

On the Fossil Echinoids of Japan.

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With 4 plates.

Although the number of fossil echinoids hitherto found in Japan is small, yet there are several interesting forms amongst them. The Palæozoic strata has yielded no echinoids, while in the Mesozoic five genera have been found, one of which, however, is doubtful. They are *Pygurus*, *Toxaster*, *Cidaris*, *Pseudocidaris*, and *Hemicidaris* (?). *Pygurus*, up to the time of its discovery in Japan, had been found only in the Oolite and Cretaceous of Europe, and in the Cretaceous of Northern and Western Africa and N. America (?). In Japan it is found in the so-called Torinosu-limestone, respecting which it is still uncertain whether it is Cretaceous or Jurassic. One feature, however, that leads us to think that it may be Cretaceous, is the presence of a species of *Toxaster*, which has been hitherto restricted to the Cretaceous of Europe, N. Africa and Asia (Syria). Many specimens of *Cidaris* and *Pseudocidaris* have been collected from the same limestone, and also from a similar one in several other localities such as Tokano and Yokodani in the Province of Tosa and Itsukaichi in the Province of Musashi.

The genera found in the Cainozoic formation are the following: *Salenia*, *Coptosoma*, *Temnopleurus*, *Strongylocentrotus*, *Fibularia*, *Clypeaster*, *Laganum*, *Echinarachnius*, *Echinodiscus*, *Astriclypeus*, *Ilarionia*, *Echinolampas*, *Linthia*, *Schizaster*, *Prenaster*, *Hypospatangus* and *Brissopsis*.

Among these, *Prenaster*, *Ilarionia* and *Hypospatangus* are forms not living in the recent seas; and all except the last, which was collected from the Neogene Tertiary of Hokkaidō, were found in the Eocene of the Bonin Islands.

Astriclypeus is a genus restricted to Japan and China, being represented by a single living species *A. manni* VERILL. This genus differs from all others in possessing five large lunules. The fossil is a new species, and was found in the Miocene of Kai, Formosa and Riukiu (Loochoo Is.)

Coptosoma has only one living species, *C. crenulare* A. AG., also found fossil in the Pliocene of the Province of Sagami.

Echinodiscus is represented in Japan by one living (*E. levis* KLEIN) and one fossil form (*E. formosus* YOSH.), the latter having been collected by myself from the Miocene of Formosa and Riukiu.

Linthia, which is no longer living in Japan, shows in the fossil form a wide distribution, being known from Kanazawa in Kaga; Sakae, Hidaka and Ikari in Shinano; Tsurushi and Hazzaki in Hitachi; Anrakujō in Uzen; and Asahigawa in Ugo. The formation in which it is found is probably Pliocene.

Schizaster has two or perhaps more species. One is *S. nummuliticus* TOK. found associated with *Nummulites* in the Eocene of the Bonin Islands; another is *S. recticanalis* YOSH. found together with *Linthia nipponica* YOSH. in Sakae. Besides the above two, I have found two indeterminate species of the

same genus in the Tertiary, of Formosa (north of Ratō near Suō) and in the Pliocene of Yokohama.

Echinolampas, which in our country is represented by a single living species *E. oviformis* GMEL., has one interesting fossil species, *E. yoshiwarai* P. DE LORIOI, collected in the Pliocene of Kanaya in Kazusa together with several reef corals.

The wide-spread genus *Salenia* has also one fossil representative in our country which was described by P. DE LORIOI as *Salenia* (*Pleurosalenia*) *hakkaidoensis*.

Echinarachnius mirabilis BARN, a very common living echinoid in Japan, was living in the Diluvial time in Hitachi, Shimōsa and in the environs of Tokyo. *Echinarachnius parma* LAM., which is said to be living in Japan (locality uncertain), is found in the Neogene Tertiary of Australia as well as in that of Etchu, Echigo and Sado.

As to the genus *Laganum*, *L. decagonalis* LESS. is widely distributed in the fossil form in several countries, such as Japan (Diluvium), Java (Miocene) and Australia (Eocene). *L. fudsiyama* Döp., which is now living in the Sagami Sea, has been collected by me in the Pliocene of Sagami.

Clypeaster testitudinarius GRAY has been found in the Miocene of Java, in the Tertiary of Australia and in the Diluvium of Loochoo and Tokuno-shima; *Brissopsis luzonica* GRAY, in the Miocene of Java and the Neogene Tertiary of Iwaki; and *Temnopleurus toreumaticus* KLEIN, in the Miocene of Java and the Diluvium of Ōji and Shinagawa. Lastly, indeterminable specimens of *Strongylocentrotus* have been collected from the Pliocene beds of Izu and Sagami.

NOTES ON THE SPECIES.

SALENIA (PLEUROSALENIA) HAKKAIDOENSIS

P. DE LORIOI.

Pl. II. Fig. 1.

LITERATURE CONSULTED :—

P. DE LORIOI, Notes pour servir a l'étude des Echinodermes,
II. série, Fasc. I., 1902.

LOCALITY :—

Ekimomaanoro, a branch of the Anoro river in Yūbari coal-field, Prov. of Ishikari, the age of which is probably Pliocene (collector K. JIMBŌ).

COPTOSOMA CRENULARE (A. AG.)SYNONYMS: *Glyptocidaris crenularis* A. AG.*Phymosoma crenulare* A. AG.

LITERATURE CONSULTED :—

A. AGASSIZ, Revision of Echini.—Illust. Catalogue Mus.
Comp. Zool. Harvard Coll., No. VII., 1872-74.

P. M. DUNCAN, A Revision of the Echinoidea from the
Australian Tertiaries.—Quart. Journ. Geol. Soc. London,
XLIII., 1877, p. 411.

P. M. DUNCAN, A Revision of the Genera and great Groups
of the Echinoidea.—Journ. Linn. Soc. Zool., Vol.
XXIII., 1889.

LOCALITIES:—

Koshiha, Prov. of Sagami (Pliocene) (coll. S. TOKUNAGA).
Living at:—Hakodate (Museum of Science College, Tokyo;
and coll. by W. STIMPSON); Kominato-wan, Prov. of
Mutsu (coll. I. IKEDA).

TEMNOPLEURUS TOREUMATICUS (KLEIN).

SYNONYMS: *Cidaritis toreumatica* KLEIN.
Echinus toreumaticus GMEL.
Echinus sculptus LAM.
Temnopleurus bothryoides AGASS.
Temnopleurus reevesii A. AG.
Temnopleurus hardwickii GRAY.
Temnopleurus japonicus MART.
Toreumatica hardwickii GRAY.
Microcyphus elegans A. AG.
Temnotrema sculpta A. AG.

LITERATURE CONSULTED:—

- A. AGASSIZ, List of Echinoderms etc.—Bull. Mus. Comp.
Zool. Harvard Coll., Vol. I., 1863.
A. AGASSIZ, Revision of Echini.—Illust. Cat. Mus. Comp.
Zool. Harvard Coll., No. VII., 1872–74.
K. MARTIN, Die Tertiärschichten auf Java, 1879–80.
F. J. BELL, Observations on the Characters of the Echinoidea.
—Proc. Zool. Soc. London, 1880, p. 423.
A. AGASSIZ, Report on the Echinoidea dredged by H. M. S.
Challenger, etc.—Challenger Report, Vol. II., 1881.

L. DÖDERLEIN, Seeigel von Japan und den Liukiu-Inseln.—

Archiv. f. Naturg., I. Bd., 5 Jahr., 1885, p. 73.

J. E. IVES, Echinoderms and Arthropods from Japan.—

Proc. Acad. Nat. Sc. Philadelphia, 1891.

LOCALITIES :

Java (Miocene) (described by K. MARTIN); Ōji and Shinagawa in the environs of Tokyo (Diluvium) (coll. S. TOKUNAGA).

Found living in the following localities : Hakodate (Mus. Sc. Coll. Tokyo ; also coll. by W. STIMPSON) ; Sendai Bay (coll. ST. JOHN) ; Tokyo Bay (coll. L. DÖDERLEIN) ; off Yokohama (Challenger Exp.) ; Misaki, Prov. of Sagami (Mus. Sc. Coll. Tokyo) ; Dōketsuba in Sagami Sea (coll. I. IJIMA) ; 4 miles west of Aburatsubo near Misaki (coll. A. OWSTON) ; Yokohama (Mus. Berlin) ; Jedo (Mus. Berlin) ; Wakano-ura, Prov. of Kii (Mus. Sc. Coll. Tokyo) ; Bay of Tango (coll. L. DÖDERLEIN) ; Maizuru, Prov. of Tango (coll. L. DÖDERLEIN) ; Miyatsu, Prov. of Tango (Mus. Sc. Coll. Tokyo) ; Tsuruga, Prov. of Echizen (Mus. Sc. Coll. Tokyo) ; Kasaoka, Prov. of Bitchū (coll. A. IZUKA) ; Tomo, Prov. of Bingo (Mus. Sc. Coll. Tokyo) ; Usuki-wan, Prov. of Bingo (coll. T. TERASAKI) ; Onomichi, Prov. of Bingo (coll. A. IZUKA) ; Hiroshima, Prov. of Aki (Mus. Sc. Coll. Tokyo) ; Kōbe (Challenger Exp.) ; Hosojima-wan, Prov. of Hyūga (coll. T. TERASAKI) ; Nagasaki (Mus. Berlin) ; Kagoshima (coll. W. STIMPSON) ; East coast of Nippon (coll. W. STIMPSON) ; Japan (coll. SALMIN) ; Korea ; Kamtschatka ; Arafura Sea ; Philippine Is. ; North China Sea ; Hongkong ; Siam ; E. Indies ; West of New Guinea ; Bombay ; Singapore ; Gulf of Persia ; Karrak Is. ; Unalaska ; Tanjong ; Kling near Malacca ; C. Rachado ; Macclesfield Bank ; Coromandel Coast ; Entrance to Palk Strait ; Ceylon ; all coasts of Australia.

FIBULARIA ACUTA YOSH.

Pl. II. Figs. 5 and 6.

LITERATURE CONSULTED :—

S. YOSHIWARA, Preliminary Notice of new Japanese Echinoids.—Ann. Zool. Japon., Vol. II., Pars. II., 1898, p. 57.

S. YOSHIWARA, On some new Fossil Echinoids of Japan.—Journ. Geol. Soc. Tokyo, Vol. VI., No. 65, 1899.

LOCALITIES :—

Ōji near Tokyo (Diluvium) (coll. S. TOKUNAGA). Living at : Misaki, Prov. of Sagami (Mus. Sc. Coll. Tokyo); Shigajima, Prov. of Chikuzen (Mus. Sc. Coll. Tokyo); Asami-wan, Prov. of Tsushima (Coll. M. NAMIYE).

CLYPEASTER TESTITUDINARIUS (GRAY)

SYNONYMS : *Echinanthus testitudinarius* GRAY.

Echinanthus australasie GRAY.

Clypeaster tumidulus MÜLL.

Clypeaster speciosus VERILL.

Clypeaster desorii MICH.

Clypeaster australasie MICH.

LITERATURE CONSULTED :—

L. AGASSIZ, Monographiës d'Échinodermes vivant et fossiles, 1838-42.

A. AGASSIZ, Revision of Echini.—Illust. Cat. Mus. Comp. Zool. Harvard Coll., No. VII., 1872-74,

- A. AGASSIZ, Report on the Results of Dredging etc.—Bull. Mus. Comp. Zool. Harvard Coll., Vol. V., 1878, and Vol. VIII., 1880.
- K. MARTIN, Die Tertiärschichten auf Java, 1879–80.
- P. M. DUNCAN, A Revision of the Echinoidea from the Australian Tertiaries.—Quart. Jour. Geol. Soc. London, XLIII., 1887, p. 411.
- L. DÖDERLEIN, Seeigel von Japan und den Liukiu-Inseln.—Archiv. f. Naturg., I. Bd., 51 Jahr., 1885, p. 73.
- F. J. BELL, On the Echinoderms collected during the Voyage of H. M. S. Penguin etc.—Proc. Zool. Soc. London, 1894.
- R. KÖHLER, Catalogue raisonné des Échinodermes etc.—Mem. Soc. Zool. France ; Tome VIII., 1895, p. 374.

LOCALITIES :—

Unten in Okinawa Is., Loochoo (Diluvium) (coll. S. TOKUNAGA) ; Ishigaki-jima in Loochoo (Diluvium) (coll. S. TOKUNAGA) ; Java (Miocene) (described by K. MARTIN) ; Lindenow, Mitchell river in Australia (Tertiary) (described by P. M. DUNCAN).

Found living in the following places : Hakodate (coll DALL) ; Japan (Bonn Museum) ; New Holland ; Red Sea ; la Paz ; Sandwich Is. ; off Twofold Bay in Australia ; off entrance to Port Philip in Australia ; Gulf of California.

LAGANUM DECAGONALIS (LESS).

SYNONYMS : *Scutella decagonalis* LESS.

Legana decagona LESS.

Rumphia lesueuri A. AG.

Polygaster elegans MICH.

Michelinia elegans DUJ HUPE.

Laganum decagonum LESS.

Laganum lesueurii VAL.

Laganum elongatum AGASS.

Laganum australe GRAY.

LITERATURE CONSULTED :

- L. AGASSIZ, Monographies d'Echinodermes vivant et fossiles, 1838-42.
- A. AGASSIZ, List of Echinoderms sent to different Institutions in Exchange etc.—Bull. Mus. Comp. Zool. Harvard Coll., Vol. I., 1863.
- A. AGASSIZ, Synopsis of the Echinoidea collected by Dr. W. STIMPSON on the North Pacific Exploring Expedition etc.—Proc. Acad. Nat. Sc. Philadelphia, No. 7, Decem. 1863, p. 352.
- A. AGASSIZ, Revision of Echini.—Illust. Catalogue Mus. Comp. Zool. Harvard Coll., No. VII., 1872-74.
- J. E. TENISON-WOODS, On some new Australian Echini.—Proc. Linn. Soc. New South Wales, Vol. IV., Part. III., 1879, p. 282.
- K. MARTIN, Die Tertiärschichten auf Java, 1879-80.
- J. E. TENISON-WOODS, On the Habits of some Australian Echini.—Proc. Linn. Soc. New South Wales, Vol. V., 1880-81, p. 193.
- A. AGASSIZ, Report on the Echinoidea dredged by H. M. S. Challenger etc.—Report on the Scientific Results of the Voyage of H. M. S. Challenger, Vol. II., 1881.
- G. PFEFFER, Die Clypeastriden des Hamburger Museums.—Verhand. Naturw. Vereins von 1880, 1881.

L. DÖDERLEIN, Seeigel von Japan und den Liukiu-Inseln.

—Archiv. f. Naturg., I Bd., 51 Jahrg., 1885, p. 73.

JACK AND ETHERIDGE, Geology and Palæontology of Queensland and New Guinea, 1892.

J. W. GREGORY, Further Additions to Australian Fossil Echinoidea.—Geological Magazine, Dec. III., 9, 1892, p. 433.

F. J. BELL, On the Echinoderms collected during the Voyage of H. M. S. 'Penguin' etc.—Proc. Zool. Soc. London, 1894.

R. KOEHLER, Catalogue raisonné des Échinodermes etc.—Mem. Soc. Zool. de France, Tome VIII., 1895, p. 374.

T. H. HEMING, Administration Report of the Marine Survey of India for the official year 1898-99, 1899.

F. P. BEDFORD, On Echinoderms from Singapore and Malacca.—Proc. Zool. Soc. London, 1900, p. 271.

LOCALITIES :—

Ōji and Shinagawa near Tokyo (Diluvium) (coll. S. TOKUNAGA); Usui, Prov. of Shimōsa (Diluvium) (coll. S. MATSUDA); Shark's Bay in west Australia (Eocene); Java (Miocene) (described by K. Martin); Yule Island in New Guinea (Lower Pliocene?):

Living in the following places: Ōmori, Prov. of Musashi (coll. S. TOKUNAGA); Tokyo Bay (coll. L. DÖDERLEIN); Misaki, Prov. of Sagami (Mus. Sc. Coll. Tokyo), Sagami Bay (coll. L. DÖDERLEIN); Wakano-ura, Prov. of Kii (Mus. Sc. Coll. Tokyo); Ōita, Prov. of Bungo (coll. T. TERASAKI); Kagoshima Bay (coll. L. DÖDERLEIN); Loochoo Is. (coll. S. TOKUNAGA); Hōkotō in Formosa (coll. T. TADA); Japan (Mus. Copenhagen); Hongkong; Canton; Philippine Is.; Singapore and Malacca; New Caledonia;

Gaspar Strait; Freemantle Bay in Australia; Port Denison and Port Jackson in Australia; Bay of Bengal; Torres Strait; Amboyña; Tongatabu; Papeete Harbour in Tahiti; near Flores; Arafura Sea; NE and W of New Guinea.

LAGANUM FUDSIYAMA DÖD.

LITERATURE CONSULTED:—

L. DÖDERLEIN, Seeigel von Japan und den Liukiu-Inseln.
—Archiv. f. Naturg., I. Bd., 51 Jahr., 1885, p. 73.

LOCALITIES:—

Koshiba, Prov. of Sagami (Pliocene) (coll. S. TOKUNAGA).
Living at: Sagami Sea (Mus. Sc. Coll. Tokyo, also coll. by L. DÖDERLEIN); Yamakawa-oki in Kagoshima Bay (coll. K. MITSUKURI AND J. HARA).

ECHINARACHNIUS MIRABILIS (BARN).

SYNONYMS: *Scaphechinus mirabilis* BARN.

Chaetodiscus scutella LÜTK.

Scutella japonica MART.

Echinarachnius pacificus PFEFFER.

LITERATURE CONSULTED:—

A. AGASSIZ, Synopsis of the Echinoids collected by Dr. W. STIMPSON on the North Pacific Exploring Expedition etc.—Proc. Acad. Nat. Sc. Philadelphia, No. 7, Decem. 1863, p. 352.

A. AGASSIZ, Revision of Echini.—Illust. Cat. Mus. Comp. Zool. Harvard Coll., No. VII., 1872-74.

G. PFEFFER, Die Clypeastriden des Hamburger Museums.—
Verh. Naturw.-Vereins von 1880, 1881.

L. DÖDERLEIN, Seeigel von Japan und den Liukiu-Inseln.
—Archiv. f. Naturg., I. Bd., 1885, 51 Jahr., p. 73.

LOCALITIES:—

Jōchū, Prov. of Hitachi (Diluvium) (coll. S. TOKUNAGA);
Ōji and Shinagawa near Tokyo (Diluvium) (coll. S. TOKUNAGA);
Narita, Prov. of Shimōsa (Diluvium) (coll. S. TOKUNAGA).

Living at: Otaru, Prov. of Nemuro (Mus. Sc. Coll. Tokyo);
Hakodate (coll. W. STIMPSON); Asamushi, Prov. of Mutsu (coll.
A. IZUKA); Yedo (coll. MARTINS); Kanagawa (coll. MARTINS);
Yokohama (Mus. Berlin, Smith. coll.); Misaki, Prov. of Sagami
(Mus. Sc. Coll. Tokyo); near Murono-hama, Prov. of Mikawa
(coll. T. KŌYAMA); Tomo, Prov. of Bingo (Mus. Sc. Coll. Tokyo);
Japan (coll. SALMIN AND WESSEL); San Francisco; Aleutian Is.

ECHINARACHNIUS PARMA (LAM).

Pl. III. Fig. 2.

SYNONYMS: *Scutella parma* LAM.

Scutella trifaria SAY.

Scutella rumphii BLAINV.

Echinodiscus parma BLAINV.

Echinarachnius rumphii AGASS.

Echinarachnius atlanticus GRAY.

Echinarachnius asiaticus MICH.

Echinarachnius australiæ MICH.

Echinarachnius undulatus MICH.

LITERATURE CONSULTED :—

L. AGASSIZ, *Monographies d'Échinodermes vivant et fossiles*, 1838-42.

A. AGASSIZ, *List of Echinoderms etc.*—*Bull. Mus. Comp. Zool. Harvard Coll.*, Vol. I., 1863.

A. AGASSIZ, *Synopsis of the Echinoids collected by Dr. W. STIMPSON on the North Exploring Expedition etc.*—*Proc. Acad. Nat. Sc. Philadelphia*, No. 7, Decem. 1863, p. 352.

A. AGASSIZ, *Revision of Echini.*—*Illust. Cat. Mus. Comp. Zool. Harvard Coll.*, No. VII., 1872-74.

J. E. TENISON-WOODS, *On some new Australian Echini.*—*Proc. Linn. Soc. New South Wales*, Vol. IV., Part III., 1879, p. 282.

J. E. TENISON-WOODS, *On the Habits of some Australian Echini.*—*Proc. Linn. Soc. New South Wales*, Vol. V., 1880-81, p. 193.

W. L. TOWER, *An abnormal Echinoid.*—*Zool. Anz.*, Bd. XXIV., No. 640, 1901, p. 188.

LOCALITIES :—

Tagawa-mura and Konade-mura in Tonami-gōri, Prov. of Etchū (Neogene Tertiary) (Imp. Hous. Mus. Tokyo); Funabashi-mura in Mishima-gōri, Prov. of Echigo (Neogene Tertiary) (Imp. Hous. Mus. Tokyo); Sado Is. (Neogene Tertiary) (Imp. Hous. Mus. Tokyo); Australia (Tertiary).

Living in : Japan (Challenger Exp.); Kamtschatka; Avatscha Bay; Aleutian Is., New Holland; Vancouver; Labrador; New Jersey; Long Island Sound; Gay Head; Nova Scotia; Nantucket Is.; South Shoals, Mass.; Cape Cod, Mass.; Massachusetts Bay; St. George's Bank; Trenton Pt. M.; Eastport; Grand Menan;

Gaspé; Mingan Is.; Straits' Bell Is.; Gilky Harbour, Maine; N. Australia; Red Sea; India.

ECHINODISCUS FORMOSUS YOSH.

Pl. I. Fig. 1 and 2. Pl. II. Fig. 2.

LITERATURE CONSULTED:—

S. YOSHIWARA, On the Geologic Structure of Riukiu Is. etc.
—Journ. Coll. Sc. Imp. Univ., Tokyo, Vol. XVI,
Part I., 1901, p. 62.

Diam.	Length odd petal.	Width odd petal.	No. of pores in odd petal.	Length ant. paired petal.	Width ant. paired petal.
100 mm.	25 mm.	11.5 mm.	75.	22.5 mm.	115 mm.
No. of pores in ant. paired petal.	Length post. paired petal.	Width post. paired petal.	Width of poriferous zone.	Distance from the extremity of petal to lunule.	
67.	22.5 mm.	6.7 mm.	4 mm.	5 mm.	

Test thin, very slightly raised dorsally; broadly ovoid, widest posteriorly, not so strongly truncated as in *Echinodiscus bioculatus* Ag.; the largest specimen having a diameter of 140 mm.

Apical system nearly central; madreporite central, polygonal; four genital pores existing in the basal plates.

Petals nearly closed, the anterior being the longest.

Lunules two, one in each posterior ambulacral space, large and elliptical; 13.5 mm. in length and 9 mm. in width in a specimen 100 mm. in diameter; the longer axis of the lunule making an angle of about 30° with the median line of the ambulacrum; distance from the extremity of the petal to the lunule only 5 mm.

Peristome central, very small; groove single near peristome, and soon bifurcating.

LOCALITIES :—

Hatto near Kelung, Formosa (Miocene) (coll. S. TOKUNAGA);
Iriomote-jima, Loochoo Is. (Miocene) (coll. S. TOKUNAGA).

ASTRICLYPEUS INTEGER YOSH.

Pl. I. Figs. 3 and 4. Pl. II. Figs. 3 and 4.

SYNONYM : *Astriclypeus integris* YOSH.

LITERATURE CONSULTED :—

S. YOSHIWARA, On some new Fossil Echinoids of Japan.—
Journ. Geol. Soc. Tokyo, Vol. VI., No. 65, 1899.

S. YOSHIWARA, Geologic Structure of Riukiu Curve etc.—
Journ. Coll. Sc. Imp. Univ. Tokyo, Vol. XVI. Part
I., 1901, p. 61.

Diam.	Length of petal.	Greatest width of petal.	Greatest width of porif. zone.	Greatest width of interp. zone.	Distance of lunule from the extremity of petal.
110 mm.	23 mm.	12 mm.	4 mm.	4 mm.	15 mm.

Test thick, with a circular or elliptical outline, regularly conical, sloping uniformly from vertex to the ambitus.

Apical system similar in form and structure to *Astriclypeus manni* VERILL.

All the petals nearly equal in length and breadth; poriferous zone broad, broadest near the extremity of petals which are nearly closed at the extremity; number of pores 37 in a specimen measuring 110 mm. in diameter; thus differing from living *Astriclypeus*.

Each of five lunules oval, very wide (14 mm.: 9 mm.), constituting the characteristic feature of this species.

Lower surface flat, teeth similar to those in the allied species. Actinal groove and tubercles not preserved.

LOCALITIES :—

Mizuho-mura in Minamitsuru-gōri, Prov. of Kai (Miocene) (coll. T. HIRABAYASHI AND S. TOKUNAGA); Hatto near Kelung, Formosa (Miocene) (coll. S. TOKUNAGA); Iriomoto-jima, Loochoo Is. (Miocene) (S. TOKUNAGA).

ILARIONIA YOSHIWARAI P. DE LORIOI.

LITERATURE CONSULTED :—

P. DE LORIOI, Notes pour servir a l'étude des Échinodermes, II. serie, Fasc. I., 1902.

The genus has hitherto been restricted to the Eocene of Europe and Sind (Asia).

LOCALITY :—

Nishi-ura in Haha-jima, Bonin Is. (Eocene) (coll. S. TOKUNAGA).

PYGURUS ASIATICUS TOK.

Pl. III. Figs. 3-6.

Length.	Width.	Height.	paired petal.	paired petal.	Distance of apical sys- tem from the ant. edge.	Distance of peristome from the ant. margin.
88 mm.	80 mm.	63 mm.	46 mm.	52 mm.	36 mm.	20 mm.
60 mm.	60 mm.	44 mm.	(?)		28 mm.	(?)

Test large, with undulating marginal outline, grooved anteriorly and broadly ridged posteriorly; very highly conical, concave actinally.

Apical system at the conical apex, eccentric in front.

Ambulacra flush dorsally, unequal; open petaloid part lance-

olate, tending to converge on the extremity, and continued over the margin as narrow lines of small pores in pairs; the greatest width of this part in a specimen having a diameter of 88 mm. measured at about $\frac{1}{3}$ distance from the apical system to the extremity, and respectively 7 mm., 11.5 mm., and 10.5 mm. in the odd, anterior paired and posterior paired ambulacra; poriferous zone about 3.5 mm. wide in the paired ambulacra, which is about $\frac{1}{3}$ as wide as the width of the whole petal; pores very numerous, about 90 in the anterior paired ambulacra in the petaloid part; width at the extremity of the petaloid part only 3.5 mm. in the paired ones; narrow lines of pairs of small pores passing over the ambital margin and continued to the peristome; ambulacral portion of the actinal side deeply and broadly grooved.

Peristome eccentric, pushed anteriorly; periproct close to the posterior edge of the actinal side of the test.

LOCALITY:—

Torinosu in Sakawa, Prov. of Tosa (probably Cretaceous)
(coll. B. Kotô).

ECHINOLAMPAS YOSHIWARAI P. DE LORIOI.

LITERATURE CONSULTED:—

P. DE LORIOI, Notes pour servir a l'étude des Échinodermes,
II. serie, Fasc. I., 1902.

LOCALITY:—

Kanaya, Prov. of Kazusa (Pliocene) (coll. S. HATTA & S. TOKUNAGA).

TOXASTER TOSAENSIS P. DE LORIO.**LITERATURE CONSULTED :—**

P. DE LORIO, Notes pour servir a l'étude des Échinodermes,
II. serie, Fasc. I., 1902.

LOCALITY :—

Torinosu in Sakawa, Prov. of Tosa (Cretaceous) (brought to
S. TOKUNAGA).

LINTHIA NIPPONICA YOSH.

Pl. I. Figs. 5-7.—Pl. III. Fig. 1.

LITERATURE CONSULTED :—

S. YOSHIWARA, On some new Fossil Echinoids of Japan.—

Journ. Geol. Soc. Tokyo, Vol. VI. No. 65, 1899.

Length.	Width.	Height.	Length of odd petal.	Length of ant. paired petal.	Length of post. paired petal.	Width of petal.	Width of interp. area.
87 mm.	86 mm.	38 mm.	48 mm.	46 mm.	32 mm.	7 mm.	2.2 mm
64 mm.	60 mm.	25 mm.	31 mm.	31 mm.	20 mm.	5.5 mm.	2 mm.
59 mm.	58 mm.	21 mm.		25 mm.	18 mm.	5.5 mm.	2 mm.
58 mm.	54.5 mm.	23 mm.	27 mm.	26 mm.	18 mm.	5.5 mm.	2 mm.
58 mm.	57 mm.	22 mm.					
64 mm.	64 mm.	30 mm.					

Test thick, large, somewhat cordiform; tumid dorsally, slightly concave actinally, a portion of apical system sunken; anterior groove very wide and shallow; posterior extremity vertically truncated.

Apical system and vertex nearly central or slightly eccentric towards the front in old specimens; basal plates four, perforated; madreporite large, central.

Ambulacra diverse; the anterior one in a broad groove, pores not obliterated, fewer in number than those of other petals, round and small; interporiferous area thickly provided with secondary tubercles. The lateral ambulacra sunken and slender; the anterior making an angle of 35° with the odd ambulacrum, straight and reaching almost to the ambitus; the posterior shortest and also straight. Poriferous zone wide, and the interporiferous area shallow, occupying nearly one third of the width of the petals. It is to be noticed that all the petals are nearly straight and retain the same width throughout their whole length, except near the vertex. The number of pores in the anterior lateral petal 39, and in the posterior one 28 in the largest specimen; interporiferous area of the paired ambulacra very narrow, leaving no space for tubercles.

Peripetalous fasciole narrow, angular with a deep reëntering angle in the anterior and posterior lateral ambulacra; undulating at the anterior ambulacrum and deeply entering outside, but almost nearly straight in the posterior interambulacrum. The lateral fasciole sloping toward the ambitus, abruptly curved near the posterior edge, and passing under the anus.

Actinal surface flat; actinostome situated at about one fourth the distance from the anterior edge. Anus elliptical, visible only in a side view. The tubercles of the abactinal surface very small and uniform in size, those of the actinal surface large and also uniform.

The living species of *Linthia* are now found in Australia, Tasmania, the Arafura Sea and the West Indies; fossils have been discovered in the Cretaceous of Europe, Africa, N. America, and in the Tertiary of Europe, Africa, W. Sind and the West Indies. The general outline, the shallow anterior groove, and the long antero-lateral petals, are characters which justify us in placing this species under *Linthia* rather than under *Schizaster*.

LOCALITIES :—

Kanazawa, Prov. of Kaga (probably Pliocene) (Mus. Sc. Coll. Tokyo); Sakae, Prov. of Shinano (probably Pliocene) (Mus. Sc. Coll. Tokyo); Ikari, Prov. of Shinano (probably Pliocene) (Mus. Higher Normal School Tokyo); Tsurushi and Hazzaki, Prov. of Hitachi (Pliocene) (coll. C. KOCHIBE); Hidaka-mura in Kamimizuta-gōri, Prov. of Shinano (probably Pliocene) (Tokyo Imp. Hous. Mus.); Anrakujō-mura in Mogami-gōri, Prov. of Uzen (Pliocene) (coll. K. INOUE); Asahigawa-mura in Minamiakita-gōri, Prov. of Ugo (coll. D. SATO).

SCHIZASTER RECTICANALIS YOSH.

Pl. IV. Figs. 1-3.

LITERATURE CONSULTED :—

S. YOSHIWARA, On some new Fossil Echinoids of Japan.—
Journ. Geol. Soc. Tokyo, Vol. VIII. No. 65, 1899.

Long. diam.	Trans. diam.	Height.	Length of odd petal.	Length of ant. paired petal.	Length of post. paired petal.
48 mm.	53 mm.	36 mm.	30 mm.	30 mm.	12 mm.

Test thick, cordiform, angular, posterior side not so elongated as in many other species; anterior groove shallow.

Apical system almost central; from the vertex situated behind the apical system the test curves suddenly to the truncated posterior extremity.

Odd ambulacrum very wide and shallow with about 23 small double pores. Antero-lateral ambulacra broad having about 35 pores, almost straight, not closed at the extremities, and very long, reaching almost to the ambitus; postero-lateral ambulacra

very short, curved, round and closed at the extremities, number of pores 21.

Peripetalous fasciole strongly recurved in postero-lateral interambulacra, and retreating far from the centre in the odd posterior interambulacrum. Lateral fasciole meeting with the former at the extremity of the antero-lateral ambulacrum.

Actinostome situated about $\frac{1}{3}$ diameter distance from anterior edge.

Tubercles on abactinal side very small, but large on actinal side.

This species is characterized by having posteriorly a not very elongate shell, a shallow anterior groove and straight antero-lateral ambulacra.

LOCALITY :—

River bank of the Saigawa near Kanazawa, Prov. of Kaga (Pliocene) (brought to O. YOSHIDA).

SCHIZASTER NUMMULITICUS TOK.

Pl. IV. Figs. 4-6.

LITERATURE CONSULTED :—

S. YOSHIWARA, Geological Age of Bonin Is. etc.—Geol. Magazine, London, Dec. IV., Vol. IX., 1902, p. 298.

Long. diam.	Trans. diam.	Height.	Length of odd petal.	Length of ant. paired petal.	Length of post. paired petal.
61.5 mm.	60 mm.	46 mm.	35 mm.	31 mm.	15 mm.
58.5 mm.	56 mm.	44 mm.		29.5 mm.	15 mm.

Test thin, high, cordiform; the broadest part lying a little anterior to the apical system, and the highest point being in that system; anterior groove broad and deep; median posterior keel not very prominent.

Apical system posteriorly 42 mm. wide in a test 61.5 mm. long, separate from the anterior edge; madreporite extending centrally and posteriorly; only one large genital pore in the basal plate adjoining the right postero-lateral interambulacrum and three small indistinct pores in the plates adjoining the remaining lateral ambulacra.

Odd ambulacrum with distinct paired pores on each side; these are 30 in number in a test 61.5 mm. long: interporiferous area closely covered with granules. Paired ambulacra petaloid, deeply sunken, bare; petals not increasing in width at the extremity as in *Schizaster japonicus* A. Ag., but closely converging, the greatest width being in their middle portion; anterior paired flexuous, extending forwards, pores 38 in number; posterior petals forming an angle of about 75° between them, pores 22.

Peristome eccentric towards front, 12 mm. from the anterior edge, semilunar, with a projecting posterior labrum. Posterior paired ambulacra of actinal side very narrow. Periproct in a truncated posterior margin, which is deeply sunken.

Peripetalous fasciole narrow, deeply re-entering at the antero-paired interambulacral spaces, running almost on the edge of petal in the postero-paired interambulacra, and slightly re-entering at the posterior interambulacrum. Lateral fasciole narrow, meeting with the former at some distance behind the extremity of the antero-lateral petals.

Tubercles close, larger on actinal side.

LOCALITY:—

Nishi-ura, in Haha-jima, Bonin Is. (Eocene) (coll. S. TOKUNAGA).

PRENASTER BONINENSIS P. DE LORIOI.

LITERATURE CONSULTED :—

P. DE LORIOI, Notes pour servir a l'étude des Échinodermes,
II. serie, Fasc. I., 1902.

The genus has hitherto been restricted to the Eocene of Europe, N. Africa and W. Sind (Asia).

LOCALITY :—

Nishi-ura in Haha-jima, Bonin Is. (Eocene) (coll. S. TOKUNAGA).

HYPSOSPATANGUS JAPONICUS P. DE LORIOI.

LITERATURE CONSULTED :—

P. DE LORIOI, Notes pour servir a l'étude des Échinodermes,
II. serie, Fasc. I., 1902.

LOCALITIES :—

Wakkanai, Prov. of Kitami (Neogene Tertiary) (coll. K. JIMBŌ); near Sanbōshi, Prov. of Kushiro (Neogene Tertiary) (Tokyo Imp. Hous. Museum).

BRISSOPSIS LUZONICA (GRAY).

SYNONYM : *Kleinia luzonica* GRAY.

LITERATURE CONSULTED :—

J. E. GRAY, Descriptions of some new Genera and Species of *Spatangidae* in the British Museum.—Ann. Mag. Nat. Hist., II. series, Vol. 7, No. 38, 1851, p. 130.

- A. AGASSIZ, Revision of Echini.—*Illust. Cat. Mus. Comp. Zool. Harvard Coll.*, No. VII., 1872-74.
- K. MARTIN, *Die Tertiärschichten auf Java*, 1879-80.
- A. AGASSIZ, Report on the Echinoidea dredged by H. M. S. Challenger during the years 1873-76.—Report on the Scientific Results of the Voyage of H. M. S. Challenger, Vol. II., 1881.
- L. DÖDERLEIN, *Seeigel von Japan und den Liukiu-Inseln*.—*Archiv. f. Naturg.*, I. Bd., 51 Jahr., 1885, p. 73.
- A. R. S. ANDERSON, On the Echinoidea collected during the Season 1893-94.—*Natural History Notes from H. M. Indian Marine Survey Steamer "Investigator" etc.*, Series II. No. 16.
- R. KOEHLER, *Catalogue raisonné des Échinodermes recuilles par K. KOROTNEV aux îles de la Sonde*.—*Mem. Soc. Zool. de France*, Tome VIII., 1895, p. 374.
- T. H. HEMING, Administration Report of the Marine Survey of India for the official year 1898-99, 1899.

LOCALITIES :—

Shiroyama near Taira, Prov. of Iwaki (Neogene Tertiary) (coll. D. SATO); Java (Miocene) (described by K. MARTIN).

Found living in the following localities: Sagami Sea (Mus. Sc. Coll. Tokyo, also coll. by L. DÖDERLEIN); Formosa (Mus. Godeff); Philippine Is; Siam; Banca Strait; Coromandel coast; North of Timor; West of New Guinea; New Zealand; New Caledonia; East Indies; Indian Ocean.

SPINES OF INDETERMINABLE SPECIES OF CIDARIS AND PSEUDOCIDARIS.

CIDARIS *α* sp.

Pl. II. Fig. 7.

Spine about 14 mm. long and 3.5 mm. in greatest diameter, club-shaped, narrowed near the base, where it is quite smooth; shaft striated with about 9 or more longitudinal bands which are all coarsely granulated; some striations do not reach the base of the shaft, but are replaced with other shorter bands. Base plain and hollowed.

LOCALITY :—

Iwasa in Tokano, Takaoka-gōri, Prov. of Tosa (probably Cretaceous).

PSEUDOCIDARIS *α* sp.

Pl. II. Fig. 11.

Spine 15.5 mm. long and 12.5 mm. in greatest diameter, pear-shaped, widest at the lower part and acuminate near apex with no narrowed or smooth portion near the base; longitudinally closely striated, the number of striations being more than 40, and each striation being very closely granulated, so that it is usually impossible to trace the lines of striation near the apex; granules more than 15 on each striation.

LOCALITY :—

Torinosu in Sakawa, Prov. of Tosa (probably Cretaceous).

PSEUDOCIDARIS β sp.

Pl. II. Fig. 12.

LITERATURE CONSULTED :—

E. NAUMANN UND M. NEUMAYR Zur Geologie und Paläontologie von Japan.—Denk. Mathem.-Naturw. Classe Kaiser. Akad. der Wissenschaften, Bd. LVII., 1890.

Spine 19 mm. long and 11.5 mm. in greatest diameter, club-shaped, acuminate near apex and narrowed near the base, very finely striated longitudinally; each striation closely granulated, the granules being larger and coarser near the apex.

This specimen was collected from the same locality as the preceding one, and probably belongs to the same species which E. NAUMANN and M. NEUMAYR named *Cidaris* cfr. *glandifera* GOLDF.

CIDARIS β sp.

Pl. II. Fig. 8.

A spine 25 mm. long and 13.5 mm. in greatest diameter, rather cuneiform, the greatest diameter lying nearer the summit than in the preceding species (*Pseudocidaris* α sp. and β sp.), narrowed near the base; striations and granulations similar to the above.

LOCALITY :—

Tarusawa near Itsukaichi, Prov. of Musashi (Jurassic or Cretaceous).

CIDARIS δ sp.

Pl. II. Fig. 10.

A very large specimen 28 mm. in greatest diameter near the summit, club-shaped, abruptly narrowed at the smooth portion of the collar; granules very numerous, longitudinal striations almost unrecognizable on account of the bad state of preservation.

LOCALITY:—

Itsukaichi, Prov. of Musashi (Jurassic or Cretaceous).

CIDARIS ϵ sp.

Pl. II. Fig. 9.

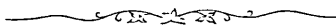
LITERATURE CONSULTED:—

E. NAUMANN UND M. NEUMAYR, Zur Geologie und Paläontologie von Japan.—Denk. Mathem.-Naturwiss. Classe Kaiser. Akad. der Wissenschaften, Bd. LVII., 1890.

This is a spine broken near the base, club-shaped, 21 mm. in greatest diameter near the base; the longitudinal striations are very numerous, and their granules close together; tolerably regular fine horizontal striations are traceable on the whole surface. This spine probably belongs to the same species as the specimen already described as a new species of *Cidaris* by E. NAUMANN and M. NEUMAYR.

LOCALITY:—

Yokodani in Shiraishizawa, Prov. of Tosa (probably Cretaceous).



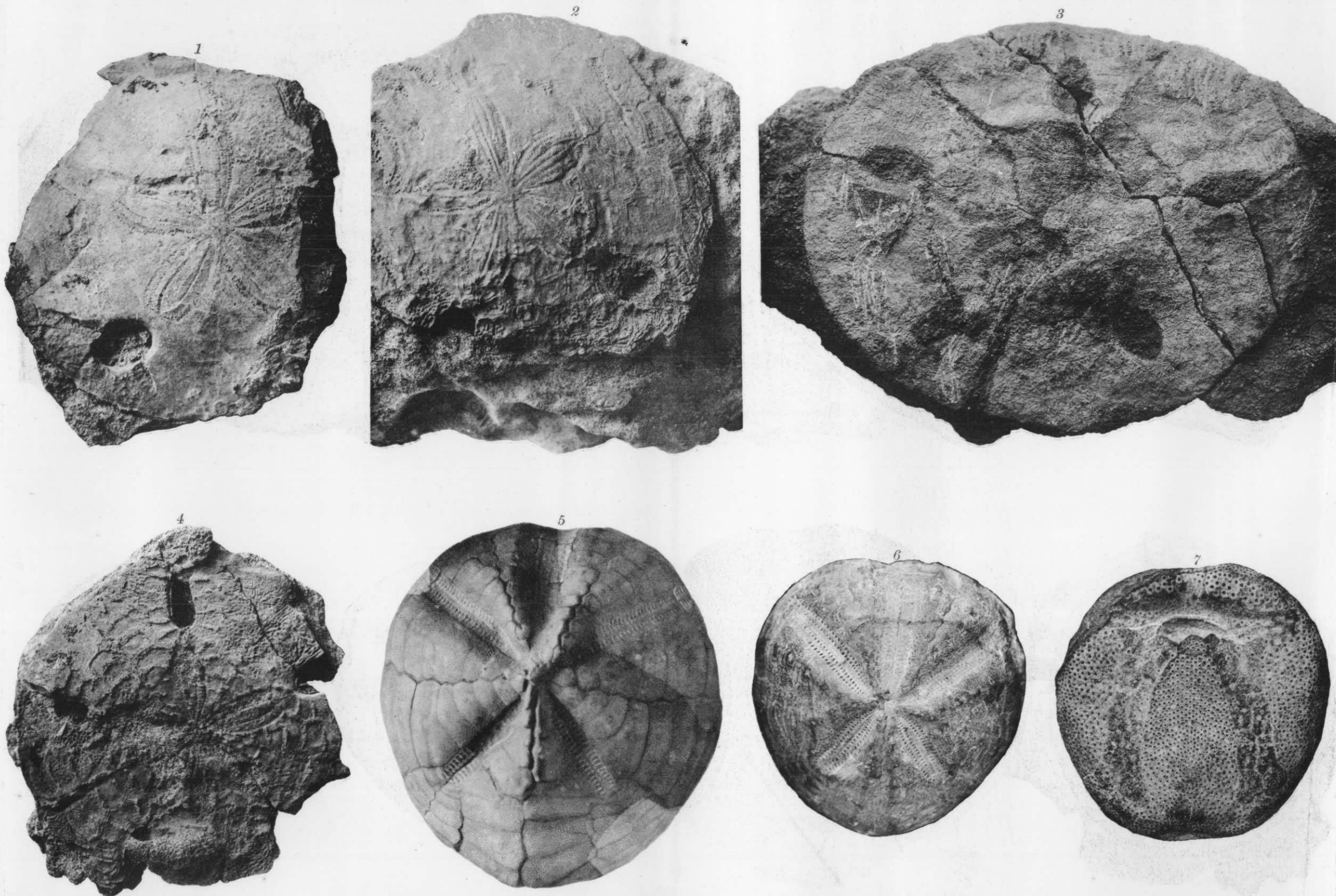
S. TOKUNAGA.
ON THE FOSSIL ECHINOIDS OF JAPAN.

PLATE I.

Plate I.

- Figs. 1-2. Abactinal view of *Echinodiscus formosus* YOSH. From Hatto near Kelung, Formosa.
- Fig. 3. Abactinal view of *Astriclypeus integer* YOSH. From Mizuho-mura in Minamitsuru-gōri, Prov. of Kai.
- Fig. 4. Abactinal view of *Astriclypeus integer* YOSH. From Hatto near Kelung, Formosa. (Surface eroded).
- Fig. 5. Abactinal view of *Linthia nipponica* YOSH. From Hidaka-mura in Kamimizuta-gōri, Prov. of Shinano.
- Fig. 6. Abactinal view of *Linthia nipponica* YOSH. From Sakae-mura, Prov. of Shinano.
- Fig. 7. Actinal view of another specimen of *Linthia nipponica* YOSH. From Sakae-mura.

(All figures in natural size).

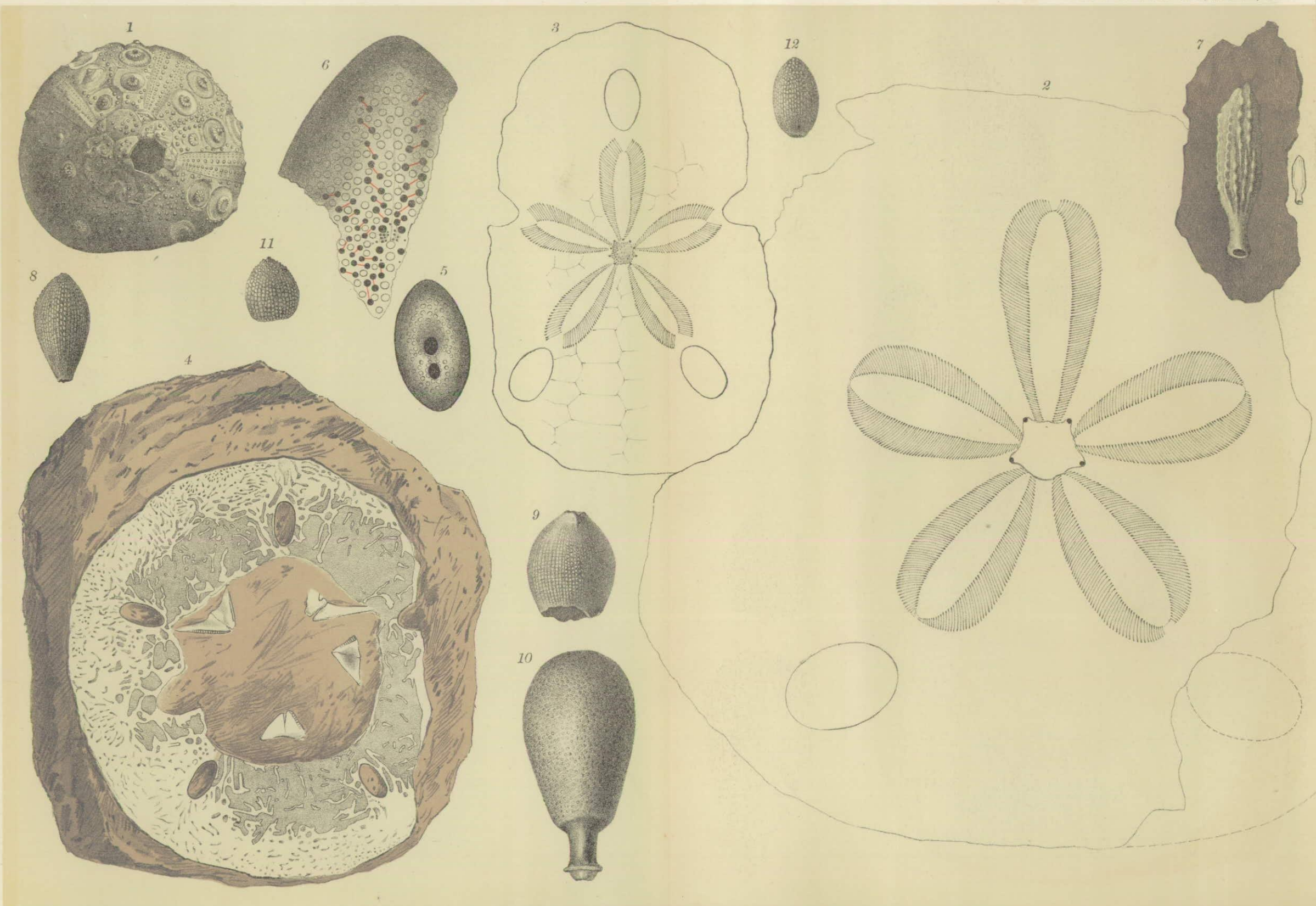


S. TOKUNAGA.
ON THE FOSSIL ECHINOIDS OF JAPAN.

PLATE II.

Plate II.

- Fig. 1. Abactinal view of *Salenia hakkaidoensis* P. DE LORIOL. From Yūbari, Prov. of Ishikari. 2 ×
- Fig. 2. Abactinal view of *Echinodiscus formosus* YOSH. Showing petals and lunules. 2 ×
- Fig. 3. Abactinal view of *Astriclypeus integer* YOSH. Showing petals and lunules.
- Fig. 4. Actinal view of *Astriclypeus integer* YOSH. Showing lunules and teeth. (Surface eroded).
- Fig. 5. Actinal view of *Fibularia acuta* YOSH. Drawn from a living specimen. (Magnified).
- Fig. 6. Abactinal view of *Fibularia acuta* YOSH. Drawn from a living specimen. (Magnified).
- Fig. 7. Spine of *Cidaris a* sp. From Iwasa, Prov. of Tosa. (Magnified).
- Fig. 8. Spine of *Cidaris β* sp. From Itsukaichi, Prov. of Musashi.
- Fig. 9. Spine of *Cidaris ε* sp. From Yokodani, Prov. of Tosa.
- Fig. 10. Spine of *Cidaris δ* sp. From Itsukaichi, Prov. of Musashi (Restored).
- Fig. 11. Spine of *Pseudocidaris a* sp. From Torinosu, Prov. of Tosa.
- Fig. 12. Spine of *Pseudocidaris β* sp. From Torinosu, Prov. of Tosa.
- (All figures except figs. 1, 2, 5, 6 and 7, in natural size).



Tokunaga : Fossil Echinoids of Japan.

S. TOKUNAGA.
ON THE FOSSIL ECHINOIDS OF JAPAN.

PLATE III.

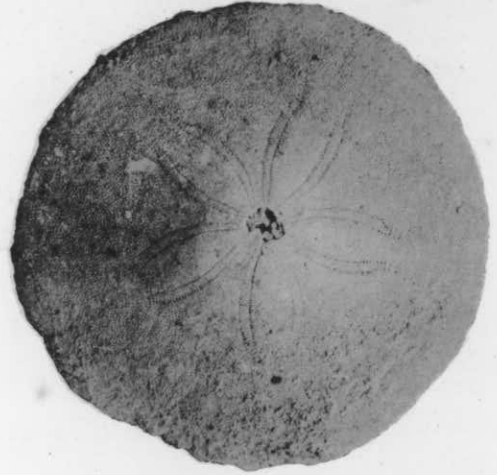
Plate III.

- Fig. 1. Cast of *Linthia nipponica* YOSH. From Sakae, Prov. of Shinano.
Fig. 2. Abactinal view of *Echinarachnius parma* LAM. From Sado Is.
Figs. 3-5. Abactinal, actinal and profile views of *Pygurus asiaticus* TOK.
From Sakawa, Prov. of Tosa. (Apical portion destructed).
Fig. 6. Profile view of another specimen of *Pygurus asiaticus* TOK.
(All figures in natural size).

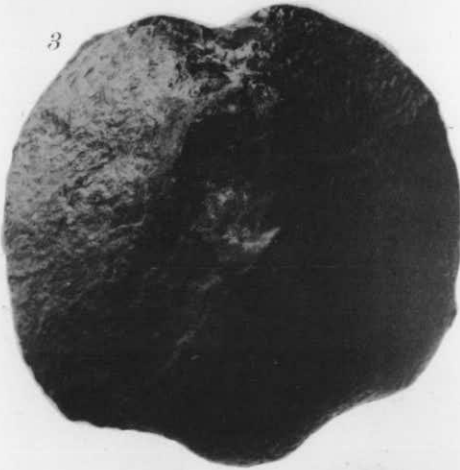
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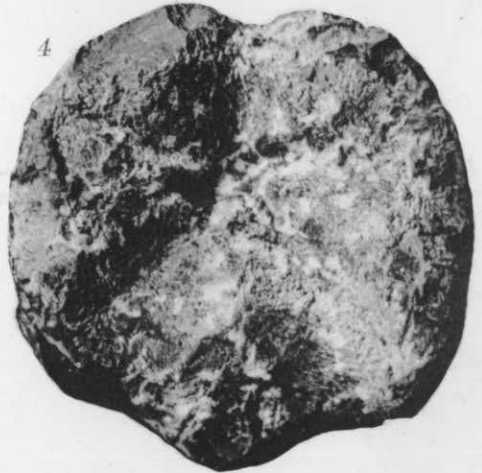
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S. TOKUNAGA.

ON THE FOSSIL ECHINOIDS OF JAPAN.

PLATE IV.

Plate IV.

Figs. 1-3. Abactinal, actinal and profile views of *Schizaster recticanalis* YOSH. From the environs of Kanazawa, Prov. of Kaga.

Figs. 4-5. Abactinal and actinal views of *Schizaster nummuliticus* TOK. From Bonin Is.

Fig. 6. Same specimen of *Schizaster nummuliticus* TOK., showing the periproctal portion.

(All figures in natural size).

