Pliocene Echinoids from Okinawa

By C. WYTHE COOKE

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 264-C

*Descriptions and illustrations
of five new species and one
new subspecies*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1954

UNITED STATES DEPARTMENT OF THE INTERIOR

Douglas McKay, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 20 cents (paper cover)

CONTENTS

	Page		Page
Abstract.....	45	Bibliography.....	50
Introduction.....	45	Index.....	53
Systematic descriptions.....	45		

ILLUSTRATIONS

[Plates 9-12 follow page 54]

- PLATE 9. *Cidaris*, *Temnotrema*, *Lytechinus*, *Echinoneus*, *Laganum*, and *Temnopleurus*.
10, 11. *Peronella* and *Clypeaster*.
12. *Schizaster*, *Breynia*, and *Oligopodia*.

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

PLIOCENE ECHINOIDS FROM OKINAWA

By C. WYTHE COOKE

ABSTRACT

A collection of fossil echinoids from Okinawa is referred to the Pliocene because it includes *Peronella merrilli* Israelsky, *Schizaster excavatus* R. Martin, and *Breynia carinata* D'Archiac and Haime. Five new species and one new subspecies are described: *Lytechinus okinawa*, *Clypeaster okinawa*, *Peronella kamimura*, *Peronella motobu*, *Laganum fudsiyama untenensis*, and *Oligopodia okinawa*.

INTRODUCTION

The fossil echinoids described in this report were collected on Okinawa in 1946-48 by a field party of the U. S. Geological Survey. The party included McClelland Dings, F. Stearns MacNeil, Delos E. Flint, Maxim M. Elias, Raymond A. Saplis, Warren Fuller, and Gilbert Corwin. The collection has been deposited in the United States National Museum.

The echinoids were obtained from the lower, partly sandy division of the Ryukyu limestone of recent authors. For this part of the Ryukyu the name Naha limestone, an early name for limestone near the port of Naha, was revived by the field party. Preliminary study by F. S. MacNeil of the molluscan fauna of the Naha limestone indicates that the formation is of Pliocene age. The upper part of the Ryukyu is retained in the Pleistocene.

The collection includes the following species; an asterisk indicates that the species still exists:

- **Cidaris metularia* (Lamarck)
- **Temnopleurus toreumaticus* (Leske), varieties
- **Temnotrema sculptum* A. Agassiz
- Lytechinus okinawa* Cooke, n. sp.
- **Echinoneus cyclostomus* Leske
- Clypeaster okinawa* Cooke, n. sp.
- * *japonicus* Döderlein
- **Peronella pellucida* Döderlein
- kamimura* Cooke, n. sp.
- motobu* Cooke, n. sp.
- merrilli* Israelsky
- **Laganum fudsiyama untenensis* Cooke, n. subsp.
- Astriclypeus* sp.
- Oligopodia okinawa* Cooke, n. sp.
- Schizaster excavatus* R. Martin
- Brissus* sp.
- Breynia carinata* D'Archiac and Haime

The names *okinawa*, *motobu*, and *kamimura* proposed for the new species are barbarous words and hence should not be altered if it becomes necessary to recombine them with a generic name having a different gender.

The fossil echinoids are obviously related to the Recent Japanese fauna, but the presence of several species and subspecies probably extinct gives them an aspect older than the Pleistocene. Perhaps the most tangible evidence as to the antiquity of the echinoid fauna consists in the presence of *Breynia carinata* D'Archiac and Haime, a characteristic species of the Gaj (Miocene) of India. Hyasaka (1948) reports it from the Miocene of Formosa. *Peronella merrilli* was described from the Pliocene Malumbang formation of Luzon, Philippine Islands. *Schizaster excavatus* is attributed to the Pliocene of Java by R. Martin.

The evidence of the echinoids agrees with that of the mollusks in indicating the Pliocene age of the Naha limestone. However, no material was available for comparison and the identifications were therefore made entirely from the literature. Published figures of most of these fossils are so obscure or incomplete that errors in identification are quite possible. Moreover, the geologic age of the types of the species used for comparison is questionable.

The bibliography is not complete, but may be helpful to persons not familiar with the literature dealing with the Asiatic region.

SYSTEMATIC DESCRIPTIONS

Cidaris metularia (Lamarck)

Plate 9, figure 1

Cidarites metularia Lamarck, 1816, Histoire naturelle des animaux sans vertèbres, v. 3, p. 56.

Cidaris metularia (Lamarck). A. Agassiz, 1872, Harvard College, Mus. Comp. Zoology, Mem., v. 3, p. 385, pl. 1c, figs. 23, 24; pl. 1g, fig. 1; pl. 35, fig. 3.

Cidaris metularia (Lamarck). A. Agassiz and H. L. Clark, 1907, Harvard College, Mus. Comp. Zoology, Mem., v. 34, p. 5, pl. 1, figs. 3-7.

Eucidaris metularia (Lamarck). Mortensen, 1928, Monograph of the Echinoidea, v. 1, p. 386, pl. 41, figs. 1-8; pl. 73, fig. 6; pl. 86, figs. 11-14.

One test measuring 16.7 mm in horizontal diameter by 9.1 mm in height is referred to this common Pacific species.

Cidaris metularia is regarded by Mortensen as the type species of *Eucidaris* Pomel, 1883, but this designation is not valid under Article 30 of the International Rules because *C. metularia* was not one of the six species (all Jurassic) that Pomel referred to by name. Pomel proposed *Eucidaris* as a section or subgenus under *Cidaris*, but Mortensen treats it as a genus.

Occurrence.—USGS 17640, small quarry near site of village of Uza, west of Highway 12, about 0.2 mile north of the junction of Highways 12 and 6 Zampa-misaki (Bolo Point Peninsula).

Figured specimen.—USNM 561553.

Cidaris sp.

Three coronal plates of a much larger *Cidaris* were found in the Naha limestone at USGS 17541, on Highway 6 about 0.75 mile west of the junction with Highway 1, near Maeta.

Temnopleurus toreumaticus (Leske), varieties

Plate 9, figure 12

Temnopleurus areolatus Herklots, 1854, Fossiles de Java, p. 4, pl. 1, fig. 3.

Temnopleurus caelatus Herklots, 1854, Fossiles de Java p. 5, pl. 1, fig. 5.

Temnopleurus toreumaticus (Leske). Gerth, 1922, Geol. Reichsmus. Leiden Samml., n. F., Band 1, Abt. 2, Heft 4, p. 501.

Temnopleurus toreumaticus (Leske). Mortensen, 1943, Monograph of the Echinoidea, v. 3, pt. 2, p. 76, pl. 1, figs. 1-3, 6-12; pl. 2, figs. 9-15, 19-21; pl. 45, figs. 27, 28.

Several varieties of a *Temnopleurus* appear to represent this well-known and exceedingly variable existing species.

Occurrence.—USGS 17440, near mouth of small stream emptying into Katena-kō at Nakaosu on the road opposite the Nakaosu Primary School. USGS 17529, cut on west side of ravine about 0.75 mile southeast of the intersection of Highways 5 and 16. USGS 17610, cut about 0.25 mile on north side of the road from Unten-kō LCT landing on Unten Peninsula.

Figured specimen.—USNM 561554.

Temnotrema sculptum A. Agassiz

Plate 9, figure 2

Temnotrema sculpta A. Agassiz, 1863, Acad. Nat. Sci. Phila. Proc., p. 358.

Temnotrema sculptum A. Agassiz. Mortensen, 1943, Monograph of the Echinoidea, v. 3, pt. 2, p. 249, pl. 19, figs. 1, 2; pl. 45, figs. 1-3, 15.

Several individuals agree in all essential characters with this Recent Japanese species. Unfortunately,

species of this group are so variable that they are of little use as horizon markers.

Occurrence.—USGS 17484, cut on road from Naha to Naha Army Air Base, at south end of quarries just east of air base, Naha. USGS 17482c, Chinen-zaki. USGS 17486, beach cliff on Unten-kō 0.25 mile north of Shima-uten. USGS 17579 and 17581, quarry on west side of Route 124 about 0.3 mile north of Kitazato, Kami-motobu.

Figured specimen.—USNM 561555.

Lytechinus okinawa Cooke, n. sp.

Plate 9, figures 3-5

Test tumid on top, weakly concave around the peristome. Peristome one-third the total width, weakly notched. Ambulacral areas slightly more than half as wide as the interambulacral areas; each plate on oral face has two primary tubercles; above the ambitus the tubercles of the inner row dwindle in size, leaving bare median areas near the apex; poriferous zones trigeminate. Interambulacral areas have four primary tubercles on each plate on oral side; above the ambitus the tubercles grow smaller and all but the second row from the outer suture disappear; a band along the median suture is bare. Tubercles imperforate and faintly crenulated.

Horizontal diameter 45 mm, crushed to 40.3 mm; height 22.8 mm.

According to Mortensen (1943, p. 434) the genus *Lytechinus* is now chiefly confined to the Atlantic and Pacific coasts of America and is not known in the western Pacific. H. L. Clark (1945, p. 317) has described *L. crassus* from the Pliocene of Lau, Fiji. *Lytechinus crassus* lacks the bare median spaces that are characteristic of most Recent species and of *L. okinawa*. *Lytechinus variegatus* (Leske), the type species, has a somewhat smaller, more sharply notched peristome, and its tubercles are somewhat larger; its zygopores are more crowded around the peristome.

Occurrence.—USGS 17486, from beach cliff on Unten-kō 0.25 mile north of Shima-uten. Smaller fragments from USGS 17576, cliff on west end of beach at Imatomari (Oyadomari). USGS 17600, halfway up the sea cliff on the trail above Kunjabaru, Nakijin-mura.

Type.—USNM 561556.

Echinoneus cyclostomus Leske

Plate 9, figure 6

Echinoneus cyclostomus Leske, 1778, Klein's Naturalis dispositio Echinodermatum, p. 173, pl. 37, figs. 4, 5.

Echinoneus cyclostomus Leske. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 1, p. 75, pl. 1, figs. 14, 26; pl. 12, figs. 21, 23.

This well-known species is represented by one medium-sized (28.5 mm long) individual from USGS 17537 and one unusually large (originally about 53 mm

long) specimen from USGS 17466. Both agree well with the Recent form.

Occurrence.—USGS 17466, large limestone quarry on top of cliff overlooking Naha-kō about 0.3 mile north of the intersection of Highways 1 and 40. USGS 17537, quarry at junction of Highway 13 and road leading to Tengan quartermaster area, about 0.5 mile south of junction of Highways 6 and 13.

Figured specimen.—USNM 561557.

Clypeaster okinawa Cooke, n. sp.

Plate 11, figures 1, 2

Test large, oval, moderately elevated centrally, with lateral slope gently concave; margin thin. Madreporic body central, pentagonal, with five genital pores at the corners. Petals extending about halfway to the margin; inner ends wide open, close to but not touching adjacent petals; outer ends of paired petals slightly curved inwards but not closed; odd petal nearly straight, wide open at both ends; poriferous zones fairly wide. Oral surface slightly concave, evenly sloping toward the peristome; ambulacral grooves not conspicuous. Periproct about one-third the distance from the margin to the peristome; ratio of length of test to distance from the margin equal 0.135.

Length 96 mm; width 88 mm; height 10.9 mm.

In shape, this species resembles the figures of *Clypeaster malumbangensis* Israelsky (1933, p. 301, pl. 1, fig. 1), but its petals are much straighter. The apical arrangement of the petals is similar to that of *Clypeaster latissimus* (Lamarck), but the anterior petal is much wider open at the outer end. *Clypeaster okinawa* is represented by the holotype and one paratype from which most of the marginal area is wanting.

Occurrence.—USGS 17536, large quarry on west side of Highway 13 about 0.25 mile south of Ishikawa.

Type.—USNM 561558.

Clypeaster japonicus Döderlein

Plate 10, figures 7, 8; plate 11, figures 3, 4

Clypeaster japonicus Döderlein, 1885, Arkiv für Naturgeschichte, Band 51, pt. 1, p. 100.

Clypeaster japonicus Döderlein. H. L. Clark, 1914, Harvard College, Mus. Comp. Zoology, Mem., v. 46, p. 32, pl. 128, fig. 5; pl. 136, figs. 2-4; pl. 138, fig. 5.

Clypeaster (Stolonocypus) japonicus Döderlein. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 2, p. 99, pl. 29, fig. 4; pl. 31, fig. 1; pl. 34, figs. 4, 6, 7; pl. 35, fig. 2; pl. 42, fig. 3; pl. 67, figs. 1, 2, 9, 10.

The shape of this highly variable existing species ranges from plump and evenly rounded to more angular and flat-bottomed. The apical part is commonly rather high, and the peristome is correspondingly deeply concave. The outline is commonly pentagonal, although some individuals are ovate. The shape of the petals is nearly uniform, but there is some variation in the width of opening at the tips.

Occurrence.—USGS 17465, limestone cliff at top of low hill west of the Naha airfield about 200 yards south of the control tower. USGS 17498, large quarry south of the docks at Naha harbor, about one-eighth mile south of the junction of Highways 1 and 7. USGS 17499, quarry about 300 yards north of the northwest corner of airstrip at Futema airfield. USGS 17509, large quarry near center of limestone plateau south of Shuri, about 0.5 mile northeast of the intersection of Highways 46 and 44. USGS 17513, quarry near northern edge of Chin (Kin) on south side of secondary road about 200 yards west of Highway 13. USGS 17518, quarry at north end of Futema airfield about 0.5 mile south of the junction of Highways 30 and 5. USGS 17522, quarry about 300 yards north of the northwest corner of the airstrip at Futema airfield. USGS 17529, road cut on west side of ravine about 0.75 mile southeast of the intersection of Highways 5 and 16. USGS 17557, outcrop on east side of small ravine about 0.75 mile southwest of the intersection of Highways 5 and 16. USGS 17583, from the road cut and quarry on the west side of the highway, 150 yards south of the road fork at Shinsatobaru (Shinzato), Kami-motobu-mura. USGS 17587, quarry on Route 112 just west of Urasaki, on the west bank of the stream, from upper fossiliferous zone. USGS 17623, small quarry on north side of creek just west of Highway 13, about 0.25 mile south of Chibana. USGS 17630, cut on Highway 1 through natural levee along north bank of the Chatan-gawa. USGS 17641c, deep quarry just west of main Highway 6, a little east of the site of village of Toya, about 0.5 mile due west of edge of Yontanzan airfield, upper zone.

Figured specimens.—USNM 561559 (pl. 11, figs. 3, 4); 561560 (pl. 10, figs. 7, 8).

Peronella pellucida Döderlein

Plate 10, figures 3, 4

Peronella (Laganum) pellucida Döderlein, 1885, Archiv für Naturgeschichte, Band 51, pt. 1, p. 104.

Peronella pellucida Döderlein. H. L. Clark, 1914, Harvard College, Mus. Comp. Zoology, Mem., v. 46, pt. 1, p. 53, pl. 142, figs. 1, 8-10.

Peronella pellucida Döderlein. Mortensen, 1948, Monograph of the Echinoidea, v. 4, pt. 2, p. 281, pl. 47, fig. 5; pl. 48, figs. 3, 4; pl. 72, figs. 1, 11.

This Recent Japanese species is represented by one well-preserved individual measuring 37.3 mm in length by 33 mm in width.

Occurrence.—USGS 17524, large quarry south of sharp bend in Highway 5 about 0.7 mile southeast of the junction of Highways 5 and 34.

Figured specimen.—USNM 561561.

Peronella kamimura Cooke, n. sp.

Plate 11, figures 5, 6

Outline oval, margin thick, upper surface very slightly tumid, lower surface slightly concave, ambulacral grooves not discernible. Apical system stellate, with long points; four genital pores, far apart, between the inner ends of the petals. Petals short, extending about halfway to the margin, wide open at the inner ends, open distally. Peristome central, small, subpentagonal. Periproct nearly as large as the peristome, transversely oval, one-third the way from the margin to the peristome.

Length 34.8 mm; width 30.7 mm; height 7.2 mm.

The shape of the petals suggests *Peronella peronii* (L. Agassiz), the existing type species, but the genital pores are not so far out, the periproct is larger and nearer the margin, and the ambulacral grooves are not so conspicuous. *Peronella kamimura* resembles *P. macroproctes* Koehler as figured by Mortensen (1948, p. 297, pl. 51, figs. 30, 36), but its petals are wider open at the apex, its genital pores are farther apart, and its periproct is somewhat nearer the margin.

Occurrence.—USGS 17464, northeasternmost quarry at the northeastern edge of the Naha airfield, about 0.25 mile northeast of the terminal. USGS 17533, road cut at sharp bend in road leading from Highway 13 to the Navy magazine (ammunition area) about one-third mile northwest of Kerabaru. USGS 17584, 150 yards south of the highway fork at Shinsatobaru (Shinzato), Kami-motobu-mura office on highway between Johana and Urasaki.

Type.—USNM 561562.

Peronella motobu Cooke, n. sp.

Plate 10, figures 1, 2

Test ovate (probably circular when young), nearly flat, with slightly thickened margin, oral surface slightly concave. Apical system stellate, with pointed prongs; only the right two genital pores visible in type; madreporic pores scattered. Petals lanceolate, extending more than halfway to the margin; poriferous zones curved inward at the apex but wide open there, nearly closed distally. Tubercles on upper surface rather widely separated, intermediate spaces filled with granules. Peristome central. Periproct less than half-way from the margin to the peristome.

Length 47 mm; width 40.7 mm; height 7 mm.

The petals of *Peronella motobu* are longer and proportionally narrower than those of *Peronella kamimura*, and the poriferous zones are turned farther inward at the apex, and they are more nearly closed at the outer ends. The periproct is farther from the margin. The petals are much longer than those of *Peronella pellucida* Döderlein. The apical system appears to be larger and the periproct farther from the margin than in *Peronella equaepetola* (Israelsky, 1933, p. 303, pl. 2, figs. 10-12).

Occurrence.—USGS 17582, large quarry east of Route 124 opposite the northeast end of the runway of Motobu airfield. USGS 17610, cut on north side of road about 0.25 mile from Unten-kō LCT landing on Unten Peninsula.

Type.—USNM 561563.

Peronella merrilli Israelsky

Plate 10, figures 5, 6

Peronella merrilli Israelsky, 1933, Philippine Jour. Sci., v. 50, no. 3, p. 304, pl. 2, figs. 17-19.

One fairly well preserved individual and several others agree with Israelsky's figures of *Peronella merrilli*.

All were covered with a deposit of calcite. The figured specimen measures 38 mm in length, 32.2 mm in width, and 7.8 mm in height.

Occurrence.—USGS 17533, road cut at sharp bend in road leading from Highway 13 to the Navy magazine (ammunition area) about one-third mile northwest of Kerabaru.

Figured specimen.—USNM 561564.

Laganum fudsiyama untenensis Cooke, n. subsp.

Plate 9, figures 7-11

Test round, oval, or subpentagonal, commonly more or less tumid in the apical region; oral surface somewhat concave, with obscure ambulacral grooves. Apical system central, with five genital pores, madreporic pores in narrow grooves. Petals narrow, extending about halfway to the margin, open at both ends; poriferous zones less than half as wide as the maximum width of the interporiferous zones, slightly incurved at the apical ends, nearly parallel at the outer tips, where they are separated by about their own width. Peristome central, nearly circular, rather small. Periproct nearly circular, less than halfway from the margin to the peristome, variable in location. The type of the subspecies measures 42 mm in length, 39.6 mm in width, and 7.3 mm in height.

Laganum fudsiyama Döderlein (Mortensen, 1948, p. 338, pl. 54, figs. 5, 6, 10-13; pl. 70, figs. 8, 9, 14, 15) varies conspicuously in the degree of elevation of the apical system. The subspecies is much less tumid than the maximum, although its upper range lies near the lower limit of variation of the species. The petals of *Laganum fudsiyama untenensis* resemble those of *L. dickersoni keiense* Mortensen (1948, p. 327, pl. 53, fig. 2) but appear to be much less widely open at the outer tips than *L. dickersoni* Israelsky (1933, p. 302, pl. 2, figs. 1-9), which may be a *Sismondia*.

Occurrence.—USGS 17466, large quarry on top of cliff overlooking Naha-kō about 0.3 mile north of the intersection of Highways 1 and 40. USGS 17482c, road cuts across ridge at Chinen-zaki, just below the limestone. USGS 17486, beach cliff on Unten-kō 0.25 mile north of Shima-unten. USGS 17496, quarry north of Naha airfield transient quarters, about 0.3 mile east of north tip of terminal runway. USGS 17517, quarry on south side of Highway 30 about 0.7 mile northeast of the junction of Highways 1 and 30. USGS 17518, quarry at north end of Futema airfield about 0.5 mile south of the junction of Highways 30 and 5. USGS 17524, large quarry south of the sharp bend in Highway 5 about 0.7 mile southeast of the junction of Highways 5 and 34. USGS 17530, outcrop along west bank of wide ravine just west of Highway 13 about 300 yards southwest of the Bailey bridge that spans the stream south of Kerabaru. USGS 17601, cut on road from beach to the upper terrace level at the west end of Kunjabaru, Nikijin-mura. USGS 17610, cut on north side of the road about 0.25 mile from Unten-kō LCT landing on Unten Peninsula (type locality of subspecies). USGS 17860, road cut in valley of Manna-kawa (Mana Gowa), about 0.75 mile east of Togouchi, Motobu-hanto.

Type of subspecies.—USNM 561565, from USGS 17610.

Figured paratype.—USNM 561566, from USGS 17860.

Astriclypeus sp.

Several unidentifiable fragments probably represent a species of *Astriclypeus*. The margin is thin, but the test thickens rapidly toward the center. The zygopores are strongly conjugate. The ambulacral lumules have steep walls, and one of them is 16 mm long.

The only known Recent *Astriclypeus* is the type species, *A. manni* Verrill (Mortensen, 1948, p. 416, pl. 59, figs. 1-3; pl. 62, fig. 1; pl. 72, figs. 17, 18, 20, 21). Hayasaka (1947, p. 116, pl. 12, fig. 2; pl. 13, fig. 1; pl. 14, fig. 1; pl. 15, fig. 1) has reported it from the uppermost horizon of the Byoritsu beds (late Pliocene or Pleistocene) of Formosa. *Astriclypeus integer* Yoshikawa (Tokunaga, 1903, p. 15, pl. 1, figs. 3, 4; pl. 2, figs. 3, 4), described from the Miocene of Japan, has been identified by Hayasaka (1947, p. 115, pl. 15, fig. 2; pl. 16, figs. 1, 2) from Formosa.

Occurrence.—USGS 17604, excavation 0.12 mile north from Geochi (Koechi), Nakijin-mura. TS-DF 3, Tokuno-shima, from old sea cliff at southern outskirts of Kametsu.

Oligopodia okinawa Cooke, n. sp.

Plate 12, figures 7-10

Shape suboval, truncate behind; greatest width just behind the apical system. Upper surface arched, sloping steeply forward, less steeply backward; margin rounded; oral surface concave around the peristome, swollen posteriorly. Apical system nearly central, plates fused, with a large central madreporic body and three open genital pores. Petals nearly equal in length, extending about two-thirds the way to the margin, paired petals curving very slightly forward; pores round, conjugate; poriferous zones wide open, not incurved at the tips, about half as wide as the interporiferous zones, outer rows of pores of paired petals longer than the inner rows. Peristome central, pentagonal, longer than wide; phyllodes and floscelle well developed. Periproct terminal, higher than wide, at the top of the posterior truncation, sunken in a tube, which opens into a shallow sulcus. Entire surface including the ambulacral areas, covered with close-set scrobiculate tubercles, which appear to be imperforate and not crenulated.

Length 26 mm; breadth 22 mm; height 14.2 mm.

This species may prove to be the same as *Pliolampas* (*Tristomanthus*) *javanus* Jeannet (Jeannet and Martin, 1937, p. 267, figs. 46a-d) from the Pliocene of Java. *Pliolampas javanus*, however, is described as having its apical system and peristome in front of the center; its poriferous zones slightly incurved; its interporiferous zones, except in the anterior paired petals, only as wide as the poriferous zones; its tubercles crenulated and perforated. This species resembles also *Nucleolites minutus* Herklots (1854, p. 10, pl. 5, figs. 8-8b), also

from Java, but the type of *N. minutus* is only half as large, its pores are not conjugate, and its poriferous zones are as wide as the interporiferous; its peristome is eccentric in front.

Oligopodia okinawa, known only from the type, is 9 mm longer than the largest known individual of the Recent *Oligopodia epigonus* (Martens) (Mortensen, 1948, p. 228, pl. 1, figs. 5-13), its poriferous zones are farther apart, and it has many more madreporic perforations (hydropores).

The type is somewhat deformed, giving it a lopsided appearance, and the anterior end is broken.

Occurrence.—USGS 17461, cliff at top of steep slope on south bank of stream about 0.25 mile southeast from Gushichan.

Type.—USNM 561567.

Schizaster excavatus R. Martin

Plate 12, figures 1-4

Schizaster cf. japonicus A. Agassiz. Gerth, 1927, Paläontologie von Timor, Lief. 15, Abh. 26, p. 183, pl. 218, figs. 3a-b.

Schizaster excavatus R. Martin, 1937, Leidsche geol. Meded., Band 8, p. 292, figs. 62a-b.

The single test referred to *Schizaster excavatus* is somewhat wider than Martin's figures, and its petals are consequently more diverging. These differences are presumably individual variations. In general appearance it is similar to the living *Schizaster lacunosus* (Linné) (*S. japonicus* A. Agassiz), but its posterior petals are only about half as large and are less deeply depressed.

Occurrence.—USGS 17576, limestone exposed in small cliff on the west end of the beach at Imatomari, Okinawa. Java (R. Martin). Timor (H. Gerth).

Figured specimen.—USNM 561568, from USGS 17576.

Brissus sp.

This species, which appears to be indistinguishable from the Recent *Brissus latecarinatus* (Leske) (A. Agassiz, 1873, p. 596, pl. 21a, figs. 1-3, as *B. carinatus*), is represented by two casts of the interior to which a few fragments of thin shell still cling. The larger cast measures about 42 mm in length, 34 mm in width, and 24.5 mm in height.

Occurrence.—USGS 17606, from quarry near coast 1.25 miles due north from Yonamine, Nakijin-mura.

Breynia carinata D'Archiac and Haime

Plate 12, figures 5, 6

Breynia carinata D'Archiac and Haime, 1853, Description des animaux fossiles du groupe nummulitique de l'Inde, p. 216, pl. 15, figs. 4a-c.

?*Eupatagus magnus* Herklots, 1854, Fossiles de Java, pt. 4, p. 13, pl. 2, fig. 7.

?*Breynia magna* (Herklots). K. Martin, 1880, Tertiärschichten auf Java, Anhang, p. 5.

Breynia carinata D'Archiac and Haime. Duncan and Sladen, 1885, *Palaeontologia Indica*, ser. 14, vol. 1, pt. 3, fasc. 5, p. 343, pl. 54, figs. 1-9; pl. 55, figs. 1-8.

?*Breynia magna* (Herklots). Gerth, 1922, *Geol. Reichs-Mus. Leiden Samml.*, n. F., Band 1, Abt. 2, Heft 4, p. 515.

?*Breynia cordata* Hayasaka, 1947, *Acta geol. Taiwanica*, v. 1, no. 2, p. 122, pl. 10, figs. 1a-b; pl. 11, figs. 1.

?*Breynia testudinaria* Hayasaka, 1947, *Acta. geol. Taiwanica*, v. 1, no. 2, p. 125, pl. 11, fig. 2.

Breynia carinata D'Archiac and Haime. Hayasaka, 1948, *Acta geol. Taiwanica*, v. 2, no. 2, p. 114, pl. 4, fig. 4.

Test large, original length probably 120 mm, width about 100 mm. Posterior petals long, pointed, zygopores in deep pits. Posterior interambulacral area decorated with nearly flush tubercles of variable size separated by many pustules; posterolateral interambulacral areas containing four rows of large, deeply sunken tubercles capped by small perforated mamelons, about 23 in each area; tubercles confined within a peripetalous fasciole having a posterior projection. Areas outside the peripetalous fasciole about half as wide as the part within; covered with pustules. Periproct transversely oval. Escutcheon covered with radiating tubercles, surrounded by a subanal fasciole. Part of an apical ("internal") fasciole is preserved.

The figured fragment appears to agree except in size with Duncan and Sladen's figures of *Breynia carinata*. Its original length of probably 120 mm compares with 90 mm as reported by D'Archiac and Haime and 70 mm, the greatest length measured by Duncan and Sladen.

The fragment from the Miocene of Java named *Eupatagus magnus* by Herklots was originally about the same size or perhaps somewhat larger than the one from Okinawa. It appears to differ from the Indian species only in the greater width of the marginal band outside the peripetalous fasciole, a difference that might readily be an individual variation. Vredenburg (1906b, p. 282) identified it as *Breynia carinata*, but Gerth (1922, p. 515) was equally sure that it is different.

Hayasaka's two supposed new species, *Breynia cordata* and *Breynia testudinaria*, from the Pliocene Byoritsu beds of Formosa, are described as being very similar to *B. carinata*, though larger. One is 111 mm long, the other 131. The differences might very well be individual variations. The types are said to be poorly preserved, and the figures are unrecognizable.

Breynia carinata is one of the most abundant and characteristic species of the Gaj limestone of India, which, according to Vredenburg (1906a, p. 182), is of upper Aquitanian (early Miocene) age. There is a variety, *Breynia carinata multituberculata* Vredenburg (1906b), in the underlying Nari beds, also Aquitanian. Hayasaka records the species from the Miocene of Formosa.

Other named fossil species of *Breynia* from the Pacific region are *B. australasiae aroensis* Currie (1924, p. 64, pl. 4, fig. 6) from the Pliocene(?) of the Aru Islands and *Breynia birmanica* Vredenburg (1932, p. 413, pl. 30, fig. 1) from the Sitsayan or Padaung stage (Aquitanian?) of Burma.

Occurrence.—USGS 17440, near mouth of small stream emptying into Katena-kō at Nakaosu, on the road opposite Nakaosu Primary School. A very small fragment probably of this species was found at USGS 17610, cut on the north side of the road about 0.25 mile from Unten-kō LCT landing on Unten Peninsula.

Geologic horizon.—According to the field records, the larger specimen was taken from the sandy facies of the Ryukyu limestone, presumably basal Naha. The matrix is gray silty, calcareous sandstone much darker than other collections from the Naha limestone. The small fragment from USGS 17610 is much lighter colored; its label reads Naha limestone.

Figured specimen.—USNM 561569, from USGS 17440.

BIBLIOGRAPHY

- Agassiz, Alexander, 1872-74, Revision of the Echini: Harvard College, Mus. Comp. Zoology, Mem., v. 3, 762 p., 94 pls., 69 text figs.
- Agassiz, Alexander, and Clark, H. L., 1907-09, Hawaiian and other Pacific Echini: Harvard College, Mus. Comp. Zoology, Mem., v. 34, 203 p., 89 pls.
- 1907, no. 1, Cidaridae, p. 1-42, pls. 1-44.
- 1908, no. 2, Salenidae to Diadematidae, p. 47-132, pls. 43-59.
- 1909, no. 3, Echinothuridae, p. 139-203, pls. 60-89.
- Böhm, August, 1882, Ueber einige tertiäre Fossilien von der Insel Madura: K. Akad. Wiss. Wien Denksch., math.-naturw. Classe, Band 45, p. 359-372, 4 pls.
- Clark, H. L., 1912, Hawaiian and other Pacific Echini; no. 4, Pedinidae to Echinometridae: Harvard College, Mus. Comp. Zoology, Mem., v. 34, no. 4, p. 209-383, pls. 90-121.
- 1914-17, Hawaiian and other Pacific Echini: Harvard College, Mus. Comp. Zoology, Mem., v. 46, 283 p., 40 pls.
- 1914, no. 1, Clypeastridae to Scutellidae, p. 1-78, pls. 122-143.
- 1917, no. 2, Echinoneidae to Spatangidae, p. 85-283, pls. 144-161.
- 1945, Echinoidea [of Lau, Fiji]: Bernice P. Bishop Mus., Bull., 181, p. 312-328, pl. 41.
- 1946, The echinoderm fauna of Australia, its composition and its origin: Carnegie Inst. Washington Pub. 566, 567 p.
- Clegg, E. L. G., 1933, Echinoidea from the Persian Gulf: *Palaeontologia Indica*, new ser. v. 22, Mem. 1, 35 p., 3 pls.
- Currie, E. D., 1924, On fossil Echinoidea from the Aru Islands: *Geol. Mag.*, v. 61, p. 63-72, pl. 4.
- 1939, Note on Echinoidea from Burma: *India Geol. Survey Records*, v. 74, pt. 2, p. 216-228, pl. 14, 5 text figs.
- D'Archiac, E. J. A., and Haime, Jules, 1853, Description des animaux fossiles du groupe nummulitique de l'Inde.
- Davies, L. M., 1943, Tertiary Echinoidea of the Kohat-Potwar basin: *Geol. Soc. London Quart. Jour.*, v. 99, p. 63-79.
- Duncan, P. M., 1877, On the Echinodermata of the Australian Cainozoic (Tertiary) deposits: *Geol. Soc. London Quart. Jour.*, v. 33, p. 42-73, pls. 3, 4.
- 1887, A revision of the Echinoidea from the Australian Tertiaries: *Geol. Soc. London Quart. Jour.*, v. 43, p. 411-430.

- Duncan, P. M., and Sladen, W. P., 1882-86, Fossil Echinoidea of Western Sind and the coast of Biluchistan and of the Persian Gulf, from the Tertiary formations: *Palaeontologia Indica*, ser. 14, v. 1, pt. 3, 382 p., 58 pls.
- 1882, Fasc. 1, Echinoidea from beneath the trap in western Sind, p. 1-20.
- 1882, Fasc. 2, Echinoidea from the Ranikot series of western Sind, p. 21-100.
- 1884, Fasc. 3, Echinoidea from the Khirtar series of western Sind, p. 101-246.
- 1884, Fasc. 4, Echinoidea from the Nari series of western Sind, p. 247-272.
- 1885, Fasc. 5, Echinoidea from the Gaj series of western Sind, p. 273-368.
- 1886, Fasc. 6, Echinoidea from the Makran series of the coast of Biluchistan and of the Persian Gulf, p. 370-382.
- 1883, The fossil Echinoidea of Kachh and Kattywar, with an introduction by W. T. Blanford: *Palaeontologia Indica*, ser. 14, v. 1, pt. 4, 91 p., 13 pls.
- Döderlein, Ludwig, 1885, Seeigel von Japan und den Liu-Kiu-Inseln: *Archiv für Naturgeschichte*, Band 51, no. 1, p. 73-112.
- 1887, Die japanischen Seeigel, I, Familien Cidaridae und Saleniidae, 59 p., 11 pls.
- Fell, H. B., 1949, An echinoid [*Brochopleurus australiae*, a temnopleurid] from the Tertiary (Janjoukian) of South Australia: *Nat. Mus. Victoria Mem.* 16, p. 17-19, pl. 1.
- Gerth, H., 1922, Echinodermata [von Java]: *Geol. Reichs-Mus. Leiden Samml.*, n. F., Band k, Abt. 2, Heft 4, p. 497-520, pl. 62.
- 1927, Ueber einige pliozän-quatäre Echiniden von Timor: *Palaeont. Timor*, Lief. 15, Abh. 26, p. 181-184, pl. 218.
- Gregory, J. W., 1890, Some additions to the Australian Tertiary Echinoidea: *Geol. Mag.*, new ser., dec. 3, v. 7, p. 481-492, pls. 13, 14.
- 1892, Further additions to Australian fossil Echinoidea: *Geol. Mag.*, new ser., dec. 3, v. 9, p. 433-437, pl. 12.
- Hall, T. S., 1907, Four new echinoids from the Australian Tertiary: *Roy. Soc. Victoria Proc.*, v. 19, new ser., pt. 2, p. 47-53, pls. 13-16.
- Hayasaka, Ichiro, 1947, Notes on some fossil echinoids of Taiwan, III: *Acta geol. Taiwanica*, v. 1, no. 2, p. 111-128, pls. 10-16.
- 1948, Notes on some fossil echinoids of Taiwan, IV: *Acta geol. Taiwanica*, v. 2, no. 2, p. 85-124, pls. 1-5.
- Hayasaka, Ichiro, and Morishita, Akira, 1947a, Fossil species of *Clypeaster* from Taiwan: *Acta geol. Taiwanica*, v. 1, no. 1, p. 39-52, pls. 1-5.
- 1947b, Notes on some fossil echinoids of Taiwan, II: *Acta geol. Taiwanica*, v. 1, no. 2, p. 93-110, pls. 8, 9.
- Herklots, J. A., 1854, Fossiles de Java, pt. 4, Echinodermes, 24 p., 5 pls. Leiden.
- Israelsky, M. C., 1933, Echinoids from the Malumbang formation, Philippine Islands: *Philippine Jour. Sci.*, v. 50, no. 3, p. 301-310, pls. 1-5.
- Jeannet, Alphonse, 1935a, Genres et sub-genres nouveaux d'échinides sculptés du tertiaire des Îles de la Sonde: *Eclogae geol. Helvetiae*, tome 28, no. 2, p. 558-559.
- 1935b, Description des espèces: échinides réguliers, in Lambert, J., and Jeannet, A., Contribution à la connaissance des échinides tertiaires des Îles de la Sonde, *Schweizer. palaeont. Gesell. Abh.*, v. 56, p. 9-60., pls. 1-4, 76 text figs.
- Jeannet, Alphonse, and Martin, R., 1937, Ueber neozoische Echinoidea aus dem niederländisch-indischen Archipel: *Leidsche geol. Mededeelingen*, Deel 8, Afl. 2, p. 216-308, 67 text figs.
- Lambert, Jules, and Jeannet, Alphonse, 1928, Contribution à la connaissance des échinides tertiaires des Îles de la Sonde: *Schweizer. palaeont. Gesell. Abh.*, v. 56, p. 1-62, 4 pls., 76 text figs.
- Laube, G. C., 1869, Ueber einige fossile Echiniden von den Murray Cliffs in Süd-Australien: *K. Akad. Wiss. Wien Sitzungsber., math.-naturw. Classe*, Band 59, Abt. 1, p. 183-198, 1 pl.
- McCoy, Frederick, 1879, Echini: *Prodromus of the palaeontology of Victoria*, dec. 6, p. 33-42, pls. 59, 60.
- 1882, Echini: *Prodromus of the palaeontology of Victoria*, dec. 7, p. 15-22, pls. 64-68.
- Martin, K., 1880, Revision der von Herklots herausgegebenen fossilen Echiniden Javas: *Die Tertiärschichten auf Java*, Anhang, 6 p., 2 text figs.
- Mortensen, Theodor, 1928-51, A monograph of the Echinoidea. Copenhagen.
- 1928, v. 1, Cidaroida, 551 p. 88 pls., 173 text figs.
- 1935, v. 2, Bothriocidaroida to Stirodonta, 647 p., 89 pls., 377 text figs.
- 1940, v. 3, pt. 1, Aulodonta, with additions to v. 2 (Lepidocentroida and Stirodonta), 370 p., 77 pls., 197 text figs.
- 1943, v. 3, pt. 2, Camarodonta I, 553 p., 56 pls., 321 text figs.
- 1943, v. 3, pt. 3, Camarodonta II, 446 p., 66 pls., 215 text figs.
- 1948, v. 4, pt. 1, Holecypoida, Cassiduloida, 363 p., 14 pls., 326 text figs.
- 1948, v. 4, pt. 2, Clypeastroida, 471 p., 72 pls., 258 text figs.
- 1950, v. 5, pt. 1, Spatangoida, I, 432 p., 25 pls., 315 text figs.
- 1951, v. 5, pt. 2, Spatangoida II, 593 p., 64 pls., 286 text figs.
- Nisiyama, Syozo, 1937, A new species of *Sismondia* from the Oligocene of Titi-zima: *Imp. Acad. Tokyo Proc.*, v. 13, no. 2, p. 41-45, figs. 1-13.
- 1941, On the Japanese species of *Echinarachnius*: *Yabe Jubilee Pub.*, v. 2, p. 803-862, pls. 43-45, 65 text figs.
- 1948, *Astrodapsis* in Japan: *Jour. Paleontology*, v. 22, no. 5, p. 601-605, pl. 88.
- Pritchard, G. B., 1908, On the occurrence of the genus *Linthia* in Victoria, with description of a new species: *Roy. Soc. Victoria Proc.*, new ser. v. 21, p. 392-400, pls. 22, 23.
- Tate, Ralph, 1877, On new species of *Belemnites* and *Salenia* from the middle Tertiaries of South Australia: *Geol. Soc. London Quart. Jour.*, v. 33, p. 256-259, 2 text figs.
- 1891, A bibliography and revised list of the described echinoids of the Australian Eocene, with descriptions of some new species: *Roy. Soc. South Australia Trans. and Proc.*, v. 14, p. 270-282.
- 1893, Unrecorded genera of the older Tertiary fauna of Australia, including diagnoses of some new genera and species: *Roy. Soc. New South Wales Prov.*, v. 27, p. 167-196, pls. 10-13.
- 1897, A second supplement to a census of the fauna of the oldest Tertiary of Australia: *Roy. Soc. New South Wales Jour.*, v. 31, p. 381-412.

- Tokunaga, S., 1903, On the fossil echinoids of Japan: Tokyo Imp. Univ., Fac. Sci. Jour., v. 17, art. 12, 27 p., 4 pls.
- Vredenburg, E., 1906a, The classification of the Tertiary system in Sind with reference to the zonal distribution of the Eocene Echinoidea described by Duncan and Sladen: India Geol. Survey Records, v. 34, pt. 3, p. 172-198.
- 1906b, *Breynia multituberculata*, an undescribed species from the Nari of Baluchistan and Sind: India Geol. Survey Records, v. 34, pt. 4, p. 266-285, pl. 38.
- 1932, Oligocene Echinoidea collected by Rao Bahadur S. Sethu Rama Rau in Burma: India Geol. Survey Records, v. 54, pt. 4, p. 412-415, pl. 30.
- Wanner, J., 1931, De Palaeontologie en Stratigraphie van Nederlandsch Oost-Indië, 13, Echinodermata: Leidsche geol. Mededeelingen, Deel 5 (K. Martin Jubilee volume), p. 436-460.

INDEX

[Italic numbers indicate descriptions]

A		Page			Page
<i>areolatus</i> , <i>Temnopleurus</i>		46	<i>latecarinatus</i> , <i>Brissus</i>		49
<i>aroensis</i> , <i>Breynia australasiae</i>		50	<i>latissimus</i> , <i>Clypeaster</i>		47
<i>Astriclypeus integer</i>		49	<i>Lytechinus crassus</i>		46
<i>manni</i>		49	<i>okinawa</i>	45, 46, pl. 9	
<i>sp.</i>		45, 49	<i>variegatus</i>		46
<i>australasiae aroensis</i> , <i>Breynia</i>		50			
B			M		
<i>birmanica</i> , <i>Breynia</i>		50	<i>macroproctes</i> , <i>Peronella</i>		48
<i>Breynia australasiae aroensis</i>		50	<i>magna</i> , <i>Breynia</i>		49, 50
<i>birmanica</i>		50	<i>magnus</i> <i>Eupatagus</i>		50
<i>carinata</i>	45, 49, 50, pl. 12		Malumbang formation of Luzon		45
<i>multituberculata</i>		50	<i>malumbangensis</i> , <i>Clypeaster</i>		47
<i>cordata</i>		50	<i>manni</i> , <i>Astriclypeus</i>		49
<i>magna</i>	49, 50		<i>merrilli</i> , <i>Peronella</i>	48, pl. 10	
<i>testudinaria</i>		50	<i>metularia</i> , <i>Cidaritis</i>	45, 46, pl. 9	
<i>Brissus carinatus</i>		49	<i>Cidarites</i>		45
<i>latecarinatus</i>		49	<i>Euclidaris</i>		45, 46
<i>sp.</i>		49	<i>minutus</i> , <i>Nucleolites</i>		49
Byoritsu beds of Formosa		50	<i>motobu</i> , <i>Peronella</i>	48, pl. 10	
			<i>multituberculata</i> , <i>Breynia carinata</i>		50
C			N		
<i>caelatus</i> , <i>Temnopleurus</i>		46	<i>Naha limestone</i>		45, 46
<i>carinata</i> , <i>Breynia</i>	45, 49, 50, pl. 12		<i>Nucleolites minutus</i>		49
<i>multituberculata</i> , <i>Breynia</i>		50			
<i>carinatus</i> , <i>Brissus</i>		49	O		
<i>Cidaritis metularia</i>	45, 46, pl. 9		<i>okinawa</i> , <i>Clypeaster</i>	45, 47, pl. 11	
<i>sp.</i>		46	<i>Lytechinus</i>	45, 46, pl. 9	
<i>Cidarites metularia</i>		45	<i>Oligopodia</i>	45, 49, pl. 12	
<i>Clypeaster japonicus</i>	45, 47, pls. 10, 11		<i>Oligopodia epigonus</i>		49
<i>latissimus</i>		47	<i>okinawa</i>	49, pl. 12	
<i>malumbangensis</i>		47			
<i>okinawa</i>	45, 47, pl. 11		P		
(<i>Stolonoclypeus</i>) <i>japonicus</i>		47	<i>pellucida</i> , <i>Peronella</i>		45, 48
<i>cordata</i> , <i>Breynia</i>		50	<i>pellucida</i> , <i>Peronella</i> (<i>Laganum</i>)		47
<i>crassus</i> , <i>Lytechinus</i>	45, 46		<i>Peronella equaepectata</i>		48
<i>cyclostomus</i> , <i>Echinoneus</i>	45, 46-47, pl. 9		<i>kamimura</i>	45, 47, 48, pl. 11	
			(<i>Laganum</i>) <i>pellucida</i>		47
D			<i>macroproctes</i>		48
<i>dickersoni keiense</i> , <i>Laganum</i>		48	<i>merrilli</i>	48, pl. 10	
			<i>motobu</i>	48, pl. 10	
E			<i>pellucida</i>		47, 48
<i>Echinoneus cyclostomus</i>	45, 46-47, pl. 9		<i>peronii</i>		48
<i>epigonus</i> , <i>Oligopodia</i>		49	<i>peronii</i> , <i>Peronella</i>		48
<i>equaepectata</i> , <i>Peronella</i>		48	<i>Pliolampas javanus</i>		49
<i>Euclidaris metularia</i>	45, 46		<i>Pliolampas</i> (<i>Tristomanthus</i>) <i>javanus</i>		49
<i>Eupatagus magnus</i>		50			
<i>excavatus</i> , <i>Schizaster</i>	45, 49, pl. 12		R		
G			<i>Ryukyu limestone</i>		45
Gaj limestone of India	45, 50		<i>Schizaster excavatus</i>	45, 49, pl. 12	
I			<i>japonicus</i>		49
<i>integer</i> , <i>Astriclypeus</i>		49	<i>lacunosus</i>		49
J			<i>sculpta</i> , <i>Temnotrema</i>		46
<i>japonicus</i> , <i>Clypeaster</i>	45, 47, pls. 10, 11		<i>sculptum</i> , <i>Temnotrema</i>	45, 46, pl. 9	
<i>Clypeaster</i> (<i>Stolonoclypeus</i>)		47	<i>Sismondia</i>		48
<i>Schizaster</i>		49	(<i>Stolonoclypeus</i>) <i>japonicus</i> , <i>Clypeaster</i>		47
<i>avanus</i> , <i>Pliolampas</i> (<i>Tristomanthus</i>)		49			
K			T		
<i>kamimura</i> , <i>Peronella</i>	45, 47, 48, pl. 11		<i>Temnopleurus areolatus</i>		46
<i>keiense</i> , <i>Laganum dickersoni</i>		48	<i>caelatus</i>		46
L			<i>toreumaticus</i>	45, 46, pl. 9	
<i>lacunosus</i> , <i>Schizaster</i>		49	<i>Temnotrema sculpta</i>		46
<i>Laganum</i>		48	<i>sculptum</i>	45, 46, pl. 9	
<i>dickersoni</i>		48	<i>testudinaria</i> , <i>Breynia</i>		50
<i>keiense</i>		48	<i>toreumaticus</i> , <i>Temnopleurus</i>	46, pl. 9	
<i>fudsiyama</i>	45, 48, pl. 9		(<i>Tristomanthus</i>) <i>javanus</i> <i>Pliolampas</i>		49
<i>untensis</i>	45, 48, pl. 9		(<i>Tristomanthus</i>) <i>javanus</i>		49
(<i>Laganum</i>) <i>pellucida</i> , <i>Peronella</i>		47			
			U		
			<i>untensis</i> , <i>Laganum fudsiyama</i>		45, 48
			V		
			<i>variegatus</i> , <i>Lytechinus</i>		46

PLATES 9–12

PLATE 9

- FIGURE 1. *Cidaris metularia* (Lamarek) (p. 45).
USNM 561553, from USGS 17614, $\times 1\frac{1}{2}$.
2. *Temnotrema sculptum* Agassiz (p. 46).
USNM 561555, from USGS 17484, $\times 1\frac{1}{2}$.
- 3-5. *Lytechinus okinawa* Cooke, n. sp. (p. 46).
USNM 561556, from USGS 17486, type, $\times 1\frac{1}{2}$.
3, Upper surface.
4, Side view.
5, Oral surface.
6. *Echinoneus cyclostomus* Leske (p. 46).
USNM 561557, from USGS 17537, $\times 1\frac{1}{2}$.
- 7-11. *Laganum fudsiyama untenensis* Cooke, n. subsp. (p. 48).
7-9, USNM 561565, from USGS 17610, type, $\times 1\frac{1}{2}$.
10-11, USNM 561566, from USGS 17860, paratype, $\times 1\frac{1}{2}$.
12. *Temnopleurus toreumaticus* (Leske) (p. 46).
USNM 561554, from USGS 17610, $\times 1\frac{1}{2}$.

CIDARIS, TEMNOTREMA, LYTECHINUS, ECHINONEUS, LAGANUM, AND TEMNOPLEURUS

PLATE 10

- FIGURES 1, 2. *Peronella motobu* Cooke, n. sp. (p. 48).
USNM 561563, from USGS 17852, type, $\times 1\frac{1}{2}$.
3, 4. *Peronella pellucida* Döderlein (p. 47).
USNM 561561, from USGS 17524, $\times 1\frac{1}{2}$.
5, 6. *Peronella merrilli* Israelsky? (p. 48).
USNM 561564, from USGS 17533, $\times 1\frac{1}{2}$.
7, 8. *Clypeaster japonicus* Döderlein (p. 47).
USNM 561560, from USGS 17578, $\times 1$.

PLATE 11

- FIGURES 1, 2. *Clypeaster okinawa* Cooke, n. sp. (p. 47).
USNM 561558, from USGS 17536, type $\times$ 1.
3, 4. *Clypeaster japonicus* Döderlein (p. 47).
USNM 561559, from USGS 17557, $\times$ 1.
5, 6. *Peronella kamimura* Cooke, n. sp. (p. 47).
USNM 561562, from USGS 17590, type, $\times$ 1.

PERONELLA AND CLYPEASTER

SCHIZASTER, BREYNIA, AND OLIGOPODIA

PLATE 12

FIGURES 1-4. *Schizaster excavatus* R. Martin (p. 49).

USNM 561568, from USGS 17575, $\times$ 1.

5, 6. *Breynia carinata* D'Archiac and Haime (p. 49).

USNM 561569, from USGS 17440, $\times$ 1.

7-10. *Oligopodia okinawa* Cooke, n. sp. (p. 49).

USNM 561567, from USGS 17461, type, $\times$ 1.5.