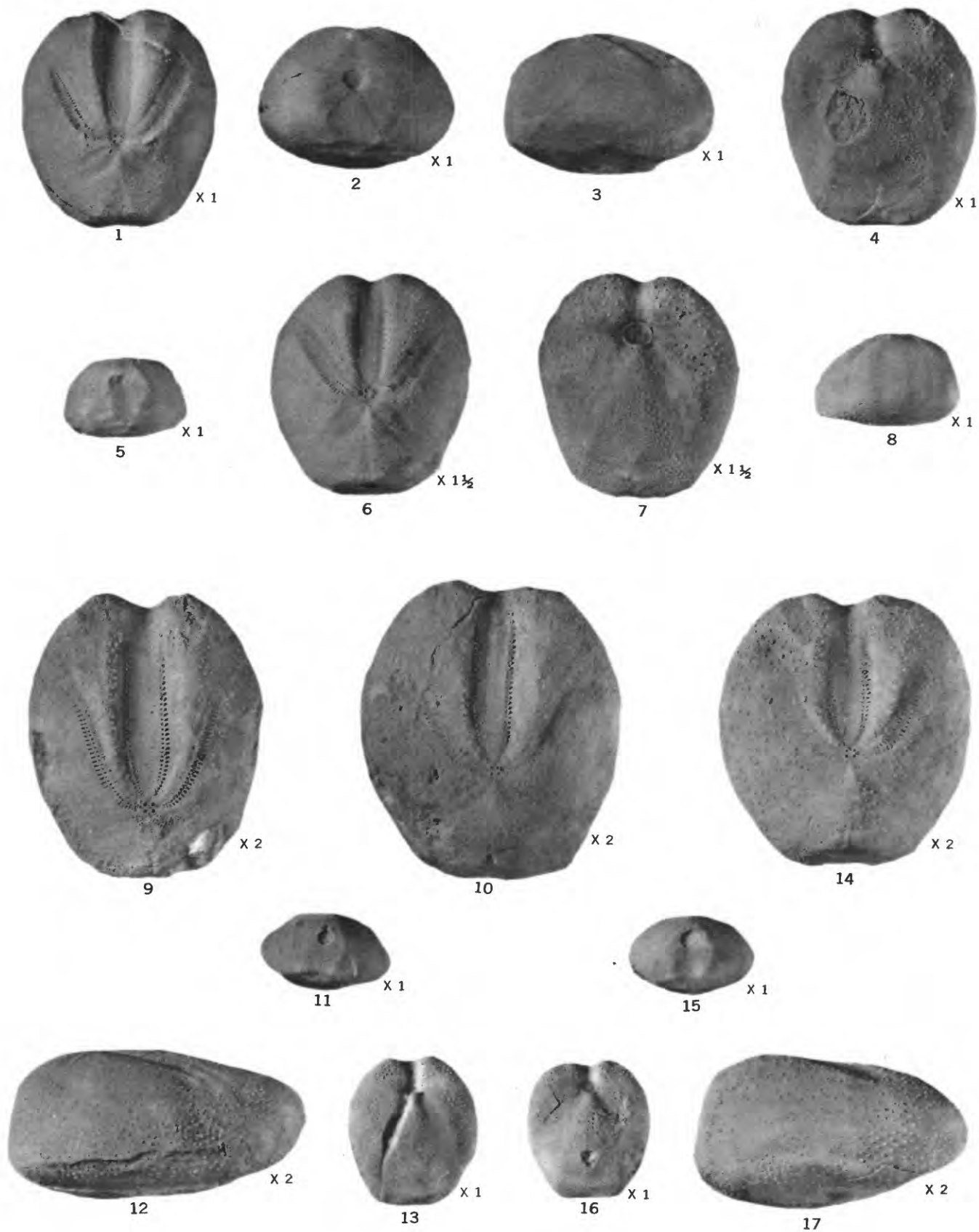
Top of type, Tex. Bur. Econ. Geology ($\times 2$). From the upper part of the Fort Worth limestone on Cedar Creek branch of Nolands River 2 miles southeast of Blum, Johnson County, Tex.

10-13. *Enallaster (Washitaster) riovistae* (Adkins) (p. 104)

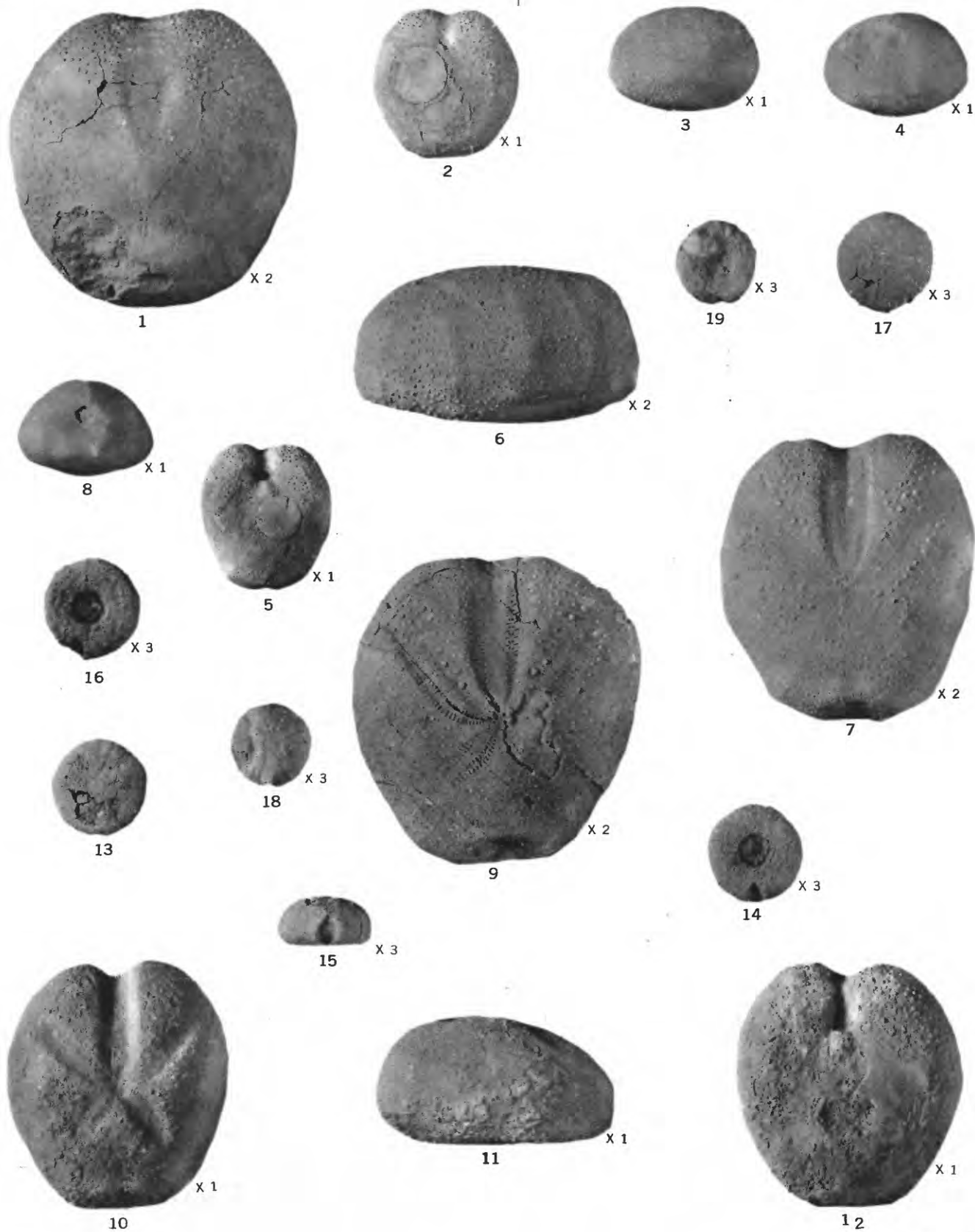
Top ($\times 2$), posterior end ($\times 1$), right side ($\times 2$), and bottom ($\times 1$) of type, Tex. Bur. Econ. Geology. From the Weno clay, 1 mile southeast of Riovista, Tex., one-half mile east of the Waco road.

14-17. *Enallaster riovistae wenoensis* Adkins (p. 105)

Top ($\times 2$), posterior end and bottom ($\times 1$) and right side ($\times 2$) of type, Tex. Bur. Econ. Geology. From the Weno clay, 1 mile southeast of Riovista, Tex., one-half mile east of the Waco road.



ENALLASTER



ENALLASTER AND HOLECTYPUS (CAENHOLECTYPUS)

PLATE 27

[All figures natural size except as indicated on plate]

FIGURES 1-4. *Enallaster (Washitaster) inflatus* Cragin (p. 105)

Top ($\times 2$), bottom, left side, and posterior end ($\times 1$) of USNM 108705. From the Grayson marl at USGS 11752 5 miles northeast of Roanoke, Tex.

5-12. *Enallaster (Washitaster) bravoensis* Böse (p. 106)

5-8, Bottom ($\times 1$), left side and top ($\times 2$), and posterior end ($\times 1$) of USNM 108709. From the Washita group at USGS 1914, Sierra Blanca Peaks, Hudspeth County, Tex.

9, Top of USNM 108708 ($\times 2$). From the Kiamichi formation at USGS 15979, Sierra Muleros, Mexico, southwest of El Paso, Tex.

10-12, Top, right side, and bottom ($\times 1$) of USNM 108701. From the late Albian at C 14025D, Rancheria Valley 10 kilometers north of Fonseca, Colombia.

13-19. *Holcotypus (Caenholcotypus) nanus* Cooke, n. sp. (p. 96)

13-15, Top, posterior end, and bottom of cotype 3 ($\times 3$).

16, 17, Top and bottom of cotype 1 ($\times 3$).

18, 19, Top and bottom of cotype 2 ($\times 3$).

All USNM 108610. From the Pawpaw formation on the Old Burleson Road about one-half mile north of the Glengarden Country Club, Fort Worth, Tex.

PLATE 28

[All figures natural size except as indicated on plate]

FIGURES 1-10. *Epiaster dartoni* Cooke, n. sp. (p. 108)

1-3, Top ($\times 1\frac{1}{2}$), right side and anterior end ($\times 1$) of cotype A.

4-6, Top ($\times 1\frac{1}{2}$), posterior end and bottom ($\times 1$) of cotype B.

Both cotypes USNM 108722. From the Aptian(?) at USGS 10159, ridge just south of Big Hatchet Mountain, Grant County, N. Mex.

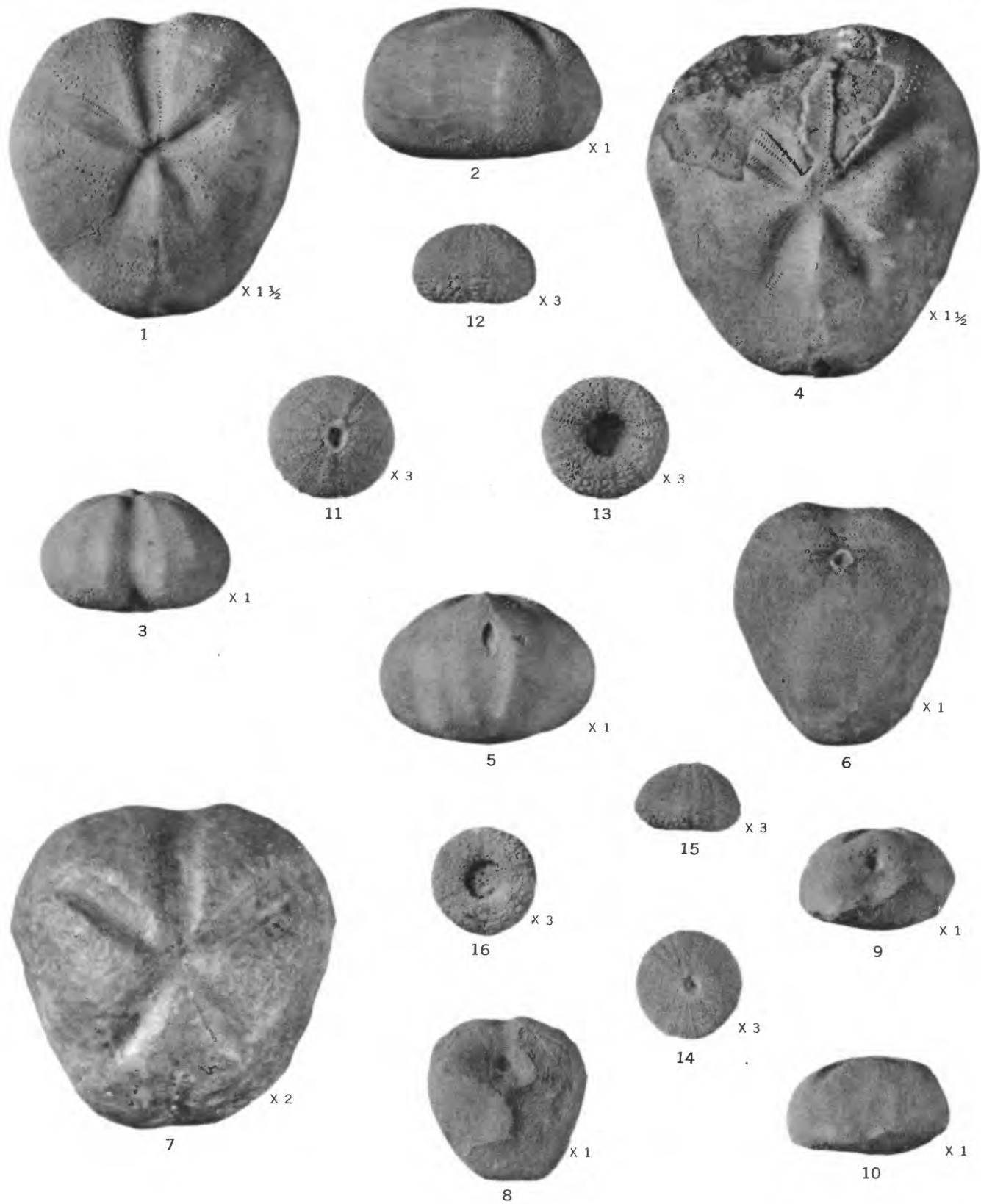
7-10, Top ($\times 2$), bottom, posterior end, and left side ($\times 1$) of USNM 108711. From the Aptian(?) at USGS 24511, Arroyo Palomas, Coahuila, Mexico.

11-16. *Boletechinus mcglameryae* Cooke, n. sp. (p. 93)

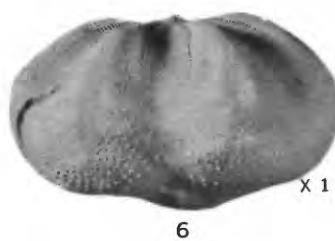
11-13, Top, side, and bottom of holotype ($\times 3$), Ala. Mus. Nat. History.

14-16, Top, side, and bottom of paratype ($\times 3$) USNM 108689.

Both from the Prairie Bluff chalk near the Industrial School, 2 miles north of Livingston, Sumter County, Ala.



EPIASTER AND BOLETECHINUS



EPIASTER AND HEMIASTER

PLATE 29

[All figures natural size except as indicated on plate]

FIGURES 1-4. *Epiaster renfroae* Cooke, n. sp. (p. 109)

Right side and posterior end ($\times 1$), top and bottom ($\times 2$) of type, USNM 108712. From the Weno clay at USGS 22352, north of 3000 block on Bomar Avenue, Fort Worth, Tex.

5-10. *Hemiaster texanus* Roemer (p. 109)

Bottom, anterior end, posterior end, top, and left side ($\times 1$), apical region ($\times 4$) of USNM 108703. From the upper part of the Napo series in the Oriente of Ecuador on Rio Napo at A 7134, about 500 meters below Latas.