NOTES ON *DELTOCYATHUS* AND *DISCOTROCHUS* FROM JAPAN

BY

HISAKATSU YABE and MOTOKI EGUCHI

With 1 Plate

The present article deals with a number of disc-shaped simple corals from Japan, fossil and living, belonging to two genera, *Deltocyathus* and *Discotrochus*, both of the family Turbinolidae. The two genera have a similar history in having been first established on fossil material and later added with living representatives as to be stated later on.

At the beginning of the present study we had at our disposal only scanty material comprising a few recent specimens and a small number of fossil ones. The latter are derived from the younger Cenozoic deposits of the Kwantô region, Sikoku, the Ryûkyû Islands and Taiwan. The fossils from the Kwantô region were collected by Mr. F. UEDA, then of our Institute, those from Sikoku by Mr. S. MABUTI, then of our Institute, and those from the Ryûkyû Islands by Mr. S. HANZAWA of our Institute, while those from Taiwan mostly by Mr. S. ANDO of the Nippon Petroleum Company and partly by Mr. S. HANZAWA. In the meanwhile, Mr. HANZAWA discovered a rich fossil locality of solitary corals in the Ryûkyû limestone of Kikai-zima, Ryûkyû Islands, and was successful in collecting several hundred deep-water corals besides innumerable bryozoa, mollusca and other fossils, which he brought back to our Institute[1]. Very fortunately we received almost simultaneously from the Imperial Fisheries Experimental Station, Tokyo, through the courtesy of Mr. H. MARUKAWA, a rich collection of living deep-water corals from the shelf sea bordering Japan[2]. In these two collections, we found a large number of specimens of *Deltocyathus* and *Discotrochus*; the acquisition of these additional material rendered specific determination much easier.

The life condition of the fossil deep-water corals found in the younger Cenozoic strata is suggested by that of the living ones, which are specifically identical or at least closely allied; therefore the results of the oceanographical observations on board the surveying ship Sôyô-maru of the Imperial Fisheries Experimental Station are of considerable value in interpretation of palaeo-ecological studies to both the geologist and palaeontologist.

All of the fossil and living specimens here photographed are deposited in the collection of our Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai, while the duplicates of the living specimens are now stored in the Imperial Fisheries Experimental Station, Tokyo.

---

1) H. YABE and M. EGUCHI: Deep-Water Corals from the Riukiu Limestone of Kikai-jima, Riukiu Islands, Proc. Imp. Acad., Vol. 8, No. 9, 1932.

2) H. YABE and M. EGUCHI: A Study of the Recent Deep-Water Coral Fauna of Japan, ibid., Vol. 8, No. 8, 1932.

Genus **Deltocyathus** MILNE EDWARDS and J. HAIME, 1848

Genotype: *Turbinolia italica* MICHELOTTI

Generic diagnosis: Turbinolid. Corallum simple, disc- or cup-shaped, free, with or without trace of former attachment; calice almost flat or convex; columella spongy, papillate at top. Pali well developed in front of septa of all cycles, except sometimes last one, unequal, arranged in chevrons or deltas. Septa, those of last cycle excluded, usually exsert. Costae distinct, variably strong, difference being especially marked among primaries; usually echinulate or spined.

The above generic diagnosis is slightly modified from that given by DUNCAN in his "Revision"[1] so as to cover all the species now known of the genus.

The genus was first established by MILNE EDWARDS and J. HAIME[2], 1848, based on a Miocene species, *Deltocyathus italicus*, previously known as *Turbinolia italica* MICHELOTTI or *Stephanophyllia italica*[3] MICHELIN of which the latter is, according to them, merely a juvenile form of the former. For a time, the genus was monotypic in spite of the wide geographic distribution of the species in European deposits ranging from the Miocene to the Pliocene, until SISMONDA described in 1874[4] two additional fossil species, *Deltocyathus cylindricus* and *D. taurinensis*, from the Miocene of Italy. Five years later, DUNCAN[5] first reported a living species *Deltocyathus orientalis* from Japan (34°12′ N. lat., 136°26′ E. long., 52 fathoms), a species which is believed by us to be inseparable from a cosmopolitan species *D. lens* ALCOCK. In 1878 TENISON WOODS[6] described four Miocene species from Australia, *Deltocyathus alatus* T. W., *D. italicus* T. W. (non MICHELOTTI, = *D. australiensis* DUNCAN), *D. tateanus* T. W., and *D. viola* WOOD and DUNCAN; according to DENNANT[7], these four forms differ slightly from the typical *Deltocyathus* by bearing a trace of former attachment at the center of the base.

In 1880, living examples of *Deltocyathus italicus* were recorded by L. F. POURTALES[8] from the Caribbean Sea in the depths of 110–1625 m. In the same year H. N. MOSELEY[9], described *Deltocyathus magnificus* on a recent material of the Challenger Expedition, a form characterized and distinguished from the typical *Deltocyathus*, by having pali in front of all septa; he, however, did not give any revised diagnsois of the genus.

Later important additions to our knowledge on *Deltocyathus* consist in the records of eight species from the Miocene of Tchechoslovakia[10] (*D. aequalis* PROCHAZKA, *D. boranicensis*

---

1) P. M. DUNCAN: A Revision of the Families and Genera of the Sclerodermic Zoantharia, EDWARDS and HAIME, or Madreporaria, p. 23, 1884.

2) MILNE EDWARDS and J. HAIME: Monographie des Turbinolides, Ann. Sci. Nat., 3 sér., Zoologie, 9, 1848 (cited after M. EDWARDS and J. HAIME, 1857).

3) H. MICHELIN: Iconographie Zoophytologique, p. 32, 1840–47.

4) E. SISMONDA: Matériaux pour servir à la Paléontologie du terrain tertiaire du Piédmont, Mém. d l'Acad. Roy. Sci. Turin, 11 sér., Vol. 25, 1871 (cited after FELIX, 1927).

5) P. M. DUNCAN: Notices of Some Deep-Sea and Littoral Corals from the Atlantic Ocean, Caribbean, Indian, New Zealand, Persian Gulf and Japanese Seas, Proc. Zool. Soc. London, p. 431, 1876.

6) TENSION WOOD: On the Extratropical Corals of Australia, Proc. Linn. Soc., N. S. Wales, Vol. 11, p. 292, 1878 (cited after GERTH and FELIX).

7) J. DENNANT: Description of New Species of Corals from the Australian Tertiaries, Trans. Roy. Soc. S. Australia, 1889–1903 (cited after FELIX).

8) L. F. POURTALÉS: Deep-Sea Corals, Illustrated Catalogue of the Museum of Comparative Zoology, p. 15, 1871.

9) H. N. MOSELEY: On the Deep-Sea Madreporaria, Rep. Sci. Res. Voy. H. M. S. Challenger, Zool., Vol. 11, p. 174, 1873–1876.

10) V. J. PROCHAZKA: Vorfäuf. Bericht über d. stratigraph. u. faunist. Verhältnisse des westlich. Miocängebietes von Mähren, Sitz-Ber. Kgl. böhm. Ges. d. Wiss. Math.-Nat. Cl. Jahrg. 1892, Prag 1893 (cited after FELIX).

PR., *D. conoides* PR., *D. costatus* PR., *D. epithecatus* PR., *D. impar* PR., *D. fungiaeformis* (REUSS) and D. *ventricosus* (PR.), of *D. andamanicus* ALCOCK[1] from the Andaman Sea, 172–363 fathoms, of *D. subviola* DENNANT[2] from the Miocene of Australia, of *D. lardensis* JUESSEN[3] from the Pliocene of Rhodus, of *D. vaughani* nov. nom. (*Leviparifer orientalis* VAUGHAN[4]) living in Japan, of *D. magnificus suluensis* ALCOCK[5] from the Siboga Expedition Station 95, 5°43′.5 N. lat., 119°40′ E. long., 522 m., and Station 100 of the same, 6°11″ N. lat., 120°37′.5 E. long., 450 m., of *D.*? sp. OPPENHEIM[6] from the Eocene of Togo, Africa, of *D. australis* GERTH and *D. tuberculatus* GERTH from the Miocene of Java[7], of *D. reussi* KREJCI[8] from the Miocene of Europe, and finally of *D. rotulus* VAN DER HORST[9] from the East of Ceylon, 1086 fathoms.

So far as we are now aware, there are 11 well established species recorded from the Miocene, 3 from the Pliocene and 9 from the present world; among them, one species, *D. italicus* ranges from the Miocene to the recent, and another, *D. lens* ALCOCK = *D. orientalis* DUNCAN from the Pliocene to the recent.

The geographical distribution of fossil *Deltocyathus* is rather restricted, being reported from Europe, Australia, Java, and Japan now in addition, while most of the living species find their distribution in the Pacific and Indian Ocean, with the exception of but two cosmopolitan species, *D. orientalis* and *D. italicus*.

We have about 170 specimens of *Deltocyathus*, fossil and recent from Japan; they fall in the following three species and one variety.

Deltocyathus orientalis DUNCAN
Deltocyathus vaughani YABE and EGUCHI
Deltocyathus magnificus MOSELEY
Deltocyathus magnificus MOSELEY, var.

The synopsis of these forms is as follows:

Pali absent in front of septa of last cycle; costae arranged distinctly in chevrons (*Paradeltocyathus* subgen. nov.) ..... *orientalis*
Pali in front of all septa; costae radial (*Deltocyathus*, s.s.)
Septa in five cycles; all complete ..... *magnificus*
Septa in five cycles; fifth incomplete ..... *magnificus* var.
Septa in four cycles; all complete ..... *vaughani*

---

1) A. ALCOCK: An Account of the Deep-Sea Madreporaria collected by the Royal Indian Marine Survey Ship Investigator, Calcutta, 1898.

2) J. DENNANT: op. cit.

3) E. JÜSSEN: Ueber pliocäne Korallen von d. Insel Rhodus, Sitz-Ber. K. Akad. d. Wiss. Math. Natur., Cl. 99, Abt. 1, p. 13, 1890.

4) T. W. VAUGHAN: A New Fossil Species of *Caryophyllia* from California, and a New Genus and Species of Turbinolian Coral from Japan, Proc. U. S. Nat. Mus., Vol. 8, No. 8, p. 388, 1900.

5) A. ALCOCK: Report on the Deep-Sea Madreporaria of the Siboga Expedition, Siboga-Expeditie, 16 a, p. 19, 1902.

6) P. OPPENHEIM: Eocäne Invertebraten in Togo, Beiträge zur geologischen Erfoschung der Deutschen Schutzbegiete, Heft 12, p. 19, 1915.

7) H. GERTH: Die Anthozoenfauna des Jungtertiärs von Borneo, Samm. Geol. Reichs-Mus., Leiden, Ser. 1, Bd. 10, p. 49, 1923.

8) K. KREJCI: Norddeutsche Miocänkorallen, Jahrb. Preuss. Geol. Landesanstalt, Vol. 56, p. 467, 1925.

9) C. J. VAN DER HORST: Some Solitary Corals from the Indian Ocean, Rec. Indian Mus., Vol. 33, Pt. 1, p. 6, 1931.

Deltocyathus magnificus, magnificus var. and *vaughani* are quite similar to the genotype *D. italicus* in discoidal corallum with prominent pali and radially arranged costae. *Deltocyathus* (*Paradeltocyathus*) *orientalis* differs from them in having subturbinate to discoidal corallum with less prominent pali and with costae arranged distinctly in chevrons near the very tip of corallum; in these features it considerably approaches *Deltocyathoides* YABE and EGUCHI[1] with the genotype *Deltocyathoides japonicus* YABE and EGUCHI.

VAUGHAN laid much stress on pali and distinguished his *Levipalifer,* with the single species *L. orientalis* VAUGHAN from Japan, from *Deltocyathus* of which the genotype is *D. italicus,* solely on account of their presence in the former species and absence in the latter, of pali before the septa of the last cycle. Pali are present in all cycles not only in *L. orientalis,* but also in *Deltocyathus magnificus* MOSELEY and its allies; consequently, the latter forms may be safely included into the same genus with the former; but the question now arises as to the value of the presence or absence of these pali for generic separation. In this connection it may be pointed out that several young specimens of *L. orientalis* in our collection, which will be described below under the name *Deltocyathus vaughani* nov. nom., show some variation in the development of these pali, and we are led to recognize *Levipalifer* as a mere section of *Deltocyathus* s.s. rather than as an independent genus.

Deltocyathus orientalis DUNCAN diverges from *D. italicus* at least in one essential feature, namely in the arrangement of costae. In the former species costae are arranged in chevrons as stated above, while in the latter they are decidedly radial. We have not seen the type specimen of *D. italicus* nor any specimen referred to it; also the details of costal arrangement are neither given in the description nor shown in the figures by MILNE EDWARDS and HAIME of their specimen from the Miocene of Tortone. But radial costae are excellently exhibited on the figures of a specimen from the Miocene of Porzteich given by REUSS in his Plate III, fig. 3. In view that different arrangement of costae is more significant and fundamental in the present case than the presence or absence of pali before the septa of the last cycle, a new subgenus *Paradeltocyathus* is here proposed for *D. orientalis* DUNCAN, in spite of the fact that this species is similar to *D. italicus* in the shape of corallum and the development of pali and that the two are common in differing from *Levipalifer* in these features. The essential differences and resemblance among them in connection of these features are tabulated below;

	Shape of Corallum	Arrangement of costae	Pali of the last cycle
Subgen. *Paradeltocyathus* *D.* (*P.*) *orientalis* DUNCAN	Subturbinate —discoidal	in chevrons	absent
Deltocyathus s.s. *D. italicus* (MICHELOTTI)	Subturbinate; lenticular in young stage	radial	absent
Deltocyathus section *Levipalifer* *L. orientalis* VAUGHAN = *D. vaughani* nov. nom.	Discoidal	radial	present

Another species of *Paradeltocyathus* is *D. australiensis* DUNCAN (= *D. italicus* var. *australiensis* DUNCAN = *D. australis* GERTH) from the Miocene of Cape Otway, Victoria, Australia[2].

---

1) H. YABE and M. EGUCHI: A Study of the Recent Deep-Water Coral Fauna of Japan, Proc. Imp. Acad., Vol. 8, No. 8, p. 389, 1932.

2) P. M. DUNCAN: On the Fossil Corals (Madreporaria) of the Australian Tertiary Deposits, Quart. Jour. Geol. Soc. London, Vol. 26, p. 297, pl. 19, fig. 4, 1870.

Deltocyathus (Paradeltocyathus) orientalis DUNCAN, 1876

Pl. XX (I), Figs. 1a–c, 2a–c, 3a–c, 4a–c, 5a–c, 6a–c, 7a–c, 8a–c, 9a–c, 10a–c.

1876. *Deltocyathus orientalis* DUNCAN: Notices of Some Deep-Sea and Littoral Corals from the Atlantic Ocean, Caribbean, Indian, New Zealand, Persian Gulf and Japan Seas. Proc. Zool. Soc. London, p. 431, pl. 38, figs. 4–7.

1902. *Deltocyathus lens* ALCOCK: Systematic Account of the Siboga Deep-Sea Madreporaria. Siboga Expeditie, Monography 16a, p. 19, pl. 2, figs. 16, 16a.

1920. *Deltocyathus lens* GRAVIER: Madréporaires prevenent des Campagnes des Yachts Princesse-Allice et Hirondelle 11 (1893–1913). Resultats des Campagnes scientifiques accomplies sur son Yacht par Albert der prince souverain de Monaco, fasc. 5, p. 36, pl. 3, figs. 47–54; pl. 13, figs. 200–201.

1925. *Deltocyathus lens* UMBGROVE: Report on Pleistocene and Pliocene Corals from Ceram. Geological, Petrographical and Palaeontological Results of Explorations carried from September 1917 till June 1919 in the Island of Ceram by L. RUTTEN and W. HOTZ, 2 Ser., Palaeontology, 1, p. 4, pl. 1, figs. 8–10.

This is one of the most common forms of deep-water corals from Japan, and is found living almost everywhere in the seas around the Japanese Islands from off the coast of Tugaru at the north to the southern end of Kyûsyû, at the south ranging in depth from 75 to 344 meters. It also occurs as fossil in the younger Cenozoic formations of the Kwantô region, Tosa (Sikoku), the Ryûkyû Islands and Taiwan (Formosa). In time, it ranges from the Pliocene to recent.

More than some 120 recent and fossil specimens of this species are now at our disposal and the following description is based on a careful examination of the rich material.

Corallum free, varying in shape from depressed subturbinate to almost lenticular, bluntly pointed, rounded or sometimes even flattened at base. Small, 5–11 mm in diameter and 2.5–8.5 mm in height; variable in ratio of diameter and height. Calice circular, widely open and shallow on some specimens, considerably narrow and deep on others, this feature varying with the growth mode of corallum. Septa 44–52, usually 48, arranged in 4 cycles of regular hexameral plan; all cycles complete; six primaries largest, free, these and the six secondaries which are next in size, reaching columella; tertiaries and quarternaries often subequal, those of latter adjacent to primaries sometimes surpassing the others in height and length; secondaries, tertiaries and quarternaries forming 6 deltoid groups by attachment of inner margin of shorter septa to lateral side of longer ones, thereby the junction of tertiaries and quarternaries shifting gradually toward columella with growth of corallum and closely approaching it in fully grown specimens. Septal faces covered by granulations arranged in curved radial rows. Upper margin of septa runs insensibly in a broad curve and without any sharp boundary to costae, which are distinct and extend to basal surface of corallum. Costae crowded, subequal, alternating with deep furrows, and densely granulated. Wall proper deep-seated, invisible on surface. Sometimes a small smooth round area lies at center of base; 12 radial costae issuing from it and shorter ones of later cycles arranged distinctly in chevrons around it. Columella usually small, formed of a few number of papillae and seated deep below at bottom of calical fossa, which is variable in space of its bottom as well as in its depth. Pali in two crowns, smaller and lower in front of tertiaries, while prominent and tall in front of secondaries.

The present species shows variation of rather wide range in the shape of the corallum and dimensions of the calicular fossa. Unless provided with so numerous specimens as now at hand, one is perhaps liable to make several distinct species out of the single one.

In 1876, P. M. DUNCAN described a new species of *Deltocyathus, D. orientalis,* on a specimen dredged, according to his statement, by Capt. St. John from off Minosa-mati, Kita-Muro-gun, province of Kii, N. 34°12′ L., E. 136°20′ long. His original daignosis runs as follows:

"The corallum is short, turbinate, widely open at the calice, and it has a circular spot to its base, which is without costate. The columella is exceedingly small; the primary septa are very exsert, and the costae are subequal, crowded, granular, and project from the wall. The septa are in four cycles, but the higher orders are incomplete in some systems. The pali are small and lower before the tertiaries, and prominent and tall but not broad before the secondaries. All the septa and pali are closely granular. Height of corals 1/5 inch, breadth of calice 1/5 inch."

Some of our specimens derived from the Sôyô-maru station 222 (Pl. XX(I), Figs. 1, 2, 3) precisely agree with his figures and description of *D. orientalis* not only in various features external and internal, but also in dimensions, whereas ten other specimens found in the same haul, diverge from the above specimens in being more depressed in form and having 48 septa in 4 cycles complete. All of these, however, agree with one another in their bowl shaped corallum.

In another group of specimens as in Pl. XX(I), Figs. 4 and 7, the base is more rounded and general shape somewhat onion-like, being more depressed than in the first type; they usually have 48 septa. The height of the corallum is more depressed than in the former and it agrees well with *Deltocyathus lens* described and figured by ALCOCK from 9 specimens of the Siboga Expedition in Philippine waters and the Indian Ocean. Judging from his figures (Pl. 11, Fig. 16a), the southern sea species seems to have a rather shallow calicular fossa although such a feature was not mentioned by that author, and moreover, the fossa seems to be completely filled up by both pali and columella. These two forms are, however, completely linked with one another by intermediate ones, and are most common in our recent material.

The third type of variation is well illustrated in Pl. XX(I), Figs. 10a–c, and this specimen agrees well with the Siboga specimens in the shape of corallum and depth of the calicular fossa. In the height of the corallum, there exists some variation, but it is found to pass into the next form.

The fourth type (Pl. XX(I), Figs. 9a–c, 6a–c), is depressed and the base is either flat or saucer-shaped; these agree with the fossil specimens described by UMBGROVE from the Plio-Pleistocene beds of Ceram. The above mentioned types of variation observed in the present material, are distinguishable only artificially, in reality, they are connected with one another by many intermediate forms, for instance the fourth type is not specifically separable from *D. lens* as once done by UMBGROVE.

Localities:—

The stations of the Sôyô-maru from where the present specimens were dredged are given in the following table together with the necessary data showing the bottom material, depth and other such features.

Register Number	Sôyô-maru		East Longitude	Depth in m	Surface temp. C	Bottom temp. C	Bottom Sp. gr.	Bottom material	Date
	Station Number	North Latitude							
50055	5	35°03′00″	140°16′20″	269	19.2	8.9	25.70	Sand	June 17, 1926
50042	23	36°58′00″	141°21′40″	170	15.9	8.5	25.35	Mud	June 29, 1926
59065	53	39°29′30″	142°10′00″	190	17.9	8.3	25.26	Fine sand & gravel	July 16, 1926
59058	54	39°32′10″	142°13′20″	494	18.7	3.4	25.11	Mud & sand	July 17, 1926
50033	59	39°52′00″	142°13′50″	168	16.1	9.1	25.24	Coarse and & shells	July 19, 1926

Register Number	Sôyô-maru		East Longitude	Depth in m	Surface temp. C	Bottom temp. C	Bottom Sp. gr.	Bottom material	Date
	Station Number	North Latitude							
50035	90	39°35′00″	142°07′20″	152	16.8	9.3	25.07	Sand & shells	Nov. 3, 1926
50041	110	35°31′00″	140°51′30″	59	15.3	13.2	25.74	Fine sand & shells	Mar. 2, 1927
50054	126	37°41′00″	141°23′45″	146	4.8	4.6	24.92	Fine sand	Mar. 7, 1927
	139	38°17′00″	142°00′00″	320	27.7	14.3	—	Sand	Aug. 25, 1926
	140	38°17′00″	142°05′00″	344	27.7	14.3	25.14		
5004	222	33°18′20″	133°44′40″	210	26.4	13.5	25.31	Fine sand	July 20, 1927
50038	238	35°05′30″	139°39′53″	106	20.2	18.9	25.67	Sand, mud & shell	Nov. 6, 1927
50046	240	35°10′30″	139°32′35″	192	20.2	15.2	25.79	Fine mud	Nov. 6, 1927
50052	247	35°09′20″	139°10′35″	159–128	19.8	17.3	25.66	Mud	Nov. 8, 1928
53679	249	35°03′30″	139°07′20″	229	20.4	13.2	25.97	Gravel, sandy-mud	Nov. 9, 1927
50006	251	34°59′30″	139°10′00″	165	21.1	15.8	25.74	Coarse sand & shells	Nov. 9, 1957
50007	254	34°50′30″	139°06′00″	174	20.7	13.8	25.53	Gravel & sand	Nov. 10, 1927
	259	34°41′15″	138°43′00″	188	19.8	12.0	25.61	Sand & mud	Nov. 15, 1927
50048	322	32°49′00″	132°15′20″	110	24.1	16.5	25.77	Coarse sand & shells	July 16, 1928
50047	324	32°51′35″	132°22′55″	106	26.2	17.5	25.52	Sand	July 21, 1928
50051	429	32°16′15″	129°33′45″	223	26.4	13.7	25.68	Rocks & gravel	July 16, 1929
59084	447	33°03′18″	129°33′45″	90	26.8	16.9	25.59	Sand & shells	July 20, 1929
50034	502	35°59′45″	132°57′00″	110	28.3	18.6	25.71	Sand	Aug. 15, 1929
50044	504	36°14′45″	133°04′45″	106	28.5	18.6	25.39	Shells & gravel	Aug. 18, 1929
50005	520	34°43′00″	133°07′30″	75	27.8	23.2	25.29	Sand	Aug. 23, 1929
50043	523	35°43′30″	133°56′15″	181	28.4	4.3	25.34	Mud	Aug. 23, 1929
50053	530	35°45′15″	134°31′45″	183	28.1	2.9	25.31	Mud & sand	Aug. 24, 1929
50050	540	35°45′10″	134°57′30″	123	27.7	14.3	25.67	Sand	Aug. 25, 1929
50007	549	36°13′00″	135°42′30″	115	25.5	2.9	25.26	Mud	July 20, 1930
50049	553	36°35′15″	136°17′00″	113	26.9	18.0	25.54	Sand & mud	July 21, 1930
50045	621	39°16′00″	139°49′45″	93	27.4	16.4	25.55	Sand & mud	Aug. 15, 1930

The oceanographical data mentioned above are quoted from the "Report of a Survey of the Continental Shelf Bordering Japan".

Besides the recent specimens dredged by the Sôyô-maru, we have several others stored in our Institute of Geology and Palaeontology, these were collected in an early time by Prof. H. MATSUMOTO and Mr. H. SONE from the sea bottom near Kinkazan and its vicinity in the province of Rikuzen, as follows;

1. Two miles off Kinkazan, Rikuzen province. *Pavonaria* Ground, Reg. Nos. 38344, and 38342.
2. Northeast of Kinkazan, Rikuzen province in 52 fathoms, Reg. No. 38349.
3. Between Enosima and Onagawa, Rikuzen province in 22 fathoms, Reg. No. 38219.
4. There are a few specimen collected by Mr. K. KIKUTI from Toyama-wan, Reg. Nos. 58225, 60409, 60413.

So far as concerns the present material, the northern limit in distribution in the Japan Sea is station 621, 39°16′ N. lat., 139°49′45″ E. long., and that in the Pacific side is station 59, 39°52′ N. lat., 142°13′50″ E. long.

The time of dredge operation is not in one and the same season; most of the dredgings were done in the months of March and November, during which time the surface water temperature ranged from 4.8°–28.5°C., and the depth from 59 to 494 meters. The stations with the lowest bottom temperature are st. 549 and 530, the temperature 2.9°C., in July and August respectively. The present species is able to withstand a temperature as low as 2.9° and more than 23.3°C. The specific gravity of bottom water ranges between 25.07 and 25.77

The bottom material in which this species lives or its environment is generally of sand and mud; but even rocky ground or gravels are also suitable.

The distribution of the present species is not confined to the Pacific, but extend to the eastern Indian Ocean and the Atlantic as well; in the east Indian Ocean it has been recorded from a depth as great as 4919 meters, and the northernmost limit in the Atlantic is of the Hirondelle Expedition, station 2214, 39°26′10″ N. lat., 31°21′30″ W. long., in the Atlantic Ocean, thus, the northernmost limit of this species is in the Japanese waters.

The fossil material were derived from geological formations ranging in age from the uppermost Miocene or lowermost Pliocene (Byôritu beds of Taiwan and Taga series of Hitati) to the Pleistocene (Narita beds in the Kwantô region). The following is the localities of the fossil specimens.

Kazusa province (Tiba prefecture) :—

Northern valley of Owasi, Naka-mura, Kimitu-gun. Reg. No. 50017.

Oyatu, Koito-mura, ditto. Reg. No. 38291.

Atebi, Makuta-mura, ditto. Reg. No. 50014.

Dizôdô, Makuta-mura, ditto. Reg. No. 50019.

Owasi, Naka-mura, ditto. Reg. No. 50016.

Nisihigasa, Akimoto-mura, ditto. Reg. No. 29315.

East of Nisihigasa, Akimoto-mura, ditto. Reg. No. 38661.

Nisikuniyosi, Usiku-mati, Itihara-gun, Reg. No. 50018.

Oti-Simosinden, Sito-mura, ditto. Reg. No. 43425.

Inunari, Urutu-mura, ditto. Reg. No. 38659.

Takadaki, Oikawa-mura, Isumi-gun. Reg. No. 50020.

Sagami province (Kanagawa prefecture) :—

Okine, Nagai-mura, Miura-gun. Reg. No. 38203.

East of Enkaizan, Mutu-uraso-mura, Kuraki-gun. Reg. No. 38463.

West of Sanbu, ditto. Reg. No. 38348.

South of Musikubo, Kokuhu-mura, Naka-gun. Reg. No. 39201.

Hitati province (Ibaraki prefecture) :—

Coast south of Turusi-zaki, Taga-gun. Reg. No. 38660.

Tosa province (Sikoku) :—

East valley of Tonohama, Yasuda-mura, Aki-gun. Reg. No. 50008.

Ryûkyû Islands :—

Osumi subgroup; Kamikatetu, Kikai-zima, Osima-gun, Kagosima prefecture. Reg. No. 50009. Ryûkyû limestone.

Ryûkyû proper:—Kotinda, Kotinda-mura, Okinawa-sima. Reg. No. 39215. Simaziri group.

Formosa (Taiwan):—

South of Bôsiho, Siko-syô, Byôritu-gun, Sintiku-syû. Reg. No. 38263. Byôritu bed.

Foreign localities:—

Recent; East Indian Sea:—

Siboga Expedition, St. 95, 4°43.5′ N., 119°40′ E., 522 meters deep.
Siboga Expedition, St. 59, 10°22.7′ S., 123°16.5′ E., 590 meters deep.
Siboga Expedition, St. 256, 5°26.6′ S., 132°32.5′ E., 397 meters deep.
Siboga Expedition, St. 275, 4°52.5′ S., 128°37′ E., 4914 meters deep.

Recent; Atlantic Ocean:—

Hirondelle Expedition, St. 866, 38°52′50″ N., 29°43′20″ W., 599 meters deep.
Hirondelle Expedition, St. 2214, 39°26′10″ N., 31°21′30″ E., 914–650 meters deep.

Fossil:—

Upper Pliocene of Ceram; W. Toluarung, S. from Ma. Kapata.

Deltocyathus vaughani n. nom.

Pl. XX (I), Figs. 11a-c, 12a-c.

1900. *Levipalifer orientalis* VAUGHAN, A New Fossil Species of *Caryophyllia* from California, and a New Genus and Species of Turbinolida Coral from Japan, Proc. U. S. Nat. Mus., Vol. 22, pp. 199–203.
1932. *Deltocyathus vaughani* n. nom., YABE and EGUCHI, A Study of the Recent Deep-Water Coral Fauna of Japan, Proc. Imp. Acad., Vol. 8, No. 8, p. 388.

Levipalifer orientalis VAUGHAN was established by that author on a specimen from Bosyû, Japan, with the following description;

"Corallum, without any sign of attachment, subdiscoid in form, the base pointed. Transverse outline of the calice circular. *Dimensions.*—Diameter, 20 mm.; altitude, 9 mm. Costae well developed, thin, distant, correspond to all septa; those of the first and second cycles of the same size; those of the third slightly smaller, and those of the fourth still smaller. They are rather tall at the calicular edge of the wall, becoming lower as the base is approached. Two cycles are continued to the apex of the base. The costal margins are beset with rather tall, rounded or blunt dentations. In some instances the ends of the dentations are swollen. Each dentation marks the emergence on the surface of a small ridge (or stria) along which are arranged rather tall but not very sharp pointed granulations. The lateral faces of the costae are perpendicular to the corallum wall; that is, the costae show no, or almost no, thickening at the wall".

"There are four complete cycles of septa, arranged in six definite systems. Six of the septa stand isolated from the other septa and extend directly to the columella. Between each pair of these six is a definite group of septa belonging to higher cycles. Those of the third cycle bend toward those of the second, and the members of the fourth bend toward those of the third. Quite frequently the members of the fourth cycle are longer than the inclosed members of the third. The longer member of the fourth cycle for any given half system is the one standing next to the septum of the first cycle. This arrangement is the common one in the Eupsammidae. The fusion of the septa into the groups above indicated is affected by the pali. The lateral ornamentation

of the septa consists of ridges or striae, which possess a line of divergence slightly interior to the wall and parallel to it, and granulations placed along the striae. Within the line of divergence the striae bend toward the interior of the corallum, and exterior to it they bend outward, ultimately downward. On the inner side of the line of divergence the septal margin is entire or shows very faint crenations. Exterior to it each ridge is terminated by a dentation, not very long just at the line of divergence, but quite soon the dentations are larger. The dentations on the peripheral ends of the septa, that is, the costae, have already been described. When one looks directly at the edge of a septum the striae are seen to alternate in position, and the septum is usually faintly undulate in a direction parallel to the long axis of the striae. The granulations are placed along the striae and are arranged in curves parallel to the septal margin. The granulations are rather tall, but are not sharp-pointed; their tips are blunt or rounded. The septal margins project considerably above the upper edge of the wall; the members of the first and second cycles are equally prominent, and are more exsert than those of the third and fourth cycles, which are equal in predominance. The septa are distant, thin, weak, and show no marked thickening at the wall. Pali are before every cycle of septa. Those before the first cycle are the broadest. The pali belonging to each septal group included between the members of the first cycle are deltoid in arrangement. The arrangement is well shown in Plate XVI, fig. 6. The pali are broad and are simple lobes, excepting usually there is an inner tooth before the delta composed of the pali of each group of septa of the third and fourth cycles. *The margins of the pali are entire.* The trabecular make-up of the pali is the same as that of the septa; each palus has its own line of divergence, etc. The fusion of the septa into deltas through the pali is effected usually by synapticula. Excepting these synapticula the interseptal loculi are entirely vacant".

"Some hints have already been thrown out as to the make-up of the wall. It is entirely naked, imperforate, and rather thin, thickening very little from internal calcareous deposits, new processes extending inward from it between the septa (such as are quite common in some Turbinolid genera) were seen. As the septa and costae do not thicken in crossing the wall, this coral would be said to possess a *eutheca*. In my mind the point to be emphasized is that the septa are distant and thin, and the connecting wall is also thin. The wall between the costae possesses no ornamentation. The columella is large, well-developed, trabecular and spongy".

We have some twenty specimens before us from the localities given below and all quite agree well with *Levipalifer orientalis* VAUGHAN of the above description by VAUGHAN based on a specimen from Bôsyû, Awa province.

As to the columella, VAUGHAN stated, "large, well developed, trabecular, and spongy", and did not refer to its shape; in our specimen it is found to be always oblong, and elongated in a direction.

As to the pali, several smaller specimens in our material show some variation in their development before the septa of the last cycle, sometimes more or less approaching *D. italicus* in this feature.

The genus *Levipalifer* now incorporated with *Deltocyathus*, the species name must be altered, as it is preoccupied by that of DUNCAN, it is hence, renamed *vaughani*, in the honor of Dr. T. W. VAUGHAN.

The localities and dimensions of the Japanese specimens are given in the table below:

Register Number	Locality	Diameter in mm	Height in mm	Septa number	Pali kind	Granules on costae	Columella shape	Base type
49774	247 (Sagami Bay)	24	10	43	4c	prominent	oblong	convex
		18	7±	48?	3c+s	moderate	oblong	convex
50058	Sagami Bay	17	6±	48	?	moderate	oblong	convex
		18	7	48	4c	moderate	oblong	convex
50060	372 (off Hamamatu)	20	8±	48	4c	prominent	oblong	convex
50068	368 (off Ise)	16×15	8±	48	4c?	moderate	oblong	convex
	366 (off Ise)	19	7±	48	4c?	moderate	oblong	sl. convex
50061	361 (off Ise)	23	7	48	4c	prominent	oblong	convex
49779	213 (Kii Channel)	16	6	48	4c?	moderate	oblong	convex
		15±	6±	48	4c?	moderate	oblong	convex
50003	*336 (off Tosa)	20	9	48	4c	prominent	oblong	convex
		19	8	48	4c	prominent	oblong	convex
		18.5	7	48	4c	prominent	oblong	convex
		17	7.5	48	4c	prominent	oblong	convex
		15	6	48	4c	moderate	oblong	convex
50078	323 (Bungo Channel)	17	7	48	3c+s	moderate	oblong	convex
		16	6	48	4c	prominent	oblong	convex
		16	6	48	4c	prominent	oblong	convex
		16	6	48	4c	prominent	oblong	convex
50066	419 (SW. of Satuma)	16	6	48	4c	moderate	oblong	convex

Numerals in the first column are the register numbers of the specimens preserved in the collection of the Institute of Geology and Palaeontology, Tôhoku Imperial University; those in the second column are the station numbers of the Sôyô-maru; * marks the specimen illustrated in accompanying plate; + in the third and fourth columns indicates damaged specimens in which dimensions are not restored; 4c, 4c? and 3c+s in the sixth column denote respectively the presence of pali before all of the septa, the same but differing in weak development of some pali belonging to the last cycle, and the presence of pali before all septa except some before the last cycle; sl. in the last column is the abbreviation for "slightly".

The geographical position and oceanographical data of these Sôyô-maru stations are given in the table below.

Station Number	North Latitude	East Longitude	Depth in mm	Surface temp. C	Bottom temp. C	Bottom Sp. Gr.	Bottom material	Date
247	35°09′20″	139°10′35″	159–128	19.8	17.3	25.66	Mud	Nov. 8, 1927
372	34°29′45″	137°39′00″	466	27.4	6.4	25.44	Mud	Aug. 13, 1928
368	34°15′14″	137°12′40″	600	27.4	5.8	25.50	Mud	Aug. 10, 1928
366	34°05′40″	136°49′00″	494	26.2	6.1	25.49	Mud	Aug. 10, 1928
361	33°51′32″	136°16′48″	582	24.7	5.3	25.41	Clay	Aug. 9, 1928
213	33°39′00″	134°55′00″	353	26.5	14.7	25.56	Sand & mud	July 18, 1927
336	32°49′50″	132°25′00″	522	26.9	6.3	25.52	Mud	July 26, 1928
323	32°55′15″	132°12′20″	88	26.0	18.1	25.52	Sand & shells	July 21, 1928
419	31°12′10″	129°49′45″	402	26.2	9.6	25.58	Pumice	July 15, 1928

From the above table it is noticed that the bottom temperature ranges, although the time and position are quite different, from 5.3 to 18.1°C., the depth from 88 to 660 m, and mostly

between 400–500 m, the character of the bottom is generally either sandy or muddy and the specific gravity for the bottom is found to range between 25.41 and 25.66.

Deltocyathus magnificus MOSELEY

Pl. XX (I), Figs. 13a–c, 14a–c.

1876. *Deltocyathus magnificus* MOSELEY, Preliminary Report to Professor WYVILLE THOMSON, F. R. S., Director of the Civilian Scientific Staff, on the True Corals dredged by H. M. S. Challenger in Deep Water between the Dates Dec. 30th, 1870 and August 31st, 1875. Proc. Roy. Soc., Vol. 24, p. 552.

1881. *Deltocyathus magnificus* MOSELEY, Report on certain Hydroid, Alcyonarian, and Madreporarian Corals, 111. On the Deep-Sea Madreporaria, Rep. Sci. Res. Voy. Challenger, 1873–76, Zool., Vol. 11, p. 174, pl. 4, fig. 10, pl. 13, figs. 1, 2.

1902. *Deltocyathus magnificus* ALCOCK, Report on the Deep-Sea Madreporaria of the Siboga Expedition, Siboga Expeditie, Monographie, 16a, p. 20.

1927. *Deltocyathus magnificus* FAUSTINO, Recent Madreporaria of the Philippine Islands, p. 76, pl. 6, figs. 3, 4, 5.

Altogether 30 specimens of this species were dredged from 12 stations of the Sôyô-maru of the Imperial Fisheries Experimental Station, Tokyo, from the continental shelf bordering Japan. All of the specimens are safely referable to this species, and the following description is of the Japanese examples, partly belonging to the typical form and partly to the varietal ones as well.

Corallum free, disc-shaped with horizontal or slightly concave base and somewhat tumid periphery, exceptionally provided with a small pointed scar at center of base. Costae thin, elevated, subequal and radiating from center of base to periphery where they are continuous with septa. Septa like-wise thin, but slightly thinning out from periphery inwards; usually 96 in number, 5 cycles in hexameral plan, completely developed; primaries extending to columella and other septa unite with each other to form 6 deltoid groups, each pair of younger septa unite over next older ones by synapticular junctions which are usually more exsert than the septa and disposed in 4 cycles; those before septa of 4th cycle larger than those before last one which are smallest in size and in extreme cases merely represented by notches. Columella usually oblong, formed of rows of granules irregularly disposed. Septa and pali minutely dentate on margin, former laterally more or less undulated and covered with granules which are arranged in radial rows. Wall horizontal but not perforated nor concealed by costae which are not as crowded as in *D. orientalis*, but rather widely apart.

The dimensions of the specimens and their respective stations are given in the following table:

Register Number	Locality	Depth in m	Diameter in mm	Height in mm	Septa number	Shape of base
50063	210 (W. of Cape Sionomisaki)	165	23	6	96?	concave
	341 (off Koti, Tosa)	126	17	5	94	convex
50075	323 (off Cape Asizuri)	88	31	8	96	concave
			29	6	96	concave
			28	6.5	94	concave
			26	6	96	concave
			25	5+	96?	concave
50067	(variety a)		28	7	70	concave
50001	325 (off Cape Asizuri)	210	25	7	96	concave
			*22.5	6	96	concave

Register Number	Locality	Depth in m	Diameter in mm	Height in mm	Septa number	Shape of base
50069	326 (off Cape Asizuri)	393	33.5	7	96	concave
50071	316 (off Hosozima)	190	21	6	96	concave
			21	6	94	concave
			20	5	96	concave
50002	301 (off Aburatu, Hyûga)	181	*16	8.5	96	convex
			17	5	96	convex
50074	293 (off Tanegasima)	203	20	5	96	concave
			16	4.5	90	concave
50070	412 (off Cape Sata)	219	17	4.5	96	concave
50064	433 (SW. of Goto Islands)	219	19	5	96	concave
			11 (radius)	5—	96?	concave
	439 (SW. of Goto Islands)	155	23	6	96	concave
			16	3—	96	concave
50072	444 (SW. of Goto Islands)	194	23	6	92?	plane
			20	7	96	convex
			18	6.5	96	convex
			18	5	96	cancave
			16	5.5	96	convex
			16	6	96	plane
			15	4	96	convex
50077	451 (W. of Goto Islands)	187	23	6	96	concave
			20.5	6	96	concave

Var. a: This is represented by but a single specimen and is characterized by having less numerous septa although larger in dimensions. Whether or not this var. a, is a distinct species or merely a varietal, extreme case of anormaly or of a pathalogical form can only be decided by the study of further material.

Remarks: The typical specimens (Pl. XX(I), Figs. 2 a–c, 3 a–c) agree quite well with the figures and description of the type given in the above, and also with the specimens identified by ALCOCK and there is no doubt about their specific identity. Var. *suluensis* ALCOCK is distinguished by having septa of the 5th cycle all free instead of being united with one another over those of the 4th as in the present specimens. From the preceding species it is easily distinguishable by having the septa of the 5th cycle while the former lack them always.

The geographical position and oceanographical data of the Sôyô-maru stations mentioned above are given in the following table.

Station Number	North Latitude	East Longitude	Depth in m	Surface temp. C	Bottom temp. C	Bottom Sp. Gr.	Bottom material	Date
210	33°29′20″	135°28′25″	165	26.1	16.2	25.73	Fine sand	July 27, 1927
341	33°20′35″	133°41′55″	126	27.7	19.0	25.34	Sand, mud & shells	July 28, 1927
323	32°55′15″	132°12′20″	88	26.0	18.1	25.52	Sand & shells	July 21, 1927

Station Number	North Latitude	East Longitude	Depth in m	Surface temp. C	Bottom temp. C	Bottom Sp. Gr.	Bottom material	Date
325	32°45′00″	132°23′30″	210	26.7	15.2	25.65	Gravel & sand	July 21, 1927
326	32°40′10″	132°25′15″	393	27.4	7.9	25.64	Mud & shells	July 21, 1927
316	32°21′10″	131°50′20″	190	25.9	15.4	25.68	Sand & shells	July 16, 1927
293	30°45′00″	130°40′40″	203	27.3	14.3	23.68	Gravel & pumice	July 10, 1927
412	31°02′00″	130°33′00″	219	25.8	13.7	25.71	Pumice	July 13, 1929
438	31°55′15″	128°17′00″	219	27.2	15.0	25.71	Shells	July 19, 1929
439	31°52′00″	128°01′00″	155	26.9	15.6	25.59	Sand & shells	July 19, 1929
444	32°25′45″	128°37′30″	194	27.2	15.0	25.74	Sand & shells	July 20, 1929
451	32°43′00″	128°11′45″	187	28.0	14.0	25.67	Sand & shells	July 22, 1929

From the above table it may be noticed that the present species is distributed to the Pacific coast of southwestern Japan and the west coast of Kyûsyû. The northern limit of the Sôyô-maru material is at station 210, Sagami Bay, 33°29′20″N. lat., 135°28′25″E. long., and at the western coast of Kyûsyû, the northern limit is at station 451, off the Goto Islands, 32′43″N. lat., 128°11′45″E. long. The bathymetrical distribution ranges from 88 to 393 meters. All of the specimens were dredged during July of 1927 and 1929, during which time the surface water temperature ranged between 25.8°–28.0°C., and that of the bottom from 7.9° to 19.0°C. The specific gravity of the bottom water ranged between 25.34–25.74. The bottom material generally consists of sand with shell fragments and sometimes with mud, pumice and gravels.

Foreign distribution: Challenger station 192, off Ki Island, Philippine Islands in 129 fathoms. East Indian Archipelago. Siboga, station 95, 5°43.5′N., 119°40′E., in 522 meters. Siboga, station 96, southeast side of Pearl Bank, Sulu Archipelago, in 15 meters. Siboga, station 196(?), 2°28.5′S., 131°3.3′E., in 118 meters, and Siboga, station 45, 7°42′S., 118°15.2′E., in 794 meters.

Genus **Deltocyathoides** YABE and EGUCHI, 1932

1932. *Deltocyathoides* YABE and EGUCHI. YABE and EGUCHI, A Study of the Recent Deep-water Coral Fauna of Japan, Proc. Imp. Acad., Vol. 8, No. 3, p. 389.

1936. *Deltocyathoides* YABE and EGUCHI. VAUGHAN and WELLS, Check List of Generic Names applied to the Madreporaria Hexacoralla, 1758–1935 (mimeographic copy), p. 11.

Genotype:—*Deltocyathoides japonicus* YABE and EGUCHI Monotypic at present.

Deltocyathoides japonicus YABE and EGUCHI, 1932

Pl. XX (I), Figs. 23a-c.

1932. *Deltocyathoides japonicus* YABE and EGUCHI. YABE and EGUCHI, op. cit., p. 389, fig. 3.

Turbinolid. Corallum simple, bowl-shaped, keeled at the central part by 2, 3 or sometimes more septa of an older corallum which are partially enclosed. Calice circular; fossa deep. Columella very rudimental, formed of a few papillae, or almost lacking. Septa in 4 cycles complete, crowded, arranged bilaterally rather than radially; subequal in thickness, different in length, those of first cycle longest, those of second cycle slightly, and those of later cycles much shorter, all almost free in inner margin, or at least being not united markedly. Pali papilla-like in aspect, usually but not always developed in front of septa of second, third and fourth cycles; also occasionally pali-like structure present in front of septa of first cycle; margin entire; lateral sides

finely echinulate, pointed granules elongated and arranged on radial lines and also concentrically. Costae prominent, in alternation of narrow deep furrows, with abundant minute, prominent granules crowded on lateral sides. No epitheca.

Dimensions:—4–10 mm in height, 10–12 mm in diameter.

Remarks:—The genus is closely related to *Deltocyathus* and *Leptocyathus*, the genotype resembling especially *Deltocyathus* (*Paradeltocyathus*) *orientalis* DUNCAN on the one side and *Leptocyathus stimpsoni* POURTALÈS on the other. Characteristic to *Deltocyathus* (*Paradeltocyathus*) are pali and columella better and more regularly developed and costae in deltoid groups; to *Leptocyathus* are pali present constantly in front of each septum. However, most peculiar to the present coral is its growth on septa of an older individual, reminding one of septal building.

The localities together with the geographical positions and other oceanographical data of the Sôyô-maru stations are given in the following table. In distribution, this species is confined to the Pacific waters of the Japanese Islands south of Rikuzen province.

The geographical positions and oceanographical data of the Sôyô-maru stations are:—

Register Number	Station Number	North latitude	East longitude	Depth in m	Surface temp. °C	Bottom temp. °C	Bottom sp. gr.	Bottom material	Date
50091	21	36°46′40″	141°14′00″	209	15.3	7.5	25.34	Sand	June 27, 1926
53677	200	34°07′00″	136°41′30″	355	23.6	8.0	25.55	Sandy mud	July 11, 1927
53678	204	33°55′00″	136°18′30″	324	24.2	8.8	25.46	Sand	July 12, 1927
53680	135	38°17′00″	141°45′00″	159	16.4	—	—	——	Nov. 21, 1925
53679	249	35°03′30″	139°07′20″	229	20.4	13.2	25.67	Gravel & sandy mud	Nov. 9, 1927
56585	259	34°41′15″	138°43′00″	188	19.8	12.0	25.61	Sandy mud	Nov. 15, 1927

Genus **Discotrochus** M. EDWARD and J. HAIME, 1848

Genotype: *Discotrochus orbignyanus* M. EDWARDS and J. HAIME.

"Le polypier est simple, discoide, libre et sans trace d'adhérence. Le calice est subplane et la columelle fasciculaire et papilleuse à sa calice. Les cloisons débordent peu en dehors. La muraille est horizontale, nue, et présente des cotes simples".[1]

The genus *Discotrochus* was first proposed by MILNE EDWARDS and J. HAIME in 1848 on *D. orbignyanus* from the Eocene of Alabama, and in a later work they recorded an additional species *D. michelottii* from the Miocene of Italy; their generic diagnosis quoted above was accepted later by P. M. DUNCAN[2] and others without any essential alteration.

In 1900, T. W. VAUGHAN[3] took the type species from the Eocene of North America into revision, describing it more in detail, especially as to its younger forms and to variations. In this occasion, he mentioned more precise accounts of the generic character and enumerated its localities, with important additional remarks made relating to the septa of higher orders which unite

1) MILNE EDWARDS and J. HAIME: Histoire Naturelle des Coralliaires ou Polypes proprement dits, Vol. 2, p. 75, 1857.

2) P. M. DUNCAN: op. cit., p. 30.

3) T. W. VAUGHAN: The Eocene and Lower Oligocene Coral Faunas of the United States with Descriptions of a few Doubtfully Cretaceous Species, U. S. Geol. Surv. Monograph, Vol. 39, p. 79, 1900.

by pseudosynapticles to the older ones, and relating to septal margin which is crenate instead of being entire as in the usual Turbinolids. Species then known of the genus were *D. duncani* REUSS[1] from the Miocene of Austro-Hungary, and *D.? alternans* SOKOLOW[2] from the Lower Oligocene of Jekaternoslow, southern Russia, in addition to the two species cited by MILNE EDWARDS and J. HAIME.

J. FELIX enumerated in the "Fossilium Catalogus"[3], 1925, two other species of the genus, *D. italicus* D'ARCHIARDI, 1866, from the Lower Oligocene of Veronesia, and *D. veronensis* PELL. and PIZZ., 1886, from the Middle Oligocene (Tongrian) of Gassino, Turin; the same author listed three more species in his Anthozoa Miocaenica[4], 1927, *D. novaki* PROCHATZKA, 1893, from the Middle Miocene (Helvetian) of Borace, Tchekoslovakia, *D. ottnangensis* PROCHATZKA from the Lower Miocene (Older Mediterranean) of Schlier von Ottnang, Upper Austro-Hungary, and *D. pausramensis* OPPENHEIM[5], 1923, from the Miocene (Niemschitz beds) of Pausram, Tchekoslovakia. According to him, the first and second Miocene species are nom. nud., being neither described nor figured.

In 1893, A. ALCOCK[6] recorded to the first time, a living species of the genus, *D. investigatoris,* from the Indian Ocean. Nine years later he[7] added also to our knowledge one more living species, *D. dentatus* on eight specimens of the Siboga Expedition from the Philippine sea; all of these specimens are coarsely serrated along the septal margin, a feature worthy of special attention.

Among numerous specimens of simple corals from Japan, there are three species, one resembling the Miocene species *Discotrochus duncani* REUSS, one thought to be safely referable to *D. dentatus* ALCOCK and another reminding one of the same species or of *D. investigatoris* ALCOCK. *D. duncani* and its Japanese ally, *minimus* sp. nov., differ considerably from the genotype of *Discotrochus, D. orbignianus,* in several features, and may well be separated from it under a new subgenus *Cylindrophyllia* with *D. minimus* as the type; also *D. dentatus* differs from *D. orbignians* by having simple septa with coarsely dentate margin. This distinguishing feature taken into consideration, *dentatus* not only may not have no real affinity with *Discotrochus,* but also may not belong to the same family with it; on the other hand, the kindship of the species *dentatus* and its allies to *Anthemiphyllia pacifica* VAUGHAN[8] can not be overlooked. At present having no sufficient knowledge about the genotype of *Anthemiphyllia* and having no specimen of *Anthemiphyllia pacifica* for direct comparison with *dentatus,* we are not in position to carry on discussions on the subject, and *"Discotrochus"* is here used for *dentatus* and its allies in quota-

---

1) A. E. REUSS: Die fossilen Korallen des Oesterr.-Ungar. Miocäns. Denkschr. d. Math.-Naturwiss. Cl. d. k. Akad. d. Wiss. Wien, Bd. 31, p. 29, 1874.

2) N. SOKOLOW: Die unteroligocäne Fauna der Glauconitsande bei der Eisenbahnbrüke von Jekaterinoslow, Mém. du Comm. géol., Vol. 9, No. 3, p. 94, 1894.

3) J. FELIX: Anthozoa eocaenica et oligocaenica, Foss. Cat., 1, Anim., Pars 28, p. 177, 1925.

4) J. FELIX: Anthozoa miocaenica, ibid., Pars 35, p. 400, 1927.

5) P. OPPENHEIM: Ueber Alter u. Fauna des Tertiärhorizontes der Miemschitzer Schichten in Mähren, Berlin, p. 17, 1923.

6) A. ALCOCK: On Some New and Rare Corals from the Deep Waters of India, Jour. Asiatic Soc. Bengal, Vol. 42, Pt. 2, 1893 (cited after ALCOCK).

7) A. ALCOCK: op. cit., 1902.

8) T. W. VAUGHAN: Recent Madreporaria of the Hawaiian Islands and Laysan, Bull. U. S. Nat. Mus., No. 59, p. 79, 1907.

tion marks in the view of our doubt as to the generic position of those species, although previous authors have assigned them to *Discotrochus*[1].

The Japanese species to be described below are;

"Discotrochus" dentatus ALCOCK

"Discotrochus" species indet.

Discotrochus (*Cylindrophyllia*) *minimus*, subgen. et sp. nov.

The typical specimens of the last species are from the Byôritu beds of Taiwan (Formosa) as fossil; similar specimens are recently procured from Toyama Bay, and varietal ones, decidedly larger in size from a raised beach deposit of Simabara Peninsula, Kyûsyû; hence its range in time is from the Miocene to recent. On the other hand, the former two species are mostly represented by the recent material; the first species being known as fossil only from the Plio-Pleistocene Ryûkyû limestone of Kikai-zima, Ryûkyû limestone of Kikai-zima, Ryûkyû Islands.

"Discotrochus" dentatus ALCOCK

Pl. XX (I), Figs. 15a–c.

1902. *Discotrochus dentatus* ALCOCK, Systematic Account of the Siboga Deep-Sea Madreporaria, Siboga Expeditie, 16a, p. 27, pl. 4, figs. 26, 26a.

1927. *Discotrochus dentatus* FAUSTINO, Recent Madreporaria of the Philippine Islands, Philippine Bur. Sci., p. 63, pl. 7, figs. 1, 2.

This species was first established by ALCOCK on 8 specimens collected by the Siboga Expedition from the Sulu Sea, under the original description as follows;

"Corallum quite flat and discoidal, of thick coarse texture. On the horizontal base is a faint scar of attachment from which numerous equal well-cut costae radiate. Septa hardly exsert beyond the thick peripheral margin, in six systems and five cycles, the fifth cycle being in complete in a few of the half-systems. The septa of the fifth cycle are thin, but those of all the other cycles are coarse and have their edges deeply and coarely serrated throughout. Though the septa of the first cycle are distinctly the largest, those of the second and even of the third cycle are not very much smaller. There is no union of septa, except at the columella, where those of the first three cycles, and usually of the fourth cycle also, meet. The columella, which is small and fascicular and consists of little but the united ends of septa, is studded with a few coarse subprismatic granules. The diameter of the disk of the largest specimen is 19 mm".

ALCOCK distinguished this species from the allied *Discotrochus investigatoris* ALCOCK, by having the septa less crowded though more numerous.

We have 20 specimens dredged from 12 stations of the Sôyô-maru, specimen collected by the Fisheries Experimental Station of Tiba Prefecture, and 5 fossil ones from the Ryûkyû limestone of Kikai-zima. They show some variations among themselves relating to size (varying in diameter from 14.5 to 27.5 mm), number of septa and dentations of septal margin. These minor differences excluded, all of them well agree with the original description quoted above. Noteworthy are two juvenile specimens which attach to the substratum. The following table shows the dimensions of the Japanese specimens examined, with their respective localities.

---

1) H. GERTH once described *Anthemiphyllia verbeeki* and *A. patella*, both new, from the Tertiary of Java. The first species was later transferred by him to *Pattalophyllia*, while the latter seems to be no doubt an ally of *"Discotrochus" dentatus*. H. GERTH, Coelenterata, Samml. geol. Reichs-Mus. Leiden, N. F., Vol. I, 2nd Div., fasc. 3, p. 404, 1923. H. GERTH, Neue Beiträge zur Kenntnis der Korallenfauna des Tertiärs von Java. I, Die Korallen des Eocaen und des älteren Neogen. Wet. Meded. Dienst Mijnb. Nederlandsch-Indie, No. 25, p. 25, 1933.

Locality	Septa Number	Diameter in mm	Height in mm	Remarks	Register Number
179	76	19.5	8		50029
,,	64	17	6		50029
,,	78	17	5.5		50029
210	96	22	4.5		50030
220	83	20	5.5		50026
239	70	17.5	6.5		50025
280	97	14.5	3.5	Columella rudimentary	50024
,,	86	23	7		50024
,,	86	27.5	9		50024
283	—	—	—	Fragment	56570
*286	86	23.8	7.2		50010
,,	86	26.9	7.5		50028
293	70	18	6		50031
,,	63	15	5		50031
301	74	20	7		50037
,,	62	18	6		50037
327	75	14.5	4	Attached	50036
352	78	20.5	7		50092
,,	89	20.5	7		50092
420	72	19.6	7		50027
440	72	19	7		50032
,,	78	18	6.5		50032
520	68	16.7	4.6		59088
45+	44	10.4	4.5	Attached	59074
Kikai-zima (fossil)	67	17	5		50021
	67	16	5.5		50021
	62	12	4		50021
	?	20	6	Fragment	50021
	?	16(?)	5(?)	Fragment	50021

Numerals in the first column are the station numbers of the Sôyô-maru and that marked with a cross is that of the Fisheries Experimental Station of Tiba Prefecture. The specimen marked with an asterisk is figured.

The geographical position and oceanographical data of the Sôyô-maru Stations are given in the following table.

Register Number	Station Number	N. lat.	E. long.	Depth in m	Water Temperature		Bottom Sp. Gr.	Bottom Material	Date
					Surface	Bottom			
50029	179	34°31′30″	138°52′00″	187	23.4°C	19.3°C	25.67	Sand & stones	June 28, 2927
50030	210	33°29′20″	135°28′25″	165	26.1	16.1	25.73	Fine sand	July 14, 1928
50026	220	33°07′20″ 33°15′20″	134°10′00″ 134°01′00″	234	27.5	11.8	25.58	Sand & shells	July 19, 1927
50025	239	35°06′00″	139°39′10″	303	12.3	9.3	25.67	Sand & stones	Nov. 6, 1927

Register Number	Station Number	N. lat.	E. long.	Depth in m	Water Temperature		Bottom Sp. Gr.	Bottom Material	Date
					Surface	Bottom			
50024	280	34°32′50″	138°28′15″	273	22.5	20.8	25.50	Mud	July 2, 1928
56570	283	34°38′25″	138°26′30″	177	22.3	12.0	25.52	Gravel, mud, shells & sand	July 4, 1928
50023	286	34°36′10″	138°26′30″	123	22.4	14.3	25.70	Sand & mud	July 4, 928
50031	293	30°45′00″	130°40′40″	203	27.3	14.3	25 68	Gravel & pumice	July 10, 1927
50037	301	31° 3′10″	131°26′10″	181	26.9	16.8	25.73	Gravel, sand & shells	July 12, 1928
50036	327	32°48′50″	132°30′10″	216	27.0	13.1	25.64	Sand & shells	July 14, 1928
50092	352	33°39′50″	135°06′30″	154	26.3	16.7	25.68	Sand & shells	Aug. 1, 1928
50027	420	31°22′15″	129°42′30″	132	25.6	16.8	25.71	Corals	July 15, 1929
50032	440	32°12′15″	128°06′30″	155	26.9	15.6	25.29	Sand & shells	July 19, 1929
59088	525	35°48′00″	138°07′30″	75	27.8	23.3	25.29	Sand	Aug. 23, 1929

All of these stations lie on the Pacific side of the Japanese Islands and the northernmost station is St. 239, off Misaki, Miura Peninsula. The range in depth is 123–273 m, that in bottom water temperature is 9.3–19.3°C., and that in the specific gravity of the bottom water is 25.22–25.73.

Ryûkyû limestone of the Plateau above Kamikatetu, Kikai-zima, Osima-gun, Osumi province. Reg. No. 50021.

Foreign localities: Southern end of the Sulu Sea (ALCOCK). Siboga Expedition stations 95, 5°43.5′N., 119°40′E., 522 m, 4 specimens; 98, 6°9′N., 120°21′E., 350 m, 3 specimens, and station 100, 6°11′N., 120°37.5′E., 459 m, 1 specimen.

"*Discotrochus*" species indet.

Corallum very variable in shape, basal disc exceeding calice in diameter in some specimens and the relation reversed in others. Septa 48 in number, 4 cycles complete; rarely with a few additional ones of the fifth; reducing in size with the increase in number of cycles; sharply serrate along their upper margin. Costae subequal, low and broad, alternating with narrow furrows and disappearing toward the finely granulated central part of base. Surface of septa and costae covered all over by fine, low granules. Calice completely filled up by sharply serrated septa and papillous columella; interseptal loculi narrow, narrower than in the preceding species.

Remarks:—The present form does not much differ from the preceding species, and it is by no means improbable that it may represent a mere variety of that species. But on account of its small sized corallum with less numerous and yet crowded septa, it may more closely be related to *D. investigatoris* ALCOCK. Unfortunately we have no copy of ALCOCK's report at hand in which he described this species and can not bring our material into direct comparison of corallum and the nature of the septal margin; the present form also resembles *Anthemiphyllia pacifica* VAUGHAN to a considerable degree though the septa are more crowded in ours. The specific determination is postponed until the aquisition of the necessary literature in concern.

The localities of this indetermined species are given below;

Register Number	Station Number	N. lat.	E. long.	Depth in m	Water Temperature		Bottom Sp. Gr.	Bottom Material	Date
					Surface	Bottom			
50080	220	33°07′20″ 33°15′20″	134°10′00″ 134°01′00″	234	27.5°C	11.8°C	25.58	Sand & shells	July 19, 1927
50079	293	30°45′00″	130°40′40″	203	27.3	14.3	25.68	Gravel & pumice	July 10, 1928
50082	427	32°07′50″	129°44′45″	499	26.2	8.7	25.54	Sand & mud	July 16, 1929
50081	429	32°16′15″	129°33′45″	223	26.4	13.7	25.68	Rock & gravel	July 16, 1929

There are 7 specimens of this form derived from 4 stations in the southwestern seas of Japan; the northernmost locality along the Pacific coast for this form is Station 220, off Tosa in Sikoku, and that of the opposite side Station 427, off Amakusa, Kyûsyû. The geographical positions and other oceanographical conditions at the time of dredge operation are given in the table above.

Discotrochus (Cylindrophyllia) minimus, sp. nov.

Pl. XX (I), Figs. 16–22.

Corallum thick discoidal or short cylindrical, usually 2 × 1 mm in size, calicular and basal surfaces horizontal. Base flat, without any sign of attachment, ornamented with 24 costae, 6 costae which correspond to primary septa arranged radially from the centre of base in alternation with 3 costae forming a deltoid group. Lateral surface normal to base and calicular plane, provided with strong subequal costae in alternation with a deep furrow. Calice shallow, filled up by septa and columella, presenting an aspect quite similar to base except for interseptal loculi being hollow downward to base, while intercostal furrows on base are limited above by its compact wall. Columella built of a few papillae at inner end of septa. Septa 24 in number, 3 cycles complete; primaries extending to columella, secondaries also reaching columella with shorter tertiaries attached to middle of lateral surface. Upper margin of septa subentire, lateral faces finely granulated. Outer surface of corallum densely covered by fine granules.

Remarks:—This minute form is very similar to *Discotrochus duncani* REUSS from the Miocene of the Vienna basin; the Vienna species which falls in the same subgenus with this, is decidedly larger in size, being 3.5 mm in diameter and 1.5–3 mm high and has all the costae grouped into 6 deltoids, with primaries not free from the others.

In the general shape of corallum it bears some resemblance to the juvenile specimens of *Peponocyathus orientalis* YABE and EGUCHI, which is, however, generically distinct by having well developed pali; furthermore, full grown individuals of that species far exceed the present form in dimensions.

This species is widely distributed in the younger Neogene Byôritu beds of Taiwan and ranges to recent, as several specimens obtained by Mr. K. KIKUCHI from Toyama Bay may probably be living ones. A similar form is known from a Neogene deposit near Motona, Hoda-mati, Tiba prefecture, and a large varietal one from the raised beach deposit of Simabara Peninsula, Kyûsyû.

Localities:

700 m East of Hakusyaton, Goryû-syô, Tikunan-gun, Sintiku-syû, Taiwan, Byôritu beds, Reg. No. 50011.

1000 m SE of Hakusyaton, ibid., Reg. Nos. 60382, 60390.

NE of Nansei-zan, ibid., Reg. No. 60393.

E of Kityô, ibid., Reg. No. 50023.

Wanga, ibid., Reg. Nos. 50012, 60381, 60383, 60385.

West of Dairyô, ibid., Reg. No. 50022. 47 specimens.

500 m SE of Zyô-tusyôwan, Tusyô-syô, Byôritu-gun, Sintiku-syû, Reg. No. 60395.

400 m SE of Zyô-tusyôwan, ibid., Reg. No. 60360.

510 m SE of Zyô-tusyôwan, ibid., Reg. No. 30361.

Upper course of the streamlet near Motona, Hoda-mati, Awa-gun, Tiba prefecture, Neogene, Reg. No. 50547.

Toyama Bay, Recent, Reg. Nos. 58224, 60416.

Postscript

After having sent this manuscript to press, we received from Dr. J. W. WELLS his recent publication "Coral Studies: Pt. I, Two New Species of Fossil Corals. Pt. II, Five New Genera of the Madreporaria" (Bull. Amer. Paleontology, Vol. XXIII, 1937), in which he assigned *Discotrochus duncani* REUSS to *Kinotrochus* DENNANT, with *K. suteri* DENNANT as the genotype, and described a new species *K. lecomptei* from the Miocene of Belgium. The last species is also very similar to the Japanese form in its discoidal corallum.

PLATE XX (I)

Figs. 1–10. *Deltocyathus* (*Paradeltocyathus*) *orientalis* DUNCAN × 2

Living specimens.

Figs. 1 a–c. Sôyô-maru station 222, Reg. No. 50004.

Figs. 2 a–c, 3 a–c. Sôyô-maru station 520, Reg. No. 50005.

Figs. 4 a–c. Sôyô-maru station 251, Reg. No. 50006.

Figs. 5 a–c. Sôyô-maru station 254, Reg. No. 50007.

Fossil specimens.

Figs. 6 a–c. Bôsihô, Tanko-syô, Byôritu-gun, Sintiku-syû, Taiwan; Byôritu beds, Reg. No. 38263.

Fig. 7. Otisimosinden, Sitô-mura, Itihara-gun, Kazusa province. Younger Cenozioc, Reg. No. 43425.

Figs. 8 a–c. Kotinda, Kotinda-mura, Okinawa-zima; Simaziri beds, Reg. No. 39215.

Fig. 9. Tônohama, Yasuda-mura, Aki-gun, Tosa province. Younger Cenozoic, Reg. No. 50008.

Figs. 10 a–c. Kamikatetu, Kikai-mura, Osima-gun, Osima province; Uppermost Pliocene, Reg. No. 50009.

Figs. 11 a–c. *Deltocyathus vaughani* YABE and EGUCHI ca. × 2

Sôyô-maru station 336, living, Reg. No. 50003.

Figs. 12 a–c. *Deltocyathus vaughani* YABE and EGUCHI × 2

Sôyô-maru station 336, living, Reg. No. 50003.

Figs. 13 a–c, 14 a–c. *Deltocyathus magnificus* MOSELEY × 2

Fig. 13. Sôyô-maru station 325, living, Reg. No. 50001.

Fig. 14. Sôyô-maru station 301, living, Reg. No. 50002.

Figs. 15 a–c. *"Discotrochus" dentatus* ALCOCK ca. × 2

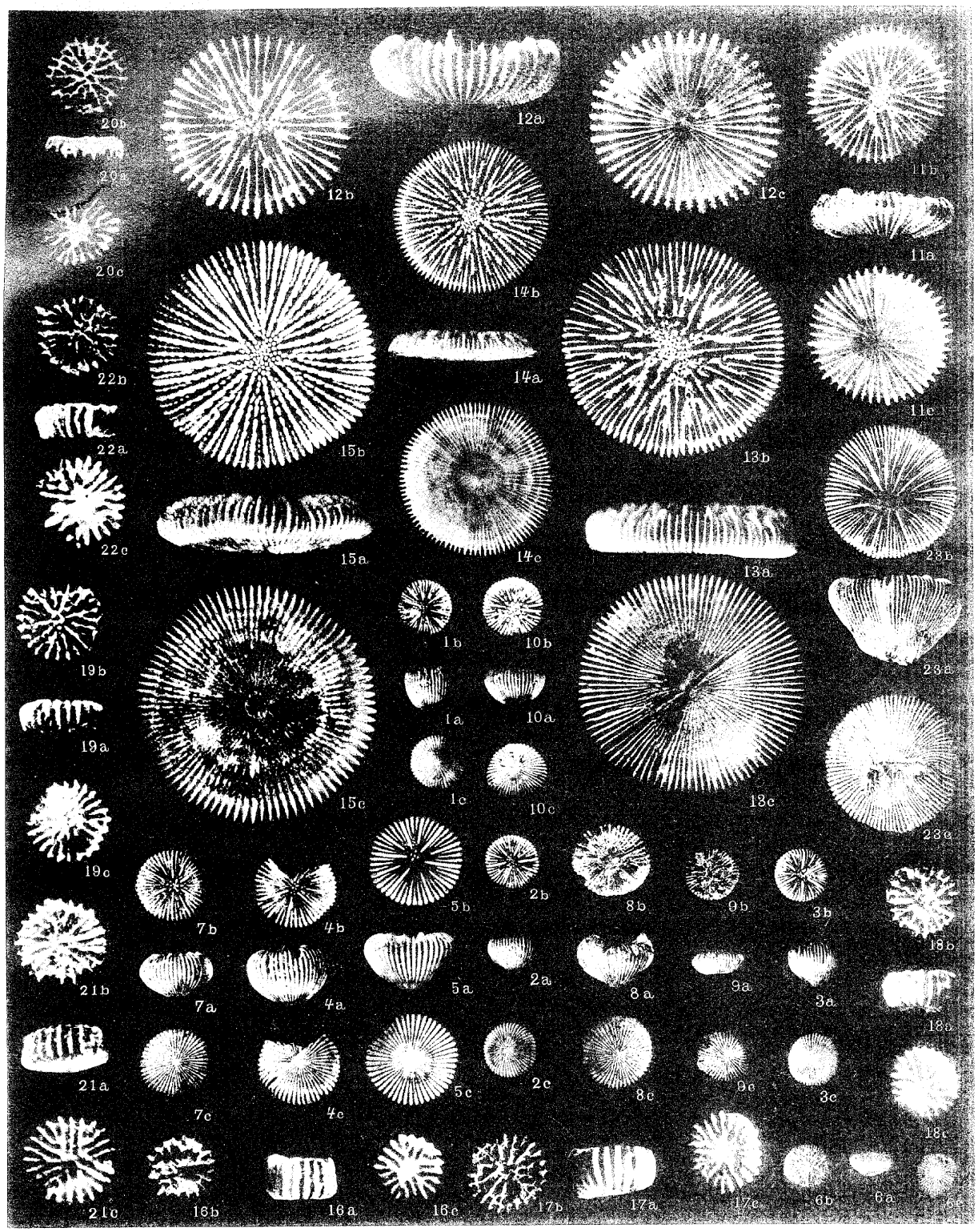
Sôyô-maru station 286, living, Reg. No. 50010.

Figs. 16–22 a–c. *Discotrochus* (*Cylindrophyllia*) *minimus* YABE and EGUCHI ca. × 8

Locality: 700 meters east of Hakusyaton, Goryû-syô, Tikunan-gun, Sintiku-syû; Byôritu beds, Reg. No. 50011.

Figs. 23 a–c. *Discocyathoides japonicus* YABE and EGUCHI ca. × 4

Sôyô-maru station 21, living, Reg. No. 50091.



K. Kimura photo.