Scleractinia of the Temperate North Pacific

STEPHEN D. CAIRNS

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ABSTRACT

Cairns, Stephen D. Scleractinia of the Temperate North Pacific. *Smithsonian Contributions to Zoology*, number 557, 150 pages, 3 figures, 42 plates, 5 tables, 1994.—The 119 species of temperate North Pacific azooxanthellate Scleractinia are described or diagnosed in two separate accounts: the 25 species known to occur in the temperate northeastern Pacific and the 102 species known to occur in the temperate northwestern Pacific, there being only eight species in common. Three genera, six species, and one subspecies are described as new; nine new combinations are suggested; and 28 new records for the northern temperate regions are reported. A neotype for *Desmophyllum dianthus* (Esper, 1794) is designated. A dichotomous key to the temperate northeastern Pacific Scleractinia is provided, as well as a key to the seven species of northwestern Pacific *Truncatoflabellum*. Separate historical resumes are discussed and tabularized for the northeastern and northwestern temperate faunas. The study is based on new material from a variety of sources, but primarily from the cruises of the *Albatross* (USNM) and the R/V *Tansei Maru* (ORI), and the collections of the California Academy of Sciences, Royal British Columbia Museum, and the Scripps Institution of Oceanography.

The region covered in this account extends from Bahia Magdalena on the Pacific coast of Baja California to Formosa Strait, off China, including two warm temperate provinces (California and Japan) and four cold temperate provinces (Oregon, Aleutian, Oriental, and Kurile). The most species-rich temperate region is the warm temperate northwestern Pacific Japan Province, which contains 92 azooxanthellate species. This province is directly adjacent to the even more species-rich Indo-West Pacific tropical region from which it receives many tropical and eurythermic tropical species via the warm, northerly flowing Kuroshio Current. Azooxanthellate species diversity decreases with higher latitude: 106 species occur in the combined warm temperate North Pacific provinces, 37 in the lower boreal provinces (Oregon and Oriental), and only 14 species occur in the combined upper boreal provinces (Aleutian and Kurile). The northernmost record of a scleractinian coral in the North Pacific is *Caryophyllia arnoldi* from Prince William Sound (60°48′N) in the Aleutian Province. This province also holds the record for the deepest living scleractinian coral, *Fungiacyathus marenzelleri*, at 6328 m in the Aleutian Trench.

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Contents

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Introduction

The temperate North Pacific coral region, as defined in greater detail in the Zoogeography section, extends from Bahia Magdelena on the Pacific coast of Baja California to Formosa Strait, China, and spans six zoogeographic provinces. The taxonomic and zoogeographic accounts are separated into northeastern and northwestern Pacific sections, the dividing point being the channel between the Aleutian and Commander islands, such that each section could be used as a regional faunistic guide. This separation is supported by an almost completely separate body of literature on the corals from these two regions (see Tables 1, 2), as well as an essentially separate fauna in each of the two regions. Of the 119 azooxanthellate species known from the temperate North Pacific, only eight species occur in both regions, most of those being cosmopolitan species.

Only seven new species or subspecies are described in this account, a surprisingly low 6% of the fauna, which is a tribute to the earlier efforts of M. Eguchi, H. Yabe, J.W. Durham, and J.L. Barnard between the years 1932–1973.

The most interesting zoogeographic result of this study was to show the strong influence of the Indo-West Pacific tropical fauna on the warm temperate northwestern Pacific Japan Province. As more Indo-West Pacific azooxanthellates are found in the Japan Province and as more Japanese "endemics" are synonymized with previously described species common in the Indo-West Pacific realm, it becomes increasingly apparent that the Japan Province is the northern border/transition zone of the dominant Indo-West Pacific fauna, a conclusion also reached by Veron (1992:3) regarding hermatypic (zooxanthellate) corals. As a result, an increasing number of species are now known to have distributions extending from the southwestern Indian Ocean to the southern coasts of Kyushu and Honshu.

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Abbreviations

Museums and Collecting Institutions

AHF	Allan Hancock Foundation, University of Southern California, Los Angeles
BM	British Museum (Natural History), London
CAS	California Academy of Sciences, San Francisco
IOM	Institute of Oceanology, Moscow
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge
MNHNP	Muséum National d'Histoire Naturelle, Paris
NMCIC	National Museum of Canada (Canadian Museum of Nature), Invertebrate Collection, Ottawa
NMW	Naturhistorisches Museum, Wien
ORI	Ocean Research Institute, University of Tokyo, Tokyo
RBCM	Royal British Columbia Museum, Victoria, Canada
RMNH	Rijksmuseum van Natuurlijke Historie, Leiden
SBMNH	Santa Barbara Museum of Natural History, Santa Barbara
SIO	Scripps Institution of Oceanography, University of California, La Jolla
TIUS	Institute of Geology and Paleontology, Tohoku (Imperial) University, Sendai, Japan
UA	University of Alaska Museum, Fairbanks
UCMP	University of California, Berkeley, Museum of Paleontology
USNM	former United States National Museum, collection now in National Museum of Natural History, Washington, D. C.
YPM	Yale Peabody Museum of Natural History, New Haven
ZMA	Zöologisch Museum, Amsterdam
ZMB	Zoologisches Museum, Berlin
ZMC	Zoologisk Museum, Copenhagen

Vessels and Expeditions

Alb	U.S.F.W.S. *Albatross*
OCSEAP	Outer Continental Shelf Environmental Assessment Program
SEPBOP	South East Pacific Biological Oceanographic Program
TM	R/V *Tansei Maru* (operated by the ORI)

Morphological Terms

GCD	Greater Calicular Diameter
GCD:LCD	Ratio of greater calicular diameter to lesser calicular diameter

D:H	Ratio of calicular diameter to height of a corallum
H:D	Ratio of height to diameter of a corallum
LCD	Lesser Calicular Diameter
PD:GCD	Ratio of pedicel diameter to greater calicular diameter
S_x, C_x, P_x, CS_x	Septa, costae, pali, or costosepta (respectively) of cycle designated by numerical subscript
$S_x > S_y$	Septa of cycle x more broad than those of cycle y

ACKNOWLEDGMENTS.—I dedicate this publication to the memory of my friend and fellow Smithsonian curator, J. Laurens Barnard (1928–1991). Much better known as an amphipod taxonomist and even as an amateur ornithologist, Jerry Barnard co-authored one paper on scleractinian corals early in his career (Durham and Barnard, 1952), which has served as the basis for coral taxonomy of the eastern Pacific.

I especially thank Yoshihisa Shirayama (ORI) for allowing me to study the diverse deep-water coral collections made off southern Japan by the R/V *Tansei Maru*. I am also very grateful to Helmut Zibrowius (Station Marine d'Endoume) and Harry Filkorn (Kent State University) for their meticulous efforts in reviewing this manuscript.

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The scanning electron photomicrographs were taken in the SEM Laboratory of the National Museum of Natural History, Smithsonian Instituion. Figure 2 was drawn by staff illustrator Molly Ryan.

Historical Resumes

TEMPERATE NORTHEASTERN PACIFIC (Table 1).—The earliest report of a scleractinian from the temperate northeastern Pacific appears to have been the original description of *Balanophyllia elegans* Verrill, 1864, from off northern California. That this should have been the first species reported is not unexpected because it is one of only three shallow-water species known from this region and it has a very colorful polyp. Shortly thereafter, Verrill (1869) described the second of the three shallow-water species, *Paracyathus stearnsii*, from off Monterey, California.

All subsequent records from this region are listed in Table 1, only the larger taxonomic papers or series of papers being discussed below. The first comprehensive review of the eastern Pacific Scleractinia was that of Durham (1947), who reported the corals from the E. W. Scripps Expedition to the Gulf of California made in 1940. Durham expanded his revision to the coral fauna north of the Gulf as well, including 15 records of species from the temperate northeastern Pacific, including seven new species: *Astrangia lajollaensis (= A. haimei), Cyathoceras (= Labyrinthocyathus) quaylei, Paracyathus montereyensis, Lophelia californica (= L. pertusa), Flabellum (= Polymyces) montereyensis, Dendrophyllia californica*, and *Balanophyllia cedrosensis*. Type and nontype material reported in this paper are deposited primarily at the University of California Museum of Paleontology (UCMP), but some are also represented in the collections of the CAS and USNM.

The most comprehensive review of the eastern Pacific Scleractinia was that of Durham and Barnard (1952), who based their new records on the collections of the *Velero III* and *IV*. Although they listed 98 species from the eastern Pacific, only 13 of these species pertain to the temperate northeastern Pacific as defined herein, including the description of four new species: *Cyathoceras (= Crispatotrochus) foxi, Dendrosmilia nomlandi (= Lophelia pertusa), Nomlandia californica*, and *Flabellum tannerense (= Polymyces montereyensis)*. Their type and nontype specimens were transferred from the Allan Hancock Foundation Museum to the Santa Barbara Museum of Natural History in 1990.

In a series of three papers, Keller (1976, 1977, 1981a) reported new records of *Fungiacyathus, Leptopenus*, and *Caryophyllia*, respectively, from bathyal and abyssal depths (to 6328 m) along the northern rim of the North Pacific from off Oregon to off Japan. Both *Fungiacyathus marenzelleri* and *Leptopenus discus* were reported for the first time from the temperate northeastern Pacific, but under different names. Her reports of *Caryophyllia ambrosia* and *C. alaskensis* are discussed in the text. Many of her *Vityaz* specimens were examined on loan from the IOM in 1991, but some voucher specimens are also deposited at the USNM.

Following the natural history observations of Gerrodette (1979, 1981) on the distribution and planular dispersal of *Balanophyllia elegans*, Fadlallah produced an excellent series of papers on the natural history of the three common, shallow-water temperate northeastern Pacific species: *Astrangia lajollaensis (= A. haimei), Balanophyllia elegans*, and *Paracyathus stearnsii* (see Fadlallah, 1982, 1983b; Fadlallah and Pearse, 1982a,b). Included in these papers are fascinating observations on reproductive ecology, sex ratios, periodicity of sexual cycles, planular sizes, growth rates, longevity, and population density of adult coralla.

Bythell (1986) published a fine identification guide to the 17 species occurring off Southern California (32°–35°N), his new records coming from the Scripps Institution of Oceanography Invertebrate Collection. Bythell included a key to the genera of this region and many useful illustrations, including some of the polyps and nematocysts.

Checklists and fieldguides too numerous to mention have included Scleractinia from the northeastern Pacific, all invariably including a reference to *B. elegans*. Although not listed in Table 1, some of these references are Ricketts and Calvin (1952), Guberlet (1962), Johnson and Snook (1967), Hand (1975), Brusca and Brusca (1978), Lewbel et al. (1981),

TABLE 1.—Chronology of Temperate Northeastern Pacific Scleractinian Publications (* denotes significant taxonomic publications).

Year	Author(s)	Comments
1864	Verrill	*Balanophyllia elegans* from off northern California
1869	Verrill	*Paracyathus stearnsii* and *P. caltha* n. spp. from off Monterey, California
1870a	Verrill	Additional records of *B. elegans* and original description of *Astrangia conferta* from off Mexico
1870b	Verrill	*B. elegans* from off Puget Sound, Washington
1886	Whiteaves	*Paracyathus caltha* and *B. elegans* from off British Columbia
1900	Vaughan	*Caryophyllia arnoldi* n. sp. from Pleistocene of San Pedro, California
1903	Vaughan	*C. pedroensis, C. californica* and *Paracyathus pedroensis* n. spp. from Pleistocene and Pliocene of San Pedro, California
1906a	Vaughan	*Coenocyathus bowersi* n. sp. from Channel Ids., California
1917	Hickman	Reiteration of British Columbia records of *B. elegans* and *P. caltha*
1924	Oldroyd	*Dendrophyllia oldroydi* n. sp. from off California
1931	Faustino	*Dendrophyllia oldroydi* n. sp. from off California
1936	Williams	Another report of *D. oldroydi* from off southern California
1941	Vaughan	*Caryophyllia alaskensis* n. sp. from Alexander Archipelago, Alaska
1943	Durham	*Dendrophyllia oldroydae* from Pleistocene of California
*1947	Durham	15 species, including 7 new species, from temperate Northeast Pacific
1949	Durham	6 species figured and discussed in context of description of polycyclic development
*1952	Durham and Barnard	13 species, including 4 new species, reported from temperate Northeast Pacific
1956	Emerson	*B. elegans* from Pacific, Baja California
1961	Addicott	*B. elegans* from Pleistocene of central California
1966	Durham	Noncritical listing of 103 species of Scleractinia from East Pacific
1972	Talmadge	*B. elegans* from Washington and British Columbia; *C. alaskensis* from Alaska; *Desmophyllum cristagalli* from northern California
1976	Keller	First record for region of *Fungiacyathus marenzelleri* (as *F. symmetricus aleuticus*) from off Alaska
1977	Keller	*Leptopenus irinae* (=*L. discus*) from off Alaska and Washington
1979	Gerrodette	Discussion of equatorial submergence of *B. elegans*
1981a	Keller	New records of two species of *Caryophyllia* from off Oregon and Alaska
1981	Gerrodette	Discussion of planula dispersal of *B. elegans*
1982	Fadlallah	Reproductive ecology of *Astrangia lajollaensis*
1982a	Fadlallah and Pearse	Discussion of sexual reproduction in *B. elegans*
1982b	Fadlallah and Pearse	Discussion of sexual reproduction in *P. stearnsii*
1983b	Fadlallah	Discussion of population dynamics of *B. elegans*
*1986	Bythell	Identification guide to 17 species occurring off southern California
1991a	Cairns	*Oculina profunda* n. sp. from off central California
1991	Hellberg	Discussion of larval dispersal in *B. elegans* (Abstract)
in press	Wilson	*Madracis* sp. cf. *M. pharensis* and *Phyllangia consagensis* from off Rocas Alijos, off Baja California

Kozloff (1983, 1987), and Austin (1985). Other useful regional references, but concerned primarily with tropical eastern Pacific species, are Marenzeller (1904b), Vaughan (1906b), Squires (1959), Parker (1964), and Wilson (1990).

In this paper 25 species are reported from the northeastern temperate Pacific (Table 4), including six new records for the region and two new species. One species not included in the species account, however, is *Solenosmilia variabilis* Duncan, 1873, which was reported from shallow water (0–200 m) off Knight Island, British Columbia by Austin (1985) in his checklist of invertebrates from the northeastern Pacific coast. Austin's specimen could not be obtained for verification. *Solenosmilia variabilis* is a widespread deep-water species that occurs throughout the Atlantic and Indian Oceans and Subantarctic region at depths of 220–2165 m (Cairns, 1982). Heretofore, it has not been reported elsewhere in the Pacific Ocean or at depths shallower than 200 m, both of which cast doubt on the British Columbia record.

TEMPERATE NORTHWESTERN PACIFIC (Table 2).—The earliest record of azooxanthellate corals from the temperate northwestern Pacific appears to be that of Gray (1849), who listed three previously described species from "off Japan," all based on specimens deposited at the BM: *Flabellum distinctum* Milne Edwards and Haime, 1848a (= *F. pavoninum*), *F. bairdi* Milne Edwards and Haime, 1848a (= *Truncatoflabellum bairdi*), and *F. elegans* Milne Edwards and Haime, 1848a

TABLE 2.—Abbreviated Chronology of Temperate Northwestern Pacific Scleractinian Publications (* denotes significant taxonomic works).

Year	Author(s)	Comments
1849	Gray	3 species of *Flabellum* reported off Japan
1850b	Milne Edwards and Haime	*Cyathelia axillaris* listed for Japan
1857	Milne Edwards and Haime	*Desmophyllum dianthus* reported from off Japan
1865	Verrill	*Eupsammia stimpsoniana (= Balanophyllia stimpsonii)* from "North China Sea"
1871	Kent	2 new species described from off Japan
1876	Duncan	2 new species described from off Honshu, Japan
1881	Moseley	*Flabellum japonicum*, new species, described from Sagami Bay
1888	Ortmann	*Stephanophyllia superstes*, new species, described from Sagami Bay
1888a	Marenzeller	3 species of *Flabellum* reported from off Japan, one new
1888b	Marenzeller	3 species reported from Sagami Bay, including 2 new species
1892	Rehberg	3 new species reported off Japan
1900	Vaughan	*Levipalifer orientalis*, new species, described off Honshu
*1922	Van der Horst	5 dendrophylliid species reported from off Japan, including 1 new species
*1932g	Yabe and Eguchi	Revision of fossil and Recent *Stephanophyllia* from Japan
*1937	Yabe and Eguchi	Revision of *Deltocyathus* from Japanese region
*1942a	Yabe and Eguchi	Revision of the 13 species of the genus *Flabellum* from off Japan
*1942b	Yabe and Eguchi	84 fossil and Recent species of solitary corals reported from off Japan, including 14 new species
*1968	Eguchi	62 Recent species reported from Sagami Bay, including 12 new species
1976	Keller	Deep-water *Fungiacyathus* reported from off Hokkaido
1977	Keller	Abyssal *Leptopenus* reported from off Kurile Islands
1977	Cheng	*Flabellum apertum* reported off Kyushu
1980	Mori and Minoura	Ontogeny of *Flabellum coalitum* (= *F. pavoninum*) discussed
1981	Zou	Checklist of azooxanthellates from East China Sea
1981a	Keller	Deep-water *Caryophyllia* reported from off Kurile Islands
1982	Keller	Deep-water *Deltocyathus* reported from off Honshu
1982	Song	First report of azooxanthellate corals from off South Korea
1983	Mori and Minoura	Discussion of genetic control of septal number in *Cylindrophyllia orientalis*
1986	Yajima	Distribution of *Rhizopsammia minuta mutsuensis* discussed
1986a	Owens	*Rhombopsammia squiresi*, new species, descibed from off Kyushu
1987	Mori	Discussion of genetic control of septal number in *Caryophyllia compressa*
1989a	Cairns	Several azooxanthellate corals reported from off Pratas Islands, northern South China Sea
*1991	Song	19 azooxanthellate corals listed for waters off South Korea

(= *Truncatoflabellum candeanum*). His report of *F. distinctum* from off Japan was a correction of the type locality of the Red Sea given in the original account, but his Japanese assignations for *F. bairdi* and *F. elegans* also contradict (supplement?) the reports of an unknown type locality given by the authors of those species (Milne Edwards and Haime, 1848a, 1857). Milne Edwards and Haime (1850b, 1857, respectively) did specifically report two azooxanthellate species from off Japan: *Cyathelia axillaris* (Ellis and Solander, 1786) and *Desmophyllum dianthus* (Esper, 1794).

Yabe and Eguchi (1942b) credited Verrill (1869) with the report of *Eupsammia stimpsoniana (= Balanophyllia stimpsonii)* from Kagosima Bay; however, Verrill's original and subsequent descriptions (Verrill, 1865, 1866) refer only to the "North China Sea," not a specific Japanese or temperate locality.

Shortly thereafter, Saville Kent (1871) described two new species from unspecified localities off Japan: *Acanthocyathus spiniger* and *Flabellum (= Aulocyathus) matricidum*, the types of which are deposited at the British Museum.

Also based on British Museum specimens, Duncan (1876) described two new species from off Owase, Mie-ken, Honshu: *Deltocyathus orientalis (= Peponocyathus australiensis)* and *Javania insignis*.

Only one species from off Japan was reported in the *Challenger* Expedition Reports: the new species *Flabellum japonicum* Moseley, 1881, from Sagami Bay, Honshu. The type of this species is deposited at the British Museum. The new species *Stephanophyllia superstes (= Letepsammia formosissima)* was also described from Sagami Bay by Ortmann (1888), the type deposited at the Strasbourg Zoological Museum (H. Zibrowius, pers. comm.).

Marenzeller (1888a) reported three species of *Flabellum* from off Japan (probably from Sagami Bay), including one new species, *F. coalitum (= F. pavoninum)*; these specimens are deposited at the NMW. In the same year Marenzeller (1888b)

described two new species from Sagami Bay, *Caryophyllia japonica* and *Stephanotrochus (= Stephanocyathus) spiniger*, and extended the range of *Cyathoceras (= Crispatotrochus) rubescens* Moseley, 1881; these specimens are also deposited in the NMW.

Rehberg (1892) reported the following three new species from off Japan: *Amphehelia adminicularis (= Enallopsammia rostrata), Dendrophyllia japonica*, and *Coenopsammia ramiculosa (= ?Tubastraea micrantha)*; and an additional Japanese record of *Dendrophyllia conferta* Quelch, 1866 (= *?D. arbuscula*). Some of Rehberg's specimens are still deposited at the ZMB.

Vaughan (1900) described the commonly collected *Levipalifer orientalis* (later renamed *Deltocyathus vaughani*) from off Honshu, but in the next 32 years only one paper was published that included azooxanthellate corals from the Japanese region: Van der Horst's (1922) report on the Indonesian *Siboga* dendrophylliids. From off Japan he reported: *Dendrophyllia jponica* (later renamed *D. boschmai* Van der Horst, 1926); *D. cribrosa* Milne Edwards and Haime, 1851; *D. coccinea* (Ehrenberg, 1834) (= *?Cladopsammia gracilis); D. willeyi* (Gardiner, 1899) (= *?Cladopsammia gracilis*); and *Balanophyllia gigas* Moseley, 1881; as well as many other species from Indonesia now known to occur in Japanese waters. His specimens are deposited at the ZMA.

Beginning in 1932 and continuing for 45 years until 1977 (one year before his death) Motoki Eguchi authored 95 papers on fossil and Recent corals of the Japanese region, many of his earlier papers coauthored with Hisakatsu Yabe. The excellent biography by Mori (1980) lists all of Eguchi's papers and includes a cross reference to every mention of a species name made in his papers. Only five of his most significant papers are listed in Table 2 and discussed herein. From the standpoint of azooxanthellate Scleractinia, the most significant contribution was: "Fossil and Recent Simple Corals from Japan" (Yabe and Eguchi, 1942b), which must be considered as the starting point for serious work on northwestern Pacific azooxanthallate corals. It was the first attempt at a synthesis of knowledge of the corals from this region, including a treatment of 84 species, 14 of them new species. Their report was based primarily on the collections of the vessel *Soyo-Maru* (1926–1930) and to a lesser extent from the vessels *Husa-Maru, Sitito-Maru*, and *Hukui-Maru*, as well as numerous fossil localities. Most of these specimens are deposited at the TIUS. Yabe and Eguchi's (1942a) revision of the 13 species of fossil and Recent flabellids from Japan is also significant in that it laid the foundation for their contemporaneous paper on the fossil and Recent simple corals from the same region.

Much later in his career, Eguchi (1968) wrote "The Scleractinian Corals of Sagami Bay," in which he described and illustrated 62 azooxanthellate species and subspecies, including 12 new species or subspecies and one new subgenus, *Alcockia*. Unlike the previously discussed paper, this book also included colonial species, but was restricted to the fauna of Sagami Bay. The specimens that he studied were primarily from the collection of Emperor Hirohito and are deposited in the Biological Laboratory of the Imperial Household, Tokyo. Two other papers by Yabe and Eguchi (1932g, 1937) deserve mention for their comprehensive revision of the micrabaciids and the genus *Deltocyathus*, respectively, in the Japanese region.

In a series of three papers, Mori and Minoura (1980, 1983) and Mori (1987) discussed genetic control of septal number using Japanese specimens of *Cylindrophyllia orientalis* and *Caryophyllia compressa*. Cheng (1977) reported *Flabellum apertum (= F. apertum borealis)* from several stations off Kyushu, and Yajima (1986) summarized all records of the Sea of Japan endemic *Rhizopsammia minuta mutsuensis*. Finally, Owens (1986a) described a new genus and species of micrabaciid from off Koshiki Island, Kyushu: *Rhombopsammia squiresi*.

Various checklists and brief species descriptions of corals from the Japanese region were published by: Utinomi (1956, 1965, 1971), Mori (1964), Kikuchi (1968), Hamada (1969), Okutani (1969), and Tribble and Randall (1986). These are not listed in Table 2 but are referenced in the Literature Cited and in species synonymies. Grygier (1983) and Zibrowius and Grygier (1985) also published records of Japanese azooxanthellates in the context of their being hosts for ascothoracid parasites. Most recently, Ogawa and Matsuzaki (1992a,b) published a listing of the 871 nominal species of Scleractinia reported from Japanese waters.

Off northern Japan, including Hokkaido and the Kurile Islands, Keller (1976, 1977, 1981a, 1982) reported various species of *Fungiacyathus, Leptopenus, Caryophyllia*, and *Deltocyathus* collected by the *Vityaz* from bathyal depths. To the south of Japan, but still in the warm temperate region (western East China Sea and Formosa Strait), azooxanthellate species were reported by Zou (1981) and Cairns (1989a). To the west of Japan, the only reports of azooxanthellate corals from off South Korea – including the eastern Yellow Sea, Chejo Do, and the western Sea of Japan – have been the papers of Song (1982, 1988, 1991), who reported a total of 19 azooxanthellate species from this region.

In this account 102 species are reported from the temperate northwestern Pacific (Table 5), including 22 new records for the region, three new genera, 5 new species, one new subspecies, and 9 new combinations. *Caryophyllia laevicostata* is mentioned in the species account but not counted as a species record.

For the sake of completeness, it should be noted that several nonima nuda have been published from the Japanese region, especially by Yabe and Eguchi (1932a,b) and Eguchi (1934), but most of these names were made available by the same authors in later publications. But, three that remain as nomina nuda are: *Balanophyllia niinoi, Eupsammia miyasakiensis*, and *Letepsammia marukawai*, all listed by Eguchi (1934:368). Another nomen nudum from Japan was listed by Blainville

(1834:354) as *Dendrophyllia semiramea*, a name later synonymized with *Dendrophyllia coccinea* by Van der Horst (1922).

Material

This study is based on the examination of previously unstudied material from nine institutional sources, herein listed in order of decreasing size of the contribution: USNM (167 stations of the USFWS *Albatross* in the northeastern and northwestern Pacific, 1888–1909), ORI (a large and diverse collection from 41 stations of the R/V *Tansei Maru* cruises off Japan, primarily cruises KT9015, KT9202, KT9309, 1974–1993), CAS (a large collection made primarily off California and the northwestern Pacific), RBCM (a large but not diverse collection made off British Columbia and Alaska), SIO (miscellaneous deep-water collections from throughout the northeastern Pacific, primarily off California), ZMC (Mortensen's Pacific Expedition of 1914, Japanese collections), IOM (several unreported specimens from off the Kurile Islands), NMCIC (several deep-water corals from off British Columbia), and UA (several specimens in Prince William Sound, Alaska).

In addition to these unstudied collections, previously reported specimens from the following museums were examined: BM (Kent, 1871; Moseley, 1881; Van der Horst, 1926); TIUS (Yabe and Eguchi, 1942a,b); CAS (Durham, 1947; Faustino, 1931); IOM (Keller, 1976, 1977, 1981a); MCZ (Verrill, 1864); NMW (Marenzeller, 1888b); RMNH (Milne Edwards and Haime, 1851); SBMNH (Durham and Barnard, 1952); SIO (Bythell, 1986); UCPM (Durham, 1947; Faustino, 1931); USNM (Vaughan, 1900, 1903, 1906a,b, 1941; Williams, 1936; Durham, 1947; Owens, 1986a; Cairns, 1989a, 1991a); YPM (Verrill, 1866, 1869); ZMA (Alcock, 1902c); and ZMB (Marenzeller, 1904a).

The examination of previously reported specimens combined with unstudied specimens provided a good base for the revision of the temperate North Pacific fauna, especially those species from the northeastern Pacific. Additional records are reported herein for 23 of the 25 species from the northeastern Pacific, only *Oculina profunda* and the unusual *Nomlandia californica* remaining known only from their type specimens. Type material of 21 of the 25 species was examined, as well as the types of the 10 junior synonyms; the four unexamined types are presumed to be lost. The coverage of the temperate northwestern Pacific corals was not as complete; however, additional records of 89 of the 102 species are reported herein and types of 64 of the 102 taxa were examined. For only four species was no material examined, in which case a diagnosis was abstracted from the literature, these species being: *Crispatotrochus niinoi* (Yabe and Eguchi, 1942b); *Trochocyathus japonicus* Eguchi, 1968; *Phyllangia hayamaensis* Eguchi, 1968; and *Dendrophyllia boschmai* Van der Horst, 1926.

Methods

It was attempted to provide complete species synonymies, at least regarding records from the temperate North Pacific region, but it is acknowledged that various checklists and smaller publications may have been overlooked. The original description and other significant references outside the North Pacific are also included in the synonymies, the latter often being a key to the extended synonymy (chresonomy) of the species. Efforts were made to examine as many types as possible and to verify as many of the previously published records as possible (see "Material"), but when specimens were not available for study and the published accounts unclear, the synonymy entries and corresponding distribution records are queried.

All 119 species included in this revision are described or diagnosed, most of them based on new material (see "Material"). Conventional scleractinian terminology is used in describing the coralla (see Wells, 1956; Cairns, 1981, 1989a; Figures 1, 2). One new ratio is introduced in this paper: PD:GCD (see "Abbreviations").

After long deliberation, it was decided to present the species account in two geographic sections rather than in a continuous phylogenetic sequence. The reason for this was to facilitate its use as a regional faunistic guide for either the northeastern or northwestern Pacific, only eight species being found in common to both regions. These eight species are presented in detail in the first (northeastern Pacific) section of the Species Account, and only cross referenced in the second section. The order of the plates follows the same rationale, the first 12 plates illustrating the northeast Pacific species, plates 13–42 illustrating the northwest Pacific species. Specimens illustrated on plates 40–42 are out of order due to the inclusion of a loan received after the main sequence of plates was finished.

It is important to document which specimens were actually examined by the author of a systematic paper and where those specimens are deposited. To this end, I have segregated the "Material Examined" sections into "New Records" and "Previous Records"; the former listing previously unreported specimens, the latter listing specimens that have been cited in previous publications. A third category is added for some species named "Reference Specimens," for specimens examined of closely related but not conspecific species. In each section each record begins with a station number followed by the number of specimens in the lot, and finally the catalog number and/or museum of deposition.

Holotypes and paratypes of all new species reported herein are deposited primarily at the USNM, some paratypes also deposited at the ORI. An effort was made to list the museum of deposition and type locality for all senior and junior synonyms of species treated in this account.

A detailed list of the geographic and bathymetric ranges

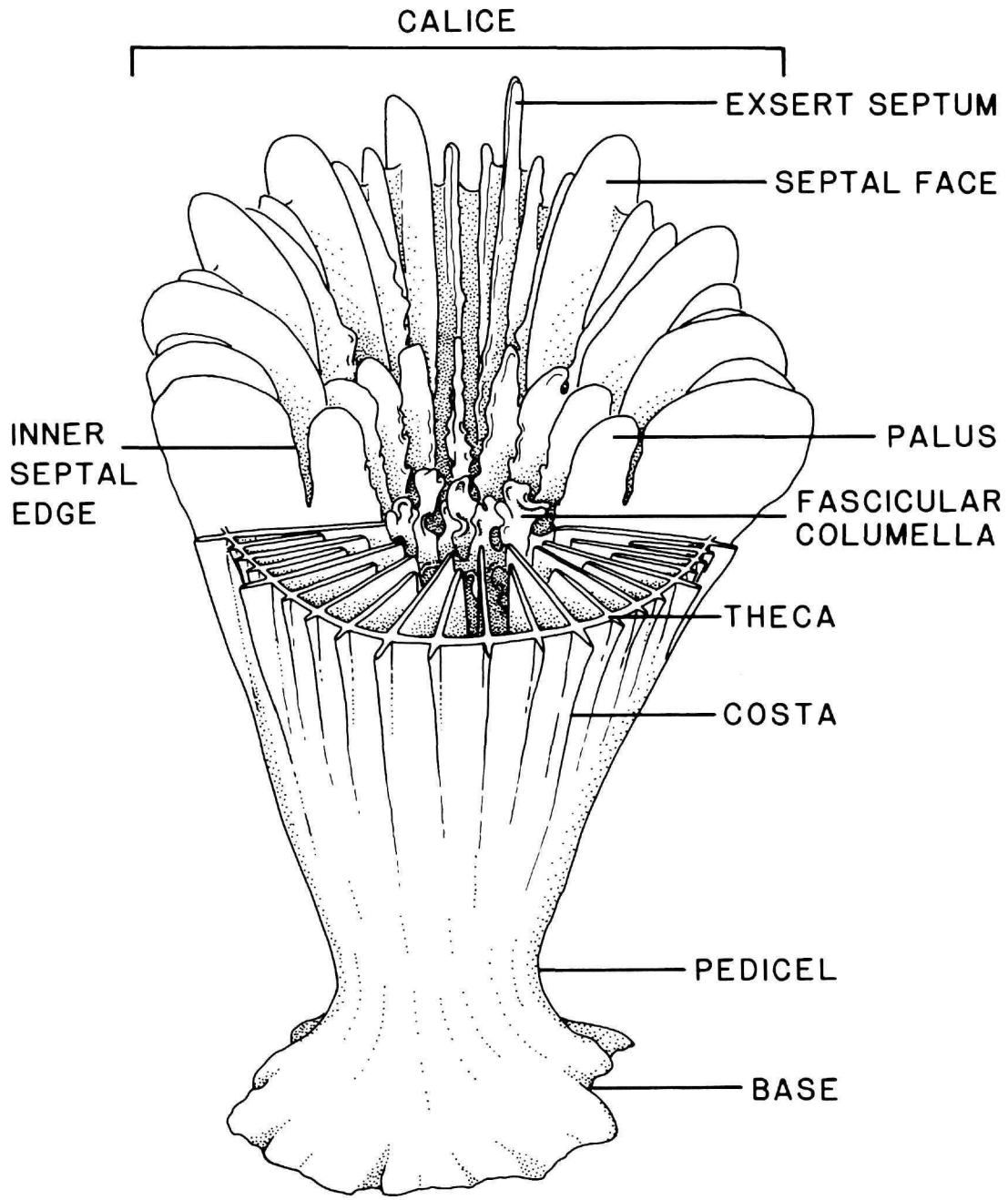

FIGURE 1.—Cutaway diagram of a species of *Caryophyllia* illustrating the basic morphological features of an attached, solitary scleractinian (after Cairns, 1981).

within the temperate North Pacific is given for each species, as well as the extended geographic and bathymetric ranges for the species, if any.

The scanning electron photomicrographs were taken by the author on a Cambridge Stereoscan 100. In some cases specimens that lacked sufficient contrast for conventional photography were dyed dark red and coated with a thin layer of sublimed ammonium chloride.

Zoogeography

I. Northeastern Pacific
  A. Tropical (PANAMANIAN PROVINCE, including "CORTEZ PROVINCE")
  B. Temperate Region
    1. Warm Temperate (CALIFORNIA PROVINCE, including "SAN DIEGO PROVINCE")
    2. Cold Temperate
      a. Lower Boreal (OREGON PROVINCE)
      b. Upper Boreal (ALEUTIAN PROVINCE)

II. Northwestern Pacific
  A. Tropical (INDO-WEST PACIFIC PROVINCE)
  B. Temperate Region
    1. Warm Temperate (JAPAN PROVINCE)
    2. Cold Temperate
      a. Lower Boreal (ORIENTAL PROVINCE)
      b. Upper Boreal (KURILE and OKHOTSK PROVINCES)

TEMPERATE NORTHEASTERN PACIFIC.—In general, the boundaries of the various zoogeographic regions and provinces discussed in this analysis follow the synthesis of Briggs (1974, see outline above); however, an exception was made with respect to the southern boundary of the warm termperate province of the northeastern Pacific. Briggs recognized a distinct warm temperate province, called the Cortez Province,

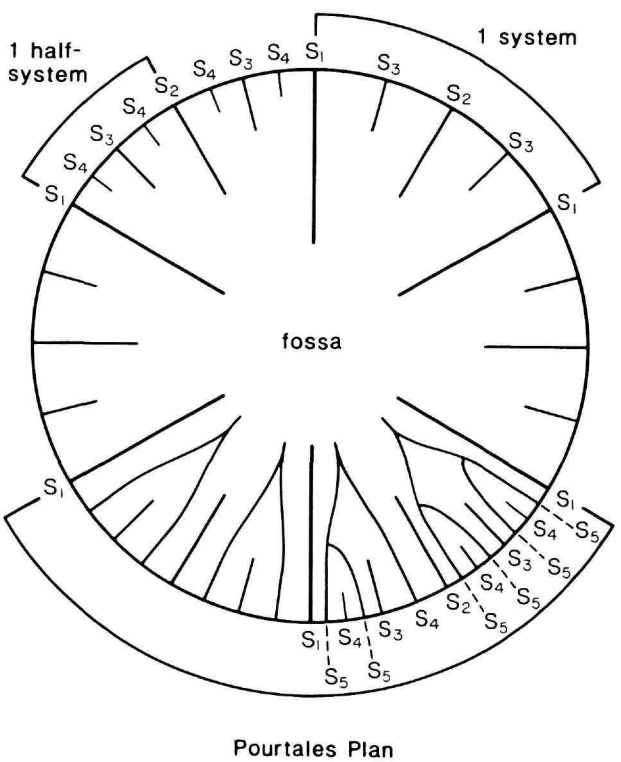

FIGURE 2.—Composite cross-sectional diagram of a calice illustrating various septal insertion patterns: upper right system with three cycles of septa, upper left system with four cycles, and lower two systems with various stages of development of the Pourtalès Plan (after Cairns and Parker, 1992). Numbers refer to cycle to which septa belong.

TABLE 3.—Azooxanthellate Scleractinia known from the Gulf of California

Astrangia haimei Verrill, 1866
Astrangia costata Verrill, 1866
Astrangia conferta Verrill, 1870a
Paracyathus stearnsii Verrill, 1869
Coenocyathus bowersi Vaughan, 1906
Ceratotrochus franciscanus Durham and Barnard, 1952
Phyllangia consagensis (Durham and Barnard, 1952)
Desmophyllum dianthus (Esper, 1794)
Balanophyllia cedrosensis Durham, 1947
Endopachys grayi Milne Edwards and Haime, 1848b
Dendrophyllia oldroydae Oldroyd, 1924
Tubastraea coccinea Lesson, 1829

that included the waters of the Gulf of California from La Paz, Baja California on the west coast of the Gulf to Topolobampo, Sinaloa, Mexico on the eastern coast. However, most zoogeographers (e.g., Ekman, 1953; Squires, 1959; Brusca, 1980) consider the Gulf of California to be an attenuated tropical or subtropical fauna. This categorization is supported by the affinities of the 12 azooxanthellate species found in the Gulf (Table 3). Aside from three species that are cosmopolitan, seven of the remaining nine species known from the Gulf are tropical species with their northern limits in the Gulf, or eurythermic tropical species having their northern limits slightly farther north in the warm temperate region. Only one species, *Paracyathus stearnsii,* is primarily temperate in distribution, and one species, *Ceratotrochus franciscanus,* is endemic to the Gulf. The endemic nature of the latter species must be viewed with doubt because it is known from only one specimen.

The northern boundary of the northeastern Pacific warm temperate California Province is generally regarded as Point Conception, California, but its southern boundary on the Pacific coast of Baja California is less well defined. Various zoogeographers have placed it as far south as Cabo San Lucas and as far north as Bahía Sebastian Vizcaíno (see Briggs, 1974); however, the latitude of Isla Magdalena (24°40′N) is most often cited, and is adopted in this analysis. At least one tropical azooxanthellate, *Astrangia conferta,* has its northern limit at Isla Magdalena, and this latitude also coincides with the northern limit of zooxanthellate corals on the northeastern Pacific coast of Baja California (Squires, 1959; Wilson, 1988, 1991). Seventeen scleractinians are known to occur in the California Province (Table 4), of which four are cosmopolitan and one, *Crispatotrochus foxi,* has a disjunct distribution in that province and the Aleutian Province. Two species are endemic to the province (*Nomlandia californica* and *Dendrophyllia californica*), but both of these are known from very few records. One species, *Leptopenus discus,* appears to be bitemperate, occurring in the northern and southern temperate regions. The remaining nine species are an almost equal mixture of five eurythermic tropical species and 4 eurythermic temperate species, consistent with Briggs' (1974) characterization of this province as a transition zone between the tropical and temperate regions. Rocas Alijos, a small group of rocks 343 km west of Isla Magdalena at 24°57′N, was included in the warm

TABLE 4.—Distribution of the 25 species of Temperate Northeastern Pacific Azooxanthellate Scleractinia.

Species	Tropical Eastern Pacific	Temperate: Warm California Province	Temperate: Cold Oregon Province	Temperate: Cold Aleutian Province	Temperate Northwest Pacific	Elsewhere	Depth
Fungiacyathus marenzelleri	x	x	x	x	x	Cosmopolitan	2999–6328
Leptopenus discus		x	x	x	x	Subantarctic	3599–5000
Astrangia haimei	x	x	x				1–53
Oculina profunda			x[2]				119–742
**Madrepora oculata*	x	x			x	Cosmopolitan	84–488
Caryophyllia arnoldi		x	x	x			40–656
Caryophyllia alaskensis			x	x	x		102–399
**Caryophyllia* sp. A				x[2]			247
Labyrinthocyathus quaylei		x	x				37–293
Crispatotrochus foxi		x[2]		x			82–274
Paracyathus stearnsii	x[3]	x	x				20–134
Paracyathus montereyensis			x[2]				75–146
Coenocyathus bowersi	x	x	x				9–302
Nomlandia californica		x[2]					82
Desmophyllum dianthus	x	x	x		x	Cosmopolitan	33–1097
Lophelia pertusa		x	x		x	Cosmopolitan	82–488
**Flabellum* sp. A				x[2]		? Antarctic	55–507
**Javania cailleti*	x		x		x	Cosmopolitan	1280–1371
**Javania borealis*				x	x		247–348
**Javania californica*			x				62–170
Polymyces montereyensis	x	x	x				69–212
Balanophyllia elegans		x	x	x			0–293
Balanophyllia cedrosensis	x	x					66–119
Dendrophyllia oldroydae	x	x					40–576
Dendrophyllia californica		x[2]					42–93
Totals	-	17	16	9	8		

* New record for temperate northeastern Pacific.

[1] Depth range in meters for records in northeastern Pacific.

[2] Presence based on very few records.

[3] Gulf of California only.

temperate province by Briggs (1974), but both of the coral species that occur there (*Madracis* sp. cf. *M. pharensis* and *Phyllangia consagensis*, fide Wilson, in press, 1994) are characteristic of the tropical region, and thus are not considered in this account. Three species are known from Isla Guadelupe 260 km off the coast of Baja California at about 29°N: *Coenocyathus bowersi*, *Desmophyllum dianthus*, and *Lophelia pertusa* (one eurythermic tropical and two cosmoplitan species, respectively).

The cold temperate region of the northeastern Pacific is divided into two provinces: the lower boreal Oregon Province and the upper boreal Aleutian Province. According to Briggs, the Oregon Province extends from Point Conception, California to Dixon Entrance, just north of the Queen Charlotte Islands, British Columbia. Sixteen species are known to occur in this province (Table 4), including four cosmopolitan and three endemic species: *Javania californica*, *Paracyathus montereyensis*, and *Oculina profunda;* the latter two are known from very few records. The bitemperate *Leptopenus discus* is also known from this province. Of the remaining eight species, three are considered as eurythermic tropical species having their northern limit at Monterey Bay, California, and five species are characteristic of the northeastern Pacific temperate region.

The upper boreal Aleutian Province is considered to extend from Dixon Entrance to the western tip of the Aleutian Islands (Briggs, 1974:280). This province contains only nine coral species (Table 4): one cosmopolitan, one endemic (*Caryophyllia* sp. A), one disjunct (*Crispatotrochus foxi*), two bipolar or bitemperate species (*Leptopenus discus* and *Flabellum* sp. A), and four species exclusively northern temperate in distribution. In the latter category, *Javania borealis* also occurs in the northwestern Pacific upper boreal Kurile Province; *Caryophyllia alaskensis* also occurs in the lower boreal (Oregon Province); and two species (*Caryophyllia arnoldi* and *Balanophyllia elegans*) have distributions encompassing all three provinces in the northeastern Pacific temperate region.

The northernmost record of a scleractinian species in the Pacific occurs in the Aleutian Province, consisting of several records of *Caryophyllia arnoldi* from Prince William Sound, Alaska (60°48′N). Several species occur throughout the Aleutian and Commander Islands, but none are known to occur

TABLE 5.—Distribution of the 102 species of Temperate Northwestern Pacific Azooxanthellate Scleractinia.

Species	Temperate						
	Tropical Indo-West Pacific	Warm Japan Province	Cold Oriental Province	Cold Kurile Province	Temperate Northeast Pacific	Elsewhere	Depth[1]
Madracis sp. A	x	x				Cosmopolitan	55–110
**Fungiacyathus stephanus*	x	x					446–1317
Fungiacyathus paliferus	x	x	x			S. Australia	70–364
Fungiacyathus sp. A[2]				x			3175–4110
Fungiacyathus marenzelleri			x	x	x	Cosmopolitan	4690–5450
**Fungiacyathus variegatus*	x	x					422–715
**Fungiacyathus granulosus*	x	x					402–410
Leptopenus discus				x	x	Subantarctic	3175–3250
Leptopenus solidus[2]	x			x			3175–3250
Letepsammia formosissima	x	x					77–307
Rhombopsammia niphada[2]	x	x					660–783
Stephanophyllia fungulus	x	x	x				15–256
Culicia japonica	x	x					5–100
Oulangia stokesiana miltoni		x	x				0–135
Madrepora oculata	x	x	x		x	Cosmopolitan	72–549
Cyathelia axillaris	x	x					15–366
Anthemiphyllia dentata	x	x	x				50–499
**Anthemiphyllia frustum*[2]		x					237–241
Caryophyllia japonica		x	x	x			77–1680
Caryophyllia alaskensis			x		x		223
Caryophyllia cf. *scobinosa*	x	x					119–805
Caryophyllia quadagenaria	x	x					70–422
Caryophyllia rugosa	x	x					71–240
Caryophyllia jogashimaensis[2]		x					52–98
Caryophyllia a. ambrosia	x	x				Atlantic	311–2450
Caryophyllia (A.) grayi	x	x					108–191
Caryophyllia (A.) spinigera[2]		?	?				?
Caryophyllia (P.) compressa		x	x				115–422
Crispatotrochus rubescens	x	x					110–344
Crispatotrochus niinoi[2]		x					104
Paracyathus pruinosus	x	x					176–198
Trochocyathus caryophylloides	x	x					115–344
Trochocyathus japonicus[2]		x					150–450
**Trochocyathus decamera*[2]		x					70–88
**Trochocyathus cooperi*[2]		x				Maldives	80–88
Deltocyathus vaughani		x					88–1097
**Deltocyathus rotulus*	x	x					799–1187
Deltocyathus magnificus	x	x				S. Australia	88–422
Stephanocyathus (A.) spiniger	x	x				S. Australia	106–783
**Stephanocyathus (O.) weberianus*	x	x					715–1302
Conotrochus funicolumna	x	x				S. Australia	88–600
**Aulocyathus recidivus*[2]	x	x				S. Australia	741
Aulocyathus matricidus		x	x				84–207
Desmophyllum dianthus	x	x			x	Cosmopolitan	77–715
**Lophelia pertusa*	x	x			x	Cosmopolitan	150–340
Anomocora sp.[2]		x					55–100
**Coenosmilia* cf. *arbuscula*[2]		x				? Atlantic	238–240
Phyllangia hayamaensis[2]		x					5.5
Rhizosmilia sagamiensis		x					60–98
Dasmosmilia pacifica		x					168–355
Goniocorella dumosa	x	x	x			New Zealand	100–366
**Notocyathus venustus*[2]	x	x					193–422
Notocyathus conicus	x	x					70–110
Peponocyathus australiensis	x	x	x			Cosmopolitan	59–494
Peponocyathus folliculus	x	x	x			Atlantic	30–402
Tropidocyathus lessoni	x	x					98–155
Tropidocyathus pileus	x	x				S. Australia	123–422

TABLE 5.—Continued.

Species	Tropical	Temperate					
		Warm	Cold		Temperate		
	Indo-West Pacific	Japan Province	Oriental Province	Kurile Province	Northeast Pacific	Elsewhere	Depth[1]
**Alatotrochus rubescens*[2]	x	x					193–422
Idiotrochus kikutii	x		x				?
Stenocyathus vermiformis[2]		x				Atlantic	300
Truncatoguynia irregularis		x					80–161
Flabellum pavoninum	x	x	x				73–658
Flabellum patens	x	x					223–402
Flabellum magnificum	x	x					307–700
Flabellum angustum[2]		x					?
Flabellum politum	x	x					70–402
Flabellum deludens	x	x	x				115–783
Flabellum japonicum	x	x					119–631
Flabellum apertum borealis		x					307–1141
Truncatoflabellum spheniscus	x	x					66–106
Truncatoflabellum candeanum	x	x					88–223
Truncatoflabellum formosum	x	x	x				106–210
Truncatoflabellum carinatum		x					30–274
**Truncatoflabellum gardineri*	x	x	x				100–144
**Truncatoflabellum* sp. A[2]		x				? E. Atlantic	964–1031
**Truncatoflabellum* sp. B[2]	x	x					80–88
**Placotrochides scaphula*	x	x					80–457
Javania insignis	x	x					46–249
Javania cailleti	x		x	x	x	Cosmopolitan	539–785
**Javania borealis*				x	x		348
Rhizotrochus typus	x	x	x				20–104
Balanophyllia cumingii	x	x	x				65–307
Balanophyllia cornu	x	x					60–274
Balanophyllia gigas	x	x					115–245
Balanophyllia ponderosa	x	x					14–16
Balanophyllia sp. A[2]		x	x				56–100
**Balanophyllia teres*		x					154–237
Endopachys grayi	x	x				E. Pac. tropics	70–274
**Eguchipsammia gaditana*	x	x				Atlantic	110–188
Eguchipsammia wellsi		x					110–196
Rhizopsammia minuta mutsuensis		x	x	x			0–2
Cladopsammia gracilis	x	x					3–95
Cladopsammia eguchii	x	x				E. Pac. tropics	7
Dendrophyllia ijimai	x	x					10–200
Dendrophyllia cribrosa[2]	x	x				E. Atlantic	7–40
Dendrophyllia japonica	x		x			New Zealand	115–250
Dendrophyllia arbuscula	x	x					40–240
Dendrophyllia boschmai		x					40–165
Dendrophyllia florulenta	x	x					70–110
Enallopsammia rostrata	x	x				Widespread	270–331
Tubastraea coccinea	x	x				Atlantic, E. Pac. tropics	0–15
**Schizopsammia songae*[2]		x					?
Totals	–	92	24	8	8		

* New record for the temperate northwestern Pacific.

[1] Depth range in meters for records in northwestern Pacific.

[2] Presence based on very few records.

in the Bering Sea proper.

Eight of the 25 temperate northeastern Pacific coral species are common to both the northeastern and northwestern Pacific (Tables 4 and 5), but six are cosmoploitan; only two species appear to be characteristic of the North Pacific temperate region: *Caryophyllia alaskensis* and *Javania borealis*. But, of

the 18 scleractinian genera known from the temperate northeastern Pacific, 12 (67%) are also represented in the northwestern Pacific.

TEMPERATE NORTHWESTERN PACIFIC.—The warm temperate northwestern Pacific Japan Province is dominated by the northerly flowing tropical Kuroshio Current. Its boundaries are quite complicated because of the complex geography of the region and the variations in the path of the Kuroshio (Veron, 1992). According to Briggs (1974), the southern limit of the warm temperate province is Hong Kong, China and includes the Chinese mainland to Wenling, the west coast of Taiwan, Formosa Strait, and most of the East China Sea, but not the southern Ryukyu Islands. The northern boundaries of the Japan Province include the southern tip of South Korea (Haenam to P'ohang), Korea Strait (including Tsushima and Mishima), the southwestern tip of Honshu to about the latitude of Hamada, the northern Ryukyu Islands from Tokara Retto northward, and the east coast of Honshu to Cape Inubo. Unlike the warm temperate northeastern Pacific in which zooxanthellate corals are absent, zooxanthellate corals are present in the Japan Province to its northern limits (Eguchi, 1968; Tribble and Randall, 1986; Veron, 1992). The 92 azooxanthellate species known from this province (Table 5) consist of six cosmopolitan species, 21 (23%) endemic species, 58 (63%) eurythermic tropical species, six species characteristic of the boreal temperate region, and one species that remains unclassified (*Stenocyathus vermiformis*). Of the 21 endemic species, 13 are poor indicators of endemism as they are known from only one or two records, but the remaining eight species appear to be characteristic of this province: *Deltocyathus vaughani, Rhizosmilia sagamiensis, Dasmosmilia pacifica, Phyllangia hayamaensis, Flabellum apertum borealis, Truncatoguynia irregularis, Balanophyllia teres, Eguchipsammia wellsi,* and *Dendrophyllia boschmai.* Among the eurythermic tropical species, many conform to the previously stated northern border of the warm temperate province (i.e., southern South Korea, Mishima, Cape Inubo), including: *Letepsammia formosissima, Culicia japonica, Cyathelia axillaris, Caryophyllia quadragenaria, Javania insignis,* and *Endopachys grayi*; however, the range of at least six species extend slightly farther north into the cold temperate Sea of Japan coast of Honshu as far as Oki Channel (e.g., *Stephanophyllia fungulus, Fungiacyathus paliferus, Anthemiphyllia dentata, Flabellum deludens, Truncatoflabellum formosum,* and *T. gardineri*), and two more species penetrate to Wakasa Bay (*Rhizotrochus typus* and *Balanophyllia cumingii*). Several other species reported from this province are primarily tropical with only marginal occurrences in the southern warm temperate province, such as: *Tropidocyathus lessoni, Stenocyathus vermiformis, Truncatoflabellum* sp. A, *T.* sp. B, and *Enallopsammia rostrata.* The six cold temperate species found in the Japan Province are: *Oulangia stokesiana miltoni, Caryophyllia compressa, C. japonica, Aulocyathus matricidus, Balanophyllia* sp. A, and *Rhizopsammia minuta mutsuensis.*

According to Briggs (1974:267), the lower boreal cold temperate Oriental Province includes the Yellow Sea and much of the Sea of Japan, from P'chang, South Korea to Oh'ongjin, North Korea to the west, Hamada to Tsugaru Strait on the west coast of Honshu, and from Cape Inubo to Tsugaru Strait on the east coast of Honshu. Of the 24 scleractinian species known to occur in this province (Table 5), the largest component (11 species, 46%) is that of eurythermic tropical species, most of which are found only a short distance into the province along the west coast of Honshu (e.g., Oki Channel, Wakasa Bay, see above). Of the remaining 13 species, five are cosmopolitan, none are endemic, six are characteristic of the northwestern temperate region, and two are unclassified (*Caryophyllia alaskensis* and *Dendrophyllia japonica*). Although no endemics are known, *Rhizopsammia minuta mutsuensis* typifies this province, being found only slightly north and south of the stated borders of the province. Of the six temperate species, four are found in the Japan and Oriental Provinces (*Oulangia stokesiana miltoni, Carophyllia compressa, Balanophyllia* sp. A, and *Aulocyathus matricidus*), the other two being characteristic of all three provinces of the northwestern Pacific region: *Caryophyllia japonica* and *Rhizopsammia minuta mutsuensis.*

Only eight species of Scleractinia are known from the upper boreal cold temperate Kurile Province (Table 5), defined as the northern Sea of Japan, off Hokkaido, and the eastern coasts of the Kurile Islands and Kamchatka Peninsula. The affinities of this fauna are quite similar to the upper boreal of the northeastern Pacific Aleutian Province, consisting of: two cosmopolitan species, one endemic (*Fungiacyathus* sp. A), one bitemperate species (*Leptopenus discus*), two northwestern temperate species (*Caryophyllia japonica* and *Rhizopsammia minuta mutsuensis*), one upper boreal endemic (*Javania borealis*), and one species having a disjunct distribution in the tropical and boreal regions (*Leptopenus solidus*).

A second, upper boreal cold temperate province is recognized by Briggs, the Okhotsk Province, which includes the Sea of Okhotsk, but no Scleractinia have been reported from this province.

COMPARISONS.—According to the zoogeographic synthesis of Briggs (1974:196), warm temperate marine faunas are usually strongly influenced by the adjacent eurythermic tropical species or simply by dispersal of tropical species that happen to be carried to higher latitudes by strong currents. This would be especially true of northwestern boundary currents, wherein a warm northerly flowing current (e.g., Gulf Stream, Kuroshio) brings tropical species into northern latitudes. This phenomenon is clearly seen in the northwestern Pacific warm temperate Japan Province wherein 58 (63%) of the 92 species are eurythermic tropical species, but less evident in the California warm temperate province wherein only 5 (29%) of the 17 species are considered as eurythermic tropical. The much higher number of azooxanthellate species in the Japan Province (92) compared to that of the California Province (17) is undoubtedly also due to their proximity to tropical faunas of vastly different sizes, i.e., the estimated number of tropical eastern Pacific azooxanthellates (Durham and Barnard, 1952; Squires, 1959; Cairns, 1991a) is about 55; that of the Indo-West

Pacific region, about 400. On the other hand, the influence of temperate species is larger in the northeastern Pacific warm temperate (4 species, 23.5%) than in the northwestern warm temperate (6 species, 6.5%), no doubt caused by the cool, southerly flowing California Current coming from higher latitudes.

The number of species in the northwestern lower boreal Oriental Province drops dramatically with regard to the adjacent Japan Province, primarily due to the great reduction of the eurythermic tropical species from 58 to 11 and the complete absence of endemic species. The paucity of collections from this region probably also contributes to its low known diversity. The sister Oregon Province in the northeastern Pacific has only one fewer species than its adjacent warm temperate province to the south (16 vs 17) and shows a greater affinity with cold temperate regions (5 species, 31%) than with the tropical region (3 species, 18%). The lesser influence of eurythermic tropical species in the Oregon Province compared to the Oriental Province (11 vs 3, difference = 8) essentially accounts for the difference in number of species of these two provinces (24 vs 16, difference = 8).

The northernmost, adjacent upper boreal provinces (Aleutian and Kurile) have virtually the same number of species and similar zoogeographic affinities, although they have only one noncosmopolitan species in common, *Javania borealis*. Both provinces have small cosmopolitan, endemic, and bipolar components, and are characterized by species that are restricted to their respective cold temperate regions. It was also noted that most of the upper boreal species have relatively deep bathymetric ranges, often exceeding 500 m. In fact, the deepest record of a scleractinian coral occurs in the Aleutian Province: *Fungiacyathus marenzelleri* (reported as *F. symmetricus aleuticus* by Keller, 1976) at 6296–6328 m in the western Aleutian Trench (53°37′N, 159°40′W).

When amphi-Pacific provinces are combined and species held in common accounted for, a total of 106 azooxanthellate species are known from the warm temperate North Pacific provinces, 37 in the lower boreal cold temperate provinces, and only 14 in the upper boreal cold temperate provinces.

SYSTEMATIC ACCOUNT

Part 1: Temperate Northeastern Pacific

Key to the 25 Species of Temperate Northeastern Pacific Scleractinia

1. Corallum solitary 2
   Corallum colonial 19
2. Corallum attached (fixed) 3
   Corallum unattached (free) 17
3. Columella present 4
   Columella absent, or only a rudimentary basal fusion of lower, inner septal edges 12
4. Corallum discoidal, without a thecal wall . . . . . ***Nomlandia californica***
   Corallum conical (trochoid, ceratoid), with a thecal wall (septo- or synapticulothecate) 5
5. Theca rough and porous; septa arranged in a Pourtalès Plan 6
   Theca costate or smooth, not porous; septa normally inserted 7
6. Columella flat to slightly concave; distinctive stellate pattern of septal arrangement; Alaska to Baja California (29°44′N) . . . . . ***Balanophyllia elegans***
   Columella convex; Pourtalès Plan not so pronounced, stellate pattern not obvious; Cedros Island, Baja California southward . . . . . ***Balanophyllia cedrosensis***
7. Pali or paliform lobes present 8
   Pali and paliform lobes absent 11
8. Paliform lobes present before all but last cycle of septa (e.g., P_{1-3}), often divided and indistinguishable from columella 9
   Pali occur only before penultimate cycle of septa (e.g., usually 12 P_3) 10
9. Septa hexamerally arranged in 5 of more cycles (≥96 septa); septa crowded; 3 or 4 palar crowns . . . . . ***Paracyathus stearnsii***
   Septa decamerally arranged in 3 to 4 cycles (42–46 septa); septa well spaced; 2 palar crowns . . . . . ***Paracyathus montereyensis***
10. Pedicel thick (up to 65% GCD); costae granular; calicular septal apices acute; San Diego to Gulf of Alaska . . . . . ***Caryophyllia arnoldi***
    Pedicel thinner (18%–33% GCD); theca porcellaneous; calicular septal apices equilateral; British Columbia to Korea Strait . . . . . ***Caryophyllia alaskensis***

11. Columella labyrinthiform, composed of short interconnected lamellae; inner septal edges straight; theca smooth . . . . . ***Labyrinthocyathus quaylei***
Columella fascicular, composed of twisted laths; inner septal edges slightly sinuous . . . . . ***Crispatotrochus foxi***
12. Theca costate and granular, often brown to grey . . . . . ***Desmophyllum dianthus***
Theca smooth and porcellaneous, white 13
13. Pedicel reinforced by 12–24 hollow rootlets, best seen in cross section of lower pedicel . . . . . ***Polymyces montereyensis***
Pedicel does not contain rootlets: either slender or stereome-reinforced 14
14. Pedicel not reinforced with stereome and therefore relatively narrow (≤16% GCD) . . . . . ***Flabellum*** sp. A
Pedicel reinforced with concentric layers of dense stereome (pedicel usually ≥25% GCD) 15
15. Corallum relatively small (≤13 mm GCD) and has only 3 cycles of septa (24) . . . . . ***Javania californica***
Corallum larger (adults 31–36 mm in GCD) and has 4 or 5 cycles of septa (48–96) 16
16. Five cycles of septa present (96) . . . . . ***Javania borealis***
Four cycles of septa present (48) . . . . . ***Javania cailleti***
17. Corallum cornute and robust; pali (P_{3-4}) present . . . . . ***Caryophyllia*** sp. A
Corallum discoidal, with a flat, delicate base; pali absent 18
18. Septa directly overlay costae; base imperforate; septa lobate, arranged in four cycles (48 septa) . . . . . ***Fungiacyathus marenzelleri***
Septa alternate in position with costae; base highly perforate; septa rudimentary, reduced to elongate spines and arranged in a bifurcating fashion (usually 72) . . . . . ***Leptopenus discus***
19. Colonies low and encrusting, not branched 20
Colonies arborescent, branched 21
20. Corallites small (≤6 mm in GCD); inner septal edges dentate, no paliform lobes; columella papillose . . . . . ***Astrangia haimei***
Corallites larger (up to 14 mm GCD); inner septa edges smooth, paliform lobes present; columella fascicular . . . . . ***Coenocyathus bowersi***
21. Theca porous (synapticulothecate); septa arranged in a Pourtalès Plan; corallites relatively large (usually >9 mm in GCD) 22
Theca costate or granular (septothecate); septa arranged normally; corallites relatively small (GCD usually < 6 mm) 23
22. Colonies large, sympodially branched; corallites 4–23 mm long . . . . . ***Dendrophyllia oldroydae***
Colonies small and bushy, with sparse, irregular branching; corallites elongate, up to 32 mm long . . . . . ***Dendrophyllia californica***
23. Columella absent; budding intratentacular . . . . . ***Lophelia pertusa***
Columella present; budding extratentacular 24
24. Corallites occur uniformly on all branch surfaces . . . . . ***Oculina profunda***
Corallites sympodially budded in a zig-zag pattern . . . . . ***Madrepora oculata***

Suborder FUNGIINA

Superfamily FUNGIOIDEA

Family FUNGIACYATHIDAE

Fungiacyathus Sars, 1872

DIAGNOSIS.—Corallum solitary, cupolate, free; septotheca horizontal to concave and usually quite fragile. Septa and costae in direct correspondence with one another, 48 or 96 of each. Costae usually thin and serrate but may be rounded and granular. Septa imperforate; septal faces usually carinate. Adjacent septa reinforced by synapticular plates that orginate from corallum base. Pali sometimes present; columella spongy. Dissepiments absent. Polyp completely invests corallum. Exclusively azooxanthellate and often found quite deep.

Subgenus *Fungiacyathus (Bathyactis)* Moseley, 1881

DIAGNOSIS.—*Fungiacyathus* having four cycles (48) of

septa (see Cairns, 1991a).

TYPE SPECIES.—*Fungia symmetrica* Pourtalès, 1871, by monotypy.

Fungiacyathus (Bathyactis) marenzelleri (Vaughan, 1906)

PLATE 1*a–f*

Bathyactis symmetrica.—Moseley, 1881:189 [in part: *Challenger*-241, 244].—Marenzeller, 1904b:76 [in part: only Alb-3376, specimens from the other three stations being too fragmentary to identify].—Not Yabe and Eguchi, 1942b:137 [= *F. paliferus*].

Bathyactis marenzelleri Vaughan, 1906b:66–67, pl. 4: figs. 1–1b.

Fungiacyathus symmetricus aleuticus Keller, 1976:39–41, pl. 2: figs. 1–5; pl. 3: figs. 1–19.

Fungiacyathus symmetricus fragilis Keller, 1976:41–43 [in part: *Vityaz*-4158, 4191].

Fungiacyathus marenzelleri.—Cairns, 1979:35–37, pl. 2: figs. 8, 9; pl. 3: figs. 3, 8 [synonymy]; 1982:5–7, pl. 1: figs. 1, 2, 8 [synonymy].—Zibrowius, 1980:24–25, pl. 6: figs. A–M; pl. 7: figs. A–K [synonymy].

Fungiacyathus sp. "a".—Zibrowius and Grygier, 1985:119 [*Challenger*-241].

DESCRIPTION.—Corallum fragile, light, and discoidal, having a very thin (0.15 mm), flat to slightly convex, circular base up to 27 mm in diameter in North Pacific specimens. Costae thin, finely serrate, slightly sinuous ridges up to 1 mm in height near calicular edge. Length and height of costae progressively decrease in size according to formula: $C_{1-2}>C_3>C_4$. Corallum white or light brown.

S_{1-2} extend from center of calice, whereas inner edges of each pair of S_3 fuse with the adjacent S_2 about one-fourth radius from center of calice in a short triangular canopy. Likewise, each pair of S_4 fuse with their adjacent S_3 about half radius distance from calicular center through more elongate canopies. S_1 largest and only independent septa, composed of 7–10 trabeculae. Innermost 3 or 4 trabeculae of S_1 project as inwardly curved carinate spines, the outermost 5 or 6 trabeculae forming a tall (up to 11 mm in height) solid peripheral lobe. Septal faces carinate, each trabeculum producing a curved, slightly serrate ridge up to 0.4 mm in height and symmetrically arranged on each side of septum. Trabecular carinae on S_1 widely spaced (up to 1.2 mm apart) but occasionally doubled, two being directly adjacent. S_2 consist of about 8 trabeculae, have a much lower peripheral lobe, and have only 5 or 6 inner spines. S_3 consist of 4 or 5 trabeculae in a single peripheral lobe; S_4 consist of 3 or 4 trabeculae in a low peripheral lamellae. The third trabecular spines from caliclular center of the 12 S_{1-2} are the most exsert, projecting up to 2.5 mm above upper septal edge. Depending on diameter of corallum, 6–11 synapticulae occur per S_1, becoming progressively larger toward calicular edge, where they intersect the curved trabecular carinae at an oblique angle (Plate 1*f*), the outermost synapticulae rising well above the S_4. Columella variable in development and sometimes even absent, but usually consists of a thin, horizontal circular plate up to 6 mm in diameter, through which project the innermost S_{1-2} trabecular spines.

DISCUSSION.—Most of Keller's (1976) types of *F. symmetricus aleuticus* were examined and found to be conspecific with *F. marenzelleri*, a species of which she was apparently unaware. Her (Keller, 1976) two Pacific records of *F. symmetricus fragilis* were examined and also found to be conspecific. The latter two records were inadvertently symbolized as *F. symmetricus aleuticus* on her distributional map (Keller, 1976:32). Her new subspecies *F. s. fragilis* is a junior primary homonym of *F. fragilis* Sars, 1872, but may not require a replacement name since her type series includes several previously described species.

Approximately 14 species comprise the subgenus *Bathyactis* (see Cairns, 1989a). *Fungiacyathus marenzelleri* is distinguished from other species by its large corallum size and by having straight septa with relatively few, widely-spaced trabecular ridges. Only one other species of *Fungiacyathus* is known from the temperate North Pacific, a species reported as *F. paliferus* by Keller (see *Fungiacyathus* sp. A in northwest Pacific account), which is easily distinguished from *F. marenzelleri* by having five cycles of septa.

Over 100 specimens of *F. marenzelleri* were collected by the PULSE cruises of SIO, which repeatedly sampled one abyssal locality about 220 km off San Luis Obispo Bay, California at 4100 m. *F. marenzelleri* is one of the few scleractinians known from that depth in the North Pacific and holds the depth record for a scleractinian coral at 6328 m (*Vityaz*-4120) in the Aleutian Trench (Keller, 1976).

MATERIAL EXAMINED.—*New Records:* Alb-4397, 1, USNM 47467; *Velero*-4-7228-60, 2, USNM 80119; *Vityaz*-5626, 2, USNM 92439; PULSE 1-124, 3, USNM 85790; PULSE 2-216, 25, USNM 87616; PULSE 2-224, 9, USNM 87615; PULSE 3-312, 1, USNM 92440; PULSE 3-314, 15, USNM 92441; PULSE 4-426, 8, USNM 92442; PULSE 5-505, 10, USNM 92443; PULSE 6-606, 3, USNM 92444; PULSE 7-721, 5, USNM 92445; PULSE 8-803, 30, USNM 92446; PULSE 9-907, 15, USNM 92447; PULSE 9-910, 8, USNM 92448; PULSE 10-1007, 10, USNM 92449; PULSE 10-1017, 6, USNM 92450; MV 66-II-4, 1, SIO Co 1272; *Washington* MV 67-III-22, 15, SIO Co 1269; *Melville* MV69-VI-9, 1, SIO Co 1288; *Melville* 70-22, 15, SIO Co 1270; *Melville* MV70-III-6, 10, SIO Co 1268; *Horizon* MET-133, 5, SIO Co 944. *Previous Records:* Alb-3376, 1, USNM 22078 (Marenzeller, 1904b); types of *F. marenzelleri* Vaughan, 1906b, Alb-4721 (USNM), Alb-4670 (MCZ); types of *F. symmetricus aleuticus* Keller, 1976: *Vityaz*-2074, 3166 (5 at USNM 92436), 4120, 5634, 5605 (Plate 1*e*), 5623, 5621, 5622, 5624 (10 at USNM 92437), 6136, 6143 (Plate 1*c,d*), 6142, 6088 (7 at USNM 92438), unless otherwise indicated deposited at IOM; types of *F. symmetricus fragilis* Keller, 1976: *Vityaz*-4158, deposited at IOM; specimens listed by Cairns (1979, 1982) and Zibrowius (1980).

TYPES.—The holotype of *F. marenzelleri* is deposited at the USNM (47415). Three paratypes from Alb-4670 are deposited at the MCZ. *Type Locality:* Alb-4721: 80°7.5′S, 104°10.5′W (off Peru), 3820 m.

The holotype and most paratypes (Plate 1*c–e*) of *F. symmetricus aleuticus* Keller, 1976 are deposited at the IOM,

some being present at the USNM (see Material Examined). *Type Locality:* *Vityaz*-6136: 53°25'N, 163°23'W (Aleutian Trench off the Fox Ids.), 4620 m.

DISTRIBUTION.—Widespread in Pacific from off Peru (Vaughan, 1906b) to Colombia (Marenzeller, 1904b); off Pacific coast of Baja California, California, and Washington (Keller, 1976); Aleutian, Kurile-Kamchatka, and Japan Trenches (Keller, 1976); Shatskiy Rise (Moseley, 1881). *Elsewhere:* Bahamas and off Cuba (Cairns, 1979); eastern Atlantic (Zibrowius, 1980); Subantarctic and off continental Antarctica (Cairns, 1982); 300–6328 m, but most records from North Pacific fall between 3800–5000 m.

Family MICRABACIIDAE

Leptopenus Moseley, 1881

DIAGNOSIS.—Corallum solitary, discoidal, and free; extremely fragile. Synapticulotheca horizontal and extremely porous. Costae and septa alternate in position. Septa rudimentary, composed primarily of a series of tall spines. Pali absent; columella spiny. Polyp completely invests corallum. Exclusively azooxanthellae and deep water in habit.

TYPE SPECIES.—*Leptopenus discus* Moseley, 1881, by subsequent designation (Wells, 1936).

Leptopenus discus Moseley, 1881

PLATE 2*a–d*

Leptopenus discus Moseley, 1881:205-208, pl. 14: figs. 1–4; pl. 16: figs. 1–7.—Cairns, 1979:37–38, pl. 3: figs. 4–7 [synonymy].—Not *Leptopenus discus*.—Squires, 1965:878, fig. 1 [= *L. solidus* Keller, 1977]; 1967:505.

Leptopenus irinae Keller, 1977:38–40, pl. 1: figs. 1–4, 6, text-fig. 2.

Not *Leptopenus* sp. cf. *L. discus*.— Cairns, 1982:9 [= *L. antarcticus* Cairns, 1989a].

DESCRIPTION.—Corallum discoidal and extremely fragile, the peripheral costal spines invariably broken during collection. Largest specimen 25 mm in diameter, the height varying from 1–4 mm, resulting in the relatively great range of D:H ratio of 5–17. Base flat, the costae alternating in position with septa. Septa and adjacent costae joined to one another by thin synapticular bridges, each separated by large pores up to 0.5 mm long and 0.25–0.30 mm wide. Six major costae radiate from a circular central region about 0.5 mm in diameter, each costa soon dividing twice resulting in 4 costae in each system. These 24 costae further subdivide to match the number of septa in the corallum and ultimately extend up to one-third the calicular radius beyond the synapticular region (Keller, 1977).

Septa hexamerally arranged in typical micrabaciid fashion (see Cairns, 1982, text-fig. 1), usually resulting in 72 septa. S_1 only independent septa, bearing 4 or 5 slender, cylindrical (0.1 mm in diameter) spines up to 0.9 mm in height, united by a low septal webbing. S_2 also originate at center of calice and bear 3 tall robust spines, the one closest to center quite large: up to 0.2 mm in diameter and over 1 mm in height, constituting the greatest height of the corallum. A high web unites the S_2 spines. A pair of S_3 diverge from each of the 6 S_2 relatively near columella, their union with the S_2 covered by a low canopy. Each S_3 bifurcates one to three times, depending on the ontogenetic stage, resulting in 48–72 septa. Examined paratype of *L. irinae* from *Vityaz*-4158 (USNM 92435) relatively small (calicular diameter = 11.0 mm), having only 48 septa. All septal spines are obliquely oriented towards calicular edge, never curved inward toward columella, and restricted to central portion of corallum. Columella a spinose central mound, penetrated by 10–15 trabecular spines, each spine about 0.1 mm in diameter.

DISCUSSION.—Keller (1977) distinguished *L. irinae* from *L. discus* by its long costal ribs that extend one-third the radius beyond the synapticular region. Although these peripheral costae are usually lost during collection, Moseley (1881, pl. 14: figs. 1, 2) clearly illustrated these costal extensions for *L. discus* extending at least 20% of the radius beyond the synapticular zone. The paratype from *Vityaz*-4158 appears to be identical to the syntypes of *L. discus* previously examined from the British Museum.

Four other Recent species of *Leptopenus* are known. *Leptopenus hypocoelus* Moseley, 1881 is easily distinguished by its very tall corallum (D:H = about 2), its enormous S_2 spines, and by having only 48 septa. *Leptopenus antarcticus* Cairns, 1989a also differs in having a low D:H ratio (about 5), a concave base, inwardly curved septal spines, and rudimentary or absent septal canopies. Likewise, *Leptopenus* sp. A Cairns, 1989a, differs in having 96 septa, rudimentary or absent septal canopies, and inwardly curved septal spines. Finally, *L. solidus* Keller, 1977, differs in having smaller thecal pores, a much more solid base, and by having incurved spines.

The seven specimens collected by Scripps vessels from four abyssal locations west of the Patton Escarpment, off northern Baja California (3599–3950 m) are only tentatively assigned to this species. All specimens were fragmentary, held together only by abundant tissue; bleaching of these specimens would have led to disarticulation of the broken fragments.

MATERIAL EXAMINED.—*New Records:* *Melville* 70-22, 3, SIO Co 1270; *Melville* 70-III-1, 1, SIO Co 1271; *Melville* 70-III-6, 1, SIO Co 1268; *Horizon* MET-123, 2, SIO Co 927. *Previous Records:* Syntype of *L. discus* from *Challenger*-147, BM 1880.11.25.159; paratype of *L. irinae* from *Vityaz*-4158, USNM 92435; specimens reported by Cairns (1979).

TYPES.—Four syntypes of *L. discus* collected from three *Challenger* stations (147, 157, and 323) are deposited at the BM, the specimen from *Challenger*-147 cataloged as: BM 1880.11.25.159. *Type Locality:* Southern Indian Ocean and southwest Atlantic; 2926-3566 m.

The holotype and 12 paratypes (Plate 2*d*) of *L. irinae* Keller, 1977 are deposited at the IOM. The holotype was collected from *Vityaz*-6143, the paratypes from *Vityaz* stations 4158, 5603, and 6142. One paratype from *Vityaz*-4158 is also deposited at the USNM (92435). *Type Locality:* 51°10'N,

163°00'W (Aleutian Trench), 4820 m.

DISTRIBUTION.—?Off Baja California (west of Patton Escarpment); off Washington (Keller, 1977); Aleutian and Kurile Trenches (Keller, 1977); 3599–500 m. *Elsewhere:* Northeast of Cuba (Cairns, 1979); off Rio de la Plata, Argentina (Moseley, 1881); near Crozet Island (Moseley, 1881); 2842–5000 m.

Suborder FAVIINA

Superfamily FAVIOIDEA

Family RHIZANGIIDAE

Astrangia Milne Edwards and Haime, 1848c

DIAGNOSIS.—Corallum colonial and attached, having extratentacular budding originating from stolons or a common basal coenosteum. Corallum base often polycyclic. Septa dentate. Pali absent; columella papillose. Primarily azooxanthellate and invariable found in shallow water.

TYPE SPECIES.—*Astrangia michelinii* Milne Edwards and Haime, 1848d (= *A. poculata* Ellis and Solander, 1786), by subsequent designation (Milne Edwards and Haime, 1850: xliv).

Astrangia haimei Verrill, 1866

PLATES 2*e–g*, 3*a–c*

Astrangia haimei Verrill, 1866:330-331; 1870a:526-527, pl. 9: figs. 6, 6a.—Marenzeller, 1904b:75.—Durham and Barnard, 1952:71–72, pl. 6: fig. 30.—Squires, 1959:415–418 [synonymy].

Astrangia sp.—Johnson and Snook, 1927:108; 1967:108–109, fig. 86.

Astrangia insignifica.—Ricketts and Calvin, 1939:39, 264.

Astrangia lajollaensis Durham, 1947:28–29, pl. 2: figs. 14, 15, 18, 20, 21; 1949: 151, pl. 5: figs. 9, 14, text-figs. 5, 6.—Durham and Barnard, 1952:74–75, pl. 7: fig. 34.—Ricketts and Calvin, 1952:37.—Fadlallah, 1982:379–387, figs. 3, 6; 1983a:139.—Bythell, 1986:13, pl. 2: fig. B; pl. 4: figs. A–B.—Cairns et al., 1991:46.—Chadwick, 1991:42–47.

DESCRIPTION.—Colonies encrust rocks and bivalve shells, the largest colony reported (Fadlallah, 1982) 1.75 m^2 in surface area, constituting approximately 14,000 corallites. Smaller colonies circular in outline (e.g., Plate 2*f*: 25 cm^2 and 90 corallites) and reptoid colonies are more common. Corallites cylindrical, rarely more than 6 mm in height and 3-6 mm in calicular diameter, the larger corallites typical of the northern (e.g., Monterey Bay) range of the species. Corallites at edge of colony invariably strongly inclined outward, their outer edges often flush with common coenosteum. Corallite base polycyclic, often consisting of 5 thecal rings (Durham, 1949). Costae well defined: broad (0.35–0.40 mm), slightly convex, and granular, separated by very thin intercostal striae. Corallum light brown, the color more intense at the calice. Polyps orange or coral-red, with white-tipped tentacles (Johnson and Snook, 1967).

Septal complement variable, depending on size and location of corallite within colony. Large, centrally-placed corallites have septa hexamerally arranged in four complete cycles (48 septa) according to the formula: $S_1 > S_{2-3} >> S_4$. However, most corallites lack pairs of S_4 in several half-systems, and smaller peripherally located corallites usually have only 24–36 septa. S_1 slightly exsert and only about 1 mm wide, their vertical to slightly inclined inner edges divided into 4 or 5 narrow, granular lobes or teeth that merge imperceptibly with the columella. S_{2-3} only slightly less exsert and as wide as the S_1, having similarly dentate inner edges. Each pair of S_3 bend toward their adjacent S_2, with a tendency to resemble the Pourtalès Plan, as mentioned by Durham and Barnard (1952). S_4 rudimentary, much smaller than S_{2-3}, and have laciniate inner edges. All septal faces highly granular, the largest granules occurring on septal teeth. Fossa relatively deep and large. Columella consists of a flat to slightly concave field of fine (80–100 μm in diameter) papillae similar in size and shape to lower septal teeth.

DISCUSSION.—It is not my goal to resolve the "*Astrangia* problem," as Squires (1959:416) phrased it, i.e., the validity of the 21 nominal *Astrangia* species described from the eastern Pacific. Fadlallah (1982) is probably correct in assuming that there is only one species of *Astrangia* north of Baja California and that it is *A. lajollaensis* (= *A. haimei*). The species problem more accurately pertains to those species occurring in the tropical eastern Pacific, particularly those described from the Gulf of California. However, a direct comparison of the lectotype of *A. haimei* to the holotype of *A. lajollaensis* shows no significant differences and thus *A. lajollaensis* is considered a junior synonym of *A. haimei*, as first suggested by Squires (1959). Nonetheless, the northern populations of *A. haimei*, previously referred to as *A. lajollaensis*, are in general, more robust than those to the south.

In a detailed study of the reproduction of *A. lajollaensis* (= *A. haimei*), Fadlallah (1982) reported that it had separate sexes that broadcast large numbers of gametes in an annual cycle, as well as extratentacular budding of contiguous corallites to form colonies. Furthermore, he predicted that a colony 1 m^2 would be 46–383 years old, the range depending on differing assumptions for the average rate of budding per year, which he estimated to vary from 0.12–1.0 bud/corallite/year.

MATERIAL EXAMINED.—*New Records:* Monterey wharf, 1 colony, CAS 74819; Anacapa I., 1 colony, CAS 74812; various Channel Islands, USNM 62489-92 and SIO Co 1167; Monterey breakwater, 1 colony, USNM 89300; Ensenada, 4 corallites, USNM 19198; off La Jolla, 10 colonies, SIO Co 1174, 1186; off San Onofre, CA, 4 colonies, SIO Co 980; off Coronado I., Gulf of California, 1 colony, SIO Co 1170. *Previous Records:* Lectotype of *A. haimei;* 1 colony from Zorritos, Peru, USNM 92451 (Verrill, 1870a); Bay of Panama, 1, USNM 22087 (Marenzeller, 1904b); holotype of *A. lajollaensis* Durham, 1947.

TYPES.—The lectotype of *A. haimei*, designated by Durham and Barnard (1952:71), is deposited at the YPM (598a) (Plate 3*d*). About 15 paralectotypes are also deposited at the YPM,

one cataloged as 593 (Lazo-Wasem, pers. comm.). The lectotype colony measures 27.5 mm in diameter and consists of 33–36 corallites, the typical calicular diameter being about 3.6 mm. *Type Locality:* Bay of Panama; depth unknown.

The holotype and paratypes of *A. lajollaensis* are deposited at the UCMP, cataloged as 30282, and 30308 and 30296, respectively. *Type Locality:* ?Ensenada, Baja California; depth unknown.

DISTRIBUTION.—Known from off Peru (Verrill, 1870a) to Monterey Bay, California, including the Gulf of California; 1–53 m.

Family OCULINIDAE

Oculina Lamarck, 1816

DIAGNOSIS.—Corallum branches through extratentacular sympodial budding; axial corallites absent. Coenosteum dense and costate. Pali present before first two cycles of septa; columella papillose. Zooxanthellate and azooxanthellate species occur, primarily in shallow water.

TYPE SPECIES.—*Madrepora virginea* Lamarck, 1816 (= *Oculina diffusa* Lamarck, 1816), by subsequent designation (Milne Edwards and Haime, 1850a:xix).

Oculina profunda Cairns, 1991

PLATE 3*d,e*

Oculina profunda Cairns, 1991a:10–11, pl. 3: figs. e,g; pl. 4: figs. a,b [synonymy].

DIAGNOSIS.—Colonies arborescent and presumably attached. Corallites uniformly distributed on branches, each 2.6–3.7 mm in diameter, and only slightly exsert. Conoesteum costate and white. Septa arranged in three complete cycles. P_1 crown composed of small pali; P_2 crown much more prominent. Columella papillose.

DISCUSSION.—*Oculina profunda* has been so recently described and illustrated (Cairns, 1991a) that it is unnecessary to recast the original description, especially as no additional specimens have been taken of this rarely collected species.

MATERIAL EXAMINED.—Type series.

TYPES.—The holotype (Plate 3*d*) and paratypes (Plate 3*e*) of *O. profunda* are all deposited at the USNM (see Cairns 1991a, b). *Type Locality:* Alb-3170: 38°17′N, 123°29′W (off Bodega Bay, California), 305 m.

DISTRIBUTION.—Off St. Lucia Range and Bodega Bay, California; Galápagos; 119–742 m. ?Pleistocene of Mexico (Palmer, 1928).

Madrepora Linnaeus, 1758

DIAGNOSIS.—Colonial, extratentacular sympodial budding forming dendroid colonies. Coenosteum dense; costae absent. Pali absent; columella papillose or absent. Exclusively azooxanthellate.

TYPE SPECIES.—*Madrepora oculata* Linnaeus, 1758, by subsequent designation (Verrill, 1901).

Madrepora oculata Linnaeus, 1758

PLATE 3*f–h*

Madrepora oculata Linnaeus, 1758:798.—Marenzeller, 1904b:79.—Durham and Barnard, 1952:11.—Eguchi, 1968:C29, pl. C8: figs 1–9.—Zibrowius, 1974a:762–766, pl. 2: figs. 3–5 [synonymy].—Cairns, 1979:39–42, pl. 3: fig. 2; pl. 4: fig. 5; pl. 5: figs. 1–3 [synonymy]; 1982:15, pl. 3: figs. 4–6 [synonymy]; 1984:10, pl. 1: fig. H; 1991a:9–10, pl. 2: fig. j; pl. 3: figs. a–d.—Zibrowius, 1980:36–40, pl. 13: figs. A–P [synonymy].

Madrepora galapagensis Vaughan, 1906b:63–64, pl. 1: fig. 2; pl. 2: figs. 1, 1b.—Durham and Barnard, 1952:11.—Wells, 1983:234, pl. 13: figs. 1, 2.

Madrepora (Sclerhelia) sp.—Eguchi, 1938, table 2.

Madrepora (Amphelia) sp.—Yabe and Eguchi, 1941b:102.

Madrepora cf. *oculata*.—Eguchi, 1942:136–137, pl. 6: fig. 1.

DESCRIPTION OF NORTHEAST PACIFIC SPECIMENS.—Colonies uniplanar, formed by closely spaced extratentacular sympodial budding. Calices circular and 3.0–3.7 mm in diameter, exsert on end branches but flush or recessed into coenosteum on larger diameter branches. Coenosteum faintly striate and finely granular; light brown in color.

Septa hexamerally arranged in 3 complete cycles (24 septa) according to the formula: $S_{1-2}>>S_3$. S_{1-2} not exsert and have slightly sinuous inner edges that fuse with the columella. S_3 rudimentary. Fossa deep and relatively broad. Columella a bolus of trabeculae, interconnected to lower, inner edges of S_{1-2}.

DISCUSSION.—*Madrepora oculata* is a widespread and highly variable species that has been described under a dozen different names in regional accounts (see Zibrowius, 1974a, for a discussion of extended synonymy). Of the four forms of the species described by Cairns (1991a) from the Galápagos, the Fieberling Seamount specimens most clearly resemble forma *galapagensis*. The Japanese specimens differ from those in the eastern Pacific in having well-developed S3, almost as large as the S2.

MATERIAL EXAMINED.—*New Records:* R/V *Washington* PPTU-II, 10 branches, USNM 83581; Alb-2978, 1 branch, USNM 92454; TM (KT7414, B2), 1 branch, ORI; off Enoshima, Sagami Bay, 1 branch, USNM 92658. *Previous Records:* Alb-3401, USNM 22085 (Marenzeller, 1904b); syntypes of *M. galapagensis* Vaughan, 1906b, USNM; specimens reported by Zibrowius (1974a, 1980) and Cairns (1979, 1982, 1984, 1991a).

TYPES.—The types of *M. oculata* are lost (see Zibrowius, 1980). *Type Locality:* Tyrrhenian Sea and Sicily, Mediterranean; depth unknown.

Two syntypes of *M. galapagensis* are deposited at the USNM (68276). *Type Locality:* Alb-4642:1°30.5′S, 89°35.0′W (south of Española, Galápagos), 549 m.

DISTRIBUTION.—*Madrepora oculata* is cosmopolitan in distribution outside Antarctic Seas, including the Atlantic (Cairns, 1979; Zibrowius, 1980), Subantarctic (Cairns, 1982), Indian Ocean (Zibrowius, 1974a), New Zealand (Squires and

Keyes, 1967), Hawaiian Islands (Cairns, 1984), Galápagos (Marenzeller, 1904b; Vaughan, 1906b; Cairns, 1991a), and off Japan (Eguchi, 1968) (off Honshu from the northwestern tip to Toyama Bay; Sagami and Suruga Bays; Korea Strait south of Tshushima) at depths of 15–1500 m. However, the two records reported herein from Anacapa Island (84 m) and Fieberling Seamount (440–488 m) are the first known from the northeast Pacific Basin.

Suborder CARYOPHYLLIINA

Superfamily CARYOPHYLLIOIDEA

Family CARYOPHYLLIIDAE

Caryophyllia Lamarck, 1816

DIAGNOSIS.—Corallum solitary, attached or free: if attached, corallum cylindrical, trochoid, or ceratoid; if free, corallum usually cornute. Calice circular, elliptical, or compressed; thecal edge spines present on species having compressed coralla. Septal symmetry variable, but hexameral symmetry with four cycles of septa most common (Cairns, 1991a). One crown of pali present before penultimate or antipenultimate cycle of septa, which is usually the S_3. Columella fascicular, composed of several twisted laths. Exclusively azooxanthellate and common in deep water.

Subgenus *Caryophyllia (Caryophyllia)* Lamarck, 1816

DIAGNOSIS.—*Caryophyllia* in which the calice is circular to elliptical (not compressed), and which do not have thecal edge spines or crests.

TYPE SPECIES.—*Madrepora cyathus* Ellis and Solander, 1786, by subsequent designation (Broderip, 1828).

Caryophyllia (C.) arnoldi Vaughan, 1900

PLATE 4*a–e*

Caryophyllia arnoldi Vaughan, 1900:199–200, pl. 16: figs. 1, 2; 1903:86, pl. 3: figs. 4, 4a.—Durham, 1947:33–34, pl. 2: figs. 3, 7, 16, 17.—Durham and Barnard, 1952:81–82, pl. 9: fig. 42a,b.—Keller, 1981:19, fig. 4, table 4.—Austin, 1985:81.—Bythell, 1986:13–14.—Cairns et al., 1991:47.

Caryophyllia alaskensis: Durham, 1947:33 [in part: specimens from California, including pl. 2: figs. 4, 8, 9, 12, 13); 1949:152–153, pl. 4: fig. 9.—Durham and Barnard, 1952:81, pl. 9: fig. 41a,b.—Talmadge, 1972:81 [in part: California specimens].—Keller, 1981:21 [in part: *Vityaz*-4139, 4179].—Bythell, 1986:14 [in part: pl. 4: figs. C-F].

Caryophyllia ambrosia.—Keller, 1981a:15 [in part: *Vityaz*-6127].

DESCRIPTION.—Corallum robust, ceratoid to trochoid, always attached through a relatively thick pedicel up to 65% of GCD. Calice circular to slightly elliptical; calicular edge serrate, each septum producing an acute triangular apex. Largest specimen known (Alb-4463) 16.0 × 14.5 mm in calicular diameter and 17.0 mm in height, with a pedicel diameter of 8.8 mm. Theca thick; costae usually have rounded edges, especially near calicular edge, and are separated by narrow and shallow intercostal striae. Costae usually bear very small, rounded granules: 4 or 5 occurring across the width of a costa. Occasionally the theca is smooth, lacking granulation. Corallum white.

Above a calicular diameter of 8 mm septa are hexamerally arranged in 4 complete cycles (48 septa) according to the formula: $S_{1-2}>S_3\geq S_4$. S_{1-2} moderately exsert (1.4–2.3 mm) and have straight inner edges that extend about three-quarters distance to columella. S_3 about three-quarters width of S_{1-2}, 0.9-1.3 mm exsert, and have slightly sinuous inner edges. S_4 80%–100% width of S_3 (the wider S_3 occurring in larger coralla), have straight inner edges, and are equally exsert as S_3. Twelve broad, extremely sinuous P_3 form a discrete circular to slightly elliptical palar crown. Pali bear tall granules, sometimes fused into oblique carinae. Viewed from above, the sinuous pali give the appearance of being thicker than the septa, but both septa and pali are equally thick. Fossa relatively shallow, containing a robust, fascicular columella composed of a circular to slightly elliptical field of 5–25 twisted laths, occasionally fused together into a massive structure.

DISCUSSION.—*Caryophyllia arnoldi* and *C. alaskensis* are very similar, so much so that Durham (1947) identified some of his specimens of *C. alaskensis* as "pathologically" robust, herein reidentified as *C. arnoldi*. Durham and Barnard (1952) expressed doubt about their identification of *C. arnoldi*, and Bythell (1986:14) stated that the differences between the two species "appear to be slight and without further ecological evidence they cannot be designated as separate species with certainty." It is admitted that they are very similar and may even be sister species or even subspecies, but examination of the types of both species and a large suite of specimens from California to Alaska show several consistent morphological differences between the two as well as a geographic division.

Caryophyllia arnoldi has a more robust and denser corallum, with thicker walls and a wider pedicel diameter. It has better defined costae that are usually granular, not porcellaneous. *C. arnoldi* consistently has 48 septa and 12 pali, whereas *C. alaskensis* occasionally has 14–16 pali and correspondingly 56 or 64 septa. The septa of *C. arnoldi* are more exsert, their S_{1-2} usually well over 1 mm above the calicular edge, whereas those of *C. alaskensis* are invariably less than 1 mm exsert. The calicular apices of *C. arnoldi* are acute; those of *C. alaskansis* are usually equilateral. Finally, the S_4 of *C. arnoldi* are almost as wide as their S_3; the S_4 of *C. alskensis* are only about three-quarters the width of their S_3. Geographically, *C. alaskensis* is known only from the boreal temperate region, whereas *C. arnoldi* has a range from San Diego to the Gulf of Alaska, their ranges overlapping only off British Columbia and the Gulf of Alaska. Perhaps no single character will definitively separate the two species, but, when taken together, the characters listed above usually are diagnostic.

Two other species of *Caryophyllia* are known from the Pleistocene of San Pedro, California, the type-locality of *C. arnoldi*: *C. californica* Vaughan, 1903, and *C. pedroensis*

Vaughan, 1903. *Caryophyllia californica* is easily distinguished by having five complete cycles of septa at a GCD of only 10.7 mm (Plate 5*d,e*, USNM 92479). The holotype of *C. pedroensis* (Plate 5*c,f*, USNM M164736) resembles *C. arnoldi* in being free and having 48 septa, but its poor preservation does not allow a definite identification, none of its pali being intact. Durham (1947:33) suggested that *C. pedroensis* Vaughan, 1903 might be the senior synonym of *C. alaskensis* Vaughan, 1941, but it is more likely to be a junior synonym of *C. arnoldi* Vaughan, 1900.

The holotype of *C. arnoldi* (USNM M157509) is unattached, whereas all subsequently collected Recent specimens are firmly attached and have a stout pedicel. This being the only apparent difference between the Pleistocene type and Recent species, I follow Durham's (1947) reasoning in using this name for the Recent species.

MATERIAL EXAMINED.—*New Records:* Alb-2862, 1, USNM 19264; Alb-2864, 6, USNM 19211; Alb-2886, 6, USNM 92467; Alb-2893, 4, USNM 19283; Alb-2935, 1, USNM 19258; Alb-2936, 1, USNM 19257; Alb-3170, 4, USNM 19232; Alb-3445, 3, USNM 19271; Alb-3449, 3, USNM 19273; Alb-3451, 1, USNM 19268; Alb-3452, 1, USNM 36430; Alb-3459, 1, USNM 19267; Alb-3666, 4, USNM 92468; Alb-4328, 1, USNM M547401; Alb-4332, 1, USNM M547399; Alb-4359, 1, USNM 92470; Alb-4361, 2, USNM 77418; Alb-4377, 1, USNM M547402; Alb-4431, 2, USNM 92471; Alb-4463, 1, USNM 77419; Alb-4518, 2, USNM M547400; Lower Inlet, B.C., 2, USNM M547319 and M547321; Departure Bay, B. C., 4, USNM M547323; Work Canal, B. C., 1, USNM M547322; 60°22′N, 147°42′W, 70–73 m, 2, USNM 91421; Treadwell Mine, Alaska, Pleistocene, 2, USNM M123169; Snittishan, Juneau, Alaska, Pleistocene, 3, USNM 92466; Eshany Bay, P.W.S., 149 m, 7, UA; Ressurection Bay, Alaska, 58 m, 1, UA; 60°48′N, 148°14′W, 1, UA; Point Valdez, Alaska, 1, UA; 45°01.5′N, 124°43.2′W, 273 m, 13, UA; Channel Islands, 10, CAS 74811, 74803, 74909, 74805, 74908, 80909, 80899; off Cordell Bank, 8, CAS 74831, 74832; OCSEAP 20136, 2, CAS; OCSEAP 26502, 1, CAS; OCSEAP 20134, 1, CAS; OCSEAP 26499, 1, CAS; off Bodega, California, 1, CAS 80911; 32°46.5′N, 118°20.5′W, 505 m, 1, SIO Co 1248; 32°00′N, 117°56.2′W, 183 m, 1, SIO Co 404; 79 specimens from off British Columbia from 40-377 m, all deposited at the RBCM and cataloged as: 974-389-5, 974-224-6, 976-1030-1, 976-1051-1, 976-1033-2, 976-111-50, 976-17-3, 980-257-40, 980-245-32, 980-268-16, 980-264-24, 980-256-18, 981-202-3, 981-204-2, 981-208-1, 986-275-3, 986-278-6, 988-2-12, 988-15-6, 988-2-13. *Previous Records:* Holotype of *C. arnoldi* (USNM); *Albatross* specimens reported by Durham, 1947 (USNM); specimen of Talmadge, 1972 (CAS); *Vityaz* (stations 4139, 4179, 6127) specimens of Keller, 1981 (IOM). *Reference Specimens:* Holotypes of *C. californica* and *C. pedroensis* (both USNM).

TYPES.—The holotype (Plate 4*a,b*) of *C. arnoldi* is deposited at the USNM (M164736). *Type Locality:* San Pedro, California (Pleistocene).

DISTRIBUTION.—Known from San Diego to Prince William Sound, Gulf of Alaska, including Queen Charlotte Islands, Vancouver Island, San Juan Island, off British Columbia, and the Channel Islands and Banks; 40–656 m.–Pleistocene of San Pedro, California and Juneau, Alaska.

Caryophyllia (C.) alaskensis Vaughan, 1941

PLATE 4*f-h,j*

Caryophyllia alaskensis Vaughan, 1941:280–281, pl. 40: figs. 1–4.—Durham, 1947:33 [in part: only specimen from Alaska].—Not Durham, 1949:152–153 [= *C. arnoldi*].—Not Durham and Barnard, 1952:81 [= *C. arnoldi*].—Talmadge, 1972:81 [in part: Alaskan specimen].—?Ricketts and Calvin, 1952:37.—Not Keller, 1981a:21 [= *C. arnoldi* and *C. japonica*].—Austin, 1985:81 [in part: northern records].—Bythell, 1986:14 [in part: not pl. 4: figs. C–F, only northern latitude range].—Cairns et al., 1991:47.

DESCRIPTION.—Corallum ceratoid, always attached through a relatively slender pedicel (18%–33% GCD). Calice circular to elliptical; calicular edge finely serrate, each septum forming a broad equilateral apex. Largest specimen examined (Alb-3317) 21.1 × 16.6 mm in diameter and 20.3 mm in height. Theca smooth, porcellaneous (not granular), and thin (translucent); milky white. C_{1-3} occasionally slightly ridged near calicular edge; otherwise, costae not expressed. Thin, chalky white intercostal striae delimit costae but there is no relief to theca.

Septa often hexamerally arranged in four complete cycles (48 septa and 12 pali) according to formula: $S_{1-2}>S_3>S_4$, but large coralla have 56 septa and 14 pali or 64 septa and 16 pali, the largest specimen having an almost complete fifth cycle (94 septa). Instead of a fourth size class of septa to accommodate the fifth cycle, larger calices maintain only three size classes by adding equivalent half-systems of septa (i.e., 1 S_2, 1 S_3, and 2 S_4), rather than two pairs of S_5. S_{1-2} very slightly exsert (less than 1 mm) and have straight to slightly sinuous inner edges that merge with the columella deep within fossa. S_3 only half width of S_{1-2}, having slightly sinuous inner edges and bordered internally by very sinuous, large pali, each 1–3 times width of an S_3. P_3 prominently granulated and extend into columella. S_4 about three-quarters width of S_3 and have sinuous inner edges. Fossa moderate to shallow, containing a fascicular columella composed of 6–17 narrow twisted laths, which are usually independent of one another.

DISCUSSION.—Comparisons to the closely related *C. arnoldi* and *C. japonica* are found in the accounts of those species.

MATERIAL EXAMINED.—*New Records:* Alb-3317, 6, USNM 19206; Alb-4225, 8, USNM 92459; Alb-4768, 1, USNM 92460; Alb-4782, 1, USNM 92461; Alb-4788, 1, USNM 92462; Alb-4789, 12, USNM 82175; Alb-4791, 20, USNM 82174; Alb-4792, 38, USNM 83523; Alb-4860, 1, USNM 92463; *Alpha Helix*-30, 1, UA; *Lets Go*-80, 1, UA; 2, RBCM 980-238-15. *Previous Records:* Syntypes of *C. alaskensis;* specimens reported by Durham, 1947 (USNM). *Reference Specimens:* Specimens reported as *C. alaskensis* by Keller (1981a) (IOM).

TYPES.—The syntypes (Plate 4 *f,h*) of *C. alaskensis* are deposited at the USNM: two from Alb-4231 (M547317) and one from Alb-4300 (M547318). *Type Locality:* Behm Canal and Summer Strait, Alexander Archipelago, Alaska; 150–399 m.

DISTRIBUTION.—Strait of Georgia, British Columbia to the Commander Islands, off Kamchatka (Keller, 1981a), including Alexander Archipelago, Gulf of Alaska, Aleutian Islands, and one record from the northern Korea Strait off South Korea; 102–399 m.

Caryophyllia (C.) sp. A

PLATE 5*a,b*

DESCRIPTION OF SPECIMEN FROM Alb-4784.—Corallum base and calice damaged: approximately 34 mm in GCD and 27 mm in height. Corallum apparently cornute and thus probably free. Costae completely covered with an encrusting bryozoan. Corallum white. Septa hexamerally arranged in 5 complete cycles (96 septa) according to formula: $S_{1-2}>>S_3>S_4>S_5$. S_{1-2} only moderately exsert (2.0–2.5 mm) and have slightly sinuous inner edges that border on the columella. S_3 only about two-thirds width of S_{1-2}, slightly less exsert, and also have slightly sinuous inner edges. S_{4-5} progressively smaller, each about three-quarters width of next lower cycle of septa, and less exsert, except for those S_5 adjacent to S_{1-2}, which are more exsert than the S_4. A crown of small P_3 occurs adjacent to the columella, well separated from their corresponding septa. Pairs of much broader P_4 also present, forming a more prominent palar crown slightly recessed from the columella and arranged in chevrons with the P_3 within each half-system. Fossa 6 mm deep, containing a massive fascicular columella composed of about 23 slender, laterally fused, twisted laths.

DISCUSSION.—Among the 56 Recent species of *Caryophyllia* listed by Cairns (1991a), only seven have a full fifth cycle of septa, and of those seven, only two are cornute: *C. grandis* Gardiner and Waugh, 1938, and *C. planilamellata* Dennant, 1906. The North Pacific *Caryophyllia* differs from these two species in having pali before not only the penultimate septal cycle (P4) but also before the antipenultimate cycle (P3) and in having a larger, more open calice. Although this specimen may represent an undescribed species endemic to the northern boreal Pacific, the examination of one damaged specimen is not considered adequate to establish a new species.

The specimens reported by Keller (1981a) as *C. ambrosia* from the Gulf of Alaska and the Kurile Islands are *C. arnoldi* and *C. alaskensis*, respectively. The Gulf of Alaska record (*Vityaz*-6127) may have been the basis for Austin's (1985) listing of *C. ambrosia* for off British Columbia.

MATERIAL EXAMINED.—*New Record:* Alb-4784, 1, USNM 92478. *Reference Specimens: Vityaz*-5638 and 6127, *C. ambrosia* of Keller, 1981 (IOM).

DISTRIBUTION.—Off Attu I., Aleutian Islands; 247 m.

Labyrinthocyathus Cairns, 1979

DIAGNOSIS.—Corallum solitary, ceratoid to trochoid, attached. Costae usually absent. Endotheca and pali absent; columella composed of an interconnected maze of lamellar plates. Exclusively azooxanthellate.

TYPE SPECIES.—*Labyrinthocyathus langae* Cairns, 1979, by original designation.

Labyrinthocyathus quaylei (Durham, 1947)

PLATES 5*g–i*, 6*a,b*

Cyathoceras quaylei Durham, 1947:32, pl. 1: figs. 1–4; 1949:153, text-fig. 8-2.—Austin, 1985:81.—Kozloff, 1987:72.—Cairns et al., 1991:47.

Labyrinthocyathus quaylei.—Cairns, 1982:22.—Bythell, 1986:15–16, pl. 2: fig. A; pl. 6: figs. C,D; pl. 7: figs. A–E.

DESCRIPTION.—Corallum ceratoid to cylindrical, often several attached to one another and thus resembling a small colony. Largest specimen examined (CAS 16405) 15.8 × 14.1 mm in calicular diameter and 21.0 mm in height. Calice usually circular, occasionally elliptical. Pedicel relatively slender: PD:GCD = 0.35–0.50. Costae usually not discernable, the theca being uniformly covered with very small, rounded granules giving a smooth aspect to theca. Occasionally costae are visible as broad flat strips delineated by narrow and shallow intercostal striae. Corallum white.

Septa hexamerally arranged in 5 cycles according to the formula: $S_{1-2}>S_3>>S_4>S_5$. A full fourth cycle (48 septa) is attained at a GCD of 4–5 mm, and the fifth cycle (96 septa) at 12–13 mm GCD, although the holotype (which is 14.0 × 12.7 mm in calicular diameter) has only 90 septa. S_{1-2} only slightly exsert (1.0–1.5 mm) and have sinuous inner edges that border the columella. S_3 about 80% width of S_{1-2} and also have sinuous edges. S_4 much smaller, only 40%–50% width of S3, and have straight inner edges. S_5 rudimentary, only about one-third size of S_4. Fossa moderate in depth, containing a large columella consisting of short, interconnected lamellae, the lamellae sometimes vertically ridged.

DISCUSSION.—Other than *L. quaylei*, seven species are recognized in *Labyrinthocyathus: L. delicatus* (Marenzeller, 1904a) (southwest Indian Ocean); *L. mentaldoensis* (Chevalier, 1961) (Miocene of Italy); *L. taurinensis* (Chevalier, 1961) (Miocene of Italy); *L. limatulus* (Squires, 1964) (New Zealand); *L. kondoi* (Wells, 1977) (Eocene of Tonga); *L. facetus* Cairns, 1979; and *L. langae* Cairns, 1979 (western Atlantic). *Labyrinthocyathus quaylei*, the only species known from the North Pacific, is distinguished from the others by having five, not four, cycles of septa. In the North Pacific, *L. quaylei* is most similar to *Crispatotrochus foxi* (Durham and Barnard, 1952), as discussed in the account of that species.

Subsequent to its original description, *L. quaylei* was reported only once from Scripps Submarine Canyon, La Jolla by Bythell (1986), who illustrated corallum variation and several living specimens. Ten additional records are reported herein.

MATERIAL EXAMINED.—*New Records:* Alb-2895, 1, USNM 92456; Alb-3666, 1, USNM 92458; Alb-4431, 1, USNM 92458; Alb-4551, 4, USNM M547418 (topotypic); Cordell Bank, 5, USNM 92455; Monterey Bay, 50-60 m, 10, CAS 16405, 16315, 16289; *Zaca*-42, 1, CAS 80932; off Santa Barbara, 64-80 m, 4, CAS 74905. *Previous Records:* Holotype and paratype of *C. quaylei* (UCMP and USNM); Bythell's (1986) specimens, 5, SIO Co 1176.

TYPES.—The holotype (Plate 5*h,i*) of *C. quaylei* is deposited at the UCMP (30245). Two paratypes (Plate 5*g*) from the same station (Alb-4551) are deposited at the UCMP (30244) and the USNM (M547417). *Type Locality:* 36°45'N, 121°55'W (Point Pinos, Monterey Bay), 84–102 m.

DISTRIBUTION.—Point Loma, San Diego to Cordell Bank, California, including the Channel Islands; 37–293 m. The record from Jarvis Inlet, B. C. (Austin 1985) has not been verified and is doubted.

Crispatotrochus Tenison Woods, 1878

DIAGNOSIS.—Corallum solitary, ceratoid to turbinate, and attached through a robust pedicel. Septotheca costate. Pali absent; columella fascicular, composed of twisted laths. Exclusively azooxanthellate.

TYPE SPECIES.—*Crispatotrochus inornatus* Tenison Woods, 1878, by monotypy.

Crispatotrochus foxi (Durham and Barnard, 1952)

PLATE 6*c-e*

Cyathoceras foxi Durham and Barnard, 1952:84-85, pl. 10: fig. 46a,b.—Bythell, 1986:15, pl. 6: figs. A,B.—Cairns et al., 1991:47.
Crispatotrochus foxi.—Cairns, 1991a:15.

DESCRIPTION.—Corallum trochoid, firmly attached through a pedicel about half calicular diameter. Holotype 14.6 × 12.8 mm in calicular diameter and 14.5 mm in height; Alaskan specimen (Alb-3324) slightly larger: 14.7 mm in calicular diameter and 18.5 mm in height, with a pedicel diameter of 6.6 mm. Calice essentially circular but slightly irregular in outline due to small outpocketings of the theca. All costae (C_{1-5}) slightly ridged, but only in upper one-third to one-half of corallum. Small, low granules cover costae. Corallum white.

Septa hexamerally arranged in 5 cycles according to the formula: $S_{1-2}>S_3>>S_4>S_5$. Holotype lacks 1 pair of S_5 (94 septa), whereas Alaskan specimen has a full 5 cycles (96 septa). S_{1-2} slightly exsert (1.3–2.5 mm) and have straight inner edges that attain the columella. S_3 less exsert, about 80% width of S_{1-2}, and also have straight inner edges. S_4 half or less width of S_3; S_5 rudimentary, only one-quarter to one-third width of S_4. Septal faces sparsely granulated but upper faces of S_{1-3} finely pleated, bearing very low, fine trabecular ridges oriented perpendicular to septal edges. Fossa of moderate depth, containing a relatively small fascicular columella consisting of 4–7 broad, twisted laths that are laterally fused to one another.

DISCUSSION.—Twelve species (Cairns, 1991a) are known in *Crispatotrochus*, the senior synonym of *Cyathoceras*, only three of which have five cycles of hexamerally arranged septa: *C. rubescens* (Moseley, 1881), *C. niinoi* (Yabe and Eguchi, 1942b), and *C. foxi* (Durham and Barnard, 1952). *C. rubescens*, which is known from the central and western Pacific (Cairns, 1984), differs from *C. foxi* in having a larger, more robust corallum with more exsert S_{1-2} and sinuous inner septal edges. *Crispatotrochus niinoi*, known only from off Japan, is similar to *C. foxi* in size and septal formula but appears to differ in having a narrower pedicel (PD:GCD = 0.13 vs 0.41–0.45 for *C. foxi*), a thicker theca, and a smooth, noncostate theca.

In the northeastern Pacific, *C. foxi* could easily be confused with *Labyrinthocyathus quaylei*, both species being about the same size and shape, and having the same septal formula. *Crispatotrochus foxi* differs by having a fascicular columella (not interconnected plates), slightly ridged upper costae, straight inner septal edges, pleated septal faces, and, in general, a more delicate corallum.

Crispatotrochus foxi is known from only three specimens: the holotype, a non-type juvenile also reported in the original description, and a third specimen reported herein, which is almost identical to the holotype. The species was originally named for the collector of the type specimen, Earl Fox, and thus it is coincidental that the specimen reported herein was collected from the Fox Islands, Alaska.

MATERIAL EXAMINED.—*New Records:* Alb-3324, 1, USNM 19210. *Previous Records:* Holotype.

TYPES.—The holotype (Plate 6*c*) is now deposited at the SBMNH (ex AHF 112). *Type Locality:* Richardson Point, San Miguel I., Channel Islands, California, 82 m.

DISTRIBUTION.—Known only from the Channel Islands (San Miguel and Santa Catalina) and off Unalaska, Fox Islands, Aleutian Chain; 82–274 m.

Paracyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Corallum solitary, turbinate, fixed or free. Septotheca costate. Paliform lobes usually bi- or trilobed, occurring before all but last cycle. Columella papillose, often indistinguishable from lower paliform lobes.

TYPE SPECIES.—*Paracyathus procumbens* Milne Edwards and Haime, 1848a, by subsequent designation (Milne Edwards and Haime, 1850a:xv).

Paracyathus stearnsii Verrill, 1869

PLATES 6*f-k*, 7*a-f*

Paracyathus stearnsii Verrill, 1869:393-394; 1870a:537-538; 1870b:560.—Durham, 1947:35, pl. 2: figs. 1, 2, 5, 6; 1949:153-156, 161, pl. 4: fig. 12; pl. 5: fig. 1, text-figs. 8-1, 9, 17-9.—Durham and Barnard, 1952:92-93, pl. 13: fig. 55a-e.—?Hertlein and Grant, 1960:80-81, pl. 19: figs. 8-13.—Lewbel et al., 1981:165.—Fadlallah and Pearse, 1982b:233-238, 6 figs.—Fadlallah, 1983a:132.—Bythell, 1986:17, pl. 3: fig. C; pl. 9: figs. A-F.—Kozloff, 1987:72.—Cairns et al., 1991:47.—Chadwick, 1991:42-47.
Paracyathus caltha Verrill, 1869:394; 1870a:537, pl. 9: figs. 9, 9a; 1870b:

560.—Whiteaves, 1886:115.—Hickson, 1917:24.—Durham, 1947:34.—Austin, 1985:81.

Paracyathus tiburonensis Durham, 1947:35–36, pl. 3: figs. 5, 6 [new synonym]; 1949:156.—Durham and Barnard, 1952:94, pl. 13: fig. 56.—Squires, 1959:423.

Paracyathus stearnsi.—Austin, 1985:81.—Kozloff, 1987:72.

Paracyathus calthus.—Cairns et al., 1991:47.

DESCRIPTION.—Corallum trochoid, firmly attached through a robust pedicel 40%–65% that of GCD, and firmly anchored to gastropod or bivalve shells or small pebbles by a thin expansive base up to twice calicular diameter in size. Young coralla (Plate 7*a–c*) demonstrate a polycyclic basal development, older coralla having up to 6 concentric basal thecal rings (Durham, 1949). Largest corallum examined (USNM 92603) 26.5 × 17.6 mm in calicular diameter and 18.3 mm in height. Calice elliptical; smaller coralla occasionally circular. Costae equal in width, low, and rounded, separated by relatively narrow and shallow intercostal striae about one-quarter width of costae. Costae covered with low, rounded granules, 2–3 occurring across the width of a costa. In some coralla, costae are slightly ridged near the calice, in which case the granules are less apparent and the intercostal striae are wider. Upper quarter to third of well-preserved coralla, including all calicular elements, pigmented a light to dark brown.

Septa hexamerally arranged in 5 cycles accordingly: $S_{1-2}>S_3>S_4>S_5$. A full fourth cycle is obtained at a GCD as small as 3.5 mm; the fifth cycle is usually complete at a GCD of 12–14 mm; and additional pairs of S_6 occur in larger coralla, up to 146 septa in the largest specimen examined (USNM 92603). All septa exsert, but only moderately so, their inner edges straight and vertical (not sinuous). S_{1-2} easily distinguished from others by their much larger size, each bordered internally by an undivided, rounded paliform lobe that sits low in the fossa directly adjacent to the columella. P_3 located higher in fossa, slightly recessed from columella, and often dissected into 2 or 3 lobes, the lowermost indistinguishable from columellar elements. P_4 located highest in fossa, most recessed from columella, and also frequently dissected into several lobes. If not fragmented, P_4 are the broadest paliform lobes, and, each pair, together with the enclosed P_3, form a chevron in each half-system. Septal faces bear prominent, pointed granules; palar faces often bear short carinae and/or granules. Paliform lobes thick as septa.

Fossa of variable depth but usually deep, containing multiple paliform crowns and a large, elliptical columella. Columella composed of a field of 2–40 small cylindrical, irregularly-shaped pillars, all pillars terminating at the same height several mm below the P_{1-2}.

DISCUSSION.—Examination of the types of *P. caltha* and *P. tiburonensis* indicate that they fall well within the range of variation for *P. stearnsii*, the former synonymy having been implied by Durham (1947:34). The distinguishing characters of *P. tiburonensis* listed by Durham (1947) (i.e., little-exsert, thin septa; straight septal edges; equal costae) are all typical of *P. stearnsii*. Durham and Barnard (1952) also suggested that the Pleistocene *P. pedroensis* Vaughan, 1903 was a junior synonym of *P. stearnsii*, but examination of the holotype (Plate 8*h*) revealed that although it is very similar, its septa are thicker and less crowded—only 66 septa present in a corallum with a GCD of 11.4 mm. A specimen of *P. stearnsii* of corresponding size would have 90–96 septa and well-developed pairs of P_4. For this reason I consider *P. pedroensis* to be a distinct species. Hertlein and Grant's (1960) Pliocene records of *P. stearnsii* rely on the synonymy of *P. pedroensis* and are therefore suspect. Comparisons of *P. stearnsii* to *P. montereyensis* are made in the account of the latter species. *Paracyathus stearnsii* is also remarkably similar to the amphi-Atlantic *P. pulchellus* (Philippi, 1842), but the Atlantic species does not attain the large size or full fifth cycle of closely spaced septa characteristic of *P. stearnsii*.

Being a common, relatively shallow-water species, *P. stearnsii* is one of the most frequently collected corals in the Northeast Pacific. Variations in hydrographic conditions associated with near-shore habitats probably contribute to the morphologic variation seen in the corallum. The most variable character of this species is the size and nature of the paliform lobes, particularly whether each lobe is intact or divided into several smaller lobes. Fossa depth is also variable, usually moderately deep but occasionally quite shallow, some specimens having paliform lobes rising even above the calicular edge. Nonetheless, the species is characterized by having crowded septa with a tendency toward five full cyles of septa, having 12 S_{1-2} that evenly divide the calice into 12 half-systems, and a characteristic P_3–P_4 chevron arrangement in each half-system.

In a study of the reproduction of *P. stearnsii*, Fadlallah and Pearse (1982a) found the species to have separate sexes in a 1:1 ratio and to broadcast its gametes in a synchronized cycle. External fertilization results in very small (about 160 μm) planktonic planulae, which suffer a high rate of mortality. Densities of *P. stearnsii* were found to average 24.5 coralla/m^2 and longevity was estimated to be about 40 years.

MATERIAL EXAMINED.—*New Records:* Alb-2879, 1, USNM 19208; Alb-2886, 10, USNM 19227; Alb-2888, 28, USNM 19220; Alb-2894, 1, USNM 92493; Alb-2895, 1, USNM 92494; Alb-2907, 7, USNM 19212; Alb-2908, 10, USNM 19203 and 19239; Alb-2913, 11, USNM 19230 and 19281; Alb-2922, 20, USNM 19213 and 19225; Alb-2932, 1, USNM 92495; Alb-2939, 10, USNM 19240 and 19254; Alb-2940, 1, USNM 19231; Alb-2943, 13, USNM 19219; Alb-2944, 5, USNM 92596; Alb-2945, 5, USNM 19204 and 19265; Alb-2958, 5, USNM 19218; Alb-2961, 4, USNM 19234 and 19253; Alb-2965, 8, USNM 19201; Alb-2968, 5, USNM 19238; Alb-2969, 10, USNM 19242; Alb-2974, 5, USNM 92597; Alb-2975, 1, USNM 19262; Alb-2976, 9, USNM 19243; Alb-2977, 5, USNM 19214 and 36447; Alb-2978, 4, USNM 92598; Alb-3085, 7, USNM 19209; Alb-3087, 1, USNM 19263; Alb-3088, 7, USNM 19216; Alb-3102, 23,

USNM 19207; Alb-3116, 24, USNM 19224; Alb-3124, 2, USNM 19261; Alb-3158, 7, USNM 19229; Alb-3159, 4, USNM 19200; Alb-3168, 2, USNM 92600; Alb-4431, 8, USNM 92602; approximately 230 specimens from the Channel Islands deposited at the CAS and cataloged as: 74827, 74911, 74800, 74826, 74824, 74825, 74804, 74801, 69608; 45 specimens from Monterey Bay: CAS 74813, 74824, 74822; off Pacific Grove, 11, CAS 74821; Cordell Bank, 22, CAS 74830, 74835; off Huntington Beach, 2, CAS 74906; south of Carmel, 2, CAS 80904; 25 specimens from Channel Islands deposited at SIO, cataloged as: Co 441, 1167, 1169; southwest of Cedros I., 27 m, 1, SIO Co 1172; off La Jolla, 13, SIO Co 1164, 1186; north side of Middle I., Coronado I., 15 m, SIO Co 1170; 27°01'N, 114°16.5'W, 99-108 m, 1, SIO Co 1273; 72 specimens from off B. C. deposited at RBCM, cataloged as: 973-234-4, 973-235-5, 973-246-2, 973-231-2, 976-1043-3, 976-1078-2, 976-1163-60, 976-1077-3, 976-1037-1, 977-156-14, 978-96-2, 980-329-25, 980-343-18, 984-417-2, 985-469-73. *Previous Records:* Holotypes of *P. stearnsii, P. caltha,* and *P. tiburonensis;* Skidgate, B. C., 25-90 m, 1, USNM 78624 (Durham, 1947). *Reference Specimens:* Holotype of *P. pedroensis,* USNM M164738.

TYPES.—The holotype (Plate 7*d-f*) of *P. stearnsii* is deposited at the YPM (2187). It measures 17.9 × 12.9 mm in calicular diameter and has 104 septa. *Type Locality:* Monterey Bay, California, depth unknown.

The holotype (Plate 6*j*) of *P. caltha* is also deposited at the YPM (965). It measures 11.5 × 8.2 mm in calicular diameter and has 96 septa. *Type Locality:* Monterey Bay, California, depth unknown.

The holotype (Plate 6*h*) of *P. tiburonensis* is deposited at the UCMP (30485). It measures 9.3 × 8.0 mm in calicular diameter and has 82 septa. *Type Locality:* Off Tiburon I., Gulf of California, 73 m.

DISTRIBUTION.—From Skidgate, Queen Charlotte Islands (Durham, 1947) to Bahía Asuncion (27°01'N), Baja California and Tiburon Island, Gulf of California (as *P. tiburonensis*); 20–134 m.

Paracyathus montereyensis Durham, 1947

PLATE 7*g-i*

Paracyathus montereyensis Durham, 1947:34–35, pl. 2: figs. 10, 19.—Durham and Barnard, 1952:11.—Austin, 1985.—Bythell, 1986:18.—Cairns et al., 1991:47.

DESCRIPTION.—Holotype 6.03 mm in circular calicular diameter and 8.4 mm in height, attached by a thick pedicel 4.6 mm in diameter that expands into a broad, thin base. Costae coarsely granular and light brown in color. Septa decamerally arranged in three cycles plus 3 pairs of quaternaries: 10:10:20:6 = 46 septa. Primary septa about 1 mm exsert and 1.6 mm wide, with straight to slightly sinuous, vertical inner edges. Inner edges of primaries separated by a narrow notch from slender pali, each about 0.4 mm wide. Secondary septa less exsert and about two-thirds width of primaries, each bordered internally by a robust palus about 0.6 mm wide and greatly thickened on its edge adjacent to the notch separating it from its corresponding septum. In addition to being wider, these pali reach higher in the fossa than the P1 and are slightly recessed from the columella, the 20 paliform lobes together forming two crowns distinguished by size, height, thickness, and position. Three sectors bear pairs of rudimentary quaternary septa. Within the crowns of pali is a papillose columella composed of 12 slender elements.

The larger specimen (Alb-2888, USNM 92604, Plate 7*g,h*) from off Oregon measures 11.1 × 9.7 mm in calicular diameter and 12.8 mm im height and also is brownish in color. Its septa are decamerally arranged in 3 cycles, with 1 additional pair of quaternaries, for a total of only 42 septa.

DISCUSSION.—This rarely collected species was previously known from only the three syntypes; one additional specimen is reported herein. *Paracyathus montereyensis* differs from the much more commonly collected *P. stearnsii* primarily in its septal symmetry and its relatively fewer septa at a corresponding calicular diameter. The septal symmetry of *P. montereyensis* appears to be decameral, attaining and maintaining 40–46 septa at a GCD of 6 mm and above. The symmetry of *P. stearnsii* is hexameral, a corallum 6 mm in calicular diameter already having about 60 septa and a specimen 11 mm in calicular diameter having a full fifth cycle (96 septa). Associated with the lower number of septa, *P. montereyensis* has only two palar crowns, not three or more as in *P. stearnsii,* and its septa are thicker, yet less crowded than those of *P. stearnsii.*

The *Albatross* specimen from off Oregon is quite similar to the type of *P. pedroensis* Vaughan, 1903, known from the Pleistocene of San Pedro, California, except that the symmetry of *P. pedroensis* is hexameral, the holotype measuring 11.3 × 10.0 mm in calicular diameter and having 66 septa (Plate 8*h*).

MATERIAL EXAMINED.—*New Record:* Alb-2888, 1, USNM 92604. *Previous Records:* Holotype of *P. montereyensis. Reference Specimen:* Holotype (Plate 8*h*) of *P. pedroensis* Vaughan, 1903 (USNM M164738).

TYPES.—The holotype (Plate 7*i*) and two paratypes are deposited at the UCMP (30341 and 30342–43, respectively). *Type Locality:* Off Point Lopez, 17 mile drive, Monterey Peninsula, California; 146 m.

DISTRIBUTION.—Known only from off Monterey, California and off Oregon Dunes, Oregon; 75–146 m.

Coenocyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Like *Caryophyllia (Caryophyllia)* but forming colonies through extratentacular budding from a thick basal coenosteum and occasionally from the theca of other corallites. Exclusively azooxanthellate, occurring in relatively shallow water.

TYPE SPECIES.—*Coenocyathus cylindricus* Milne Edwards

and Haime, 1848a, by subsequent designation (Milne Edwards and Haime, 1850a:xii).

Coenocyathus bowersi Vaughan, 1906

PLATE 8*a-f*

Coenocyathus bowersi Vaughan, 1906a:847, pl. 77: figs. 1-3.—Durham, 1947:34.—Durham and Barnard, 1952:83-84, pl. 10: fig. 45a-d.—Wells, 1956:F422, fig. 323,8.—Squires, 1959:422.—Parker, 1964:150.—Zibrowius, 1980:73.—Austin, 1985:81.—Bythell, 1986:14-15, pl. 3: fig. A; pl. 5: figs. A-F, color cover illustration.—Cairns et al., 1991:47.

DESCRIPTION.—Corallum colonial, the most common habit being a thick mounded coenosteal encrustation from which cylindrical corallites arise by extratentacular budding, each corallite 5–8 mm in height. However, some colonies have widely spaced and taller (up to 20 mm) corallites (Plate 8*b*) and others have closely spaced (cerioid) and very short corallites (Plate 8*a*). One corallum (Plate 8*c*) even adopted a branching mode, some of its corallites budding from the theca of parent corallites. Holotypic colony only 4 cm in width; however, Durham (1947) reported a colony 1 foot (30.5 cm) in diameter, and a specimen at the CAS (77797) measures 37 cm across. Colonies usually encrust bivalves or rocks. Calices usually circular, but may be elliptical or somewhat irregular in shape. Calice size quite variable, some colonies (e.g., the holotype) having corallites 3.5–7.5 mm in calicular diameter, others averaging up to 13–14 mm in diameter. In addition to the typical method of extratentacular budding, examples of intratentacular budding are found in most coralla, in which a corallite is in the process of or has split into two or as many as 10 smaller corallites (Plate 8*d,e*), a process termed multiple fission by Durham and Barnard (1952). Costae broad and flat to slightly convex, equal in width, and separated by very narrow, slender striae. Costae sometimes extend over coenosteal base. Corallum white.

Septal symmetry extremely irregular. Each calice has 6–14 primary septa, which are larger than all others and extend to the columella or center of calice, dividing the corallite into 6–14 sectors. Each sector encloses 3, 5, or 7 septa. The 3-septa-sectors consist of 1 secondary and 2 smaller tertiary septa plus 1 P_2. The 5-septa-sector consists of 1 secondary, 2 tertiary, and a pair of small quaternary septa, plus 1 P_2. The 7-septa-sector consists of 1 secondary, 2 tertiary, and two pairs of quaternary septa, accompanied by 2 P_3. Some calices have a typical hexameral symmetry of 12 primary, 12 secondary, and 24 tertiary septa with 12 P_2 (48 septa, Plate 8*f*), but most calices have a mixture of developmental stages, producing a very irregular septal insertion pattern, but no corallite examined had over 56 septa. All septa little exsert and have slightly sinuous inner edges. Pali (P_2 or P_3) relatively slender and extremely sinuous. In some calices they form a well-defined crown (Plate 8*f*) as in *Caryophyllia*, but in others pali are poorly formed or even missing in various sectors.

Fossa of moderate depth, containing a small fascicular columella composed of 1–4 twisted laths. Occasionally the columella is absent, the inner edges of the primary septa being slightly expanded and almost meeting in center of calice.

DISCUSSION.—Five Recent species of *Coenocyathus* are known: *C. cylindricus* Milne Edwards and Haime, 1848a (northeastern Atlantic); *C. anthophyllites* Milne Edwards and Haime, 1848a (northeastern Atlantic); *C. bowersi* Vaughan, 1906a; *C. sagamiensis* Eguchi, 1968 (Japan); and *C. goreaui* Wells, 1972 (Bermuda). Although Zibrowius (1980) expressed some reservation about placing *C. bowersi* in this genus, comparison to the type species does appear to justify its placement. The only other known Pacific species, *C. sagamiensis*, differs in having a papillose columella, hexamerally arranged septa, and in apparently lacking pali.

Both Durham and Barnard (1952) and Bythell (1986) commented on the extreme variability of this species, with which I agree. Characters showing variation include: colony shape; corallite diameter and height; method of budding; septal insertion pattern; palar development; and columellar development. Nonetheless, *C. bowersi* is a distinctive species known from a circumscribed area, not easily confused with any other species in the northeastern Pacific. According the Bythell (1986), the peculiar intratentacular budding may be caused by the mechanical stress of sediment burial.

MATERIAL EXAMINED.—*New Records:* Alb-2895, 6 colonies, USNM 19236; Alb-2942, 6, USNM 19252; Alb-2944, 2, USNM 19241; Alb-2962, 1, USNM 19205; Alb-2963, 1, USNM 19248; Alb-2978, 1, USNM 19245; Alb-4431, 1, USNM 92607; off southern California, 20–45 m, 1, USNM 78634; off Santa Cruz, 2, USNM 78631 and 78643; off Santa Catalina, 1, USNM 92608; Monterey Bay, 1, USNM 78613; *Pillsbury*-512, USNM 92609; east of Point Conception, 64–80 m, 2, CAS 74904; *Zaca*-23, 2, CAS 80913; *Zaca*-42, 2, CAS 80916; *Zaca*-43, 1, CAS 80921; off Bird Rock, Santa Catalina, 13–15 m, 3, CAS 77797, 77799 and SIO Co 1168; off Catalina I., 1, CAS 80903; off Palos Verde, California, 13–15 m, CAS 80939; *Agassiz* MV71-I-1, 1, SIO Co 1309. *Previous Records:* Holotype of *C. bowersi*; Alb-4463, 1, USNM M547379 (Durham, 1947); off La Jolla, 30 fms (= 55 m), 1, USNM 92920 (Durham, 1947).

TYPES.—The holotype colony (Plate 8*b*) of *C. bowersi* is deposited at the USNM (21138). *Type Locality:* Off San Miguel Island, Channel Islands, California; depth unknown.

DISTRIBUTION.—Colonet, Pacific coast of Baja California (Parker, 1964) to Monterey Bay, including Channel Islands, Cortes Bank, and Isla Guadelupe; Gulf of California; Gulf of Panama (reported herein); 9–302 m.

Nomlandia Durham and Barnard, 1952

DIAGNOSIS.—Corallum solitary, discoidal, and attached. Thecal wall lacking. Pali present (?); columella fascicular. No dissepiments or synapticulae.

TYPE SPECIES.—*Nomlandia californica* Durham and Barnard, 1952, by original designation.

Nomlandia californica Durham and Barnard, 1952

PLATE 8*g*

Nomlandia californica Durham and Barnard, 1952:91, pl. 12: fig. 53.—Wells, 1956:F423.—Bythell, 1986, 19.—Cairns et al., 1991:47.

REDESCRIPTION OF HOLOTYPE.—Corallum discoidal and firmly attached (encrusting): 9.7 × 7.0 mm in calicular diameter and only 2.4 mm in height. Thecal wall and costae absent; outer edges of septa attenuate in height toward perimeter of basal plate. Septa hexamerally arranged in 4 complete cycles (48 septa) according to formula: $S_1>S_2>S_3>S_4$. S_1 extend to columella, the higher cycle septa progressively less wide. All septa semi-circular in shape (arched), the S_1 being the highest of the septa. Septal edges finely pleated corresponding to underlying trabeculae that are oriented perpendicular to septal edges. Closer to basal plate and toward columella the septa bear tall, elongate carinae oriented parallel to septal edges. A sinuous palus (P_3) occurs in only one half-system, being absent from all other half-systems. Columella a single low, twisted lath, which is attached to the inner edges of the 6 S_1.

DISCUSSION.—This unusual species is known from only the holotype, collected from a sunken bouy off San Miguel Island, California. It does not resemble any North Pacific or any other previously described coral, justifying Durham and Barnard's creation of a new genus. Durham and Barnard (1952) suggested that *Nomlandia* was related to *Bathycyathus*, but its inconsistent presence of pali and lack of a thecal wall argue against that relation. Wells (1956) questioningly placed the genus in the Caryophylliinae. The holotype appears to be a mature specimen, not a juvenile stage of a larger, better-known species, but, until more specimens are collected, its range of variation and phylogenetic affinities remain enigmatic. Its encrustation of a sunken bouy suggests that it might have been transported a great distance, either alive or after death.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Holotype.

TYPE.—The holotype (Plate 8*g*) of *N. californica* is deposited at the SBMNH (35560) ex AHF 19. *Type Locality:* 1.1 km off Richardson Point, San Miguel Island, Channel Islands, California; 82 m on a sunken bouy.

DISTRIBUTION.—Known only from the type locality.

Desmophyllum Ehrenberg, 1834

DIAGNOSIS.—Solitary, trochoid, fixed. Septothecate. Pali absent; columella absent or quite rudimentary. Sparse endothecal dissepiments. Azooxanthellate.

TYPE SPECIES.—*Madrepora dianthus* Esper, 1794, here designated. Milne Edwards and Haime (1850a:xvii) have been cited as the authors to have subsequently designated *Desmophyllum cristagalli* Milne Edwards and Haime, 1848a, as the type species of *Desmophyllum*, however this cannot be valid since *D. cristagalli* was not included as a species in the original description of the genus. In Ehrenberg's (1834:299) original description of *Desmophyllum*, he listed two species: "*D. dianthus* (= *Madrepora dianthus* Esper)" and *D. stellaria* sp. nov. Since the type species of a genus must originate from the species originally placed in that genus when it was established (ICZN Articles 67g and 69a), *D. cristagalli* cannot be considered as the type species, even if it is considered to be a junior synonym of the type species. In 1857, Milne Edwards and Haime made a distinction between the Red Sea specimens Ehrenberg called *D. dianthus* (having five cycles of septa) and the "East Indian" specimen (having six cycles of septa) that Esper called *D. dianthus*. This undoubtedly led Wells (1956:F426) to designate Ehrenberg's "*D. dianthus* (non *Madrepora dianthus* Esper)" as the type species of the genus. But, regardless of the specimens Ehrenberg had in hand at the Musée de Berlin (see Zibrowius, 1980:117), he clearly equated his *D. dianthus* to Esper's species, and thus the type of the genus cannot be *D. dianthus* sensu Ehrenberg, as implied by Wells (1956), but must be the original *D. dianthus* (Esper, 1794). According to Zibrowius (1980:117), Ehrenberg's *D. stellaria* is a junior synonym of *Balanophyllia europaea* (Risso, 1826). It is therefore appropriate (ICZN recommendation 69B(3): choice by elimination) to designate the other species listed by Ehrenberg (1834) in his original generic account, *M. dianthus* Esper, 1794, as the type species of the genus.

Esper's type of *D. dianthus* is lost (Scheer, 1990:406), and his description and illustrations leave room for doubt as to its identity, but it is known (Cairns, 1979, 1982) that *D. cristagalli* is a widespread and quite variable species, having five, six, or even more cycles of septa. It is quite likely that Esper's six-cycle *D. dianthus* from the "East Indies" was the same as Ehrenberg's five-cycle *D. dianthus* from the Red Sea, a species better known as *D. cristagalli* Milne Edwards and Haime, 1848a. Even though the type of Esper's *D. dianthus* is lost, this name has nomenclatural priority as well as being the type species of the genus, and thus a neotype is chosen for this species: a specimen having six cycles of septa from Sagami Bay (Plate 9*a,b*).

Desmophyllum dianthus (Esper, 1794)

PLATE 9*a–d*

Madrepora dianthus Esper, 1794, pl. 69: figs. 1–3; 1795:85–86.—Scheer, 1990:406.

Desmophyllum dianthus.—Ehrenberg, 1834:299–300.—Milne Edwards and Haime, 1848a:254–255; 1857:77–78.—Yabe and Eguchi, 1942b:113–114, pl. 9: figs. 1–3.—Eguchi, 1965:290, 2 figs.; 1968:C41, pl. C33: fig. 6.

Desmophyllum cristagalli Milne Edwards and Haime, 1848a:253, pl. 7: figs. 10, 10a.—Marenzeller, 1904b:81.—Durham, 1947:36–37, pl. 1: figs. 6, 10, 15, 17; 1949:158–159, pl. 4: figs. 2, 4, 7, 8.—Durham and Barnard, 1952: 86–87, pl. 11: fig. 48 [not Cartego Bay specimen].—Parker, 1964:150.—Talmadge, 1972:81, 2 figs.—Zibrowius, 1974a:758–761, pl. 3: figs. 1–10 [synonymy]; 1980:117–121, pl. 61: figs. A-O; pl. 62: figs. A-M.—Cairns, 1979:117–119, pl. 21: figs. 7, 8; pl. 22: fig. 8; 1982:29–30, pl. 8: figs. 9–12;

pl. 9: figs. 1-3 [synonymy]; 1991a:17, pl. 6: figs. g-i.—Austin, 1985:81.—Bythell, 1986:16-17, pl. 8: figs. A-D.—Kozloff, 1987:72.

Desmophyllum cumingii Milne Edwards and Haime, 1848a:254, pl. 7: fig. 11.

DESCRIPTION.—Corallum ceratoid, often flaring at calice (trumpet-shaped), attached through a robust pedicel 20%–40% that of GCD. Largest North Pacific specimen (USNM 83583) 60 × 40 mm in calicular diameter and 50 mm in height, with a pedicel diameter of 20 mm. Calice circular, elliptical, or scalloped. Theca uniformly covered with small low granules; costae rarely expressed, but occasionally C_{1-3} are present in upper half of corallum as thin ridges. Corallum light brown or grey.

Septa hexamerally arranged in 5 to 6 cycles according to the formula: $S_{1-2}>S_3>>S_4>S_5>S_6$. Fourth cycle (48 septa) attained at a calicular diameter of about 7 mm and fifth cycle at a calicular diameter of about 18 mm; a complete sixth cycle (192 septa) is often present in Japanese specimens. S_{1-2} extremely robust, up to 2 mm thick at thecal edge, and up to 11 mm exsert. S_{1-2} have straight, vertical inner edges that define a deep, narrow fossa, the inner edges of opposing S_{1-2} sometimes almost touching in center of fossa. S_3 also highly exsert, but narrower—only 80%–90% width of S_{1-2}. S_4 much smaller than S_3 (50%–70% width) and least exsert of the septal cycles. S_5 only about half width of S_4, but highly exsert, rising well above S_4 and often becoming incorporated into adjacent S_{1-3} in large coralla. Septal faces smooth, covered with small, fine, rounded granules. Fossa deep and slender. Columella usually absent but may consist of up to 5 slender fascicular or papillose elements, usually hidden from view in an intact corallum.

DISCUSSION.—Specimens from the northeastern Pacific tend to have five cycles of thick septa, occasionally with pairs of S_6. Japanese specimens tend to have a full sixth cycle, typifying the typical form originally described by Esper and the form identified as *D. dianthus* by Yabe and Eguchi (1942b).

MATERIAL EXAMINED.—*New Records:* Alb-2946, 8, USNM 19249; Alb-2978, 1, USNM 83536; Alb-2984, 1, USNM 92477; Alb-2987, 4, USNM 19202 and 19250; Alb-3170, 1, USNM 83537; Alb-4359, 1, USNM 92476; Alb-4912, 3, USNM M547422; R/V *Washington*, 32°25.78′N, 127°47.4′W (Fieberling Seamount), 440–488 m, 4, USNM 83583; Cobb Seamount, 312 m, 2, USNM 78630; off Santa Barbara, 64–80 m, 2, CAS 74903; Eel Canyon, 366 m, 5, CAS 74910; Carmel Bay, 183 m, 1, CAS 80926; Monterey Bay, 91–110 m, 2, CAS 15647 and 16309; La Jolla Canyon, 33 m, 1, SIO Co 1265; 32°46′N, 117°22.8′W, 183 m, 8, SIO Co 1193; 32°46.5′N, 118°20.5′W, 505 m, 2, SIO Co 1276; east of South Point, Guadelupe, 274 m, 3, SIO Co 1333; off Point Loma, 229 m, 10, SIO Co 945; TM (KT7802,Z61), 1, IOM; Enoshima, Sagami Bay, 9, USNM 92612; 32°21′N, 128°41′E, 179–201 m, 2, ZMC; 32°21′N, 128°39′E, 274–366 m, 5, ZMC. *Previous Records:* Neotype of *D. dianthus*; holotype of *D. cristagalli*; specimens reported by Marenzeller (1904b) from Alb-3384 and 3401 (USNM); specimens reported by Durham (1947) from Alb-4370, 4373, 4376, 4377 (USNM).

TYPES.—Although we may never know the identity of Esper's *D. dianthus* from the "East Indies" because the type is lost and the description is brief, it nonetheless must be considered as the type species of the genus (see above). Because it is the type species of *Desmophyllum*, it is appropriate to designate a neotype (Plate 9*a,b*) for the species, herein deignated as a specimen from Sagami Bay, depth unknown (USNM 92475).

The holotype of *D. cristagalli* is deposited at the MNHNP and illustrated by Cairns (1979, pl. 21: figs. 7, 8). *Type Locality:* Gulf of Gascogne, depth unknown.

The type of *D. cumingii* has not been traced. *Type Locality:* "Pacific coast of South America," depth unknown.

DISTRIBUTION.—Northeast Pacific: Vancouver Island, British Columbia (Austin, 1985); Cobb Seamont, Washington to off San Diego, including Channel Isalnds, Cordell Bank, and Fieberling Seamount; Isla de Guadelupe, Mexico; Gulf of California (Parker, 1964); Gulf of Panama (Marenzeller, 1904b); Cocos and Galápagos Islands (Cairns, 1991a); 33–1097 m. Off Japan: Sagami Bay to Kii Strait, Honshu; off Shikoku; off Koshiki Island, southwest Kyushu; 77–715 m. *Elsewhere:* Cosmopolitan except for off continental Antarctica and northern boreal Pacific; 35–2460 m (Cairns, 1982). Common on seamounts, guyots, and deep-water coral banks associated with framework building species (Cairns and Stanley, 1982).

Lophelia Milne Edwards and Haime, 1849

DIAGNOSIS.—Colonial, forming large dendroid colonies by intratentacular budding. Coenosteum dense; costae poorly developed. Pali absent; columella rudimentary. Sparse tabular endothecal dissepiments present. Azooxanthellate.

TYPE SPECIES.—*Madrepora prolifera* Pallas, 1766 (= *L. pertusa* L., 1758), by subsequent designation (Milne Edwards and Haime, 1850a:xx).

Lophelia pertusa (Linnaeus, 1758)

PLATE 9*e–i*

Madrepora pertusa Linnaeus, 1758:797.

Madrepora prolifera Pallas, 1766:307.

Lophelia californica Durham, 1947:36, pl. 1: figs. 13, 16; pl. 2: fig. 11.—Bythell, 1986:18, pl. 10: figs. A-E.—Kozloff, 1987:72.—Cairns, 1991a:17.

Dendrosmilia nomlandi Durham and Barnard, 1952:85, pl. 10: fig. 47.—Cairns, 1979:126.—Bythell, 1986:16, pl. 10: fig. F; 1991a:18.

Lophelia prolifera.—Cairns, 1979:125–127, pl. 24: figs. 1–5 [synonymy]; 1982:30–31, pl. 9: fig. 6; 1991a:17–18, pl. 6: fig. j.

Lophelia pertusa.—Zibrowius, 1980:126–130, pl. 66: figs. A-L [synonymy].

Description of northeastern Pacific Specimens.–Colonies up to 25 × 12 cm in size (Bythell, 1986), achieved by profuse intratentacular budding. Up to 8 corallites may bud from the perimeter of a single corallite (Plate 9*f*), which ultimately produces a very dense, sometimes anastomotic, colony.

Corallites ceratoid, often slightly curved, long, and slender: up to 25 mm long and usually 4–6 mm in diameter, but some large corallites up to 11 mm in diameter. Calices circular to slightly elliptical. Costae usually not present, the theca covered with low, closely spaced, rounded granules. Occasionally C_{1-2} expressed as low ridges near calice. Corallum white.

Septa irregularly arranged in 3 or 4 size classes. Six to 12 primary septa define an equal number of sectors, each sector bisected by a smaller secondary septum. Another cycle of tertiaries follows and a variable number of quaternaries, 32–66 septa per calice being the most common totals for those examined. Primary septa fairly highly exsert (up to 1.2 mm), quite thin, and relatively narrow, their straight, vertical inner edges reaching halfway to calice center. Secondary septa about half width of primaries and correspondingly less exsert. Tertiaries quite small, but slightly enlarged if flanked by a pair of quaternaries. Lower, inner edges of all septa slightly sinuous. Septal faces smooth, covered by very small, low, rounded granules. Tabular endothecal dissepiments present low in fossa. Fossa deep and often curved, such that base cannot be seen. Columella usually absent, but occasionally expressed as a small crispate lath.

DISCUSSION.—As discussed by Cairns (1979, 1991a), both *L. californica* and *Dendrosmilia nomlandi* are considered to be junior synonyms of *L. prolifera (= L. pertusa). Lophelia californica* represents the *gracilis* variation (sensu Duncan, 1873), characterized by delicate, slender, elongate corallites. Also typical of this form is extremely profuse budding. *D. nomlandi* represents the more robust *brachycephala* variation (sensu Moseley, 1881), characterized by short, stout corallites and, in this case, a rudimentary columella.

MATERIAL EXAMINED.—*New Records:* Alb-2946, 10 colonies, USNM 92606; Alb-2948, 1 branch, USNM 19215; Alb-2984, 4 colonies, USNM 19237; Alb-2987, 10 colonies, USNM 19247; R/V *Washington,* 32°55′N, 127°47′W (Fieberling Seamount), 440–488 m, 1 branch, USNM 83582; Cobb Seamount, 415 m, branches, USNM 78616; Cobb Seamount, 312 m, 2 branches, USNM 78605; Saucer Dive 345, off Bird Rock, La Jolla, 110–200 m, many fragments, SIO Co 532; TM (KT7414, B2), 1 branch, USNM 92611, 1 branch, ORI. *Previous Records:* Holotype of *Dendrosmilia nomlandi.*

TYPES.—The Linnaean type of *M. pertusa* appears to be lost (Zibrowius, 1980). *Type Locality:* Not stated, but probably the fjords of Norway.

The holotype of *L. californica,* stated to be deposited at the Los Angeles County Museum (2001), is no longer there and is presumed to be lost (G. Hendler, pers. comm.). *Type Locality:* Off "Southern California," depth unknown.

The holotype of *Dendrosmilia nomlandi* (Plate 9*h,i*) is deposited at the SBMNH (35559) ex. AHF 15. *Type Locality: Velero*-1172-40: 8.8 km southeast of Santa Catalina, 82–274 m.

DISTRIBUTION.—Northeastern Pacific: known primarily from offshore seamounts and islands, including: Cobb Seamount, Washington; Channel Islands; off La Jolla (Bird Rock); Fieberling Seamount; and Isla de Guadelupe, off Baja California, Mexico; 82–488 m. Northwestern Pacific: Suruga Bay, Honshu; 150–340 m (first record for western Pacific). *Elsewhere:* Amphi-Atlantic (Cairns, 1979); northeast of Madagascar (Cairns and Keller, 1993) and off South Africa; Saint Paul and Amsterdam Islands (Zibrowius, 1974a); and Macquarie Ridge (Cairns, 1982); 60–2170 m. *Lophelia pertusa* is a framework species of deep-water coral banks (Cairns and Stanley, 1982), often providing the substrate for attachment by *Desmophyllum dianthus.*

Superfamily FLABELLOIDAE

Family FLABELLIDAE

Flabellum Lesson, 1831

DIAGNOSIS.—Corallum solitary, fixed or free. Corallum ceratoid, campanulate, or compressed; base not reinforced with stereome. Wall epithecal, usually lacking costae. Transverse division lacking. Pali, dissepiments, and synapticulae absent. Columella rudimentary: a simple fusion of lower inner edges of larger septa. Exclusively azooxanthellate.

Subgenus *Flabellum (Flabellum)* Lesson, 1831

DIAGNOSIS.—*Flabellum* with a smooth (not serrate) calicular edge.

TYPE SPECIES.—*Flabellum pavoninum* Lesson, 1831, by monotypy.

Flabellum (F.) sp. A

PLATE 10*a,b*

DESCRIPTION.—Corallum ceratoid, largest specimen examined (Plate 10*a,b*) 25.8 × 21.5 mm in calicular diameter and 38.5 mm in height, with a pedicel diameter of 4.1 mm and a basal plate diameter of 5.3 mm. Three of the 7 specimens reported herein attached to epitheca of conspecific specimens. Thin, shallow, longitudinal intercostal striae visible on worn specimens, otherwise, well-preserved coralla display transverse epithecal bands encircling the theca. Calice slightly elliptical (GCD:LCD = about 1.2); calicular edge very slightly scalloped, the outer edges of the S_{1-3} rising about 0.8 mm as apices.

Septa hexamerally arranged in 5 complete cycles according to the formula: $S_{1-2}>S_3>>S_{4-5}$. A juvenile corallum only 4.8 mm in calicular diameter has only 2 cycles of septa (12), whereas at a calicular diameter of 5.2 mm a full third cycle (24) is present and at a calicular diameter of 11.6 mm a full fourth plus 3 pairs of S_5 are present (54 septa). The illustrated specimen (GCD = 25.8 mm) has a perfectly symmetrical arrangement of 5 cycles (96 septa). All septa nonexsert and quite thin, their faces covered with small, pointed granules. S_{1-2} have straight inner edges, which fuse to one another deep in fossa. S_3 one-half to two-thirds width of S_{1-2}, their inner edges reaching deep into fossa but not joining to S_{1-2} fusion. S_4 one-tenth to one-third width of S_3; S_5 rudimentary, less than

1 mm wide. S_4 extend deep into fossa but S_5 extend only one-third distance down inner thecal wall.

DISCUSSION.—None of the 28 Recent species in the nominate subgenus of *Flabellum* (see Cairns, 1989a:46) occur in the eastern Pacific or boreal North Pacific; however, the Alaskan specimens are most similar to several Antarctic-Subantarctic species that have conical (not flabellate) coralla, especially *F. impensum* Squires, 1962. Comparison of the Alaskan specimens to ceratoid specimens of *F. impensum* of equivalent size show them to be similar in shape, pedicel diameter, theca, septal shape, and septal formula. The only difference noted between the two was the slightly scalloped calicular margin of the Alaskan specimens, the calice of *F. impensum* being perfectly smooth. *Flabellum impensum* is known only from the Antarctic and Antipodes Islands at a depth range of 46–2260 m (Cairns, 1982).

Several specimens of an unnamed species belonging to this subgenus (*F. (F.)* sp. A) were reported from the Galápagos Islands at 441–717 m (Cairns, 1991a), but are easily distinguished from the Alaskan specimens by their much smaller size, smaller pedicel diameter, and fewer septa.

MATERIAL EXAMINED.—Alb-3315, 4, USNM 19226; Station 69RD3, 3, NMCIC 1982-1492. *Reference Specimens:* Numerous specimens of *F. impensum* reported by Cairns (1982).

DISTRIBUTION.—Aleutian Islands: Unalaska Bay, Fox Islands and off Amchitka, Rat Islands; 55–507 m.

Javania Duncan, 1876

DIAGNOSIS.—Corallum solitary, ceratoid to trochoid, and firmly attached by a stereome-reinforced pedicel and base; transverse division lacking. Theca smooth. Septa usually highly exsert; calicular edge scalloped. Fossa deep; pali lacking, columella absent or rudimentary. Azooxanthellate.

TYPE SPECIES.—*Javania insignis* Duncan, 1876, by monotypy.

Javania cailleti (Duchassaing and Michelotti, 1864)

PLATE 10*g–i*

Desmophyllum cailleti Duchassaing and Michelotti, 1864:66, pl. 8: fig. 11.
Desmophyllum eburneum Moseley, 1881:162, pl. 6: figs. 1, 1a,b.
Desmophyllum nobile Verrill, 1885:150–151.
Desmophyllum vitreum Alcock, 1898:20, pl. 2: figs. 2, 2a,b.
Desmophyllum galapagense Vaughan, 1906b:63, pl. 1: figs. 1–1b.—Durham and Barnard, 1952:11.—Durham, 1962:46; 1966:125.
Desmophyllum delicatum Yabe and Eguchi, 1942b:115, 144, pl. 9: fig. 7a,b.
Javania delicata.—Zibrowius, 1974b:18.
Javania cailleti.—Cairns, 1979:153–156, pl. 28: figs. 8–12; pl. 30: figs. 1, 4 [synonymy and discussion]).—Zibrowius, 1980:157–159, pl. 82: figs. A-L [synonymy and discussion].—Cairns, 1982:46–48, pl. 14: figs. 9–12; 1991a:21, pl. 8: figs. c–e.—Not Wells, 1983:238.

DESCRIPTION.—Corallum of large specimens ceratoid, firmly attached, and distally flared (trumpet-shaped). One figured specimen (Plate 10*g*) is 31 × 23 mm in calicular diameter (estimated) and 29 mm in height, with a thick pedicel 7.5 mm in diameter. Pedicel diameter of a damaged specimen from British Columbia 13.8 mm. Theca white, porcellaneous, and smooth, except near calice where the theca overlaying the S_3 is flared outwards.

Septa hexamerally arranged in 4 complete cycles (48 septa) according to the formula: $S_{1-2}>S_3>S_4$. S_{1-2} usually highly exsert (up to 4.5 mm in the British Columbia specimens) and have straight inner edges that fuse lower in fossa as a solid, rudimentary columella. S_3 less exsert (about 2 mm above calicular edge), about three-quarters width of S_{1-2}, and extend deep into fossa but do not merge with columella. S_4 nonexsert, about one-third width of S_3, and extend only about halfway down inner thecal wall.

DISCUSSION.—*Javania cailleti* is distinguished from all but one of the other nine species known in this genus (Cairns, 1989a) by having four, not three or five, cycles of septa. *J. pseudoalabastra* Zibrowius, 1974b, known only from several records in the Atlantic (Zibrowius, 1980), also has four cycles of septa, but is easily distinguished by its elongate calice and red-brown coenosteum. At least six names have been applied to this species, which is not unusual for widely distributed species that are collected and described from the various ocean basins.

Javania cailleti has been collected only rarely in the North Pacific. It is known from only three specimens from two localities in the Queen Charlotte Islands in the northeastern Pacific, and likewise from only three specimens from two localities off Japan (two of these specimens reported as *Desmophyllum delicatum* by Yabe and Eguchi, 1942b).

MATERIAL EXAMINED.—*New Records:* LM49, 2, NMCIC 1900-8362; 67-41GBR, 1, NMCIC 1982-1491; Alb-4982, 1, USNM 92747. *Previous Records:* Types of *D. eburneum, D. nobile,* and *D. galapagense.*

TYPES.—The holotype of *D. cailleti* appears to be lost (Cairns 1979). *Type Locality:* Lesser Antilles, depth unknown.

Five syntypes of *D. eburneum* are deposited at the BM (1880. 11.25.65). *Type Locality: Challenger*-306A: 48°27′S, 74°30′W (off southern Chile), 627 m.

The holotype of *D. nobile* is deposited at the USNM (7964). *Type Locality:* 44°28′N, 57°13′W (off Nova Scotia), 549 m.

Most of the syntypes of *D. vitreum* are deposited at the Indian Museum, Calcutta, but five syntypes are also deposited at the MNHNP, two at the ZMA (Coel. 1198), and two at the MCZ. *Type Locality: Investigator*-232: 7°17′30″N, 76°54′30″E (Laccadive Sea), 787 m.

The holotype of *D. galapagense* is deposited at the USNM (68275). *Type Locality:* Alb-4642: 1°30.5′S, 89°35′W (Galápagos), 549 m.

The holotype of *D. delicatum* is deposited at the TIUS (59131). *Type Locality: Soyo Maru*-22: 36°46′N, 141°30′E, off Hitachi, Honshu), 539 m.

DISTRIBUTION.—Widespread (perhaps cosmopolitan): previously reported from throughout Atlantic Ocean from Nova

Scotia to Burdwood Bank (Cairns, 1979; Zibrowius, 1980); southern Chile (Moseley, 1881; Cairns, 1982); Galápagos (Cairns, 1991a); off Japan (off Hitachi, Honshu and Sea of Japan, off southwestern Hokkaido); Arabian Sea (Alcock, 1898); 86–2165 m. The two records reported from off British Columbia are the first for the northeastern Pacific.

Javania borealis, sp. nov.

PLATE 10*c,d*

?Javania cailleti.—Wells, 1983:238 [in part: Alb-2816].
Javania n. sp.—Cairns, 1989a:76.
?Javania sp. A.—Cairns, 1991a:21, pl. 8: figs. g,h.

DESCRIPTION.—Corallum massive and trochoid, the thecal walls growing upward at a constant angle (not flared). Holotype 36.4 × 27.8 mm in calicular diameter and 34.4 mm in height, firmly attached through a robust stereome-reinforced pedicel 10.6 mm in diameter. A broken cross section of a pedicel of a paratype revealed 11 concentric layers of solid stereome. Calice elliptical; calicular edge slightly serrate, each S_{1-4} rising to a small triangular apex around calicular perimeter. Costae glisteny white. Theca and septa thin and fragile, easily broken, both about 0.2 mm thick.

Septa hexamerally arranged in 5 complete cycles (96 septa) according to the formula: $S_{1-2}>S_3>S_4>>S_5$. All septa have slightly sinuous inner edges and faces sparsely covered with low, pointed granules. Upper, inner edges of opposing S_{1-2} almost meet in center of fossa, and fuse into a rudimentary columella deeper in fossa. S_3 about 80% width of S_{1-2} and nonexsert, their lower inner edges also fused with the S_{1-2} even deeper within fossa. S_4 about half width of S_3; S_5 rudimentary, only about one-fourth width of S_4. Fossa elongate and quite deep, defined by inner edges of S_{1-2}.

DISCUSSION.—Of the seven Recent species of *Javania* (see Cairns, 1989a:76), four have five cycles of septa: *J. insignis* Duncan, 1876; *J. lamprotichum* (Moseley, 1880); *J. antarcticum* (Gravier, 1914); and *J. borealis*. *Javania borealis* is quite similar to *J. lamprotichum*, which is known only from the Hawaiian Islands and off Johnston Atoll at 244–322 m (Cairns, 1984). The Hawaiian species differs in having a flared calice, a reddish brown corallum, and more sinuous septal edges. *Javania borealis* differs from *J. insignis* by having: much less exsert septa; thinner, and thus more delicate, theca and septa; and more widely spaced septa. Each septum of *J. borealis* is separated from its adjacent septa by 0.5–0.6 mm, whereas in *J. insignis* the distance is 0.3 mm or less, their S_{1-2} often so thick that adjacent S_5 become fused to them near thecal edge. An unidentified species of *Javania* collected from off the Galápagos Islands at 143 m was also compared to *J. borealis* by Cairns (1991a), but the Galapagan specimen was not adequately preserved to make a definite identification.

ETYMOLOGY.—The species name *borealis* (Latin *borealis*, northern) refers to the high northern latitude distribution of this species.

MATERIAL EXAMINED/TYPES.—*Holotype:* Alb-4784, USNM 82019 (Plate 10*c,d*). *Paratypes:* Alb-4784, 3, USNM 92618; ALB-4994, 1, USNM 92619. *Type Locality:* 52°55′40″N, 173°26′E (northeast of Attu Island, Near Islands, Aleutian Chain, Alaska), 247 m. *Reference Specimen: Javania* sp. A of Cairns (1991a), Alb-2816, USNM 19142.

DISTRIBUTION.—Known only from off Attu Island (western Aleutian Chain) and off Rebun Island (Sea of Japan off northwest tip of Hokkaido); 247–348 m.

Javania californica, sp. nov.

PLATE 10*e,f*

Flabellum montereyense Durham, 1947:37 (in part: paratype and 3 nontype specimens from Alb-4551; specimen from Alb-4550; 1 specimen from Alb-4553).

DESCRIPTION.—Corallum trochoid and relatively small, attached by a thick, stereome-reinforced pedicel. Largest specimen (holotype) only 12.6 × 10.7 mm in calicular diameter and 12.6 mm in height, with a pedicel diameter of 3.6 mm. Calice elliptical; calicular edge highly serrate. Theca white, porcellaneous, and relatively thin in upper corallum.

Septa hexamerally arranged in 3 complete cycles (only 24 septa) according to the formula: $S_1>S_2>>S_3$. Each S_1 forms a triangular apex about 1.2 mm high at calicular edge and has a straight inner edge that thickens lower in fossa. S_2 also form triangular calicular apices of equal size and are about 80% width of S_1, their lower, inner edges also thickened and fused with those of the S_1 into a rudimentary columella. S_3 much smaller, only about 20%–25% width of S_2, have slightly sinuous inner edges, and form smaller calicular apices of about 0.5 mm height. Septa thin (about 0.2 mm thick) and widely spaced, separated by approximately 1.1–1.2 mm from one another. Fossa deep and elongate.

DISCUSSION.—*Javania californica* is distinguished from other Recent species in the genus by having only three cycles of widely spaced septa. Only one other species in the genus, *J. duncani* Wells, 1977 (Eocene of Tonga), has three septal cycles, but its generic placement is questionable and furthermore, the Eocene species has a much more slender corallum and thicker septa.

Durham (1947) included several specimens of *J. californica* in his description of *Polymyces montereyensis*. Although similar in young stages, and sometimes found together, *J. californica* is distinguished by having a solid, stereome-reinforced pedicel (no rootlets); only three cycles of septa (S_4 are present in *P. montereyensis* even in the protothecal stage at 6 mm calicular diameter); septa more exsert; a more robust columella; and a smaller adult size.

Etymology.—The species name alludes to the region of collection of the type material.

MATERIAL EXAMINED/TYPES.—*Holotype:* Alb-4550, USNM 92613 (ex. USNM M547411), Plate 10*e,f*. *Paratypes:* Alb-3168, 1, USNM 92615; Alb-4550, 4, USNM

M547411, reported as *F. montereyensis* by Durham (1947); Alb-4551, 4, USNM M547407, M547410, reported as paratype and nontypes by Durham (1947); Alb-4543, 1, USNM 92614 (ex. USNM M547409) reported as *P. montereyensis* by Durham (1947). *Reference Specimen:* Holotype of *J. duncani* Wells, 1977 (USNM I208332). *Type Locality of* J. californica: Alb-4550: 36°45′N, 121°55′W (off Point Pinos, Monterey Bay, California), 91–104 m.

DISTRIBUTION.—Known only from Monterey Bay and Cordell Bank; 62–170 m.

Polymyces Cairns, 1979

DIAGNOSIS.—Corallum solitary, ceratoid to trochoid, fixed. Wall epithecal, reinforced basally by symmetrically or asymmetrically arranged, contiguous hollow rootlets. Calicular edge lacerate to serrate. Pali absent; columella rudimentary.

TYPE SPECIES.—*Rhizotrochus fragilis* Pourtalès, 1871, by original designation.

Polymyces montereyensis (Durham, 1947)

PLATE 11*a–f*

Flabellum (?) montereyense Durham, 1947:37, pl. 1: figs. 5, 9 [in part: not paratype from Alb-4551; only 1 of 2 specimens from Alb-4543; only 1 of 3 nontypes from Alb-4551; not Alb-4550: all *Javania californica*].—Durham and Barnard, 1952:97, pl. 14: fig. 59a–c.—Austin, 1985:81.

Flabellum tannerense Durham and Barnard, 1952:97–98, pl. 14: fig. 60a–c [new synonym].—Bythell, 1986:19.

Polymyces montereyensis.—Cairns, 1979:158; 1991a:22.—Cairns et al., 1991:48.

Polymyces montereyense.—Bythell, 1986:19–20.

Polymyces tannerensis.—Cairns, 1991a:22.—Cairns et al., 1991:48.

DESCRIPTION.—Corallum trochoid, the thecal walls increasing in diameter at a constant angle. Largest known specimen (SEPBOP 18B-764, Plate 11*f*) 39.1 × 30.7 mm in calicular diameter and 34.4 mm in height, with a pedicel diameter of 10.8 mm. Calice elliptical and only slightly serrate, each S_{1-4} forming a small triangular apex. Corallum pedicel enlarged by a ring of contiguous rootlets, characteristic of the genus (see Discussion for more detail). Corallum white.

Septa hexamerally arranged in five incomplete cycles according to the formula: $S_{1-2}>S_3>S_4>>S_5$. At a GCD of 11 mm 36–48 septa are present; the largest two coralla examined have only 90 or 92 septa, each lacking several pairs of S_5. All septa have slightly sinuous inner edges and sparsely granular septal faces. S_{1-2} slightly exsert: the upper, inner edges of opposing lateral septa almost meeting in center of fossa, their lower inner edges fusing into a rudimentary columella deep in fossa. S_3 about 80% width of S_{1-2}, nonexsert, and do not fuse with columella. S_4 50%–80% width of S_3; S_5 rudimentary, about one-quarter width of S_4 and extending only 4–5 mm down inner theca. Fossa deep and elongate, defined by inner edges of S_{1-2}.

DISCUSSION.—*Polymyces montereyensis* is easily distinguished from the two other species in the genus (Cairns, 1991a) by having five cycles of septa, the other species having only four cycles. It is more difficult to distinguish it from the genus *Javania*, especially *J. borealis*, the basic difference between the two species being that *J. borealis* has a solid, stereome-reinforced pedicel, whereas that of *P. montereyensis* is reinforced by hollow rootlets and secondarily by stereome, which gives it a less dense corallum. Because rootlets are hard to detect in adult coralla, a cross section of the pedicel sometimes must be made to verify the generic placement. *Polymyces montereyensis* also differs from *J. borealis* in having less wide S_3 that do not fuse with the S_{1-2}. The broad pedicel of *P. montereyensis* led Durham (1947) to correctly doubt its placement in *Flabellum*; the inclusion of specimens of *Javania californica* in the type series of *F. montereyense* added to that uncertainty.

Polymyces tannerensis is herein synonymized with *P. montereyensis*. It was previously thought that it could be distinguished from *P. montereyensis* by its lack of a fifth cycle and its highly exsert S_{1-2}; however, small specimens of *P. montereyensis* of the same size as the types of *P. tannerensis* (holotype: 11.2 × 8.9 mm in calicular diameter; paratype: 9.9 × 8.6 mm in calicular diameter) have only four septal cycles. The highly exsert S_{1-2} of *P. tannerense* may be explained by the poor preservation of the two types, their epitheca entirely worn away at the calicular edge between major septa. In all other characters, *P. tannerensis* resembles *P. montereyensis* of an equivalent size. Furthermore, both "species" were collected at the same station (*Velero*-1348-41) and no additional specimens of the *P. tannerensis* growth form have been collected subsequently.

The rootlets appear to form in the following manner. Each corallum forms a prototheca about 5–6 mm in height and diameter. A secondary epitheca develops from the basal plate and encircles the prototheca at a distance of 1.0–1.5 mm, the secondary epitheca eventually growing upward to form the adult wall. In the basalmost 1–2 mm of the pedicel, the ring formed by the encirclement of the prototheca by the epitheca is divided into 12 compartments (rootlets) by outward extentions of the S_3 (Figure 3A; Plate 11*c*). Slightly higher in the pedicel (4–6 mm above basal plate) outward extensions of the S_{1-2} further subdivide the ring into 24 compartments (rootlets). These 24 chambers communicate with the polyp through a series of 12 pairs of pores, each pair flanking an S_3 about 6–8 mm above calicular base, essentially at the top of the prototheca ring (Figure 3B). Rudimentary S_4 are also found within the prototheca, these septa being continuous with the S_4 of the adult corallum, only higher in the corallum. S_5 are not found within the prototheca, these septa formed later and thus higher in the corallum. The space between each S_4 and adjacent S_1 and S_2 within the prototheca does not result in an additional pore, but is sealed with a dissepiment-like structure. Sometimes rootlet development is irregular, several pairs missing from one side of a corallum. Rootlets can usually be distinguished

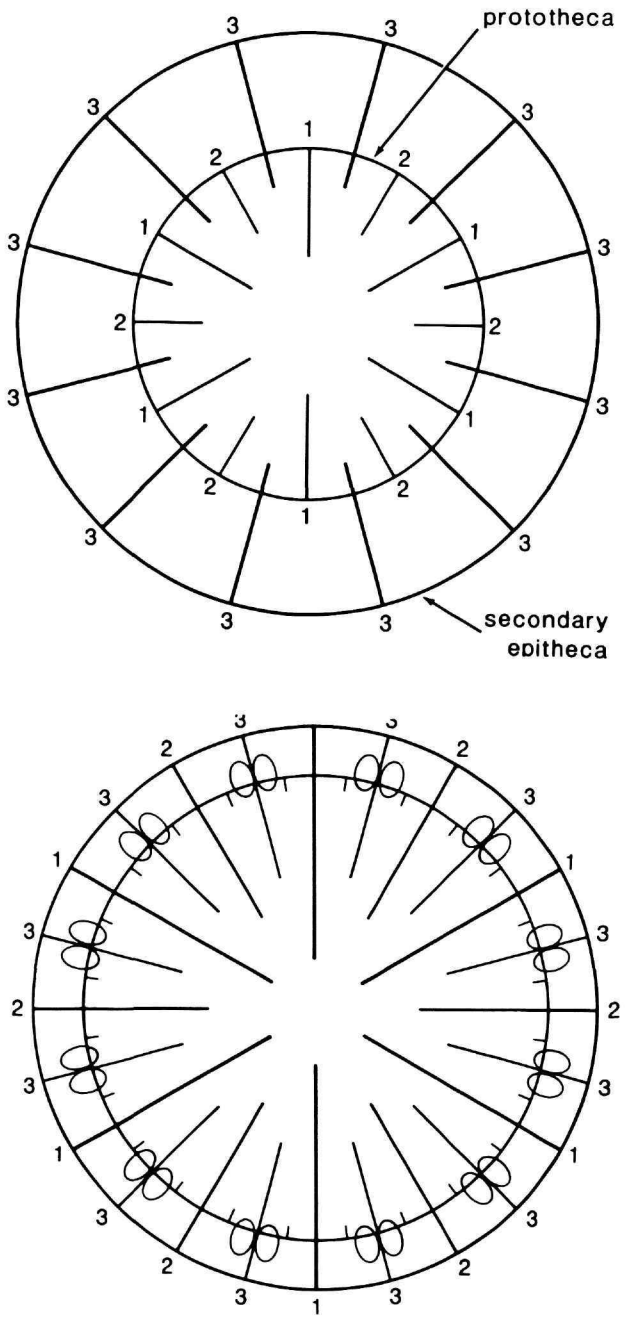

FIGURE 3.—Cross-section diagram of two stages of rootlet development in *Polymyces montereyensis*. A (top), Early stage of rootlet development characterized by relatively wide outer ring (= 12 rootlets) and only three septal cycles (see Plate 11*c*). B (bottom), Later development characterized by a narrower outer ring (24 rootlets) and four septal cycles. Location of pores through which rootlets communicate to polyp indicated by ellipses.

externally as slightly convex, longitudinal strips near the corallum base that often alter the architecture of the epitheca; however, in larger coralla the pedicel is secondarily reinforced with peripheral stereome and thus rootlets are seen only in cross section of the pedicel. Rootlets can also be seen in a calicular view of juvenile coralla, in which the paired pores leading to the rootlets flanking each S_3 are visible within the corallum.

MATERIAL EXAMINED.—*New Records:* Alb-2895, 1, USNM 92616; Alb-2977, 1, USNM 83528; Alb-4431, 1, USNM 83528; SEPBOP 18B-764, 1, USNM 83521; *Zaca*-42, 1, CAS 80931. *Previous Records:* Holotype, paratypes, and nontypes of *F. montereyense* Durham, 1947 [Alb-4543 (USNM M547409), 4550 (= *J. californica*, USNM M547411), 4551 (ex USNM M547410, now USNM 92617)]; holotype of *F. tannerense*.

TYPES.—The holotype (Plate 11*a,b*) of *F. montereyense* is deposited at the USNM (M547406). Two paratypes also exist: one deposited at the USNM (Alb-4551, USNM M547407, = *J. californica*) and one at the CAS (loc. 21810, CAS 7852). *Type Locality:* Alb-4543: 36°45′N, 121°55′W (west of Point Pinos Lighthouse, Monterey Bay), 97–170 m.

The holotype (Plate 11*d,e*) and paratype of *F. tannerense* are both deposited at the SBMNH, the holotype numbered 35562 (ex AHF 22). *Type Locality:* *Velero* 1348-41: Tanner Bank, off Southern California, 82–84 m; however, *Velero* 1348-41 is given as 33°16′N, 118°15′W (off southeastern Santa Catalina) at 212 m in the station log.

DISTRIBUTION.—Channel Islands, including Cortes and Tanner Banks, to Monterey Bay; off Cape Blanco, Peru; 69–212 m.

Suborder DENDROPHYLLIINA

Family DENDROPHYLLIIDAE

Balanophyllia Wood, 1844

DIAGNOSIS.—Corallum solitary, turbinate to trochoid, fixed or free. Costae usually well developed. Synapticulotheca especially well developed near calice. Septa arranged in a Pourtalès Plan. Pali may or may not be present; columella invariably spongy. Azooxanthellate; variable in depth range.

TYPE SPECIES.—*Balanophyllia calyculus* Wood 1844, by monotypy.

Balanophyllia elegans Verrill, 1864

PLATE 12*a–f*

Balanophyllia elegans Verrill, 1864:44; 1870a:511–512, pl. 10: fig. 3; 1870b:560.—Whiteaves, 1886:115.—Hickson, 1917:24.—Durham, 1947:41, pl. 1: figs. 7, 8, 11, 12; pl. 10: figs. 3, 4, text-fig. 2A; 1949: 142–145, 161, text-figs. 3, 17–7, pl. 5: figs. 2, 3, 6, 7, 10, 12, 15.—Durham and Barnard, 1952:99–100, pl. 14: fig. 62a–c.—Ricketts and Calvin, 1952:37, pl. 6: fig. 5.—Emerson, 1956:394.—Hertlein and Emerson, 1960:84, pl. 19: figs. 24, 19–21, pl. 24: figs. 4, 5, 8, 13, 15–17.—Guberlet, 1962:53, figure.—Addicott, 1966, pl. 1: figs. 25, 26.—Johnson and Snook, 1967:109, pl. 3: fig. 87.—Talmadge, 1972:81, fig.—Hand, 1975:93.—Brusca and Brusca, 1978:54, fig. 30.—Gerrodette, 1979:227–234; 1981:611–618.—Lewbel et al., 1981:165.—Fadlallah and Pearse, 1982a:223–230, 9 figs.—Fadlallah, 1983a:132; 1983b:200–206, 7 figs.—Austin, 1985: 81.—Bythell, 1986:20, pl. 3: fig. B; pl. 11: figs. A–F.—Kozloff, 1987:72.—Hellberg, 1991:30.—Cairns et al., 1991:48.—Chadwick, 1991:42–47.

DESCRIPTION.—Corallum cylindrical to trochoid, often short and squat, but occasionally taller and more vasiform. Pedicel robust: PD:GCD = 0.50–0.80; base polycyclic (Durham, 1949). Largest specimen examined (Alb-4552, Plate 12*b,c*) 16.8 × 13.7 mm in calicular diameter and 17.3 mm in height. Coralla invariably secondarily epithecate, the epitheca covering at least the lower third to as much as the entire underlying synapticulothecate wall. Epitheca often encrusted with coralline algae, bryozoans, and serpulids. Synapticulotheca porous; costae usually not well developed, but when present are low and rounded, separated by porous intercostal furrows about one-quarter width of a costa. Costae covered with small fine granules. Corallum white; polyp a vivid red-orange or bright red.

Septa hexamerally arranged in four or five incomplete cycles. Fourth cycle (48 septa) complete at a GCD of about 7–8 mm, half the fifth cycle (72 septa) at a GCD of 11–12 mm, and up to 88 septa in the largest coralla examined; a full fifth cycle was not observed. S_{1-2} equal in size, only slightly exsert, and have straight, entire inner edges that attain the columella. S_3 one-third to half width of S_{1-2} and have dentate lower inner edges. Remaining septa arranged in a Pourtalès Plan (Figure 2). In small coralla having no S_5, each pair of S_4 meet before its adjacent S_3 and extends to the columella as a single septum. When pairs of S_5 occur, they first occur flanking S_4 that are adjacent to S_1, not those adjacent to S_2 (Figure 2, lower right half-system adjacent to medial S_1). At this stage the pair of S_5 in each half-system unites before its adjacent S_3 and also joins with the singleton S_4 near the columella. After 12 pairs of S_5 are inserted in this manner (72 septa), additional pairs of S_5 form flanking the S_4 adjacent to the S_2 (Figure 2, lower right half-system adjacent to lateral S_1). Inner edges of S_{4-5} laciniate. All septal faces finely granular. Fossa of moderate depth, containing an elongate, spongy columella, which may have a flat of concave surface.

DISCUSSION.—*Balanophyllia elegans* is without doubt the most commonly collected and highly visible scleractinian in the northeastern Pacific and therefore has been cited in many fieldguides (see synonymy) and is one of the few azooxanthellates for which life history information is known. Durham (1947) used it as an example to explain his discovery of polycyclic development, by which he illustrated that *B. elegans* originally possesses an epithecal prototheca, surrounded by two concentric synapticulothecate walls, the outermost usually partially covered by another epitheca. Gerrodette (1981) published a study of larval dispersal of the species, showing it to have demersal planulae with extremely limited dispersal ability. In a study of its reproductive habits, Fadlallah and Pearse (1982a) discovered that it reproduced only sexually, had populations of equal sex ratio, and brooded large embryos to an advanced planula stage in large calicular cavities structured by its Pourtalès Plan septal arrangement. Production of sperm was found to be seasonal (late summer) but oocytes were found year round in females. Population densities of 530/m^2 were reported. In a follow-up study on growth, population dynamics, and demography of *B. elegans*, Fadlallah (1983b) estimated coralla to have a longevity of 6–11 years, based on mortality curves and growth rates, the latter averaging 1.7 mm/year in calicular diameter, 1.8 mm/year in height, and 175 mm^3/year in volume. Population densities ranged from 385–816 coralla/m^2 in his study area. Individuals reached reproductive maturity relatively early (less than a year) and planula mortality was relatively low.

Comparisons to its neighboring species *B. cedrosensis* are made in the account of that species.

MATERIAL EXAMINED.—*New Records:* Alb-2864, 3, USNM 92620; Alb-2865, 2, USNM 29212; Alb-2876, 1, USNM 19275; Alb-2879, 2, USNM 92621; Alb-2895, 6, USNM 92622; Alb-3158, 11, USNM 92623; Alb-3159, 5, USNM 92624; Alb-3160, 3, USNM 19233; Alb-3168, 16, USNM 92625; Alb-3174, 1, USNM 36416; Alb-3443, 2, USNM 19228; Alb-3465, 1, USNM 19270; Alb-3593, 30, USNM 92626; Alb-4552, 2, USNM 92627; off Cordell Bank, 73 m, 8, USNM 92628 and CAS 74802, CAS 74834, CAS 80940, CAS 74836; Monterey Bay, 42, USNM 78640 and CAS 74810, CAS 16325, CAS 74809, CAS 74814; Moss Beach, 15, USNM 78636 and CAS 7602; off Nanaimo, B.C., 1, USNM 92629; off Banks I., B.C., 1, USNM 92630; Pleistocene of San Pedro, 1, USNM 92631; off Pigeon Point, 1, CAS 6149; Neah Bay, B.C., 3, CAS 69606; off Santa Barbara, 1, CAS 74817; 36°3′N, 121°58′W, 183 m, 3, CAS 74808; Snipe Bay (west coast of Baranof I.), Alaska, 3, UA; Quast Rock, La Jolla, 21 m, 15, SIO Co 1164 and 1186; Ben's Rock, Isla San Martin, Pacific coast of northern Baja California, 27 m, 8, SIO Co 1171; Islas Coronados, Pacific coast of northern Baja California, 15 m, 9, SIO Co 1170; Point Loma, 13 m, 7, SIO Co 1173; 127 specimens collected off British Columbia deposited at the RBCM, cataloged as: 973-180-2, 973-138-3, 973-251-10, 973-154-2, 973-166-2, 973-139-23, 974-230-8, 974-234-2, 974-239-2, 975-753-23, 975-772-26, 976-1040-3, 976-1238-59, 976-111-39, 976-111-38, 977-156-10, 980-350-19, 980-327-24, 980-381-5, 980-338-24, 980-267-29, 980-343-17, 981-212-7. *Previous Records:* Syntypes of *B. elegans*; specimen reported by Durham (1947) [Alb-4534, 1, USNM M547412; Alb-4543, 2, USNM M547414-15; Alb-4555, 1, USNM M547413].

TYPES.—Forty-two syntypes of *B. elegans* are deposited at the MCZ in three lots: Crescent City (old MCZ 1085, new MCZ 5472, Plate 12*e,f*), 3 dry syntypes; Crescent City (MCZ 223), 23 syntypes preserved in alcohol; Mendacino (MCZ 222), 16 syntypes preserved in alcohol. All syntypes were received and cataloged in the early 1860s and bear Verrill's handwriting regarding type status. *Type Locality:* Off Crescent City and Mendacino, California, depth unknown.

DISTRIBUTION.—*Pliocene:* San Diego (Hertlein and Grant, 1960). *Pleistocene:* San Pedro, California (Addicott, 1966). Recent: Snipe Bay, Alaska to Sacramento Reef, Pacific coast of northern Baja California (29°44′N) (Gerrodette, 1979), including Queen Charlotte Islands, Vancouver Island, and Cortes, Tanner, and Cordell Banks. Bathymetrically known from

0–293 m (Durham, 1947), with one outlying record at 587 m (Durham and Barnard, 1952). According to Gerrodette (1979), specimens south of Point Conception are always found deeper than 10 m, which he suggests is an example of equatorial submergence that occurs at the cold-warm temperate zoogeographic boundary.

Balanophyllia cedrosensis Durham, 1947

PLATE 11*g–j*

Balanophyllia cedrosensis Durham, 1947:40–41, pl. 11: figs. 3, 5.—Durham and Barnard, 1952:99, pl. 14: fig. 61a,b.

Balanophyllia tiburonensis Durham, 1947:41–42, pl. 10: figs. 5, 7 [new synonym].—Squires, 1959:423–426.

REDESCRIPTION OF HOLOTYPE.—Corallum poorly preserved, obviously dead when collected. Corallum ceratoid: 13.7 x 10.4 mm in calicular diameter and 16.4 mm in height, with a pedicel diameter of 6.2 mm. Costal granulation worn; intercostal striae almost as wide as costae and quite porous. A thin epitheca covers lower two-thirds of corallum. Septa hexamerally arranged in 5 cycles, the last cycle incomplete, the corallum having approximately 64 septa. S_{1-2} equal in size, porous near the theca, but solid on edge toward fossa. Inner edges of S_{1-2} vertical and straight, reaching the columella. S_3 and S_4 bear large pores, each pair of S_4 fused before its adjacent S_3 and continuing to the columella. Pairs of S_5 present in some half-systems, each pair fused to their adjacent S_4. Depth of fossa difficult to determine because of damage to corallum. Columella discrete, elongate, and spongy, the numerous columellar elements quite fine and fused to one another.

DISCUSSION.—Examination of nontype specimens show that the species can attain a calicular diameter of 19 × 15 mm and a height of 23 mm (*Pillsbury*-521) and have a full fifth cycle of septa (96). With greater age and size, the porosity of the septa decreases until they are solid. No other specimens examined displayed an epitheca, the costae being distinct from calice to base. The inner edges of the fused S_4 are usually coarsely dentate, not smooth as is the case in the worn type. Finally, the columella may consist of a rounded, elliptical field of slightly swirled elements.

Balanophyllia cedrosensis is distinguished from *B. elegans* by having a discrete, convex columella; porous septa in early ontogeny; and less dentate inner S_4 margins. It lacks the stellate septal pattern characteristic of the strong Pourtalès Plan of *B. elegans*. The species are also geographically distinct, *B. elegans* known only north of Sacremento Reef, northern Baja California, and *B. cedrosensis* from south of Isla Cedros to the Bay of Panama, including the Gulf of California. No differences were found between the types of *B. cedrosensis* and *B. tiburonensis*, notwithstanding the variation discussed by Durham (1947, text-fig. 2B,C).

MATERIAL EXAMINED.—*New Records: Pillsbury*-521, 5, USNM 83531; *Pillsbury*-530, 20, USNM 83532. *Previous Records:* Holotype of *B. cedrosensis*; holotype and paratype of *B. tiburonensis; Velero* 1259-41, 1, SBMNH (Durham and Barnard, 1952).

TYPES.—The holotype (Plate 11*i-j*) of *B. cedrosensis* is deposited at the CAS (29961). *Type Locality:* "Near Cedros Island on the way to San Benito," depth unknown.

The holotype (Plate 11*g*) and paratype of *B. tiburonensis* are deposited at the UCMP (14833, 14834, respectively). *Type Locality:* 28°44.3′N, 112°34.6′W (off Tiburon I., Gulf of California), 73 m.

DISTRIBUTION.—Known only from a small region from Cedros Island to Punta Abreojos, Pacific coast of Baja California Sur; off Tiburon Island, Gulf of California; and the Bay of Panama; 66–119 m.

Dendrophyllia Blainville, 1830

DIAGNOSIS (emended).—Extratentacular budding forms colonies of three general forms: arborescent colonies with axial corallites, small bushy colonies with sparse branching, or dendroid colonies with sympodial branching. All three forms originate from a single basal stem. Synapticulothecate; costae usually well defined. Septa arranged in a Pourtalès Plan. Pali may be present or absent; columella spongy. Tabular endothecal dissepiments may be present. Azooxanthellate, often found in shallow water.

TYPE SPECIES.—*Madrepora ramea* Linnaeus, 1758, by subsequent designation (Milne Edwards and Haime, 1850a:liii).

Dendrophyllia oldroydae Oldroyd 1924, nom. correct

PLATES 12*j,k*, 13*a,b*

Dendrophyllia oldroydi Oldroyd, 1924, pl. 49: fig. 7.—Williams, 1936:27–28, 1 fig.

Dendrophyllia oldroydi Faustino, 1931:286–287, pl. 1: fig. 2.—?Durham, 1943:201, pl. 32: fig. 1; 1947:38, pl. 10: figs. 1, 9.—Bythell, 1986:21, pl. 12: figs. a–d.—Prahl, 1987:230, figs. 6, 7.—Prahl and Erhardt, 1989:549–550, fig. 9.—Cairns et al., 1991:48.

Dendrophyllia californica.—Durham and Barnard, 1952:101 [in part: pl. 15: fig. 65a,b].—Cairns, 1991a:23–24, pl. 10: figs. c–e.

Dendrophyllia cortezi Durham and Barnard, 1952:102–103, pl. 16: fig. 66a,b.—Squires, 1959:426.

Dendrophyllia cf. *D. oldroydi* Faustino.—Hertlein and Grant, 1960:82–83, pl. 19: figs. 5, 6, 15.

DESCRIPTION.—Corallum sympodially branched, forming large bushy colonies up to 1 m in height (Cairns, 1991a) and having robust basal branches up to 5 cm in diameter; largest colonies examined from off California only 35 cm in height with a basal branch diameter of 2.2 cm. Corallites short and stout on large-diameter basal branches, projecting only 4–7 mm perpendicular to main branch (e.g., Durham and Barnard, 1952, pl. 15: fig. 65a), but distal corallites, especially those of fast growing coralla, are inclined distally and elongate, up to 23 mm long (e.g., Williams, 1936, fig. 1). Calices elliptical and usually less than 10 mm in GCD, but may reach up to 15 × 13 mm in GCD x LCD (USNM 80453). Costae equal in width and slightly convex, separated by narrow intercostal striae and

covered with small (0.10 mm diameter) granules. However, within 5–7 mm of the calice, intercostal striae are often perforate, and C_{1-2} in this region are slightly narrower than the others and slightly ridged. Corallum white; coenosarc yellow, drying to a dark brown.

Septa hexamerally arranged in 5 cycles, the last cycle always incomplete. Each half-system usually contains either no S_5, sometimes 1 pair of S_5, or rarely 2 pairs of S_5, for a total of only 48 septa if no S_5 are present, and up to 72 if 12 pairs of S_5 are present, as in the case of the largest calice. Most corallites have 48–58 septa (0–6 pairs of S_5). S_{1-2} equal in size, only about 1.5 mm exsert, relatively narrow (only about 1.5 mm wide), and have straight inner edges that attain the columella. S_3 little exsert and are the smallest septa, only about 0.5 mm wide and merging into the paliform lobe formed by flanking S4. S_4 paired and equal in exsertness to S_3, but about 1.2 mm in width, the inner edges of each pair solidly fused before its adjacent S_3 to form a tall, rounded paliform lobe, which is thicker than an S_3 and of equal width to an S_4. In most corallites these 12 P_3 form a crown of lobes, but in larger corallites having pairs of S_5, 2 P_4 are formed in each half-system instead of 1 P_3. Inner edges of paliform lobes reach columella and appear to be continuous with columellar structure. Fossa shallow, containing a columella of variable size and structure. Columella usually composed of an elongate to elliptical mass of swirled elements, sometimes appearing fascicular, other times as coarsely papillose. Columella width varies from rudimentary, only 12% LCD, to quite large (Plate 12*j*), up to 37% LCD. All septal faces, paliform lobes, and columellar elements covered with a fine granulation.

DISCUSSION.—*Dendrophyllia oldroydae* was first published as a figure and its caption by Oldroyd (1924) without description, but with a reference to an unpublished manuscript by Faustina (sic). According to Article 12b7 of the *International Code of Zoological Nomenclature* (1985), because this illustration and figure caption were published before 1931, they satisfy the criteria of availability, and thus Oldroyd (1924) must be considered as the author of the species. When Faustino's (1931) *D. oldroydi* was finally published as a new species account, based on topotypic but different specimens, it thus must be considered as a junior primary homonym as well as a junior subjective synonym, subjective because different holotypes were chosen. The intent of the name in both cases was obviously to honor Ida S. Oldroyd, and thus the spelling of the name should be changed to the feminine *oldroydae*.

I (Cairns, 1991a) was in error to have identified specimens of *D. oldroydae* from the Galápagos Islands as *D. californica*. At that time I had not examined the types of *D. oldroydi* nor did I appreciate the great variability of its columella and growth form. I was also influenced by Durham and Barnard's (1952, pl. 15: fig. 65b) misidentification of their *D. californica*. However, I still support the synonymy of *D. cortezi* and *D. oldroydae*, the former having poorly formed paliform lobes (dentate inner margins), slightly porous S_4 fusions, and elongate corallites, all characteristic of a rapidly growing terminal branchlet of *D. oldroydae*.

Dendrophyllia oldroydae is compared to *D. californica* in the account of the latter species.

MATERIAL EXAMINED.—*New Records:* 6.4 km off Del Mar, California, 99–125 m, 1 colony, USNM 80453; San Pedro Bay, California (topotypic), 366 m, 10 colonies, USNM 38114; 27°28.3′N, 114°51′W, 110 m, 2 branches, SIO Co 1317. *Previous Records:* Holotype and paratypes of *D. oldroydi* Faustino, 1931; off Huntington Beach, 183 m, 1 colony, USNM 92610 (Williams, 1936); holotype of *D. cortezi; Velero* 1254-41, 1 colony, SBMNH 35563 (*D. californica* of Durham and Barnard, 1952); off Gorgona I., Colombia, 40 m, 1 colony, USNM 78795 (Prahl, 1987); off La Jolla, 100–180 m, 1 colony, SIO Co 1179 (Bythell, 1986).

TYPES.—The holotype of *D. oldroydi* Oldroyd, 1924, originally deposited in the Paleontology Department of Stanford University, appears to be lost (Hertlein and Grant, 1960). *Type Locality:* Off San Pedro, California, 366 m.

Faustino (1931) mentioned two specimens in the description of his *D. oldroydi*, the illustrated specimen (holotype (Plate 12*k*), cataloged as CAS 36397) being part of a larger colony having two more pieces. The identification of his "second" specimen, which must be considered a paratype (Plate 13*b*), is confused, since the CAS has eight other colonies of the same species from the same locality also numbered 36397. There is also a specimen of *D. oldroydi* deposited at the UCMP (12200) designated as a paratype, mentioned by Durham (1947). Finally, there are 10 colonies from the same collection deposited at the USNM (38114), which are topotypic but not considered to be type specimens. *Type Locality:* "Sunken Valley, between San Pedro and Redonda, California, 200 fathoms [= 366 m]; deep water off San Diego, California."

The holotype (Plate 13*a*) of *D. cortezi* is deposited at the SBMNH (35564) ex AHF 24. *Type Locality: Velero* 561-36: south of Isla Partida, Gulf of California, 128 m.

DISTRIBUTION.—*Dendrophyllia oldroydae* is the most common *Dendrophyllia* found off California and Baja California, occasionally being snagged by deep-sea fishermen. It is known from off Redondo (type locality) to halfway down the Pacific coast of Baja California (27°28′N), 99–366 m; also off Angel de la Guardia and Isla Partida, Gulf of California. *Middle Pliocene* San Diego (Hertlein and Grant, 1960). ?Plio-Pleistocene of Humboldt Co., California (Durham, 1943). *Elsewhere:* Off Pacific coast of Colombia (Prahl, 1987) and off Galápagos and Cocos Islands (Cairns, 1991a); 40–576 m.

Dendrophyllia californica Durham, 1947

PLATE 12*g–i*

Dendrophyllia californica Durham, 1947:37–38, pl. 10: figs. 2, 6.—Bythell, 1986:21, pl. 12: figs. e, f.

Not *Dendrophyllia californica*.—Durham and Barnard, 1952:101–102, pl. 15: fig. 65a,b [= *D. oldroydae*].—Cairns, 1991a:23–24, pl. 10: figs. c–e [= *D. oldroydae*].

DESCRIPTION.—Colonies small, none known over 5 cm in

height or diameter. Extratentacular budding sparse, colonies examined have no more than 6 or 7 corallites and lack third generation buds. Corallites elongate and ceratoid, up to 19.9 × 14.4 mm in calicular diameter and 32 mm long. Pedicel diameter of holotype 14.8 mm. Costae slightly convex and separated by narrow, porous intercostal striae. C_{1-2} slightly narrower than other costae, but not ridged. Costae finely granular, producing a rough texture. Corallum white.

Septa hexamerally arranged in 5 cycles, the last cycle complete only in largest corallites. S_{1-2} only about 0.7 mm exsert and quite slender (only about 1.5 mm wide), with straight, vertical inner edges that merge with columella low in fossa. Remaining septa barely exsert, the S_3 being the smallest septa, only about 0.9 mm wide. Inner edges of each pair of S_4 form a rudimentary, porous fusion before the S_3 and extend to the columella but do not contribute to it. Occasionally pairs of S_4 do not quite fuse near the columella, especially if S_5 are present. Inner edges of the 12 S_{1-2} and 12 combined S_4 extend same distance into calice. If present, inner edges of S_5 fuse before their adjacent S_4. Paliform lobes absent. Fossa deep. Columella similar to that of *D. oldroydae*: an elongate, swirled mass of elements, but modest in size, only 20%–25% LCD in width.

DISCUSSION.—*Dendrophyllia californica* is distinguished from *D. oldroydae* by having a small colony with very sparse branching; longer, larger corallites with more septa; and a much deeper fossa. It also differs in lacking paliform lobes, lacking ridged costae, and in having rudimentary, porous S_4 fusions. It also is known from a more limited geographic and depth range.

MATERIAL EXAMINED.—*New Record:* Alb-2832, 2 branches, USNM 38113. *Previous Records:* Holotype of *D. californica*; 26°12′N, 112°35′W, 51–55 m, 1 colony, SIO Co 437 (Bythell, 1986). *Reference Specimens:* Specimens reported as *D. californica* by Durham and Barnard (1952) and Cairns (1991a).

TYPES.—The holotype (Plate 12*g,h*) of *D. californica* is deposited at the CAS (29960). *Type Locality:* 27°52′30″N, 114°54′45″W (Bahia Sebastián Vizcaino, near Cedros I., Pacific coast of Baja California), 42 m.

DISTRIBUTION.—Known from only three localities from the Pacific coast of Baja California, from Bahia Sebastián Vizcaino to Bahia Magdalena; 42–93 m.

Part 2: Temperate Northwestern Pacific

Suborder ASTROCOENIINA

Family POCILLOPORIDAE

Madracis Milne Edwards and Haime, 1849

DIAGNOSIS.—Colonial, extratentacular budding producing massive, encrusting, or branching coralla. Coenosteum solid. Septa arranged in groups of 6, 8, or 10, but rarely in more than two cycles (i.e., 12, 16, or 20 septa). Columella styliform; paliform lobes sometimes present.

TYPE SPECIES.—*Madracis asperula* Milne Edwards and Haime, 1849, by monotypy.

Madracis sp. A

PLATE 13*c–f*

?Madracis sp.: Wells, 1954:414, pl. 99: fig. 5.
Madracis asanoi.—Eguchi, 1968:C11, pl. C5: figs. 3–7.

DIAGNOSIS.—Colonies delicately branched, terminal branchlets slender (2–3 mm in diameter), basal branches somewhat compressed and up to 5 mm in diameter. Largest colony examined (ZMC, Sagami Bay) only 26 mm in height. Corallites circular to elliptical in shape and closely spaced, some directly adjacent to one another, and rarely separated by more than 1 mm from adjacent corallites. Corallites 1.7–2.5 mm in diameter. Coenosteum faintly striate and covered with tall (up to 0.4 mm), slender (0.12–0.18 mm) coenosteal spines. Corallum white.

Septa decamerally arranged in 2 cycles (10:10 = 20 septa). Primary septa highly exsert but rather slender, each bearing a small paliform lobe, the 10 lobes forming a crown encircling the columella. Secondary septa rudimentary, each composed of a row of small, slender teeth. Fossa relatively shallow, its central portion a circular horizontal platform on which the columella and paliform lobes project. Columella a prominent, plate-like style up to 0.4 mm in height and 0.14 mm in diameter, usually reaching above the calicular edge. Longer axis of columellar plate aligned parallel to branch axis.

DISCUSSION.—The geographically closest known species of *Madracis* to Japan is *M. asanoi* Yabe and Sugiyama, 1936, described from the Pelau Islands. *Madracis asanoi* is similar to the Japanese species in calicular diameter and corallite spacing, but differs in having only 10 (not 20) septa; thicker, more robust branches; and in lacking paliform lobes. The Japanese specimens are quite similar to the unnamed species of *Madracis* reported by Wells (1954) from Bikini Atoll, Marshall Islands; however, the growth form of that small specimen was encrusting. It is not possible to determine if the encrusting mode was the permanent growth form of this specimen or just the foundation of a larger branching colony. *Madracis kauaiensis* Vaughan, 1907, (Hawaiian and Johnston Islands) differs in having robust branches; smaller, more widely spaced corallites; only one cycle of 10 septa; no paliform lobes; and a much smaller columella. *Madracis* sp. cf. *M. asperula*, reported by Durham and Barnard (1952) and Cairns (1991a) from the Galápagos Islands, differs in having smaller, more widely spaced corallites; only 10 septa per corallite; and no paliform lobes. Thus, the specimens from Sagami Bay appear to represent an undescribed species, but not enough material is available to justify the proposal of a new species.

MATERIAL EXAMINED.—*New Records:* Off Okinose, Sagami Bay, 110 m, Mortensen's Pacific Expedition of 1914, 3 colonies, ZMC; 26°30′N, 127°50′54″E (off Okinawa), 64 m, 1 colony, USNM 88378. *Previous Records: Madracis* sp. of Wells (1954), USNM 44407. *Reference Specimens:* Types of

M. kauaiensis, USNM; *M.* sp. cf. *M. asperula* of Durham and Barnard (1952), AHF 1.1.

DISTRIBUTION.—Sagami Bay, Honshu; off Okinawa, Ryukyu Islands; ?Bikini Atoll, Marshall Islands; ?46-55-110 m.

Suborder FUNGIINA

Superfamily FUNGIOIDEA

Family FUNGIACYATHIDAE

Fungiacyathus Sars, 1872

DIAGNOSIS.—See Part 1.

Subgenus *Fungiacyathus (Fungiacyathus)* Sars, 1872

DIAGNOSIS.—*Fungiacyathus* having five cycles of septa.

Fungiacyathus (F.) stephanus (Alcock, 1893)

PLATE 13*g-i*

Bathyactis stephanus Alcock, 1893:149, pl. 5: figs. 12, 12a.
Bathyactis stephana.—Alcock, 1898:28-29, pl. 3: figs. 5, 5a; 1902c:38.
Fungiacyathus stephanus.—Cairns, 1989a:7-9, pl. 1: figs. a-k; pl. 2: figs. a,b [synonymy].—Cairns and Keller, 1993:230:

DESCRIPTION.—Corallum circular and quite fragile, the more typical concave-base form up to 39 mm in diameter and 20 mm in height (D:H = 1.95), whereas the flat-base form attains 45 mm in diameter but only 16-17 mm in height (D:H = 2.7). Costal ridges thin, finely dentate, and straight to slightly sinuous. Corallum white.

Septa hexamerally arranged in 5 complete cycles according to the formula: $S_1>S_2>S_3>S_4>S_5$. S_1 composed of an extremely tall inner lobe bearing 12-14 vertical, finely dentate ridges (trabeculae) and a lower outer marginal shelf about 5 mm wide and only about 1.5-2.0 mm in height. Ten to 13 synapticulae occur along an S_1 of a large specimen, the largest synapticulae being 6th or 7th from columella, which rise about to level of adjacent S_4. Each S_2 bears a prominent paliform lobe internally, followed by a tall septal lobe (but smaller than that of the S_1) composed of 10-12 trabeculae, and a similar outer marginal shelf. Each S_3 also has an inner paliform lobe but more recessed from the columella, a smaller and lower septal lobe, and a peripheral marginal shelf. S_4 joined to adjacent S_3 in a canopied structure, lack paliform lobes, and have only a small septal lobe and low marginal shelf. S_5 quite small, lacking both paliform and septal lobes, and merge with adjacent S_4 via a long, low canopied structure; their outer shelf region is only about 0.5 mm in height. All septal faces corrugated, but upper septal edges are often straight. Columella a low, circular trabecular mass 4-5 mm in diameter.

DISCUSSION.—A more complete synonymy and description of this species is given by Cairns (1989a) in the context of a revision of the Philippine deep-water Scleractinia. The records reported herein constitute a northern range extension for the species and the first records from the Japanese region.

Fungiacyathus stephanus is distinguished from other species in the subgenus by having extremely tall septal lobes, a broad marginal shelf, and corrugated septa. Bathymetrically, it is intermediate between the shallower *F. paliferus* and the much deeper *F.* sp. A.

MATERIAL EXAMINED.—*New Records:* Alb-4907, 2, USNM 80121; Alb-4908, 4, USNM 80122; Alb-4909, 1, USNM 80853; Alb-4911, 1, USNM 80123; Alb-4912, 1, CAS 1160; Alb-4915, 2, CAS 74999; Alb-4916, 1, USNM 80124; Alb-4919, 1, USNM 80125; Alb-4956, 1, USNM 80126; Alb-4958, 1, USNM 80127; Alb-4959, 1, USNM 92633; Alb-4960, 1, USNM 80128; Alb-4966, 3, USNM 82150; Alb-4968, 3, CAS 80929; Alb-4970, 2, USNM 80129; Alb-5086, 6, USNM 80130; TM (KT9202, YT6), 1, ORI.

TYPES.—The holotype of *B. stephanus* is presumed to be deposited at the Indian Museum, Calcutta. *Type Locality: Investigator*-133: 15°43'30"N, 81°19'30"E (off Kistna Delta, Bay of Bengal), 1240 m.

DISTRIBUTION.—Japan: Off southeastern Honshu from Sagami Bay to Wakayama Prefecture; Bungo Strait; off Koshiki Island, Kyushu; East China Sea off northern Ryukyu Islands; 446-1317 m. *Elsewhere:* Throughout the Philippines, Indonesia, and western Indian Ocean (Cairns, 1989a); 245-1977 m.

Fungiacyathus (F.) paliferus (Alcock, 1902)

PLATE 14*a-e*

Bathyactis palifera Alcock, 1902a:108; 1902c:38, pl. 5: figs. 34, 34a.—Yabe and Eguchi, 1942b:137-138, pl. 12: fig. 5.
Fungia (*Diaseris* form).—Yabe and Eguchi, 1932e: 387.
Bathyactis symmetrica.—Yabe and Eguchi, 1942b:137 [in part: *Syo Maru*-283, *Soyu Maru*-259].
Bathyactis kikaiensis Yabe and Eguchi, 1932b:443 [nomen nudum]; 1942b:138, 155-156, pl. 12: figs. 6, 7.
?Fungiacyathus symmetricus.—Utinomi, 1965:248-249.
Not *Fungiacytahus palifera.*—Keller, 1976:33-34 [= *Fungiacyathus* sp. A].
Fungiacyathus paliferus.—Cairns, 1989a:9-10, pl. 2: figs. c-i; pl. 3: figs. a-c [synonymy].—Cairns and Parker, 1992:6-7, fig. 1a,b.

DESCRIPTION.—Coralla occur in two shapes: (1) circular (Plate 14*a*), up to 16.2 mm in calicular diameter and 7.0 mm in height (D:H = 2.3-3.45), and (2) semi-circular (Plate 14*b*), rarely greater than 10 mm in diameter, the latter form apparently the result of fragmentation and referred to as the *Diaseris* form by Yabe and Eguchi (1932a, 1942b) because of its resemblance to that genus. Base flat to only slightly concave, bearing low, rounded, granulated costae. Corallum white.

Septa hexamerally arranged in 5 complete cycles according to the formula: $S_1>S_2>S_3>S_4>S_5$ (98 septa). The semi-circular *Diaseris* form usually consists of 2 full systems flanked by 2 half-systems, including the S_2, for a total of 48 septa, but paliform lobes and columellas are usually absent in these forms. S_1 consist of 4 or 5 inner trabecular spines; an intermediate septal lobe bearing up to 15 coarsely dentate,

closely spaced carinae; and a low, arched peripheral marginal shelf about 1.5 mm wide. Seven or eight synapticulae occur along an S_1, the largest being the fourth or fifth from the columella. S_2 consist of 2 or 3 inner spines, a broad paliform lobe, an intermediate septal lobe of 11 or 12 trabeculae, and a peripheral marginal shelf. S_3 have a broad internal paliform lobe, a small septal lobe composed of 5–8 trabeculae, and a marginal shelf. S_4 consist of only a small septal lobe of 4 or 5 trabeculae and a small marginal shelf. S_5 exist only in the marginal shelf region and are not lobate or spinose. All septa planar, with straight septal edges. Columella rudimentary to absent.

DISCUSSION.—*Fungiacyathus paliferus* is easily distinguished from the two other Japanese congeners having five cycles of septa by having granular costae; a small, relatively robust corallum; and a tendency to asexually fragment into semi-circular fragments. Bathymetrically, it is the shallowest of the three species.

As noted in a previous publication (Cairns, 1989a), *Bathyactis kikaiensis* is undoubtedly a junior synonym of *F. paliferus*, but the types of this species were not available for the confirmation of the synonymy.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, BS1), 1, USNM 92634; TM (9015, BS2), 4, USNM 92635; TM (KT9015, CB1-2), 4, USNM 92636; TM (9015, CB1-1), 1, USNM 92637; TM (KT9015, HK5), 4, ORI; TM (KT9015, OK1), 2, USNM 92638; TM (KT9015, OK2), 1, USNM 92639; TM (KT9202, OS2), fragments, USNM 92640; TM (KT9202, OS3), 1, USNM 92641; TM (KT9202, YS1), 4, USNM 92642; TM (KT9209, AM6), 1, ORI. *Previous Records: Soyu Maru*-412, 1, TIUS 58913 (*B. palifera* of Yabe and Eguchi, 1942b); *Soyu Maru*-259, 1, TIUS 58948 (*F. symmetrica* of Yabe and Eguchi, 1942b); *Soyu Maru*-283, 1, TIUS 58950 (*F. symmetrica* of Yabe and Eguchi, 1942b); syntypes of *B. palifera*, 3, ZMA.

TYPES.—Three syntypes of *Bathyactis palifera* are deposited at the ZMA, collected at *Siboga*-153 (Coel. 1171) (van Soest, 1979). *Type Localities: Siboga* stations 98 and 153: Sulu Sea and off the Moluccas, 143–350 m.

One hundred ten syntypes of *B. kikaiensis* are deposited at the TIUS, the measurements of three of which are given in the text. Two catalog numbers were given to this lot by Yabe and Eguchi: 50236 (pages 155–156 and plate caption) and 50097 (pages 138, 173). The earlier number was also assigned to the type of *Stephanophyllia japonica*, which might imply that 50097 is the correct number. *Type Locality:* Plio-Pleistocene of the Ryukyu Limestone of Kakai-jima, Kagoshima-ken.

DISTRIBUTION.—Japan: Suruga Bay, Honshu; off Shikoku and Bungo Strait; off southern Kyushu; East China Sea off Danjo Gunto; off Mi Shima, Korea Strait; Oki Strait, Sea of Japan; northern Tokara Retto and off Amami Oshima, Ryukyu Islands; 70–364 m. *Elsewhere:* Pleistocene of Vanuatu and Ryukyu Islands; Recent: Philippines, Indonesia, Great Australian Bight, Reunion; 75–522 m (Cairns, 1989a:10).

Fungiacyathus (F.) sp. A

PLATE 14*f–h*

Fungiacyathus palifera [sic].—Keller, 1976:33–34, pl. 1: figs. 1, 2.

DIAGNOSIS.—Two specimens of Keller's (1976) *F. palifera* were examined, both from *Vityaz*-2209, including her figured specimen, which is 35.7 mm in calicular diameter and 6.0 mm in height and missing 2 systems of its corallum. Its base is flat and thin, bearing 5 cycles of sinuous, nongranular costal ridges. Five full cycles of septa are present (96 septa). All septa planar and have straight inner edges, each S_{1-2} bearing 20–23 low, closely spaced trabecular carinae. Large, porous canopies occur at S_{3-4} and S_{4-5} junctions. Eight to nine synapticulae occur per S_1, the outermost being the most highly developed. Columella 4.5 mm in diameter, circular, and quite spongy.

DISCUSSION.—The specimen described above is distinguished from *F. paliferus* by having a much larger corallum, lacking paliform lobes, and having ridged (not rounded or granular) costae. It is actually more similar to *F. stephanus* than *F. paliferus*, especially in corallum size and fragility, but differs in having relatively low and straight (noncorrugated) septa, no marginal shelf or paliform lobes, and very spongy columellar and canopy regions. It differs from *F. fragilis* Sars, 1872, in having planar septa and spongy canopies and columella. *Fungiacyathus* sp. A is bathymetrically and geographically distinct from the two other Japanese species that have five cycles of septa in being by far the deepest of the three and the most northerly in distribution.

Despite the distinctness of *Fungiacyathus* sp. A, until additional specimens are collected and examined, a formal description is postponed.

MATERIAL EXAMINED.—*Vityaz*-2209, 1, IOM, and 1 central disc, USNM 92643 (Plate 14*f–h*).

DISTRIBUTION.—Off eastern Kurile Islands bordering Kurile Trench; 3175–4110 m. Keller's (1976) mapping of *Vityaz*-5603 and *Vityaz*-5635 off the Aleutian Islands and off Honshu, respectively, are mistaken, the coordinates of all three of her stations being off the Kurile Islands.

Subgenus *Fungiacyathus (Bathyactis)* Moseley, 1881

DIAGNOSIS.—See Part 1.

Fungiacyathus (B.) marenzelleri (Vaughan, 1906b)

Account.—See Part 1.

Fungiacyathus (B.) variegatus Cairns, 1989

PLATE 15*a,b*

Fungiacyathus (B.) variegatus Cairns, 1989a:11–12, pl. 5: figs. a–h [synonymy].

DIAGNOSIS.—The largest Japanese specimen (Alb-4911) is a slightly worn corallum 9.0 mm in calicular diameter, probably

dead when collected. Base slightly concave, circular in outline, but with a finely serrate edge, each septum projecting slightly beyond calicular perimeter. C_{1-2} more highly ridged than C_{3-4}, each costa bearing a linear row of coarse granules. Corallum white. Septa hexamerally arranged in 4 complete cycles. S_1 consist of 4 or 5 inner trabecular spines and an outer lobe bearing 10–12 coarsely dentate ridges. S_2 also have 5 or 6 inner spines, the third or fourth from the columella being quite robust and curved inward toward the columella. A pair of S_3 joins to each S_2 through a robust, solid canopy, each S_3 consisting of 11 or 12 trabeculae, which, like those of the lower cycle septa, extend above the upper septal edges as narrow spines. Likewise, each pair of S_4 joins to an adjacent S_3 through a robust canopy, each S_4 consisting of 8 or 9 small trabecular spines. All septa planar, with straight inner edges. No marginal shelf present, the outer edges of all septa extending around calicular edge and thus continuous with underlying costae. Synapticulae sparse, only 3 or 4 along length of an S_1, the innermost 2 linking the S_1 to its adjacent S_4 in the region of the S_{3-4} canopy, and the outermost synapticulae linked directly to the S_4. Columella rudimentary.

DISCUSSION.—The Japanese specimens differ from the type series only in lacking the characteristic pigmentation of the species, but it is noted that some of the worn paratypes from Alb-5278 and Alb-5314 also lack pigmentation. *Fungiacyathus variegatus* is easily distinguished from other species in this subgenus in this region by usually having a pigmented corallum, having very few synapticulae, and quite well-developed septal canopies.

MATERIAL EXAMINED.—*New Records:* Alb-4911, 1, USNM 82018; TM (KT9309, AM8), 3, USNM 93167, 3, ORI. *Previous Records:* Type series.

TYPES.—The holotype and paratypes of *F. variegatus* are all deposited at the USNM (Cairns, 1991b). *Type Locality:* Alb-5113: 13°52′N, 120°51′E (off Luzon, Philippines), 291 m.

DISTRIBUTION.—Japan: Off Koshiki Island, southwestern Kyushu; off Amami Oshima, Ryukyu Islands; 422–715 m. *Elsewhere:* Pleistocene of Vanuatu; *Recent:* Philippines; South China Sea off Hong Kong; 187–333 m (Cairns, 1989a).

Fungiacyathus (B.) granulosus Cairns, 1989

PLATE 15*d,e*

Fungiacyathus granulosus Cairns, 1989a:11, pl. 4: figs. d–i [synonymy].

DISCUSSION.—The single, worn specimen (now in three pieces) reported herein serves only to verify the existence of *F. granulosus* in Japanese waters, which is the northernmost record of the species. The specimen is 15.8 mm in calicular diameter and has a slightly concave base with coarsely granular, rounded costae. Each S_1 has approximately 22 closely spaced trabecular ridges and about 8 synapticulae, but the worn condition of the specimen does not allow remarks on the upper septal edges. All septa are planar with straight edges. The columella is circular and 2.6 mm in diameter.

MATERIAL EXAMINED.—*New Record:* TM (KT9202, YT4), 1, USNM 92645. *Previous Records:* Type series.

TYPES.—The holotype and paratypes are all deposited at the USNM. *Type Locality:* Alb-5590: 4°10′50″N, 118°39′35″E (off Sabah, Celebes Sea), 567 m.

DISTRIBUTION.—Off Japan: Osumi Shoto, northern Ryukyu Islands; 402–410 m. *Elsewhere:* Off Philippine Islands; Celebes Sea off Sabah; 390–567 m.

Family MICRABACIIDAE

Leptopenus Moseley, 1881

DIAGNOSIS.—See Part 1.

Leptopenus discus Moseley, 1881

ACCOUNT.—See Part 1.

Leptopenus solidus Keller, 1977

PLATE 15*g,h*

Leptopenus discus.—Squires, 1965:878–879, fig. 1; 1967:505.
Leptopenus solidus Keller, 1977:40–41, pl. 1: fig. 5a,b, text-fig. 3.
Leptopenus sp.—Cairns, 1989a:15, pl. 6: figs. h,i.

DESCRIPTION OF HOLOTYPE.—Corallum discoidal and very fragile, having only 2 peripheral costal spines intact. Corallum 12.6 mm in maximum calicular diameter (including costal spines) and 3.1 mm in height, resulting in a D:H of 4.1. Costae alternate in position with septa, joined together only by thin synapticular bridges about 0.08 mm in diameter. Thecal pores up to 0.21 × 0.10 mm in diameter only in circular region 0.35–2.9 mm from center of corallum, the epicenter and outermost 1.5 mm perimeter being solid. As in *L. discus*, 6 major costae radiate from a solid, circular epicenter, each costa dividing twice to form 24 broad (0.30 mm wide), flat costae, which further subdivide into 68 costae in the holotype.

Septa arranged in micrabaciid fashion; however, S_1 are not independent, but are usually united to an adjacent S_2 near the center. S_1 consist of 5 or 6 tall, slender (about 0.15 mm in diameter), outwardly inclined trabecular spines that are united basally by a low web. The third and fourth trabecular spines from the center are the highest, their tips slightly recurved. S_2 are the most robust septa, also composed of 5 or 6 spines, the third of which is quite thick (about 0.35 mm in diameter), constituting the maximum corallum height. S_2 trabecular spines also outwardly inclined but recurved at tips. Higher cycle septa composed of 1–3 spines of similar size to those of the S_1. Septal canopies occur at S_2-S_3 and S_3-$S_{3'}$ junctions. Columella consists of 9 tall, slender spines similar in shape to the S_1 trabecular spines.

DISCUSSION.—Among the four other species of *Leptopenus*, *L. solidus* is most similar to *L. discus*, both having massive S_2 trabecular spines, but *L. solidus* differs in having a lower D:H

ratio and a more solid base, with much smaller and fewer thecal pores.

Keller (1977) reported the diameter of the holotype to be 24 mm, but the actual diameter (including spines) is only about half this size. Likewise, she described the thecal pores to be small, with a diameter of 0.1 cm or less, but undoubtedly she meant to say 0.1 mm or less. She also stated that the septa were pierced with very large pores, but essentially they are solid. Finally, she reported five cycles of septa, implying 96 septa, whereas there are only about 54 septa (and 68 costae) present in the damaged holotype. The development of higher order septa appears to lag that of the costae.

MATERIAL EXAMINED.—No new records.–Previous Records: Holotype of *L. solidus*; *Galathea*-453, 1, ZMC (*L. discus* of Squires, 1965).

TYPE.—The holotype (Plate 15*g,h*) is deposited at the IOM.

Type Locality: *Vityaz*-5603: 46°22′N, 153°03′E (Kurile Trench), 3175–3250 m.

DISTRIBUTION.—Kurile Trench and Makassar Strait, Indonesia; 2000–3250 m.

Letepsammia Yabe and Eguchi, 1932g

DIAGNOSIS.—Corallum solitary, discoidal, and free. Synapticulothecate; marginal shelf present. Costae thin dentate ridges, the intercostal spaces much broader than costae and penetrated by large pores. Septa also highly porous, with complex dentition. Septa alternate in position with costae. Septa arranged in typical micrabaciid pattern, having multiple bifurcations of the S_3; number of septa a function of calicular diameter, but 120 is the common adult number. Columella spongy.

TYPE SPECIES.—*Stephanophyllia formosissima* Moseley, 1876, by original designation.

Letepsammia formosissima (Moseley, 1876)

PLATE 15*c,f*

Stephanophyllia formosissima Moseley, 1876:561–562; 1881: 201–204, pl. 4: fig. 11; pl. 13: figs. 6, 7; pl. 16: figs. 8, 9.—Eguchi, 1934:368; 1938, table 2.—Utinomi, 1965:249.

Stephanophyllia superstes Ortmann, 1888:160–161, pl. 6: fig. 5.—Yabe and Eguchi, 1932g:58; 1942b:112.—Owens, 1986b:487.

Stephanophyllia (Letepsammia) formosissima.—Yabe and Eguchi, 1932b:443; 1932g:61–63, pl. 8: figs. 7, 8; 1942b:138–139.—Eguchi, 1968:C16–17, pl. C6: figs. 7–11; pl. C25: figs. 10–13; pl. C27: figs. 2, 3.—Eguchi and Miyawaki, 1975: 58.

Stephanophyllia (Letepsammia) japonica Yabe and Eguchi, 1932b:443 [nomen nudum]; 1934b:281, figs. 1–3; 1942b:139, 156–157, pl. 12: fig. 8.

Micrabacia japonica.—Omura, 1983:119.

Stephanophyllia japonica.—Zou, 1988:75, pl. 5: fig. 7.

Letepsammia formosissima.—Owens, 1986b:486–487.—Cairns, 1989a:15–18, pl. 6: fig. j; pl. 7: figs. g–i; pl. 8: figs. a–d [synonymy].—Cairns and Parker, 1992:8–9, fig. 1f,h.—Cairns and Keller, 1993:230–231, fig. 3E.

DESCRIPTION.—Corallum circular, Japanese specimens up to 20 mm in diameter, and extremely porous, resulting in a very low density corallum. Base slightly convex, composed of thin costae 0.10–0.15 mm wide separated by wide intercostal spaces 3–4 times that width. Intercostal spaces bridged at regular intervals by thin synapticulae, which produce a series of large, elliptical pores adjacent to each costa. Corallum white.

Septa arranged in micrabaciid fashion: S_1 independent (nonbifurcating) and straight, extending from columella to calicular edge, but appearing somewhat isolated because their adjacent septa are always inclined away from them. S_2 also straight (nonbifurcate), and extend from columella to calicular edge, but are usually taller than the S_1 and are joined by adjacent S_3 near columella. Each S_3 usually bifurcates into 7 (sometimes 6) septa, resulting in 96 or 84 septa, respectively. S_3 tallest septa, gradually decreasing in height as they repeatedly bifurcate toward calicular edge. All septa highly porous. A small marginal shelf occurs peripherally. Columella elliptical in shape and papillose.

DISCUSSION.—*Letepsammia formosissima* is a commonly collected deep-water coral in the Japanese region, representing the northern range of a widely distributed Indo-West Pacific species. The Japanese specimens are uniformly smaller (≤20 mm GCD) than typical specimens, which can attain a diameter of 39 mm, and consequently have fewer septa: ≤96 septa vs the more typical 120 septa. The Japanese specimens are further distinguished by having a papillose columella instead of a low spongy mass. Because of these consistent differences, I refer the Japanese specimens to forma *superstes*, a junior synonym described by Ortmann (1888) from Sagami Bay. It is interesting to note that at the opposite end of its range in the southwest Indian Ocean, another slightly different form of the species exists (Cairns, 1989a:16; Cairns and Keller, 1993), both of these forms occurring at the edges of the species distribution.

Yabe and Eguchi (1942b) were the first to suggest that *S. superstes* Ortmann, 1888, was a juvenile form of *L. formosissima*, and they (Yabe and Eguchi, 1942b:157) also remarked on the similarity of *L. japonica* to *L. formosissima*. Owens (1986b) synonymized *L. japonica* with *L. superstes* and Cairns (1989a) consolidated the synonymy, listing both the Pleistocene *L. japonica* and *L. superstes* as junior synonyms of *L. formosissima*, resulting in it being the only valid species in the genus.

MATERIAL EXAMINED.—*New Records:* Alb-4894, 1, USNM 81870; Alb-5311, 1, USNM 81871; TM (KT9015, BS2), 2, ORI; TM (KT9202, YS1), 1, USNM 92648; TM (KT9202, YS2), 3, USNM 92649; CR79-8, 2, USNM 92650. *Previous Records:* Syntypes of *S. formosissima*, BM.

TYPES.—Five syntypes of *S. formosissima* are deposited at the BM (Cairns, 1989a:18). *Type Locality: Challenger*-192, 209: Philippine/Indonesian region, 174–236 m.

The holotype of *S. superstes* is deposited at the Strasbourg Zoological Museum (H. Zibrowius, pers. comm.). *Type Locality:* Sagami Bay, 183–366 m.

Two syntypes of *S. japonica* are deposited at the TIUS (50236). *Type Locality:* Pleistocene limestone of Kikai-jima, Ryukyu Islands.

DISTRIBUTION.—Japan: Pleistocene of Kakai-jima, Ryukyu Islands. *Recent:* Southeastern Honshu from Sagami Bay to the Inland Sea; Bungo Strait; Osumi Shoto, northern Ryukyu Islands; western Kyushu; Korea Strait south of Tsushima and northeast of Cheju Do, South Korea; off Hong Kong; 77–307 m. *Elsewhere:* Philippines, Indonesia, New Zealand, Australia, Tasmania, Hawaiian Islands, southwest Indian Ocean; 97–470 m.

Rhombopsammia Owens, 1986a

DIAGNOSIS.—Corallum solitary, discoidal, and free. Synapticulothecate; broad marginal shelf present. Costae thin dentate ridges; intercostal spaces broader than costae, penetrated by large pores. Septa alternate in position with costae. Septa imperforate, numbering 96–144. Columella spongy.

TYPE SPECIES.—*Rhombopsammia squiresi* Owens, 1986a, by original designation.

Rhombopsammia niphada Owens, 1986

PLATES 15*i–k*, 16*e*

Rhombopsammia niphada Owens, 1986a:252–255, figs. 2B, 3A-D.—Cairns, 1989a:19–20, text-fig. 2, pl. 9: figs. d–i; pl. 10: figs. a,b [synonymy].

DIAGNOSIS.—Discoidal corallum up to 41.6 mm in diameter; base usually flat. Costae thin (0.06–0.07 mm) ridges. Intercostal regions much wider (about 0.45 mm) than costae, traversed by thin synapticulae, which produce a series of pores in each elongate space. Septa arranged in typical micrabaciid fashion, both costae and septa attaining 144 elements. Marginal shelf present but not wide and often damaged. Columella elongate and spongy.

DISCUSSION.—Only two additional specimens are reported herein, the larger (TM (KT9202, YT5)) measuring 41.6 mm in diameter. *R. niphada* has been adequately described and figured by Owens (1986a) and Cairns (1989a); nothing more can be added to its characterization from these specimens. This species is distinguished from other micrabaciids in the North Pacific by having 144 imperforate septa and a relatively large calicular diameter.

MATERIAL EXAMINED.—*New Records:* Alb-4912, 1, CAS 74999; TM (KT9202, YT5), 1, USNM 92647. *Previous Records:* Type series, USNM; specimen from Misake reported by Cairns (1989a).

TYPES.—The holotype (Plate 15*k*) and paratypes are all deposited at the USNM. *Type Locality:* Alb-4911: 31°38′N, 129°19′E (East China Sea off southwestern Kyushu), 715 m.

DISTRIBUTION.—East China Sea off Kyushu; Osumi Shoto, northern Ryukyu Islands; off Misaki, Honshu; 660–783. *Elsewhere:* South China Sea off Philippines; 512–686 m.

Stephanophyllia Michelin, 1841

DIAGNOSIS.—Corallum solitary, discoidal, and free. Synapticulothecate; narrow maginal shelf usually present. Costae granular, equal to or thicker than intercostal spaces; base thick. Septa alternate in position with costae. Septa primarily imperforate, being perforate only near base; 96 septa present in a mature specimen. Columella solid, compact, and often lenticular.

TYPE SPECIES.—*Fungia elegans* Bronn, 1837, by original designation.

Stephanophyllia fungulus Alcock, 1902

PLATE 16*a–d, f, g*

Stephanophyllia fungulus Alcock, 1902b:122; 1902c:40, pl. 5: fig. 35a,b.—Yabe and Eguchi, 1932b:443; 1932g:58, 60–61, pl. 8: figs. 1–6; pl. 9: figs. 1–8; 1942b:138.—Eguchi, 1934:368.—Uchida, 1963:17–21.—Cairns, 1989a:21–23, pl. 10: figs. c–k; pl. 11: figs. a,b [synonymy].—Cairns and Keller, 1993:231.

DESCRIPTION.—Corallum circular, with a flat base and evenly rounded convex calice having a D:H of 1.9–2.1. Largest northwestern Pacific specimen (Alb-5311) 12.9 mm in diameter. Base quite thick (up to 0.6 mm) and usually upturned at calicular edge as much as 1 mm. Costae flat, about 0.15 mm wide, and separated by narrow intercostal spaces 70–100 μm wide. Each costa bordered on both edges by a row of very small (0.02 mm in diameter) granules (Plate 16*f*). Costae solidly fused via rings (about 13 in figured specimen) of massive mural synapticulae termed fulturae by Gill (1979) (Plate 16*c,d*), altogether producing a sturdy, robust corallum. Mural fulturae closely spaced and parallel in orientation, each about 0.2 mm thick but of variable height, increasing in size from center of calice to peripheral edge (0.2 to 0.8 mm). Corallum white.

Septal arrangement quite conservative, all specimens above a calicular diameter of about 6.9 mm having 96 septa arranged in typical micrabaciid fashion as illustrated by Cairns (1989a, text-fig. 3, but having 96 septa, not 98 as I mistakenly indicated in the caption). S_{1-2} straight, extending from columella to calicular edge, nonbifurcate, and composed of 20–22 trabeculae, each trabeculum projecting about 0.3 mm above septal edge as a transversely flattened spine. A pair of S_3 originate from each S_2 very close to the columella: the S_3' closest to the S_1 invariably divide twice to form 3 terminal septa, the S_3' closest to the S_2 divide 3 times to form 4 terminal septa. Septa fairly solid, perforate only near base and at points of S_3 bifurcation. All septa structurally reinforced by massive septal fulturae, which are irregular in distribution and parallel to septal trabeculae. Columella usually consists of a massive lamella, lenticular in cross section, and aligned with the 2 principal septa. Often additional papillae surround the central structure. Occasionally, especially in small specimens, the columella is formed of a massive fusion of aligned tubercles.

DISCUSSION.—Two other Recent species of *Stephanophyllia* are known, both occurring in the Indonesian region: *S. neglecta* Boschma, 1923 and *S. complicata* Moseley, 1876. *Stephanophyllia fungulus* is distinguished by its massive columella and thick, upturned base (also see Cairns, 1989a, table 2).

MATERIAL EXAMINED.—*New Records:* TM (KT9015, BS2), 88, USNM 92652, 22, ORI; TM (9015, HK2), 1, USNM 92653; TM (KT9015, OK2), 1, USNM 92654; TM (KT9202, OS2), 1, USNM 92655; USGS 17633 (Pleistocene of Okinawa), 1, USNM 88438. *Previous Records:* 5 syntypes, ZMA; Alb-5311 and Alb-5312 (reported by Cairns, 1989a); Pleistocene of Ryukyu Islands, 1, USNM 81858 (reported by Yabe and Eguchi, 1932b).

TYPES.—Five syntypes of *S. fungulus* are deposited at the ZMA (1321). *Type Locality: Siboga*-100: 6°11'N, 120°37.5'E (Sulu Archipelago), 450 m.

DISTRIBUTION.—Pleistocene of Kazusa, Honshu; Okinawa and Kakai-shima, Ryukyu Islands. *Recent:* Tokyo Bay, Honshu; Bungo Strait; Van Dienem Strait, Kyushu; East China Sea off Goto Retto; Eastern Channel of Korea Strait; Oki Strait, Sea of Japan, western Honshu; off Hong Kong; 73–256 m. *Elsewhere:* Philippines, Celebes Sea, Maldives, South Africa, Mozambique; 98–635 m (Cairns, 1989a).

Suborder FAVIINA

Superfamily FAVIOIDEA

Family RHIZANGIIDAE

Culicia Dana, 1846

DIAGNOSIS.—Corallum colonial (reptoid), consisting of low, cylindrical corallites linked together by stolons. Corallites epithecate. S_1 weakly dentate or lobate; higher cycle septa finely dentate. Pali absent; columella rudimentary (papillose). Shallow water cryptic azooxanthellates.

TYPE SPECIES.—*Culicia stellata* Dana, 1846, by subsequent designation (Wells, 1936).

Culicia japonica Yabe and Eguchi, 1936

PLATE 17*a–e*

Culicia japonica Yabe and Eguchi, 1936:167–168, figs. 1–3.—Eguchi, 1968:C26–27, pl. C9: figs. 1–3.—Kikuchi, 1968:7, pl. 4: fig. 9a,b.—Song, 1982:133–134, pl. 1: figs. 7–9; 1988:26–27, pl. 1: figs. 7–10; 1991:131.—Tribble and Randall, 1986:108.

Culitia [sic] japonica.—Yabe and Eguchi, 1942b:128.

DIAGNOSIS.—Corallites cylindrical, 3.1–3.7 mm in calicular diameter and up to 7 mm in height, although most are only 2–3 in height. Corallites encrusting and well spaced, their placement ranging from directly adjacent to 5–6 mm from one another, connected to their parent corallite by a thin, flat stolon. Corallites epithecate and white, the epitheca often rising well above upper septal margins. Polyps yellowish orange. Septa hexamerally arranged in 4 cycles, the last cycle always incomplete, corallites usually having 34–44 septa. S_1 composed of a tall, broad septal lobe bordered internally by 2 or 3 smaller lobes. S_{2-3} about equal in size and composed of 3 or 4 tall, slender, bluntly tipped septal lobes, their inner edges fused near columella. S_4 rudimentary and irregular in occurrence. Columella circular and papillose, the elements indistinguishable from the S_{1-3} inner septal lobes.

DISCUSSION.—The differences among *C. japonica, C. truncata* Dana, 1846, and *C. stellata* Dana, 1846, are slight, if any. A revision of the 15–18 nominal species of this genus is badly needed.

MATERIAL EXAMINED.—*New Records:* Alb-4925, 1 colony, USNM 92657; TM (KT9015, CB2-2), 1 colony, ORI; off Sesoko Island, Okinawa, 1, USNM 86826; off Horseshoe Cliffs, Onna Village, Okinawa, 1, USNM 88385; off Ogasawara Island, Bonin Islands, 1 colony, USNM 92656. *Reference Specimens:* Types of *C. stellata* and *C. truncata,* USNM.

TYPES.—The holotype of *C. japonica* is deposited at the TIUS (59328). *Type Locality:* Off Owasi, Mie Prefecture, Honshu, 100 m.

DISTRIBUTION.—Southeastern Honshu from Sagami Bay to Owasi; Tokara Retto and Okinawa, Ryukyu Islands; off Amakusa Island, Kyushu; Eastern Channel, Korea Strait; off southern Cheju Do, Korea; western Channel, Korea Strait off southeastern Korea; Bonin Islands; 5–100 m.

Oulangia Milne Edwards and Haime, 1848c

DIAGNOSIS.—Corallum colonial (reptoid), corallites connected by thin stolons. Corallites shaped as low, wide cylinders. Theca costate. Septa exsert, usually in five cycles; inner septal edges finely dentate to laciniate. Pali absent; columella papillose, merging with lower, inner septal processes. Shallow water azooxanthellates.

TYPE SPECIES.—*Oulangia stokesiana* Milne Edwards and Haime, 1848d, by subsequent designation (Milne Edwards and Haime, 1850a:xlv).

Oulangia stokesiana miltoni Yabe and Eguchi, 1932

PLATES 17*f*, 41*a,b*

Oulangia stokesiana var. *miltoni* Yabe and Eguchi, 1932e:29–31, pl. 4: figs. 1–9; 1933:83–85, figs. 1, 2.

Oulangia stokesiana miltoni.—Eguchi, 1968:C27, pl. C4: figs. 2, 3 [color].—Hamada, 1969:253, pl. 2: fig. 6a–c.—Song, 1991:132, pl. 1: fig. 2; pl. 2: figs. 2, 3.

?Oulangia cf. *O. stokesiana.*—Tribble and Randall, 1986:158.

DIAGNOSIS (based primarily on syntypes).—Corallites short, squat cylinders, up to 10 mm in GCD and 4 mm in height, but invariably wider than tall. Propagation by asexual budding from a thin layer of common basal coenosteum, the connection among polyps usually lost or obscured after budding. Base polycyclic, up to three concentric thecal walls visible in worn corallites. Costae broad, flat to slightly convex, and equal in width (about 0.5 mm), separated by narrow (0.15 mm), shallow intercostal striae, which become wider near calice as costae become correspondingly narrower. Costae finely granular, 2 or 3 granules occurring across a costal width. Corallum blackish brown. Septa hexamerally arranged in 5 cycles according to the

formula: $S_{1-2}>S_3>S_4>S_5$. Last (fifth) cycle rarely present and never complete, the largest number of septa reported being 68, corallites with only 48 septa being most common. S_{1-2} only slightly exsert, their inner edges attaining the columella, their upper edges bearing 5–7 coarse teeth. S_3 shortest septa, bearing 3 or 4 small, blunt teeth. Each S_3 flanked by a pair of long S_4, each bearing 7 or 8 blunt teeth and meeting in a V-shaped junction near inner edge of common S_3 and continuing to columella to meet the inner edge of the S_2. Fossa of variable depth, but usually quite shallow. Columella papillose, consisting of papillae indistinguishable from teeth on inner edges of S_{1-2}, and S_4.

DISCUSSION.—*Oulangia stokesiana miltoni* is distinguished from the nominate subspecies and two other Recent species (*O. bradleyi* Verrill, 1866, and *O. cyathiformis* Chevalier, 1971) by having a relatively small corallum with correspondingly fewer septa: 48–66 instead of 96. Previously known only from off northeastern Honshu, and South Korea, this subspecies is herein reported from the Sea of Japan in the Oki Channel, off southwestern Honshu at 100–135 m, the greatest recorded depth for this subspecies. Like *Letepsammia formosissima*, specimens from the northern range (off Japan) of this widespread Indo-West Pacific species have a smaller corallum, and thus has been distinguished as a subspecies.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, CB-6), 3 corallites, USNM 92646. *Previous Records:* 75 syntypes, TIUS.

TYPES.—Approximately 150 syntypes (Plate 41*a,b*) are deposited at the TIUS (41051). *Type Locality:* Shiogama-machi (east of Teizan Canal), Matsushima Bay, near Sendai, Honshu, depth unknown.

DISTRIBUTION.—Pleistocene of Sagami Bay region. *Recent:* Northeastern coast of Honshu from Shiogama to Sagami Bay; ?Miyake-jima; Oki Channel, off southwestern Honshu; coast of South Korea from Pusan to Tokchokto, Yellow Sea; 0–135 m.

Family OCULINIDAE

Madrepora Linnaeus, 1758

DIAGNOSIS.—See Part 1.

Madrepora oculata Linnaeus, 1758

ACCOUNT.—See Part 1.

Cyathelia Milne Edwards and Haime, 1849

DIAGNOSIS.—Colonies arborescent, formed by regular, alternate, extratentacular budding. Coenosteum dense and faintly costate. Well-developed pali occur before first three septal cycles; columella papillose.

TYPE SPECIES.—*Madrepora axillaris* Ellis and Solander, 1786, by monotypy.

Cyathelia axillaris (Ellis and Solander, 1786)

PLATE 18*a–c*

Madrepora axillaris Ellis and Solander, 1786:153, pl. 13: fig. 5.
Cyathelia axillaris.—Milne Edwards and Haime, 1850b:72–73.
Cyathohelia axillaris.—Milne Edwards and Haime, 1857:110–111.—Duncan, 1876:438.—Alcock, 1898:28.—Bedot, 1907:145, pl. 15: fig. 103.
Cyathelia cf. *axillaris.*—Eguchi, 1942:138 (142), pl. 6: figs. 2, 3 [synonymy].
Cyathelia axillaris.—Eguchi, 1968:C28, pl. C20: figs. 5–7; pl. C24: figs. 4, 5 [synonymy].—Kikuchi, 1968:8, pl. 5: fig. 1.

DESCRIPTION.—Coralla sparsely branched, resulting in small, robust, bushy colonies, the largest known about 7.5 cm in height, supporting approximately 100 corallites (Eguchi, 1968, pl. C24: fig. 4). Branching is essentially sympodial, but two buds often originate on opposite sides of a terminal corallite, the parent corallite ultimately becoming immersed in thick coenosteum within the branch axil. Corallites circular when small, often becoming elliptical or even medially constricted if located at a branch axil. Corallites relatively large, up to 11 mm in GCD. Branch coenosteum dense, granular, light brown to tan in color, and usually faintly costate. Corallites often pigmented a darker shade of brown.

Septa usually hexamerally arranged in 4 cycles; however, small corallites (i.e., <8.5 mm in GCD) often lack several pairs of S_4 from lateral septal systems, whereas larger corallites (i.e., >10 mm GCD) sometimes have an extra (13th) half-system for a total of 52 septa. Septal formula: $S_{1-2}>S_3>S_4$. S_{1-2} up to 1.5 mm exsert, quite thick, and have straight inner edges reaching about one-fourth distance into fossa. S_3 equally exsert but only about two-thirds as wide as S_{1-2}. S_4 less exsert and about 80% width of the S_3. Twelve thick pali, each about 1.5 mm wide, form a palar crown encircling columella. Another crown of 12 P_3, each palus of equal width but slightly thicker than P1–2, occurs slightly recessed from the columella and slightly higher in fossa. Pali and septal faces highly granular. Columella papillose.

DISCUSSION.—*Cyathelia* is a montypic genus distinguished from other oculinid genera by having two crowns of pali before its first three septal cycles. It has a distinctive colony shape, easily recognized by its sparse branching and large corallites in relation to its branch diameter.

MATERIAL EXAMINED.—*New Records:* Alb-4944, 1 colony, USNM 92660; TM (KT9015, CB2-2), 1 colony, ORI; TM (KT9015, CB1-2), 2 colonies, USNM 92661; TM (KT9202, YS1), 1, USNM 92662; TM (KT9202, YT2), 1, USNM 92663; off Yenoshima, Honshu, 4 colonies, USNM 92664; Monoiso, Misaki, Sagami Bay, 1 colony, USNM 92665; Ashima, Sagami Bay, 1 colony, USNM 92666. *Previous Records: Challenger*-196, 1 colony, BM 1880.11.25.88 (reported by Moseley, 1881).

TYPES.— The types of *M. axillaris* have not been traced, although Ellis and Solander's (1786) original illustration of the species is diagnostic for this distinctive species. *Type Locality:* Eastern Indian Ocean, depth unknown.

DISTRIBUTION.—Japan: Sagami Bay to Izu Bay, Honshu; Osumi Shoto, northern Ryukyu Islands; Kagoshima Bay and off Amakusa Island, Kyushu; off Mishima, Eastern Channel, Korea Strait; 15–366 m. *Elsewhere:* Moluccas; Arabian Sea and Bay of Bengal; 161–?1509 m.

Moseley's (1881) specimen from 1509 m is correctly identified but clearly was dead when dredged. It seems unlikely that *C. axillaris* would occur at such a great depth. Likewise, although the identity of Alcock's (1898) record from 810 m has not been verified, it would also seem to be too deep for this species based on all other known records.

Family ANTHEMIPHYLLIIDAE

Anthemiphyllia Pourtalès, 1878

DIAGNOSIS.—Solitary, patellate or discoidal, and free. Septotheca thick: porcellaneous or costate. Septal edges lobate to laciniate. Pali absent; columella papillose.

TYPE SPECIES.—*Anthemiphyllia patera* Pourtalès, 1878, by monotypy.

Anthemiphyllia dentata (Alcock, 1902)

PLATE 18*d–f*

Discotrochus dentatus Alcock, 1902a:104; 1902c:27, pl. 4: figs. 26, 26a.—Yabe and Eguchi, 1932b:443; 1937a:143–145, pl. 20: fig. 15a–c.

?Discothrochus [sic] sp.—Yabe and Eguchi, 1937:145–146.

Anthemiphyllia dentata.—Yabe and Eguchi, 1942b:128–129.—Eguchi, 1968:C29–30, pl. C6: figs. 12–21.—Not Cairns, 1984:11 [= undescribed species].—Best and Hoeksema, 1987:398–399, fig. 9a–c.—Cairns and Parker, 1992:16–17, fig. 4e,f [synonymy].—Cairns and Keller, 1993:233, fig. 3E.

Anthemiphyllia dentatus.—Eguchi, 1965:285, 2 figs.

?Anthemiphyllia sp..—Eguchi, 1968:C30–31, pl. C9: figs. 13, 14.

Deltocyathus andamanicus.—Keller, 1982:52 [in part: pl. 1 [= 4]: figs. 3, 4).

DISCUSSION.—*Anthemiphyllia dentata* is a widespread species known from the western Indian Ocean to off Japan, the latter being the northernmost range for the species. It has been widely reported (Yabe and Eguchi, 1937, 1942b) from off southern Japan from moderate depths (50–499 m). The three specimens reported herein (1 fossil, 1 badly preserved, and 1 juvenile) do not add to the previous descriptions of the species given by Alcock (1902a) and Cairns and Parker (1992), and the fine illustrations published by Yabe and Eguchi (1937) and Eguchi (1968). *Anthemiphyllia dentata* is distinguished from the three other Recent species in the genus by attaining a fifth cycle of septa at a relatively small calicular diameter, ultimately attaining a large (up to 27 mm) calicular diameter, and in having finely dentate to laciniate septal margins.

MATERIAL EXAMINED.—*New Records: Pleistocene:* USGS 17455 (south of Tomari, Okinawa, Shimijin marl), 2 fragments, USNM 88435; *Recent:* Alb-5094, 1, USNM 92667; TM (KT9202, OS3), 1, ORI.

TYPES.—Seven syntypes of *D. dentatus* are deposited at the ZMA (Coel. 716-718) (van Soest, 1979). *Type Locality:* *Siboga* stations 95, 98, 100 (Sulu Sea), 350–522 m.

DISTRIBUTION.—Pleistocene of Ryukyu Islands off Kikaijima and Okinawa. *Recent:* Japan: southeastern Honshu from Sagami Bay to Kii Strait; off eastern Shikoku and southern Kyushu; Sea of Japan, Oki Strait; 50–499 m. *Elsewhere:* Sulu Sea (Alcock, 1902a), Philippines (Keller, 1982), Banda Sea (Best and Hoeksema, 1987), southern Australia (Cairns and Parker, 1992), Maldives, Arabian Sea, Saya de Malha; 75–560 m.

Anthemiphyllia frustum, sp. nov.

PLATES 18*g–i*, 19*a,b*

DESCRIPTION.—Corallum tympanoid or frustum-shaped, with a flat base and a low, slightly inwardly curved theca resulting in a basal diameter slightly larger than that of calice. Holotype 9.94 mm in basal diameter, 8.96 mm in calicular diameter, and 4.71 mm in height. Costae equal in width (0.5–0.7 mm at edge of base), relatively flat, and separated by quite narrow (0.02–0.05 mm), shallow intercostal striae. Costae finely granular, 5 or 6 small (0.05 mm in diameter) rounded granules occurring across the width of a costae near corallum edge. Corallum white or reddish brown.

Septa hexamerally arranged in 4 complete cycles (48 septa) in all specimens examined. S_1 bear 5 or 6 massive triangular teeth, each tooth up to 1 mm in height and 0.9 mm in width, the innermost tooth being directly adjacent to columella. S_2 similar to S_1 in construction, but their teeth not quite as tall. Both S_1 and S_2 quite robust and closely spaced, measuring about 0.5 mm in thickness at calicular edge and separated by only about 0.1 mm. S_3 support 4 or 5 tall, triangular teeth, each tooth up to 0.5 mm wide, but not quite as tall as those of the S_{1-2}. S_4 bear 5 or 6 triangular teeth, which decrease in width toward columella. S_{3-4} about 0.35 mm in thickness. Each pair of S_4 within a half-system unites before its adjacent S_3 near the columella in a common triangular septal tooth about 0.2 mm wide. Orientation of faces of septal teeth is parallel to that of septal faces. All septal faces coarsely granular, except for tips of large septal teeth, which are smooth. Columella papillose, composed of 10–15 massive, rounded, finely granular papillae.

DISCUSSION.—*Anthemiphyllia frustum* is readily distinguished from *A. patera* Pourtalès, 1878; *A. dentata* (Alcock, 1902); and *A. pacifica* Vaughan, 1907, by: its frustum-shaped corallum (the other three species are bowl-shaped); its limitation to 48 septa (the other species have some or all of the fifth cycle); and its massive septal teeth, the faces of which are parallel to the septal plane, not perpendicular as in the other three species. *Anthemiphyllia frustum* is most similar to *A. pacifica* Vaughan, 1907, particularly in having the same number of septa, the same orientation and number of septal teeth per septum, and approximately the same corallum size. *Anthemiphyllia pacifica* differs significantly, however, in corallum shape (bowl-shaped), having much smaller S_4 in relation to its S_3, having broader intercostal and interseptal

spaces, and in having clavate, not triangular, septal teeth.

ETYMOLOGY.—The species name *frustum* (Latin *frustum*, meaning "a bit," or "part"), refers to the corallum shape. In geometry, a frustum is the solid figure formed when the top of a cone is cut off by a plane parallel to the base, which is the shape of the corallum of this species.

MATERIAL EXAMINED (Types).—*Holotype:* TM (KT9202, OS2), USNM 92668 (Plate 19*a,b*). *Paratypes:* TM (KT9202, OS2), 4, USNM 92669 (Plate 18*g–i*), 1, ORI. *Type Locality:* 30°59′N, 130°32′′E (Osumi Strait, southern Kyushu), 237–241 m.

DISTRIBUTION.—Known only from the type locality.

Suborder CARYOPHYLLIINA

Superfamily CARYOPHYLLIOIDEA

Family CARYOPHYLLIIDAE

Caryophyllia Lamarck, 1816

DIAGNOSIS.—See Part 1.

Subgenus *Caryophyllia (Caryophyllia)* Lamarck, 1816

DIAGNOSIS.—See Part 1.

Caryophyllia (C.) japonica Marenzeller, 1888

PLATES 4*i*, 19*c–i*

Caryophyllia (C. japonica Marenzeller, 1888b:16.—Yabe and Eguchi, 1941b:102; 1942b:119, pl. 10: figs. 1–3.—Eguchi, 1965:285, 2 figs.; 1968:C31–32, pl. C11: figs. 4–6, 10–29; pl. C23: figs. 7–9; pl. C25: figs. 5, 6; pl. C29: figs. 6, 7.—?Kikuchi, 1968:8, pl. 5: fig. 8.—Eguchi and Miyawaki, 1975:56.—Song, 1982:134, pl. 2: figs. 3–5; 1988:27, pl. 3: figs. 9–11; 1991:132–133.

Caryophyllia ephyala.—Yabe and Eguchi, 1932a:388, 389.

Caryophyllia arcuata.—Yabe and Eguchi, 1936:167.—Eguchi, 1938, table 2.

Caryophyllia alaskensis.—Keller, 1981a:21 [in part: *Vityaz*-2078, 3353, 5592, 5640], pl. 2: fig. 1.

Caryophyllia ambrosia.—Keller, 1981a:15 [in part: *Vityaz*-5638].

DESCRIPTION.—Corallum robust, ceratoid to trochoid, and firmly attached by a relatively slender pedicel: PD:GCD = 0.25–0.39. Calice circular to elliptical. Largest corallum examined (Alb-4982) 17.8 × 16.0 mm in calicular diameter and 18.4 mm in height, with a pedicel diameter of only 6.7 mm. Theca thick. C1-3 sometimes slightly ridged near calice; otherwise, costae are flat with low, rounded granules or porcellaneous in texture. Corallum white.

Septa hexamerally arranged in 4 complete cycles according to the formula: $S_{1-2}>S_3>S_4$. S_{1-2} moderately exsert (1.5–2.1 mm) and have straight, vertical inner edges that merge with the columella low in fossa. S_3 70%–75% width of S_{1-2}, less exsert (about 1 mm), and have sinuous inner edges. S_4 less exsert and slightly less wide than S_3. A crown of 12 slender, lamellar but sinuous pali occurs before the S_3, each palus 1.5–2.0 mm in width.

Fossa of moderate depth. Columella well developed, composed of a large elliptical field of 10–20 fused, twisted elements. The previous description was based primarily on specimens from Alb-4982 and the two syntypes.

DISCUSSION.—Three species—*Caryophillia japonica, C. alaskensis* and *C. arnoldi*—form a closely related group that might well be considered as geographic subspecies of one species: *C. japonica,* known from Japan to the Commander Islands; *C. alaskensis,* from the Commander Islands (at shallower depths) to British Columbia; and *C. arnoldi,* from Prince William Sound, Alaska to the California Channel Islands. *Caryophyllia japonica* differs from the geographically adjacent *C. alaskensis* in much the same ways that *C. arnoldi* differs from *C. alaskensis. Caryophyllia japonica* has a more robust corallum; consistently 48, more highly exsert septa; and S_4 that are only slightly less wide than the S_3. *Caryophyllia japonica* is almost indistinguishable from its trans-Pacific cognate, *C. arnoldi,* differing only in having a narrower pedicel.

MATERIAL EXAMINED.—*New Records:* Alb-4982, 13, USNM 82158, 2, ORI; Alb-5088, 1, USNM 92676; Alb-5093, 1, USNM 92677; *Academik Keldish*-2312, 4, IOM. *Previous Records:* 2 syntypes of *C. japonica;* specimens reported as *C. alaskensis* by Keller (1981a) from: *Vityaz*-2078 (IOM), 3353 (USNM 92678, Plate 19*c,f*), and 5640 (IOM); specimen reported as *C. ambrosia* by Keller (1981a) from *Vityaz*-5638, IOM (Plate 4*i*).

TYPES.—Two syntypes (Plate 19*d,g,i*) of *C. japonica* are deposited at the NMW (8168). *Type Locality:* "Enosima," Japan, depth unknown. Although there are several Enosima's (= Enoshima) listed in a Japanese gazetteer, the most likely is the one in Sagami Bay.

DISTRIBUTION.—Throughout Japanese waters from Ishikari Bay, Hokkaido to southern Kyushu, including both Pacific and Sea of Japan coasts; off Cheju Island, Korea Strait and Sea of Japan off South Korea; Pacific coast of Kurile Islands; Commander Islands, Bering Sea; 77–1680 m, with a tendency to occur deeper in the northern range.

Caryophyllia (C.) alaskensis Vaughan, 1941

ACCOUNT.—See Part 1.

Caryophyllia (C.) sp. cf. *C. scobinosa* Alcock, 1902

PLATES 19*j–l*, 20*a,b*

Caryophyllia scobinosa Alcock, 1902a:90; 1902c:8, pl. 1: figs. 2, 2a.—Yabe and Eguchi, 1942b:119–120 [in part; not pl. 10: fig. 5].—Utinomi, 1965: 254.—Eguchi, 1965:285, fig.—Cairns and Keller, 1993:235 [synonymy].

Caryophyllia cf. *scobinosa.*—Utinomi, 1956:42.

DESCRIPTION OF SPECIMENS FROM TM (KT7911, OT4).—Corallum ceratoid, free, and curved about 45. Corallum 10.4 mm in calicular diameter, 17.9 mm in height, and 1.7 mm in pedicel diameter. Costae flat and granular, separated by narrow intercostal striae. Corallum white. Septa hexamerally arranged

in 4 complete cycles according to the formula: $S_{1-2}>S_3>>S_4$. S_{1-2} only slightly exsert and have straight, vertical inner edges that do not attain the columella. S_3 about three-fourths width of S_{1-2} and have slightly sinuous inner edges. S_4 rudimentary, only about one-third width of S_3, and have irregular to lacerate inner edges. Twelve broad lamellar pali occur in a crown before the S_3, each palus almost as wide as its adjacent S_3 and having only moderately sinuous inner edges. Fossa of moderate depth, containing a columella of 5 slender, twisted elements.

DISCUSSION.—Although the specimens reported herein, as well as those reported by Yabe and Eguchi (1942b) and Utinomi (1965), are similar to typical *C. scobinosa,* they are consistently different in several characters. The Japanese specimens have much smaller S_4 in relation to their S_3; in typical *C. scobinosa* the S_4 are equal to or wider than the S_3. Also, the Japanese specimens have less exsert septa and a narrower, less curved corallum. They may represent an extreme variation for the species at its northern limit, or, perhaps, a separate species.

MATERIAL EXAMINED.—*New Records:* Alb-4972, 1, CAS 74994; TM (KT7911, OT4), 3, USNM 92680. *Previous Records:* Syntypes of *C. scobinosa,* ZMA.

TYPES.—Six syntypes (Plate 20*a,b*) of *C. scobinosa* are deposited at the ZMA (Coel. 574, 575)(see van Soest, 1979). *Type Localities: Siboga* stations 45 and 102: Celebes and Sulu Seas, 535–794 m.

DISTRIBUTION.—Japan: Suruga Bay and Kii Strait, Honshu; off eastern Shikoku; East China Sea off southwestern Kyushu; Tokara Retto, northern Ryukyu Islands; 119–805 m. *Elsewhere (as C. scobinosa)*: Philippines, Sulu Sea, Celebes, southwestern Indian Ocean; 535–960 m.

Caryophyllia (C.) quadragenaria Alcock, 1902

PLATES 20*c–h*, 41*c,d*

Caryophyllia quadragenaria Alcock, 1902a:91–92; 1902c:10, pl. 1: figs. 4, 4a.—Cairns, 1991a:12.

Caryophyllia scobinosa.—Yabe and Eguchi, 1942b:119 [in part: pl. 10: fig. 5a,b].

Caryophyllia scobinosa decapali Yabe and Eguchi, 1942b:120, 149, pl. 10: figs. 6, 7.—Eguchi, 1968:C33–34.—Eguchi and Miyawaki, 1975:56.—Cairns, 1991a:12.

Caryophyllia decapali.—Grygier, 1983:420.—Zibrowius and Grygier, 1985:120, figs. 10, 11.

DESCRIPTION.—Corallum ceratoid to subcylindrical, straight to slightly curved, and attached by a rather narrow pedicel (PD:GCD = 0.16–0.33). Largest specimen examined (paratype of *C. scobinosa decapali, Soyo Maru*-222) 12.2 × 10.3 mm in calicular diameter and 21.8 mm in height, with a slender pedicel diameter of 1.39 mm. Costae equal in width (about 0.5 mm), flat, and covered with large, low, rounded granules, 2–3 across the width of a costa. Intercostal striae shallow and narrow. Corallum white to light brown. Calicular margin serrate, each primary septum along with its fused adjacent pair of tertiary septa projecting as a thecal extension.

Septa decamerally arranged in 3 size classes: 10:10:20 (40 septa). Primary septa highly exsert (up to 1.8 mm) and have vertical, slightly sinuous inner edges that do not reach the columella. Secondary septa least exsert (about 0.7 mm), about three-quarters width of primaries, and have extremely sinuous inner edges. Tertiary septa about 1.0 mm exsert and have moderately sinuous inner edges, the upper outer edge of each S_3 fused to its adjacent primary septum. Width of tertiary septa variable, usually equal to or wider than the secondaries, but in some specimens only one-third to one-half width of secondaries. A crown of 10 broad (1.3 mm wide), very sinuous P_2 tightly encircle the elongate columella, the latter composed of 4–8 broad, twisted elements.

DISCUSSION.—Among the approximately 60 species of Recent *Caryophyllia,* only seven have decameral septal symmetry (Cairns, 1991a, table 3). In their original diagnosis of *C. scobinosa decapali,* Yabe and Eguchi (1942b) noted the extreme resemblance of their Japanese subspecies to *C. quadragenaria,* according to them the latter differing only in its attachment by a "cylindrical stalk." In fact, both the Japanese *C. decapali* and *C. quadragenaria* are attached by narrow pedicels, and comparison of syntypes of *C. quadragenaria* to Japanese specimens show no differences, and therefore *C. decapali* is synonymized with *C. quadragenaria.*

The character of the relative widths of the last (tertiaries) and penultimate cycle (secondaries) of septa can usually be used as a species level character, but in *C. quadragenaria* the tertiaries may be wider or considerably less wide than the secondaries. For instance, the smallest and largest syntypes of *C. quadragenaria* (*Siboga*-90, 289) have tertiaries larger than secondaries, whereas the tertiaries of the syntype from *Siboga*-251 are only one-third the width of a secondary. And, in the lot of 8 specimens from TM (KT9202, OS2), most specimens have broad tertiaries, but several have tertiaries less broad than the secondaries.

The specimen from *Soyo Maru*-220, identified by Yabe and Eguchi (1942b) as *C. scobinosa,* is identical to specimens in the type series of *C. decapali,* but has 48 septa and 12 pali. It is either an aberrant specimen or indicative that the species may have either 10 or 12 pali (40 or 48 septa).

MATERIAL EXAMINED.—*New Records:* Alb-3707, 1, USNM 92670; TM (KT7811, OT6), 1, USNM 92671; TM (KT9015, CB1-2), 4, ORI; TM (KT9202, OS2), 8, USNM 92672; TM (KT9309, AM8), 1, USNM 93162, 2, ORI; Sagami Bay, 110 m, 11 June 1914, Mortensen's Pacific Expedition, 1, ZMC; 32°10′N, 128°20′E, 183 m, 23 May 1898, 1, ZMC. *Previous Records:* Two syntypes of *C. quadragenaria* (*Siboga*-90, 251); holotype and 6 paratypes of *C. scobinosa decapali, Soyo Maru*-222, TIUS; *C. scobinosa* of Yabe and Eguchi (1942b), *Soyo Maru*-220, TIUS 53634.

TYPES.—Two of the three syntypes of *C. quadragenaria* are deposited at the ZMA: *Siboga*-90 (Coel. 5534) and *Siboga*-251 (Coel. 5529, Plate 20*d,g*). The third syntype from *Siboga*-289 is missing (Van Soest, 1979). The missing syntype was the

largest and figured specimen. *Type Localities:* Indonesia (Makassar Strait, Banda and Timor seas), 54–281 m.

The holotype of *C. scobinosa decapali* (53640), as limited by Yabe and Eguchi by the designation of a type locality, and paratypes are deposited at the TIUS (Plate 41*c,d*). *Type Locality: Soyo Maru*-210: 33°29′N, 135°28′E (Kii Strait, off southeastern Honshu), 165 m.

DISTRIBUTION.—Japan: Sagami and Suruga Bays, Honshu; Kii Strait; off Shikoku; Osumi Shoto, northern Ryukyu Islands; East China Sea off Danjo Gunto; Eastern Channel of Korea Strait off Mishima; 70–422 m. *Elsewhere:* Makassar Strait, Banda and Timor Seas; 54–281 m.

Caryophyllia (C.) rugosa Moseley, 1881

PLATES 20*i*, 21*a*

Caryophyllia rugosa Moseley, 1881:141–143, pl. 1: fig. 8.—Wells, 1954:469, pl. 177: figs. 5, 6.—Cairns, 1984:11–13, pl. 2: figs. A,B; pl. 4: fig. I [synonymy].—Cairns and Keller, 1993:236, fig. 3I.
Caryophyllia paraoctopali Yabe and Eguchi, 1942b:120, 150, pl. 10: fig. 12.

DESCRIPTION.—Corallum ceratoid to cylindrical, often firmly attached to a bivalve or barnacle through a broad pedicel. Largest specimen examined (ZMC) 8.5 × 7.5 mm in calicular diameter and 14.3 mm in height. Costae equal in width (about 0.6 mm wide in large coralla), flat, and covered with fine transverse rugae (Plate 21*a*). Corallum white.

Septa of most coralla (i.e., calicular diameter < 5.5 mm) octamerally arranged in 3 cycles: 8:8:16 (= 32 septa). Primary septa only slightly exsert (about 0.8 mm), extend about three-quarters distance to columella, and have very sinuous inner edges. Secondary septa less exsert (about 0.5 mm), about three-quarters width of a primary, and also have very sinuous inner edges. Tertiary septa about 0.4 mm exsert, three-quarters width of a secondary, and have moderately sinuous inner edges. A crown of 8 slender, quite sinuous pali occur before the secondary septa. In larger coralla (i.e., calicular diameter > 5.5 mm), additional septa occur but octameral symmetry is maintained. In these larger coralla, pairs of tertiary septa within various sectors are accelerated to an equivalent width of a secondary and are flanked by smaller quaternary septa. In such a sector, a palus occurs before each tertiary septa, not the secondary, leading to coralla with 52 septa and 9 pali, or 56 septa and 10 pali. If only 1 tertiary septum is enlarged within a sector, the palus remains single before the secondary septum. Fossa quite shallow, containing 3–6 slender, twisted elements.

DISCUSSION.—There are four species of octamerally symmetrical *Caryophyllia* with 32 septa (Cairns, 1991a); *C. rugosa* is distinguished from the other three by having transversely sculptured costae and a very small corallum. In their description of *C. paraoctopali*, Yabe and Eguchi (1942b) distinguished it from *C. rugosa* by its having octameral symmetry; however, *C. rugosa* also has octameral symmetry and is clearly the senior synonym.

MATERIAL EXAMINED.—*New Records:* Alb-4924, 1, USNM 92673; TM (KT9202, YS1), 3, USNM 92674; TM (KT9202, YS2), 1, ORI; 32°15′N, 128°20′E, 181 m, 17 April 1926, 30 specimens, ZMC; 32°21′N, 128°49′E, 179–291 m, 2 specimens, ZMC.

TYPES.—The syntypes of *C. rugosa* are deposited at the BM. *Type Localities: Challenger* stations 192 and 201 (Indonesia and Philippine Islands), 187–230 m.

Four syntypes of *C. paraoctopali* are deposited at the TIUS (53645–53648). *Type Locality:* "Pacific coast of Honshu, Shikoku, and Kyushu," 71–183 m.

DISTRIBUTION.—Japan: Suruga Bay, Honshu; off southeastern Kyushu and northern Ryukyu Islands (Colnett Strait and Tokara Retto); East China Sea off Danjo Gunto; 71–240 m. *Elsewhere:* Off Taiwan, Philippines, Ceram Sea, Bikini, Hawaiian Islands, and southwest Indian Ocean; 100–439 m.

Caryophyllia (C.) jogashimaensis Eguchi, 1968

PLATE 21*b,c*

Caryophyllia jogashimaensis Eguchi, 1968:C33, pl. C18: figs. 4–8.—Cairns, 1991a:12.

Description of Specimen from TM (KT9202, YT2).—Corallum trochoid: 12.1 × 9.7 mm in calicular diameter, 15.7 mm in height, and 4.7 mm in pedicel diameter. Theca worn and heavily encrusted with serpulids and foraminifera; however, theca near base appears to bear fine transverse rugae. Upper outer (near theca) septal edges light red in color.

Septa arranged in 4 size classes accordingly: 9:9:18:34 (= 70 septa), 1 of the 18 half-sectors missing its pair of quaternaries. Primary septa moderately exsert (about 1.6 mm), extend about three-quarters distance to columella, and have slightly sinuous inner edges. Secondary septa less exsert (about 0.9 mm), about the same width, and also have slightly sinuous inner edges. Tertiary septa least exsert (about 0.5 mm), about three-quarters width of a secondary, and have very sinuous inner edges. Quaternary septa slightly more exsert than tertiary septa because they are fused at calicular edge to their adjacent S_1 and S_2 in short, rectangular projections. Quaternaries quite broad, almost as wide as tertiaries, and have slightly sinuous inner edges. A crown of 17 well-developed (1.2 mm wide), highly granular, sinuous pali occur before the tertiary septa. Fossa of moderate depth, containing an elongate columella consisting of 4 or 5 twisted and partially fused elements.

DISCUSSION.—Eguchi (1968) described the larger (GCD = 19–20 mm) syntype (1968, pl. C18: figs. 4, 5) of this species as having 72 septa arranged 9:9:18:36 and 18 pali in 18 half-sectors; however, it easily can be seen from his illustration that there are either 17 or 19 half-sectors (17:17:34:4 or 19:19:34, respectively) and 19 pali, two end half-sectors being in the process of expanding. The smaller syntype (pl. C18: figs. 6–8; GCD = 14 mm) appears to have 15 half-sectors arranged: 15:15:30 (60 septa), with 1 palus per half-sector. The number of sectors, septa, and pali (i.e., 15–19 half-sectors, 60–72 septa,

and 15–19 pali) thus appears to a function of size, additional sectors and pali first forming near the end-sectors.

MATERIAL EXAMINED.—TM (KT9202, YT2), 1, USNM 93675, 1, ORI. *Previous Records:* The type specimens were unavailable for study.

TYPES.—Two syntypes are presumed to be deposited at the Biological Laboratory of the Imperial Household, Tokyo (#852). *Type Locality:* Off Jogashima, 1.4 km west of the Lighthouse, Sagami Bay, 52–56 m.

DISTRIBUTION.—Sagami Bay; Colnett Strait, Osumi Shoto, northern Ryukyu Islands; 52–98 m.

Caryophyllia (C.) ambrosia ambrosia Alcock, 1898

PLATE 21*d–h*

?Caryophyllia scillaeomorpha Alcock, 1894:186; 1898:13, pl. 1: figs. 3, 3a.
Caryophyllia ambrosia Alcock, 1898:12, pl. 1: figs. 1, 1a.—Zibrowius, 1980:63–65, pl. 25: figs. A–K [synonymy].—Keller, 1981a:15–16 [in part: *Akademik Kurchatov* station 441].
Caryophyllia cf. *alcocki*.—Yabe and Eguchi, 1942b:120, pl. 10: fig. 8.
"Unidentified solitary coral."—Okutani, 1969:12, pl. 1: fig. 7.
Caryophyllia ambrosia ambrosia.—Cairns, 1979:59.—Cairns and Keller, 1993:234, fig. 3H.

DESCRIPTION.—Corallum cornute and free, pedicel invariably curved about 90° and terminating in a narrow point or worn nub. Largest specimen examined (Alb-4960) 31.4 × 26.1 mm in calicular diameter and 26 mm in height. Costae equal, broad, and flat; separated by thin, shallow intercostal striae; and covered with low, rounded granules. Primary costae slightly ridged at calicular margin. Lower half to two-thirds of theca usually discolored or eroded, the costae being well preserved only within 5–7 mm of calicular edge. Corallum otherwise white.

Septa arranged in 3 size classes, with a tendency of most specimens examined to have 18–20 primary, 18–20 secondary, and 36–40 tertiary septa (72–80 total). Smaller specimens (e.g., those of Yabe and Eguchi, 1942b) of only 19 mm GCD have only 12 primary septa (48 septa total); specimens of 24–26 mm GCD (e.g., the syntypes) have 14–16 primary septa (56–64 total septa). Primary septa highly exsert (up to 6 mm) and have straight, vertical inner edges that do not quite reach the columella. Secondary septa are the smallest septa, only 1–2 mm exsert, three-quarters width of a primary, and have a sinuous inner edge. Tertiary septa 2–3 mm exsert (pairs fused to each adjacent primary septa at calicular edge) and equal to or slightly wider than the flanked secondary septum. Each secondary septum bordered internally by a high, granular, sinuous palus, usually wider (about 5 mm) than the secondary septum it borders. Total number of pali in palar crown corresponds to the number of secondary (or primary) septa in the calice, which is, in turn, correlated to the GCD. Fossa moderate in depth, containing a well-developed, elongate fascicular columella, composed of broad, closely adjacent elements.

DISCUSSION.—*Caryophyllia ambrosia* belongs to a group of five species (see Cairns, 1991a, table 3) characterized by having relatively large, cornute, unattached coralla and three size classes of nonhexamerally arranged septa, the total usually exceeding 48: *C. seguenzae* Duncan, 1873; *C. ambrosia* Alcock, 1898 (?= *C. scillaeomorpha* Alcock, 1894); *C. planilamellata* Dennant, 1906; *C. grandis* Gardiner and Waugh, 1938; and *C. valdiviae* Zibrowius and Gili, 1990. *Caryophyllia ambrosia* is distinguished from the other four species by having tertiary septa that are wider than their secondary septa and very broad columellar elements. There is little doubt that Yabe and Eguchi's (1942b) *Caryophyllia* cf. *alcocki* is simply an immature specimen of this species.

Caryophyllia ambrosia occurs from the western Atlantic eastward to Honshu, Japan (Cairns, 1979; Zibrowius, 1980; Cairns and Keller, 1993); however, a separate subspecies, *C. ambrosia caribbeana* Cairns, 1979, was distinguished for the tropical western Atlantic populations. Likewise, North Pacific specimens differ from typical Indian Ocean specimens in having a tendency to have more septa and pali, i.e., usually 72–80 septa and 18–20 pali. The typical form is not known to have more than 72 septa and 18 pali (Zibrowius, 1980). This may ultimately warrant the naming of another subspecies for the North Pacific specimens.

Caryophyllia scillaeomorpha Alcock, 1894 antedates *C. ambrosia* by four years and appears to be conspecific, but until the types are examined I hesitate to make this synonymy, especially because of its unusually shallow depth of occurrence (196 m).

MATERIAL EXAMINED.—*New Records:* Alb-4959, 1, USNM 92791; Alb-4960, 1, USNM 92792; Alb-4969, 1, CAS 15259; TM (KT8916, T3-2), 2, USNM 92793; TM (KT9202, YT6), 17, USNM 92794, 3, ORI. *Previous Records:* 2 syntypes of *C. ambrosia* from Laccadive Sea, 1070 fms, USNM 18157; specimens reported from eastern Atlantic by Zibrowius (1980), USNM and MNHNP; *C. alcocki* of Yabe and Eguchi (1942b), *Soyo Maru*-223, TIUS 53625 (Plate 21*e*).

TYPES.—Two hundred syntypes of *C. ambrosia* are presumably deposited at the Indian Museum, Calcutta; two are also deposited at the USNM (18157, Plate 21*d,g*); and several specimens are at the MNHNP. *Type Localities: Investigator* station 104: 11°12′47″N, 74°25′30″E, 1829 m (Elicapeni Bank, Laccadive Sea, Arabian Sea) and *Investigator* station 176: 11°47′06″N, 73°57′30″E (Laccadive Sea), 1957 m.

The holotype of *C. scillaeomorpha* is presumed to be deposited at the Indian Museum, Calcutta. *Type Locality: Investigator* station 170: 13°01′06″N, 80°36′56″E (off Madras, Bay of Bengal), 196 m.

DISTRIBUTION.—Japan: Pleistocene of Okinawa, Naha limestone, 2, USNM 88678. Recent: off Sagami Bay and southeastern Honshu; Miyaki-jima; mouth of Bungo Strait; Osumi Shoto, northern Ryukyu Islands; 311–2450 m. *Elsewhere:* Amphi-Atlantic, Indian Ocean; 430–2670 m.

Caryophyllia (C.) laevicostata Moseley, 1881

Caryophyllia laevicostata.—Yabe and Eguchi, 1932a:388.
Caryophyllia sp.—Yabe and Eguchi, 1942b:162.

DISCUSSION.—Yabe and Eguchi (1932a) listed a specimen of *C. laevicostata* from 604 m "off Japan" but did not describe or illustrate it. The only *Soyo Maru* station made at that depth was station 262, from Suruga Bay. The specimen was later (Yabe and Eguchi, 1942b) referred to as *Caryophyllia* sp. Because the specimen has never been described, illustrated, or definitively identified, it is not considered as a legitimate record for the North Pacific. *Caryophyllia laevicostata* was originally described from off Ascension Island, Atlantic at 776 m and later synonymized by Zibrowius (1980) with *C. atlantica* (Duncan, 1873). *C. atlantica* has a distribution including the eastern Atlantic and Hawaiian Islands at depths of 776–2165 m.

Subgenus *Caryophyllia (Acanthocyathus)* Milne Edwards and Haime, 1848

DIAGNOSIS.—*Caryophyllia* having coralla with edge spines.

TYPE SPECIES.—*Acanthocyathus grayi* Milne Edwards and Haime, 1848a, by subsequent designation (Milne Edwards and Haime, 1850a:xiii).

Caryophyllia (A.) grayi Milne Edwards and Haime, 1848

PLATE 21*i–k*

Acanthocyathus grayi Milne Edwards and Haime, 1848a:293, pl. 9: figs. 2, 2a.—Yabe and Eguchi, 1942b:121–122 [synonymy, no figure].—Umbgrove, 1950:641–642, pl. 81: figs. 27–32 [synonymy].—Wells, 1984:209, pl. 2: figs. 5–9 [synonymy].—Eguchi and Miyawaki, 1975:57.—Zou, 1988:76, pl. 5: figs. 8, 9.

DESCRIPTION.—Corallum ceratoid, compressed (GCD:LCD = 1.3–1.5), and usually slightly curved in plane of GCD. Largest specimen examined (USNM 71846, Pleistocene of Vanuatu) 21.7 × 16.9 mm in calicular diameter, but Yabe and Eguchi (1942b) reported a specimen 28 × 20 mm in calicular diameter, and the holotype is reported to be even larger at 30 × 20 mm in calicular diameter and 40 mm in height. Coralla unattached, the pedicel narrowing to 1.5–1.8 mm in diameter. Each mature specimen bears up to 8 lateral spines: 2 or 3 on the concave edge and 3–5 on the convex edge. Spines up to 8 mm in length (but commonly broken) and circular to slightly elliptical in cross section. Costae equal in width, slightly convex, and finely granular. Corallum light reddish brown.

Septa arranged in 14 to 18 sectors, the most common arrangement being: 14:14:28 (= 56 septa); however, end half systems often have extra pairs of quaternaries, i.e., 14:14:28:6 (= 62 septa) and coralla with 18 sectors have up to 72 septa. Primary septa up to 2.8 mm exsert, extend about three-quarters distance to columella, and have straight inner edges. Secondary septa about 1.8 mm exsert, three-quarters width of primaries, and have sinuous inner edges. Tertiary septa equally exsert as secondaries but only about three-quarters their width, and have slightly sinuous inner edges. Quaternary septa usually restricted to end half-systems. A distinct crown of 14–18 wide (about 2 mm) pali occur before the secondary septa, each palus planar but with slightly sinuous edges. Fossa of moderate depth, containing an elongate columella composed of 7–10 highly fused, slender twisted elements.

DISCUSSION.—The only specimens of this species previously known from off Japan were those reported by Yabe and Eguchi (1942b) off Seto, Wakayama-ken, and those reported by Eguchi and Miyawaki (1975) off Kushimoto, Honshu. The two large specimens reported by Yabe and Eguchi (1942b), stated to be deposited at the Seto Marine Biological Laboratory of Kyoto University, are no longer there (Grygier, pers. comm.). Comparisons of this species to *C. (A.) spiniger* are made in the account of that species.

MATERIAL EXAMINED.—*New Records:* TM (KT9309, AM6), 3, ORI; TM (KT9309, AM7), 5, USNM 93161, 8, ORI. *Previous Records:* Vanuatu Pleistocene specimens reported by Wells (1984), USNM.

TYPES.—Holotype not traced. *Type Locality:* Unknown.

DISTRIBUTION.—Japan: Off Seto and Kushimoto, Honshu; off Amami Oshima, Ryukyu Islands; 108–191 m. *Elsewhere:* Pliocene of Java. Plio-Pleistocene of Java, Japan, Ceram, Talaud, and Vanuatu. *Recent:* South China Sea; Philippines (*Alb*-5381, 5593); Andamans; off Burma; 37–490 m.

Caryophyllia (A.) spiniger Kent, 1871

PLATES 21*l*, 22*a–d*

Acanthocyathus spiniger Kent, 1871:275–276, pl. 23: fig. 1a–c.—Yabe and Eguchi, 1941c:212; 1942b:112, 122.

DESCRIPTION.—Corallum ceratoid to trochoid, compressed (GCD:LCD = 1.3–1.4), and straight. Largest specimen examined (Alb-5371) 18.2 × 14.1 mm in calicular diameter and 17.6 mm in height. Corallum unattached, the pedicel only 0.8–1.3 mm in diameter. C_{1-2} ridged, the two lateral C_1 giving the corallum alate edges. A pair of short (up to 5 mm), slender (about 0.7 mm in diameter) edge spines occurs close to the pedicel. A much larger pair of spatulate spines occurs slightly higher on calicular edges, each measuring up to 13 mm in length and up to 3.1 × 0.8 mm in cross section, the greater diameter of the spine being in plane of greater axis of corallum. In some large coralla, a third pair of spines similar to the second pair occur higher on thecal edge. In about one-quarter of the specimens examined, 4 large additional thecal spines occur (Plate 22*d*), similar to the second edge pair in size, one midway on each lateral C1. Corallum reddish brown to white.

Septa hexamerally arranged in four complete cycles according to the formula: $S_1 > S_2 > S_3 > S_4$. S_1 highly exsert (up to 4.5 mm), extend about four-fifths distance to columella, and have straight inner edges. S_2 only about 2.5 mm exsert, only four-fifths width of an S_1, and also have straight inner edges. S_3 least exsert (about 1.5 mm), about two-thirds width of an S_2, and have sinuous inner edges. Each pair of S_4 adjacent to an S_1 are highly exsert (about 2.3 mm) and fused to its adjacent S_1; likewise, each pair of S_4 adjacent to an S_2 are as exsert as an S_3 and also fused to its adjacent S_2. S_4 about two-thirds width of

an S_3 and have slightly sinuous inner edges. Septa are well spaced. A crown of 12 planar (2 mm wide) P_3 occurs within the fossa encircling a linear columella composed of 3–6 broad, twisted elements.

DISCUSSION.—The only Japanese record of this species was Kent's original description from an unspecified location and depth off Japan. No additional North Pacific specimens are reported herein, and the description above is based on three syntypes and a suite of specimens from off the Philippines (Alb-5369, 5371).

Caryophyllia (A.) spiniger is distinguished from *C. (A.) grayi* by several characters. *Caryophyllia spiniger* always has 48 septa and 12 pali; *C. grayi* has 56–72 septa and 14–18 pali. Also, *C. spiniger* has: ridged C_{1-2}, not low, slightly convex costae; highly exsert S_1 that are larger than its S_2; and a straight, not curved, corallum and thus a symmetrical arrangement of edge spines, not unequal as in *C. grayi*. Furthermore, the edge spines of *C. spiniger* are spatulate, those of *C. grayi* are circular to elliptical in cross section. Finally, there is a tendency for lateral thecal spines to occur in *C. spiniger*, but not in *C. grayi*.

MATERIAL EXAMINED.—*New Records:* Alb-5369, 15, USNM 92689; Alb-5371, 28, USNM 92690, 2, ORI. *Previous Records:* 3 syntypes, BM.

TYPES.—At least 3 syntypes (Plates 21*l*, 22*c*) of *A. spiniger* are deposited at the BM (uncataloged). *Type Locality:* "Japan," depth unknown.

DISTRIBUTION.—Off Japan, depth range unknown. *Elsewhere:* Philippines; 152–194 m.

Subgenus *Caryophyllia (Premocyathus)* Yabe and Eguchi, 1942b

DIAGNOSIS.—*Caryophyllia* having compressed coralla with alate to carinate lateral edges.

TYPE SPECIES.—*Premocyathus compressus* Yabe and Eguchi, 1942b, by original designation.

DISCUSSION.—Yabe and Eguchi (1942b) established *Premocyathus* as a separate genus but Wells (1956) later considered it to be a subgenus of *Caryophyllia*. I (Cairns, 1991a) treated it as separate genus, but now agree with Wells, that it should be a subgenus of *Caryophyllia*. Its variation from typical *Caryophyllia* is no more than that of the other subgenus *Acanthocyathus*, both subgenera differing only in the degree of septal edge modification.

Caryophyllia (P.) compressa Yabe and Eguchi, 1942

PLATE 22*e,f*

Caryophyllia compressa Yabe and Eguchi, 1932b:443 [nomen nudum].

Premocyathus compressus Yabe and Eguchi, 1942b:121, 151–152, pl. 10: figs. 13, 14.—Eguchi, 1965:285, fig.—Eguchi and Miyawaki, 1975:57.

Not *Caryophyllia compressa* Gardiner and Waugh, 1938:180 [junior homonym, replacement name *C. zanzibarensis* Zou, 1984].

Not *Caryophyllia (Premocyathus) compressus*.—Wells, 1956:F422, fig. 323, 3.

Not *Premocyathus compressus*.—Cairns, 1984:14.

Caryophyllia (Premocyathus) compressa.—Mori, 1987:21–30, 9 figs.

Description of Recent Specimens.—Corallum compressed, free, and evenly curved up to 90° in plane of GCD. Largest specimen examined (TM (KT9015, BS2)) 8.3 × 5.4 mm in calicular diameter (GCD:LCD = 1.53) and 18.5 mm in height. Base of corallum invariably broken, revealing an irregularly circular scar 1.5–2.0 mm in diameter. Outer (convex) side of corallum slightly ridged; inner (concave) edge evenly rounded. Costae well developed, slightly convex, and coarsely granular. Corallum white.

Septa usually decamerally arranged in three size classes, the tertiary cycle often incomplete. Common septal/palar arrangements include: 10:10:20, 10; 10:10:18, 9; 10:10:10, 5; and 10:10:8, 4 (notation follows that of Mori, 1987, in which the number of pali follows the comma). There is in general a direct correlation between number of septa and GCD, the first pairs of tertiary septa (and P_2) occurring in sectors adjacent to the principal septa (termed "spaces iv and v" by Mori, 1987). Primary septa moderately exsert (up to 0.7 mm), and have sinuous, vertical inner edges that attain the columella. Secondary septa about three-quarters width of primaries and also have quite sinuous inner edges. Tertiary septa equal to or only slightly less wide than secondaries, and have almost straight inner edges. Slender, sinuous pali occur only before those secondary septa flanked by tertiary septa, the palar crown thus ranging from 1–10 elements. Fossa of moderate depth, containing a fascicular columella composed of 8–15 slender, twisted elements.

DISCUSSION.—In a thorough mophological analysis of over a thousand Pleistocene specimens of *C. compressa* from the type locality, Mori (1987, fig. 3) graphed a direct relationship between calicular size and number of septa, showing that when tertiary septa are present, they are most likely to first occur in the sectors adjacent to the principal septa and least likely to occur in lateral sectors. Nonetheless, he concluded that septal number was not a function of size, but rather genetically determined. Mori also found an enormous range of variation of septal arrangements (57) and septal symmetries (9), ranging in symmetry from hexameral (6:6:12, 6) to decatetrameral (14:14:12, 6), the first and last symmetries being quite rare. The most common symmetry was decameral (68% of the coralla) and the most common septal arrangement was: 10:10:14, 7 (i.e., 34 septa, 7 pali); the maximum number of septa and pali never exceeding 48 and 12, respectively.

Specimens reported as *P. compressus* by Wells (1956) and Cairns (1984) from the Philippines are now thought to be misidentified for the following reasons. The Philippine specimens have: papillose (not fascicular) columellas; less compressed calices; straight-edged septa; and consistently dodecamerally arranged septa (×12). Notwithstanding the fact that Mori found some (3%) dodecameral *C. (P.) compressa*, virtually all of the Philippine specimens have that symmetry.

MATERIAL EXAMINED.—*New Records:* USGS 17450, near Iwa, Okinawa, Shimijiri marl (Pleistocene), 1, USNM 88652; TM (KT9015, BS2), 8, USNM 92686, 3, ORI; TM (KT9202, OS2), 1, USNM 92687; TM (KT9202, OS3), 4, USNM 92688; TM (KT9309, AM8), 1, ORI; off Misaki, Japan, Mortensen Expedition, 30 June 1914, 366 m, ZMC. *Previous Records:* Specimen illustrated by Wells (1956), USNM.

TYPES.—Syntypes of *P. compressus* are deposited at the TIUS (see Yabe and Eguchi, 1942b). *Type Locality:* Pleistocene, Ryukyu limestone of Kikai-jima.

DISTRIBUTION.—Pleistocene of Ryukyu Islands. *Recent:* Kii and Bungo Straits; van Dienem Strait, southern Kyushu; Wakasa Bay, Honshu, Sea of Japan; off Amami Oshima, Ryukyu Islands; 115–422 m.

Crispatotrochus Tenison Woods, 1878

DIAGNOSIS.—See Part 1.

Crispatotrochus rubescens (Moseley, 1881)

PLATE 22*g,h*

Cyathoceras rubescens Moseley, 1881:157, pl. 2: fig. 8a–c.—Marenzeller, 1888b:21–22.—Yabe and Eguchi, 1942b:117.—Cairns, 1984:15.
Cyathoceras diomedeae Vaughan, 1907:77–78, pl. 7: figs. 1, 2.
Cyathoceras diomedae [sic].—Yabe and Eguchi, 1942b:116–117, pl. 9: fig. 8.
Crispatotrochus rubescens.—Cairns, 1991a:15.

DESCRIPTION.—Corallum ceratoid, with a flared calice and a firmly attached pedicel about one-quarter diameter of calice. Illustrated specimen (*Soyo Maru*-331) 24.3 × 20.6 mm in calicular diameter and 30.4 mm in height, with a pedicel diameter of 6.6 mm. Costae ridged only near calice, otherwise consisting of broad, flat, finely granulated strips. Corallum white or reddish brown.

Septa hexamerally arranged in 5 cycles: $S_{1-2}>S_3>S_4>S_5$. S_{1-2} highly exsert (as much as 7 mm), and have sinuous, vertical inner edges that join the columella. S_3 considerably less exsert (about 4 mm), but as much as 80% as wide as S_{1-2} and also have sinuous inner edges. S_{4-5} equally exsert (about 2.5 mm), the S_4 about half size of S_3 and the S_5 about half size of S_4. Fossa moderately deep, containing a crispate, fascicular columella composed of 15–20 slender, twisted elements.

DISCUSSION.—Of the 12 valid species of *Crispatotrochus* (see Cairns, 1991a), only three have five cycles of hexamerally arranged septa: *C. rubescens* (Moseley, 1881); *C. niinoi* (Yabe and Eguchi, 1942b); and *C. foxi* (Durham and Barnard, 1952), all of which occur in the temperate North Pacific and included in this account. *C. rubescens* is compared to the other two species in the discussions of those species.

Both new records reported herein are small specimens with a GCD less than 8 mm and have only four cycles of septa.

MATERIAL EXAMINED.—*New Records:* TM (CR79-1), 1, USNM 92685; Okinose, Sagami Bay, 110 m, 11 June 1914, 1, ZMC. *Previous Records:* *Soyo Maru*-425, 2, TIUS 53695 (*C. rubescens* of Yabe and Eguchi, 1942b); *Soyo Maru*-331, 1, TIUS 53694 (*C. diomedae* of Yabe and Eguchi, 1942b), Plate 22*h*.

TYPES.—The holotype of *Cyathoceras rubescens* is lost (see Cairns, 1984). *Type Locality: Challenger*-192: 5°49′15″S, 132°14′15″E (Kei I., Banda Sea, Indonesia), 236 m.

The types of *Cyathoceras diomedeae* are deposited at the USNM (see Cairns, 1991b). *Type Locality:* Alb-3835: 21°00′10″N, 157°50′W (south of Molokai, Hawaiian Islands), 309–333 m.

DISTRIBUTION.—Japan: Sagami Bay and off Kushimoto, Honshu; off southeastern Shikoku; off Koshiki I., southwestern Kyushu; 110–344 m. *Elsewhere:* Hawaiian Islands, Christmas I., Philippines, Banda Sea; 183–634 m.

Crispatotrochus niinoi (Yabe and Eguchi, 1942)

Cyathoceras niinoi Yabe and Eguchi, 1942b:117, 145–146, pl. 9: fig. 9a,b.—?Song, 1982:134–135, pl. 2: figs. 1, 2; 1991:133.
Crispatotrochus niinoi.—Cairns, 1991a:15.

REDIAGNOSIS OF HOLOTYPE.—Corallum ceratoid: 15 × 10.5 mm in calicular diameter and 20 mm in height, with a pedicel diameter of 2 mm (PD:GCD = 0.13). Theca thick and smooth; noncostate. Upper theca white, lower three-quarters of theca eroded and encrusted. Septa hexamerally arranged in 5 complete cycles (96 septa) according to the formula: $S_{1-2}>S_3>S_4>S_5$. S_{1-2} slightly exsert (about 1.1 mm) and extend to the columella. S_3 about three-quarters width of an S_{1-2}; S_4 about three-quarters width of an S_3; S_5 rudimentary. Columella fascicular, composed of 7 fused twisted elements.

DISCUSSION.—*Crispatotrochus niinoi* is known from only one, perhaps two (if Song's specimen is included), specimens, neither of which is available for study. The dignosis above comes from Yabe and Eguchi's (1942b) original description.

Only two other species of *Crispatotrochus* are known to have five cycles of septa: *C. rubescens* (Moseley, 1881) and *C. foxi* (Durham and Barnard, 1952). *Crispatotrochus niinoi* differs from *C. rubescens* in having a smaller corallum and pedicel (PD:GCD = 0.13 vs 0.22–0.27 for *C. rubescens*); a thicker, noncostate theca; and less exsert septa. *Crispatotrochus niinoi* is compared to *C. foxi* in the account of that species. Song's (1982) record from off South Korea is queried because the PD:GCD is 0.80.

MATERIAL EXAMINED.—None.

TYPES.—The holotype of *Cyathoceras niinoi* is deposited at the TIUS (59070). *Type Locality:* Taito-zaki, Chiba-ken (off Boso Peninsula, Honshu), 104 m.

DISTRIBUTION.—Off Boso Peninsula, Honshu; ? Western Channel of Korea Strait off Pusan, South Korea, depth unknown (Song, 1982); 104 m.

Paracyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—See Part 1.

Paracyathus pruinosus Alcock, 1902

PLATES 22*i,j*, 42*a*

Paracyathus pruinosus Alcock, 1902c:18, 19, pl. 3: figs. 17, 17a.—Van der Horst, 1931:9, pl. 1: figs. 9, 11; pl. 2: fig. 6.—Yabe and Eguchi, 1942b:126, pl. 11: fig. 1.—Eguchi, 1965:287, fig.—Not Zou, 1988:76, pl. 5: figs. 10, 11.

REDESCRIPTION OF FIGURED SYNTYPE (ZMA Coel. 1307).—Corallum robust and dense, 20.1 × 15.6 mm in calicular diameter, and 21.9 mm in height, with a pedicel diameter of 11.8 mm (PD:GCD = 0.59). Theca worn and encrusted, but near calice costae are flat and equal in width (about 1 mm), covered with very small granules 5–6 across the width of a costa. Intercostal striae thin and shallow. Corallum light brown. Septa arranged in 13 half-systems accordingly: 13:13:26:4 (56 septa). The other, slightly larger (GCD = 20.6 mm) syntype (ZMA 1089) has 82 septa, but its symmetry is obscured by the polyp. Eleven of the half-systems are composed of two thick bordering primary septa, a secondary septum, and a pair of tertiary septa, whereas 2 of the half-systems also have a pair of quateraries. Primary septa only slightly exsert (about 1.8 mm) and have straight, entire inner edges, each bordered by a thick palus 1–2 mm wide that is adjacent to the columella. Secondary and tertiary septa only slightly less exsert than primary septa (about 1.6 mm), the secondaries about 80% width of a primary and also bordered by a palar crown, each P_2 standing taller in the fossa and frequently divided into 2–4 subelements. Tertiary septa of about the same width as secondaries but much less thick. All septa closely spaced and covered with prominent ridge-like granules, the orientation of the ridges parallel to the septal edges. Palar faces also prominently ridged. Fossa shallow, containing a large elliptical and slightly convex papillose columella composed of about 25 elements.

DISCUSSION.—The two Japanese specimens examined (*Soyo Maru*-235) are 18.0 and 14.8 mm in GCD and appear to be conspecific. Although the septal symmetry is difficult to distinguish, both specimens seem to have hexamerally arranged septa in five cycles, the last incomplete. The larger specimen contains 66 septa: 6 half-systems having no S_5, 3 half-systems having 1 pair of S_5, and 3 half-systems having 2 pairs of S_5. The smaller specimen has 70 septa: 4 half-systems without S_5, 5 with 1 pair of S_5, and 3 with 2 pair of S_5. The half-systems that lack pairs of S_5 are invariably those on the lateral faces of the calicular ellipse; those having 2 pairs invariably in the end half-systems. The most similar species to *P. pruinosus* in the North Pacific is *Trochocyathus caryophylloides*, both species having a similar corallum shape, size, columella, and palar configuration. *Paracyathus pruinosus* is distinguished by having divided paliform lobes (P3); little exsert, very thick septa; highly granular septal and palar faces; and a shallower fossa.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* *Soyo Maru*-235, 2, TIUS 53681 (Yabe and Eguchi, 1942b) (Plate 42*a*); syntypes of *P. pruinosus*.

TYPES.—Two syntypes (Plate 22*i,j*) of *P. pruinosus* are deposited at the ZMA (Coel. 1307, 1089). *Type Locality:* *Siboga*-96: Southeast of Pearl Bank, Sulu Archipelago; ?15 m.

DISTRIBUTION.—Japan: Off Hochijo Jima (off Sagami Bay); 176–198 m. *Elsewhere:* Sulu Archipelago; Saya de Malha, Indian Ocean; [15]–150 m.

Trochocyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Corallum solitary, turbinate to ceratoid, fixed or free. Septotheca costate, sometimes covered with a thin epitheca. Pali before all but last cycle in two crowns; columella papillose.

TYPE SPECIES.—*Turbinolia mitrata* Goldfuss, 1827, by subsequent designation (Milne Edwards and Haime, 1850a:xiv).

Trochocyathus caryophylloides Alcock, 1902

PLATE 23*a–c,h*

Trochocyathus caryophylloides Alcock, 1902a:94; 1902c:14–15, pl. 2: figs. 10, 10a.—Yabe and Eguchi, 1942b:123–124, pl. 10: fig. 21.—Not Zou, 1988:76, pl. 5: fig. 5, 5a.

DESCRIPTION OF SPECIMEN FROM Alb-4891.—Corallum trochoid: 15.6 × 13.9 mm in calicular diameter, 15.2 mm in height, and 6.8 mm in pedicel diameter (PD:GCD = 0.44). Costae broad (0.6–0.7 mm), flat, and equal in width, covered with small (0.10 mm in diameter) granules up to 4 across a costal width near the calice; intercostal striae quite thin (0.05 mm) and shallow. Corallum white.

Septa arranged in 15 sectors accordingly: 15:15:30:2 (62 septa). Primary septa only slightly exsert (about 1.7 mm) and extend about two-thirds distance to columella, where each is bordered by a small (0.7 mm width), low palus, together forming a palar crown tightly encircling the columella. Secondary septa only slightly less exsert (about 1.5 mm), half width of primaries, and have sinuous inner edges. Each secondary septum bordered by a broad (about 1.8 mm wide), sinuous, highly granular palus, together forming a second palar crown that is much more prominent than the first. Tertiary septa only slightly less exsert and less wide than secondaries. In one (developing?) sector, a pair of quaternaries encloses the tertiary septum, the latter bearing a palus, thus resulting in 31 pali in the corallum. Fossa of moderate depth, containing an columella composed of an elliptical field of 15 discrete, papillose elements.

DISCUSSION.—The *Albatross* specimen differs from the syntypes (GCD up to 21 mm) in having a smaller corallum, two less septa and one less palus, and a wider pedicel. The lesser number of septa and pali are probably due to the smaller size of the *Albatross* specimen, one of its sectors apparently being in the process of enlarging. Alcock (1902c) illustrated only one of the six syntypes, one having a very narrow pedicel (PD:GCD =

0.11); however the other syntypes have much more robust pedicels, up to a PD:GCD of 0.38 (*Siboga*-253). Therefore, the PD:GCD of 0.44 of the *Albatross* specimen is not considered unusual. Yabe and Eguchi's (1942b) specimen of 21.0 mm GCD has the typical 64 septa in 16 sectors and a PD:GCD of 0.29. *T. caryophylloides* is easily distinguished from the other North Pacific *Trochocyathus* by its decahexameral (x16) septal symmmetry. For this reason, Zou's (1988) identification probably is not correct, his specimen having four hexamerally arranged cycles of septa (48 septa).

MATERIAL EXAMINED.—*New Record:* Alb-4891, 1, CAS 74940. *Previous Records:* Syntypes of *T. caryophylloides* from *Siboga*-96 (1) ZMA Coel. 1325, *Siboga*-253 (2) ZMA Coel. 1324.

TYPES.—Six syntypes (Plate 23*b,c*) of *T. caryophylloides* were discussed by Alcock, five of which are deposited at the ZMA (Coel. 1324, 1325, 5436, 5437) (see van Soest, 1979). *Type Localities:* *Siboga*-96, 251, 253: Celebes and Banda seas, Indonesia, ?15, 115–304 m.

DISTRIBUTION.—Japan: Off Boso Hanto, Honshu; Bungo Strait; East China Sea south of Fukue Jima; 115–344m. *Elsewhere:* Celebes and Banda Seas; [15]–304 m.

Trochocyathus japonicus Eguchi, 1968, nom. correct

Trochocyathus japonica Eguchi, 1968:C34–35, pl. C6: figs. 4–6.
Ceratotrochus japonicus Eguchi, 1968:C38, pl. C6: figs. 1–3 [not pl. C11: figs. 1–3; pl. 20: figs. 1, 2).
?Ceratorochus [sic] *jogashimaensis* Eguchi, 1968:C38, pl. C11: figs. 7–9.

DISCUSSION.—Eguchi (1968) described three remarkably similar species from virtually the same locality, the holotypes of the first two species coming from the same haul: *Trochocyathus japonicus, Ceratotrochus japonicus,* and *Ceratotrochus jogashimaensis.* Each species was described from a single specimen.

From Eguchi's (1968) account, *Trochocyathus japonicus* can be characterized as having a small (GCD = 12 mm), trochoid corallum; hexamerally arranged septa in four complete cycles ($S_{1-2}>S_3>S_4$); two crowns of pali, one before the S_{1-2} and another before the S_3; a papillose columella; and a costate theca. *Ceratotrochus japonicus,* illustrated on the same plate as *T. japonicus* (plate C6) and collected in the same haul, is 10 mm in GCD and also has four hexamerally arranged cycles of septa, a papillose columella, and costate theca. Eguchi was equivocal about the presence of pali, stating that lobes were present before some of the S_3 as well as having 6 "pali-like rods" radiating from the columella. By definition (see Chevalier, 1961), the genus *Ceratotrochus* is distinguished from *Trochocyathus* by having lobes before only the first two cycles, whereas in *Trochocyathus,* they occur before all but the last cycle (i.e., in this case, the first three cycles) in two crowns. The preservation of the holotype of *C. japonicus* apparently does not allow this observation, but, if some P_3 are present in this specimen, they would indicate an affinity to *Trochocyathus,* not *Ceratotrochus,* and probably conspecificity with *T. japonicus.* The additional specimen of *C. japonicus* illustrated by Eguchi (Specimen #796b: Plate C11: figs. 1–3; Pl. 20: figs. 1, 2) is not mentioned in the text and appears to be a juvenile *Conotrochus;* it may have been confused or mislabelled in his text.

The holotype of *Ceratotrochus jogashimaensis* (GCD = 11 mm) was also collected from virtually the same locality but from slightly deeper water. It is identical to the other two species except that it appears to lack pali.

MATERIAL EXAMINED.—None. The types of these three species are not available for study and, unfortunately, no additional specimens are available to further characterize and illustrate this taxon.

TYPES.—The holotypes of *Trochocyathus japonica* and *Ceratotrochus japonicus* are presumed to be deposited at the Biological Laboratory of the Imperial Household, Tokyo (#785, 782, respectively). *Type Locality:* 5 km WSW of Jogashima, Sagami Bay, 150–250 m.

The holotype of *Ceratotrochus jogashimaensis* is also presumed to be deposited at the Biological Laboratory of the Imperial Household, Tokyo (#779). *Type Locality:* 5 km SW of Jogashima, Sagami Bay, 300–450 m.

DISTRIBUTION.—Known only from 5 km WSW of Jogashima, Sagami Bay, Honshu, Japan; 150–450 m.

Trochocyathus decamera, sp. nov.

PLATE 23*d,e*

DESCRIPTION.—Corallum trochoid to subcylindrical and firmly attached through a wide pedicel. Holotype 6.4 × 6.3 mm in calicular diameter, 7.9 mm in height, and 5.0 mm in pedicel diameter. Theca faintly costate, overlain with very thin, transversely banded epitheca through which underlying granules can be seen. Corallum white.

Septa decamerally arranged in three cycles, the holotype having an extra pair of quaternary septa (10:10:20:2, 42 septa). Primary septa little exsert (about 0.7 mm), extend about 80% distance to the columella, and have slightly sinuous inner edges. Each primary septum bordered internally by a small palus about 0.5 mm in width, which together form a crown adjacent to and rising just above the columella. Secondary septa about 0.5 mm exsert, extend about half distance to columella, and are bordered by much larger, sinuous pali. Each palus about 0.9 mm in width, together forming another palar crown that is higher in the fossa than the first but reaching the same distance into the fossa. Tertiary septa equally exsert and slightly more wide than secondary septa. The pair of quaternaries in the holotype reach only one-third distance to the columella and cause a palus to form before the tertiary septum in this sector, thus resulting in 21 pali in the holotype. The unique tertiary palus is larger than the others and extends even higher in the fossa than those before secondary septa. Fossa

shallow, containing an elliptical field of 12–15 small, granulated pillars.

DISCUSSION.—*Trochocyathus decamera* is superficially similar to *T. japonicus* but can be distinguished by having decameral symmetry, a thin epitheca, and tertiary septa wider than its secondary septa. In *T. japonicus*, the S_4 (equivalent to tertiaries of *T. decamera*) are less wide than the S_3 (equivalent to secondaries of *T. japonica*).

The genus *Tethocyathus* differs from *Trochocyathus* in having a thick epitheca, *Trochocyathus* having only a thin or no epitheca (Cairns, 1979:76–77). Therefore, *T. decamera* is placed in *Trochocyathus*.

ETYMOLOGY.—The species name *decamera* (Greek: *deka*, meaning 10, and *meros*, meaning division or parts) refers to the decamerally arranged septa in 10 septal sectors.

MATERIAL EXAMINED/TYPES.—*Holotype:* TM (KT9202, YT1), USNM 92693.–Paratypes: TM (KT9202, YT1), 1, USNM 92694; TM (KT9015, CB1-2), 1, ORI. *Type Locality:* 30°15′N, 130°46′E (Osumi Shoto, northern Ryukyu Islands), 80–88 m.

DISTRIBUTION.—Osumi Shoto, northern Ryukyu Islands and off Mishima, Eastern Channel, Korea Strait; 70–88 m.

Trochocyathus cooperi (Gardiner, 1905), comb. nov.

PLATE 23*f,g*

Tropidocyathus cooperi Gardiner, 1905:955, pl. 93: fig. 30.
Trochocyathus.—Vaughan and Wells, 1943:48, fig. 20b.

DESCRIPTION.—Corallum (anthocyathus) a highly compressed (GCD:LCD = 1.4–2.3), straight cylinder, with parallel thecal edges and only slightly divergent thecal faces. Largest Japanese specimen 13.4 × 8.6 mm in calicular diameter and 18.5 mm in height. Base of each thecal edge bears a downward projecting crest up to 4.5 mm in length and flattened in plane of GCD. Between these 2 crests is the basal scar of attachment, which is elliptical to almost circular: 3.9–4.3 × 3.3–3.4 mm in diameter. Only one small specimen is fully intact, still having its anthocyathus attached to the fixed anthocaulus. It measures 7.3 × 3.9 mm in calicular diameter and 8.0 mm in height, with 2 edge crests, but it is assumed that the eventual transverse division would have taken place about 3.3 mm from the basal disc, just under the edge crests, where the cross sectional diameter is about 4 × 3 mm. The holotype also has a partial anthocaulus remaining attached to its base. Costae equal in width (0.5 mm), flat, and granular (about 2 granules across a costa), becoming slightly convex and separated by deeper furrows near calicular edge. Corallum reddish brown, with slightly more intense color and dark costal speckling in a narrow band about 1.5 mm from the calicular edge.

Septa hexamerally arranged in 4 complete cycles: $S_{1-2}>S_3>S_4$ (48 septa); however, larger coralla often have pairs of S_5 in the end half-systems comprising up to 56–62 septa. S_{1-2} little exsert (about 0.7 mm), extend about two-thirds distance to columella, and have slightly sinuous inner edges. A slender (about 0.6 mm wide) palus sometimes occurs on the inner edge of each S_{1-2}, forming a deep-seated palar crown directly adjacent to the columella, but often these pali are missing or indistinguishable from columellar elements. S_3 only slightly less exsert (0.6 mm), about two-thirds width of S_{1-2}, and have sinuous inner edges. Each S_3 bordered by a wide (up to 1.1 mm) palus, together forming a prominent palar ring encircling columella. S_4 0.5 mm exsert and about three-quarters width of an S_3. When present, pairs of S_5 are quite small. Fossa of moderate depth, containing an elongate columella consisting of several papillae, some of which may be indistinguishable in size and position with P_{1-2}.

DISCUSSION.—Several caryophylliid genera reproduce asexually by transverse division (Cairns, 1989b), *Trochocyathus* being one of them. The original reference to transverse division in this genus was Vaughan and Wells (1943:47), who cited the process in two undescribed species from the Philippines and in *Trochocyathus hastatus* Bourne, 1903. Bourne's species subsequently has been divided (Wells, 1984) into two species: *Stephanocyathus (A.) hastatus* and *Bourneotrochus veroni* Wells, 1984 (= *Deltocyathus stellulatus* Cairns, 1984), the latter established for a spinose, discoidal, deltocyathid-like species having transverse division. Therefore, *T. cooperi* is the only described species of *Trochocyathus* that is known to have transverse division.

The two syntypes reported by Gardiner (1905) are larger than the Japanese specimens, having up to 10 pairs of S_5 (68 septa) and a better developed columella. The Japanese specimens appear to be the first report of this species subsequent to its description.

MATERIAL EXAMINED.—*New Records:* TM (KT9202, YT1), 23, USNM 92691, 3, ORI.

TYPES.—Two syntypes of *T. cooperi* are presumed to be deposited at the BM. *Type Locality:* Kolumadulu and Suvadiva, Maldive Islands, 64–70 m.

DISTRIBUTION.—Off Japan: Osumi Shoto, northern Ryukyu Islands; 80–88 m. *Elsewhere:* Maldive Islands; Philippines; 64–70 m.

Deltocyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Solitary, discoidal to patellate, free in adult stage. Well-developed costae present. Pali present before all but last cycle; within each system the inner edges of each pair of P_3 fuse to the P_2 near the columella, forming characteristic chevrons (deltas). Paliform lobes may also be present before fourth septal cycle. Columella papillose.

TYPE SPECIES.—*Turbinolia italica* Michelotti, 1838, by monotypy.

Deltocyathus vaughani Yabe and Eguchi, 1932

PLATES 23*i,j*, 24*a–c,f*

Not *Deltocyathus orientalis* Duncan, 1876:431 [= *Peponocyathus*].
Levipalifer orientalis Vaughan, 1900:201–202, pl. 16: figs. 3–7 [junior

secondary homonym of *D. orientalis* Duncan, 1876].

Deltocyathus vaughani Yabe and Eguchi, 1932a:388–389 [replacement name for *D. orientalis* Vaughan, 1900]; 1937:130, 135–138, pl. 20: fig. 11a–c, 12a–c; 1942b:113, 126.—Eguchi, 1965:287, 3 figs.; 1968:C35.—Eguchi and Miyawaki, 1975:57.—Not Keller, 1982:51, pl. 1 [= 4, plates miscaptioned]: figs. 1, 2, 7.—Zibrowius and Grygier, 1985:121, fig. 12.

Deltocyathus (Levipalifer) vaughani.—Wells, 1956:F423-424, figs. 325, 4a,b.

DESCRIPTION.—Corallum patellate, having a convex to almost flat base with a basal angle ranging from 130°–170°. Largest corallum examined (Alb-4973) 22.9 mm in calicular diameter and 8.9 mm in height, but Yabe and Eguchi (1937) reported an even larger specimen of 24 mm calicular diameter. Holotype 19.7 mm in calicular diameter and 7.8 mm in height. Costae ridged, becoming increasingly prominent toward calicular edge where they are up to 1.5 mm in height. C_{1-2} originate at epicenter; C_3, about 0.5 mm from epicenter; and C_4, about 2 mm from epicenter. Each costa bears a linear row of tall, blunt to clavate granules, giving costal edges a coarsely serrate aspect. Costae also laterally spinose. Intercostal space up to twice width of a costa and usually flat; however, near calicular edges of large specimens there is sometimes a low ridge bisecting this space. Corallum white.

Septa hexamerally arranged in 4 complete cycles, all specimens examined (as small as 9 mm in calicular diameter) having 48 septa. S_1 highly exsert (up to 3.5 mm), each bearing a prominent palus 1.3–1.6 mm wide, which joins the columella. S_2 less exsert (about 3.0 mm), about three-quarters width of an S_1, and also bear a similar-sized palus, but positioned slightly higher in fossa and more recessed from columella than the P_1. S_{3-4} equally exsert (about 2.5 mm), the S_3 being about two-thirds width of an S_2, but S_4 are slightly wider than S_3, about three-quarters width of an S_2. Each S_3 bears a very wide palus equal to or wider than the septum it borders, these lobes forming a crown higher in the fossa and more recessed than P2 crown. S_4 often bear narrow paliform lobes, each pair of which fuse to its enclosed P_3. If P_4 are absent, S_4 inner edges fuse to P_3. Inner edges of P_2 and P_3 loosely connected near columella. Fossa shallow. Columella an elongate field of small interconnected papillae.

DISCUSSION.—*Deltocyathus vaughani* is a relatively common and very distinctive deep-water species in the Japanese region. It resembles the Atlantic *D. conicus* Zibrowius, 1980 (= *D.* sp. cf. *D. italicus* sensu Cairns, 1979) in conical corallum shape and costal morphology, but differs in having P_4. In fact, the character of having P_4 distinguishes *D. vaughani* from all other species in the genus that have four cycles of septa and was used as the basis for the creation of the genus *Levipalifer* Vaughan, 1900. However, I agree with Yabe and Eguchi (1937), not Vaughan (1900) or Wells (1956), that the variable presence of P_4 does not justify a separate genus or even subgenus.

Even though Duncan's (1876) *Deltocyathus orientalis* was transferred to the genus *Peponocyathus*, it was necessary to provide a replacement name for Vaughan's (1900) *Levipalifer orientalis*, being a junior secondary homonym of Duncan's species. Yabe and Eguchi (1932a, 1937) provided the name *Deltocyathus vaughani* as this replacement name.

The specimens reported by Keller (1982) from the South Pacific (425–1640 m) are similar to *D. vaughani* in corallum shape and in having P_4 lobes, but their costae appear to be very different and are therefore not included in the synonymy of this species.

One specimen (TM (KT7811, OT4), Plate 24*f*) has a well-developed ascothoracid gall, similar to those previously described by Zibrowius and Grygier (1985) for this species.

MATERIAL EXAMINED.—*New Records:* Alb-4906, 3, USNM 92712; Alb-4908, 12, USNM 92713; Alb-4909, 1, USNM 92714; Alb-4911, 13, USNM 92715; Alb-4913, 2, USNM 92716; Alb-4915, 32, CAS 74942; Alb4958, 1, USNM 92717; Alb-4966, 1, USNM 82152; Alb-4967, 6, CAS 16326; Alb-4968, 3, CAS 80906; Alb-4972, 11, CAS 80942; Alb-4973, 1, USNM 92718; Alb-5054, 57, USNM 92719; Alb-5056, 43, USNM 92720; Alb-5088, 35, USNM 92721; Alb-5093, 4, USNM 92722; TM (KT7811, OT4), 4, USNM 92723, 26, ORI; TM (KT7818, OT10), 2, USNM 92724; TM (KT7911, OT4), 7, USNM 92725. *Previous Records:* Holotype of *L. orientalis*, USNM.

TYPES.—The holotype (Plate 23*i,j*) of *Levipalifer orientalis* is deposited at the USNM (19391). *Type Locality:* "Bosyu (= Awa), Japan," depth unknown.

DISTRIBUTION.—Japan: from Sagami Bay to Bungo Strait, Honshu; off southwestern Kyushu; 88–1097 m, but most records are deeper than 400 m.

Deltocyathus rotulus (Alcock, 1898)

PLATE 24*j,k*

Trochocyathus rotulus Alcock, 1898:16, pl. 2: figs. 1, 1a.

Deltocyathus fragilis Alcock, 1902a:99–100; 1902c:21, pl. 2: figs. 15, 15a.

Deltocyathus rotulus.—Cairns and Keller, 1993:245, fig. 51 [synonymy].

DESCRIPTION.—Corallum shaped like a shallow bowl, with a flat to gently rounded base and upturned edges. Largest Japanese specimen examined (Alb-5079) 31.1 mm in diameter and 7.3 mm in height; however, a specimen from the Celebes Sea (Alb-5582) is larger, measuring 36.4 mm in diameter. Circular region 7–12 mm in diameter at center of base of large coralla invariably worn and without costae. Otherwise, peripheral region of base crenulated, the theca associated with each C_4 and flanking C_5 forming slightly raised radial strips about 2 mm wide that project up to 1.5 mm beyond the calicular edge formed by the C_{1-3}. C_{1-3} extremely narrow (about 0.2 mm), finely serrate ridges that are slightly recessed in valleys formed by ridged C_{4-5}. Corallum white.

Septa hexamerally arranged in 5 cycles, the fifth cycle usually completed at a calicular diameter of 30–32 mm. Small coralla often lack all 4 S_5 within one or more half-systems, a specimen 20–30 mm in diameter having anywhere from 72–92 septa. S_{1-2} moderately exsert (about 3 mm) and are independent septa, i.e., not fused to any adjacent septa. Each S_{1-2} usually bears a small palus (about 1 mm wide), which is

separated from its septum by a relatively wide notch. S_3 slightly less exsert and usually do not bear pali, but, if present, pali are irregular in occurrence and usually quite small. S_4 equally exsert as S_3, each bearing a very wide (up to 4 mm), tall palus, together producing a prominent and distinct palar crown of up to 24 lobes. In a half-system lacking all 4 S_5, the S_3 within that half-system resembles an S_4 and has a correspondingly large palus. Inner edges of paired P_4 merge with inner edges of adjacent S_3 near columella. S_5 rudimentary, each connected to its adjacent S_4 through a porous lamella in the P_4 region, but close to basal theca. Fossa shallow, containing a circular to elliptical columella in the form of an undercut, horizontal platform, through which irregularly shaped papillae penetrate.

DISCUSSION.—Only two species of *Deltocyathus* are known to attain five cycles of septa in the adult state: *D. magnificus* and *D. rotulus*. The latter is distinguished from *D. magnificus*, as well as all other congeners, by its prominent P_4 crown and distinctively serrate calicular margin. Its bowl-shaped corallum and unique columella also serve to distinguish it from *D. magnificus*.

MATERIAL EXAMINED.—*New Records:* Alb-4957, 6, CAS 16331 and 80934; Alb-4970, 3, USNM 82157; Alb-4972, 18, CAS 80942; Alb-4973, 8, USNM 82155, 1, ORI; Alb-5079, 1, USNM 92726; Alb-5582, 8, USNM 92727.

TYPES.—The holotype of *Trochocyathus rotulus* is presumed to be deposited at the Indian Museum, Calcutta. *Type Locality:* North Maldive Atoll (probably *Investigator* station 216), 1408–1756 m.

Six syntypes of *Deltocyathus fragilis* are deposited at the ZMA (Coel. 1188). *Type Locality: Siboga*-45: 7°24′S, 118°15.2′E (Flores Sea), 794 m.

DISTRIBUTION.—Off southeastern Japan from off Hamamatsu, Honshu to the Bungo Strait (new record for Japanese waters); 799–1187 m. *Elsewhere:* Flores and Celebes Seas; Indian Ocean from Durban, South Africa to Sri Lanka; 510–1986 m.

Deltocyathus magnificus Moseley, 1876

PLATE 24*d,e,g,h*

Deltocyathus magnificus Moseley, 1876:552–553; 1881:147–148, pl. 4: fig. 10; pl. 13: figs. 1, 2.—Alcock, 1902c:20.—Yabe and Eguchi, 1937:138, pl. 20: figs. 13a–c, 14a–e.—Eguchi, 1938, table 2; 1942b:126; 1965:286, 2 figs.—Utinomi, 1965:254.—Eguchi and Miyawaki, 1975:57.—Cairns and Parker, 1992:27–28, pl. 7: figs. j–l; pl. 8: fig. a.

DESCRIPTION.—Corallum discoidal, with a flat to slightly concave base that is not upturned at its edges. Largest Japanese specimen examined (Tsuchida-102) 30.0 mm in calicular diameter and 8.4 mm in height; however, Yabe and Eguchi (1937) reported a specimen 33.5 mm in diameter, and a specimen from the USNM collection from the Philippines (Alb-5444) measures 37.5 mm in diameter. Costae thin (0.2 mm), straight, finely serrate ridges separated by rather wide, flat intercostal spaces 3–4 times a costal width. All costae project about 1.5 mm beyond calicular edge and are continuous with their corresponding septa above. Corallum white; according to Moseley (1881), the coenosarc is ochre-yellow in color, somewhat red toward the margin, the polyps having white tentacles.

Septa hexamerally arranged in 5 complete cycles (96 septa), a juvenile 6.2 mm in calicular diameter having only 4 cycles, but a slightly larger corallum of 8.2 mm having all 96 septa. One large specimen (Tsuchida-102) has 2 S_6, for a total of 98 septa. S_1 are the only independent septa, joining the columella through a wide (about 4.5 mm) palus. S_2 equal in height to S_1 but slightly less wide, due to their even wider (about 6 mm) palus, which reaches to the columella. S_3 also equal in height but considerably less wide, each bearing a broad palus that is connected to its adjacent P_2 near the columella. S_4 much lower in height than S_{1-3} and only 3–4 mm wide, but bordered internally by a broad palus that is fused to the adjacent P_3 through a porous lamella. S_5 least exsert septa but equally as wide as an S_4, each S_5 usually bordered by a narrow P_5, each pair fused to the adjacent P_4 through porous lamellae. Notch separating P_5 from S_5 sometimes quite broad or poorly formed, making the distinction of the P_5 ambiguous. Fossa absent; columella an elongate fusion of irregular papillae.

DISCUSSION.—*Deltocyathus magnificus* is relatively easy to distinguish from *D. rotulus*, the only other congener having five cycles of septa (see Discussion of *D. rotulus*). Furthermore, in the Japanese region, *D. magnificus* consistently is found at shallower depths than *D. rotulus* (88–393 m vs 869–1187 m).

Material Examined.—*New Records:* Alb-4903, 1, USNM 92728; Alb-5444, 1, USNM 62712; TM (KT9015, BS2), 10, USNM 92729, 2, ORI; TM (KT9309, AM8), 2, ORI; Tsuchida-102, 1, USNM 92730; Tsuchida-851, 2, USNM 92731. *Previous Records:* Syntype of *D. magnificus*, BM.

TYPES.—The single remaining syntype (Plate 24*d,e*) of *D. magnificus* is deposited at the BM (uncataloged). *Type Locality: Challenger*-192: 5°49′S, 132°14′E (off Kei Islands, Banda Sea), 236 m.

DISTRIBUTION.—Off Pacific coast of Japan from Kii Strait to Makejima, northern Ryukyu Islands; East China Sea off southwestern Kyushu, including Danjo Gunto; 88–422 m. *Elsewhere:* Sulu Archipelago, Moluccas, off southern Australia, and Bass Strait; 118–1500 m.

Stephanocyathus Seguenza, 1864

DIAGNOSIS.—Solitary, patellate to bowl-shaped, and free. Costae usually well developed, some of which are sometimes highly spinose. Paliform lobes usually present on all septa. Columella trabecular, papillose, of fused.

TYPE SPECIES.—*Stephanocyathus elegans* Seguenza, 1864, by subsequent designation (Wells, 1936).

Subgenus *Stephanocyathus (Acinocyathus)* Wells, 1984

DIAGNOSIS.—*Stephanocyathus* having six elongate, slender basal spines (C_1).

TYPE SPECIES.—*Stephanotrochus spiniger* Marenzeller, 1888, by original designation.

Stephanocyathus (Acinocyathus) spiniger (Marenzeller, 1888)

PLATE 25*a-c*

Stephanotrochus spiniger Marenzeller, 1888b:20–21.

Odontocyathus japonicus Yabe and Eguchi, 1932c:151–152, text-figs. 1–3, pl. 14; 1942b:125.

Odontocyathus spiniger.—Yabe and Eguchi, 1942b:124–125, pl. 10: figs. 26–28.—Eguchi, 1968:C39–40, pl. C20: figs. 12–14; pl. C23: fig. 1.

Stephanocyathus spiniger.—Eguchi, 1965:288, 2 figs.

Stephanocyathus (Odontocyathus) spiniger.—Utinomi, 1965:254.—Eguchi and Miyawaki, 1975:57.—Song, 1982:136, pl. 4: figs. 1, 2; 1991:134.

Stephanocyathus (Odontocyathus) spinifer [sic].—Eguchi and Miyawaki, 1975:57.

Stephanocyathus (Acinocyathus) spiniger.—Wells, 1984:209, pl. 2: figs. 10–13.—Cairns and Parker, 1992:26–27, pl. 7: figs. g-i [synonymy].—Cairns and Keller, 1993:243.

Description of Specimen from Tosa Bay.—Corallum bowl-shaped: 47.9 mm in diameter (exclusive of costal spines) and 26.0 mm in height, supported by 6 massive, tapered thecal spines (C_1), each reaching over 15 mm in length and 5 mm in basal diameter. Lateral theca covered with equally wide, slightly convex, finely granulated costae. Calicular margin serrate, with 6 very prominent apices corresponding to the CS_1 and 6 lesser apices corresponding to the 6 CS_2. Corallum uniformly white.

Septa hexamerally arranged in 5 cycles with 6 additional pairs of S_6 (= 108 septa) according to the formula: $S_1>>S_2>S_3>S_4>>S_5$. Each S_1 extremely exsert (as much as 10 mm) and bears a small (about 1.1 mm wide) paliform lobe that is separated from its septum by a broad notch, the lobes located directly adjacent to columella. Each S_2 much less exsert (about 4 mm) and bears a paliform lobe slightly larger and positioned higher in fossa than P_1, but, like the P_1, are separated by a broad, shallow notch from their septa, and are also located directly adjacent to the columella. S_{3-6} all about 2 mm exsert, except for those S_{5-6} directly adjacent to an S_1, which are much more highly exsert and laterally fused to the S_1 at the calicular margin. Each S_3 bears a paliform lobe about the same size of a P_2, but positioned higher and recessed farther from the columella than the P_{1-2}. Each S_4 bears 1–3 small, broad paliform lobes, the innermost lobe fused to its adjacent P_3. S_{5-6} rudimentary and lack lobes. Fossa shallow; columella papillose.

DISCUSSION.—*Stephanocyathus spiniger* is easily distinguished from all other North Pacific species by its 6 distinctive costal spines, which apparently elevate the corallum above the substratum or stabilize it in a soft substatum. Because of its unusual apperance and relatively shallow depth range, it is sometimes found for sale in shell and curio shops. *Acinocyathus* includes about ten nominal species (see Wells, 1984; Cairns and Parker, 1992), ranging from the Miocene to Recent and throughout the Indo-West Pacific. Both Wells (1984) and Cairns and Parker (1992) suggested that they may all represent the same species; however, at least one other species is known: *S. (A.) explanans* (Marenzeller, 1904), from the southwest Indian Ocean.

MATERIAL EXAMINED.—*New Records:* Alb-4915, 1, CAS 74944; Alb-4933, 2, USNM 92732; Tosa Bay, Shikoku, depth unknown, 1, USNM 92733.

TYPES.—The holotype of *S. spiniger* is deposited at the NMW. *Type Locality:* Enosima (Sagami Bay), Honshu; depth unknown.

The holotype of *O. japonicus* is deposited at the TIUS (40876). *Type Locality:* Neogene of Segoe, near Takaoka-machi, Miyazaka-ken, southwestern Kyushu.

DISTRIBUTION.—Japan: Neogene of southwestern Kyushu. Recent: Sagami Bay to Kii Strait; Tosa Bay, Shikoku; off southern Kyushu; off Cheju Do, Korea Strait, South Korea; 106–783 m. *Elsewhere:* Philippines, Indonesia, Great Australian Bight, southwest Indian Ocean; 120–695 m.

Subgenus *Stephanocyathus (Odontocyathus)* Moseley, 1881

DIAGNOSIS.—*Stephanocyathus* having 12–18 short basal spines or tubercles (C_{1-3}), sometimes fusing into a basal rim.

TYPE SPECIES.—*Platytrochus coronatus* Pourtalès, 1867, by monotypy.

Stephanocyathus (Odontocyathus) weberianus (Alcock, 1902), comb. nov.

PLATE 25*d-f*

Stephanotrochus weberianus Alcock, 1902a:101–102; 1902c:25, pl. 3: figs. 22, 22a.

Stephanotrochus Sibogae Alcock, 1902a:102–103; 1902c:25–26, pl. 3: figs. 23, 23a.

Stephanotrochus sp.—Alcock, 1902c:26.

Stephanocyathus (Odontocyathus) ixine Squires, 1958:54 [in part: pl. 8: figs. 3, 4].

Stephanocyathus nobilis.—Zou, 1988:74–75 [in part: pl. 1: figs. 1–3].

DESCRIPTION.—Corallum bowl-shaped, with a flat to slightly convex base up to 26–28 mm in diameter, beyond which the thecal walls are inflected upward at an angle of 75°–80° from the horizontal. At level of thecal inflexion there are often 12–18 costal tubercles, each up to 2 mm long, one corresponding to each C_{1-2} and those C_3 in which that half-system possesses 4 C_5. Usually, however, the entire base and several mm of the lower thecal edge are completely eroded, which causes the tubercles to appear quite worn or to be absent. Tubercles often best developed on small coralla, before basal erosion occurs. In some coralla, thecal region corresponding to costal tubercles appears 'swollen' into a thick rim encircling the corallum base. Largest specimen examined (Alb-4969) 41.8

mm in calicular diameter and 22.2 mm in height. Costae on thecal perimeter slightly convex and granular, the C_{1-2} being slightly wider than other costae and ridged near the calice. Corallum white.

Septa hexamerally arranged in 5 cycles, the last incomplete, according to the formula: $S_{1-2}>S_3>S_4>>S_5$. Large specimens (e.g., GCD > 40 mm) have only 72 septa, whereas mid-sized coralla of GCD 25–37 mm have only 64–70, and smaller coralla 18–25 mm GCD have 50–68 septa. No specimens were found with only 48 septa. Half-systems within a single specimen quite variable in development, some having 0, 2, or 4 S_5. S_{1-2} highly exsert (about 5 mm), each bearing a low, oblique to almost horizontally projecting paliform lobe that extends into the columellar region. S_3 slightly less exsert (3.0–3.5 mm), each also bearing a small paliform lobe but positioned slightly higher in fossa and slightly farther from columella than P_{1-2}. S_4 smaller still (only about 2.7 mm exsert), each bearing a wide paliform lobe which contributes to a palar crown that is located higher and farther recessed from the columella than the P_3 crown. Inner edges of P_4 usually bend toward and are fused to P_3 near columella. S_5 rudimentary, extending as narrow lamellae only partially down inner theca. When S_5 are absent from a half-system, the S_3 bears a wide paliform lobe equal in size and position to that of a P_4. All septa have very finely sinuous inner edges and virtually smooth septal faces. All paliform lobes separated from their respective septa by broad, shallow notches. Fossa moderately deep, containing a papillose columella.

DISCUSSION.—*Stephanocyathus weberianus* is very similar to the type-species of the subgenus, *S. (O.) coronatus* (Pourtalès, 1867), which is known only from the western Atlantic at 543–1250 m (Cairns, 1979). A detailed comparison, however, reveals that *S. coronatus* invariably has only 12 large, often complexly ornamented costal tubercles, whereas *S. weberianus* has 12–18 rather simple tubercles that are usually quite worn. The base of *S. coronatus* is usually convex and coarsely dentate (C_{1-2}); that of *S. weberianus* is flat and eroded. The corallum of *S. coronatus* is, in general, higher in proportion to its diameter (H:D) than *S. weberianus* in proportion to its diameter, producing a more slender corallum with less septa. For instance, coralla containing only 48 septa are common for *S. coronatus* but quite rare for *S. weberianus*, the latter often having half-systems with a full complement of 4 S_5. Finally, the S_{3-5} of *S. coronatus* are less exsert in relation to their S_{1-2} than in *S. weberianus*.

Stephanocyathus weberianus is also similar to *S. nobilis* (Moseley, 1873), known only from the Atlantic and western Indian Oceans at 609–2200 m (Cairns and Keller, 1993). Zou (1988) synonymized the two species, considering *S. nobilis* to be a cosmopolitan species in the Atlantic, Pacific, and Indian Oceans. However, when closely compared, *S. nobilis* differs significantly in having very inconspicuous paliform lobes and in lacking costal tubercles, having only a series of large costal spines on the C_{1-2}. Furthermore, its costal spines are limited to the twelve C_{1-2}, even when a half-system has all 4 S_5, whereas additional costal tubercles are invariably present in specimens of *S. weberianus* having the same number of septa. *Stephanocyathus nobilis* also has an evenly rounded, convex base, and, like *S. coronatus*, much more exsert S_{1-2} in relation to the remaining S_{3-5}.

The difference between *S. weberianus* and *S. sibogae* as described by Alcock (1902a) was that the former had a swollen ring around its base, the latter, a worn base with atrophied costal tubercles. It is now clear that these conditions are within the range of variation for one species: *S. weberianus*.

MATERIAL EXAMINED.—*New Records:* Alb-4908, 1, USNM 92734; Alb-4909, 2, USNM 92735; Alb-4911, 1, USNM 92736; Alb-4957, 4, CAS 1102; Alb-4958, 1, USNM 92737; Alb-4959, 1, USNM 92738; Alb-4960, 2, USNM 92739; Alb-4969, 2, USNM 82159; Alb-4973, 3, USNM 92740; Alb-4975, 1, USNM 92741; TM (KT9202, AT1), 2, USNM 92742; TM (KT9202, YT6), 10, USNM 92743, 4, ORI. *Previous Records:* Holotype of *S. weberianus*, ZMA; Alb-5445, 46, USNM 46819 (*S. ixine* of Squires, 1958).

TYPES.—The holotype of *S. weberianus* is deposited at the ZMA (Coel. 1322). *Type Locality: Siboga*-284: 8°43.1′S, 127°16.7′E (Timor Sea), 828 m.

The holotype of *S. Sibogae* is presumed to be deposited at the ZMA, but is not listed by van Soest (1979). *Type Locality: Siboga*-88: 0°34.6′N, 119°08.5′E (Makassar Strait), 1301 m.

DISTRIBUTION.—First reports from off Japan: Off southeastern Honshu; Bungo Strait; off Koshiki I., southwestern Kyushu; northen Ryukyu Islands (Osumi Shoto and Tokara Retto); 715–1302 m. *Elsewhere:* South China Sea, Sulu Sea, Makassar Strait, Banda and Timor Seas; 206–1301 m.

Conotrochus Seguenza, 1864

DIAGNOSIS.—Solitary, ceratoid to trochoid, free or attached through a small pedicel, which is often augmented by a lateral thecal attachment. Theca thick, but covered with epitheca; costae usually obscure. Septa exsert, but upper outer septal edges join the theca below upper thecal edge, forming an exsert calicular rim. Pali absent; columella prominent, composed of elongate, twisted lamellar elements.

TYPE SPECIES.—*Conotrochus typus* Seguenza, 1864, by original designation.

Conotrochus funicolumna (Alcock, 1902)

PLATES 24*i*, 25*g–l*

Ceratotrochus (Conotrochus) funicolumna Alcock, 1902a:93; 1902c:11–12, pl. 1: figs. 6, 6a.—Faustino, 1927:66, pl. 9: figs. 7, 8.—Yabe and Eguchi, 1942b:117, pl. 9: fig. 11.—Eguchi, 1968:C38–39.—Zou, 1988:77, pl. 5: figs. 1, 1a.

Conotrochus funicolumna.—Cairns, 1984:14, pl. 2: figs. I,J.

Conotrochus sp. cf. *C. funicolumna*.—Cairns and Parker, 1992:22, pl. 6: figs. c,f.

Ceratotrochus hiugaensis Yabe and Eguchi, 1942b:117, 146, pl. 9: fig.

10a,b.—Eguchi, 1965:288, 2 figs.

Ceratotrochus (Conotrochus) parahispidus Yabe and Eguchi, 1942b:118, 147–148, pl. 9: fig. 12a,b.—Eguchi, 1965:288, 2 figs; 1968:C39.—Eguchi and Miyawaki, 1975:57.

DESCRIPTION.—Corallum trochoid to ceratoid, slightly curved, and usually free, but sometimes attached through a slender pedicel or attached along a small section of lower theca. One illustrated specimen (Plate 25*i,l*) is 13.6 × 13.0 mm in calicular diameter and 17.8 mm in height. Alcock's (1902c) figured syntype is 11.9 × 11.7 mm in calicular diameter and 13.1 mm in height. Theca thick but invariably worn, revealing coarsely granular costae covered by a thin epitheca. Upper theca projects 0.5–0.7 mm above upper, outer septal edges as a continuous rim, which is characteristic of the genus. Corallum white.

Septa hexamerally arranged in 4 complete cycles: $S_{1-2}>S_3>S_4$. S_{1-2} only slightly exsert above encircling thecal rim and have straight, vertical inner edges that join the columella only deep within fossa. S_3 about 80% width of S_{1-2} and also have straight inner edges that fuse with the columella only lower in fossa. S_4 one-quarter to one-third width of S_3 and have entire inner edges that do not attain the columella. All septal faces bear very low granules, giving the impression of smooth septal faces. Fossa shallow. Columella prominent, composed of an elliptical mass of slightly swirled lamellar elements, the uppermost 5 mm remaining free of septal fusion.

DISCUSSION.—*Conotrochus parahispidus* (Yabe and Eguchi, 1942b) was originally distinguished from *C. funicolumna* by having a narrower (GCD = 9.5–14 mm), elongate corallum, all other characters being similar. Having examined two syntypes of *C. parahispidus*, I conclude that they fall within the range of corallum shape variation of *C. funicolumna* and therefore suggest its synonymy. Likewise, although not examined, the holotype of *Ceratotrochus hiugaensis* Yabe and Eguchi, 1942b (GCD = 9.0 mm) appears to be simply a juvenile *C. funicolumna*.

At least three other species of *Conotrochus* are known: *C. typus* Seguenza, 1864 (Miocene of Italy); *C. elongatus* Yabe and Eguchi, 1942b (Plio-Pleistocene of Ryukyu Islands); and *C. brunneus* (Moseley, 1881) (Recent, Indo-West Pacific). *Conotrochus funicolumna* differs from the latter, the only other Recent species, in having a larger adult corallum with more septa (≥48 septa vs <48 septa for *C. brunneus*), lacking stereome within the corallum, and lacking a brown pigmentation.

MATERIAL EXAMINED.—*New Records:* Off Misaki, 1, USNM 92700; TM (KT7911, OT4), 1, ORI; Tsuchida-272A, 1, USNM 92701. *Previous Records:* 1 syntype of *C. funicolumna*, *Siboga*-95, ZMA (Coel. 709); 2 syntypes of *C. parahispidus*, *Soyo Maru*-323, TIUS 59174; *Soyo Maru*-268, 3, TIUS 50243 (*C. funicolumna* of Yabe and Eguchi, 1942b).

TYPES.—Three syntypes (Plate 25*g,i*) of *C. funicolumna* are deposited at the ZMA (Coel. 709, 1183). *Type Localities:* *Siboga* stations 95, 100: Sulu Sea, 450–522 m.

The three type specimens of *Ceratotrochus hiugaensis* are deposited at the TIUS: holotype (50245), 2 paratypes (50246). *Type Locality:* *Soyo Maru*-315: 32°16′N, 131°50′E (Pacific coast of Kyushu), 421 m.

Ten syntypes (Plate 25*h,k*) of *Conotrochus parahispidus* are deposited at the TIUS: 50247 (8 specimens) and 59174 (2 specimens). *Type Locality:* *Soyo Maru*-323: 32°55′N, 132°12′E (Bungo Strait), 88 m.

DISTRIBUTION.—Off southeastern Japan from Suruga Bay, Honshu to Osumi Shoto, northern Ryukyu Islands; 88–600 m. *Elsewhere:* South China Sea; Sulu Sea; Hawaiian Islands; off Victoria, Australia; 442–522 m.

Aulocyathus Marenzeller, 1904a

DIAGNOSIS.—Solitary, ceratoid, free; corallum invariably showing evidence of budding from longitudinally fragmented parent corallum. Costae poorly defined. Upper outer edges of septa join theca below upper thecal edge, usually forming a trough around calice. Small multiple paliform lobes present on S_{1-2}; columella trabecular.

TYPE SPECIES.—*Aulocyathus juvenescens* Marenzeller, 1904a, by monotypy.

Aulocyathus recidivus (Dennant, 1906)

PLATE 26*a,b*

Ceratotrochus recidivus Dennant, 1906:159–160, pl. 6: figs. 1a,b, 2a–c.

Aulocyathus recidivus.—Cairns, 1982:25–26, pl. 7: figs. 7–9; pl. 8: fig. 1 [synonymy].—Cairns and Parker, 1992:22–24, pl. 6: figs. d,e,g,h.—Cairns and Keller, 1993:247, fig. 5C.

DESCRIPTION OF SPECIMEN FROM Alb-4958.—Corallum ceratoid: 8.7 mm in calicular diameter, 11.4 mm in height, and 3.9 mm in pedicel diameter. Corallum still attached to a wedge of parent corallum from which it asexually budded. Costae well defined only near calicular edge, being equal in width (about 1 mm), flat, and bearing coarse, hollow, conical granules. Calicular perimeter evenly serrate, a small triangular to rounded apex corresponding to each septum. Upper thecal edge extends about 0.7 mm above upper outer septal edges, forming a circular rim around the calice and extending above the upper septal edges. Corallum white.

Septa hexamerally arranged in 4 cycles, the last cycle incomplete, only 4 pairs of S_4 being present (32 total septa). S_1 not exsert and have vertical, slightly sinuous, thin inner edges that extend to the columella. S_2 about three-quarters width of S_1, also have sinuous inner edges, and also attain the columella low in fossa. If an S_3 is flanked by a pair of S_4, the S_3 is enlarged to almost the width of an S_2, but if not flanked by S_4, S_3 only about half width of S_2. S_4 equal in size to unflanked S_3. Fossa deep. Columella robust, composed of 10 tall, slender, granular papillae, some of which might be interpreted as paliform lobes of the S_{1-2}.

DISCUSSION.—*Aulocyathus recidivus* is distinguished from

A. matricidus by its broader and shorter corallum, its thinner S_{1-2}, and its 1:1 correspondence of septa and costae. It is quite similar to *A. atlanticus* Zibrowius, 1980 (known only from the northeast Atlantic at 450–1716 m), the Pacific species differing primarily in having notched septa near the thecal edge. It might also be confused with *Conotrochus funicolumna*, but is usually easily distinguished by its residual parent fragment that remains attached to the base.

MATERIAL EXAMINED.—*New Record:* Alb-4958, 1, USNM 92704.

TYPES.—The "numerous" syntypes of *A. recidivus* reported by Dennant (1906) cannot be located (see Zibrowius, 1980). *Type Localities:* Off Cape Jaffa and Neptune Island, South Australia, 165–190 m.

DISTRIBUTION.—Japan: Bungo Strait (Okino I.) off Shikoku (new record for North Pacific); 741 m. *Elsewhere:* South Australia, Tasmania, Macquarie Ridge, off Madagascar; 128–1000 m.

Aulocyathus matricidus (Kent, 1871)

PLATES 26*c–g*, 42*b–d*

Flabellum matricidum Kent, 1871:276, pl. 23: fig. 2a–c.
Fragilocyathus conotrochoides Yabe and Eguchi, 1932a:388, 389, fig. 1; 1941b:101; 1942b:116, 145, pl. 9: fig. 15.—Eguchi, 1965:288, 4 figs.—Eguchi and Miyawaki, 1975:57.—Zibrowius, 1980:105, 107.
Aulocyathus cf. *matricidum*.—Yabe and Eguchi, 1941b:101.
Aulocyathus cf. *matricidus*.—Yabe and Eguchi, 1942b:112, 116.

DESCRIPTION.—Corallum elongate-conical, up to 31.0 mm in length but with a maximum calicular diameter of 8.5 mm (Yabe and Eguchi, 1942b). Illustrated specimen (TM (KT7802, Z4)) only 16.4 mm in length and 6.2 mm in diameter, tapering gradually to a broad pedicel 2.1 mm in diameter. Coralla appear to reproduce predominantly by budding from corallum fragments following the longitudinal fission of a parent corallum. Theca rough and striate, possessing twice the number of longitudinal ridges as septa. The true costae, those ridges corresponding in position to the septa, are 0.18–0.20 mm wide; whereas, between each costa occurs another narrower ridge 0.10–0.11 mm in width. Both ridges bear hollow, conical, apically inclined granules, many of which are abraded apically revealing a hollow interior. Corallum light brown.

Septa hexamerally arranged in 4 cycles, the fourth cycle rarely complete. Each system of a typical corallum contains 1 S_2, 2 S_3, and only 2 S_4, resulting in a corallum total of 36 septa. As the corallum increases in size, additional pairs of S_4 are added, completing various systems. Yabe and Eguchi (1942b) reported specimens of GCD = 6–8.5 mm to have 36–49 septa; the holotype of *F. conotrochoides* (GCD = 6.6 mm) has 44 septa; specimens reported herein (GCD = 5.2–7.5 mm) range from 38–40 septa; and a syntype of *F. matricidum* (GCD = 7.4 mm) has 40 septa. S_1 only very slightly exsert (0.5 mm) and have vertical, straight to slightly sinuous inner edges, which become quite thick (up to 0.7 mm) and coarsely granular to tuberculate at their lower edges. S_2 about three-quarters width of an S_1 and also have thickened, tuberculate inner edges, sometimes bearing a narrow paliform lobe or columellar process that extends upward into the fossa. S_3 that are flanked by a pair of S_4 are about three-quarters width of an S_2 and have thick inner edges; S_3 that stand alone are only half width of an S_2 and have coarsely dentate, narrow inner edges. S_4 similar in shape to those S_3 unflanked by S_4. Upper outer edges of septa not notched near thecal edge. Fossa deep. Columella rudimentary, composed of the tuberculate, widened lower inner edges of the S_{1-2} and often a single rudimentary tubercle.

DISCUSSION.—The holotype of *F. conotrochoides* is a well-preserved specimen 30.9 mm in height and 6.6 mm in calicular diameter, having 44 septa. It is the only specimen known to me that does not evidence asexual development from a parent fragment, instead having a slender pedicel 0.9 mm in diameter including the six original protoseta. It is also distinctive in bearing 14 brown longitudinal stripes of various thickness on its theca, these stripes not associated with any particular septal cycle. Despite these peculiarities, *F. conotrochoides* is considered to be a junior synonym of *Aulocyathus matricidus*.

Three other species occur in the genus: *A. juvenescens* Marenzeller, 1904a (known only from off Tanzania, 302–463 m); *A. recidivus* (Dennant, 1906) (S. Australia, New Zealand, Madagascar, off Japan, 128–1000 m); and *A. atlanticus* Zibrowius, 1980 (northeast Atlantic, 450–1716 m). *Aulocyathus matricidus* is unique in having pseudocostae in addition to costae and tuberculate inner edges of S_{1-2}. It is more slender and has a less well-developed columella than *A. recidivus* and *A. atlanticus*, but has a broader corallum than *A. juvenescens* (Plate 26*h,i*). Among the four species, it has the shallowest depth range (84–207 m).

MATERIAL EXAMINED.—*New Records:* TM (KT7802, Z4), 1, USNM 92703; TM (KT7414, B2), 1, ORI. *Previous Records:* Syntypes of *F. matricidum*, BM. *Reference Specimens:* 4 syntypes of *A. juvenescens*, ZMB 5064 and 7032; holotype of *F. conotrochoides*, TIUS; Toyama Bay, 2, TIUS 58223 (Yabe and Eguchi, 1942b) (Plate 42*c,d*).

TYPES.—Two syntypes (Plate 26*c,e,f*) of *Flabellum matricidum* are deposited at the BM (1862.7.16.72). *Type Locality:* "Off Japan," depth not reported, but Zibrowius (1980) gives 84 m, this information obtained from the label with the syntypes.

The holotype (Plate 42*b*) and paratype of *Fragilocyathus conotrochoides* are deposited at the TIUS (50084 and 50083, respectively). *Type Locality:* *Soyo Maru*-352: 33°39′50″N, 135°06′30″E (Kii Strait, Honshu), 154 m (elucidated by Yabe and Eguchi, 1942b:145, footnote).

DISTRIBUTION.—Tsugara Strait; Pacific coast of Honshu from Suruga Bay to Kii Strait; Sea of Japan from Toyama Bay to Wakasa Bay; 84–207 m.

Desmophyllum Ehrenberg, 1834

DIAGNOSIS.—See Part 1.

Desmophyllum dianthus (Esper, 1794)

ACCOUNT.—See Part 1.

Lophelia Milne Edwards and Haime, 1849

DIAGNOSIS.—See Part 1.

Lophelia pertusa (Linnaeus, 1758)

ACCOUNT.—See Part 1.

Anomocora Studer, 1878

DIAGNOSIS.—Corallum subcylindrical and free, with a tendency to bud new corallites at random from thecal wall, the buds subsequently losing their organic connection. Before bud detachment the corallum is colonial. Wall thin. Columella trabecular; multiple irregularly shaped paliform lobes usually present on S_{1-3}. Tabular endothecal dissepiments common and widely spaced.

TYPE SPECIES.—*Coelosmilia fecunda* Pourtalès, 1871, by monotypy.

Anomocora sp.

Parasmilia fecunda Yabe and Eguchi, 1932b:443.

Anomocora fecunda.—Eguchi, 1965:290, 2 figs.; 1968:C42, pl. C10: figs. 1–5; ?pl. C20: figs. 10, 11; ?pl. C23: fig. 3.—Cairns, 1991a:19.

DISCUSSION.—No additional specimens of *Anomocora* are reported in the present study and the two specimens of *A. fecunda* reported by Eguchi (1968) are not available for study. Eguchi (1968) did not describe his Japanese specimens, but his specimen (#701) illustrated on plate C10 does appear to be an *Anomocora;* the other specimen (#741) cannot be identified from the illustrations. Specimen #701, from off Chigasaki, Sagami Bay (100 m), has relatively large corallites 12-16 mm in calicular diameter; thin, ridged costae; an incomplete fifth cycle of septa; prominent paliform lobes; and sparse budding. I agree with Zibrowius (1980) that the Japanese specimens are not *A. fecunda,* which appears to be restricted to the Atlantic (Cairns, 1979). The Japanese specimens have larger corallites, more septa per corallite, more prominent paliform lobes, and less frequent budding. *Anomocora* has been reported several times in the Indo-West Pacific by: Gardiner and Waugh (1939) Red Sea; Marenzeller (1904a) off Sumatra; Cairns (1984) Hawaiian Islands; and Cairns (1991a) off the Galápagos.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Reference specimens of *A. fecunda* from the western Atlantic (Cairns, 1979).

DISTRIBUTION.—Sagami Bay; 50–100 m.

Coenosmilia Pourtalès, 1874

DIAGNOSIS.—Corallum colonial, small bushy colonies formed by extratentacular budding of ceratoid corallites just below calice edge or from a commom basal coenosteum. Corallum firmly attached. Columella a solid fusion of elements; paliform lobes absent. Tabular endothecal dissepiments present.

DISCUSSION.—*Coenosmilia* and *Anomocora* are quite similar in morphology and have been synonymized by Zibrowius (1980). *Coenosmilia,* however, can be distinguished by having an attached corallum, more regular budding, a more solid columella, and the absence of paliform lobes.

TYPE SPECIES.—*Coenosmilia arbuscula* Pourtalès, 1874, by monotypy.

Coenosmilia sp. cf. *C. arbuscula* Pourtalès, 1874

PLATE 27*a,b*

DESCRIPTION OF SPECIMENS FROM TM (KT9202, YS2).—A well-preserved corallum is ceratoid: 7.6 × 6.7 mm in calicular diameter, 3.1 mm in pedicel diameter, and 24 mm in height, bearing no buds. A second poorly preserved specimen is only slightly smaller and has 3 buds equally spaced just below the caliclar edge. C_{1-2} low, finely serrate ridges; C_3 slightly less prominent ridges; C_4 broad and unridged. Corallum white.

Septa hexamerally arranged in four cycles, but with one pair of S_4 missing (= 46 septa), according to the formula: $S_1>S_2>>S_3>S_4$. S_1 little exsert (0.8 mm), and not wide (about 0.8 mm wide), having vertical, slightly sinuous inner edges that merge with the columella. S_2 of same exsertness, less wide (0.6 mm), and have inner edges that also merge with the columella. S_3 less exsert and only about half width of S_{1-2}, their inner edges not coming close to the columella. S_4 rudimentary, each composed of a row of small spines. Pali and paliform lobes absent. Fossa deep, containing a large trabecular columella. Tabular endothecal dissepiments present.

DISCUSSION.—The Japanese specimens are extremely similar to *C. arbuscula,* including aspects of their budding pattern, size, costal shape, and number of septa. The two specimens at hand differ only in having a deeper fossa and smaller S_3 than *C. arbuscula. Coenosmilia arbuscula* is known only from the North Atlantic from 109–622 m (Cairns, 1979; Zibrowius, 1980); before a confident identification can be made, more North Pacific specimens will need to be examined and compared.

MATERIAL EXAMINED.—*New Records:* TM (KT9202, YS2), 2, USNM 92709. *Reference Specimens:* Specimens from Atlantic reported by Cairns (1979) and Zibrowius (1980), including the syntypes (MCZ).

DISTRIBUTION.—A seamount (Yaku-Shinsone) in the northern Tokara Retto, Ryukyu Islands; 238–240 m.

Phyllangia Milne Edwards and Haime, 1848c

DIAGNOSIS.—Colonial, extratentacular budding forming reptoid to plocoid colonies, often basally united by thick coenosteum. Inner edges of S_1 smooth, those of higher cycle septa smooth to finely dentate. Sparse endotheca present. Columella rudimentary; P_2 or P_3 sometimes present.

TYPE SPECIES.—*Phyllangia americana* Milne Edwards and Haime, 1849, by subsequent designation (Milne Edwards and Haime, 1850a:xliv).

Phyllangia hayamaensis (Eguchi, 1968)

Astrangia hayamaensis Eguchi, 1968:C26, pl. C27: figs. 8–10; pl. C28: fig. 7.—Wells, 1983:233.
Phyllangia hayamaensis.—Cairns, 1991a:18.

DIAGNOSIS.—This species is known only from the holotype colony, which is about 7.4 cm wide and consists of an encrusting corallum of about 40 corallites. Unfortunately this specimen is not available for study and thus the following diagnosis is taken from the original description. Corallites cylindrical, up to 7 × 6 mm in diameter and 7 mm in height, and bud from a thick, common basal coenosteum. Theca thin and covered with small granules. Septal symmetry octameral, each corallite having 8 primary, 8 secondary, and 2–5 pairs of tertiary septa, for a total of 20–26 septa. Primary septa thick, exsert, and have entire (smooth) vertical inner edges. Secondary septa only slightly less wide but have dentate inner edges. S_3 rudimentary and also have dentate inner edges. A crown of 8 paliform lobes (P_2) occur before the secondary septa. Columella spongy.

DISCUSSION.—Wells (1983) implied that *A. hayamaensis* belonged in the genus *Phyllangia* by stating that it was a "related species" to *Phyllangia consagensis*. I concur that the species belongs to *Phyllangia*, but suggest that it is probably more closely related to the eastern Pacific *P. dispersa* Verrill, 1864. These two species have approximately the same calicular diameter, and both have highly exsert primary septa, rudimentary P_2, and a similar growth form. *Phyllangia hayamaensis* appears to differ in having only about 20–26 octamerally arranged septa, whereas *P. dispersa* usually has 48 hexamerally arranged septa. Examination of additional specimens from off Japan is required to understand this species and to properly compare it with its eastern Pacific congener.

MATERIAL EXAMINED.—*New Records:* None. *Reference Specimens: P. dispersa*, Paitilla Point, Canal Zone, Gulf of Panama, 1 colony, USNM 83526.

TYPES.—The holotype of *P. hayamaensis* is deposited in the Biological Laboratory of the Imperial Household, Tokyo (#640). *Type Locality:* Kamegisho One, Sagami Bay, 5.5 m.

DISTRIBUTION.—Known only from the type locality.

Rhizosmilia Cairns, 1978

DIAGNOSIS.—Phaceloid coralla formed by extratentacular budding from a thin common basal coenosteum. Corallite bases increase in diameter by adding exothecal dissepiments over raised costae producing concentric rings of partitioned chambers resembling polycyclic development in cross section. Vesicular endothecal dissepiments present. Paliform lobes present before penultimate cycle (usually P_3). Columella variable, including papillose, lamellar, and fascicular.

TYPE SPECIES.—*Rhizosmilia gerdae* Cairns, 1978, by original designation.

Rhizosmilia sagamiensis (Eguchi, 1968), comb. nov.

PLATE 27*c–e*

Coenocyathus sagamiensis Eguchi, 1968:C34, pl. C10: figs. 6, 7.

DESCRIPTION OF SPECIMENS FROM Alb-4944.—One corallum consists of a phaceloid clump of 13 interconnected corallites (Plate 27*c*), the other corallum is a large solitary specimen (Plate 27*d,e*). Corallites of colony connected basally by a thin encrusting coenosteum. Corallites ceratoid, the largest measuring 13.3 × 10.3 mm in calicular diameter, 20.1 mm in height, and 5.2 mm in pedicel diameter. Pedicel reinforced by thin raised costae overlain with exothecal dissepiments, this process usually visible on any large specimen. Costae equal in width (0.5–0.6 mm) and finely granular, the C_{1-3} being slightly ridged near calice. Lower half of theca of largest (solitary) specimen also bears fine transverse rugae. Corallum white, except for brown crescent-shaped bands that parallel the septal edges of S_{1-2}.

Septa generally hexamerally arranged in 4 complete cycles according to the formula: $S_1 > S_2 > S_3 > S_4$, but larger corallites have additional septa and paliform lobes, the largest calice having 68 septa and 16 paliform lobes. S_1 highly exsert (up to 3.4 mm), relatively thick, and have straight, vertical inner edges that almost attain the columella. S_2 up to 2.5 mm exsert, three-quarters width of S_1, and also have straight inner edges. S_3 least exsert septa (about 1.1 mm), about three-quarters width of S_2, and have slightly sinuous inner edges. A wide (1.1–1.3 mm), lamellar paliform lobe occurs before each S_3, separated from its adjacent septum by a deep, narrow notch. S_4 less wide but more exsert (1.6–2.0 mm) than S_3. Each pair of S_4 flanking an S_1 or S_2 is fused with that septum at the calicular edge to form a 3-septum calicular extension resulting in a highly serrate calicular edge. Fossa of moderate depth, containing the P_3 crown of 12–16 lobes and a central fascicular columella consisting of several slender, loosely twisted elements.

DISCUSSION.—The holotype, which was the only known specimen of this species, is unavailable for study. Eguchi's illustration of the holotype shows a worn or rejuvenescent corallum of three corallites. The specimens described above are consistent with Eguchi's description and depth range and thus believed to be conspecific.

Three other species of *Rhizosmilia* are known: *R. maculata* (Pourtalès, 1874); *R. gerdae* Cairns, 1978; and *R. robusta* Cairns in Cairns and Keller, 1993. *R. sagamiensis* is most similar to the type species, *R. gerdae*, known only from the western Atlantic at 123–287 m, both species having four cycles of septa and approximately the same calicular diameter. *Rhizosmilia sagamiensis* differs in having ceratoid corallites, a fascicular columella, and highly exsert, pigmented S_{1-2}.

MATERIAL EXAMINED.—*New Records:* Alb-4944, 1 col-

ony and 1 corallite, USNM 92705; TM (KT9202, YT2), 1 corallite, USNM 92706.

Types.—The holotype is deposited in the Biological Laboratory of the Imperial Household, Tokyo (#657). *Type Locality:* Amadaiba, Okino-Kannonzukadashi, Sagami Bay, 60–80 m.

DISTRIBUTION.—Known only from off Japan: Sagami Bay; Kagoshima Bay, Kyushu; Colnett Strait, Osumi Shoto, northern Ryukyu Islands; 60–98 m.

Dasmosmilia Pourtalès, 1880

DIAGNOSIS.—Solitary, ceratoid to turbinate, free. Parricidal budding common. Theca and septa very thin. Paliform lobes present before penultimate cycle of septa and occasionally also before lower cycle septa. Columella trabecular. Endotheca sparse or absent.

TYPE SPECIES.—*Parasmilia lymani* Pourtalès, 1871, by subsequent designation (Wells, 1933).

Dasmosmilia pacifica (Yabe and Eguchi, 1932), comb. nov.

PLATES 27*f–i*, 41*f,g*

Goniocyathus pacificus Yabe and Eguchi, 1932a:389, text-fig. 2; 1932b:443; 1942b:122, 152–153, pl. 10: figs. 15, 16.—Eguchi, 1965:286, 2 figs.—Zibrowius, 1980:70.

Caryophyllia pacifica.—Wells, 1956:F422.

DESCRIPTION.—Corallum fragile, due to extremely thin theca and septa. All specimens examined had asexually generated from a wedge-shaped fragment of parent corallum, often resulting in somewhat irregular septal development and symmetry. Largest specimen examined (syntype) 14.9 mm in GCD. Corallum above base ceratoid, with a circular to irregularly shaped calice. Each primary septum, along with its 2 adjacent higher-cycle septa, are fused at calicular edge and project 1.0–1.5 mm above the edge, producing a serrate margin. Costae slightly convex and coarsely granular, the 12–24 primary costae ridged. Corallum white, with a slight brownish tint near the calice.

Septal symmetry irregular, the number of septa apparently correlated with calicular diameter. Among the few specimens examined, there are coralla with 12–24 primary septa, 12–24 secondary septa, 24–48 tertiary septa, one corallum (large syntype, TIUS 50086) also having a pair of quaternary septa, for a total of 98 septa. Primary septa exsert as much as 2.2 mm and have vertical, sinuous inner edges, several of which clearly bear tall twisted fascicular columella elements. Secondary septa least exsert and only about 40% width of a primary. Each secondary septum bears a wide paliform lobe (about 1.3 mm), together forming a crown of 12–18 lobes. Tertiary septa slightly more exsert but less wide than secondaries, becoming rudimentary lower in fossa. When pairs of quaternary septa occur within a half-system, they resemble tertiaries in size, and the flanked tertiary is slightly enlarged in width and adds a paliform lobe. Endothecal dissepiments not observed.

DISCUSSION.—Vaughan and Wells (1943) and Wells (1956) placed the monotypic *Goniocyathus* Yabe and Eguchi, 1932a in synonymy with *Caryophyllia;* however, Zibrowius (1980) suggested that it might fall closer to *Dasmosmilia*. After comparing the Japanese specimens reported herein with typical *D. lymani*, I agree with Zibrowius that *Goniocyathus* is a junior synonym of *Dasmosmilia*. In fact, the differences between *D. pacifica* and *D. lymani* are quite minor. *Dasmosmilia pacifica* differs in having exsert primary septa, always fused with adjacent higher-cycle septa to form a serrate calicular margin, whereas the primary septa of *D. lymani* are not very exsert and not fused with adjacent septa near the calice. Also, the corallum of *D. pacifica* is more open and the septa more widely spaced than in *D. lymani*.

The thin theca of this genus facilitates its mode of asexual budding.

MATERIAL EXAMINED.—*New Records:* Alb-3738, 1, USNM 92710; Alb-5055, 1, USNM 92711; YO70-1009, 1, ORI. *Previous Records:* 3 syntypes, TIUS.

TYPES.—The syntypes of *G. pacificus* are deposited at the TIUS (50086, 50097)(Plate 41*f,g*). *Type Locality* (vide Yabe and Eguchi, 1942b): *Soyo Maru*-198: 34°17′45″N, 137°04′45″E (off Ise Bay, Honshu), 168 m.

DISTRIBUTION.—Known only from the Pacific coast of Japan from off Boso Hanto, Chiba-ken, Honshu to southeastern Kyushu; 168–355 m. Pleistocene of Ryukyu Islands (Yabe and Eguchi, 1932b).

Goniocorella Yabe and Eguchi, 1932a

DIAGNOSIS.—Colonial, extratentacular budding forming bushy colonies. Branch anastomosis common, the integrity of the corallum further increased by numerous slender, tubular coenosteal bridges. No pali or columella. Tabular endothecal dissepiments common and widely spaced.

TYPE SPECIES.—*Pourtalosmilia dumosa* Alcock, 1902, by original designation.

Goniocorella dumosa (Alcock, 1902)

PLATE 27*j*

Pourtalosmilia dumosa Alcock, 1902c:36–37, pl. 5: fig. 33.

Goniocorella dumosa.—Yabe and Eguchi, 1932a:389–390; 1936:167; 1943:494–496, figs. 1, 2; 1942b:162, 163.—Eguchi, 1965:291, 2 figs.; 1968:C43, pl. C9: figs. 11, 12.—Cairns, 1982:31–34, pl. 9: figs. 7–9; pl. 10: figs. 1, 2 [synonymy].—Cairns and Keller, 1993:250, fig. 6E.—Song, 1991:134–135, pl. 1: fig. 3; pl. 2: figs. 4–7.

Goniocorella sp. aff. *G. dumosa*.—Eguchi and Miyawaki, 1975:58.

DESCRIPTION.—Colony bushy, budding often at right angle to parent branch. Colony reinforced by slender (about 2 mm in diameter), hollow, tubular coenosteal bridges, which unite adjacent branches. Branches cylindrical, 3–5 mm in diameter, each bearing a terminal calice of equal diameter. Costae inconspicuous. Corallum white or light brown.

Septa hexamerally arranged in 3 complete cycles according to the formula: $S_1>>S_2>S_3$. S_1 not very exsert and quite narrow (only about 0.6 mm wide), with straight, vertical inner edges that extend to uppermost dissepiment. S_2 much thinner (only about 0.2 mm wide); S_3 smaller still (only about 0.1 mm wide), both S_2 and S_3 extend deep into fossa. Fossa usually deep and vacuous, bordered laterally by inner edges of narrow septa and basally by a horizontal dissepiment. Thin, tabular endothecal dissepiments occur every 2–10 mm, giving the corallum a very low density.

DISCUSSION.—This species is well described and illustrated by Yabe and Eguchi (1936) and Cairns (1982). *Goniocorella* is monotypic.

MATERIAL EXAMINED.—*New Records:* Sagami Bay, depth unknown, 1 colony, USNM 92708, 1 fragment, ORI; Okinose, Sagami Bay, 366 m, several colonies, ZMC; off Izu Peninsula, Honshu, depth unknown, 1 colony, USNM 92707.

TYPES.—Several syntypes of *P. dumosa* are deposited at the ZMA (Coel. 1097). Another syntype is presumed to be deposited at the Indian Museum, Calcutta (see van Soest, 1979; Cairns, 1982). *Type Localities: Siboga* stations 156, 259, Banda Sea, Indonesia, 469–487 m.

DISTRIBUTION.—Off Honshu from Sagami Bay to Owase; off southwestern Shikoku; off Ullung Do, South Korea, Sea of Japan; 100–366 m. *Elsewhere:* Off South Africa; Banda Sea; New Zealand region; 100–760 m.

Family TURBINOLIIDAE

Notocyathus Tenison-Woods, 1880

DIAGNOSIS.—Corallum solitary, cylindro-conical or cuneiform, with a pointed, unattached base; transverse division absent. Theca imperforate; costae serrate and correspond to septa. Septa highly exsert. Pali before all but last cycle, but P_{1-2} suppressed in adult; pairs of P_3 unite in V-shaped structures in each system. Columella papillose.

TYPE SPECIES.—*Caryophyllia viola* Duncan, 1865, by subsequent designation (Felix, 1927).

Notocyathus venustus (Alcock, 1902)

PLATE 27*k,l*

Citharocyathus venustus Alcock, 1902b:119; 1902c:22, pl. 3: figs. 19, 19a.—?Yabe and Eguchi, 1932b:443, 444.
?Citharocyathus conicus forma *venustus*.—Wells,1984: 214, pl. 4: figs. 2–5.
Notocyathus venustus.—Cairns, 1989a:27–28, pl. 12: figs. c–h [synonymy].

DESCRIPTION.—Lower half of corallum conical (ceratoid), but upper half a constant-diameter cylinder. Largest Japanese specimen examined 7.15 × 6.95 mm in calicular diameter and 12.6 mm in height, which is the largest reported specimen. C_1 independent. C_2 trifurcate very near base epicenter, resulting in 2 C_3 and a medial C_2. C_3 also trifurcate within 2 mm of epicenter, each C_3 producing 2 C_4 and a medial C_3. C_{1-2} slightly broader than C_{3-4}. All costae bear a uniserial row of teeth as well as smaller lateral granules that project into intercostal spaces. Intercostal furrows deep and narrow, which is characteristic of the family. Corallum white.

Septa hexamerally arranged in 4 complete cycles according to the formula: $S_1>S_2>S_3>>S_4$. S_1 highly exsert (about 2.2 mm) and have straight, vertical inner edges that fuse with the columella deep in fossa. S_2 less exsert (about 1.6 mm) and about two-thirds width of an S_1, their inner edges fused to the V-shaped palar fusion of adjacent P_3. S_3 slightly less exsert and about two-thirds width of an S_2, each S_3 separated by a broad notch from a tall, lamellar palus about 0.5 mm wide. Inner edges of each P_3 pair fused near columella, producing a V-shaped paliform structure in each of the 6 systems. S_4 small, only about one-third as exsert and two-thirds as wide as an S_3. Fossa lacking, the columellar and palar elements rising well above calicular edge. Columella papillose, composed of 7–12 fused elements.

DISCUSSION.—Yabe and Eguchi (1942b, 1946) did not consider *N. venustus* and *N. conicus* to be distinct species, but after examining the types of both species, I (Cairns, 1989a) listed several characters that consistently differentiate the two. To summarize, *N. venustus* has (1) a nearly circular calice (GCD:LCD = 1.02–1.05 vs 1.05–1.22 for *N. conicus*), (2) more exsert S_{1-3} and less exsert S_4, and 3) no fossa. Furthermore, the inner septal edges of *N. venustus* are straight, whereas the inner edges of the S_{1-3} of *N. conicus* are sinuous.

Notocyathus venustus was described and illustrated in greater detail by Cairns (1989a); however, his distributional record of Pleistocene from the Ryukyu Islands attributed to Yabe and Eguchi (1942b) was an error.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, BS2), 12, USNM 92778; TM (KT9309, AM8), 4, ORI. *Previous Records:* 3 syntypes of *C. venustus*, ZMA; *C. conicus* forma *venustus* of Wells (1984), USNM 73968.

TYPES.—Three of the four syntypes of *C. venustus* are deposited at the ZMA (Coel. 1244); the location of the fourth syntype is unknown (Van Soest, 1979). *Type Locality: Siboga*-59: 10°22.7′S, 123°16.5′E (Savu Sea, Indonesia), 390 m.

DISTRIBUTION.—Japan: Bungo Strait off northeastern Kyushu; off Amami Oshima, Ryukyu Islands (new record for Japan); 193–422 m. *Elsewhere:* South China Sea; Philippines; Celebes and Savu Sea, Indonesia; 70–555 m. ?Pleistocene of Vanuatu (Wells, 1984) and Ryukyu Islands (Yabe and Eguchi, 1932b).

Notocyathus conicus (Alcock, 1902)

PLATE 28*a,b*

Citharocyathus conicus Alcock, 1902b:118–119; 1902c:22, pl. 3: figs. 18, 18a.—Yabe and Eguchi, 1941c:212, fig. 4a,b; 1942b:122, pl. 10: figs. 17, 18.
Sphenotrochus viola.—Gerth, 1921:393, pl. 57: figs. 10, 11.
Notocyathus conicus.—Yabe and Eguchi, 1946:7.—Eguchi, 1965:289, 2 figs.—Cairns, 1989a:28, pl. 13: figs. a–i [synonymy].

DESCRIPTION.—Corallum regularly conical, never cylindrical, with a slightly compressed calice having a GCD:LCD

range of 1.05–1.22. Largest Japanese specimen examined (TM (KT9015, CB1-2)) 5.85 × 5.39 mm in calicular diameter and 7.60 mm in height. Costal structure and corallum color as in *N. venustus*.

Septa hexamerally arranged in 4 complete cycles, as in *N. venustus*, but the relative sizes of septa differ. S_1 exsert (about 1.2 mm) and have sinuous vertical inner edges that fuse with the columella deep within fossa. S_2 slightly less exsert (about 1.0 mm), two-thirds width of S_1, and also have sinuous inner edges that join with the inner P_3 fusions. S_3 slightly less exsert than S_2 (about 0.8 mm) and about two-thirds width of an S_2, each S_3 separated by a wide notch from a tall, wide (about 0.75 mm) palus. Inner edges of each pair of P_3 within a system fused in a V-shaped structure before the S_2, as in *N. venustus*. S_4 slightly less exsert than S_3 and equal to or slightly less wide than the S_3. Fossa quite shallow, containing a papillose columella.

DISCUSSION.—Characters differentiating *N. conicus* from *N. venustus* are listed by Cairns (1989a) and in the previous species account. A more complete description and illustration of this species is given by Cairns (1989a). Based on the GCD:LCD ratio of Yabe and Eguchi's (1941c) specimen from the Philippine Pleistocene (1.19), I now consider it to be *N. conicus*, not *N. venustus*.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, CB1-2), 1, USNM 92777; TM (KT9015, HK3), 1, ORI. *Previous Records:* Syntypes of *C. conicus*, ZMA.

TYPES.—Two syntypes of *C. conicus* are deposited at the ZMA (Coel. 1185). *Type Locality: Siboga*-95: 5°43.5′N, 119°40′E (Sulu Sea), 522 m.

DISTRIBUTION.—Japan: Bungo Strait; off Mi Shimi, Eastern Strait, southwestern Honshu; 70–110 m. *Elsewhere:* Philippines; Makassar Strait; off Sabah, Indonesia; 34–923 m. Pleistocene of Philippines and Ryukyu Islands; Miocene of Java (Gerth, 1921).

Peponocyathus Gravier, 1915

DIAGNOSIS.—Corallum solitary and free, but quite variable in shape, including bowl-shaped, cylindrical, and globose. Theca imperforate; costae serrate, corresponding to septa. Septa highly exsert. Pali present before all but last cycle in two crowns, but P_1 often suppressed. Columella papillose.

TYPE SPECIES.—*Peponocyathus variabilis* Gravier, 1915 (= *P. folliculus*), by original designation.

Peponocyathus australiensis (Duncan, 1870)

PLATES 28*c–f*, 41*i*

Deltocyathus italicus var. *australiensis* Duncan, 1870:297, pl. 19: fig. 4.

Deltocyathus orientalis Duncan, 1876:431, pl. 38: figs. 4–7.—Yabe and Eguchi, 1932a:387, 388; 1941a:418–420, text-figs. 1–3; 1941b:102; 1942b:112, 125–126.—Mori, 1964:314, pl. 46: figs. 1, 2.

Deltocyathoides japonicus Yabe and Eguchi, 1932a:389, fig. 3; 1937:140–141, pl. 20: fig. 23a–c.—Eguchi, 1968:C35–36.—Eguchi and Miyawaki, 1975:57.

Not *Peponocyathus orientalis* Yabe and Eguchi, 1932b:444—445 [= *P. folliculus*].

Deltocyathus (Paradeltocyathus) orientalis Duncan.—Yabe and Eguchi, 1937:130, 131–135, pl. 20: figs. 1–10.

Deltocyathus (Paradeltocyathus) australiensis.—Yabe and Eguchi, 1937:130.

Deltocyathoides japonicum.—Yabe and Eguchi, 1942b:126.

Paradeltocyathus orientalis Duncan.—Eguchi, 1965:289, 2 figs.—Kikuchi, 1968:11.

Notocyathus (Paradeltocyathus) orientalis Duncan.—Eguchi, 1968:C40-41.—Hamada, 1969:253–254, pl. 2: fig. 4a–c.—Omura et al., 1984: 33, fig. 1B.

Deltocyathus sp.—Eguchi, 1974:228, pl. 70: figs. 6–11.

Peponocyathus australiensis.—Cairns, 1989a:29, 30 32, pl. 14: figs. d–j; pl. 15: figs. a–d [synonymy].—Cairns and Parker, 1992:39–40, pl. 13: figs. c–d.—Cairns and Keller, 1993:259–261.

DESCRIPTION.—Corallum bowl-shaped and small, rarely exceeding 8 mm in calicular diameter or 7 mm in height. Largest typical specimen examined (TM (KT9015, BS2)) only 8.6 mm in calicular diameter, but most Japanese specimens only 5.0–6.5 mm in diameter with a relatively high H:D ratio of 0.70–0.83. Costae rounded and equal in width (0.18–0.22 mm), separated by very thin (about 0.1 mm) and deep (up to 1 mm at calicular edge) intercostal furrows, which do not afford a view of underlying theca. Epicenter of base 0.8–1.0 mm in diameter and granular, from which 6 independent C_1 originate. Within every system the C_2 and 2 C_3 originate in a trifurcation at the border of the epicentral region. Only 0.5 mm beyond this region a pair of C_4 split from each C_3. Corallum white.

Septa invariably hexamerally arranged in 4 complete cycles (48 septa). S_1 easily distinguished by their highly exsert upper margins and greater width, each having a straight, vertical inner edge that almost reaches the columella. S_2 less exsert and about three-quarters width of an S_1, each usually bearing a small (0.5 mm wide) lamellar paliform lobe, the 6 P_2 forming a palar crown encircling columella. S_3 about three-quarters width of an S_2 and often bear 1–3 papillose paliform lobes, positioned slightly outward from the columella with resepect to P_2 crown. S_4 adjacent to S_1 usually slightly wider than those adjacent to S_2. All septal and palar faces highly granular. Fossa shallow. Columella papillose, composed of up to 12 cylindrical, granular elements.

DISCUSSION.—I (Cairns, 1989a) synonymized *Deltocyathoides japonicus* with *Peponocyathus australiensis*, but did not explain why. Specimens of the *D. japonicus* growth form invariably result from asexual regeneration of a parent fragment, which is easily recognized by the incorporation of the parent fragment into the new corallum (Plate 28*d,e*). Specimens of this form are usually larger than typical specimens and have more septa (e.g., 72 septa in holotype of GCD 15.1 mm); have taller costal spines; and have much wider intercostal spaces, allowing a view of the underlying theca. Their septal symmetry is irregular, their palar structure is often rudimentary, and the columella is often lacking. In general, these specimens have a poorly organized structure typical of a juvenile corallum, even though they are among the largest specimens of the species. Because this morphology was believed to be the result of asexual fragmentation of *P. australiensis*, it was synonymized

with that species (Cairns, 1989a), but may still be referred to as the *"japonicus"* growth form.

Good descriptions of the typical form of this species are given by Yabe and Eguchi (1937), Cairns (1989a), and Cairns and Parker (1992). A complete synonymy is given by Cairns (1989a).

MATERIAL EXAMINED.—*New Records of Typical Form:* Alb-3708, 9, USNM 92754; Alb-4807, 2, CAS 80912; Alb-5071, 6, USNM 81827; TM (KT7802, B), 1, USNM 92755; TM (KT78-11, OT1), 2, USNM 92756; TM (KT78-11, OT6), 43, USNM 92757; TM (CR79-1), 31, USNM 92758; TM (KT9015, BS1), 2, USNM 92759; TM (KT9015, BS2), 3, USNM 92760; TM (KT9015, CB1-1), 2, USNM 92761; TM (KT9015, CB1-2), 4, USNM 92762; TM (KT9015, CB6-1), 30, USNM 92763; TM (KT9015, HK2), 2, USNM 92764; TM (KT9015, HK3), 13, USNM 92765; TM (KT9015, HK5), 5, USNM 92766; TM (KT9015, OK2), 142, USNM 92767; TM (KT9015, OK1), 63, ORI; TM (KT9202, KB3), 2, USNM 92768; TM (KT9202, OS2), 1, USNM 92769; TM (KT9202, OS3), 1, USNM 92770; USGS 17445, 17447, 17450, 17451, 17503, Pleistocene of Okinawi, USNM 88666-671. *New Records of* japonicus *form:* ALB-3738, 2, USNM 81828; TM (KT7414, B4), 3, USNM 92917; TM (KT7818, OT10), 3, USNM 92915, 1, ORI; TM (KT7911, OT4), 4, USNM 92916. *Previous Records:* Holotype of *D. italicus australiensis*, BM; holotype of *D. japonicus*, TIUS.

TYPES.—The holotype of *Deltocyathus italicus* var. *australiensis* is deposited at the BM (R29255). *Type Locality:* 2.5 km west of Cape Otway, Victoria, Australia (Miocene).

The holotype of *Deltocyathus orientalis* Duncan appears to be lost (Zibrowius, 1980). *Type Locality:* 34°12′N, 136°20′E (off Owase, southeastern Honshu), 95 m.

The holotype (Plate 41*i*) of *Deltocyathoides japonicus* is deposited at the TIUS (50091). *Type Locality: Soyo Maru*-21: 36°47′N, 141°14′E (off Hitachi, Honshu), 209 m. Although Yabe and Eguchi (1932a) did not specify the type or type locality, a specimen captioned as the holotype from *Soyo Maru*-21 was illustrated by Yabe and Eguchi (1937).

DISTRIBUTION.—*Peponocyathus australiensis* is the most commonly collected and reported deep-sea coral in the Japanese region, and also one of the most widely distributed species worldwide (Cairns, 1989a).

It is found off both the Sea of Japan and Pacific coasts of Honshu, from Tsugaru Strait to the Eastern Channel, Korea Strait, as well as off Shikoku and southwestern Kyushu; 59–494 m. Pleistocene of Ryukyu Islands. *Elsewhere:* Widespread in Atlantic and Indo-West Pacific, including Southern Australia and New Zealand; 44–635 m.

Peponocyathus folliculus (Pourtalès, 1868)

PLATE 28*g–k*

Stephanophyllia folliculus Pourtalès, 1868:139.

Peponocyathus orientalis Yabe and Eguchi, 1932b:444–445, 15 figs. [= junior secondary homonym of *Deltocyathus orientalis* Duncan, 1876]; 1942b:123.—Eguchi, 1974:228, pl. 70: figs. 17, 18.

Discotrochus (Cylindrophyllia) minimus Yabe and Eguchi, 1937: 146–147, pl. 20: figs. 16–22; 1942b:118.

Kionotrochus minimus.—Yabe and Eguchi, 1941b:102.

Cylindrophyllia minima.—Eguchi, 1965:289, 2 figs.—Kikuchi, 1968:8, pl. 5: fig. 3.

Cylindrophyllia orientalis.—Mori and Minoura, 1983:185–191, fig. 1A–O.

Peponocyathus folliculus.—Cairns, 1979:113–115, pl. 22: figs. 1–4; pl. 20: fig. 11 [synonymy]; 1989a:32–33 [in part: pl. 15: figs. e–h; not pl. 16: figs. a–c, not Alb-5277, 5584, 5577, synonymy].

DESCRIPTION.—Corallum cylindrical with a flat base that appears to be the result of transverse division. Corallum relatively small: coralla rarely exceed 5 mm in calicular diameter and 6.5 mm in height, adults invariably taller than their diameter, usually having H:D greater than 1. Large illustrated specimen (TM (KT9015, CB1-2)) 4.9 mm in calicular diameter and 5.1 mm in height. Costae equal in width but not uniformly wide from base to calice, being widest (0.32–0.37 mm) near base to mid-corallum, and narrowest near calice. Deep intercostal furrows correspondingly narrow near base and wider near calice. Costae evenly rounded and uniformly covered on outer and lateral edges with fine (50 μm diameter) granules. Corallum white.

Septa hexamerally arranged in 4 cycles, the last cycle rarely complete. Many specimens have only 1 pair of S_4 in each system for a total of 36 septa, whereas juvenile coralla usually have only 24 septa. S_1 only slightly more exsert than other septa and have straight, vertical inner edges that fuse with the columella. S_2 about three-quarters width of an S_1, each bearing a lamellar paliform lobe about 0.4 mm wide, the 6 P_2 forming a small palar crown encircling the columella. S_3 about three-quarters width of an S_2 and their inner edges usually fused to adjacent S_2; P_3 were not observed in the specimens examined. S_4 about three-quarters width of an S_3. Fossa shallow to absent. Septal faces covered with prominent (up to 80 μm tall), blunt granules. Columella papillose but small.

DISCUSSION.—*Peponocyathus orientalis* and *Cylindrophyllia minima* were names originally given and predominantly applied to Neogene fossil specimens from the Japanese region; however, some Recent specimens were reported under the latter name by Yabe and Eguchi (1937, 1941b) and Kikuchi (1968). In a detailed study of almost 800 Pleistocene specimens, Mori and Minoura (1983) demonstrated that *P. orientalis* and *C. minima* were synonymous, the former name generally applying to specimens having 30–48 septa, the latter to smaller specimens with only 24 septa. They also stated that septal number was controlled by intrinsic genetic factors and was thus not a function of size, with 24 and 36 being the bimodal distribution of this character. I (Cairns, 1989a) synonymized the Japanese species with *P. folliculus* and still maintain their equivalence; however, the Japanese specimens are, in general, larger than those from the Atlantic and tend to have more S_4. If the Japanese populations are found to be a separate species, its correct name would be *Peponocyathus minimus* (Yabe and

Eguchi, 1937), since *P. orientalis* Yabe and Eguchi, 1932 is a junior secondary homonym of *Deltocyathus orientalis* Duncan, 1876 (= *Peponocyathus australiensis*).

MATERIAL EXAMINED.—*New Records:* TM (KT9015, HK2), 1, USNM 92772; TM (KT9015, CB2-2), 2, USNM 92773; TM (KT9015, CB1-2), 6, USNM 92774, 2, ORI; TM (KT9202, YT4), 1, USNM 92775; USGS 17681, Pleistocene of Okinawa, 1, USNM 88670. *Previous Records:* Holotype of *S. folliculus*, MCZ.

TYPES.—The holotype of *Stephanophyllia folliculus* is deposited at the MCZ. *Type Locality: Bibb*-51: 24°12′40″N, 81°19′25″W (Straits of Florida), 433 m.

Five syntypes of *Peponocyathus orientalis* Yabe and Eguchi, 1932b are deposited at the TIUS (43423). *Type Locality:* Pleistocene ofKikai-jima, Ryukyu Islands.

Approximately 62 syntypes of *Discotrochus minimus* from 11 localities are deposited at the TIUS. *Type Localities:* Neogene of Taiwan; Chiba Prefecture, Honshu; Shimbara Peninsula, Kyushu. Recent of Toyama Bay, depth unknown.

DISTRIBUTION.—Recent of Japan: Sagami and Suruga Bays, Honshu; off Amakusa Island, Kyushu; Eastern Strait off southwestern Honshu; Toyama Bay, Honshu; Osumi Shoto, northern Ryukyu Ids; 30–402 m. Neogene of Chiba Prefecture; Shimbara Peninsula, Kyushu; Okinawa, Ryukyu Islands. *Elsewhere:* South China Sea, Philippines, Celebes, Atlantic Ocean; 50–582 m.

Tropidocyathus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Corallum solitary and cuneiform to campanulate, with a rounded base; transverse division absent, but asexual fragmentation occurs in some species. Alate lateral thecal crests present in some species. Theca imperforate; costae serrate to granular and correspond to septa. Septa highly exsert. Pali occur in three crowns before all but last cycle; columella papillose to lamellar.

TYPE SPECIES.—*Flabellum Lessonii* Michelin, 1842, by monotypy.

Tropidocyathus lessoni (Michelin, 1842)

PLATE 29*a,b*

Flabellum Lessonii Michelin, 1842:119.

Trochocyathus (Tropidocyathus) cf. *lessoni*.—Yabe and Eguchi, 1942b:124.

Trochocyathus (Tropidocyathus) wellsi Yabe and Eguchi 1942b:124, 153, pl. 10: fig. 22a,b.

Tropidocyathus lessonii.—Eguchi, 1965:289, 2 figs.

Tropidocyathus wellsi.—Eguchi, 1965:290, 2 figs.

Tropidocyathus lessoni.—Cairns, 1989a:33–34, pl. 16: figs. d–l [synonymy].—Cairns and Keller, 1993:253, fig. 7C.

DESCRIPTION.—Corallum cuneiform, with a rounded base and pronounced edge crests that may project laterally up to 5.2 mm and be 0.6–1.4 mm thick. Largest specimen known, the holotype of *T. wellsi*, measures 18 × 14 mm in calicular diameter and is 17 mm in height. Calice elliptical to diamond-shaped, with GCD:LCD ratios of 1.1–1.5. Costae broad and flat, the C_{1-3} being slightly wider than the C_4. C_{1-3} bear 3 or 4 granules across their width near the calice, whereas C_4 are only about 2 granules wide. Intercostal furrows narrow (about 0.15 mm) and relatively shallow (0.4 mm), degenerating about two-thirds distance to corallum base, the lower third of the thecal faces uniformly granulated and lacking costal furrows. Theca of fresh specimens pale orange; septa white.

Septa hexamerally arranged in 4 complete cycles according to the formula $S_1>S_2>S_4>S_3$. S_1 highly exsert (up to 2.5 mm), extend about three-quarters distance to columella, and have thick, straight inner edges. A relatively small (0.3 mm wide), low P_1 occurs on every S_1. S_2 almost as exsert and as wide as an S_1, and also have thick straight inner edges, but each usually bears a large palus (e.g., 0.5 mm wide) that reaches higher in the fossa than the P_1; P_2 occasionally missing. S_3 considerably less exsert than S_{1-2}, about three-quarters width of an S_2, and have relatively thin, slightly sinuous inner edges. Each S_3 bears a rather large palus up to 1.6 mm in width, pairs of which often loosely fuse to its flanked P_2 near the columella into a chevron-like structure. Inner edges of all pali (P_{1-3}) border on columella. S_4 less exsert but slightly wider than an S_3. Septal and palar faces bear tall granules. Fossa of moderate depth, containing an elongate columella composed of basally fused papillae.

DISCUSSION.—*Tropidocyathus lessoni* is relatively easily distinguished from *T. pileus* by the following characters. *Tropidocyathus lessoni* has prominent, granular thecal edge crests; *T. pileus* does not. The costae of *T. lessoni* degenerate into granules towards the base and the intercostal spaces are shallow; costae and well-defined intercostal spaces of *T. pileus* extend to the corallum base. Furthermore, the costae of *T. lessoni* are flat and bear 2–4 granules across their width, whereas those of *T. pileus* are rounded and bear essentially a single row of peripheral granules. Finally, the theca of *T. lessoni* is orange, that of *T. pileus* is white.

A more complete description is given by Cairns (1989a).

MATERIAL EXAMINED.—*New Records:* TM (KT9202, YT2), 7, USNM 92779, 2, ORI; TM (KT9309, AM6), 3, ORI; USGS 17451, north of Iwa, Okinawa, Pleistocene, 1, USNM 88674. *Previous Records:* Specimens reported from the Philippines (Cairns, 1989a) and the southwest Indian Ocean (Cairns and Keller, 1993).

TYPES.—The holotype of *Flabellum Lessonii* is deposited in the Michelin Collection at the MNHNP. No type locality was given.

The holotype of *Trochocyathus wellsi* is deposited at the TIUS (43691). *Type Locality: Soyo Maru*-439: 31°52′N, 128°01′E (off Danjo Gunto, East China Sea), 155 m.

DISTRIBUTION.—Japan: East China Sea off southwestern Kyushu and Danjo Gunto; off Osumi Shoto and Amami Oshima, northern Ryukyu Islands; 98–155 m. Pleistocene of Ryukyu Islands. *Elsewhere:* South China Sea, Philippines, Indonesia, southwest Indian Ocean; 62–421 m.

Tropidocyathus pileus (Alcock, 1902)

PLATE 29*d,e*

Trochocyathus pileus Alcock, 1902a:96–97; 1902c:15–16, pl. 2: figs. 11, 11a.—Yabe and Eguchi, 1942b:123, pl. 10: figs. 19, 20.—Eguchi, 1965:286, 2 figs.

Trochocyathus (Tropidocyathus) intermedius Yabe and Eguchi, 1932b:443 [nomen nudum].

Tropidocyathus pileus.—Cairns, 1989a:34–35, pl. 17: figs. a–h [synonymy].

DESCRIPTION.—Looking at a lateral face, the corallum is trapezoidal, the lower lateral edges being either rounded or slightly protuberent, but never carinate (crested). Largest Japanese specimen examined (TM (KT9015, BS2)) 18.7 × 11.0 mm in calicular diameter and 19.5 mm in height. Costae continuous from calice to base, where many are continuous with their counterparts from the opposite face. Edge protuberances, if present, vertically costate and not granular. Costae rounded and equal in width, each bearing an outer unilinear row of coarse teeth, as well as smaller granules on their lateral faces. Intercostal furrows deep. Corallum white.

Septa hexamerally arranged in 4 cycles, larger specimens having pairs of S_5 in their end half-systems, e.g., the illustrated specimen has 6 pairs of S_5 for a total of 60 septa. S_1 about 2 mm exsert and have slightly sinuous inner edges, each S_1 bordered by a small (about 0.8 mm wide), highly granular palus that is positioned directly adjacent to the columella. S_2 only slightly less exsert and about 80% width of an S_1, each S_2 also bearing a palus of equal width and position to that of the P_1 but rising higher in the fossa. S_3 least exsert septa (only about 1 mm) and about two-thirds width of an S_2, each having a broad (about 1.5 mm wide) palus slightly recessed from the columella and rising higher in the fossa than the P_2. Each pair of P_3 within a system slant toward their flanked P_2, the inner edges of these triads (1 P_2 and 2 P_3) sometimes loosely fused into a chevron arrangement. S_4 slightly more exsert and wider than S_3, their outer edges fused to adjacent S_{1-2} at calicular edge producing calicular projections that result in a serrate calicular margin. P_4 present only if pairs of S_5 present in a half-system. Fossa of moderate depth. Columella linear-papillose, the elements strongly fused together into a solid lamella.

DISCUSSION.—The name *Tropidocyathus intermedius* (Yabe and Eguchi, 1932b), attributed to a Pleistocene fossil coral, was never described but nonetheless was synonymized by Yabe and Eguchi in 1942(e). A second Pleistocene specimen from the same general region is reported herein.

Comparisons to *T. lessoni* are made in the account of that species. A more complete description and illustration of *T. pileus* can be found in Cairns (1989a).

MATERIAL EXAMINED.—*New Records:* TM (KT9015, BS2), 6, USNM 92781, 1, ORI; TM (KT9202, OS2), 2, USNM 92780; TM (KT9309, AM8), 11, ORI, 5, USNM 93164; USGS 17445, 1.6 km west of Yonabaru, Okinawa, Ryukyu Islands, Pleistocene, 1, USNM 88673. *Previous Records:* Syntypes of *Trochocyathus pileus*, ZMA.

TYPES.—Four syntypes of *T. pileus* are deposited at the ZMA (Coel. 7352). *Type Locality: Siboga*-95: 5°43′N, 119°40′E (Sulu Sea), 522 m.

DISTRIBUTION.—Off Japan: Suruga Bay, Honshu; off Shikoku; off southern Kyushu; off Amami Oshima, Ryukyu Islands; 123–422 m. Pleistocene of Ryukyu Islands. *Elsewhere:* South China Sea, Philippines, off southeastern Australia, ?Gulf of Manaar; 123–522 m.

Alatotrochus, gen. nov.

DIAGNOSIS.—Corallum cuneiform, with a rounded (free) base and prominent, costate thecal edge crests. Theca imperforate. Costae serrate, extending from calice to base; costae number twice that of septa. Four cycles of highly exsert septa. Pali absent; columella linear-papillose.

DISCUSSION.—Using my key to the turbinoliid genera (Cairns, 1989a:25–26), *Alatotrochus* would key to *Platytrochus*, the genus in which Moseley (1876) originally placed the type species. *Alatotrochus* does share several characters with *Platytrochus*, such as a cuneiform corallum with edge crests, a papillose columella, and the absence of pali. *Alatotrochus* differs from the type species, *Platytrochus stokesi* (Lea), however, in several significant characters. It has a much larger corallum, an additional cycle of septa, and twice as many costae as septa. Its costae are serrate and continuous from calice to base, whereas those of *P. stokesi* are discontinuous and granular. Finally, its columellar elements are large and linearly arranged, whereas those of *Platytrochus* are much smaller and grouped in an elliptical field or two rows.

Moseley (1881) later placed *Platytrochus rubescens* in the genus *Sphenotrochus*, which is not surprising given the similarity of *Platytrochus* and *Sphenotrochus* (see Cairns, 1989a: 38). Nonetheless, *Alatotrochus* differs from species of *Sphenotrochus* in having a papillose (not lamellar) columella; a larger corallum; serrate (not smooth) costae; and twice as many costae as septa.

Alatotrochus is monotypic.

ETYMOLOGY.—The name *Alatotrochus* (Latin *alatus*, meaning "winged" + *trochus*, a common coral suffix, literally meaning "wheel"), refers to the prominent edge crests of this genera that resemble wings. Gender: masculine.

TYPE SPECIES.—*Platytrochus rubescens* Moseley, 1876, here designated.

DISTRIBUTION.—Bungo Strait, off Kyushu; off Amami Oshima, Ryukyu Islands; 193–422; Banda Sea, 236 m; Pleistocene of Okinawa, Ryukyu Islands.

Alatotrochus rubescens (Moseley, 1876), comb. nov.

PLATE 29*g–l*

Platytrochus rubescens Moseley, 1876:553.

Sphenotrochus rubescens.—Moseley, 1881:157–159, pl. 6: figs. 8, 8a.

DESCRIPTION.—Corallum compressed, very much resembling the shape of *Tropidocyathus lessoni*, with thin, solid (not hollow) edge crests extending as much as 4 mm from the thecal

edge. Largest Japanese specimen examined 16.1 × 10.5 mm in calicular diameter and 14.7 mm in height; however, the syntypes are larger: up to 20 × 16 mm in calicular diameter and 17–19 mm in height. Costae thin (about 0.8 mm wide), high, serrate ridges, one corresponding to each septum, and another of equal size corresponding to each interseptal space. Near calice the costae that correspond to septa widen at the expense of the interseptal costae. Additional costae, also uncorrelated to septa, cover the thecal edge crests, oriented at right angles to face costae. Many, but not all, costae are continuous from calice to base. The 2 principal costae extend along the outside of each lateral crest and are continuous along the sharp-edged base of the corallum, meeting one another at base epicenter. Intercostal spaces broad (0.18–0.20 mm) but diminish in width near calice. Theca, calicular edge, and exsert portion of septa reddish brown.

Septa hexamerally arranged in 4 cycles (48 septa) according to the formula: $S_1>S_2>S_3>S_4$; however, some larger syntypes have pairs of S_5 in end half-systems, for a total of 56 septa. S_1 highly exsert (up to 4 mm) and quite thick (0.25 mm), with straight, vertical inner edges that fuse with the columella low in fossa. S_2 only slightly less exsert (about 3.5 mm), but otherwise similar to the S_1. S_3 2.0–2.2 mm exsert and about two-thirds width of an S_{1-2}, with finely sinuous inner edges that do not attain the columella. S_4 1.3–1.5 mm exsert and only about one-third width of an S_3. All septal faces covered with very low, rounded granules, producing an apparently smooth aspect. Fossa shallow but commodious, caused by widely spaced septa and the absence of pali. Columella papillose, composed of 5 or 6 tall, cylindrical, finely granulated, aligned pillars, each pillar 0.4–0.7 mm in diameter and reaching almost to level of calice.

DISCUSSION.—This is only the second report of this rare and beautiful species, heretofore known only from four syntypes from the type locality. Aside from the six specimens reported herein from Bungo Strait, a Pleistocene specimen (USGS 17633) is tentatively assigned to this species. It differs only in that its four lateral C_1 are swollen into robust protuberances near the calicular edge.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, BS2), 5, USNM 92776, 1, ORI; TM (KT9309, AM7), 4, ORI; TM (KT9309, AM8), 1 ORI; USGS 17633, 1 km southwest of China, Chinen Peninsula, Okinawa, Ryukyu Islands, Pleistocene, 1, USNM 88672. *Previous Records:* 1 syntype of *P. rubescens*, BM.

TYPES.—Four syntypes of *Platytrochus rubescens*, one illustrated in Plate 29*h,i,l*, are deposited at the BM (1 numbered 1880.11.25.163). *Type Locality: Challenger*-192: 5°49′15″S, 132°14′15″E (off Kei Island, Banda Sea), 136 m.

DISTRIBUTION.—Same as that for genus.

Idiotrochus Wells, 1935

DIAGNOSIS.—Corallum cuneiform; anthocaulus often having a compressed but expansive base, which may bear 2 lateral projections; transverse division present. Theca imperforate; costae smooth; intercostal striae shallow. Septa alternate in position with costae. Septal faces carinate and granular. Pali present before first 2 cycles; columella papillose to fascicular.

TYPE SPECIES.—*Sphenotrochus emarciatus* Duncan, 1865, by original designation.

Idiotrochus kikutii (Yabe and Eguchi, 1941)

PLATE 30*a–d*

Placotrochides ? kikutii Yabe and Eguchi, 1941b:104, 3 figs.; 1942b:118, 149, pl. 9: fig. 16a–c.

Idiotrochus kikutii.—Cairns, 1989a:36–37, pl. 18: figs. a,b, d–h [synonymy].

DIAGNOSIS.—Corallum (anthocyathus) compressed, with a "pinched," blade-like lower edge. Specimens typically 2.3 × 1.7 mm in calicular diameter and 4–5 mm in height. Costae wide (0.21 mm) and smooth to only slightly granular; intercostal striae very narrow and shallow. Septa hexamerally arranged in 3 cycles, most septal faces bearing elongate carinae. Ten to 12 pali occur before S_{1-2}, the 2 principal P_1 often absent. Columella fascicular.

DISCUSSION.—No additional specimens of this unusually shaped species are reported herein. It is known from only one record in Japanese waters, the type locality in Toyama Bay, Honshu. A full description with illustrations of this species based on Philippine specimens is given by Cairns (1989a).

MATERIAL EXAMINED.—*New Records:* None. *Reference Specimens:* Philippine specimens reported by Cairns (1989a).

TYPES.—Six syntypes of *Placotrochides kikutii* are deposited at the TIUS (63088). *Type Locality:* Toyama Bay, Honshu, depth not recorded.

DISTRIBUTION.—Sea of Japan, Toyama Bay, Honshu; South China Sea; Philippines; Celebes Sea; 143–645 m.

Superfamily FLABELLOIDEA

Family GUYNIIDAE

Stenocyathus Pourtalès, 1871

DIAGNOSIS.—Solitary, ceratoid to cylindrical, free or attached. Wall epithecate; rows of thecal spots in every intercostal region, aligned somewhat closer to the C_3 than C_{1-2}. Only 3 cycles of septa. Pali opposite S_2; columella formed of 1–2 twisted, crispate elements.

TYPE SPECIES.—*Coenocyathus vermiformis* Pourtalès, 1868, by monotypy.

Stenocyathus vermiformis (Pourtalès, 1868)

PLATES 22*g*, 29*c,f*

Coenocyathus vermiformis Pourtalès, 1868:133.

Stenocyathus vermiformis.—Cairns, 1979:168–170, pl. 32: figs. 8–10; pl. 33: figs. 1, 2 [synonymy]; 1982:52, pl. 16: figs. 8–11.—Cairns and Parker, 1992:43, pl. 14: figs. b,c.

DISCUSSION.—*Stenocyathus* is a monotypic genus, and thus the generic dignosis also serves as the species diagnosis. *S.*

vermiformis is easily distinguished from all other North Pacific corals by its small, slender, cylindrical corallum and aligned mural spots. Its small size and inconspicuous habit have undoubtedly caused this relatively widespread species to have been overlooked in the past. The specimen reported herein from *Soyo Maru*-425 is 2.3 mm in calicular diameter and 3.2 mm in length with large P_2 and a fascicular columella. It can be identified based on the generic diagnosis; illustrations of this species may be found in the references listed in the synonymy.

MATERIAL EXAMINED.—*New Records:* *Soyo Maru*-425, 1 specimen attached to a dead *Crispatotrochus rubescens*, TIUS 53695, Plate 22*g*. *Previous Records:* Syntypes of *C. vermiformis*, MCZ; specimens reported by Cairns (1979, 1982) and Cairns and Parker (1992).

TYPES.—Thirty-eight syntypes of *Coenocyathus vermiformis* are deposited at the MCZ (Cairns, 1979). *Type Locality:* Off Florida Keys, 274–329 m.

DISTRIBUTION.—The single Japanese record from off Koshiki Retto, southwestern Kyushu (300 m) is the first report of this genus from the North Pacific. It was apparently overlooked by Yabe and Eguchi (1942b) in their report of *Cyathoceras rubescens*. *Elsewhere:* It is known to be common on both sides of the Atlantic; off St. Paul and Amsterdam Islands, southern Indian Ocean; the New Zealand region, including the Antipodes and Campbell Plateaus; off Tasmania; and off southeastern Australia; 80–1229 m.

Truncatoguynia Cairns, 1989a

DIAGNOSIS.—Solitary, elongate compressed-cylindrical, and free. Budding by transverse division. Epitheca smooth; rows of thecal pores occur in every intercostal space, alignment of rows appearing to flank the secondary costae. Septa only slightly exsert and variable in symmetry, arranged in 2 or 3 size classes. Pali and columella absent.

TYPE SPECIES.—*Truncatoguynia irregularis* Cairns, 1989a, by monotypy.

Truncatoguynia irregularis Cairns, 1989

PLATE 30*e,f*

Truncatoguynia irregularis Cairns, 1989a:43, pl. 22: figs. f,g; pl. 23: figs. c, f.

DESCRIPTION.—Corallum an elongate, laterally compressed cylinder with rounded thecal edges. Largest Japanese specimen examined 44.4 mm in length, with calicular diameters up to 5.8 × 4.3 mm. Base of specimens (anthocauli) terminate in an elliptical scar about 3.9 × 3.1 mm in diameter, revealing 12–24 primary septa. Theca thin, smooth, and in all Japanese specimens, somewhat worn, the coralla obviously dead when collected. Thecal pores irregular in appearance, more common toward the base of a corallum and often absent from theca near calice. In several weathered coralla and the older (basal) portions of others, the secondary septa and associated overlying theca are absent, resulting in a characteristic diagenetic form consisting of 12–18 lamella (septa) radiating from a central columella. Corallum white.

Most coralla hexamerally arranged in three cycles of septa and an additional pair of S_4 in each of the four end half-systems according to the formula: $S_{1-2}>S_3>S_4$ and a total of 32 septa; however, one specimen had 14 primary septa and another had 18. S_{1-2} slightly exsert (1.1 mm) with slightly sinuous inner edges that are strongly fused to the columella. S_3 only one-third to one-half width of an S_1 and also have slightly sinuous inner edges, but they do not attain the columella. S_4 rudimentary, consisting of a short row of spines. Fossa deep. Columella an elongate fusion of lower, inner edges of S_{1-2}.

DISCUSSION.—This species was previously known only from its type locality in the South China Sea. Although all the Japanese specimens were dead when collected, they do allow a refinement of the original description and reinforce the observation that the septal symmetry of this species is indeed irregular.

MATERIAL EXAMINED.—*New Records:* TM (KT9202, YT1), 7, USNM 92753, 2, ORI. *Previous Records:* Types of *T. irregularis*, USNM.

TYPES.—The holotype (81890) and 10 paratypes (81891) of *T. irregularis* are deposited at the USNM. Another paratype is deposited at the Australian Museum (G15252). *Type Locality:* Alb-5311: 21°33′N, 116°15′E (South China Sea north of Pratas Island), 161 m.

DISTRIBUTION.—Osumi Shoto, northern Ryukyu Islands; north of Pratas Island, South China Sea; 80–161 m.

Family FLABELLIDAE

Flabellum Lesson, 1831

DIAGNOSIS.—See Part 1.

Subgenus *Flabellum (Flabellum)* Lesson, 1831

DIAGNOSIS.—See Part 1.

Flabellum (F.) pavoninum Lesson, 1831

PLATES 30*g–i*, 31*a–e*

Flabellum pavoninum Lesson, 1831:2.—Gray, 1849:75–76.—Marenzeller, 1888a:41–42.—Cairns, 1989a:46–50, pl. 23: figs. g–l; pl. 24: figs. a–d,g,h [synonymy].

Flabellum distinctum Milne Edwards and Haime, 1848a:262.—Marenzeller, 1888a:42.—Yabe and Eguchi, 1932a:387, 389; 1932b:443; 1941b:101; 1942a:93–95, pl. 5: figs. 3–6; pl. 6: figs. 3, 4, 9, 10; pl. 7: fig. 7; 1942b:112, 130–131, pl. 11: figs. 10–12.—Eguchi, 1938, table 2; 1944:132–134, 5 figs; 1968:C44 [in part: pl. C28: figs. 5, 6].—Utinomi, 1965:255.—Eguchi and Miyawaki, 1975:58.—Mori and Minoura, 1980:321–326, figs. 1–5.—Zou et al., 1981, pl. 1: figs. 2, 3.—Song, 1982:136–137, pl. 3: figs. 1–4; 1991:135.

Flabellum coalitum Marenzeller, 1888a:48–49.—Cairns, 1989a:46, 50, pl. 24: figs. e, f,i–l.

Flabellum sp. cf. *distinctum*.—Okutani, 1969:12.—?Hamada, 1969:254.

DESCRIPTION.—Corallum compressed, the planar faces meeting at acute edges and projecting 2.5–3.8 mm beyond the

edge as low, discontinuous crests. Angle of thecal edges quite variable, ranging from 74° (*coalitum* form) to 139° (typical form); inclination of lateral faces, 27°–42°. Edge angle of lower 5–8 mm of corallum considerably lower (e.g., 48°) than remainder of corallum. GCD:LCD also variable, ranging from 1.9–2.1 (*coalitum* form) to 2.4 (typical form). Largest specimen known (lectotype of *F. distinctum*) 60.6 × 25.1 mm in calicular diameter and 42.8 mm in height. Holotype of *F. coalitum* 32.3 × 14.3 mm in calicular diameter and 30.0 mm in height. Pedicel circular, 1.0–1.5 mm in diameter, and usually worn, revealing 6 protosepta. Thecal faces of most specimens examined discolored and worn; however, in well-preserved specimens there are narrow brown stripes associated with the theca overlaying every septum. Calicular edge a smooth arc.

Septa hexamerally arranged in 6 cycles (S_1-3>S_4>S_5>S6), the last cycle progressively appearing throughout a GCD range of 30–45 mm, and a full sixth cycle (192 septa) usually attained at a GCD of 45–47 mm. S_{1-3} quite wide, their inner edges extremely sinuous and thick, almost touching their counterparts from the opposite face. S_4 of larger coralla as wide as S_{1-3}, but have less thick and less sinuous inner edges. S_4 of smaller coralla about 80% width of an S_{1-3} and thus more easily distinguished. S_5 about half width of an S_{1-4} and also have moderately sinuous inner edges. S6 rudimentary, only one-quarter to one-third width of an S_5. Fossa very deep and elongate. Columella an elongate fusion of inner edges of S_{1-4}, but often obscured from view by the narrow fossa.

DISCUSSION.—Yabe and Eguchi (1942a) synonymized *F. coalitum* Marenzeller, 1888a (type locality: Japan) with *F. distinctum* Milne Edwards and Haime, 1848a (type locality: Japan); however, based on an examination of the type series of both species, I (Cairns, 1989a) maintained their distinction based on the considerably lower edge angle (74°) and lower number of septa (130°) of the holotype of *F. coalitum*. Despite its long synonymy, *F. pavoninum (= F. distinctum)* is known from remarkable few specimens, but the Japanese material reported herein includes one group (TM (KT8412, 14)) of 44 specimens that displays a range of edge angles of 78°–117° and a range of septal number from 130°–192°, the septal number being directly correlated to GCD. Since all other characters of *F. pavoninum* and *F. coalitum* are the same, these Japanese specimens would appear to link the two extremes of the species: form *coalitum* having a relatively low edge angle and 5 1/2 septal cycles; the typical form having a greater edge angle (up to 139°) and 6 full cycles. Although only several of Yabe and Eguchi's (1942a,b) Japanese specimens were examined (see "Material Examined"), they all appear to be the *coalitum* form of the species.

MATERIAL EXAMINED.—*New Records:* Alb-5310, 1, USNM 86552; Alb-5312, 3, USNM 40752; TM (KT7802, Z2), 1, USNM 92818; TM (KT8412, 14), 38, USNM 92819, 6, ORI; TM (KT9015, CB2-2), 1, USNM 92820; TM (KT9202, KB3), 1, USNM 92815; Tsuchida-45, 1, USNM 92821; Formosa Strait, 90 m, 2, CAS 74995; East China Sea, southeast of Cheju Do, 80 m, 1, CAS 74997. *Previous Records:* Types of *F. pavoninum, F. distinctum,* and *F. coalitum; F. distinctum* of Yabe and Eguchi (1942b): *Soyo Maru*-437, 1, TIUS 43448; *Soyo Maru*-429, 1, TIUS 39732 (Plate 30*i*); Sagami Bay, 1, TIUS 43409; near Seto, 2, TIUS 39236 (Plate 30*g,h*); *F. distinctum* of Marenzeller (1888a), off Japan, NMW 8197 (Plate 31*b,c*); *F. pavoninum* of Marenzeller (1888a), off China, NMW 8201 (Plate 31*a*).

TYPES.—The lectotype and 4 paralectotypes of *F. pavoninum* are deposited at the MNHNP (#372) (Cairns, 1989a). *Type Locality:* "Sandwich Islands" (?Hawaiian Islands), depth unknown.

The lectotype and 3 paralectotypes of *F. distinctum* are deposited at the BM and MNHNP (Cairns, 1989a). *Type Locality:* "Japan" (see Gray, 1849), depth unknown.

The holotype (Plate 31*d,e*) of *F. coalitum* is deposited at the NMW (#8196). *Type Locality:* "Japan," depth unknown.

DISTRIBUTION.—Japan: common off Honshu, Shikoku, and Kyushu, its northern limits at 39°36'N (*Soyo Maru*-624) in the Sea of Japan and 35°18'N (*Hasu Maru*-45) on the Pacific coast of Japan. Also known from Korea Strait and off Cheju Do, Korea; Formosa Strait; South China Sea north of Pratas Island; 73–658 m. *Elsewhere:* Hawaiian Islands, southwest Indian Ocean; 98–665 m.

Flabellum (F.) patens Moseley, 1881

PLATE 31*g-i*

Flabellum patens Moseley, 1881:172 [in part: pl. 6: fig. 5].—Cairns, 1989a:51-52, pl. 26: figs. a-i [synonymy].

Flabellum pavoninum paripavoninum.—Yabe and Eguchi, 1942a:91-93 [in part: *Soyo Maru*-343, 419, pl. 5: fig. 7a-c]; 1942b:129 [in part: *Soyo Maru*-343, 419, not pl. 11, fig. 9].—Eguchi, 1965:291, 2 figs.—Utinomi, 1965:255.

?Flabellum pavoninum lamellulosum.—Yabe and Eguchi, 1942b:131.

DESCRIPTION.—Corallum highly compressed, having virtually planar thecal faces that meet at a sharp angle and project as much as 6 mm as prominent edge crests. Angle of thecal edges (exclusive of edge crests) 117°–155°, but including the aliform crests, the thecal edges may approach 180°. Inclination of lateral faces 20°–32°, the faces of large specimens slightly concave. GCD:LCD = 2.05–2.50; GCD:H about 1.04, the corallum being about equally tall as broad. Largest specimen known (Alb-5313) 67.5 × 28.9 mm in calicular diameter and 54.7 mm in height. Pedicel small and circular, only 1.5–2.0 mm in diameter, and often exposing the 6 protosepta. Theca white to grey, relatively smooth, and regularly partitioned by thin intercostal striae. Theca near calice often discolored by an arched band about 5 mm wide than parallels the calicular edge, which is the indication of a former association with a commensal *Lumbrineris* polychaete (Zibrowius, Southward, and Day, 1975). Upper calicular edge smooth.

Septa hexamerally arranged in 7 cycles according to the formula: S_1-4>S_5>S6>>S7. Sixth cycle complete at a GCD of

38–41 mm; seventh cycle gradually added up to a GCD of about 65 mm at which size all 384 septa are usually present. S_{1-4} equal in size only in large coralla, the S_4 being slightly less wide than S_{1-3} in smaller coralla; regardless of size, inner edges of all S_{1-4} attain the columella. Upper, inner edges of S_{1-4} moderately sinuous, becoming thicker and more sinuous deeper in fossa. S_5 half to three-quarters width of S_{1-4}, have moderately sinuous inner edges, and do not attain the columella. S6 about one-third width of S_5, and S7, if present, rudimentary: only about 0.5 mm wide and 2–3 mm long. Fossa deep and narrow, formed by vertical inner edges of S_{1-4}. Columella elongate, composed of a trabecular to solid fusion of the lower, inner edges of the S_{1-4}, as much as 30 mm long and about 2 mm wide.

DISCUSSION.—Several of the Indo-West Pacific species of *Flabellum (Flabellum)* were compared by Cairns (1989a, table 5) and further distinguished by discriminant analysis (Cairns, 1989b). *Flabellum patens* was found to be most similar to *F. pavoninum*, differing primarily in corallum shape. To quantify the difference in shape, *F. patens* has a lower face angle (20°–32° vs 32°–42° for *F. pavoninum*), a higher GCD:LCD (2.05–2.50 vs 1.98–2.41), a lower GCD:H (1.04 vs 1.34), higher edge crests (4.8–6.1 vs 2.5–3.8 mm), and a tendency to have S7.

Yabe and Eguchi's (1942a) report of *F. pavoninum lamellulosum* from off Seto was not illustrated and their two specimens cannot be located, but based on their description, these specimens would appear to be *F. patens*.

MATERIAL EXAMINED.—*New Records:* Alb-5313, 8, USNM 40757, 2, ORI; Alb-5314, 1, USNM 92813; YO70-770, 1, USNM 92314; off Pengue, Taiwan, 3, CAS 74993. *Previous Records:* 4 syntypes of *F. patens*, BM; *F. pavoninum paripavoninum* of Yabe and Eguchi (1942a,e): *Soyo Maru*-419, 1, TIUS 43441; *Soyo Maru*-343, 1, TIUS 43445.

TYPES.—The lectotype and 5 paralectotypes of *F. patens* are deposited at the BM, the lectotype designated by Cairns (1989a:52). *Type Locality: Challenger*-192: 5°49′S, 132°14′E (Kei Islands, Banda Sea), 256 m.

DISTRIBUTION.—Japan: Kii Strait, Honshu; off northeastern Shikoku; off southwestern Kyushu; Formosa Strait; South China Sea north of Pratas Island; 223–402 m. *Elsewhere:* Philippines, Banda Sea; 256–439 m.

Flabellum (F.) magnificum Marenzeller, 1904

PLATE 31*j–l*

Flabellum magnificum Marenzeller, 1904a:276–277, pl. 17: fig. 13.—Utinomi, 1965:255.—Cairns, 1989a:50–51, pl. 25: figs. a–j [synonymy].

Flabellum pavoninum.—Yabe and Eguchi, 1942a:90–91, pl. 5: fig. 2a–c [in part: *Soyo Maru*-437]; 1942b:129, pl. 11: fig. 7a–c.

Flabellum pavoninum magnificum.—Yabe and Eguchi, 1942a:89–90, pl. 5: fig. 1a–c; 1942b:129, pl. 11: fig. 8a–c.

DIAGNOSIS.—Angle of thecal edges 140°–172°; inclination of planar thecal faces quite open, 44°–58°. Discontinuous edge crests usually not present. Thecal faces bear reddish brown stripes associated with each costa. Pedicel narrow, only 1.5–2.3 mm in diameter. Ratio of GCD:LCD = 1.65–1.96. Septa hexamerally arranged in 7 cycles, the last cycle never complete, the largest known specimen having 376 septa. Septal formula: $S_{1-4}>S_5>S_6>S_7$. Columella well developed.

DISCUSSION.—No additional specimens of this large and elegant species are reported herein. It is known in Japanese waters from only four specimens reported by Yabe and Eguchi (1942a,b) and Utinomi (1965). A full description and illustrations are given by Cairns (1989a). It is distinguished (Cairns, 1989a,b) from other Indo-West Pacific *Flabellum* by attaining a very large corallum size with up to 7 cycles of septa, having the largest face angle (44°–58°), and having very long lateral edges.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records: Soyo Maru*-437, 1, TIUS 43448 (*F. pavoninum* of Yabe and Eguchi, 1942a) (Plate 31*j*); *Soyo Maru*-416, 1, TIUS 50094 (*F. p. magnificum* of Yabe and Eguchi, 1942a).

TYPES.—The holotype appears to be lost from the ZMB (see Cairns, 1989a). *Type Locality: Valdivia*-199: 0°15.5′N, 98°04′E (off western Sumatra), 470 m.

DISTRIBUTION.—Japan: Off Seto, Kii Strait, Honshu; off southeastern Shikoku; East China Sea off southwestern Kyushu (incluing off Danjo Gunto); 307–700 m. *Elsewhere:* Philippines, Indonesia, west of Sumatra; 291–616 m.

Flabellum (F.) angustum Yabe and Eguchi, 1942

PLATE 31*f*

Flabellum distictum angustum Yabe and Eguchi, 1942a:95, pl. 6: figs. 5–7; 1942b:131.—Eguchi, 1968:C4.

DISCUSSION.—A new subspecies of *F. distinctum* was described by Yabe and Eguchi (1942a,b) based on 60 Pliocene coralla from Kochi-ken, Shikoku. Although a Recent specimen from Sagami Bay was also attributed to this taxon, Yabe and Eguchi (1942a) clearly indicated that the type locality corresponded to the fossil locality and illustrated only fossil specimens. Their rationale for the new subspecies was that the specimens had edge angles less than 70°. In fact, the edge angle of the fossil specimens is bimodal, ranging from 102°–123° near the pedicel to 52°–54° in upper corallum. The fossil specimens from Shikoku do appear to be a separate species, but the Recent specimen(s) from Sagami Bay were not illustrated and were not examined by the author.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Syntypes of *F. p. angustum*, TIUS.

TYPES AND TYPE LOCALITIES.—Sixty syntypes (Plate 31*f*) from the Pliocene of Tonohama, Kochi-ken, Shikoku are deposited at the TIUS (43436). Additional Recent syntypes from Sagami Bay are also deposited at the TIUS (59333).

DISTRIBUTION.—Known only from the type localities.

Flabellum (F.) politum Cairns, 1989

PLATE 32*a–c*

Flabellum pavoninum paripavoninum.—Yabe and Eguchi, 1942a:91–93 [in part: *Soyo Maru*-419, pl. 5: fig. 8a–c]; 1942b: 129–130 [in part: pl. 11: fig. 9a–c].

Flabellum politum Cairns, 1989a:53–54, pl. 28: figs. a–f [synonymy].

DISCUSSION.—The 10 specimens reported herein are either juvenile or poorly preserved coralla collected when dead. Aside from the distributional records they contribute nothing to our knowledge of this species. The reader is referred to Cairns (1989a) for a complete description and illustration of *F. politum*. It is distinguished from other Japanese species in the subgenus by having highly sinuous septa; a smooth, lustrous theca; and a very tall corallum, invariably taller than wide.

MATERIAL EXAMINED.—*New Records:* Alb-4903, 1, USNM 40735; Alb4935, 1, USNM 40790; Alb-4936, 2, USNM 40736; TM (KT9015, CB1-2), 4, ORI; TM (KT9015, HK2), 1, USNM 92816; TM (KT9015, HK5), 1, USNM 92817. *Previous Records:* Types of *F. politum*, USNM.

TYPES.—All types of *F. politum* are deposited at the USNM. *Type Locality:* Alb-5391: 12°13′15″N, 124°05′03″E (Philippines), 216 m.

DISTRIBUTION.—Japan: Eastern Channel of Korea Strait off southwestern Honshu; East China Sea off southern and southwestern Kyushu, including off Fukue Island and Osumi Retto; 70–402 m. *Elsewhere:* South China Sea, Philippines, Banda Sea; 40–717 m.

Subgenus *Flabellum (Ulocyathus)* Sars, 1851

DIAGNOSIS.—*Flabellum* having a serrate (jagged) calicular edge.

TYPE SPECIES.—*Ulocyathus arcticus* Sars, 1851 (= *Flabellum macandrewi* Gray, 1849), by monotypy.

Flabellum (U.) deludens Marenzeller, 1904

PLATE 32*d,e*

Flabellum japonicum.— Marenzeller, 1888a:45–46.

Flabellum deludens Marenzeller, 1904a:269–272, pl. 17: figs. 10, 10a.—Yabe and Eguchi, 1932a:387; 1942a:101–103, pl. 5: figs. 9a,c, 10a,c, 11a,c; 1942b:135–136, pl. 12: fig. 1a–c.—Eguchi, 1938: table 2; 1965:292, 2 figs; 1968:C44–45, pl. C22: figs. 4, 5; pl. C25: figs. 3, 4.—Utinomi, 1965: 256.—Eguchi and Miyawaki, 1975:58.—Cairns, 1989a:55–56, pl. 29: figs. a–f [synonymy].

?Flabellum cf. *apertum.*—Yabe and Eguchi, 1942a:89, pl. 5: fig. 12a,c; 1942b:136, pl. 12: fig. 3a–c.

DESCRIPTION.—Corallum highly compressed, with virtually planar thecal faces joined at sharp, carinate thecal edges. Thecal edge crests up to 2 mm in height and usually extend from pedicel to calice. Angle of thecal edges, 115°–150°; inclination of lateral faces, 44°–80°. GCD:LCD = 1.3–1.5. Largest Japanese specimen examined (Alb-4915) 47.9 × 37.7 mm in calicular diameter; however, Cairns (1989a) reported a larger specimen from the Philippines of 53 mm GCD. Thecal faces flat (unridged) and bear a uniform coarse granulation in addition to chevron-shaped growth lines looped between all costae but the C_5. Calicular edge deeply lacerate, a tall (up to 6 mm), rectangular thecal extension corresponding to each S_{1-2} and adjacent pair of S_4 (S_5 rarely developed adjacent to S_{1-2}). A smaller, triangular calicular apex up to 1.7 mm in height corresponds to each S_3. Theca and septa fragile. Base color white, with reddish brown stripes corresponding to the C_{1-2} and occasionally the C_3; septal faces of S_{1-2} also reddish brown near theca.

Septa hexamerally arranged in 5 cycles, the fifth cycle never complete even in large specimens. Medium-sized specimens (about 35 mm GCD) often have only 4 cycles of septa; larger specimens have pairs of S_5 that form adjacent to S_3 up to a total of 72 total septa. S_5 rarely form adjacent to S_{1-2}. S_{1-2} equal in size and have vertical, sinuous inner edges that define a deep, narrow fossa. S_3 about three-quarters width of an S_1 and also have sinuous inner edges. S_4 half to three-quarters width of an S_3 and have free inner edges, not fused to adjacent S_3 or the columella. When present, S_5 rudimentary. Lower, inner edges of S_{1-2} form an elongate columella; inner edges of S_3 barely attain the columella.

DISCUSSION.—*Flabellum deludens* is compared to *F. japonicus* in the account of the latter species. A more complete synonymy and description of this species is found in Cairns (1989a).

MATERIAL EXAMINED.—*New Records:* Alb-4933, 1, USNM 40701; Alb-5091, 1, USNM 92832; Alb-5092, 3, USNM 40760; Alb-5094, 2, CAS 16310 and 74992; YO69-3, 1, ORI; YO69-37-39, 1, USNM 92833; Tsuchida-197, 1, USNM 92834; TM (KT7802, Z4), 1, USNM 92835; TM (KT7811, OT1), 1, USNM 92836; TM (KT9015, BS2), 3, USNM 92837; TM (KT9202, OS3), 1, USNM 92838. *Previous Records:* Syntypes of *F. deludens*, ZMB; *Soyo Maru*-421, 1, TIUS 43443 (*F.* cf. *apertum* of Yabe and Eguchi, 1942a,b); Philippine specimens (Cairns, 1989a), USNM.

TYPES.—Two syntypes of *F. deludens* are deposited at the ZMB (#5086, 7086). *Type Locality: Valdivia* stations 185, 203: west of Sumatra, 614–660 m.

DISTRIBUTION.—Quite common off Pacific coast of Honshu (from 36°16′N southward), Shikoku, and Kyushu; East China Sea off southwestern Kyushu; Eastern Channel, Korea Strait; Sea of Japan off southwestern Honshu; 115–783 m. *Elsewhere:* Philippines, eastern Indian Ocean; 106–1035 m.

Flabellum (U.) japonicum Moseley, 1881

PLATE 32*g,h*

Flabellum japonicum Moseley, 1881:168–169, pl. 7: figs. 4, 4a; pl. 16: fig. 12.—Faustino, 1927:47–48, pl. 2: figs. 5, 6.—Yabe and Eguchi, 1942a:101, pl. 7: fig. 11a,c; 1942b:136, pl. 12: fig. 2a–c.—Eguchi, 1968:C45, pl. C28:

figs. 2, 3.—Kikuchi, 1968:8.—Fadlallah, 1983a:135.—Cairns, 1989a:56-57, pl. 29: figs. g-i [not Alb-5083] [synonymy].
Not *Flabellum japonicum*.—Marenzeller, 1888a:45-46 [= *F. deludens*].

DESCRIPTION.—Corallum campanulate, but laterally compressed, with gently rounded, slightly convex thecal faces and a sharp, crested thecal edge. Angle of thecal edges, 90°-108°; inclination of lateral faces, 65°-88°. GCD:LCD = 1.3-1.4. Largest specimen known (YO69-37-39) 57.6 × 39.5 mm in calicular diameter and 37.0 mm in height. Thecal edge crests up to 2.0 mm in height, but rarely extend to the calice of a medium- to large-sized specimen. Pedicel size constant throughout ontogeny, 2.5 × 2.0 mm in diameter and 2.0 mm in height. The 10 C_{1-2} occurring on thecal faces slightly raised as rounded ridges. Fine chevron-shaped thecal growth lines occur between all costae but C_5; theca otherwise smooth, not granular. In well-preserved specimens, calicular edge regularly serrate, with an equilaterally triangular apex up to 3.5 mm in height corresponding to each S_{1-2}, a smaller apex of about 1.3 mm in height corresponding to each S_3, and a very small apex about 0.5 mm in height corresponding to each S_4. Theca and septa thin and fragile, theca of lower half of corallum often discolored. Upper, fresh theca white or reddish brown, with more intense pigmentation occuring in stripes overlaying the C_{1-2} and upper, inner (thecal) edges of S_{1-2}.

Septa hexamerally arranged in 5 cycles according to the formula: $S_{1-2}>S_3>S_4>>S_5$. S_{1-2} have vertical, highly sinuous inner edges that define a deep, elongate fossa. S_3 about three-quarters width of an S_1 and also have sinuous inner edges. S_4 half to three-quarters width of an S_3 and have sinuous inner edges that often loosely join to their adjacent S_3 low in fossa. S_5 rudimentary, extending only partially down inner theca. Lower, inner edges of S_{1-2} form a rudimentary columella; inner edges of S_3 barely attain columella.

DISCUSSION.—Large, well-preserved specimens of *F. japonicum* are easily distinguished from *F. deludens* by having less serrate calicular margins (i.e., equilateral calicular apices vs rectangular). If the calicular edges are broken, which is common, *F. japonicum* can be distinguished by having less prominent edge crests near the calice; a less open corallum (a smaller edge angle); the presence of S_5 adjacent to S_{1-2}; and smooth, nongranular theca. Small specimens (GCD < 20 mm) are virtually indistinguishable. Comparisons to the closley related *F. apertum borealis* are made in the account of that species.

MATERIAL EXAMINED.—*New Records:* YO69-3, 3, USNM 92828; YO69-37-39, 3, USNM 92829, 2, ORI. *Previous Records:* One syntype of *F. japonicum;* specimens from off Japan and the Philippines reported by Cairns (1989a).

TYPES.—Eight syntypes of *F. japonicum* are deposited at the BM (uncataloged). *Type Locality: Challenger*-232: 35°11′N, 139°28′E (Sagami Bay), 631 m.

DISTRIBUTION.—Japan: Off southeastern Honshu from Sagami Bay to off Owase; Kii Strait, Shikoku; off Amakusa Islands, Kyushu; 119-631 m. *Elsewhere:* Philippines, Indonesia; 128-1141 m.

Flabellum (U.) apertum borealis, subsp. nov.

PLATE 32*f,i-l*

Not *Flabellum* cf. *apertum*.—Yabe and Eguchi, 1942a:89, pl. 5: fig. 12a-c; 1942b:136, pl. 12: fig. 3a-c [= ?*F. deludens*].
Flabellum apertum.—Cheng, 1977:135-137, 6 figs.
Flabellum japonicum.—Cairns, 1989a:57 [in part: Alb-5083].

DESCRIPTION.—Corallum campanulate and laterally compressed, the thecal edges forming a sharp angle but not crested. Angle of thecal edges, 90°-112°; inclination of lateral faces, 54°-75°. GCD:LCD = 1.17-1.32. Largest specimen examined (Alb-5086) 35.3 × 30.4 mm in calicular diameter and 31.6 mm in height. The 4 lateral C_1 are invariably ridged for a short distance about 9-14 mm above pedicel; C_2 not expressed. In well-preserved specimens, calicular edge is serrate, having a tall, isosceles triangular apex up to 4 mm in height corresponding to every S_{1-2} and a smaller apex corresponding to each S_3. Pedicel invariably eroded, the lower half to three-quarters of theca often discolored. Theca porcellaneous, without granulation; coralla often white or reddish brown with darker pigment overlaying the C_{1-2}.

Septa hexamerally arranged in 5 cycles according to the formula: $S_{1-2}>S_3>S_4>>S_5$, small specimens (GCD < 24 mm) have only 48 septa, but larger specimens (GCD > 30 mm) have a full fifth cycle. S_{1-2} have vertical, sinuous inner edges that define a very narrow, elongate fossa. S_3 two-thirds to three-quarters width of S_{1-2} and also have sinuous inner edges but do not fuse with the columella. S_4 about half width of an S_3 and do not fuse to adjacent S_3. S_5 rudimentary. Lower, inner edges of S_{1-2} form the rudimentary columella.

DISCUSSION.—This subspecies is similar to *F. apertum* in that both taxa have campanulate coralla and 6 ridged (but not crested) C_1. The Japanese subspecies differs in its tendency to have an additional cycle of septa (S_5) and thus more closely spaced septa. *Flabellum apertum borealis* also has a lesser upward inflection of its thecal faces above the ridged C_1, *F. apertum apertum* having a fuller, more campanulate corallum. Given the similarity of this form to typical *F. apertum*, but the disjunct distribution of the two forms (*F. apertum* is known only from the Subantarctic), this taxon is described as a subspecies of *Flabellum apertum*.

Flabellum apertum borealis could easily be confused with *F. japonicum*, but differs by (1) having protuberant (ridged) C_1, (2) lacking edge crests, (3) having S_3 that do not extend to the columella, (4) having a sharper calicular serration (isosceles apices vs equilateral apices), and 5) living at a greater depth.

ETYMOLOGY.—The subspecies name *borealis* (Latin *borealis*, meaning "boreal" or "northern"), refers to the disjunct northern distribution of this subspecies.

MATERIAL EXAMINED AND TYPES.—Holotype: Alb-5086, 1, USNM 40710 (Plate 32*f,i,l*). Paratypes: Alb-4960, 1, USNM 40703; Alb-4969, 1, CAS 74943; Alb-4973, 2, USNM 40705; Alb-5083, 1, USNM 40709, (Plate 32*j,k);* off Jogashima, Sagami Bay, depth unknown, 1, USNM 92841, 1, ORI; TM (KT9202, AT1), 1, USNM 92842; TM (KT9202, YT5), 6,

USNM 92843; TM (KT9202, YT6), 1, USNM 92844. Nontypes: Alb-5054, 4, USNM 40706. *Type Locality:* Alb-5086: 35°08′N, 139°20′E (Sagami Bay), 534 m.

DISTRIBUTION.—Japan from Sagami Bay to southwestern Kyushu, including Bungo Strait and northern Ryukyu Islands; southwest of Ishigaki Islands (east of Taiwan); 307–1141 m. Distribution of *Flabellum apertum apertum* is circumsubantarctic at 220–1500 m (Cairns, 1982).

Truncatoflabellum Cairns, 1989a

DIAGNOSIS.—Like *Flabellum,* but also reproducing asexually by transverse division resulting in a distal anthocyathus budded from a basal anthocaulus. Upper calicular margin smooth to slightly serrate. Most species with one or more pairs of thecal edge spines or edge crests on anthocyathus and one pair of spines on anthocaulus. Pali absent; columella rudimentary.

DISCUSSION.—Yabe and Eguchi (1942a,b) reported Recent *Flabellum rubrum* (Quoy and Gaimard, 1833) and three of its subspecies *(stokesii, debile,* and *candeanum)* from approximately 35 localities in Japanese waters (88–353 m); however, Squires (1963) convincingly demonstrated that *F. rubrum* is endemic to New Zealand waters, the species later being transferred to the genus *Monomyces* (see Cairns, 1989a). After examining about one-third of Yabe and Eguchi's (1942a,b) specimens of *F. rubrum,* I (Cairns, 1989a) concluded that they comprised at least four species: *Truncatoflabellum spheniscus, T. formosum, T. candeanum,* and *T. carinatum.* Other records of Japanese *F. rubrum* by Yabe and Eguchi (1932b), Eguchi (1938), Utinomi (1965), Kikuchi (1968), Eguchi (1968), and Eguchi and Miyawaki (1975) may also represent a mixture of species.

In similar manner, *Flabellum transversale* Moseley, 1881 was widely reported from Japanese waters as the nominate species and two subspecies (*conicum* Yabe and Eguchi, 1942a; and *triangulare* Eguchi, 1968) by Yabe and Eguchi (1942a), Eguchi (1968) and others: Yabe and Eguchi (1932a,b, 1941b, 1942b), Eguchi (1938, 1965), Mori (1964), and Eguchi and Miyawaki (1975). However, *F. transversale* appears to be endemic to the coast of Victoria, Australia (Cairns and Parker, 1992) and the Japanese records pertain to other species. Although I have not examined all of the records (summarized by Eguchi, 1968), the specimens reported as typical *F. transversale* (38–219 m) appear to represent at least three species: an undetermined fossil species of *Truncatoflabellum* (Yabe and Eguchi, 1942a, pl. 7: figs. 1–5, 12), an undetermined fossil species of *F. (Flabellum)* (Yabe and Eguchi, 1942a, pl. 7: fig. 6), and an undescribed Recent species of *Truncatoflabellum* (Yabe and Eguchi, 1942a, pl. 7: fig. 9a–c) similar to *T. formosum. Flabellum transversale* belongs to the nominate subgenus of *Flabellum.* The specimens identified as subspecies *F. transversale conicum* (70–219 m) (Plate 41*e,i*) and *F. transversale triangulare* (50–60 m) all appear to be juvenile specimens of undetermined species of *Flabellum (Flabellum)* or perhaps the anthocauli of a *Truncatoflabellum.* A precise identification is not attempted.

TYPE SPECIES.—*Euphyllia spheniscus* Dana, 1846, by original designation.

Key to the Temperate Northwest Pacific *Truncatoflabellum*

1. Edges of corallum bear one or more pairs of spines 2
   Edges of corallum do not bear spines: edges may bear crests or lack both spines and crests 5
2. Calicular edge slightly serrate; inclination of lateral faces (FAN) = 30°–41° . . . . . ***T. candeanum***
   Calicular edge smooth; face angle < 25° 3
3. Corallum small (GCD < 8 mm); calices having 32 septa; thecal edges virtually parallel . . . . . *T.* sp. B
   Corallum larger (GCD up to 50 mm); calices having 80-192 septa; thecal edge angle 37°–88° 4
4. Calice elongate (GCD:LCD = 2.3–3.4), containing 6 cycles of hexamerally arranged septa (192) . . . . . ***T. sphenicus***
   Calice elliptical (GCD:LCD = 1.4-1.9), containing 80 septa arranged in 3 size classes . . . . . ***T. formosum***
5. Edges of coralla without crests; lives at depth greater than 900 m . . . . . *T.* sp. A
   Edges of coralla bear 1 or more crests; lives at less than 300 m 6
6. Coralla have five cycles of septa (96) and several pairs of edge crests; edge angle 35–57 . . . . . ***T. carinatum***
   Coralla with fifth cycle of septa absent or incomplete (48–66 septa) and only 1 pair of basal edge crests; edges virtually parallel . . . . . ***T. gardineri***

Truncatoflabellum spheniscus (Dana, 1846)

PLATE 33*a–d*

Euphyllia spheniscus Dana, 1846:160–161, pl. 6: fig. 1a–e.
Flabellum debile Milne Edwards and Haime, 1848a:274.
Flabellum bairdi Milne Edwards and Haime, 1848a:274–275 [new synonymy]; 1857:93.—Cairns, 1989a:66–67, pl. 33: fig. k; pl. 34: figs. a–c.
Flabellum profundum Milne Edwards and Haime, 1848a:276 [new synonym]; 1857:93–94, pl. D1: figs. 5, 5a.—Cairns, 1989a:67, pl. 34: figs. d–h.
Flabellum crenulatum Milne Edwards and Haime, 1848a:277 [new synonym]; 1857:95.—Yabe and Eguchi, 1942b:134.
?Flabellum sumatrense Milne Edwards and Haime, 1848a:271; 1857:89.
Flabellum affine Milne Edwards and Haime, 1848a:274.
?Flabellum stokesi.—Yabe and Eguchi, 1932b:443.
Flabellum rubrum stokesii.—Yabe and Eguchi, 1942a:98–99 [in part: pl. 8: fig. 5a–c].
?Flabellum cf. *multifore*.—Yabe and Eguchi, 1942a:103, pl. 6: fig. 8a–c; 1942b:136.
Flabellum rubrum debile.—Yabe and Eguchi, 1942b:132–133 [in part: pl. 11: fig. 15a–c].—Not Kikuchi, 1968:8, pl. 5: fig. 13 [= *Truncatoflabellum*].
Truncatoflabellum spheniscus.—Cairns, 1989a:65–66, pl. 32: figs. g–k [synonymy].

DESCRIPTION.—Anthocyathus robust and highly compressed (GCD:LCD = 2.3–3.4), the planar thecal faces meeting in rounded thecal edges that bear 1 or 2 pairs of thecal spines. Angle of thecal edges large, 57°–88°; inclination of lateral faces narrow, 20°–31°. Largest specimen known (holotype of *F. profundum*) 50.0 × 21.0 mm in calicular diameter and 35.1 mm in height. Basal scar of anthocyathus usually large: 5.3–7.3 × 11.5–13.5 mm in diameter. Upper calicular margin evenly arched and smooth to very finely serrate. In well-preserved specimens fine chevron-shaped thecal growth lines form apices at every S_{1-5}. In other specimens (e.g., types of *F. profundum*) growth lines are lacking but coarse longitudinal costae corresponding to C_{1-3} are present. Theca reddish brown to blackish brown in color, concentrating in bands parallel to calicular margin.

Septa essentially hexamerally arranged in 6 cycles (192 septa), larger specimen having several pairs of S_7 in end half-systems, and smaller specimens having developmental stages of 40, 42, 44, or 46 primary septa (S_{1-4}), with a corresponding number of S_5 and S_6, resulting in 160, 168, 176, or 184 septa. Primary septa (S_{1-4}) slightly concave (notched) near calicular margin but project well into fossa and have slightly sinuous inner edges that thicken near the columella. S_4 of small- to medium-sized specimens sometimes slightly less wide than the S_{1-3}, but their lower, inner edges also attain the columella. Secondary septa (S_5) only about half the width of a secondary and do not attain the columella. Tertiary septa (= S_6) rudimentary, only about one-quarter width of a secondary. Fossa deep and elongate, containing a well-developed columella about 1.1–1.5 mm wide composed of the fusion of the lower, inner edges of the S_{1-4}.

DISCUSSION.—I (Cairns, 1989a) previously included *Flabellum debile* and *F. affine* in the synonymy of *Truncatoflabellum spheniscus*, but treated *Truncatoflabellum profundum* and *T. bairdi* as separate species based on their lesser number of septa and/or thecal texture. These latter two species were known from very few specimens, essentially their type series, which led to an unavoidably typological characterization. A lot of 13 specimens from the Formosa Strait (CAS 74990), however, allowed a study of variation as it related to corallum size, which demonstrated the developmental stages of septal insertion characteristic of the other nominate species.

Truncatoflabellum spheniscus is distinguished from the other Indo-West Pacific congeners by its high thecal edge angle (57°–88°) and its narrow, elongate calice that results in the high GCD:LCD of 2.3–3.4.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, CB-00-1), 2, USNM 92796; TM (KT9015, CB-02-2), 12, USNM 92798; TM (KT9015, HK2), 2, USNM 92799; TM (KT9202, CB1-2), 17, USNM 92797; TM (KT9202, YT1), 5, USNM 92800; TM (KT9202, YT2), 5, USNM 92801; off Pescadores Islands, Taiwan Strait, 30–50 m, 5 May 1972, 13, CAS 74990. *Previous Records:* 4 syntypes of *F. spheniscus*, USNM; holotypes of *F. bairdi*, *F. profundum*, *F. crenulatum*, and *F. sumatrense*; *Soyo Maru*-339, 1, TIUS 50228 (*F. rubrum stokesi* of Yabe and Eguchi, 1942a); *F.* cfr. *multifore* of Yabe and Eguchi (1942a), TIUS 41052.

TYPES.—The four syntypes of *Euphyllia spheniscus* are deposited at the USNM (89, 91-93). *Type Locality:* Off Singapore, 3–6 m.

The illustrated syntype of *F. debile* is deposited at the BM (1855.12.27.2). *Type Locality:* Philippines, depth unknown.

The holotype of *F. profundum* is deposited at the MNHNP (1026). *Type Locality:* "Off China," depth unknown.

The holotype of *F. crenulatum* is deposited at the MNHNP (1020). *Type Locality:* Unknown.

The holotype of *F. sumatrense* is deposited at the MNHNP (374). *Type Locality:* Off Sumatra, depth unknown.

The holotype of *F. affine* appears to be lost. *Type Locality:* Sir Charles Hardy Island, Torres Strait, depth unknown.

DISTRIBUTION.—Japan: Tosa Bay, Shikoku; Eastern Channel, Korea Strait, Honshu; Osumi Shoto, northern Ryukyu Islands; 66–106 m. *Elsewhere:* Formosa Strait, South China Sea; off Singapore; Philippines; Torres Strait; ?off Sumatra; 2–36 m.

Truncatoflabellum candeanum (Milne Edwards and Haime, 1848)

PLATE 33*e,f*

Flabellum candeanum Milne Edwards and Haime, 1848a:278, pl. 8: fig. 13.—Marenzeller, 1888a:46–48.
Flabellum elegans Milne Edwards and Haime, 1848a:277.
Flabellum rubrum.—Yabe and Eguchi, 1942a:96–98 [in part: form C, pl. 8: figs. 13–15, 21, 22].
?Flabellum candeanum.—Yabe and Eguchi, 1942b:133–134.—Kikuchi, 1968:8.
Truncatoflabellum candeanum.—Cairns, 1989a:70–71, pl. 36: figs. d–h [synonymy].

DIAGNOSIS.—Angle of rounded thecal edges 50°–80°;

inclination of convex thecal faces 30°–41°. Large specimens up to 32 × 16 mm in calicular diameter and 22 mm in height. Two or three pairs of long thecal edge spines on anthocyathus. Basal scar 4-6 × 3-4 mm in diameter. GCD:LCD = 1.6–1.7. Calicular edge slightly scalloped, the apices corresponding to the primary septa. Septa arranged in 3 size classes, usually 20:20:40 (80 septa). Columella well developed.

DISCUSSION.—Based on the six small specimens reported herein little can be added to my previous redescription of this species (Cairns, 1989a) except that the anthocyathus basal scar may attain a greater diameter of up to 8 mm.

Truncatoflabellum candeanum is distinguished from its congeners by its very long and broad edge spines; its slightly scalloped calicular margin; its relatively wide thecal face angle (30°–41°); and its striped reddish brown corallum (see Cairns, 1989a, table 6).

MATERIAL EXAMINED.—*New Records:* TM (KT9015, HK3), 3 including 2 anthocauli, USNM 92802, 2, ORI; TM (KT9015, HK5), 1 anthocyathus, USNM 92803. *Previous Records:* Neotype of *F. candeanum;* holotype of *F. elegans; F. candeanum* of Marenzeller (1888a), 1, ZMB 8194; *Soyo Maru*-422 (2) and 465 (Plate 33*e*)(3 of 4 mentioned), TIUS 50233 and 50229, respectively (*F. rubrum* of Yabe and Eguchi, 1942a); Philippine specimens of Cairns (1989a).

TYPES.—The neotype of *Flabellum candeanum,* designated by Cairns (1989a:71), is deposited at the USNM (81963). *Type Locality:* Alb-5369: 13°48′N, 121°43′E (Tayabas Bay, Luzon, Philippines), 194 m.

The holotype of *F. elegans* is deposited at the BM (1846.7.1.58). *Type Locality:* ?Japan, depth unknown.

DISTRIBUTION.—Japan: Eastern Channel, Korea Strait, Honshu; northwestern Kyushu; off Kagoshima, southwestern Kyushu; reports off Shikoku by Yabe and Eguchi (1942b) and Kikuchi (1968) are not verified; north of Pratas Islands, South China Sea; 88-223 m. *Elsewhere:* Philippines, Celebes Sea; 70–249 m.

Truncatoflabellum formosum Cairns, 1989

PLATE 33*g,h*

Flabellum rubrum.—Yabe and Eguchi, 1942a:96-98 [in part: form A, pl. 8: figs. 16-19, 23, 24]; 1942b:131-132 [in part: *Soyo Maru*-107, 540, pl. 11: fig. 14].

Truncatoflabellum formosum Cairns, 1989a:69-70, pl. 35: figs. j,k; pl. 36: figs. a,b.—Cairns and Keller, 1993:265, figs. 10I, 11A.

Truncatoflabellum n. sp.: Cairns, 1989a:73, pl. 38: figs. g,h.

DESCRIPTION.—Corallum compressed, the convex thecal faces meeting in rounded thecal edges. Angle of thecal edges, 37°–48°; inclination of thecal faces, 18°–25°. Largest specimen known (anthocyathus from TM (CR79-18)) 26.7 × 14.5 mm in calicular diameter and 28.9 mm in height, having a basal scar of only 3.3 × 4.6 mm. Two pairs of edge spines usually present, the lower pair cylindrical in cross section and pointed downward, the upper pair much more broadly based and oriented perpendicular to theca. GCD:LCD = 1.42–1.85. Theca reddish brown to white, bearing very fine transverse (not chevron-shaped) epithecal corrugations. Inside calice, 1–2 mm below calicular edge, theca adjacent to each of the 20 primary septa is lightly pigmented against a white background, giving the impression of a circumferential band within the theca. Calicular margin smooth.

Septa arranged in 3 distinct size classes in all specimens examined regardless of calicular diameter, accordingly: 20:20:40 (80 total septa). Primary septa nonexsert, their upper, outer margins meeting the thecal wall in a broad, graceful arch. Inner edges of primary septa vertical and slightly sinuous, merging with the columella. Secondary septa half to two-thirds width of primaries, their inner edges less sinuous and not attaining the columella. Tertiary septa only one-quarter to one-third width of a secondary. Fossa deep and narrow, containing an elongate, solid columella formed from fusion of lower, inner edges of 20 primary septa.

DISCUSSION.—*Truncatoflabellum formosum* differs from other species in the genus by having a septal arrangement of 20:20:40 and having attenuate primary septa. I (Cairns, 1989a:69) previously indicated that one of Yabe and Eguchi's (1942a, pl. 8: fig. 14) specimens of *F. rubrum* was *T. formosum,* but, this synonymy should have read: pl. 8: fig. 16a–c.

MATERIAL EXAMINED.—*New Records:* Alb-4903, 4, USNM 40789; Alb-4937, 1, USNM 40791; TM (CR79-18), 1, USNM 92804. Pleistocene of Ryukyu Islands, 1, TIUS. *Previous Records:* Types of *T. formosum,* USNM; *Flabellum rubrum* form A of Yabe and Eguchi (1942a,b): *Soyo Maru*-465, 1, TIUS 50229; *Soyo Maru*-107, 1, TIUS 50231; ?*Soyo Maru*-540, 1, TIUS 50230.

TYPES.—The type series of *T. formosum* is deposited at the USNM. *Type Locality:* Alb-5249: 7°06′06″N, 125°40′08″E (Daveo Gulf, off Mindinao, Philippines), 42 m.

DISTRIBUTION.—Japan: Off Boso Hanto, Honshu; off Kii Peninsula, Honshu; Tosa Bay, Shikoku; East China Sea off southwestern Kyushu; Eastern Channel, Korea Strait; Sea of Japan, Wakasa Bay, Honshu; 106–210 m. *Elsewhere:* Philippines, Celebes Sea, southwest Indian Ocean; 37–933 m.

Truncatoflabellum carinatum Cairns, 1989

PLATE 33*j,k*

Flabellum rubrum.—Faustino, 1927:53 [in part: Alb-5311].—Yabe and Eguchi, 1942a:96–98 [in part: *Soyo Maru* 222, pl. 8: figs. 6-12, 20]; 1942b:131-132 [in part].

Flabellum rubrum stokesii.—Yabe and Eguchi, 1942a:98-99 [in part: *Soyo Maru*-295, 304].

Truncatoflabellum carinatum Cairns, 1989a:73-74, pl. 38: figs. b–e.

DESCRIPTION.—The following description is based on one well-preserved specimen from off the Pescadores Islands (ex CAS 74990). Corallum (anthocyathus) compressed, the evenly convex thecal faces meeting in an acute angle at thecal edges. Three or 4 pairs of low (about 1.0 mm in height) discontinuous

crests or spurs (not spines) occur along each thecal edge. Corallum 26.7 × 14.4 mm in calicular diameter, 22.5 mm in height, and 3.7 × 6.2 mm in basal scar diameter, making it the largest specimen known. Edge angle 57°; inclination of lateral faces, 33°. Theca white and somewhat rough, displaying chevron-shaped epithecal growth lines that peak at the 24 S_{1-3}.

Septa hexamerally arranged in 5 complete cycles, with 4 additional pairs of S_6 in quarter-systems adjacent to the 2 principal septa (104 septa). S_{1-3} have vertical, sinuous inner edges that attain the columella. Septal faces distinctively lined with 15–18 low ridges oriented perpendicular to the septal edge, each ridge bearing a series of low, triangular granules. Ridges alternate in position with those on opposite face of same septum. S_4 about two-thirds width of an S_{1-3} and have poorly formed, finely dentate inner edges that do not fuse with the columella. S_5 quite small, only about one-quarter width of an S_4. The 4 pairs of S_6 are rudimentary. Fossa deep and elongate, containing a well-formed, elongate columella about 2.1 mm wide.

DISCUSSION.—All previously reported specimens of this species were poorly preserved, either represented as fossils or Recent specimens that were dead when collected. The specimen described above is the largest known specimen and is well preserved, making possible an improvement of the original description. *Truncatoflabellum carinatum* is distinguished from most congeners by having nonspinose but acutely angled and crested thecal edges; a very small face angle, especially near the basal scar; and a rather small basal scar. The edge spines attributed to this species by Cairns (1989a) are more accurately interpreted as low, discontinuous edge crests.

MATERIAL EXAMINED.—*New Records:* Alb-5311, 6, USNM 40787; off Pescadores Islands, Formosa Strait, South China Sea, 30–50 m, 1, ex CAS 74990. *Previous Records:* Types of *T. carinatum; F. rubrum* of Yabe and Eguchi (1942a,b): Pleistocene of Tonbe, Sizuoko-ken, 2, TIUS 29233; Pliocene of Koti-ken, 1, TIUS 43434; *F. rubrum stokesii* of Yabe and Eguchi (1942a), *Soyo Maru*-295, 1, TIUS 51220; *F. rubrum* of Yabe and Eguchi (1942a), *Soyo Maru*-222, 3, TIUS 50232.

TYPES.—The holotype and most paratypes of *T. carinatum* are deposited at the USNM; 1 paratype is also at the Australian Museum. *Type Locality:* Alb-5312: 21°30′N, 116°32′E (north of Pratas Island, South China Sea), 256 m.

DISTRIBUTION.—*Recent:* Formosa Strait north of Pratas Islands, South China Sea; southeastern coast of Kyushu; Tusa Bay, Shikoku; 30–274 m. Pliocene-Pleistocene of Honshu and Shikoku, Japan.

Truncatoflabellum gardineri Cairns, 1993

PLATE 34*a,b*

Truncatoflabellum gardineri Cairns in Cairns and Keller, 1993:266, figs. 11B–D.

DESCRIPTION.—Coralla elongate and compressed, having a relatively low thecal edge angle of 21°–39°, the thecal edges becoming almost parallel in upper region of some coralla. Inclination of thecal faces, 18°–23°. Largest specimen from Japan (TM (KT9202, OS3) 16.7 × 11.3 mm in calicular diameter and 19.8 mm in height, with a basal scar diameter of 3.7 × 4.5 mm. Calicular edge smooth; GCD:LCD = 1.30–1.48. Basal scar of anthocyathus rather small and elliptical, almost circular, ranging from 4.5–4.7 × 3.3–3.7 mm in diameter. Thecal edges rounded except for region approximately 3–10 mm above basal scar, which extends as a single narrow crest up to 2.5 mm in height. Theca bears narrow longitudinal striae corresponding to each septum as well as chevron-shaped growth lines that peak at all but last septal cycle. In one well-preserved corallum, the theca was reddish brown with an indication of longitudinal striping along the major septa.

Septa hexamerally arranged in 4 complete to 5 incomplete cycles according to the formula: $S_{1-2}>S_3>S_4>S_5$. Coralla less than 11 mm GCD usually have 48 septa arranged in 4 complete cycles. Between a GCD of 11–14 mm pairs of S_5 begin to appear in the quarter-systems directly adjacent to the 2 principal septa (50–56 septa) with a corresponding increase in the width of the flanked S_4 to the size of an S_2 and the acceleration of the adjacent S_3 to the size of an S_{1-2}. Above a GCD of 15 mm additional pairs of S_5 may occur in the remainder of the end half-systems and even quarter-systems adjacent to those, up to a total of 66 septa. S_{1-2} wide and have thickened, sinuous lower inner edges that fuse with the columella. S_3 about half width of S_{1-2} and do not attain the columella, unless it is adjacent to an S_5 (see above), in which case it is almost as wide as an S_{1-2} and fuses with the columella. S_4 small, only about one third width of an S_3, larger if flanked by a pair of S_5. S_5 rudimentary. Septa widely spaced, separated from one another by 2–3 septal thicknesses. Fossa deep and narrow, containing a well-developed elongate fossa about 1.8 mm wide.

DISCUSSION.—The only differences between the Japanese specimens of *T. gardineri* and the type series of that species from off Durban, South Africa is that the Japanese specimens are larger and thus have more septa. The largest South African specimens of 11–12 mm GCD have 56 septa, which is consistent with the number of septa of a Japanese specimen of equivalent size.

Truncatoflabellum gardineri is most similar to *T. carinatum*, both species having acutely angled thecal edges that bear low crests (not spines), but *T. gardineri* can be distinguished by having only one pair of edge spines, virtually parallel thecal edges, and fewer septa (see Key 2).

MATERIAL EXAMINED.—*New Records:* TM (KT9015, CB6-1), 1, USNM 92807; TM (KT9202, KB3), 3, USNM 92808; TM (KT9202, OS3), 17, USNM 92809, 2, ORI. *Previous Records:* Types of *T. gardineri.*

TYPES.—The holotype and most paratypes of *T. gardineri* are deposited at the USNM (91736, 91737); 3 paratypes are also deposited at the South African Museum. *Type Locality: Anton Bruun*-390S: 29°34′S, 31°42′E (off Durban, South Africa), 138 m.

DISTRIBUTION.—Japan: Oki Strait, Honshu, Sea of Japan; Osumi Strait, Kyushu; 100–144 m. *Elsewhere:* Off Durban, South Africa; 138 m.

Truncatoflabellum sp. A

PLATE 34*c–e*

?Flabellum stabile Marenzeller, 1904a:273–274, pl. 17: fig. 12.—Zibrowius, 1980:150.

?Truncatoflabellum stabile.—Cairns, 1989a:61.—Zibrowius and Gili, 1990:39.

Truncatoflabellum sp. cf. *T. stabile.*—Cairns and Keller, 1993:264–265, fig. 10C,F.

DESCRIPTION BASED ON 2 SPECIMENS FROM TM (KT9202, YT6).—Angle of straight thecal edges 60°–65°; inclination of slightly convex thecal faces, 33°–34°. Thecal faces meet in acutely angled edges that are quite long but that lack spines and crests. Largest specimen: 42.6 × 26.5 mm in calicular diameter and 40.5 mm in height, with a basal scar diameter of 2.1 × 6.0 mm. Calicular edge arched and finely serrate; GCD:LCD of both specimens 1.61; GCD:H = 1.05–1.07. Basal scar small in relation to corallum size: 2.1–2.6 × 5.0–6.0 mm. Even though these specimens appear to have been collected alive, the theca is quite worn and chalky in texture.

Septa hexamerally arranged in 5 complete cycles according to the formula: $S_{1-3}>S_4>S_5$, both specimens having 96 septa. S_{1-3} wide, their lower, inner edges thickened and sinuous, fusing with the medial columella. S_4 about three-quarters width of an S_{1-3} and do not fuse with the columella. S_5 small, only about one-quarter width of an S_4. Fossa deep and elongate, containing a well-developed columella about 3 mm in width.

DISCUSSION.—Five species of *Truncatoflabellum* are characterized as having nonspinose and noncrested thecal edges: *T. paripavoninum* (Alcock, 1898); *T. stabile* (Marenzeller, 1904a); *T. inconstans* (Marenzeller, 1904a); *T. trapezoideum* (Keller, 1981b); and *Truncatoflabellum* sp. (Zibrowius and Gili, 1990). All but *T. inconstans* are found exclusively in deep water (600–3000 m). Having five cycles of septa, the Japanese specimens must be compared to *T. trapezoideum* and *T. stabile,* the other species having either four or six cycles of septa. The Japanese specimens differ from *T. trapezoideum* in having a much smaller basal scar; nonridged costae; rounded thecal edges; and a much taller corallum (having a lower GCD:H ratio, 1.05–1.07 vs about 1.20 for *F. trapezoideum*). They are, however, very similar to *T. stabile,* especially to the specimen reported from off Mozambique by Cairns and Keller (1993). Because the types of *F. stabile* are lost and there are few other specimens of this species with which to compare, the identity of the Japanese specimens remains uncertain.

MATERIAL EXAMINED.—*New Records:* TM (KT9202, YT6), 2, USNM 92810. *Previous Records:* Specimen reported by Cairns and Keller (1993), IOM.

TYPES.—The two syntypes of *Flabellum stabile* are presumed to be lost. *Type Locality: Valdivia*-37: 16°14′01″N, 22°38′03″W (Cape Verde Islands), 1694 m.

DISTRIBUTION.—Japan: Off Osumi Shoto, northern Ryukyu Islands; 964–1031 m. *Elsewhere:* Off Cape Verde, Selvagems, and Madeira Islands; off southeastern Mozambique; 1450–3010 m.

Truncatoflabellum sp. B

PLATE 33*i,l*

DESCRIPTION OF SPECIMEN FROM TM (KT9202, TY1).—Corallum 5.9 × 3.1 mm in calicular diameter (GCD:LCD = 1.9) and 17.8 mm in height, with a basal scar diameter of 3.7 × 2.3 mm. Thecal edges rounded and straight, virtually parallel to one another as are the convex thecal faces. Thecal edges bear 6 pairs of small (0.4 mm in diameter), hollow spines. Thecal faces porcellaneous and reddish brown in color, the pigmentation stonger in crescent-shaped bands parallel to upper calicular edge.

Septa hexamerally arranged in 3 cycles plus 4 pairs of S_4 in end half-systems for a total of 32 septa. S_{1-2} equal in size and have sinuous inner edges that reach the columella. S_3 half width of S_{1-2} and do not reach the columella unless they are flanked by a pair of S_4, in which case they are the same width of an S_{1-2}. S_4 small, only about one-quarter width of an S_3. Columella robust, about 1.1 mm wide.

DISCUSSION.—This species is distinguished from its congeners by its virtually parallel thecal edges and elongate corallum. Together with additional specimens from the Kermadec Islands, these specimens will form the basis of the description of a new species (Cairns, in prep.).

MATERIAL EXAMINED.—TM (KT9202, YT1), 1, USNM 92811.

DISTRIBUTION.—Japan: Osumi Shoto, northern Ryukyu Islands; 80–88 m. *Elsewhere:* Kermadec Islands.

Placotrochides Alcock, 1902b

DIAGNOSIS.—Corallum compressed-cylindrical; transverse division present, resulting in an anthocyathus with a basal scar almost as large at its calicular diameter. Thecal spines absent. Three to four cycles of nonexsert septa; calicular edge smooth. Columella well developed, trabecular.

TYPE SPECIES.—*Placotrochides scaphula* Alcock, 1902b, by subsequent designation (Wells, 1936).

Placotrochides scaphula Alcock, 1902

PLATE 34*f–h*

Placotrochides scaphula Alcock, 1902b:121–122; 1902c:34, pl. 4: figs. 32, 32a.—Cairns, 1989a:78–79, pl. 40: fig. 1; pl. 41: figs. a–e [synonymy].—Cairns and Keller, 1993:272–273, fig. 12D,G.

DESCRIPTION.—Corallum shaped like a flattened cylinder, with virtually parallel thecal faces and parallel, rounded thecal edges. No edge spines. Largest Japanese specimen 10.0 × 5.4 mm in calicular diameter and 9.4 mm in height, with a basal scar measuring 9.5 × 5.3 mm, almost as large as the calice.

Theca marked by thin (0.05 mm wide), shallow, vertical striae that delimit wide (0.5–0.6 mm), flat costae.

Septa hexamerally arranged in 4 cycles according to the formula: $S_{1-2}>S_3>S_4$, 4 pairs of S_4 often lacking resulting in 40 septa. S_{1-2} about one-third LCD in width, their vertical, slightly sinuous lower, inner edges fusing to the columella. S_3 unflanked by S_4 only about one-quarter width of an S_1 and have finely serrate inner edges; however, if S_3 are flanked by a pair of S_4, they are about three-quaters width of an S_1 and have smooth inner edges that fuse with the columella. S_4 rudimentary, only about 0.3–0.4 mm wide, and have finely serrate inner edges. All septa relatively thin (S_{1-2} about 0.2 mm thick) and widely spaced, i.e., 0.5–0.6 mm from one another. Fossa deep and elongate, containing a well-developed, elongate trabecular columella that occupies the medial third of fossa.

DISCUSSION.—*Placotrochides* is very similar to *Truncatoflabellum,* but can be distinguished by its more robust columella, and by having virtually parallel thecal edges and faces. Only one other species is known in the genus, *P. frustum* Cairns, 1979 (nom. correct.), which is known only from the Atlantic. It is distinguished by its smaller corallum size and fewer (≤26) number of septa.

MATERIAL EXAMINED.—*New Records:* TM (KT7911, OT4), 5,USNM 92748; TM (KT9202, YT1), 2, USNM 92749, 1, ORI. *Previous Records:* Holotype of *P. scaphula;* Philippine specimens (Cairns, 1989a).

TYPES.—The holotype of *P. scaphula* is deposited at the ZMA (Coel. 1094). *Type Locality: Siboga*-212: 5°54.5′S, 120°19.2′E (Flores Sea), 462 m.

DISTRIBUTION.—Japan: Suruga Bay, Honshu; Osumi Shoto, northern Ryukyu Islands (first records for Japan); 80–457 m. *Elsewhere:* Philippines, Flores Sea; southwest Indian Ocean; 462–1628 m.

Javania Duncan, 1876

DIAGNOSIS.—See Part 1.

Javania insignis Duncan, 1876

PLATE 34*i–k*

Javania insignis Duncan, 1876:435, pl. 39: figs. 11–13.—Zibrowius, 1974b: 8–9, pl. 1: figs. 1–6.—Cairns, 1989a:77–78, pl. 40: figs. d,e,g,h,j,k [synonymy].—Cairns and Keller, 1993:272.

Flabellum weberi Alcock, 1902a:107.

Desmophyllum cf. *insigne*.—Yabe and Eguchi, 1942b:115, pl. 9: figs. 5, 6.

Desmophyllum insignis.—Eguchi, 1965:290, 2 figs.; 1968:C41–42, pl. C9: figs. 4–9.—Song, 1982:136, pl. 2: figs. 5, 6; 1988:27–28, pl. 3: figs. 9–11; 1991:134.

DESCRIPTION.—Corallum ceratoid and robust, with thick theca and septa, and a massive, stereome-reinforced pedicel 24%–55% of GCD. Largest Japanese specimen examined (ZMC: Fukue Jima) 32.7 × 24.9 mm in calicular diameter and 56.2 mm in height, with a pedicel 7.8 mm in diameter, although a slightly larger specimen was reported by Cairns (1984) from Christmas Island. Theca milky white and smooth, sometimes porcellaneous.

Septa hexamerally arranged in 5 complete cycles according to the formula: $S_{1-2}>S_3>S_4>S_5$ (96 septa). S_{1-2} exsert as much as 4 mm and have quite thick, straight, vertical inner edges that disappear into the fossa. S_3 exsert as much as 2.5 mm, about four-fifths width of an S_1, and have relatively thin inner edges. S_{4-5} nonexsert, the S_4 only about one-third width of an S_3, the S_5 about half width of an S_4. S_{1-2} often so thick that their adjacent S_5 are fused to them. Fossa very deep and elongate; no columella visible.

DISCUSSION.—I (Cairns, 1989a:77) previously cited and figured Alcock's "manuscript type" of *Flabellum weberi* as a specimen of *J. insignis*. Because *F. weberi* was not reported by Alcock (1902c) in his *Siboga* report, I assumed that he had chosen not to describe this species. But since 1989, I have become aware of two obscure papers published by Alcock (1902a,b) in July, 1902, one month before his *Siboga* report was published, in which he briefly described most of the *Siboga* new species. However, for some reason, eight species described in those earlier papers (Alcock, 1902a,b) were not redescribed in the later *Siboga* report (Alcock, 1902c), *F. weberi* being one of them. Thus, *F. weberi* is a legitimate junior synonym of *J. insignis,* not merely a manuscript type.

Javania insignis is compared to *J. borealis* in the account of that species.

MATERIAL EXAMINED.—*New Records:* TM (KT7811, OT6-2), 1, USNM 92744; TM (KT9015, CB1-2), 1, USNM 92745; off Jogashima, Sagami Bay, 1, USNM 92746, 1, ORI; off Misaki, Sagami Bay, 1, ZMC; 32°26′N, 128°37′E, 249 m, 1, ZMC. *Previous Records:* Holotype of *F. weberi,* ZMA; Philippine and Japanese specimens (Cairns, 1989a).

TYPES.—The holotype of *J. insignis* is deposited at the BM (1973.2.20.1). *Type Locality:* 34°13′N, 136°13′E (off Owase, Mie-ken, Honshu), 88 m.

The holotype of *F. weberi* is deposited at the ZMA (Coel. 1232). *Type Locality: Siboga*-310: 8°30′S, 119°07.5′E (Flores Sea), 73 m.

DISTRIBUTION.—Japan: Sagami and Suruga Bays, Honshu; off Owase, Mie-ken, Honshu; East China Sea off Fukue Jima; Eastern Channel, Korea Strait, off southwestern Honshu; southern Cheju Do, Korea; 46–249 m. *Elsewhere:* Widespread, including Hawaiian Islands, Philippines, Indonesia, Red Sea, and southwest Indian Ocean; 73–825 m.

Javania cailleti (Duchassaing and Michelotti, 1864)

ACCOUNT.—See Part 1.

Javania borealis sp. nov.

ACCOUNT.—See Part 1.

Rhizotrochus Milne Edwards and Haime, 1848a

DIAGNOSIS.—Corallum ceratoid to turbinate or compressed. Transverse division absent; pedicel small and not reinforced with stereome. Thecal spines absent; however, 2–20 slender

hollow rootlets anchor corallum base, the rootlets tending to be concentrically arranged in cycles. Three to six cycles of nonexsert septa, the lower cycle septa being highly concave near calicular edge. Pali absent; columella rudimentary.

TYPE SPECIES.—*Rhizotrochus typus* Milne Edwards and Haime, 1848a, by monotypy.

Rhizotrochus typus Milne Edwards and Haime, 1848

PLATES 35*a–c*, 40*h,i*

Rhizotrochus typus Milne Edwards and Haime, 1848a:282, pl. 8: fig. 16.—Cairns, 1989a:79–81, pl. 41: figs. f–j [synonymy].

Rhizotrochus niinoi Yabe and Eguchi, 1942b:136–137, 154–155, pl. 12: fig. 4a,b [new synonym].

Monomyces niinoi.—Eguchi, 1965:292, 2 figs; 1968:C48-49.—Kikuchi, 1968:8, pl. 5: fig. 9.

Monomyces typica.—Eguchi, 1968:C49.

Flabellum transversale.—Nishimura and Suzuki, 1971:11, pl. 4: fig. 1.

Monomyces uchiuraensis Eguchi, 1972:160, pl. 1: figs. 1–7; 1973:83–84, pl. 1: figs. 1, 2.

DISCUSSION.—Based on the 10 small specimens reported herein, nothing can be added to the characterization (Cairns, 1989a) of this species. *R. typus* is distinguished from the other Pacific species, *R. levidensis* Gardiner, 1899 (Loyalty Islands), by having a rather squat (trochoid) corallum; up to six cycles of septa; and one to two or more cycles of rootlets (6, 18, ≥20). *Rhizotrochus levidensis* has a much smaller, ceratoid corallum; an incomplete fourth cycle of septa; and 7 or less rootlets.

At a GCD of 10–12 mm a full four cycles of septa are usually present; between 12–27 mm the fifth cycle is formed; and above 27 to 57 mm GCD the sixth cycle is formed, but never fully completed (Cairns, 1989a). The holotype of *R. niinoi* has a GCD of 9.75 mm and has 48 septa (the S_4 being rudimentary), which is consistent with the ontogeny of *R. typus*. Furthermore, at this small size it is not unusual for the S_1 to be larger and thicker than the S_2. It can also be seen from this small specimen that the pores that lead to the first ring of six rootlets flank the six S_1, whereas the pores that correspond to the second, higher ring of 6–12 rootlets flank both the S_1 and S_2.

MATERIAL EXAMINED.—*New Records:* Off Misaki, Sagami Bay, depth unknown, 9, USNM 92750, 1, ORI; Okinose, Sagami Bay, 110 m, 1, ZMC. *Previous Records:* Holotype of *R. niinoi*, TIUS; Philippine specimens (Cairns, 1989a). *Reference Specimens:* 3 syntype of *R. levidensis*, BM 1970.1.26.9-10.

TYPES.—Two syntypes of *R. typus* are deposited at the MNHNP. *Type Locality:* Singapore, depth unknown.

The holotype (Plate 40*h,i*) of *R. niinoi* is deposited at the TIUS (60820). *Type Locality: Hukui Maru*-16: Wakasa Bay, Sea of Japan, Honshu, 76–104 m.

The deposition of the 3 syntypes of *Monomyces uchiuraensis* is unknown. Eguchi (1973b) designated a lectotype from the syntype series (specimen #45), a specimen that was originally illustrated by Eguchi (1972d, pl. 1: figs. 3, 4). *Type Locality:* Near Awashima, Uchiura Bay, Suruga Bay, Honshu, 20 m.

DISTRIBUTION.—Japan: Sagami, Suruga, and Wakasa Bays; off Amakusa Island, Kyushu; 20–104 m. *Elsewhere:* Philippines, Singapore, Pelau, Indonesia, Andaman Islands, Persian Gulf, Red Sea (see Cairns, 1989a); 20–1048 m.

Suborder DENDROPHYLLIINA

Family DENDROPHYLLIIDAE

Balanophyllia Wood, 1844

DIAGNOSIS.—See Part 1.

DISCUSSION.—The taxonomy of the genus *Balanophyllia* is quite confused, there being about 53 described Recent species, at least 31 of which occur in the Indo-West Pacific region. This number will certainly be refined and perhaps reduced as larger collections and more types are examined. Not all of the specimens available for study have been reported herein. In this regard I agree with Yabe and Eguchi (1942b:142), who stated: "Besides the above mentioned species, we have examined many different forms of the genus *Balanophyllia*, some of them may probably constitute new species, but mostly represented by [a] single, worn specimen; their description are left for another occasion."

Balanophyllia cumingii Milne Edwards and Haime, 1848b

PLATE 35*d,e*

Balanophyllia cumingii Milne Edwards and Haime, 1848b:87–88, pl. 1: fig. 8.—Eguchi, 1968:C51, pl. C21: figs. 7, 8.

Balanophyllia cumingi.—Eguchi, 1934:368.

?Balanophyllia affinis.—Yabe and Eguchi, 1942b:140–141, pl. 12: figs. 11, 12.—Eguchi, 1968:C50-51, pl. C12: figs. 1–3, 7–9, 13, 14.

Balanophyllia cf. *cumingii*.—Yabe and Eguchi, 1942b: 141 [in part: pl. 12: fig. 13a,b, and specimen from *Soyo Maru*-429 cataloged as TIUS 58990, not 58236].

Balanophyllia diomedae [sic].—Yabe and Eguchi, 1942b:142.

?Balanophyllia cf. *imperialis*.—Eguchi, 1968:C52–53, pl. C21: figs. 9, 10.

DESCRIPTION.—Corallum ceratoid and small, the largest specimen examined (TM (KT9015, CB1-2)) only 10.3 × 7.8 mm in calicular diameter and 18.9 mm in height, with a pedicel diameter of 4.0 mm. Corallum firmly attached: PD:GCD = 0.40–0.50. Costae porous and coarsely granular. Often a thin epitheca encircles the lower synapticulotheca, providing a better substratum for encrusting organisms. Corallum white.

Septa hexamerally arranged in 4–5 cycles, the fourth cycle complete at a GCD of about 7.5 mm, and the fifth cycle remaining incomplete (up to total complement of 90 septa) even in the largest specimens examined. S_{1-2} equal in size, about 1.3 mm exsert, and thickened at upper, outer (thecal) edges such that they fuse with their adjacent lower cycle septa. Inner edges of S_{1-2} straight, vertical, and smooth for upper half, but becoming dentate to laciniate adjacent to columella. S_{3-4} equally exsert (about 0.8 mm), the S_3 only about half the width of an S_{1-2}. In small coralla, each pair of S_4 fuse before its adjacent S_3 and extends to the columella as a single septum, its

inner edge being dentate to laciniate along its full margin. In larger coralla (Plate 35*e*) containing pairs of S_5, the S_3 extend to the columella and S_4 are short septa, each S_4 flanked by a pair of S_5 arranged in the Pourtalès Plan, the S_5 adjacent to the S_{1-2} (not the S_3) being the predominant septum. In these coralla the paired S_5 either fuse before the S_4 or extend independently (but closely parallel) to the columella. Their inner edges are highly dentate. Fossa deep, containing a large, elliptical columella flat to slightly convex in shape, composed of numerous, interconnected papillose elements, sometimes arranged in a swirled fashion.

DISCUSSION.—The seven lots of specimens reported herein are conspecific and appear to be the four species reported by Yabe and Eguchi (1942b) as: *B. affinis* Semper, 1872; *B. diomedae* Vaughan, 1907; *B. imperialis* Kent, 1871; and *B. cumingii* Milne Edwards and Haime, 1848b. *Balanophyllia affinis* (junior synonym of *B. stimpsonii* (Verrill, 1865), see Zibrowius, 1985) differs in having a free, unattached corallum. Likewise, it is not *B. diomedeae*, a conclusion I reached earlier (Cairns, 1984) after comparing Yabe and Eguchi's specimens to the types of *B. diomedeae*. *B. imperialis* differs in having a larger, more robust corallum; having a curved corallum; and having a smaller pedicel. The identification with *B. cumingii* is consistent with the original description of that species; however, for a definitive identification the type would have to be examined. The most distinctive characteristics of *B. cumingii* are its regular dentition of its septal edges and its relatively large columella.

MATERIAL EXAMINED.—*New Records:* Alb-3720, 1, USNM 92884; Alb-3764, 1, USNM 22062; Alb-4944, 1, USNM 92885; TM (KT9015, CB1-2), 7, USNM 92886; TM (KT9015, CB-2-2), 1, ORI; TM (KT9015, HK2), 1, USNM 92887; Okinose, Sagami Bay, 183 m, Mortensen's 1914 Pacific Expedition, 15 June 1914, 1, ZMC. *Previous Records:* *B. diomedae* of Yabe and Eguchi (1942b): *Soyo Maru*-244, 1, TIUS 59027; *Soyo Maru*-266, 1, TIUS 29026; *B.* cf. *cumingii* of Yabe and Eguchi (1942b), *Soyo Maru*-429, 3, TIUS 58990 and 1, TIUS 58236).

TYPES.—The holotype of *B. cumingii* is presumed to be deposited at the MNHNP. *Type Locality:* Philippines, depth unknown.

DISTRIBUTION.—Japan: Sagami and Suruga Bays, Honshu; Eastern Channel off southwestern Honshu; off southern Kyushu; Wakasa Bay, Sea of Japan, Honshu; 65–307 m. *Elsewhere:* Philippines.

Balanophyllia cornu Moseley, 1881

PLATE 35*f–i*

Balanophyllia cornu Moseley, 1881:192–193, pl. 12: figs. 11–15.

?Balanophyllia cf. *hawaiiensis*.—Eguchi, 1934:368.—Yabe and Eguchi, 1942b:142, pl. 12: fig. 20.

?Balanophyllia ponderosa.—Eguchi, 1968:C54 [in part: pl. C12: figs. 15–17].

DESCRIPTION (based on specimen from Formosa Strait, CAS 74991).—Corallum trochoid: 24.0 × 18.6 mm in calicular diameter and 34 mm in height, with a slender pedicel 4.5 mm in diameter (only 18% of GCD). Corallum regularly curved. Costae variable in width, alternating between 0.3 and 0.6 mm; intercostal striae narrow, about 0.05 mm wide. Costae flat and very finely granular. Synapticulotheca porous and white, the edge zone extending only 6–9 mm from calicular edge, below which corallum is epithecate but free from encrustation.

Septa hexamerally arranged in 5 complete cycles. S_1 slightly wider and have thicker inner edges than S_2. S_{1-2} 1.2–1.5 mm exsert and have straight, vertical, smooth inner edges that extend to the columella, the inner edges of the 4 lateral S_1 actually constricting the columella into 3 lobes. S_3 only about 0.8 mm exsert and two-thirds width of an S_{1-2}, also having straight and entire inner edges. S_{4-5} arranged in a Pourtalès Plan, the S_4 being only slightly exsert and about two-thirds width of an S_3. S_5 adjacent to S_{1-2} fused to those septa at calicular edge. Inner edges of S_5 curve toward each other, each pair fusing before their adjacent S_4, these 2 combined S_5 within each half-system uniting before the S_3 near the columella. S_5 adjacent to S_3 equal to or only slightly wider and as exsert as adjacent S_3, but S_5 adjacent to S_{1-2} are the predominant S_5, being much more exsert and extending to the columella. Inner edges of S_{4-5} also smooth, without teeth or laciniation. Fossa of moderate depth, containing an elongate, solid (not porous) columella composed of tightly fused, twisted laths.

DISCUSSION.—The South China Sea specimen described above differs from the syntypes in having a larger corallum (5 mm larger in GCD) and consequently more septa (96 vs 72 for the largest syntype). It also has a proportionately smaller pedicel, the PD:GCD being only 0.18 for the South China Sea specimen, but 0.41–0.46 for the syntypes.

The specimen figured as *B.* cf. *hawaiiensis* by Yabe and Eguchi (1942b) (TIUS 58994) could not be found in the TIUS collections in 1980 and is presumed to be lost. From its illustration it would appear to be *B. cornu* (see Cairns, 1984:26).

Balanophyllia cornu is similar to *B. imperialis* Kent, 1871 (type locality: Singapore) in growth form, size, and number and arrangement of septa. However, *B. imperialis* differs in having laciniate inner edges on S_5, a much deeper fossa, and an even smaller pedicel diameter (PD:GCD of holotype = 0.09).

MATERIAL EXAMINED.—Alb-5311, 3, USNM 92879; Alb-5313, 11, USNM 92880; TM (KT9015, BS2), 3, USNM 92881, 2, ORI; Formosa Strait, South China Sea, 60 m, Feb. 1972, 1, CAS 74991. *Previous Records:* Syntypes of *B. cornu*. *Reference Specimens:* Holotype of *B. imperialis*, BM 1984.4.27.3.

TYPES.—Four syntypes (Plate 35*f,i*) of *B. cornu* are deposited at the BM (1880.11.25.143). *Type Locality: Challenger*-192: 5°42′S, 132°25′E (Kei I., Banda Sea), 236 m.

DISTRIBUTION.—North Pacific: Bungo Strait; ?Sagami Bay, Honshu (*B. ponderosa* of Eguchi, 1968); ?Amakusa Islands, off Kyushu (*B. hawaiiensis* of Yabe and Eguchi, 1942b); Formosa Strait and north of Pratas Islands, South China Sea; 60–274 m.

Elsewhere: Philippines, Banda Sea, Hawaiian Islands; 236–470 m.

Balanophyllia gigas Moseley, 1881

PLATE 35*j–l*

Balanophyllia gigas Moseley, 1881:193.—Van der Horst, 1922:58–59, pl. 8: fig. 22.—Eguchi, 1934:368; 1965:292, 2 figs.; 1968:C51–52, pl. C21: figs. 1, 2; pl. C31: figs. 5, 6.—Yabe and Eguchi, 1942b:113, 139–140.—Utinomi, 1965:256.—Eguchi and Miyawaki, 1975:59.

?Balanophyllia ponderosa.—Yabe and Eguchi, 1942b:140, pl. 12: fig. 9.—Eguchi, 1965:293, 2 figs.

DESCRIPTION.—The following description is based primarily on the specimen from Alb-5070, which is quite similar to the holotype. Corallum ceratoid: 29.1 × 23.6 mm in calicular diameter and 76 mm in height, with a slender but sturdy pedicel 10.0 mm in diameter (PD:GCD = 0.34). Holotype 28.9 × 20.0 mm in calicular diameter and 58.8 mm in height, with a pedicel diameter of 10.5 mm (PD:GCD = 0.36). Corallum irregularly bent, not regularly curved. Costae slightly convex and 0.6–0.7 mm wide, separated by thin, porous intercostal striae and covered with fine granules and slightly larger, coarse spines, altogether producing a rough texture. Synapticulotheca porous and white, the edge zone extending only 7–16 mm below calicular edge, below which the corallum is epithecate, discolored, and covered with encrusting organisms.

Septa hexamerally arranged in 5 cycles, the last cycle not complete, both the holotype and *Albatross* specimen having only 88 septa. S_{1-2} equal in size, up to 4 mm exsert, and have straight, smooth inner edges that attain the columella. S_3 half as exsert and about three-quarters width of an S_{1-2} and also have straight, smooth inner edges. S_{4-5} arranged in a Pourtalès Plan. In quarter-systems lacking S_5, the S_4 is independent, extending to the columella. If, however, the S_4 is flanked by a pair of S_5, the S_4 is short, a pair of S_5 fusing before it, this combined S_5 extending to the columella. Whereas inner edges of S_{1-3} are entire (smooth) and their faces are solid, inner edges of the S_{4-5} are corsely dentate and the septa porous. Fossa of moderate depth, containing a discrete, slender, elongate, columella, composed of many slender elements loosely fused together.

DISCUSSION.—Several authors, including Moseley (1881), have attributed the authorship of *B. gigas* to Brueggemann based on an apparently unpublished manuscript in which he described and named this species. However, the authorship must be attributed to Moseley (1881) who first published the name and commented on the species, if only as a brief comparison to another species.

Balanophyllia gigas can be distinguished from other congeners by its large size and the coarse dentition and porosity of its higher cycle septa.

MATERIAL EXAMINED.—*New Records:* Alb-5070, 1, USNM 92882; TM (KT7818, OT8-1), 1, USNM 92883; TM (KT8412, 14), 1, ORI. *Previous Records:* Holotype of *B. gigas*, BM.

TYPES.—The holotype (Plate 35*k*) of *B. gigas* is deposited at the BM (1876.10.11.23). *Type Locality:* "Japan," depth unknown.

DISTRIBUTION.—Japan: From Boso Honto, Honshu (including Sagami Bay) to southwestern Kyushu, including Shikoku; 115–245 m. *Elsewhere:* Kei Islands, Banda Sea; 90 m.

Balanophyllia ponderosa Van der Horst, 1926

PLATE 36*a,b*

Balanophyllia ponderosa Van der Horst, 1926:49–50, pl. 3: figs. 6, 7.—Not Yabe and Eguchi, 1942b:140, pl. 12: fig. 9 [= *?B. gigas*].—Not Eguchi, 1965:293, 2 figs.; 1968:C54 [in part: pl. C17: figs. 6–11, 13, 14).—?Kikuchi, 1968:9, pl. 5: fig. 11a,b.—?Eguchi and Miyawaki, 1975:54, pl. 6: fig. 3.—Cairns and Keller, 1993:274.

DISCUSSION.—No additional specimens of *B. ponderosa* are reported herein and the Japanese specimens reported by Yabe and Eguchi (1942b) and Eguchi (1968) are unavailable for study, but the holotype of *B. ponderosa* was examined and compared to the published illustrations of specimens from Japan. The specimens figured by Eguchi (1968, pl. C17: figs. 6–11, 13, 14) appear to be conspecific; however, the specimen illustrated in pl. C12, figs. 15–17 appears to be *B. cornu*, and the specimen illustrated by Yabe and Eguchi (1942b, pl. 12: fig. 9) appears to be *B. gigas*.

The holotype of *B. ponderosa* is 23.7 × 17.5 mm in calicular diameter and 30.0 mm in height, with a thick pedicel measuring 14.2 × 13.4 mm in diameter (PD:GCD = 0.60). A thick, horizontally striate epitheca covers lower half of corallum, the upper synapticulotheca consisting of finely granular, convex costae 0.4–0.6 mm wide separated by very narrow striae. Septa hexamerally arranged in 5 cycles, only 1 pair of S_5 lacking, for a total of 94 septa. S_{1-2} equal in size and have straight, vertical, entire inner edges. S_3 about half width of an S_{1-2} and have similar inner edges, all 24 S_{1-3} reaching the columella. S_4 are the smallest septa. Each pair of S_5 fuses before an S_4 and extends to the columella, where it fuses to the inner edges of adjacent S_3. Inner edges of S_{4-5} finely dentate. All septa nonexsert. Fossa deep, containing a large, elliptical columella 10.0 × 3.8 mm in size that is virtually flat on top. The columella consists of numerous small, flattened elements weakly swirled in a clockwise direction and tightly fused to one another.

Balanophyllia ponderosa is distinguished from other Japanese congeners by its relatively thick pedicel and its large, low, spongy columella.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Holotype of *B. ponderosa*, BM; 1 specimen off South Africa (Cairns and Keller, 1993).

TYPES.—The holotype (Plate 36*a,b*) and two paratypes of *B. ponderosa* are deposited at the BM, the holotype cataloged as 1939.7.20.62. *Type Locality:* Off Nilandu, Maldive Islands; depth unknown.

DISTRIBUTION.—Japan: Sagami Bay, Honshu; 14–16 m (Eguchi, 1968). *Elsewhere:* Southwest Indian Ocean; Maldive Islands; 51–59 m.

Balanophyllia sp. A

PLATE 40*j*

Balanophyllia italica.—Eguchi, 1934:368.

Balanophyllia cf. *italica*.—Yabe and Eguchi, 1942b:140, pl. 12: fig. 10a,b.—Eguchi, 1968:C53-54, pl. C12: figs. 10-12; pl. C20: figs. 3, 4.

DISCUSSION.—Yabe and Eguchi (1942b) and Eguchi (1968) reported 7 specimens from off Japan for which they suggested a comparison to the French Miocene species *B. italica*. They did not provide a description of their species and only one specimen was available for examination and illustration. From their illustration it would appear that these specimens differ from their Japanese congeners by having a crown of pali (P4) and a more prominent upper thecal edge along the thecal faces rather than the edges. No specimens in the study material has pali or such a corallum shape. However, the relatively small specimen examined (*Soyo Maru*-647) of GCD = 10.2 mm had only incipient S_5 development and no pali.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* *Soyo Maru*-647, 1, TIUS 59163 (Yabe and Eguchi, 1942b) (Plate 40*j*). *Reference Specimens:* Pliocene *B. italica* from Pavona, Italy, 1, USNM M156368.

DISTRIBUTION.—Sagami Bay, Honshu; Sea of Japan off extreme northwestern Honshu; 56–100 m.

Balanophyllia teres, sp. nov.

PLATE 36*c,d*

Balanophyllia fistula Yabe and Eguchi, 1942b:141 [in part: "first form," pl. 12: fig. 14a,b).—Eguchi, 1968:C63.

Dendrophyllia fistula.—Eguchi, 1965:295 [in part: middle figure]; 1968:C62-63 [in part: "simple form," ?pl. 12: fig. 4–6].

DESCRIPTION.—Corallum terete (cylindrical to slightly conical) and quite elongate, straight to irregularly curved. Holotype 4.33 mm in calicular diameter and 30.7 mm long; largest specimen (Alb-4903) 7.0 mm in calicular diameter and 60.0 mm long. Basal tip of colony free: either pointed and worn or transversely fractured. Buds absent. Corallum obviously epithecate, a continuous, smooth, thick epitheca extending virtually to calice. Underlying noncostate synapticulotheca visible only on lower half of corallum or on coralla dead when collected. Corallum white.

Septa arranged in a weak Pourtalès Plan of 3–4 cycles. A corallum of 3.5–4.5 mm GCD has only 3 septal cycles (24 septa), whereas a slightly larger specimen of GCD = 5.6 mm has about 40 septa, and the largest specimen of GCD = 7.0 mm has a full fourth cycle (48 septa). S_1 slightly exsert (0.3–0.6 mm) and relatively narrow, with straight, entire inner edges that fuse with the columella only deep within fossa. S_2 of small coralla (e.g., holotype) small (only about one-third width of an S_1) but in a larger corallum having pairs of S_4 within their half-systems, S_2 are three-quarters width of an S_1 and almost attain the columella. S_3 of smaller coralla slightly wider than the S_2, the inner laciniate edges of each pair of S_3 within a system fusing before its adjacent S_2 near the columella. S_3 of larger coralla quite small, each flanked by a pair of larger S_4 that loosely fuse near the columella. Fossa moderately deep, containing a discrete spongy columella, that, in larger specimens, is constricted by the inner edges of the 4 lateral S_1.

DISCUSSION.—Yabe and Eguchi (1942b) distinguished two similar taxa of dendrophylliids that they referred to as forms of *Balanophyllia fistula*, but later (Eguchi, 1968) as two separate species: *Dendrophyllia*/*Balanophyllia fistula* and *Alcockia wellsi*. The former species was characterized as being simple and epithecate, the latter as colonial and costate (nonepithecate). It is clear from Yabe and Eguchi's (1942b, pl. 12: fig. 14a,b) illustration of a specimen from *Soyo Maru*-316, later listed as *Balanophyllia fistula* by Eguchi, 1968, that it is conspecific with *B. teres*. *Balanophyllia teres* is distinctive among the other Recent species in having such a slender, elongate, cylindrical corallum. It is not *Balanophyllia fistula* Alcock, 1902 (Plate 36*f,g*), which is a colonial coral herein assigned to the genus *Eguchipammia*. The costate colonial form referred to as *Alcockia wellsi* by Eguchi (1968) is discussed in the account of *Eguchipsammia wellsi*.

ETYMOLOGY.—The species name *teres* (Latin *teres*, meaning "rounded," "well turned," "cylindrical" or "terete") refers to the slender corallum shape of this species.

MATERIAL EXAMINED/TYPES.—*Holotype:* TM (KT9202, OS_2), USNM 92888 (Plate 36*c*). *Paratypes:* Alb-4903, 3, USNM 92889; Alb-4904, 2, USNM 92890; TM (KT9015, BS2), 7, USNM 92891; TM (KT9202, OS2), 1, ORI. *Previous Records:* *B. fistula* of Yabe and Eguchi (1942b), *Soyo Maru*-316, 1, TIUS 58971. *Type Locality:* 30°59′N, 130°31′E (mouth of Kagoshima Bay, Kyushu), 237–241 m.

DISTRIBUTION.—Kii Strait, Honshu to Fukue Jima, East China Sea; 154–237 m.

Endopachys Lonsdale, 1845

DIAGNOSIS.—Corallum solitary, cuneiform, and free, with alate edge crests. Septa arranged in a Pourtalès Plan. Paliform lobes present; columella spongy.

TYPE SPECIES.—*Turbinolia maclurii* Lea, 1833, by subsequent designation (Milne Edwards and Haime, 1850a:lii).

Endopachys grayi Milne Edwards and Haime, 1848

PLATES 36*e,h*, 37*i*

Endopachys grayi Milne Edwards and Haime, 1848b:82–83, pl. 1: figs. 2, 2a.—Yabe and Eguchi, 1942b:139.—Cairns, 1984:27, pl. 5: fig. E [synonymy].—Zibrowius and Grygier, 1985:128, figs. 39–42.—Cairns and Keller, 1993:276 [synonymy].

Endopachys japonicum Yabe and Eguchi, 1932a:388, 389 [nomen nudum]; 1932b:443 [nomen nudum]; 1932d:14–17, pl. 2: figs. 1–6; 1942b:139.—Eguchi, 1934:268; 1965:293, 3 figs.—Eguchi and Miyawaki, 1975:59.

Endopachys vaughani Durham, 1947:39–40, pl. 11: figs. 6–8, 10, 11.—Durham and Barnard, 1952:103, pl. 16: fig. 67a,b.—Squires, 1959:426–427.

DESCRIPTION.—Edge angle, exclusive of lateral crests, 50°–55°; inclination of lateral faces changes 7–8 mm above the base, increasing from a rather narrow 22°–28° to a more open

48°–58°. Lateral edges meet at an acute angle and project outward up to 3 mm as lateral edge crests. Crests usually confined to lower half of corallum and are about 1 mm thick. Up to 4 buds, none over 4 mm in GCD, have been observed to grow from a thecal edge (Plate 37*i*), above the region of the edge crest. Largest Japanese specimen examined (TM (KT9015, BS1)) 15.3 × 11.0 mm in calicular diameter and 14.6 mm in height; however, the species can grow much larger, e.g., up to 39 mm in GCD (Cairns and Keller, 1993).

Septa hexamerally arranged in 5 incomplete cycles, the fourth cycle usually complete at a GCD of 8–10 mm and a specimen of 15 mm GCD having 72 septa. Larger (non Japanese) specimens have a full complement of 5 cycles (96 septa). S_{1-2} equal in size, moderately exsert, and fairly thick and porous near their upper edges; their inner edges are straight and vertical, extending to the columella. S_3 only about one-third width of an S_{1-2}. Each pair of S_4 within a half-system unites before its adjacent S_3 to form a small paliform lobe at the junction. In larger coralla having a fifth cycle, pairs of S_5 also fuse before their adjacent S_4, forming another crown of paliform lobes. Fossa deep and narrow, containing a rudimentary, spongy columella composed of slender, interconnected papillae.

DISCUSSION.—Only one widely distributed Recent species of *Endopachys* is acknowledged, most of the nominal species having been synonymized by Umbgrove (1950); however, there are at least five species known exclusively from fossils (see Wells, 1975) dating from as early as the Eocene. *Endopachys* is sometimes confused with *Tropidocyathus*, both genera having the same shape, but the porous synapticulotheca and Pourtalès Plan easily distinguish *Endopachys*. Phylogenetically *Endopachys* is closest to *Balanophyllia*, but is distinguished by its compressed (cuneiform) corallum.

MATERIAL EXAMINED.—*New Records:* Alb-2999, 6, USNM 19221; Alb-5311, 24, USNM 92861; Alb-5312, 1, USNM 92862; Alb-5313, 15, USNM 92863; Alb-5314, 2, USNM 92864; Alb-5315, 1, USNM 92865; TM (KT9015, BS1), 70, USNM 92866; TM (KT9015, BS2), 28, ORI; TM (KT9015, CB1-2), 1, USNM 92867; TM (KT9015, HK2), 1, USNM 92868; TM (KT9202, OS3), 1, USNM 92869; 27.3N, 121.3E, 80-100 m, 1, CAS 74996; TM (KT9309, AM6), 1, ORI; TM (KT9309, AM7), 3, ORI; USGS 17441, 17456, 17457, 17503, Pleistocene of Okinawa, 6, USNM 88661-88665.

TYPES.—The holotype of *E. grayi* was not traced. *Type Locality:* Unknown.

The description of *E. japonicum* was based on 47 specimens (TIUS 41929) from the Plio-Pleistocene of Makuta-maru, Boso Peninsula, Honshu (type locality) and 3 specimens (TIUS 41930) from the Pliocene Byoritsu Beds of Kanpouko, Taiwan. The designation of a holotype from the Honshu lot was made by Yabe and Eguchi (1932d) in the figure captions, and thus the other 49 specimens should be considered as paratypes.

The holotype and three paratypes of *E. vaughani* are deposited in the CAS Paleontology Museum (7839-7842). Two additional paratypes are deposited at the UCMP (30199-30200). *Type Locality:* Loc. 27584: 23°.3′N, 109°36′W (mouth of Gulf of California), 27–402 m.

DISTRIBUTION.—Northwest Pacific: Off Boso and Kii Peninsulas; off Shikoku; off eastern Kyushu; Eastern Channel, Korea Strait, off western Honshu; off Amami Oshima, Ryukyu Islands; northern Formosa Strait, East China Sea; South China Sea northeast of Pratas Islands. Pleistocene of Ryukyu Islands and Honshu. Pliocene of Taiwan; 70–274 m. *Elsewhere:* Widely distributed in Indo-Pacific from off South Africa to the Gulf of California, including the Hawaiian Islands; 37–274 m.

Eguchipsammia, gen. nov.

Dendrophyllia (Alcockia) Eguchi, 1968:C63 [junior homonym].

DIAGNOSIS.—Unattached, recumbent coralla formed through sparse extratentacular (rarely intratentacular) budding from a predominant axial corallite, only rarely with third generation buds present on a colony. Synapticulothecate: costate and/or epithecate. Septa arranged in a Pourtalès Plan. Pali absent; columella spongy.

TYPE SPECIES.—*Dendrophyllia cornucopia* Pourtalès, 1871, here designated.

DISCUSSION.—Six species are assigned to the genus *Eguchipsammia: E. gaditana* (Duncan, 1873); *E. cornucopia* (Pourtalès, 1871); *E. fistula* (Alcock, 1902); *E. serpentina* (Vaughan, 1907); *E. oahensis* (Vaughan, 1907); and *E. wellsi* (Eguchi, 1968). The genus is characterized by having a free (unattached), recumbent corallum with a variable number of asexually generated buds attached to the theca. Because the buds often become free of the parent corallum, these species are not considered as a true *Dendrophyllia*, but because the buds are temporarily part of the corallum, these taxa cannot be considered as *Balanophyllia*. As Eguchi (1968) stated in his discussion of the subgenus *Alcockia*, it "has intermediate characters between *Balanophyllia* and *Dendrophyllia*." Because the species of *Eguchipsammia* have a different reproductive mode than either *Balanophyllia* of *Dendrophyllia* and because they are free-living, which would also have ecological consequences, a new genus is proposed.

ETYMOLOGY.—Eguchi (1968) was the first to suggest a supraspecific name for those species having the above-mentioned characteristics, i.e., *Alcockia*, but that name was preoccupied by Goode and Beane (1896) for a genus of fish. The genus is thus renamed in honor of Motoki Eguchi (1905–1978). Gender: feminine.

DISTRIBUTION.—Miocene (Cairns and Wells, 1987) to Recent. Living species circumtropical to warm temperate in western Pacific; 34–960 m.

Eguchipsammia gaditana (Duncan, 1873), comb. nov.

PLATE 37*d-f,h*

Balanophyllia gaditana Duncan, 1873:333.

Balanophyllia fistula.—Yabe and Eguchi, 1942b:141 [in part: ?pl. 12: fig. 15a,b).

Dendrophyllia gaditana.—Cairns, 1979:181–182, pl. 36: figs. 5–10; 1984:25, pl. 4: fig. 1 [synonymy].—Zibrowius, 1980:176–178, pl. 89: figs. A–N.—Cairns and Keller, 1993:279–280 [synonymy].

DESCRIPTION.—The corallum consists of a relatively slender, irregularly bent, cylindrical axial corallite from which smaller corallites bud at irregular intervals. Largest corallum (ZMC, Okinose) only 53 mm long and bears 15 secondary corallites or broken bases of corallites from the axial corallite and 1 tertiary corallite that originates from a secondary. In only one of the 17 coralla examined was there an example of intratentacular budding. All coralla examined were free, with no evidence of previous attachment to the substrate. Axial corallites (and branches) 3.0–4.9 mm in diameter; secondary corallites slightly smaller: 2.6–4.0 mm in diameter. Synapticulotheca covered by a very thin, transparent epitheca, which often extends to calicular edge and gives the theca a coarsely granular porcellaneous texture. Theca porous only near calice. Six C1 often slightly ridged, giving branches a polygonal cross section. Corallum white.

Septa arranged in a Pourtalès Plan of 3 cycles (24 septa) in small corallites and up to 36 septa in larger corallites. S_1 significantly exsert (0.5–0.6 mm), along with their adjacent pairs of higher cycle septa, together forming 6 calicular apices around calicular margin. S_1 relatively thin and have vertical, entire inner edges that attain the columella. In small corallites, S_2 are quite small, each flanked by a pair of larger S_3 that fuse before the S_2 high in the fossa and extend to the columella as a combined septum. In larger corallites each system contains 5, not 3, septa, consisting of a medial S_2, 1 wide S_3 and 1 small S_3, the latter flanked by 2 wide S_4 that fuse and extend to the columella. Inner edges of S_4 and those S_3 that extend to the columella laciniate. Fossa of moderate depth, containing a rudimentary, spongy, nondiscrete (edges of columella merge with inner septal edges) columella.

DISCUSSION.—Yabe and Eguchi were insightful when in 1942(e) they distinguished three forms of *Balanophyllia fistula*, some of which occured at the same stations. One form was solitary and heavily epithecate (their pl. 12: fig. 14), which is described as *Balanophyllia teres* herein. The other forms were colonial and non- or little epithecate (their pl. 12: figs. 15, 16). The colonial forms consist of two very similar species: *Eguchipsammia gaditana* and *E. wellsi*, *E. fistula* being a much more robust species with four full cycles of septa (Plate 36*f,g*). *E. gaditana* differs from *E. wellsi* by having a spongy (not honeycomb-shaped) and nondiscrete columella (the columellar edges are not vertical, but merge directly with the inner septal edges). Secondly, in *E. gaditana* pairs of S_4 and some S_3 fuse high in the fossa and continue to the columella as a laciniate septum. In *E. wellsi*, the S_3 and S_4 paired septa rarely if ever fuse and they have entire inner edges. Thirdly, *E. gaditana* has a very thin epitheca covering most of its synapticulotheca and inconspicuous costae; *E. wellsi* has a costate theca, lacking an epitheca. Finally, the coralla of *E. gaditana* are more delicate than those of *E. wellsi*.

Because the differences between *E. gaditana* and *E. wellsi* are so subtle, all previously published records of *Balanophyllia*/*Dendrophyllia fistula* from Japan should be re-examined for a proper identification. This includes reports by: Yabe and Eguchi (1932a, 1932b, 1936, 1941b, 1942b), Utinomi (1956, 1965), Kikuchi (1968), Eguchi (1968), and Eguchi and Miyawaki (1975).

MATERIAL EXAMINED.—*New Records:* Okinose, Sagami Bay, 110 m, Mortensen's 1914 Pacific Expedition, 16 coralla, ZMC, 1, USNM 92894. *Previous Records:* Specimens reported from Atlantic (Cairns, 1979; Zibrowius, 1980), Hawaiian Islands (Cairns, 1984), and southwest Indian Ocean (Cairns and Keller, 1993).

TYPES.—The holotype of *B. gaditana* is deposited at the BM (1883.12.10.97). *Type Locality: Porcupine*-29: 36°20′N, 6°47′W (Iberian-Morocco Gulf), 417 m.

DISTRIBUTION.—Off Japan: Sagami Bay, Honshu; ?Bungo Strait, Shikoku (*Soyo Maru*-231); Osumi Strait, southern Kyushu; 110–188 m. *Elsewhere:* Widespread, including Atlantic, southwestern Indian Ocean, Hawaiian Islands, Australia; 73–505 m.

Eguchipsammia wellsi (Eguchi, 1968), comb. nov.

PLATE 37*a–c,g*

Balanophyllia fistula.—Eguchi, 1934:368.—Yabe and Eguchi, 1942b:141 [in part: pl. 12: fig. 16a,b].

Dendrophyllia fistula.—Eguchi, 1965:295 [in part: right fig.].

Dendrophyllia (Alcockia) wellsi Eguchi, 1968:C63–64.

DESCRIPTION.—Corallum shape identical to that of *E. gaditana*, consisting of an axial corallite from which slightly smaller secondary corallites bud at irregular intervals, although *E. wellsi* is slightly more robust that *E. gaditana*, their axial corallites being 4.5–5.1 mm in GCD and their secondaries 2.5–4.0 mm in GCD. Largest corallum (ZMC, Okinose) 74 mm in length and bears 8 secondary corallites. Tertiary corallites and examples of intratentacular budding absent. Synapticulotheca costate, with no evidence of an epitheca. Costae equal in width (about 0.3 mm) and bear very fine, sharp granules. Corallum white.

As in *E. gaditana*, septa hexamerally arranged in 3 to 4 cycles (up to 36 septa) in a Pourtalès Plan. S_1 slightly exsert and have entire, vertical inner edges that attain the columella. S_2 of small corallites are small and flanked by a pair of S_3, each of which extends almost to the columella but do not quite fuse with one another. In larger corallites having systems including 5 septa, there is a large S_2, 1 even wider S_3 that attains the columella and another very small S_3 that is flanked by a pair of S_4. Inner edges of each S_4 pair within in a half-system bend toward each other but do not quite meet. Inner edges of all septa entire (i.e., smooth), not dentate or laciniate. Fossa of medium depth, containing a discrete (a self-contained structure with vertical edges, not merging imperceptibly with inner septal edges) columella composed of small lamellae densely fused into a honeycomb-like structure.

DISCUSSION.—*Eguchipsammia wellsi* is one of the three

forms of *B. fistula* reported by Yabe and Eguchi (1942b) and one of the two forms of *D. fistula* reported by Eguchi (1968). See the previous discussion of *E. gaditana* for comparisons to that species.

MATERIAL EXAMINED.—*New Records:* Alb-4903, 2, USNM 92895; Alb-4936, 2, USNM 92896; TM (KT9202, YS1), 1, ORI; Okinose, Sagami Bay, 110 m, Mortensen's 1914 Pacific Expedition, 7 coralla, ZMC, 1, USNM 92897; *Soyo Maru*-212, 3, TIUS 58974. *Reference Material:* Syntypes of *B. fistula*, ZMA (Coel. 564).

TYPES.—The original description of the new subgenus and species *Alcockia wellsi* is quite confusing and rather brief, but qualifies as a legitimate description under Article 13C of the ICZN. It can be deduced that *A. wellsi* was reported by Eguchi (1968) from 13 *Soyo Maru* stations, all of these specimens herein considered to be syntypes. Two of these specimens were previously illustrated by Yabe and Eguchi (1942b, pl. 12: figs. 15, 16), but because I consider one of these specimens (*Soyo Maru*-231, pl. 12, fig. 15) to be *E. gaditana*, I suggest that the other figured specimen from *Soyo Maru*-210 (pl. 12: fig. 16a,b, TIUS 58969) be considered as the lectotype. *Type Locality: Soyo Maru*-210: 33°29′N, 135°28′E (off Kii Peninsula, Honshu), 165 m.

DISTRIBUTION.—Sagami Bay and Kii Peninsula, Honshu; south of Fukue Jima; Osumi Strait, Kyushu; Tokara Retto, northern Ryukyu Islands; 110–196 m.

Rhizopsammia Verrill, 1870a

DIAGNOSIS.—Like *Balanophyllia*, but forming reptoid colonies by extratentacular stoloniferous budding. Pourtalès Plan present. Pali absent; columella rudimentary.

TYPE SPECIES.—*Rhizopsammia pulchra* Verrill, 1870a, by monotypy.

DISCUSSION.—*Rhizopsammia* represents the first level of polyp organization among the Recent colonial dendrophylliids having a Pourtalès Plan, i.e., that of stoloniferous budding, being just a short step from a solitary *Balanophyllia*. The next higher level of organization is characterized by *Cladopsammia* in which phaceloid colonies originate from a common basal coenosteum.

Rhizopsammia minuta mutsuensis Yabe and Eguchi, 1932

PLATE 40*f,g*

Rhizopsammia minuta var. *mutsuensis* Yabe and Eguchi, 1932f:208–209, pl. 9: figs. 1–3.—Abe, 1939:175–187.—Fadlallah, 1983a:133.

Rhizopsammia minuta mutsuensis.—Eguchi, 1934:368; 1965:293, 2 figs.; 1968:C72, pl. C4: fig. 4 [color]; pl. C14: figs. 1–3.—Yabe and Eguchi, 1942b:143.—Suzuki, 1969:17–24, figs. 6–9.—Yajima, 1986:37–40.—Song, 1991:138–139, pl. 1: fig. 15; pl. 3: figs. 3, 6.

DESCRIPTION OF HOLOTYPIC COLONY.—Corallum consists of approximately 46 interconnected encrusting corallites covering an area of about 5 cm^2. Corallites bud extratentacularly from reptoid stolons, the stolons maintaining their connection throughout colony development. Corallites elliptical (GCD:LCD about 1.1), up to 5.8 mm in GCD, and 4 mm in height. All corallites epithecate, the synapticulotheca visible only at calicular edge. Corallum white; coenosarc yellow-orange (Song, 1991).

Septa hexamerally arranged in 4 cycles in a Pourtalès Plan. Only the largest corallites (>5.5 mm GCD) have the full 48 septa; most corallites lack several pairs of S_4. S_1 only independent septa, and have straight, smooth inner edges that attain the columella. S_2 also have smooth inner edges, but do not quite attain the columella. S_3 smallest septa and have finely dentate inner edges extending only about half distance to columella. Inner edges of S_4 coarsely dentate, each pair of S_4 fused before the inner edge of its common S_3 and continues toward columella where it is loosly fused to an S_2 near columella. Fossa of moderate depth, containing a small elliptical papillose to porous columella.

DISCUSSION.—*Rhizopsammia minuta mutsuensis* is stated to differ from the nominate subspecies, *R. minuta minuta* van der Horst, 1922, by having taller corallites, a deeper fossa, and costate stolons. The nominate subspecies was described from the Lesser Sunda Islands, Banda Sea. A third subspecies, *R. minuta bikiniensis* Wells, 1954, described from the Marshall Islands, differs in having smaller corallites and consequently fewer septa. Eleven other species are attributed to this genus (Cairns and Keller, 1993).

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Holotype of *R. minuta mutsuensis*, TIUS. *Reference Specimens:* Holotype of *R. minuta bikiniensis*, USNM 45106.

TYPES.—The holotype colony of *R. minuta mutsuensis*, which was designated in a plate caption, is deposited at the TIUS (41391). Four more paratype colonies exist. *Type Locality:* Moura-shima (40°55.5′N), near Asamushi, Mutsu Bay, Honshu, Japan, 1–2 m.

DISTRIBUTION.—Endemic to the cold temperate northwest Pacific: Sea of Japan coast of Honshu from Wakasa Bay to Mutsu Bay; Ishikari Bay, Hokkaido; Sagami and Suruga Bays, Honshu; Yellow Sea off South Korea; Sea of Japan coast of South Korea; Ullung Do, Sea of Japan; 0–2 m.

Cladopsammia Lacaze-Duthiers, 1897

DIAGNOSIS.—Small phaceloid colonies formed by extratentacular budding from a common basal coenosteum and from edge zone of larger corallites. Pourtalès Plan well developed. Pali absent; columella spongy.

TYPE SPECIES.—*Cladopsammia rolandi* Lacaze-Duthiers, 1897, by monotypy.

DISCUSSION.—If *Dendrophyllia* applies to those species with axial, sympodial, or bushy growth forms originating from a single pedicel, then *Cladopsammia* may be reserved for those species having a phaceloid growth form characterized by numerous corallites budding from a common basal coenosteum. The next lower level of corallite integration is that of stoloniferous, reptoid budding, designated as the genus *Rhizopsammia;* the next higher level of integration is the branching mode, i.e., *Dendrophyllia*. Four species are recognized in *Cladopsammia: C. rolandi* Lacaze-Duthiers, 1897; *C.*

gracilis (Milne Edwards and Haime, 1848b); *C. eguchii* (Wells, 1982); and *C. echinata* Cairns, 1984.

Cladopsammia gracilis (Milne Edwards and Haime, 1848), comb. nov.

PLATE 38*d,e*

Dendrophyllia gracilis Milne Edwards and Haime, 1848b:100–101, pl. 1: fig. 13.—Faulkner and Chesher, 1979:305–306, pl. 179–189.—Wells, 1983:240–241, pl. 17: figs. 1–4 [synonymy].—Cairns, 1991a:23, pl. 10: figs. a,b.

?Dendrophyllia coccinea.—Van der Horst, 1922:55–56, pl. 8: fig. 21.

?Dendrophyllia willeyi.—Van der Horst, 1922:56, pl. 8: figs. 17, 18.

Dendrophyllia coccinea titigimaensis Eguchi, 1934:367 [nomen nudum].

Tubastraea coccinea titijimaensis Eguchi, 1968:C71-72, pl. C17: fig. 16; pl. C31: figs. 1–4; pl. C33: figs. 1–4.

Dendrophyllia cf. *gracilis.*—Eguchi, 1968:C60, pl. C23: figs. 4–6.

?Dendrophyllia sp.—Eguchi, 1968:C66, pl. C14: figs. 6, 7; C67, pl. C30: figs. 6, 7.

Dendrophyllia arbuscula Utinomi, 1971:220, pl. 13: fig. 4a,b.

DESCRIPTION.—Illustrated colony a small (5 cm broad) phaceloid clump of 18 corallites, some of the corallites budding in close proximity from a common basal coenosteum, the rest budding from the lower edge zone of larger corallites. Calices up to 12 × 11 mm in calicular diameter. Theca thin and porous; no epitheca present. Costae fairly well defined and about 0.3 mm wide, each bearing a unilinear row of small teeth. Corallum white; coenosarc orange, pink, yellow, salmon, or green.

Septa arranged in a pronounced Pourtalès Plan in 5 incomplete cycles, pairs of S_5 often missing even from largest corallites. S_1 slightly exsert and relatively narrow, with straight, vertical, entire inner edges that reach the columella. S_2 about half width of an S_1 and also have entire inner edges, the S_{2-5} having laciniate inner edges. S_3 quite narrow, but independent, as are the S_4; however, each pair of S_5 unite before its adjacent S_4, which in turn unites with its counterpart before the S_3 and then curves toward the S_2 within its system and almost meets its counterpart from the adjacent half-system near the columella. Fossa quite deep, containing a spongy columella of variable size.

DISCUSSION.—Faulkner and Chesher (1979) published 11 color plates of this colorful species in situ, which Faulkner referred to as the "Festival Tube Coral" and the "Monet Tube Coral." In the captions to their plates they credit J. W. Wells with the observation that the coenosarc color is of no taxonomic importance for this species.

Cladopsammia gracilis has been previously identified in the genus *Tubastraea* and more commonly in *Dendrophyllia*. To reiterate, *C. gracilis* differs from *Tubastraea* in having a Pourtalès Plan septal arrangement and differs from *Dendrophyllia* in having a low, phaceloid colony with corallites originating from a common basal coenosteum. Comparisons to *C. eguchii* are made in the account of that species.

MATERIAL EXAMINED.—*New Records:* Off Seto Marine Lab, Shirahama, Honshu, 3 m, 1 colony, USNM 92870. *Previous Records:* Specimens reported by Faulkner and Chesher (1979) and Cairns (1991a), all at the USNM.

TYPES.—The types of *D. gracilis* are deposited at the MNHNP. *Type Locality:* Off "China"; depth unknown.

The holotype of *Tubastraea coccinea titijimaensis* is deposited at the TIUS (#895). *Type Locality:* Futami port, Chichijima, Bonin Islands, depth unknown.

DISTRIBUTION.—Sagami Bay, Honshu; Shirahama, Kii Strait; Bonin Islands; 3–95 m. *Elsewhere:* Common throughout Indo-West Pacific and eastern Australia; 0–45 m.

Cladopsammia eguchii (Wells, 1982), comb. nov.

PLATE 38*a,b*

Dendrophyllia arbuscula var. *compressa* Eguchi and Suzuki, 1973:84, pl. 1: fig. 3.

Balanophyllia eguchii Wells, 1982:211, 213, pl. 1: figs. 4–6; 1983:239–240.—Cairns, 1991a:23, pl. 9: figs. h–j.

DESCRIPTION.—Illustrated colony a small (2.5 cm in width) phaceloid corallum composed of only 5 corallites, 3 of them rooted in a common basal coenosteum, the other 2 budded from 2 of the larger corallites. Calices of small corallites circular, but calices of larger corallites (up to 13 × 9 mm in diameter) tend to be elongate. Synaticulotheca thick and porous, covered by costae 0.35 mm wide, each bearing a unilinear row of dentate granules. Corallum white; polyps red (Eguchi and Suzuki, 1973).

Septa hexamerally arranged in a weak Pourtalès Plan, the largest corallites having a full fifth cycle (96 septa), but most corallites lacking many pairs of S_5. S_{1-3} equal in size, little exsert, and have straight, vertical, entire inner edges that border the columella. All S_4 quite narrow. Pairs of S_5 unite before their mutually adjacent S_4 and either extend as a single septum to the columella or are fused with their counterpart within the half-system before the S_5 and continue on to the columella. Thus, inner edges of 24–48 septa may border the columella of a large corallite. Fossa of moderate depth, containing an elongate, spongy columella.

DISCUSSION.—*Cladopsammia eguchii* differs from *C. gracilis* primarily by having a weakly developed Pourtalès Plan, its S_2 and even S_3 often attaining the columella, only its S_5 consistently fused before the S_4. *C. eguchii* also has a thicker synapticulotheca and septa, more elongate calices, and more widely spaced corallites. In the last character, *C. eguchii* approximates the reptoid growth form of *Rhizopsammia,* but no stolons were ever observed uniting adjacent corallites, only the continuous basal coenosteum diagnostic of the genus.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Holotype of *B. eguchii,* USNM; off Seto Lab, Shirahama, Kii Strait, 7 m, 1 colony, USNM 78646 (Wells, 1982).

TYPES.—The holotype of *Balanophyllia eguchii* is deposited at the USNM (46966). *Type Locality:* Marchena I., Galápagos; 6 m.

DISTRIBUTION.—Off Japan: Off Nakagi, Minami-Izu machi, Shizuoka Prefecture, Honshu; off Shirahama, Kii Strait; 7 m. *Elsewhere:* Hawaiian Islands; off Queensland, Australia; Gulf of Panama; Malpelo Island; Galápagos Islands; 1–85 m.

Dendrophyllia Blainville, 1830

DIAGNOSIS.—See Part 1.

DISCUSSION.—Of the 25–30 Recent species of *Dendrophyllia*, three basic growth forms can be discerned, (1) tall, arborescent colonies, often flabellate, having several larger axial corallites from which short corallites bud in an irregular manner, (2) small, bushy colonies that also have axial corallites, each bearing relatively few, large corallites, and (3) large, dendroid colonies with fairly regular, sympodial branching, the terminal corallite of each branch being replaced by each successive corallite. The type-species, *D. ramea* (Linnaeus, 1758), and four other species (*D. cribrosa* Milne Edwards and Haime, 1851; *D. minuscula* Bourne, 1905; *D. ijimai* Yabe and Eguchi, 1934; and *D. indica* Pillai, 1967) are characteristic of the first form, termed the "axial" group. Species belonging to the second ("bushy") group include: *D. cornigera* (Lamarck, 1816); *D. japonica* Rehberg, 1892; *D. arbuscula* (Van der Horst, 1922); *D. cladonia* Van der Horst, 1927; *D. horsti* (Gardiner and Waugh, 1939), and several others. The third "sympodial" group consists of: *D. alternata* Pourtalès, 1880; *D. florulenta* Alcock, 1902; *D. oldroydae* Oldroyd, 1924; *D. boschmai* Van der Horst, 1926; *D. dilatata* Van der Horst, 1927; *D. californica* Durham, 1947; *D. alcocki* (Wells, 1954); and *D. johnsoni* Cairns, 1991a. All species of *Dendrophyllia* are herein characterized by having a single basal branch from which all subsequent branching occurs. Two species that were previously listed in *Dendrophyllia*, both of which bud from a common basal coenosteum, are herein considered to belong to *Cladopsammia: C. gracilis* (Milne Edwards and Haime, 1848b) and *C. eguchii* (Wells, 1982). Likewise, several other species are transferred from *Dendrophyllia* to *Eguchipsammia* based on their quasicolonial, unattached growth form: *E. gaditana* (Duncan, 1873); *E. cornucopia* (Pourtalès, 1871); *E. fistula* (Alcock, 1902); *E. serpentina* (Vaughan, 1907); and *E. oahensis* (Vaughan, 1907).

Dendrophyllia ijimai Yabe and Eguchi, 1934

PLATE 38*c,f*

Dendrophyllia ijimai Yabe and Eguchi, 1934a:2026.—Eguchi, 1965:294, 2 figs.; 1968:C65, pl. C16: figs. 1, 2; pl. C22: fig. 1; pl. C30: figs. 4, 5 [synonymy].—Kikuchi, 1968:9, pl. 15: fig. 2.—Eguchi and Miyawaki, 1975:54.—Cairns and Keller, 1993:280, fig. 13G.

Dendrophyllia micranthus.—Eguchi, 1965:294, 1 fig; 1968:C66, pl. C24: figs. 2, 3.—?Utinomi, 1965:256–257; 1971:219–220.—Not Kikuchi, 1968:9, pl. 5: fig. 10.—Not Eguchi and Miyawaki, 1975:54, pl. 7: fig. 1.—Not Song, 1991:137, pl. 1: fig. 6; pl. 3: fig. 2.

Dendrophyllia minuscula.—Utinomi, 1965:257.—?Eguchi, 1968:C60–61.—Tribble and Randall, 1986:159.

DESCRIPTION.— Corallum composed of elongate, relatively straight axial coralites, circular in cross section, and gradually attenuating in diameter to terminal calices 6–7 mm in diameter. Numerous stout corallites bud perpendicular and in all directions from the axial corallite, usually only 3–9 mm in height and 5–6 mm in diameter. Costae well defined, 0.3–0.4 mm wide, and separated by deep, porous intercostal furrows about 0.15 mm wide. Costae bear 1, sometimes 2, rows of small pointed granules. Corallum white.

Septa hexamerally arranged in 4 cycles (48 septa) in a Pourtalès Plan. S_1 largest septa and have vertical, straight, entire inner edges that reach the columella. S_2 only about half width of an S_1 and have laciniate inner edges. S_3 rudimentary and also have laciniate inner edges. S_4 equal in width to an S_3 near calice but lower in fossa each pair of S_4 are fused before its adjacent S_3 and extended toward columella where it unites with the other combined S_4 within the system before the common S_2 near the columella. Inner edges of S_4 highly laciniate. Axial corallites differ from the more numerous lateral corallites in being slightly larger and having correspondingly more septa (some S_5), having a deeper fossa, and lacking the final S_4 fusion before the S_2. Fossa of lateral corallites of moderate depth and contains a small, spongy columella.

DISCUSSION.—As stated in the genus discussion, four other species are recognized in the same group (axial) of *Dendrophyllia* species as *D. ijimai*, only one of which occurs in the Japanese region: *D. cribrosa*. *Dendrophyllia ijimai* is distinguished from that species by have nonanastomotic branches and exsert corallites (not flush with the coenosteum).

The axial corallite growth form of *D. ijimai* is similar to that of *Tubastraea micranthus*, with which it has been confused. *Tubastraea micranthus* can be distinguished by having normally arranged septa; *D. ijimai* has a Pourtalès Plan.

MATERIAL EXAMINED.—*New Records:* Moroisa, Sagami Bay, 55 m, 2 colonies, USNM 92872, 1 colony, ORI; off Japan, 1 colony, USNM 92874; TM (KT9202, YT1), 1 colony, USNM 92873; Misaki, Sagami Bay, 55 m, Mortensen's 1914 Pacific Expedition of 1914, 5 colonies, ZMC.

TYPES.—The types of *D. ijimai* have not been traced. *Type Locality:* Unknown, but presumed to be off Japan.

DISTRIBUTION.—Japan: Sagami Bay and Izu Peninsula, Honshu; off Kii Peninsula; Osumi Shoto, northern Ryukyu Islands; Amakusa Islands; north of Cheju Do, South Korea, East China Sea; 10–200 m. *Elsewhere:* Western Indian Ocean (Cairns and Keller, 1993), 37–366 m.

Dendrophyllia cribrosa Milne Edwards and Haime, 1851

PLATE 38*g,h*

Dentipora cribrosa Blainville, 1830:348 [nomen nudum]; 1834:382 [nomen nudum].

Dentipora anastomozans Blainville, 1830:348 [nomen nudum]; 1834:382 [nomen nudum].

Oculina anastomozans Blainville, 1830:348 [nomen nudum]; 1834:382 [nomen nudum].

Dendrophyllia sp.—Milne Edwards and Haime, 1850b:137.

Dendrophyllia cribrosa Milne Edwards and Haime, 1851:137; 1860: 117–118.—Van der Horst, 1922:52–53, pl. 7: fig. 2.—Eguchi, 1965:295, 1 fig.; 1968:C58–59 [but not second paragraph], pl. C2: fig. 2; pl. C21: figs. 3, 4.—Hamada: 1969:255–257, pl. 1: fig. 1a–e; pl. 2: figs. 2, 3.—?Song, 1982:139, pl. 3: figs. 9, 10; ?1988:29, pl. 3: figs. 1–8; ?1991:137.

?Dendrophyllia anastomozans.—Monod, 1950:60; 1954:226–230, text-figs. 6–10, pl. 1: figs. 1–3.—Chevalier, 1966:1379–1382, text-fig. 30.

REDESCRIPTION OF LARGER SYNTYPE (RMNH 9212).—Corallum 15 cm wide and 12 cm in height, essential planar in

shape. Colony obviously dead when collected, the coenosteum well worn and discolored to a light brown. Branches robust, basal branches about 31 mm in diameter, distal blunt tipped branches about 13 mm in diameter; branch anastomosis common. Corallites 5–6 mm in diameter and flush with coenosteum, perhaps due to wear of corallum. Theca vermiculate as well as obscurely costate, the coenosteum penetrated by numerous small (0.32 mm in diameter) circular pores (?borings). Septa hexamerally arranged in 4 cycles in a Pourtalès Plan, some of the larger corallites having several pairs of S_5. S_1 slightly wider than S_2, both cycles of septa attaining the columella. S_3 narrowest of septa, each S_3 flanked by a pair of S_4 which fuse before the S_3 and extend to the columella. Fossa shallow, containing a large, spongy columella.

DISCUSSION.—*Dendrophyllia cribrosa* is treated as a member of the first group of species as defined in the generic discussion because it has an arborescent corallum and nonsympodially budded corallites. It is relatively easily distinguished from other North Pacific species by having thick, anastomotic branches; very short (flush) corallites oriented perpendicular to parent branches; circular corallites 4.5–8.0 mm in diameter; and a robust columella. The proper authorship of the species is Milne Edwards and Haime (1851), not Milne Edwards and Haime (1860), as suggested by some authors. Blainville's earlier names published in lists must be considered as nomina nuda and de Haan's *Oculina anastomozans* was apparently only another unpublished manuscript name cited by Blainville (1830).

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Larger syntype of *D. cribrosa*, RMNH.

TYPES.—Two syntypes (Plate 38*g,h*) of *D. cribrosa* are deposited at the RMNH: the larger specimen described above (RMNH 9212, manuscript type of *Dentipora anastomozans*) and a much smaller fragment 8.2 cm long (RMNH 9209, manuscript type of *Dentipora cribrosa*). *Type Locality:* Unknown.

DISTRIBUTION.—Japanese region: Sagami Bay, Honshu; ?Sea of Japan off eastern and southern South Korea (Song, 1982); Pleistocene of Kanagawa-ken; 7–40 m. *Elsewhere:* Off Banka, southeastern Sumatra; ?off Angola (Cabinda) and the Congo; 20–30 m.

Dendrophyllia japonica Rehberg, 1892

Dendrophyllia japonica Rehberg, 1892:28–29, pl. 4: fig. 4.—Van der Horst, 1926:44–45, pl. 3: figs. 4, 5.—Yabe and Eguchi, 1932a: 388; 1941b:102.—Eguchi, 1934:367; 1965:295, 2 figs.; 1968:C61–62, pl. C13: figs. 3–5 [synonymy].—Squires and Keyes, 1967:28, pl. 6: figs. 6–8 [synonymy].

Not *Dendrophyllia japonica* Van der Horst, 1922:51, pl. 7: fig. 6 [junior homonym: replacement name *D. boschmai* Van der Horst, 1926].

DIAGNOSIS.—Colonies consist of a primary axial corallite up to 9 cm in height and up to 27 mm in GCD from which several slightly smaller, but still quite robust, corallites bud at irregular intervals. All colonies examined as well as those reported in the literature are broken basally, but it would appear from the larger diameter of the basal fractures that the normal condition of the species is attached, not free as in *Eguchipsammia*. Costae are flat and porous; epitheca absent. Septa hexamerally arranged in a Pourtalès Plan, larger corallites having a full fifth cycle of septa (96), smaller corallites usually having numerous pairs of S_5. S_{1-2} equal in size, slightly exsert, and quite wide, their smooth inner edges bordering the columella. S_3 and S_4 progressively smaller. Pairs of S_5 fuse before their adjacent S_4 and again before the S_3 in their half-system before reaching the columella. Fossa deep, containing an elongate narrow columella.

DISCUSSION.—*Dendrophyllia japonica* belongs to the "second group" of *Dendrophyllia* species, those characterized as bushy, having small colonies with sparsely budded large corallites. It is compared to *D. arbuscula* in the account of that species.

MATERIAL EXAMINED.—*New Records:* None. *Previous Records:* Specimens reported by Squires and Keyes (1967) from off New Zealand, NZOI.

TYPES.—Two syntypes of Rehberg's *D. japonica* were present at the ZMB in the 1920's (Van der Horst, 1926), but it is likely that they were subsequently lost or destroyed. *Type Locality:* "Japan," depth unknown.

DISTRIBUTION.—Japan: Sea of Japan off northwestern Honshu from Tsugaru Strait to Wakasa Bay; Sagami Bay; 115–250 m. *Elsewhere:* Banda Sea; North Island, New Zealand; 114–549 m.

Dendrophyllia arbuscula Van der Horst, 1922

PLATE 38*i–l*

?Dendrophyllia conferta.—Rehberg, 1892:28.

Dendrophyllia arbuscula Van der Horst, 1922:53, pl. 8: fig. 6.—Yabe and Eguchi, 1932a:388; 1941b:102.—Eguchi, 1934:367; 1965:294, 2 figs.; 1968:C55–56, pl. C21: figs. 5, 13.—Not Kikuchi, 1968:9, pl. 5: fig. 6 [= *Cladopsammia* sp.].—Not Utinomi, 1971:220 [= *Cladopsammia gracilis*].—Eguchi and Miyawaki, 1975:54, pl. 6: fig. 4.—? Song, 1991:136, pl. 1: fig. 4; pl. 3: fig. 1.

?Dendrophyllia subcornigera Eguchi, 1934:367 [nomen nudum]; 1968:C64, pl. C32: figs. 3, 4.

?Dendrophyllia subcornigera cylindrica Eguchi, 1934:367 [nomen nudum]; 1968:C64–65, pl. C32: figs. 1, 2.

?Dendrophyllia sp.—Eguchi, 1968:C67, pl. C30: figs. 6, 7.

Tubastraea coccinea.—Song, 1982:140, pl. 4: figs. 7, 8.

DESCRIPTION.—Colonies small, sparsely branched, and bushy. Largest colonies examined only 6 cm tall and rarely consist of more than 8 corallites, most buds originating from 1 or 2 larger-diameter axial corallites that persist as the terminal corallites of each branch. Corallites relatively large (e.g., 13 × 11 mm in diameter) and cylindrical. Colony pedicels up to 16 mm in diameter. Costae inconspicuous: flat, 0.5–0.6 mm wide, and porous, each covered by small, pointed granules arranged 3 or 4 across a costa. Intercostal striae narrow and shallow, 0.10–0.15 mm wide. Corallum white.

Septa hexamerally arranged in 4 cycles, the fourth cycle attained at a GCD of 6–7 mm; S_5 rare, present only in largest corallites up to a total of about 60 septa. S_1 slightly exsert

(0.8–0.9 mm), with smooth, vertical inner edges that reach the columella only low in fossa. S_2 less exsert and slightly less wide than an S_1, but also have smooth inner edges that almost attain the columella. S_3 about half width of an S_2. Each pair of S_4 within a half-system bend towards each other, resulting in either a loose fusion of their inner edges before their enclosed S_3 or a closely parallel arrangement leading to the columella. Inner edges of S_4 slightly porous and laciniate to dentate, the S_{1-3} being solid septa with entire inner edges. Fossa of moderate to shallow depth, containing a well-developed, discrete, elongate columella, sometimes constricted into 3 lobes by inner edges of the 4 lateral S_1. Columella composed of small, flattened, swirled elements that are tightly fused together.

DISCUSSION.—*Dendrophyllia arbuscula* belongs to the "second group" of *Dendrophyllia* species described in the generic discussion: species having small, bushy colonies, with relatively few large corallites. The only other species in this group from the Japanese region is *D. japonica* Rehberg, 1892, which differs in having larger corallites, more septa, and a less developed columella.

Dendrophyllia subcornigera Eguchi, 1968 is only tentatively synonymized with *D. arbuscula*, as the type and only reported specimen of this species is not available for study. Its description and illustrations are consistent with a large, well-developed colony of *D. arbuscula*, much like that of the holotype; in his original description, Eguchi (1968) noted the resemblance. Likewise, *D. subcornigera cylindrica* Eguchi, 1968, which is also known from only one specimen, is also tentatively synonymized but this specimen is even more robust with long internodes between budded corallites and quite long secondary corallites. Its growth form resembles that of the "first group" of species of *Dendrophyllia*.

MATERIAL EXAMINED.—*New Records:* Alb-3707, 6, USNM 22057, 2, ORI; Alb-3716, 4, USNM 22054; Alb-3718, 1, USNM 22053; Alb-3720, 2, USNM 22052; Alb-3730, 1, USNM 22056; Alb-3746, 2, USNM 22055; Alb-4935, 1, USNM 92853; Alb-5068, 4, USNM 92854; Alb-5070, 2, USNM 92855; TM (KT7811, OT6-2), 1, USNM 92856; Okinose, Sagami Bay, 183 m, Mortensen's Pacific Expedition, 15 June 1914, 3, ZMC.

TYPES.—Three syntypes of *D. arbuscula* are deposited at the ZMA (Coel. 1254, 5477). *Type Localities:* *Siboga*-260, 277: Banda Sea, 45–90 m.

The holotype of *D. subcornigera* is deposited at the Biological Laboratory of the Imperial Household, Tokyo (specimen number 896, reg. no. 40859). *Type Locality:* Enoura Bay, Shizuoka-ken, Honshu, depth unknown.

The holotype of *D. subcornigera cylindrica* is deposited at the Biological Laboratory of the Imperial Household, Tokyo (specimen number 897). *Type Locality:* Off Seto, Kanayama-maru, Nishimuragun, Wakayama-ken; depth unknown.

DISTRIBUTION.—Japan: Sagami and Suruga Bays, Honshu; Kii Strait; off Amakusa Islands; off Cheju Do, East China Sea; 40–240 m. *Elsewhere:* Banda Sea; 45–90 m.

Dendrophyllia boschmai Van der Horst, 1926

Dendrophyllia japonica Van der Horst, 1922:51, pl. 7: fig. 6 [junior primary homonym of *D. japonica* Rehberg, 1892].

Dendrophyllia boschmai Van der Horst, 1926:44 [replacement name for *D. japonica* Van der Horst, 1922].—Eguchi, 1934:367.—Yabe and Eguchi, 1936:167; 1968:C56–57, pl. C15: figs. 4, 7; pl. C16: figs. 3, 4; pl. C17: figs. 12, 15; pl. C30: fig. 1.—Song, 1982:138, pl. 4: figs. 3, 4; 1991:136.

Dendrophyllia cyathoheloides Eguchi, 1934:367 [nomen nudum].

Dendrophyllia boschmai cyathoheloides Eguchi, 1965:294, 1 fig.

Dendrophyllia boschmai cyathohelioides [sic].—Eguchi, 1968:C57, pl. C2: fig. 1; pl. C15: figs. 1–3; pl. C15: figs. 1–3, 5, 6, 8, 9.

Dendrophyllia boschmai cyathoheliodes [sic].—Song, 1991:136, pl. 1: figs. 7, 8.

DIAGNOSIS.—Colonies robust and uniplanar, up to 9 cm in height and width. Corallites primarily sympodially budded from branch edges but in a very crowded manner, with additional corallites on corallum faces. Coenosteum costate and nonepithecate. Corallites large, up to 9 × 11 mm in diameter. Septa hexamerally arranged in 4 cycles in a typical Pourtalès Plan, larger corallites having some pairs of S_5. Inner edges of S_1 smooth, those of S_{2-5} dentate. Columella well developed and spongy. Corallum white; polyps red with yellow tentacles.

DISCUSSION.—No specimens of this species were examined and thus the diagnosis above is taken from the literature. *D. boschmai* differs from the other sympodially branched species known from Japan, *D. florulenta*, in having larger corallites, a more robust corallum, and a much denser budding arrangement.

MATERIAL EXAMINED.—None.

TYPES.—The holotype of *D. boschmai* (= *D. japonica* of Van der Horst, 1922) is deposited at the ZMA (Coel. 5451) (Van Soest, 1979). *Type Locality:* "Japan," depth unknown.

The holotype of *D. boschmai cyatheloides* is deposited at the TIUS (57443). *Type Locality:* Off Kowa, Mie-ken, Honshu, depth unknown.

DISTRIBUTION.—Known only from the Japanese region: Sagami and Suruga Bays, Honshu; off Kii Peninsula, Honshu; off Shikoku; south of Cheju Do, South Korea; 40–165 m.

Dendrophyllia florulenta Alcock, 1902

PLATE 39*a–c*

Dendrophyllia florulenta Alcock, 1902a:111.

Dendrophyllia florulenta Van der Horst, 1922:54–55, pl. 7: fig. 5 [junior homonym of Alcock, 1902a].—Van Soest, 1979:115.—Song, 1982:139, pl. 4: figs. 5, 6; 1991:137.

?Dendrophyllia florentula [sic].—Wells, 1954:473, pl. 180: figs. 4, 5.

Dendrophyllia cf. *fluolenta* [sic].—Eguchi, 1934:367; 1968:C59.

DIAGNOSIS.—Corallum small, the largest Japanese specimen (TM (KT9015, CB2-2)) only 3.2 cm in height consisting of 6 corallites. Van der Horst's (1922) syntypes are also small branches 3.3 and 4.0 cm long with only 5 or 6 corallites, but Wells' (1954) specimen from Bikini is quite large: 15 cm in height and having over 50 corallites. Branching uniplanar and strictly sympodial, with a regular alternation of buds on right and left sides of the branch. Corallites about 1 cm long and

6.0–6.5 × 4.0–4.5 mm in diameter, Wells' specimen having larger corallites up to 9 × 7 mm in diameter. Costae evident, separated by narrow intercostal striae, and covered with fine granules; epitheca absent. Corallum white. Septa hexamerally arranged in 4 complete cycles in a Pourtalès Plan. S_{1-2} highly exsert and have smooth (entire) inner sdges that attain the columella. S_3 small; pairs of S_4 fuse before their adjacent S_3 and extend to columella. Inner edges of S_3-4 dentate. Fossa deep, containing a small, spongy columella.

DISCUSSION.—The specimen reported by Wells (1954) from the Marshall Islands differs from typical *D. florulenta* in several characters and thus its identification is queried. It has larger corallites; more septa (occasional pairs of S_5 in large corallites); and a smaller, almost lamellar, columella. Comparisons to the only other sympodially branched *Dendrophyllia* from the Japanese region, *D. boschmai*, are made in the account of that species.

Van der Horst (1922) described *D. florulenta* as a new species apparently unaware that Alcock (1902a) had previously described the same species under the same name, making Van der Horst's species both a junior homonym and junior synonym. Most of Alcock's (1902a,b) brief descriptions of his new species from the *Siboga* collection were republished one month later (Alcock, 1902c), but eight of them were not, including *Dendrophyllia florulenta*. I suspect that Alcock's type specimens were labelled as *D. florulenta* in the ZMA collections but not recognized as types, such that when Van der Horst (1922) later revised the *Siboga* Dendrophylliidae, he used what he thought were Alcock's manuscript types as his type specimens and adopted the name as well.

MATERIAL EXAMINED.—*New Records:* TM (KT9015, CB1-1), 1, USNM 92875; TM (KT9015, CB1-2), 2, USNM 92876; TM (KT9015, CB2-2), 2, USNM 92877; 34°20′N, 130°10′E (off Okino Shima), 110 m, 18 May 1914, Mortensen's 1914 Pacific Expedition, 1, ZMC. *Previous Records:* Specimen from Marshall Islands (Wells, 1954), USNM 45102.

TYPES.—The holotype of Alcock's *D. florulenta* is presumed to be deposited at the ZMA, probably one of the two syntypes of Van der Horst's *D. florulenta*, but Alcock (1902a) did not document the *Siboga* station from which his specimens came. *Type Locality:* Unknown, but undoubtedly from the *Siboga* Expedition to Indonesia, probably *Siboga*-51 or 305.

Two syntypes of Van der Horst's (1922) *D. florulenta* are deposited at the ZMA (Coel. 1195, 1256). *Type Localities: Siboga*-51, 305: Banda Sea, 69–113 m.

DISTRIBUTION.—Off Japan: Sagami Bay; Eastern Channel, off Mishima and Okinoshima; north and south of Cheju Do, South Korea, East China Sea; 70–110 m. *Elsewhere:* Banda Sea, Bonin Islands, ?Marshall Islands; 69–243 m.

Enallopsammia Michelotti, 1871

DIAGNOSIS.—Colonial, arborescent colonies formed by extratentacular budding. Corallites often, but not always, unifacially arranged. Coenosteum dense, synapticulotheca porous only near calice and on distal branches. Septa arranged normally. Columella small.

TYPE SPECIES.—*Coenopsammia scillae* Seguenza, 1864, by monotypy.

Enallopsammia rostrata (Pourtalès, 1878)

PLATE 39*d–f*

Amphihelia rostrata Pourtalès, 1878:204, pl. 1: figs. 4, 5.
Dendrophyllia amphelioides Alcock, 1902a:112–113.
Amphehelia adminicularis Rehberg, 1892:10, pl. 4: fig. 1.
Dendrophyllia amphelioides var. *cucullata* Vaughan, 1907:157, pl. 47: fig. 3; pl. 48: figs. 1–4.
Anisopsammia amphelioides.—Eguchi, 1934:368.
Enallopsammia rostrata.—Zibrowius, 1973:44–45, figs. 14, 15.—Cairns, 1979:186–188, pl. 37: figs. 2, 3, 6; 1982:57–58, pl. 18: figs. 1–4 [synonymy].—Cairns and Parker, 1992:52–53, fig. 18e–i.
Enallopsammia (Anisopsammia) amphelioides.—Eguchi, 1965:296, 1 fig.
Enallopsammia amphelioides disticha Eguchi, 1968:C68, pl. C24: figs. 1, 6; pl. C29: figs. 1, 2.—Zibrowius and Grygier, 1985:134.

DESCRIPTION.—Colonies usually planar, having close, dichotomous branching, which occasionally leads to branch anastomosis. Corallites occur on only 1 side of colony and are circular to slightly elliptical in shape: up to 5.6 mm in GCD, but usually only 4.0–4.5 mm in diameter. Costae better developed on acalicular face, being about 0.5 mm wide, slightly convex, and finely granular, separated by narrow, porous intercostal regions. No septocostal rostra present on Japanese specimens. Corallum white.

Septa hexamerally arranged in 3 complete cycles (24 septa). S_{1-2} equal in size, nonexsert, and quite slender, having vertical, smooth inner edges. S_3 only only half width of an S_{1-2} and thus quite slender, usually having a dentate or irregularly shaped inner edge. Inner edges of pairs of S_3 fuse to their adjacent S_2 near columella. Fossa quite deep, sometimes slightly curved, and quite open because of the very narrow septa. Columella rudimentary, consisting of several small extensions from lowermost inner edges of S_{1-2}.

DISCUSSION.—*Enallopsammia rostrata* was first reported from Japan by Rehberg (1892) based on one specimen, and later by Eguchi (1965, 1968) as *E. amphelioides disticha*, again apparently based on one additional specimen. Eguchi's (1968) reference to a locality record from Enoshima, Sagami Bay is not documented in his papers. The two lots reported herein are from the East China Sea southwest of Kyushu, not far from the type locality of *E. a. disticha*.

All Japanese specimens lack the septocostal rostrum that characterizes the typical form of this species. But, as earlier stated (Cairns, 1982:57), the development of a rostrum seems to be a response to an environmental factor, not a species level character. The Japanese specimens thus belong to the *"amphelioides"* form of this species, i.e., those specimens lacking a rostrum.

MATERIAL EXAMINED.—*New Records:* Alb-4891, 2 colonies, USNM 92849, 1 branch, ORI; Alb-4892, 2 colonies,

USNM 92850, 2 branches, CAS 80924. *Previous Records:* Syntypes of *A. rostrata* and *D. a. cucullata*, MCZ and USNM, respectively.

TYPES.—The syntypes of *A. rostrata* are deposited at the MCZ (unnumbered). *Type Locality: Blake*-2: 23°14'N, 82°25'W (Straits of Florida), 1472 m.

The syntypes of *D. amphelioides* are deposited at the ZMA and the Indian Museum, Calcutta (Van Soest, 1979). *Type Localities: Siboga*-156, 177: Pulau Waigeo and Palau Misool, Indonesia; 469–1633 m.

Type material of *A. adminicularis* is deposited at the ZMB (2670, 2691) (H. Zibrowius, pers. comm.) *Type Locality:* "Japan," depth unknown.

The syntypes of *D. amphelioides* var. *cucullata* are deposited at the USNM (Cairns, 1991a). *Type Locality:* Off Hawaiian Islands; 426–679 m.

The holotype of *E. amphelioides disticha* is presumed to be deposited at the Biological Laboratory of the Imperial Household, Chiyoda-ku, Tokyo (specimen # 857). *Type Locality:* Off Satsuma Peninsula, Kagoshima-ken, southwestern Kyushu, 270 m.

DISTRIBUTION.—Japan: East China Sea off southwestern Kyushu; ?Sagami Bay; 270–331 m. *Elsewhere:* Cosmopolitan except for eastern Pacific; 229–2165 m.

Tubastraea Lesson, 1829

DIAGNOSIS.—Colonies dendroid, bushy, or plocoid, all achieved by extratentacular budding. Costate, no epitheca. Septa arranged normally. Pali absent; columella usually small and spongy.

TYPE SPECIES.—*Tubastraea coccinea* Lesson, 1829, by monotypy.

Tubastraea coccinea Lesson, 1829

PLATE 39*g–i*

Tubastraea coccinea Lesson, 1829:93.—Wells, 1983:243–244, pl. 18: figs. 1, 2 [synonymy].—Prahl, 1987:230–231, fig. 8.—Wilson, 1990:137–138, fig. 1.—Cairns, 1991a:26–27, pl. 12: figs. c–e [synonymy].—Cairns and Keller, 1993:282–284 [synonymy].

Lobopsammia aurea Quoy and Gaimard, 1833:195.

Astropsammia peterseni Verrill, 1869:392.

Dendrophyllia aurea.—Eguchi, 1934:367.

Tubastraea tenuilamellosa.—Durham, 1947:38–39, pl. 11: figs. 1, 2, 4, 9; pl. 12: figs. 6, 7.—Durham and Barnard, 1952:105–106, pl. 12: fig. 50d.

Tubastraea aurea.—Squires, 1959:427–428.—Utinomi, 1965:257–258; 1971:220–221.—Eguchi, 1965:295, 1 fig.; 1968:C68–70, pl. C16: figs. 5, 6; pl. 17: fig. 17; pl. C26: figs. 2, 3 [synonymy].—Kikuchi, 1968:9.—Eguchi and Miyawaki, 1975:54, pl. 7: fig. 3.—?Song, 1982:139–140, pl. 3: figs. 11, 12; 1991:137–138.—Tribble and Randall, 1986:159.

Dendrophyllia coccinea.—Eguchi, 1965:296, 1 fig.—Utinomi, 1965:257.

?Dendrophyllia sibogae.—Kikuchi, 1968:9.

?Tubastraea coccinea.—Eguchi, 1968:C70–71, pl. C2: fig. 3; pl. C14: figs. 4, 5, 8, 9.—Kikuchi, 1968:9, pl. 5: fig. 4.—Utinomi, 1971:221, pl. 13: fig. 5a,b.—Eguchi and Miyawaki, 1975:54, pl. 7: fig. 2.

Not *Tubastraea coccinea.*—Song, 1982:140, pl. 4: figs. 7, 8 [= *Dendrophyllia*]; 1988:29–30; 1991:138.

DESCRIPTION.—Mature colonies roughly spherical, the corallites closely spaced in a plocoid arrangement. Corallites bud extratentacularly at colony edge and between older corallites, thus maintaining a plocoid structure as colony increases in size. Calicular edges often directly adjacent to one another, but occasionally corallites project 1–10 mm above basal coenosteum. Corallites circular to slightly elliptical in shape, the largest examined being about 13 mm in GCD, but most are only 7–9 mm in GCD. Costae equal in width (0.30–0.35 mm) and coarsely granular, separated by wide (0.15–0.20 mm), very deep intercostal furrows that are highly porous. Corallum white; coenosarc orange.

Septa hexamerally arranged in 4 cycles. S_{1-2} virtually equal in size, but S_1 slightly thicker and wider, penetrating farther into the columella than S_2. Upper edges of S_{1-2} nonexsert and slightly tapered, reaching their greatest width 3-4 mm into fossa, where they have vertical, smooth inner edges. S_3 much smaller than S_{1-2}, only 0.2–0.3 mm in width, or about 15%–20% width of an S_{1-2}. Inner edges of S_3 dentate to highly laciniate from top to bottom. S_4 rudimentary or of same size as the S_3, 1 or both lacking from each half-system. Inner edges of S_4 also laciniate, occasionally loosely fused to adjacent S_3. Fossa moderate to deep, containing a columella of variable size, but usually containing a rather large, spongy columella.

DISCUSSION.—*Tubastraea coccinea* is a very common shallow-water azooxanthellate with a circumtropical distribution, and, probably because of its accessibility, has been described under many (approximately 18) names, more complete synonymies given by Eguchi (1968) and Wells (1983). Its broad distribution may be the result of introductions caused by transport on ship hulls. Its apparent spread throughout the Caribbean, first noticed in the Netherland Antilles and progressively in other parts of the Caribbean, would indicate that the western Atlantic was not its original range. Coralla of specimens from the Caribbean, Galápagos, Japan, and the southwest Indian Ocean are indistinguishable.

MATERIAL EXAMINED.—*New Records:* Off Partida Island, Espiritu Santo Islands, Gulf of California, 3 colonies, USNM 91428; off Conception Point, Gulf of California, 4 colonies, USNM 91429; off Seto Marine Lab, Shirahama, 2–8 m, 2 colonies, USNM 83644, 83657; off Tanabe, Kii Strait, 1 colony, USNM 92851; Misaki, Sagami Bay, 1, ORI; Misaki, Sagami Bay, 15 June 1914, Mortensen's 1914 Pacific Expedition, 4 colonies, ZMC; TM (KT9202, YT1), 1 colony, USNM 92852. *Previous Records:* Holotype of *A. peterseni*, USNM; specimens reported by Cairns (1991a) and Cairns and Keller (1993).

TYPES.—The holotype of *T. coccinea* is deposited at the MNHNP (Wells, pers. comm.). *Type Locality:* Bora Bora, Society Islands, depth unknown.

The types of *L. aurea* were not traced. *Type Localities:* Port du Roi George and Port Jackson, Australia, depth unknown.

The holotype of *A. peterseni* is deposited at the USNM

(38354). *Type Locality:* La Paz, Gulf of California, depth unknown.

DISTRIBUTION.—As discussed above, *T. coccinea* is a circumtropical shallow-water species. In the northeastern Pacific its northen limit is at the border of the tropical/warm temperate region, being found in the Gulf of California, but only to Cabo San Lucas on the Pacific side of Baja California Sur (Wilson, 1990). In the northwest Pacific, however, records extend into the warm temperate region as far north as Sagami Bay. It also occurs in the Kii and Bungo Straits; Osumi Shoto, northern Ryukyu Islands; off the Amakusa Islands; and East China Sea off Cheju Do, South Korea; 0–15 m. *Elsewhere:* 0–110 m.

Schizopsammia, gen. nov.

DIAGNOSIS.—Dendroid colonies formed exclusively by equal, intratentacular budding. Pourtalès Plan poorly developed. Pali absent; columella spongy. Tabular endothecal dissepiments present.

TYPE SPECIES.—*Schizopsammia songae*, herein designated.

DISCUSSION.—Only three dendrophylliid genera form colonies by intratentacular division: *Lobopsammia* Milne Edwards and Haime, 1848b; *Stichopsammia* Felix, 1885; and *Reussopsammia* Wells, 1937, all three of which are known only from the Eocene to Oligocene of Europe. One Recent species of *Eguchipsammia, E. gaditana,* is also known to bud intratentacularly, but only as a rare secondary mode, its primary mode being extratentacular. *Schizopsammia* differs from *Stichopsammia* in having monostomadeal, not polystomadeal, budding; it differs from *Reussopsammia* in having a weak Pourtalès Plan, not a normal septal insertion. *Schizopsammia,* however, is quite similar to *Lobopsammia* in corallum shape, size, and septal arrangement, but differs in having tabular endothecal dissepiments.

The colony shape of *Schizopsammia* that results from equal intratentacular budding and the presence of tabular endothecal dissepiments resembles that of *Solenosmilia,* a deep-water azooxanthellate genus in the suborder Caryophylliina.

ETYMOLOGY.—The genus name *Schizopsammia* (Greek *schizo,* meaning "to split" + Greek *psammos,* meaning "sand," a common suffix used in dendrophylliid generic names) refers to the equal intratentacular division found within the genus. Gender: feminine.

DISTRIBUTION.—Known only from the Western Channel of the Korea Strait off South Korea; depth unknown.

Schizopsammia songae, sp. nov.

PLATE 40*a–e*

DESCRIPTION.—Corallum dendroid, dichotomously branching in three dimensions with no branch anastomosis. Holotypic colony 46 mm in height and 43 mm broad, with a broken basal pedicel 6–7 mm in diameter that supports a colony of 16 corallites. Branches circular in cross section and fairly uniform in diameter (cylindrical), both corallites and branch diameters ranging from 5–7 mm. Calices in process of intratentacular division quite common. Intratentacular budding initiated by the enlargement of 2 opposing lateral S_1, which eventually fuse across center of calice and form a thin wall between the two daughter corallites. Eventually small septa begin to form perpendicular to the faces of the bridging S_1. Synapticulotheca thick (1.2–1.4 mm), and porous only within 4–8 mm of the calice; otherwise, theca solid. Costae poorly delineated, each costa bearing numerous small, low (40–50 μm) granules arranged 4 or 5 across a costa. Intercostal regions porous, the pores usually circular and quite deep. Corallum white.

Septa hexamerally arranged in essentially 4 cycles; however, just before intratentacular division a corallite is often elongate and may have more than 48 septa, whereas just after division corallites usually have fewer than 48 septa. S_1 nonexsert and rather narrow, with straight, vertical, smooth inner edges that extend to the columella. S_2 about three-quarters width of an S_1 and also have smooth inner edges, but do not extend to the columella. S_3 rudimentary, each flanked by a pair of S_4 not much wider than an S_3 in upper fossa, but which fuse before the S_3 lower in fossa and have extremely laciniate inner edges. Long (up to 1.5 mm), narrow extensions of lower, inner edges of S_4 intermingle with columellar elements. Fossa deep, containing a small, loose, trabecular columella. Tabular endothecal dissepiments present every 1.5–4.0 mm within branches, producing a relatively low density corallum.

DISCUSSION.—See "Generic Discussion."

ETYMOLOGY.—This species is named in honor of Jun-Im Song, the first to review the South Korean coral fauna.

MATERIAL EXAMINED/TYPES.—*Holotype:* 1 colony, USNM 15847 (Plate 40*a–e*). *Paratypes:* 10 colony fragments from type locality, USNM 92910, 1 branch, ORI. *Type Locality:* Western Channel of Korea Strait, off Pusan, South Korea; depth unknown. Collected by P.L. Joey and received by USNM in January 1887. *Reference Specimen: Lobopsammia cariosa* (Goldfuss, 1827) from Eocene of France, USNM 64630.

DISTRIBUTION.—Known only from the type locality.

NOTE.—When this paper was in galley stage (May, 1994), I received a reprint from J.-I. Song (Song, 1994) published in April, 1994, in which she described a new genus and species of dendrophylliid from the Korean Strait: *Dichopsammia granulosa.* Her species is the same as my *Schizopsammia songae,* described herein, and therefore must be considered as the senior synonym. Her type series of three specimens also came from off Pusan, Korea, at a depth of 20–30 m. She considered this species to be hermatypic (zooxanthellate).

Appendix

Station List

USFWS Albatross (Alb)

Station	Latitude	Longitude	Depth (m)	Date
2816	1°17′00″S	90°31′30″W	144	09 APR 1888
2832	24°38′00″N	112°17′30″W	93	02 MAY 1888
2862	50°49′00″N	127°36′30″W	435	01 SEP 1888
2864	48°22′00″N	122°51′00″W	88	06 SEP 1888
2865	48°12′00″N	122°49′00″W	73	06 SEP 1888
2876	48°33′00″N	124°53′00″W	108	25 SEP 1888
2879	48°53′00″N	125°53′00″W	62	26 SEP 1888
2886	43°59′00″N	124°56′30″W	91	19 OCT 1888
2888	43°58′00″N	124°57′30″W	75	19 OCT 1888
2893	34°12′30″N	120°32′30″W	265	05 JAN 1889
2894	34°07′00″N	120°33′30″W	97	05 JAN 1889
2895	34°07′00″N	120°33′30″W	97	05 JAN 1889
2907	34°24′30″N	120°20′00″W	80	08 JAN 1889
2908	34°25′25″N	120°20′00″W	57	08 JAN 1889
2913	32°25′30″N	119°03′30″W	48	16 JAN 1889
2922	32°27′15″N	119°05′15″W	86	17 JAN 1889
2932	32°26′15″N	117°16′15″W	37	26 JAN 1889
2935	32°44′30″N	117°23′00″W	221	04 FEB 1889
2936	32°49′00″N	117°27′30″W	656	04 FEB 1889
2939	33°36′00″N	118°09′30″W	49	05 FEB 1889
2940	33°36′00″N	118°11′00″W	48	05 FEB 1889
2942	33°38′45″N	118°13′45″W	37	05 FEB 1889
2943	34°00′30″N	119°28′30″W	57	06 FEB 1889
2944	34°00′00″N	119°28′30″W	55	06 FEB 1889
2945	34°00′00″N	119°29′30″W	55	06 FEB 1889
2946	33°58′00″N	119°30′45″W	274	06 FEB 1889
2948	33°55′30″N	119°41′30″W	486	07 FEB 1889
2958	34°04′00″N	120°19′30″W	48	09 FEB 1889
2961	34°22′45″N	119°40′30″W	38	11 FEB 1889
2962	34°23′30″N	119°39′30″W	302	11 FEB 1889
2963	34°23′10″N	119°39′40″W	37	11 FEB 1889
2965	34°21′20″N	119°38′30″W	49	11 FEB 1889
2968	34°21′40″N	119°38′20″W	57	11 FEB 1889
2969	34°20′40″N	119°37′45″W	48	11 FEB 1889
2974	34°19′30″N	119°44′45″W	134	11 FEB 1889
2975	34°01′30″N	119°29′00″W	66	12 FEB 1889
2976	34°00′00″N	119°26′30″W	57	12 FEB 1889
2977	33°59′30″N	119°25′30″W	82	12 FEB 1889
2978	33°59′45″N	119°22′15″W	84	12 FEB 1889
2984	28°57′15″N	118°15′45″W	207	28 FEB 1889
2987	28°54′15″N	118°18′00″W	313	28 FEB 1889
2999	24°54′30″N	110°39′00″W	71	16 MAR 1889
3085	44°29′30″N	124°17′00″W	77	02 SEP 1889
3087	44°28′00″N	124°26′00″W	84	03 SEP 1889
3088	44°28′00″N	124°25′30″W	84	03 SEP 1889
3102	37°40′40″N	122°59′00″W	49	10 MAR 1890
3116	37°05′30″N	122°19′00″W	29	12 MAR 1890
3124	36°55′10″N	122°04′00″W	38	13 MAR 1890
3158	37°47′30″N	123°10′40″W	53	22 MAR 1890
3159	37°47′20″N	123°10′00″W	49	22 MAR 1890
3160	37°48′35″N	123°12′40″W	71	22 MAR 1890
3168	38°01′25″N	123°26′55″W	62	24 MAR 1890
3170	38°17′00″N	123°29′00″W	305	28 MAR 1890
3174	38°15′30″N	123°14′15″W	119	28 MAR 1890

Station List.—Continued.

Station	Latitude	Longitude	Depth (m)	Date
3315	54°02′40″N	166°42′00″W	507	15 AUG 1890
3317	53°57′40″N	166°59′00″W	302	16 AUG 1890
3324	53°33′50″N	167°46′50″W	199	20 AUG 1890
3401	00°59′00″S	88°58′30″W	722	28 MAR 1891
3443	48°13′30″N	123°11′20″W	177	27 AUG 1891
3445	48°16′00″N	123°45′05″W	183	27 AUG 1891
3449	48°29′40″N	124°40′10″W	247	28 AUG 1891
3451	48°25′10″N	124°37′50″W	193	28 AUG 1891
3452	48°24′40″N	124°29′10″W	229	29 AUG 1891
3459	48°24′20″N	124°24′40″W	225	02 SEP 1891
3465	48°21′00″N	123°14′00″W	88	04 SEP 1891
3593	48°11′30″N	122°48′00″W	68	30 APR 1894
3666	36°45′00″N	121°53′00″W	124	13 APR 1897
3707	35°02′-N	138°46′-E	115	08 MAY 1900
3708	35°02′-N	138°46′-E	110	08 MAY 1900
3716	35°02′-N	138°46′-E	119	11 MAY 1900
3718	35°02′-N	138°46′-E	119	11 MAY 1900
3720	35°02′-N	138°46′-E	115	11 MAY 1900
3730	34°40′-N	138°20′-E	62	16 MAY 1900
3738	34°58′-N	138°45′-E	205	17 MAY 1900
3746	35°02′-N	139°50′-E	90	19 MAY 1900
3764	34°57′-N	139°53′-E	80	22 MAY 1900
4225	55°--N	130°--W	272	06 JUL 1903
4328	32°--N	117°--W	104	08 MAR 1904
4332	32°--N	117°--W	113	09 MAR 1904
4359	32°--N	117°--W	179	15 MAR 1904
4361	32°--N	117°--W	166	15 MAR 1904
4370	32°--N	117°--W	181	16 MAR 1904
4373	32°--N	117--W	174	17 MAR 1904
4376	32°--N	117--W	170	17 MAR 1904
4377	32°--N	117--W	232	17 MAR 1904
4397	33°10′15″N	121°42′15″W	4016	01 APR 1904
4431	34°--N	120°10′-W	69–82	15 APR 1904
4451	36°45′-N	121°55′-W	?	11 MAY 1904
4463	36°45′-N	121°55′-W	88–203	13 MAY 1904
4518	36°45′-N	121°55′-W	121	24 MAY 1904
4534	36°45′-N	121°55′-W	139	28 MAY 1904
4543	36°45′-N	121°55′-W	97	01 JUN 1904
4550	36°45′-N	121°55′-W	91	07 JUN 1904
4551	36°45′-N	121°55′-W	84	07 JUN 1904
4552	36°45′-N	121°55′-W	121	09 JUN 1904
4553	36°45′-N	121°55′-W	119	09 JUN 1904
4555	36°45′-N	121°55′-W	121	09 JUN 1904
4768	54°20′30″N	179°09′30″E	1397	03 JUN 1906
4782	52°55′00″N	173°27′00″E	104	09 JUN 1906
4784	52°55′40″N	173°26′00E	247	11 JUN 1906
4788	54°50′24″N	167°13′00″E	102	14 JUN 1906
4789	54°49′45″N	167°12′30″E	102	14 JUN 1906
4791	54°36′15″N	166°58′15″E	132	14 JUN 1906
4792	54°36′15″N	166°57′15″E	132	14 JUN 1906
4807	41°36′12″N	140°36′00″E	80	16 JUL 1906
4860	36°18′00″N	129°44′00″E	223	31 JUL 1906
4891	32°27′00″N	128°34′00″E	331	09 AUG 1906
4892	32°27′30″N	128°33′00″E	331	09 AUG 1906
4894	32°33′00″N	128°32′10″E	174	09 AUG 1906
4903	32°31′10″N	128°33′20″E	196	10 AUG 1906
4904	32°31′20″N	128°32′40″E	196	10 AUG 1906
4906	31°39′00″N	129°20′30″E	675	11 AUG 1906
4908	31°40′00″N	129°29′40″E	796	11 AUG 1906

Station List.—Continued

Station	Latitude	Longitude	Depth (m)	Date
4909	31°38′30″N	129°27′30″E	796	11 AUG 1906
4911	31°38′30″N	129°19′00″E	715	12 AUG 1906
4912	31°39′40″N	129°20′00″E	715	12 AUG 1906
4913	31°39′10″N	129°22′30″E	715	12 AUG 1906
4915	31°31′00″N	129°25′30″E	783	12 AUG 1906
4916	30°25′00″N	129°06′40″E	660	13 AUG 1906
4919	30°34′00″N	129°19′30″E	805	13 AUG 1906
4924	30°05′00″N	130°21′20″E	291	14 AUG 1906
4925	Off Yaku Shima, Osumi Shoto		302	14 AUG 1906
4933	30°59′00″N	130°29′50″E	278	16 AUG 1906
4935	30°57′20″N	130°35′10″E	188	16 AUG 1906
4936	30°54′40″N	130°37′30″E	188	16 AUG 1906
4937	31°13′00″N	130°43′10″E	106	16 AUG 1906
4944	31°38′15″N	130°46′50″E	79	17 AUG 1906
4956	32°32′00″N	132°25′00″E	1317	23 AUG 1906
4957	32°36′00″N	132°23′00″E	799	23 AUG 1906
4958	32°36′20″N	132°24′30″E	741	23 AUG 1906
4959	32°36′30″N	132°23′20″E	741	23 AUG 1906
4960	32°34′00″N	132°21′45″E	1057	23 AUG 1906
4966	33°25′20″N	135°36′20″E	446	29 AUG 1906
4967	33°25′10″N	135°37′20″E	446	29 AUG 1906
4968	33°24′50″N	135°38′40″E	463	29 AUG 1906
4969	33°23′40″N	135°33′00″E	1073	29 AUG 1906
4970	33°23′30″N	135°36′30″E	914	30 AUG 1906
4972	33°25′45″N	135°33′00″E	805	30 AUG 1906
4973	33°24′15″N	135°30′30″E	1097	30 AUG 1906
4975	33°21′30″N	135°38′50″E	997	31 AUG 1906
4979	33°53′00″N	137°42′00″E	1727	01 SEP 1906
4982	43°00′00″N	140°10′30″E	713	19 SEP 1906
4994	45°27′50″N	140°54′00″E	348	22 SEP 1906
5054	34°52′45″N	138°42′20″E	516	12 OCT 1906
5055	34°53′00″N	138°44′15″E	227	12 OCT 1906
5056	34°57′35″N	138°43′35″E	472	12 OCT 1906
5070	35°03′25″N	138°47′40″E	198	15 OCT 1906
5071	35°03′10″N	138°49′50″E	104	15 OCT 1906
5083	34°04′20″N	137°57′30″E	1141	20 OCT 1906
5086	35°08′15″N	139°20′00″E	534	23 OCT 1906
5088	35°11′25″N	139°28′20″E	675	25 OCT 1906
5091	35°04′10″N	139°38′12″E	360	26 OCT 1906
5092	35°04′50″N	139°38′18″E	128	26 OCT 1906
5093	35°03′15″N	139°37′42″E	553	26 OCT 1906
5094	35°04′42″N	139°38′20″E	161	26 OCT 1906
5310	21°33′00″N	116°13′00″E	183	04 NOV 1908
5311	21°33′00″N	116°15′00″E	161	04 NOV 1908
5312	21°30′00″N	116°32′00″E	256	04 NOV 1908
5313	21°30′00″N	116°43′00″E	274	04 NOV 1908
5314	21°41′00″N	116°46′00″E	223	05 NOV 1908
5315	21°40′00″N	116°58′00″E	271	05 NOV 1908
5369	13°48′00″N	121°43′00″E	194	24 FEB 1909
5371	13°49′40″N	121°40′15″E	152	24 FEB 1909
5381	13°14′15″N	122°44′45″E	161	06 MAR 1909
5444	12°43′51″N	124°58′50″E	563	03 JUN 1909
5445	12°44′43″N	124°59′50″E	699	03 JUN 1909
5582	04°19′54″N	118°58′38″E	1628	26 SEP 1909
5593	04°02′40″N	118°11′20″E	70	29 SEP 1909
	R/V *Tansei Maru* (TM)			
KT7414,B2	34°36.6′N	138°43.8′E	150–340	19 SEP 1974
KT7414,B4	34°45.8′N	138°42.5′E	312–328	23 SEP 1974
KT7802,B	35°03.9′N	138°46.9′E	300–370	10 FEB 1978

Station List.—Continued.

Station	Latitude	Longitude	Depth (m)	Date
KT7802,Z2	34°37.9′N	138°27.0′E	95–100	08 FEB 1978
KT7802,Z4	34°36.5′N	138°25.6′E	138–145	08 FEB 1978
KT7802,Z61	34°43.5′N	138°30.2′E	70–71	08 FEB 1978
KT7811,OT1	34°56.1′N	138°44.8′E	198–205	13 JUL 1978
KT7811,OT4	34°56.3′N	138°43.1′E	490–500	13 JUL 1978
KT7811,OT6	35°03.4′N	138°49.8′E	105–110	14 JUL 1978
KT7811,OT6-2	35°03.3′N	138°50.0′E	108–120	14 JUL 1978
KT7818,OT8-1	34°55.2′N	138°44.8′E	210–245	20 NOV 1978
KT7818,OT10	34°53.9′N	138°43.1′E	382–425	20 NOV 1978
KT7911,OT4	34°46.7′N	138°41.4′E	380–457	19 JUL 1979
KT8412,14	33°29.1′N	135°28.9′E	214–235	01 SEP 1984
KT8916,T3-2	32°19.09′N	134°00.85′E	1917–1950	08 NOV 1989
KT9015,BS1	32°50.50′N	132°05.22′E	89–90	03 NOV 1990
KT9015,BS2	32°43.38′N	132°06.52′E	193–199	03 NOV 1990
KT9015,CB0-1	34°52.90′N	131°11.09′E	66–72	02 NOV 1990
KT9015,CB1-1	34°54.70′N	131°07.48′E	71–78	02 NOV 1990
KT9015,CB1-2	34°54.49′N	131°07.56′E	70–71	02 NOV 1990
KT9015,CB2-2	34°58.08N	131°04.87′E	74–78	02 NOV 1990
KT9015,CB6-1	35°45.17N	132°52.22′E	100–101	01 NOV 1990
KT9015,HK2	34°25.23′N	130°46.83′E	86–87	29 OCT 1990
KT9015,HK3	34°30.11′N	130°52.24′E	93–95	29 OCT 1990
KT9015,HK5	34°55.07′N	131°18.74′E	97	02 NOV 1990
KT9015,OK1	35°45.20′N	133°09.92′E	71	01 NOV 1990
KT9015,OK2	35°49.80′N	133°26.27′E	93–96	01 NOV 1990
KT9202,AT1	29°13.67′N	129°45.22′E	1058–1065	18 FEB 1992
KT9202,KB3	31°08.41′N	130°39.92′E	100–101	21 FEB 1992
KT9202,OS2	30°58.42′N	130°31.82′E	237–241	20 FEB 1992
KT9202,OS3	31°06.17′N	130°34.88′E	143–144	20 FEB 1992
KT9202,YS1	29°46.59′N	130°24.11′E	150–151	18 FEB 1992
KT9202,YS2	29°44.02′N	130°29.12′E	238–240	18 FEB 1992
KT9202,YT1	30°14.80′N	130°46.10′E	80–88	16 FEB 1992
KT9202,YT2	30°10.10′N	130°52.50′E	95–98	17 FEB 1992
KT9202,YT4	30°04.64′N	130°55.73′E	402–410	17 FEB 1992
KT9202,YT5	30°02.43′N	130°57.37′E	660–711	17 FEB 1992
KT9202,YT6	29°59.28′N	130°57.88′E	964–1005	17 FEB 1992
	PULSE Cruises (R/V *New Horizon*)			
1-124	34°49′N	123°07′W	4100	25 JUN 1989
2-216	34°48′N	123°00′W	4100	26 OCT 1989
2-224	34°41′N	123°08′W	4100	30 OCT 1989
3-312	34°43′N	123°11′W	4100	17 FEB 1990
3-314	34°44′N	123°11′W	4100	18 FEB 1990
4-426	34°44′N	123°08′W	4100	24 JUN 1990
5-505	34°43′N	123°10′W	4100	23 OCT 1990
6-606	34°46′N	123°06′W	4100	20 FEB 1991
7-721	34°45′N	123°07′W	4100	24 JUN 1991
8-803	34°44′N	123°07′W	4100	22 JUL 1991
9-907	34°43′N	123°07′W	4100	01 AUG 1991
9-910	34°43′N	123°06′W	4100	02 AUG 1991
10-1007	34°45′N	123°04′W	4100	21 OCT 1991
10-1017	34°42′N	123°03′W	4100	25 OCT 1991
	Vityaz (IOM)			
2078	44°09′N	148°09′E	1080	11 MAY 1953
2209	49°46′N	157°48′E	3660	?
3353	53°53′N	169°15′E	1680	05 JUN 1955
5626	45°26′N	154°12′E	5220	20 AUG 1966
5638	44°36′N	149°07′E	1675–1847	10 SEP 1966
5640	44°41′N	148°57′E	780	10 SEP 1966

Station List.—Continued.

Station	Latitude	Longitude	Depth (m)	Date
		R/V *Melville* (SIO)		
MV66-II-4	40°30.5′N	125°45.2′W	2999–3017	22 MAY 1966
MV69-VI-9	31°12′N	119°37′W	3600–3676	18 DEC 1969
MV70-III-22	31°19.7′N	119°39.2W	3599–3676	18 DEC 1969
MV70-III-1	31°47.0′N	120°12′W	3880–3950	21 MAR 1970
MV70-III-6	31°36′N	120°07.4′W	3706–3806	23 MAR 1970
		OCSEAP (R/V *Searcher*)		
20134	60°22′N	147°00′W	67–73	05 AUG 1978
20136	60°21′N	147°04′W	67–82	05 AUG 1978
26499	59°12.4′N	140°17.6′W	126	15 NOV 1979
26502	59°21.7	141°04.8′W	237	15 NOV 1979
		R/V *Zaca*		
23	33°27′N	118°35′W	?	16 SEP 1938
31	33°21′N	118°18′W	165	17 SEP 1938
42	32°30′N	119°17′W	91	19 SEP 1938
43	32°34′N	119°16′W	91	19 SEP 1938
51	34°25′N	120°18′W	155	21 SEP 1938
		MISCELLANEOUS VESSELS		
Agassiz MV71-I-1	28°51.5′N	118°16.0′W	81–95	18 MAY 1971
Alpha Helix-30	60°28′N	147°59′W	149	?
CR79-1	Off Kushimoto, Kii Strait		110	05 JAN 1979
CR79-8	Off Kushimoto, Kii Strait		120	22 JAN 1979
CR79-18	Off Kushimoto, Kii Strait		55	22 JAN 1979
Horizon MET-123	32°35′N	120°38′W	3634–3713	05 FEB 1981
Horizon MET-133	32°25′N	120°40′W	3632–3689	07 FEB 1981
Keldish-2312	55°23′N	167°15′E	375–470	02 AUG 1990
Lets Go-80	52°03.54′N	177°20.63′E	168	?
LM49	53°01′N	132°54′W	1280–1371	19 OCT 1966
MUSORSTOM2-33	13°32.3′N	121°07.5′E	130–137	34 NOV 1980
Pillsbury-521	07°48′N	79°35′W	119	04 MAY 1967
Pillsbury-530	08°15′N	79°10′W	66–77	06 MAY 1967
Pillsbury-861	12°42′N	61°06′W	18–744	04 JUL 1969
SEPBOP 18B-764	04°06′S	81°09′W	90	08 SEP 1966
Tsuchida-45	Off Tanabe, Kii Strait		396–413	?
Tcuchida-102	Off Tanabe, Kii Strait		239–272	?
Tsuchida-197	Off Kowuna, Kii Strait		248	24 JUN 1969
Tsuchida-272A	Off Shusankai, Kii Strait		396	?
Tsuchida-851	Off Futakishima, Kii Strait		248	?
Velero				
4-7228-60	27°37′17″N	115°49′16″W	3724–4393	30 DEC 1960
Washington				
MV67-III-22	37°22′N	123°54′W	3582–3799	14 JUN 1967
PPTU-II	32°54′47″N	127°47′24″W	440–488	18 AUG 1986
YO69-3	Off Esuzaki, Kii Strait		454	03 MAY 1969
YO69-37-39	Off Hiwasa, Kii Strait		380–446	?
YO70-770	33°53′N	135°04′E	248	13 FEB 1970
YO70-1009	East of Tanabe, Kii Strait			233–248
?				
67-41 GBR	53°45′N	133°31′W	1371	10 AUG 1967
69-RD3	51°25.5′N	179°15.3′E	55	09 OCT 1969

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Plates 1-42

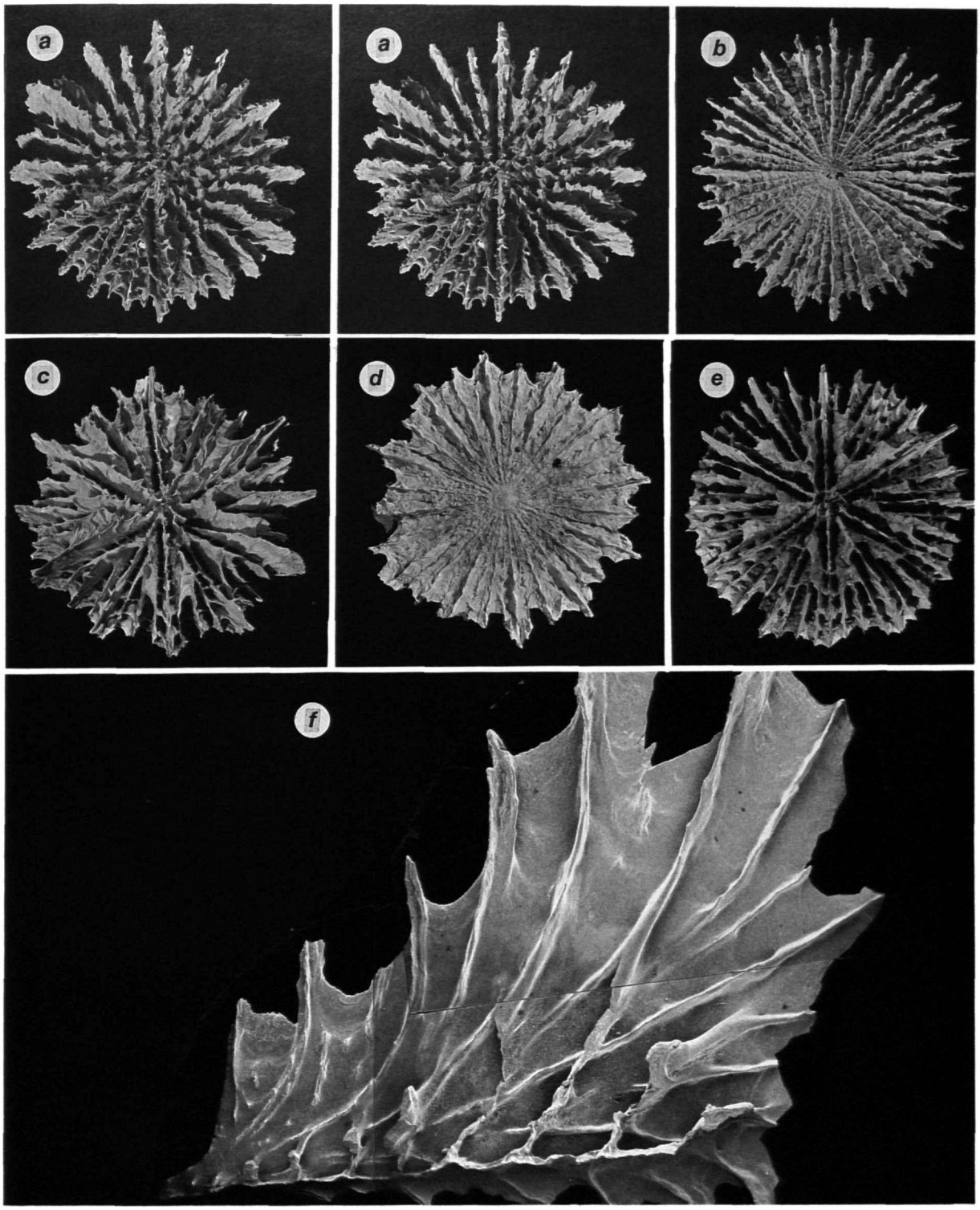

PLATE 1.—*Fungiacyathus marenzelleri (a,b, Pulse* 2-215, USNM 87616; *c,d, Vityaz*-6143 (paratype of *F. symmetricus aleuticus* Keller, 1976), IOM; *e, Vityaz*-5605 (paratype of *F. symmetricus aleuticus*), IOM; *f, Pulse* 1-124, USNM 85790): *a,b*, stereo calicular and basal views of a well-preserved corallum, both × 2.0; *c–e*, oblique and basal views of *Vityaz* specimens, all × 2.0; *f*, lateral view of an S_1 showing trabeculae, synapticulae, basal plate, and costa, × 10.

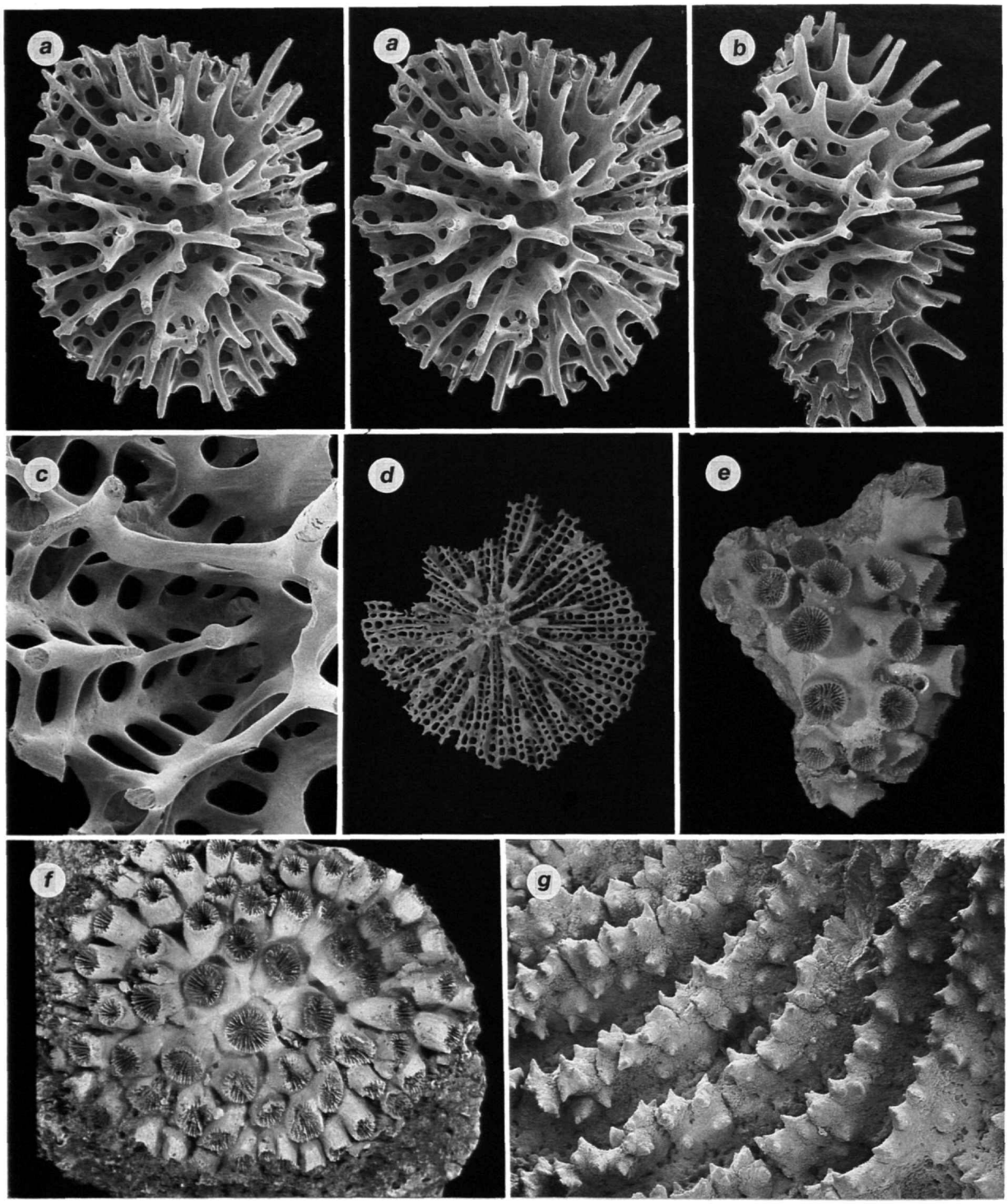

PLATE 2.—*Leptopenus discus* (*a–c*, *Melville* 70-III-1, SIO Co 1271; *d*, paratype of *L. irinae*, *Vityaz*-4158, USNM 92435): *a,b*, oblique and stereo lateral views of a corallum, × 12.5, × 13.5, respectively; *c*, enlargement of 2*b* showing porous network between septa and costae, × 42; *d*, calicular view, × 3.8. *Astrangia haimei* (*e*, lectotype of *A. haimei*, YPM 598a; *f*, off Monterey wharf, CAS 74819; *g*, off Coronado, Baja California, SIO Co 1170): *e*, colony, × 2.3; *f*, small hemispherical colony, × 1.6; *g*, granular costae, × 45.

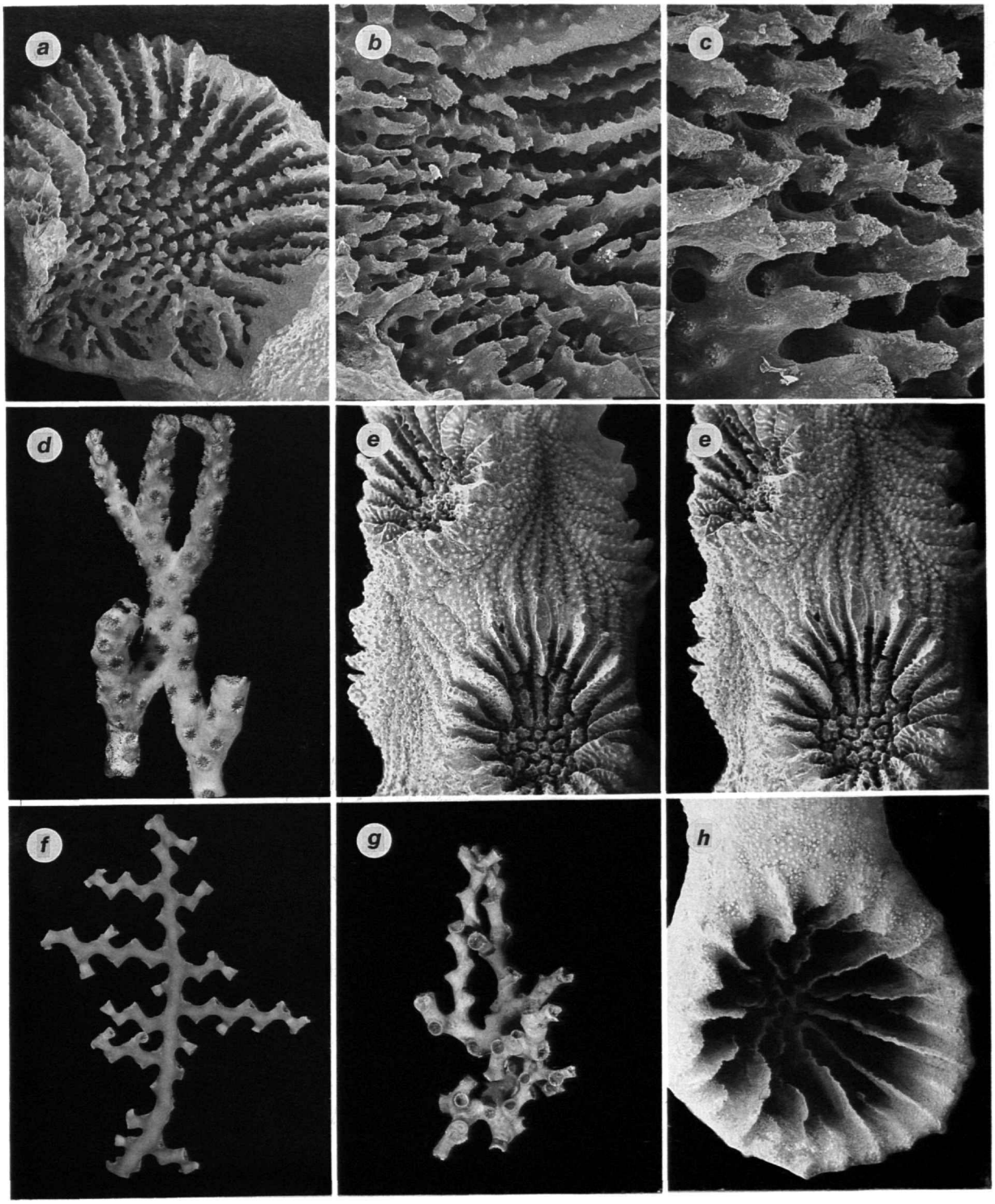

PLATE 3.—*Astrangia haimei* (*a–c*, off Coronada, Baja California, SIO Co 1170): *a*, calice, × 12; *b,c*, progressive enlargement of columella and paliform lobe region, × 21, × 51, respectively; *Oculina profunda* (*d*, holotype, USNM 84792; *e*, paratype, USNM 36372): *d*, branches, × 1.1; *e*, stereo view of branch segment showing calices and granular costae, × 14. *Madrepora oculata* (*f,h*, Fieberling Guyot, USNM 83581; *g*,off Enoshima, Sagami Bay, USNM 92658): *f*, *h*, branch fragment and calice, × 0.73, × 15, respectively; *g*, colony, × 0.76.

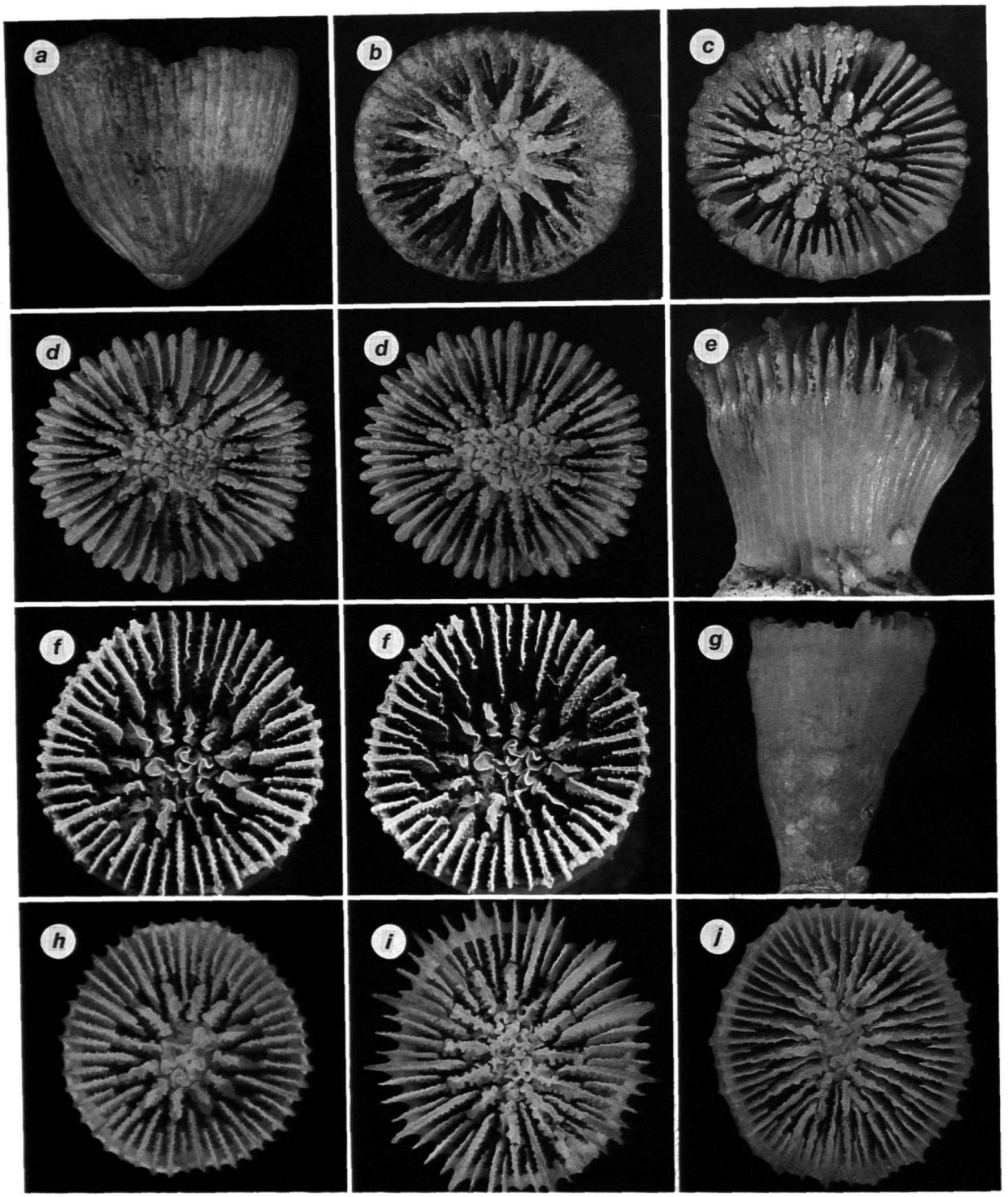

PLATE 4.—*Caryophyllia arnoldi* (*a,b*, holotype, USNM M157509; *c*, Alb-4463, USNM 77419; *d*, Alb-4359, USNM 92470; *e*, 49°27′N, 124°18′W, RBCM 976-1030-1): *a,b*, lateral and calicular views, × 3.0, × 3.1, respectively; *c,d*, calicular views of two specimens, both × 3.0 (*d* is a stereo pair); *e*, lateral view of costae and upper theca, × 3.5. *Caryophyllia alaskensis* (*f–h*, syntype, USNM M547317; *j*, Alb-4792, USNM 83523): *f*, *h*, calicular views of a syntype, × 5.3, × 4.5, respectively (*f* is a stereo pair); *g*, lateral view of same specimen, × 3.2; *j*, calicular view of a specimen, × 3.4. *Caryophyllia japonica*: *i*, *Vityaz*-5638, *C. ambrosia* of Keller (1981a), IOM, × 3.0.

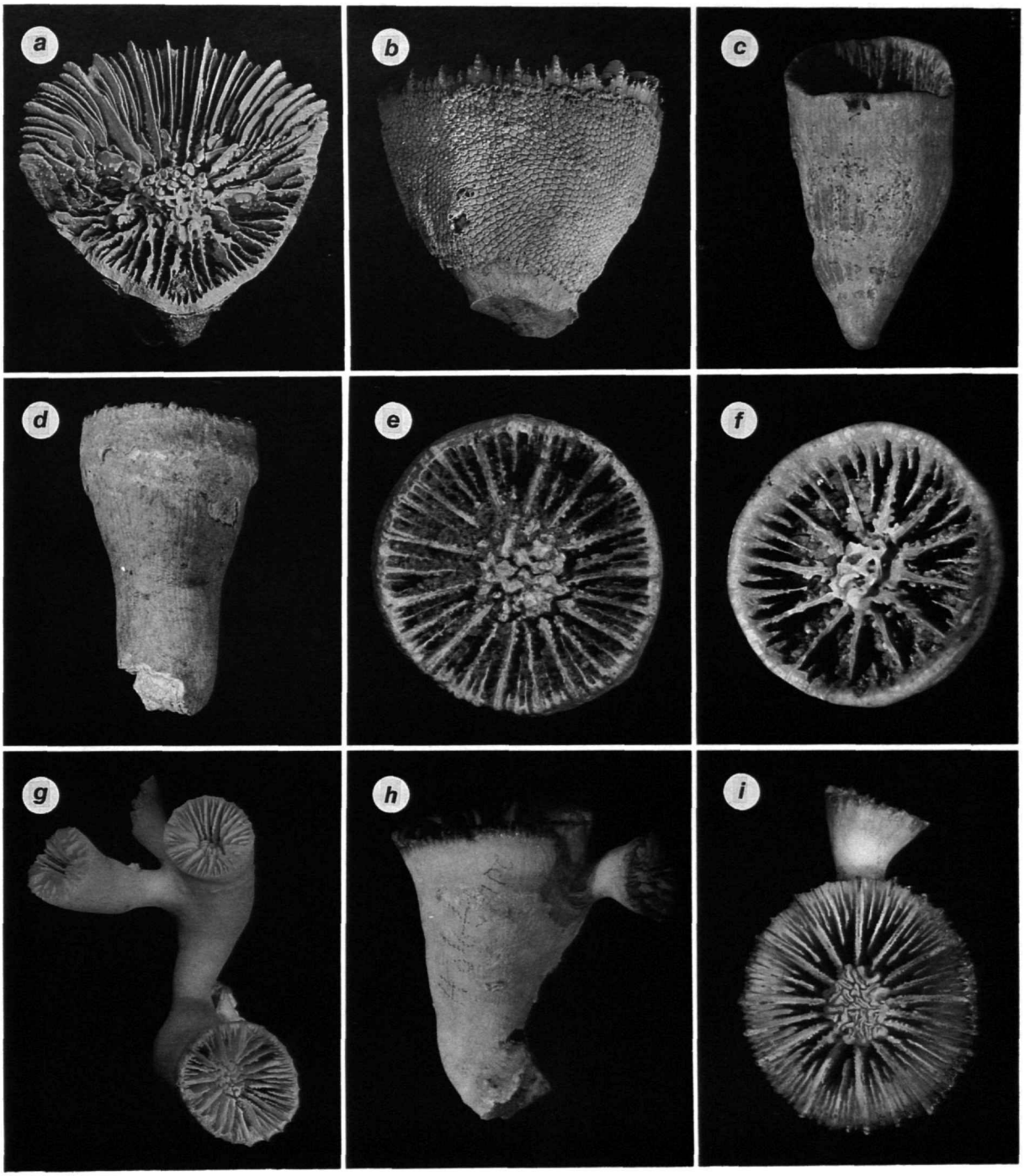

PLATE 5.—*Caryophyllia* sp. A from Alb-4784, USNM 92478: *a,b*, calicular view and lateral views, × 1.5, × 1.4, respectively. *Caryophyllia pedroensis*, holotype, USNM M164736: *c,f*, lateral and calicular views, × 2.3, × 3.9, respectively. *Caryophyllia californica*, Pleistocene of San Pedro, California, USNM 92479: *d,e*, lateral and calicular views, × 3.0, × 5.2, respectively. *Labyrinthocyathus quaylei* (*g*, Alb-4551, paratype, USNM M547417; *h,i*, holotype, UCMP 30245): *g*, a cluster of solitary coralla attached to one another, × 3.0; *h,i*, lateral and calicular views of holotype, × 2.6, × 3.6, respectively.

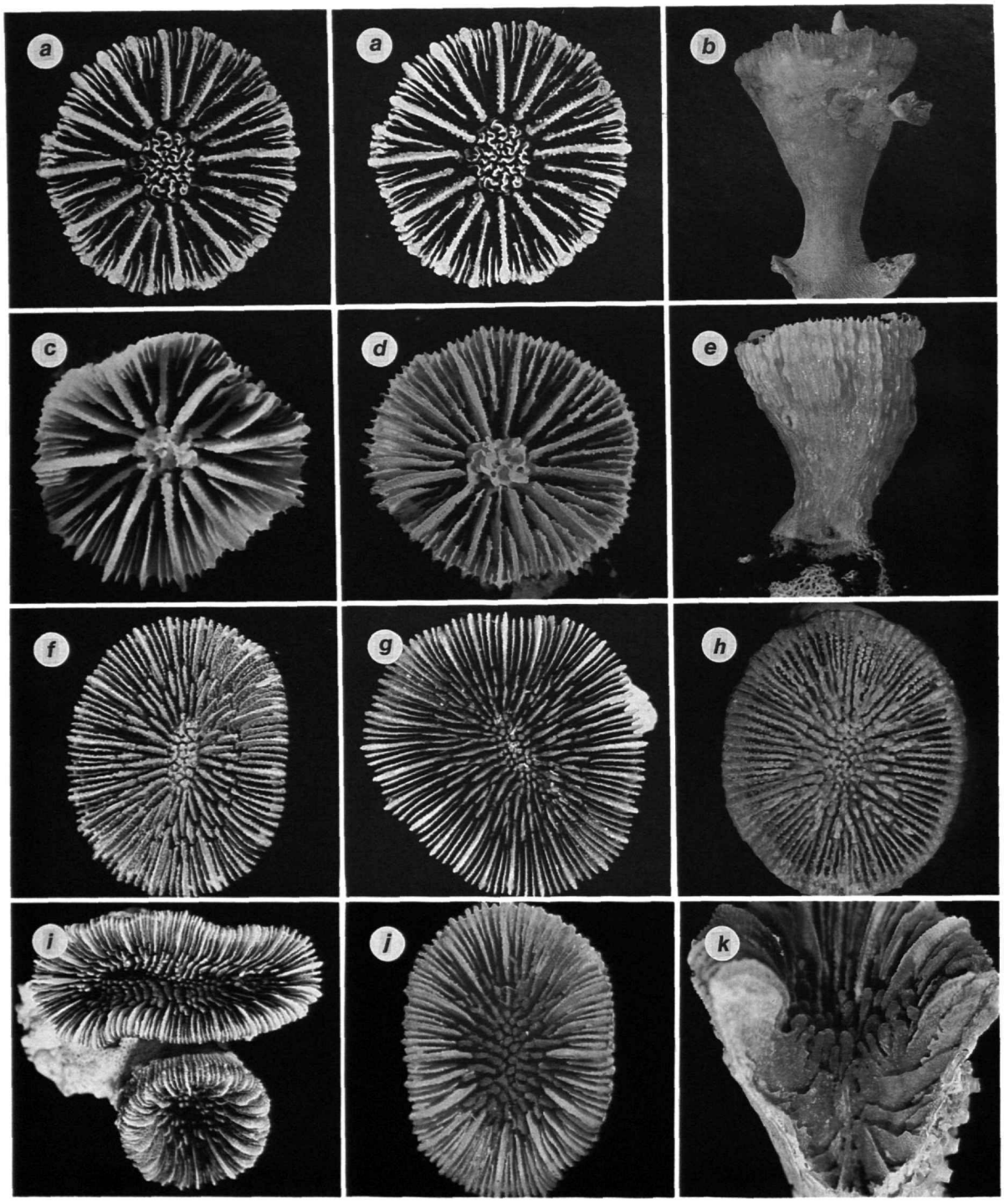

PLATE 6.—*Labyrinthocyathus quaylei* (*a*, Alb-4551, USNM M547418; *b*, Monterey Bay, CAS 16405): *a*, stereo view of calice, × 3.7; *b*, lateral view of corallum, × 3.2. *Crispatotrochus foxi* (*c*, holotype, SBMNH; *d,e*, Alb-3324, USNM 19210): *c*, calicular view of holotype, × 3.5; *d,e*, calicular and lateral views of second specimen, × 3.1, × 2.4, respectively. *Paracyathus stearnsii* (*f*, Alb-4431, USNM 92602; *g*, Bear Rock, Isla San Martin, SIO Co 1171; *h*, holotype of *P. tiburonensis*, UCMP 30485; *i*, off Santa Cruz, SIO C0 1167; *j*, holotype of *P. caltha*, YPM 965; *k*, off Pacific Grove, CAS 74821): *f*, typical calice with five septal cycles, × 3.2; *g*, large calice with over five septal cycles, × 3.3; *h*, × 5.6; *i*, irregularly shaped coralla, × 2.5; *j*, × 4.7; *k*, broken corallum exposing paliform lobes, × 5.3.

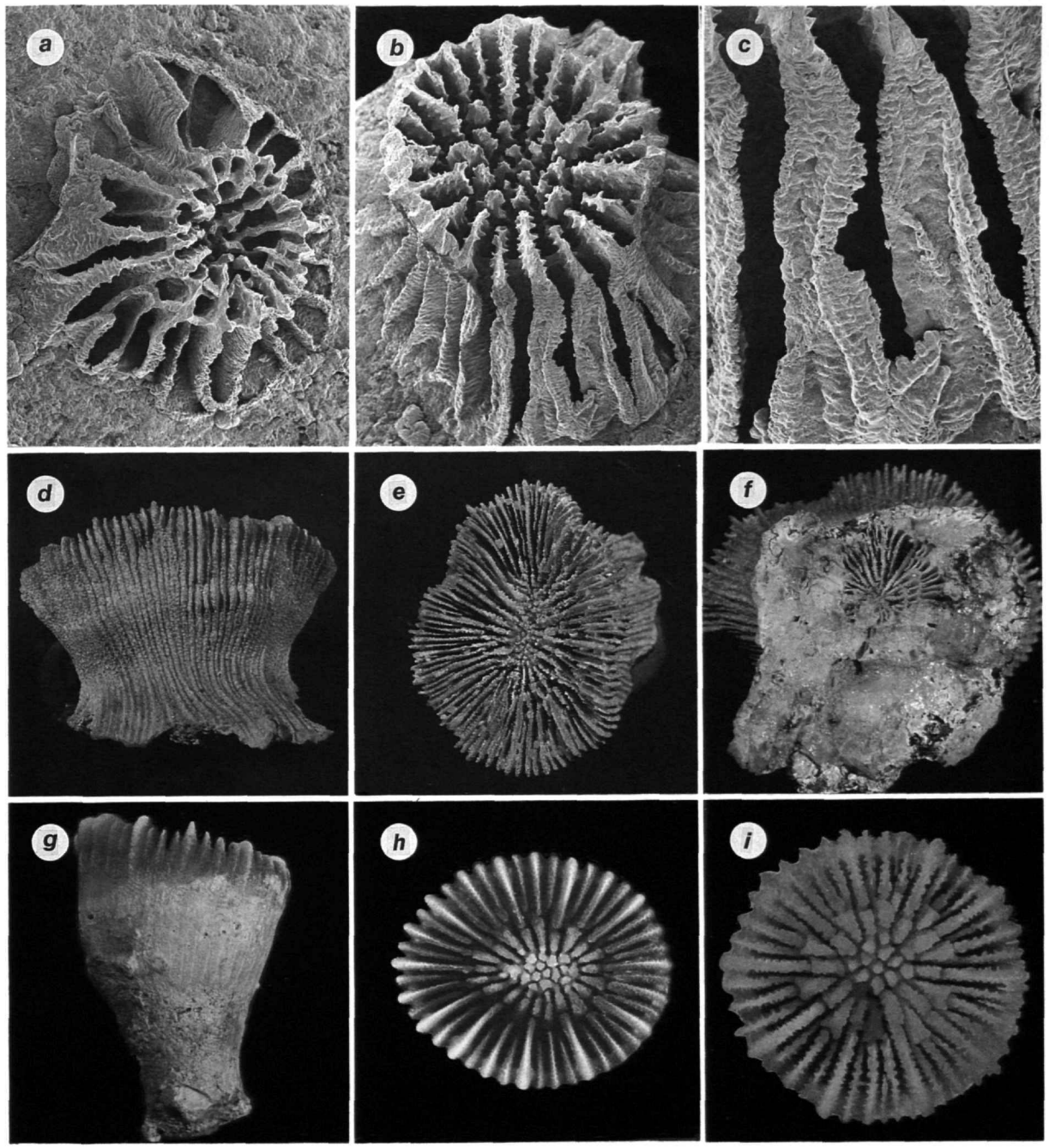

PLATE 7.—*Paracyathus stearnsii* (*a–c*, off Santa Catalina, CAS 74828; *d–f*, holotype of *P. stearnsii*, YPM 2187): *a–c*, coralla illustrating early stages of polycyclic development, × 20, × 18, × 42, respectively; *d–f*, theca, calice, and polycyclic base of holotype, × 3.0, × 2.9, × 3.3, respectively. *Paracyathus montereyensis* (*g,h*, Alb-2888, USNM 92604; *i*, holotype, UCPM 30341): *g,h*, lateral and calicular views of Oregon specimen, × 3.6, × 4.3, respectively; *i*, calicular view of holotype, × 9.0.

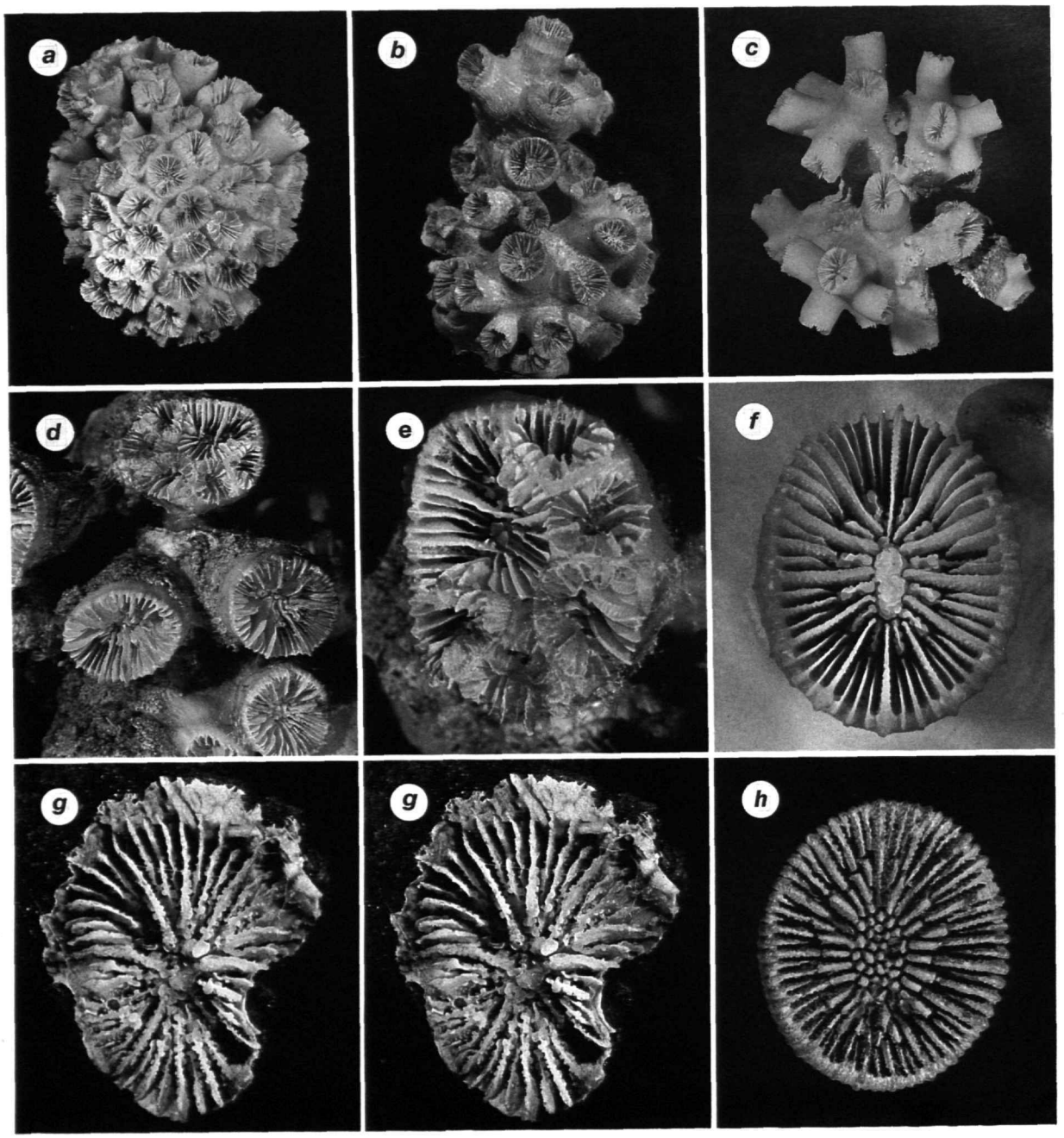

PLATE 8.—*Coenocyathus bowersi* (*a*, off Santa Cruz, USNM 78631; *b*, holotype, USNM 21138; *c*, Alb-2978, USNM 19245; *d,e*, off Bird Rock, SIO Co 1168; *f*, off La Jolla, USNM 92920): *a*, cerioid corallum, × 0.95; *b*, holotype, × 1.3; *c*, branching corallum, × 0.85; *d–e*, intratentacular division, × 2.8, × 5.9, respectively; *f*, regular calice with four septal cycles, × 5.0. *Nomlandia californica: g*, stereo pair of holotype, SBMNH 35560, × 6.0. *Paracyathus pedroensis: h*, calice of holotype, USNM M164738, × 4.5.

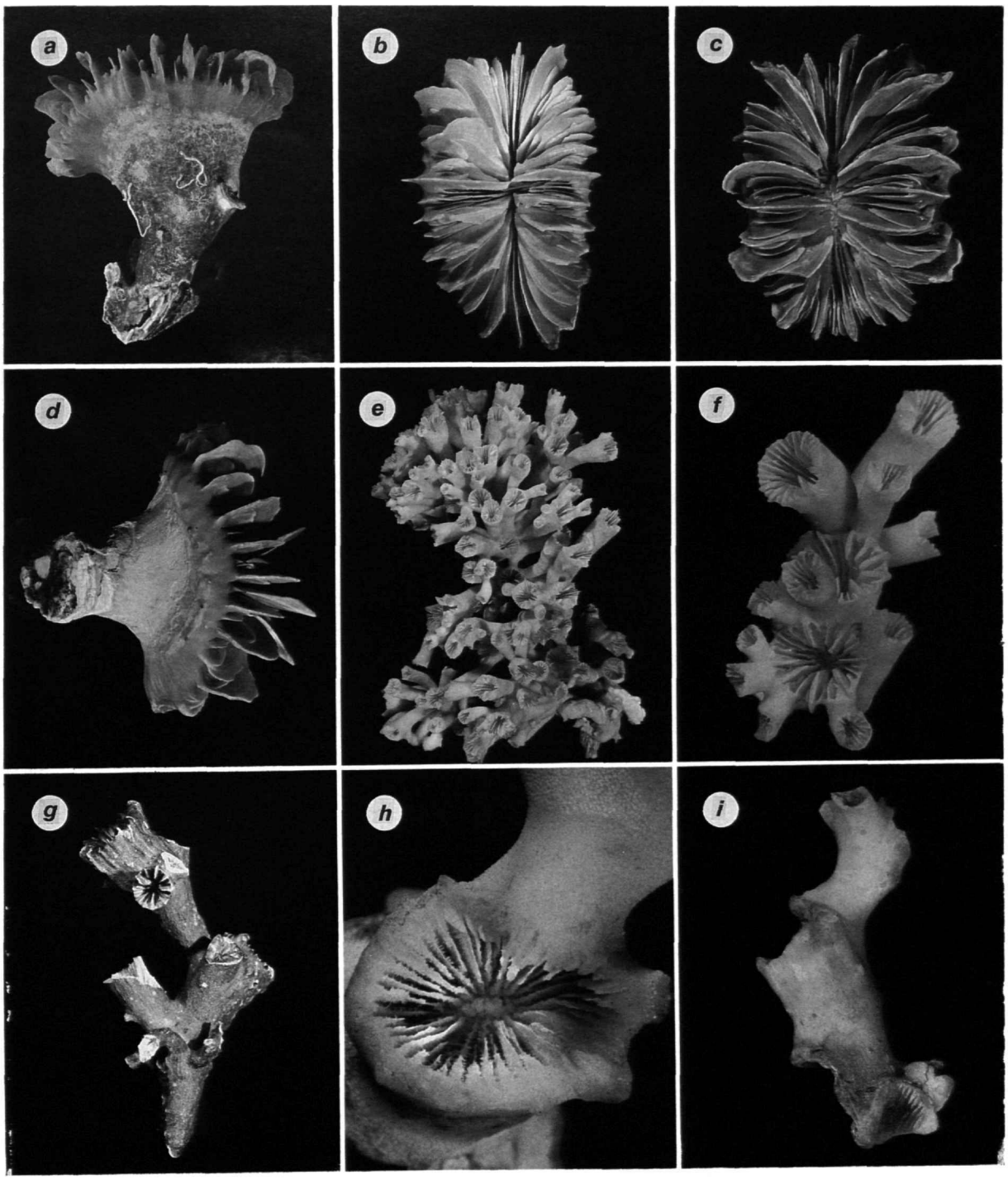

PLATE 9.—*Desmophyllum dianthus (a,b,* neotype, USNM 92475; *c,d,* Fieberling Guyot, USNM 83583): *a,b,* lateral and calicular views, ×0.8, × 1.0, respectively; *c,d,* calice and corallum of Californian specimen having five cycles of septa, × 1.0, × 0.9, respectively. *Lophelia pertusa (e,f,* Alb-2946, USNM 92606; *g,* TM (KT7414, B2), USNM 92611; *h,i,* holotype of *Dendrosmilia nomlandi,* SBMNH 35559): *e,* bushy corallum, × 0.8; *f,* aspect of dense branching, × 2.3; *g,* specimen from Sagami Bay, × 2.0; *h,i,* a calice and the entire holotypic branch fragment, × 5.6, × 2.1, respectively.

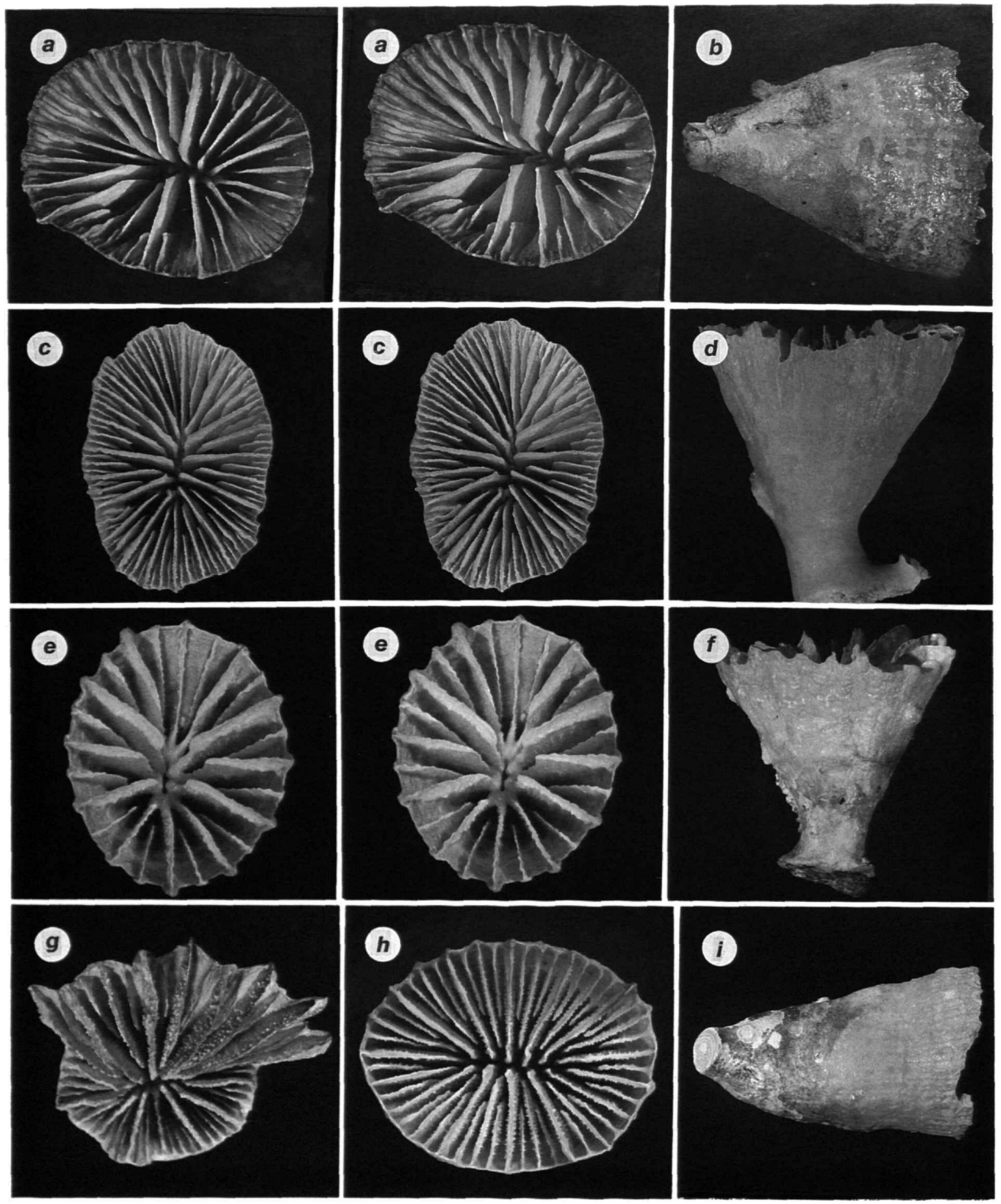

PLATE 10.—*Flabellum* sp. A: *a,b*, NMCIC 1982-1492, stereo calicular and lateral views of a specimen, × 2.4, × 2.3, respectively. *Javania borealis*: *c,d*, stereo calicular and lateral views of holotype, USNM 82019, × 1.3, × 1.2, respectively. *Javania californica*: *e,f*, stereo calicular and lateral views of holotype, USNM 92613, × 4.0, × 3.7, respectively. *Javania cailleti* (*g*, LM 49, off British Columbia, NMCIC 1900-8362; *h,i*, Alb-4982, USNM 92747): *g*, a broken calice, × 1.9; *h,i*, calicular and lateral views of a specimen, × 3.1, × 1.6, respectively.

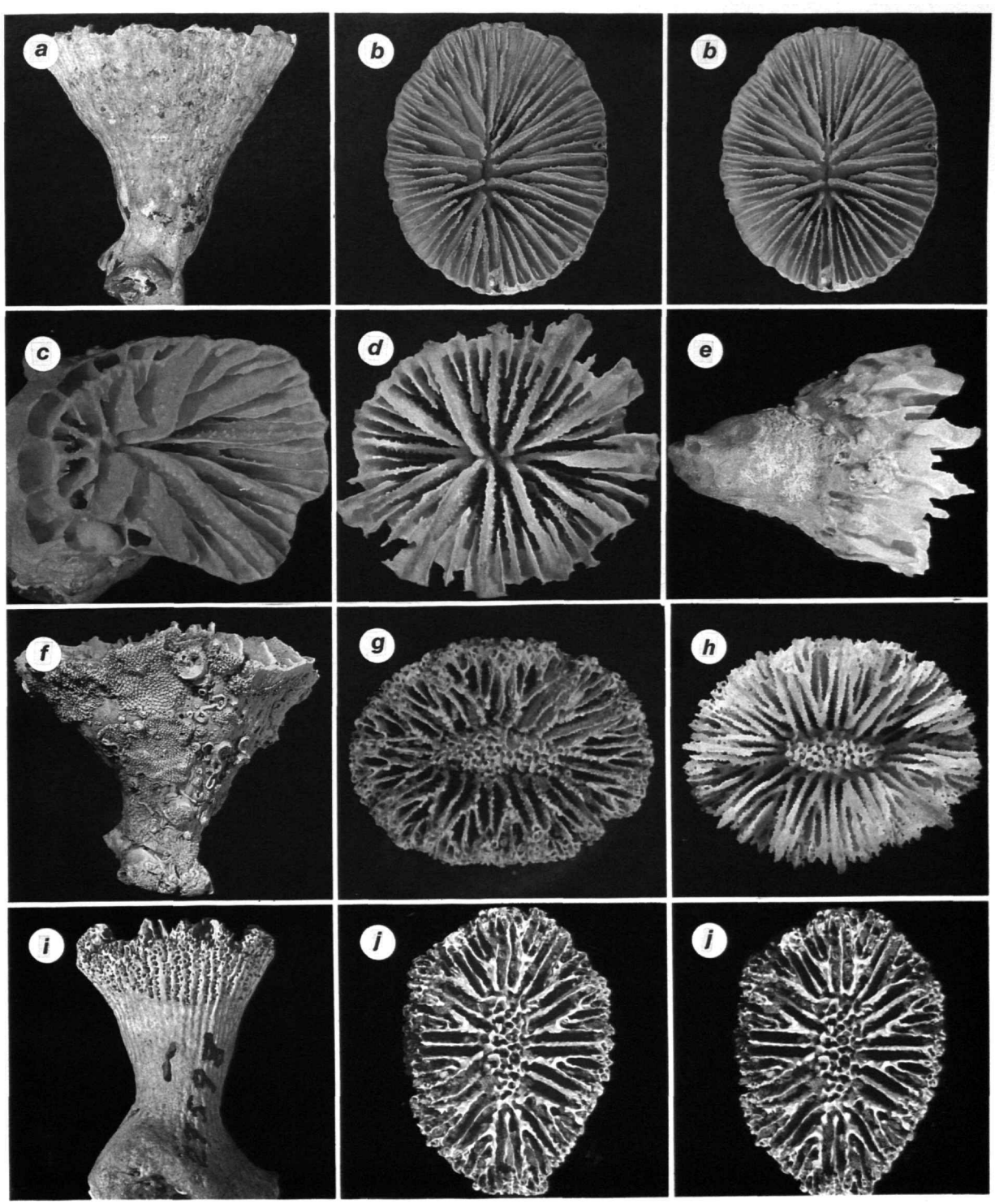

PLATE 11.—*Polymyces montereyensis* (*a,b*, holotype, USNM M547406; *c*, Alb-2977, USNM 83529; *d,e*, holotype of *F. tannerense*, SBMNH 35562; *f*, SEPBOP 18B-764, USNM 83521): *a,b*, lateral and stereo calicluar views of holotype, × 1.9, × 2.0, respectively; *c*, broken base revealing rootlet development consistent with stage diagramed in figure 3a, × 4.7; *d,e*, calicular and lateral views of damaged holotype, × 5.0, × 3.7, respectively; *f*, highly encrusted theca of large Peruvian specimen, × 1.4. *Balanophyllia cedrosensis* (*g*, holotype of *B. tiburonensis*, UCMP 14833; *h*, *Velero*-1257-41, SBMNH; *i,j*, holotype of *B. cedrosensis*, CAS 29961): *g*, calice, × 5.1; *h*, calice, × 3.6; *i,j*, lateral and stereo calicular views of holotype, × 2.7, × 3.9, respectively.

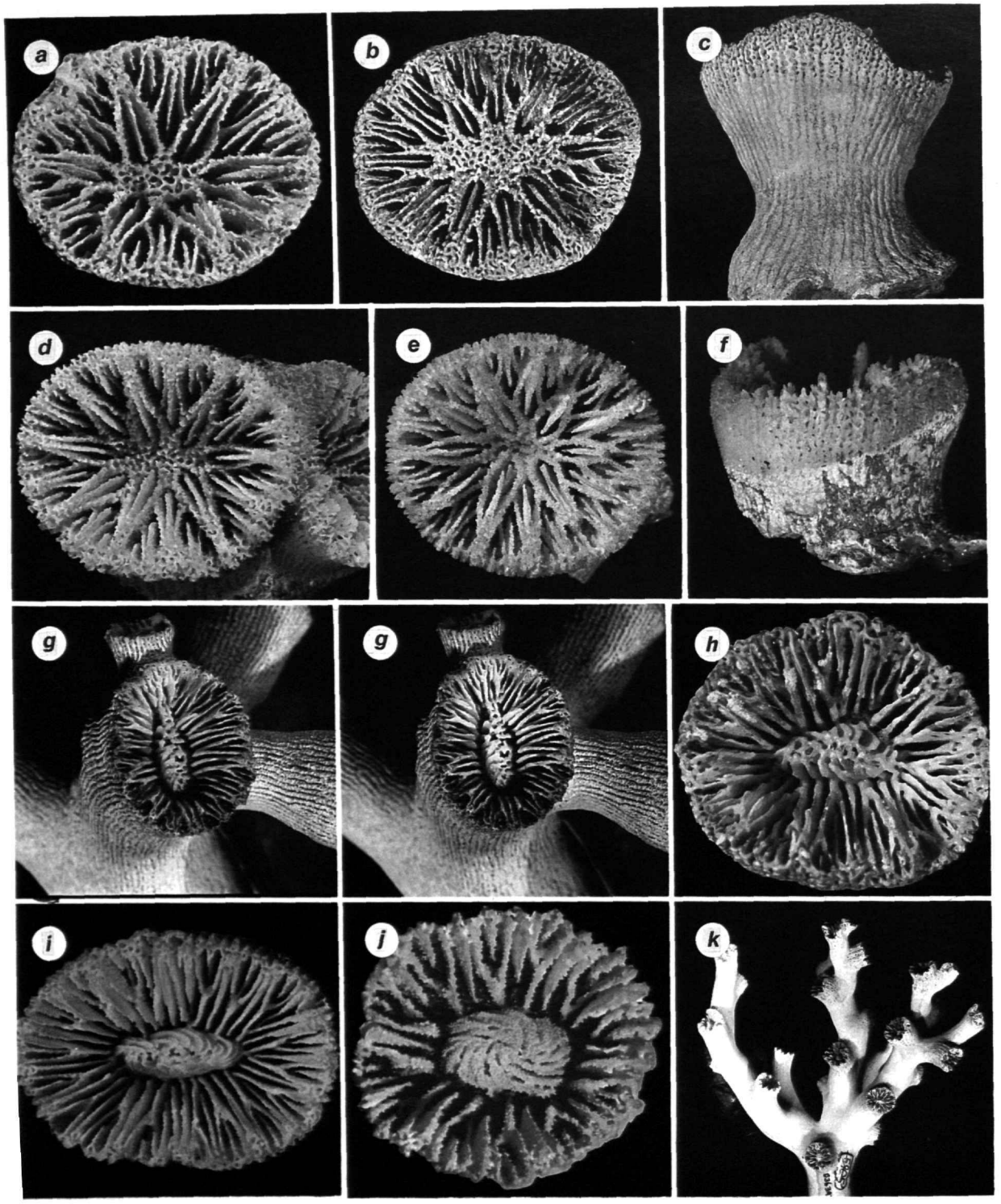

PLATE 12.—*Balanophyllia elegans* (*a*, Snipe Bay, Alaska, UA; *b,c*, Alb-4552, USNM 92627; *d*, CAS 74809; *e,f*, syntype, MCZ 5472): *a*, calice of northernmost record, × 4.5; *b,c*, calicular and lateral views of largest specimen examined, × 3.2, × 2.8, respectively; *d*, calice, × 4.0; *e,f*, calicular and lateral views of a syntype, × 4.1, × 3.8, respectively. *Dendrophyllia californica* (*g,h*, holotype, CAS 29960; *i*, Alb-2832, USNM 38113): *g,h*, calices of holotypic colony, × 1.7, × 3.2 (*g* is a stereo pair); *i*, calice, × 3.6. *Dendrophyllia oldroydae* (*j*, off La Jolla, SIO Co 1179; *k*, holotype of Faustino's *D. oldroydi*, CAS 36397): *j*, calice with a large columella, × 5.0; *k*, largest fragment of holotypic colony, × 0.6.

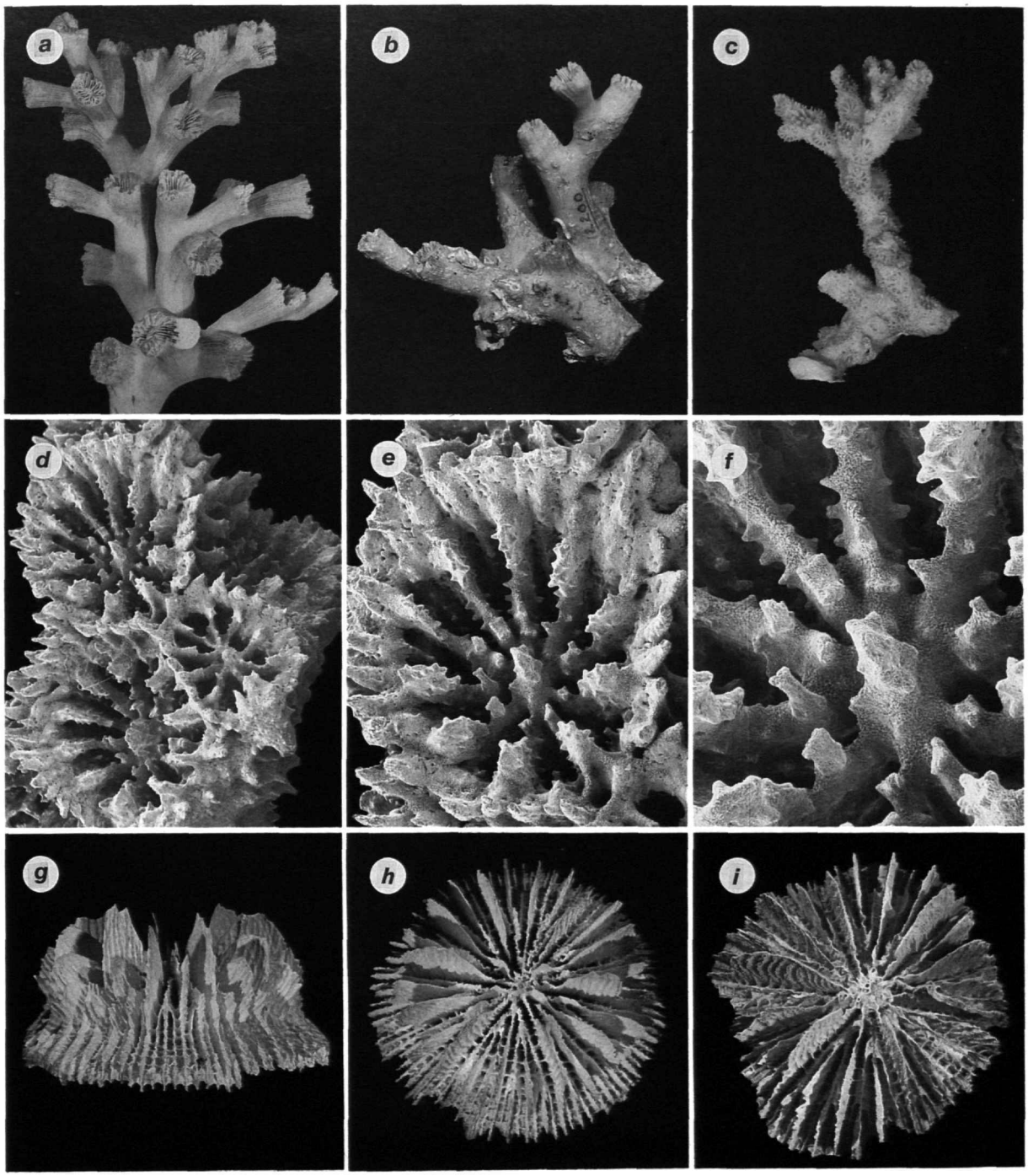

PLATE 13.—*Dendrophyllia oldroydae* (*a*, holotype of *D. cortezi*, SBMNH 35564; *b*, paratype of Faustino's *D. oldroydi*, UCMP 12200): *a*, colony, × 0.6; *b*, colony, × 0.7. *Madracis* sp. A (*c–f*, Sagami Bay, 110 m, ZMC): *c*, branch fragment, × 2.2; *d–f*, progressive enlargements of calices, × 15, × 26, × 57, respectively. *Fungiacyathus stephanus* (*g,h*, Alb-4916, USNM 80124; *i*, Alb-4919, USNM 80125): *g,h*, lateral and oblique calicular views of a concave-based specimen, both × 3.0; *i*, oblique calicular view of a flat-based specimen, × 1.3.

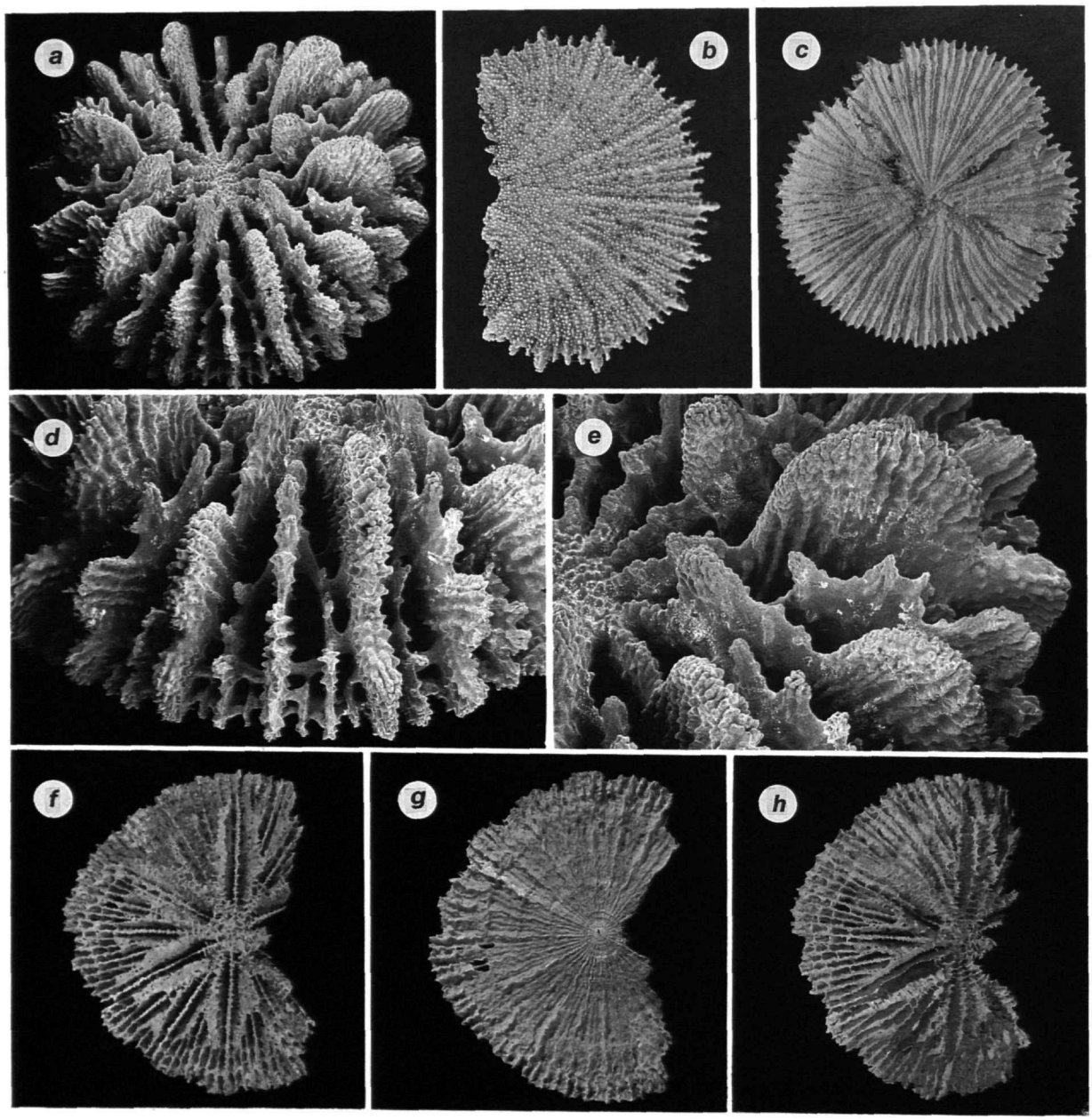

PLATE 14.—*Fungiacyathus paliferus* (*a, d,e,* TM (KT9202, YS1), USNM 92642; *b,c,* TM (KT9015, OK1), USNM 92638; TM (KT9015, BS2), USNM 92635): *a,* oblique calicular view showing paliform lobes, × 8.3; *b,c,* granular costal base of two *Diaseris*-form specimens, × 6.6, × 3.4, respectively; *d,* oblique view of a half-system showing small S5 and paliform lobes, × 16; *e,* oblique view of paliform lobes, × 20. *Fungiacyathus* sp. A: *f–h,* *Vityaz*-2209, *F. palifera* of Keller, 1976, IOM, base and calicular views of larger corallum, all × 1.5.

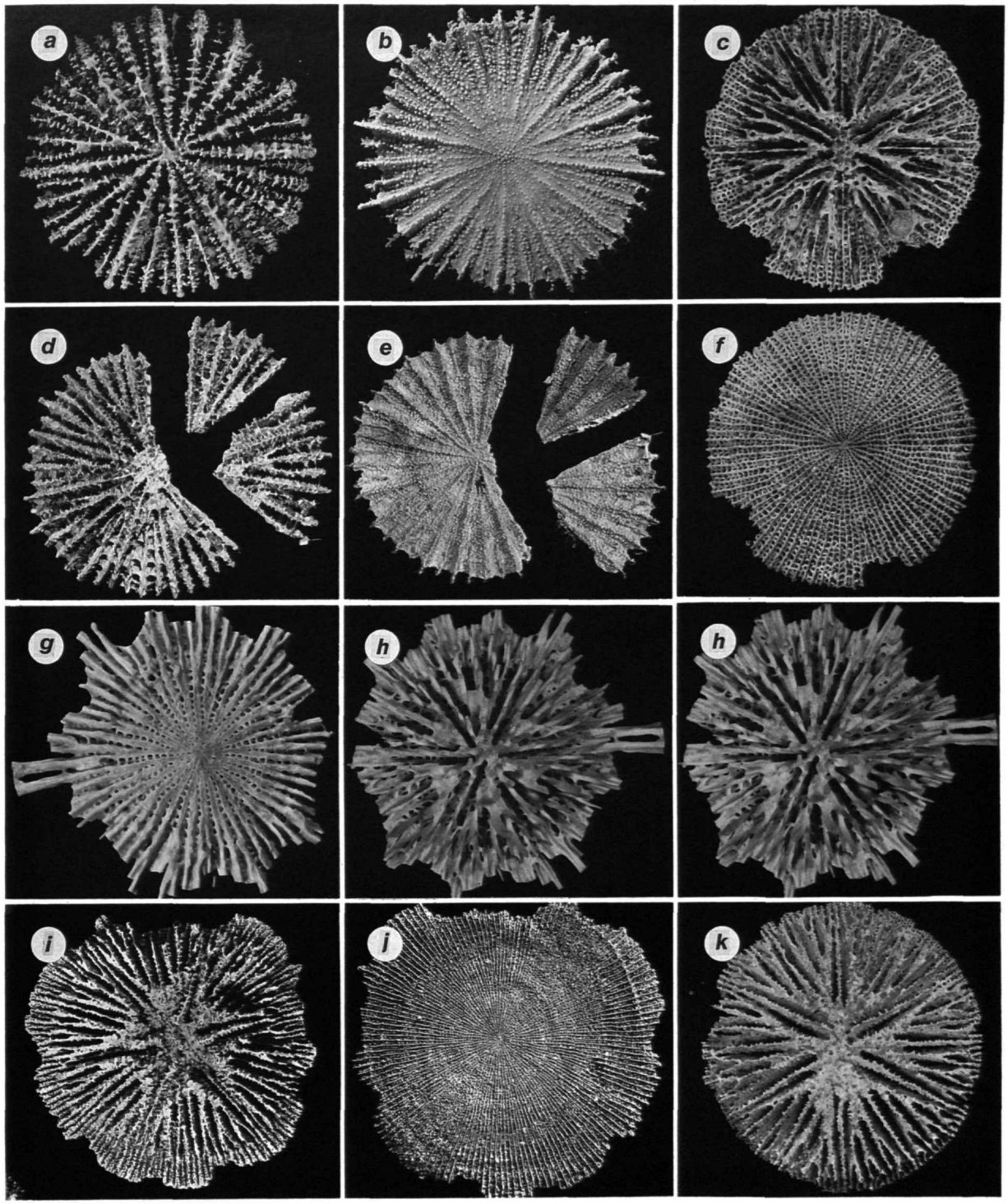

PLATE 15.—*Fungiacyathus variegatus: a,b,* Alb-4911, USNM 82018, calicular and basal views, both × 6.0. *Letepsammia formosissima: c,f,* TM (CR79-8), USNM 92650, calicular and basal views, both × 2.6. *Fungiacyathus granulosus: d,e,* TM (KT9202, YT4), USNM 92645, calicular and basal views, both × 3.1. *Leptopenus solidus: g,h,* holotype, IOM, basal and stereo calicular views, both × 4.5. *Rhombopsammia niphada* (*i,j,* TM (KT9202, YT5), USNM 92647; *k,* holotype, Alb-4911): *i,j,* calicular and basal views of a specimen, × 1.3, × 1.4, respectively; *k,* calice, × 1.4.

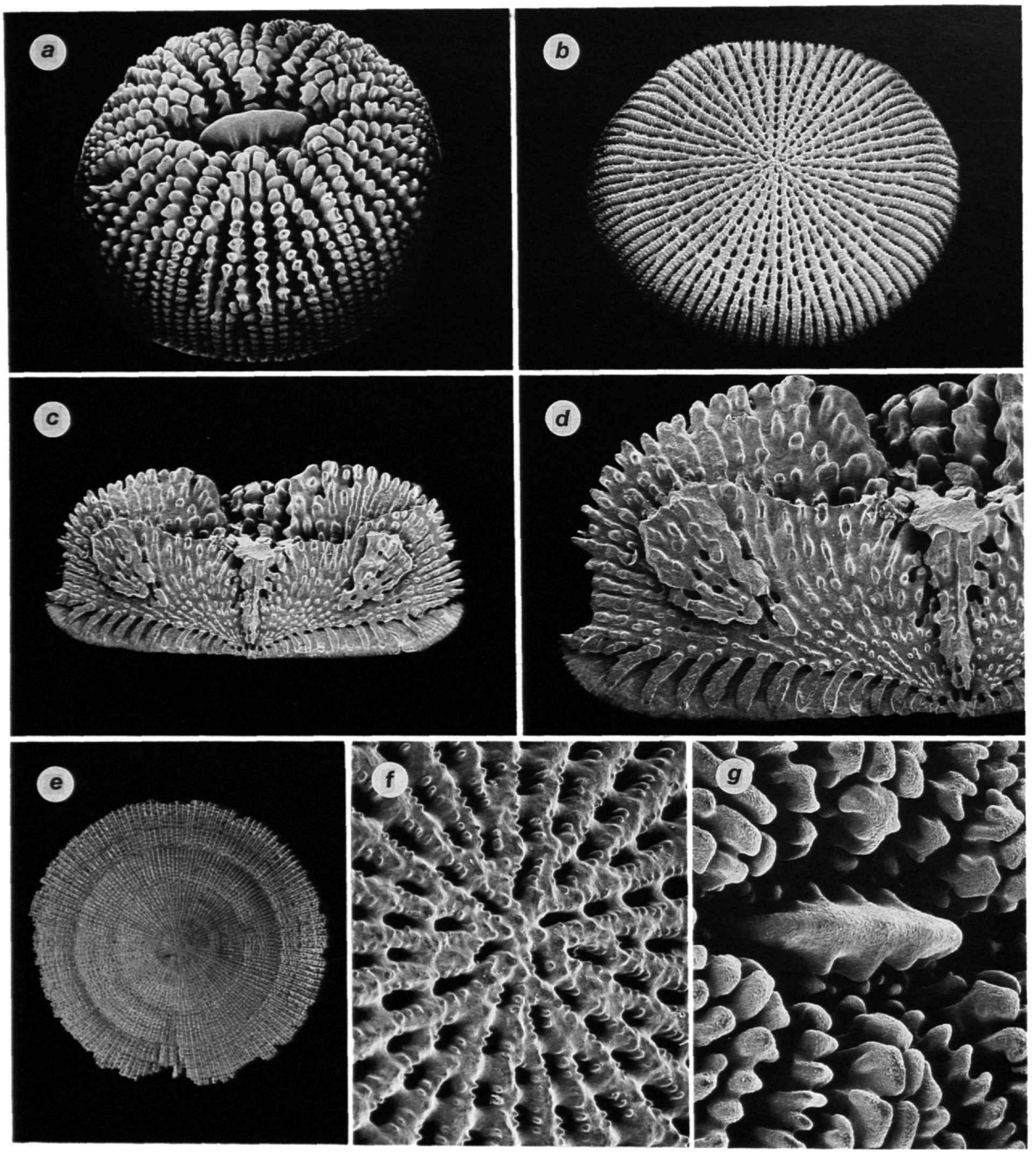

PLATE 16.—*Stephanophyllia fungulus* (*a–d,f,g*, TM (KT9015, BS2), USNM 92652): *a,b*, oblique calicular and basal views, × 8, × 11, respectively; *c,d*, longitudinal view of fractured corallum revealing horizontal thecal wall, oblique fulturae, septal faces, and synapticulae, × 9, × 17, respectively; *f*, granular base at epicenter, × 51; *g*, lamellar columella, × 18. *Rhombopsammia niphada*: *e*, base of holotype, Alb-4911, × 14.

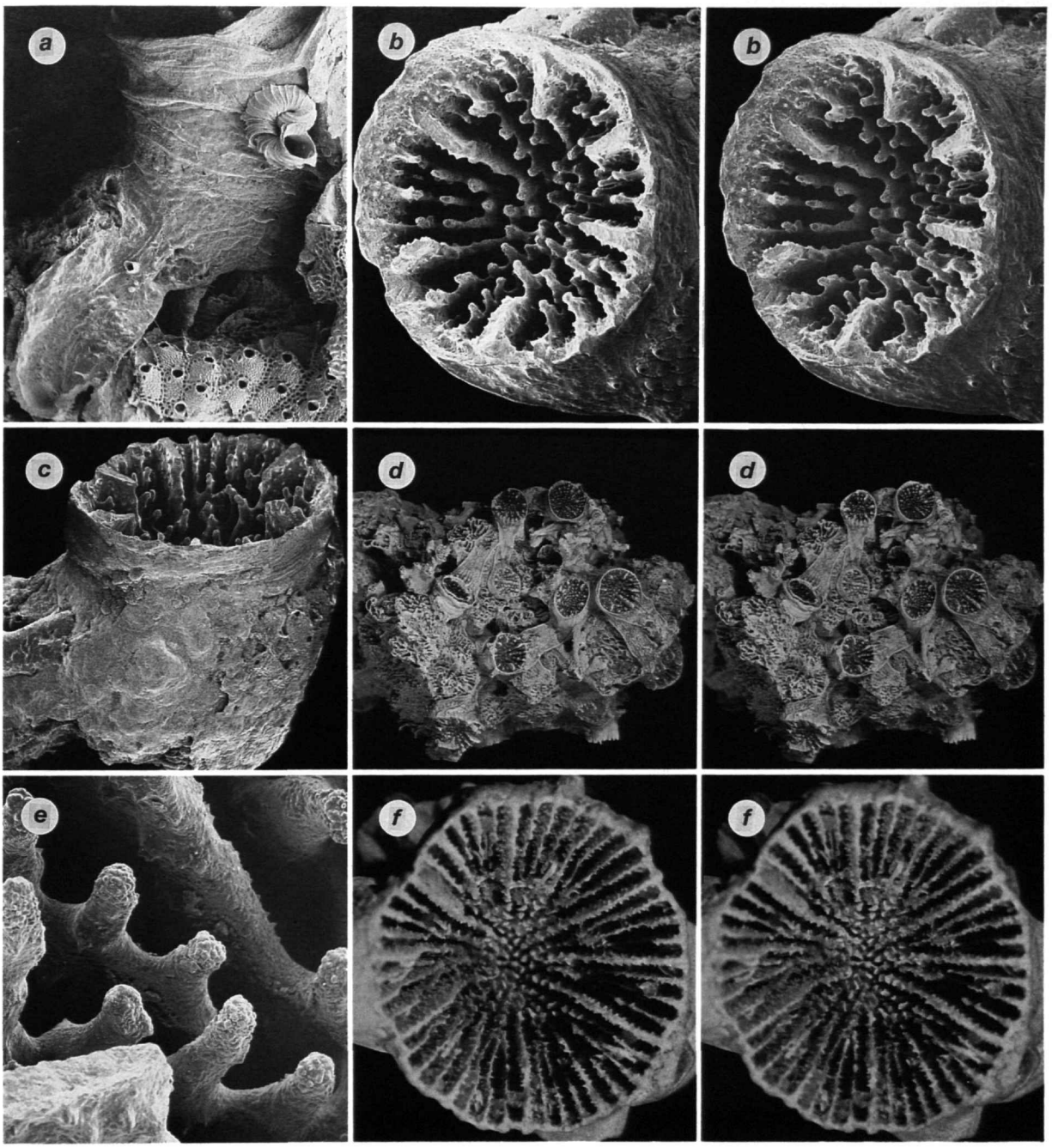

PLATE 17.—*Culicia japonica* (*a–e*, off Sesoko, Okinawa, USNM 86826): *a*, lateral view of epitheca and stolon, × 17; *b*, stereo view of calice, × 17; *c*, lateral view of epithecate corallum, × 14; *d*, stereo view of corallites linked by stolons, × 2.3; *e*, paliform lobes on S_{2-3}, × 78. *Oulangia stokesiana miltoni*: *f*, TM (KT9015, CB6), USNM 92646, stereo view of calice, × 9.6.

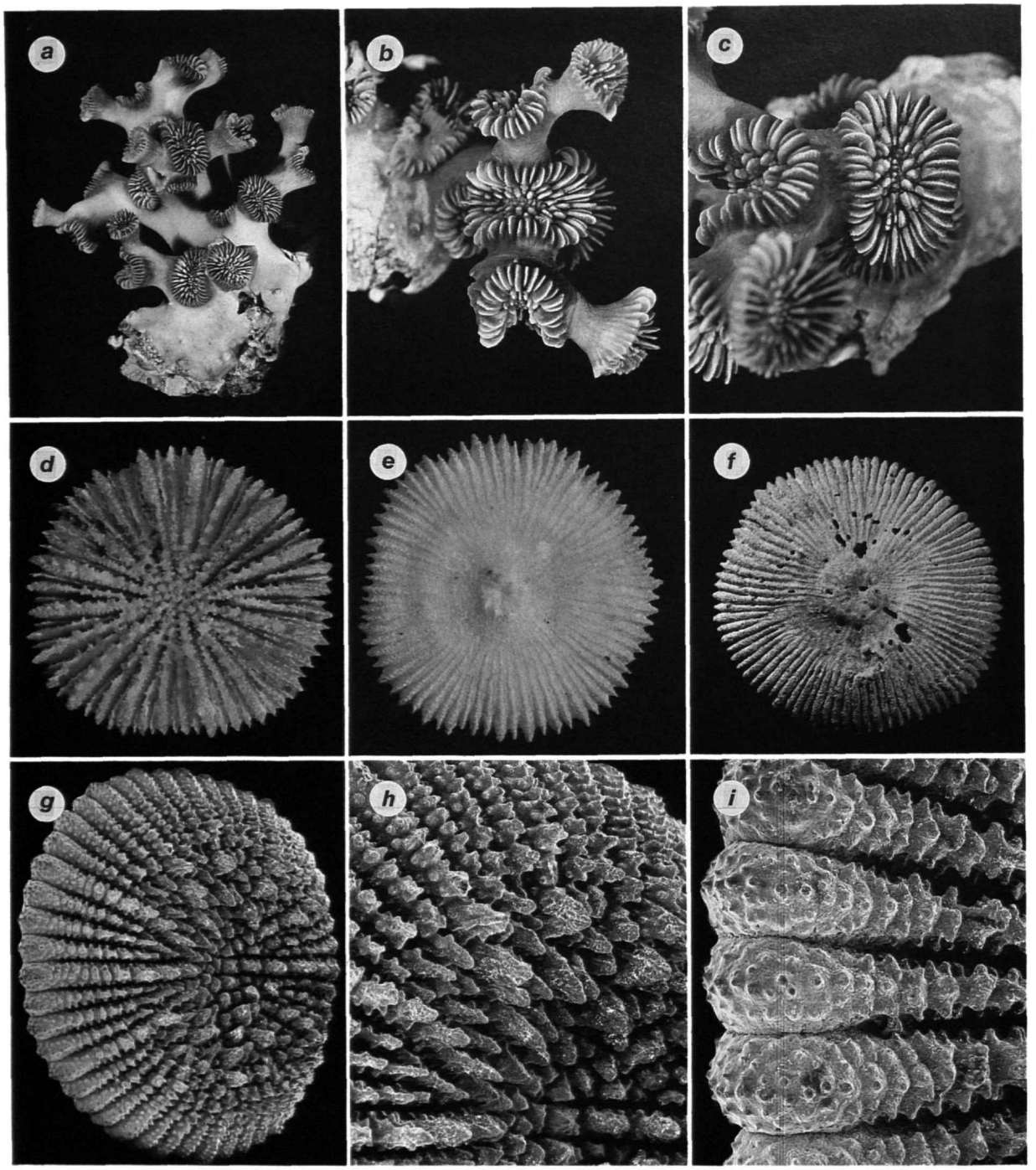

PLATE 18.—*Cyathelia axillaris* (*a*, Monoisa, Sagami Bay, USNM 92665; *b,c*, Alb-4944, USNM 92660): *a*, colony, × 1.0; *b,c*, calices, × 2.1, × 2.9, respectively. *Anthemiphyllia dentata* (*d,e*, TM (KT9202, OS3), ORI; *f*, Alb-5094, USNM 92667): *d,e*, calicular and basal views, both × 5.0; *f*, basal view of long-dead corallum, × 2.2. *Anthemiphyllia frustum* (*g–i*, paratype, TM (KT9202, OS2), USNM 92669): *g*, oblique calicular view, × 8.5; *h*, oblique view of paliform lobes, × 17; *i*, edge view of thick septocostae, × 32.

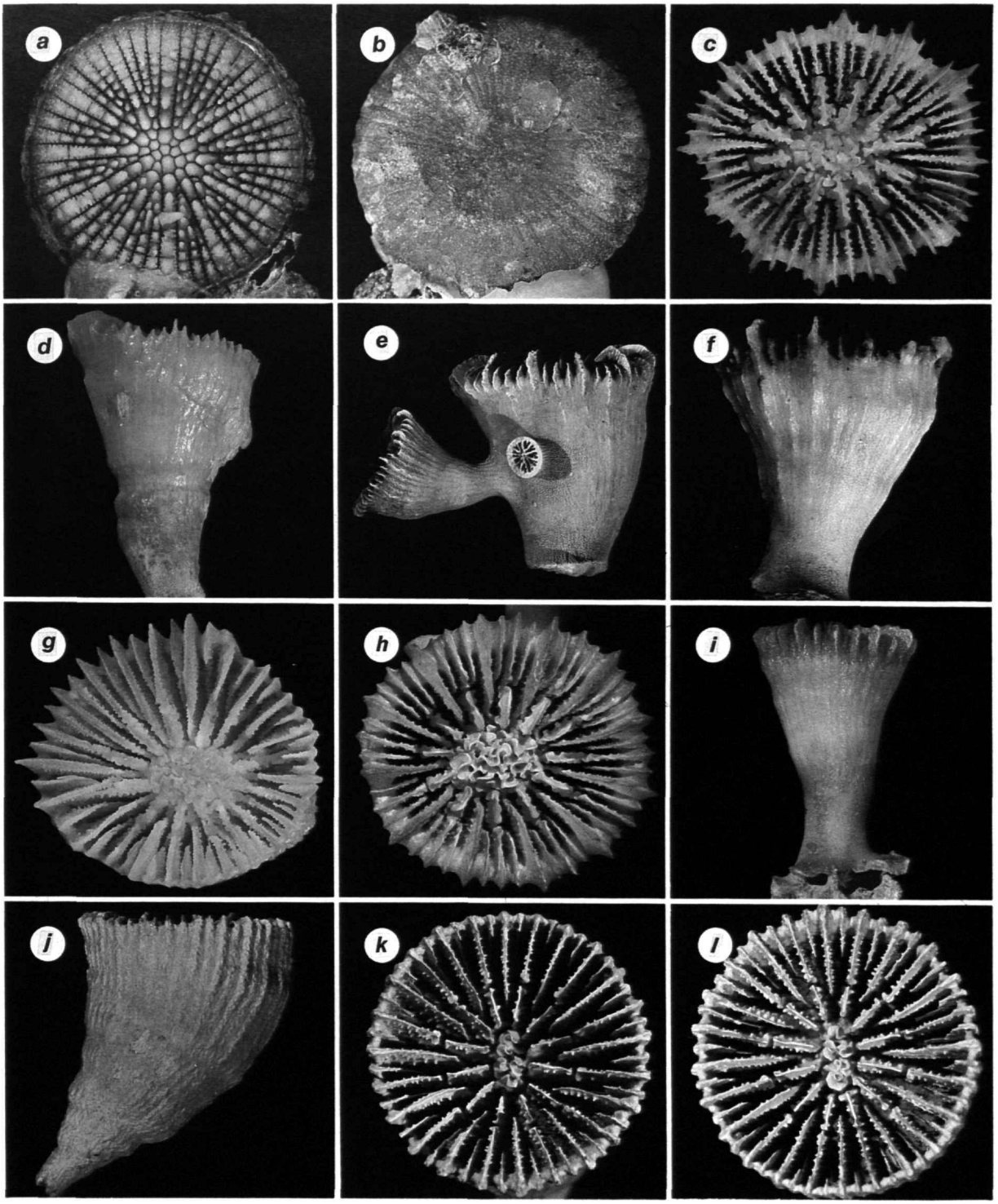

PLATE 19.—*Anthemiphyllia frustum: a,b,* calicular and basal views of holotype, USNM 92668, both × 6.1. *Caryophyllia japonica* (*c,f, Vityaz*-3353, USNM 92678, *C. alaskensis* of Keller, 1981a; *d,g,* syntype, Enoshima, Sagami Bay, NMW 8168; *e,h,* Alb-4982, USNM 82158; *i,* smaller syntype, NMW 8168): *c,f,* calicular and lateral views of a specimen with over 48 septa, × 2.8, × 2.3, respectively; *d, g,* larger syntype, × 2.3, × 3.4, respectively; *e,h,* lateral and calicular views of a specimen with 48 septa, × 2.2, × 2.9, respectively; *i,* syntype, × 2.8. *Caryophyllia* sp. cf. *C. scobinosa: j-l,* TM (KT7911, OT4), USNM 92680, lateral and calicular views of a specimen, × 3.7, × 5.1, × 5.3, respectively.

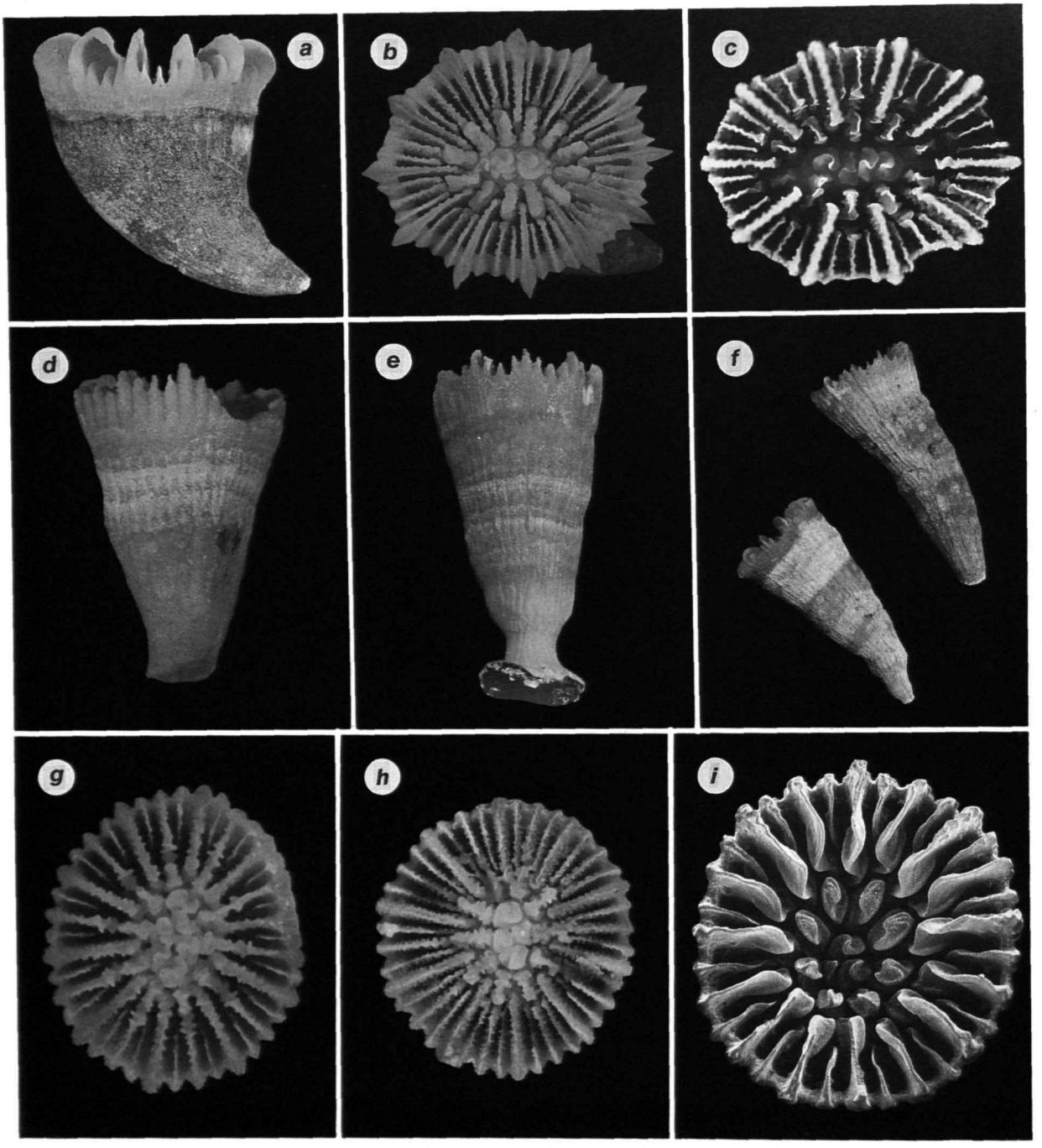

PLATE 20.—*Caryophhylia scobinosa: a,b,* lateral and calicular views of a syntype from *Siboga*-45, ZMA Coel. 574, ×2.4, ×3.0, respectively. *Caryophyllia quadragenaria* (*c,f,* TM (KT9202, OS2), USNM 92672; *d,g,* syntype, *Siboga*-251, ZMA Coel. 5529; *e,h,* 32°10′N, 128°20′E, ZMC): *c,* calice, × 7.7; *d,g,* lateral and calicular views of a syntype, × 5.4, × 7.7, respectively; *e,h,* lateral and calicular views of a specimen, × 3.9, × 6.5, respectively; *f,* lateral view of two specimens, × 2.3. *Caryophyllia rugosa: i,* calice of specimen from 32°21′N, 128°49′E, ZMC, × 10.5.

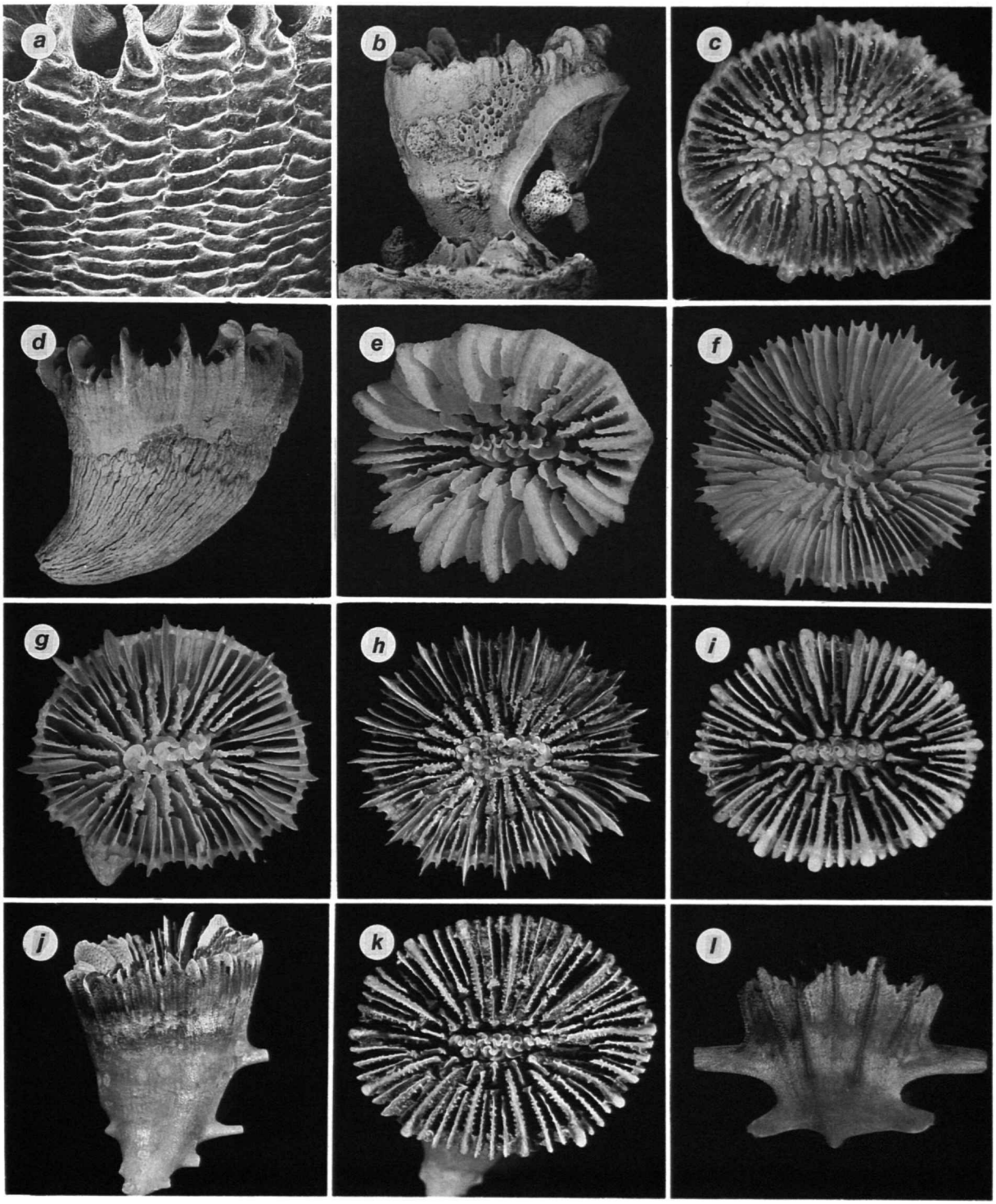

PLATE 21.—*Caryophyllia rugosa: a,* transverse costal rugae of specimen from Plate 20*i*, ZMC, × 26. *Caryophyllia jogashimaensis: b,c,* lateral and calicular views of specimen from TM (KT9202, YT2), USNM 92675, × 3.5, × 4.7. *Caryophyllia ambrosia ambrosia* (*d,g,* syntypes, *Investigator*-176, USNM 18157; *e, Soyo Maru*-223, TIUS 53625, *C. alcocki* of Yabe and Eguchi, 1942b; *f,* TM (KT9202, YT6), USNM 92794; *h,* Alb-4960, USNM 92792): *d,g,* lateral and calicular views of two syntypes, × 1.7, × 1.9, respectively; *e,* specimen with only 12 pali, × 2.2; *f,* specimen with 18 pali, × 1.5; *h,* specimen with 20 pali, × 1.6. *Caryophyllia grayi*: (*i–k,* Kere River, Vanuatu, Pleistocene, USNM 73964): *i,* calice of a well-preserved specimen, × 2.4; *j,k,* lateral and calicular views of a specimen, × 1.7, × 2.6, respectively. *Caryophyllia (A.) spiniger: l,* lateral view of syntype from "off Japan," BM, × 3.1.

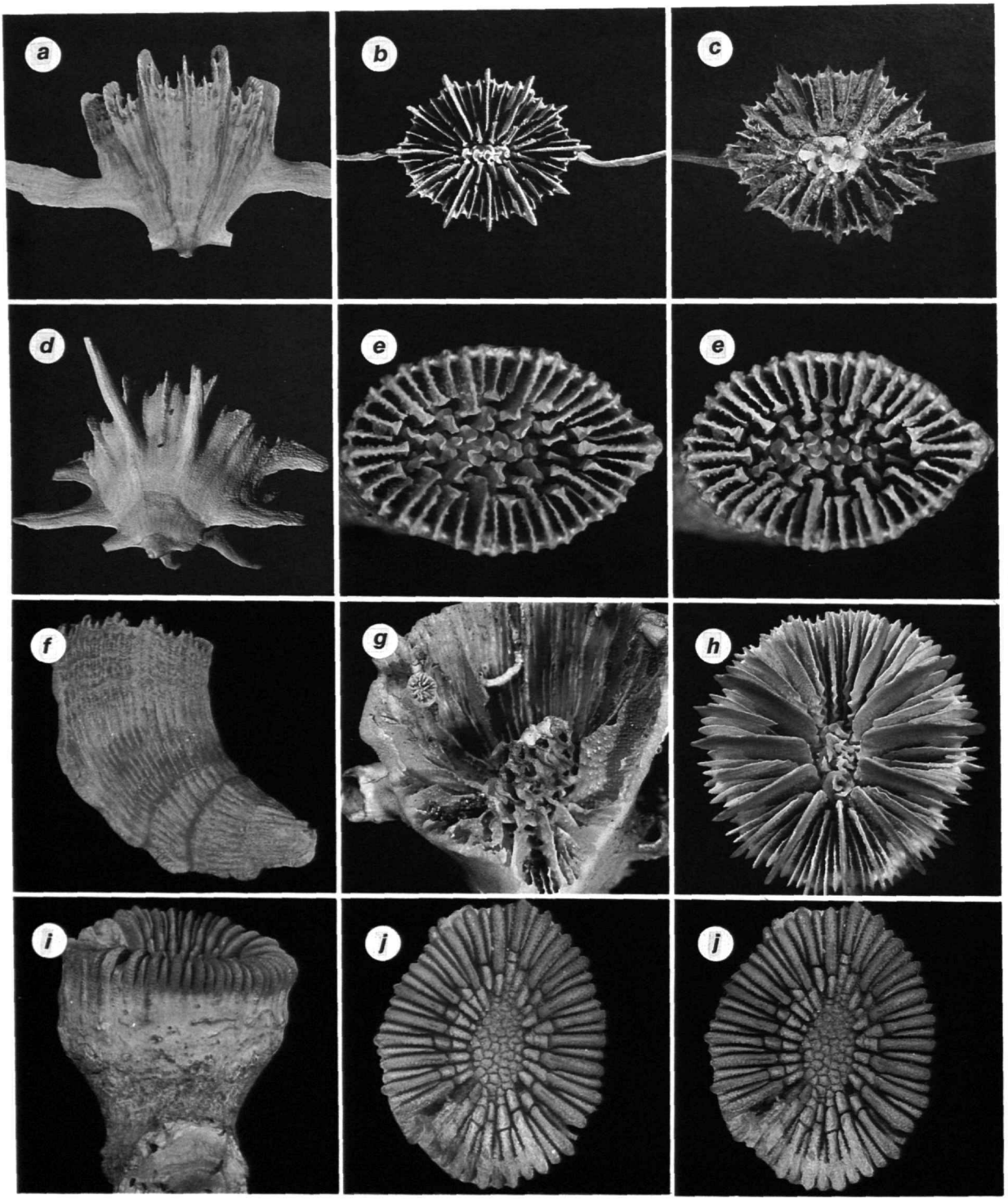

PLATE 22.—*Caryophyllia (A.) spiniger* (*a,b, d,* Alb-5371, USNM 92690; *c,* syntype of Plate 21*l*, BM): *a,b,* specimen with long, broad edge spines, ×2.0, ×1.9, respectively; *c,* syntype, ×3.3; *d,* specimen having additional lateral thecal spines, ×2.2. *Caryophyllia (P.) compressa: e,f,* stereo calicular and lateral views of a corallum from TM (KT9015, BS_2), USNM 92686, ×6.9, ×3.6, respectively. *Crispatotrochus rubescens* (*g, Soyo Maru*-425, TIUS 53695; *h, Soyo Maru*-331, TIUS 53694 (*Cyathoceras diomedae* of Yabe and Eguchi, 1942b)): *g,* poorly preserved corallum with a *Stenocyathus vermiformis* attached in upper left quadrant, ×2.4; *h,* well-preserved corallum, ×2.2. *Paracyathus pruinosus: i–j,* lateral and stereo calicular views of syntype from *Siboga*-96, ZMA Coel. 1307, ×2.1, ×2.7, respectively.

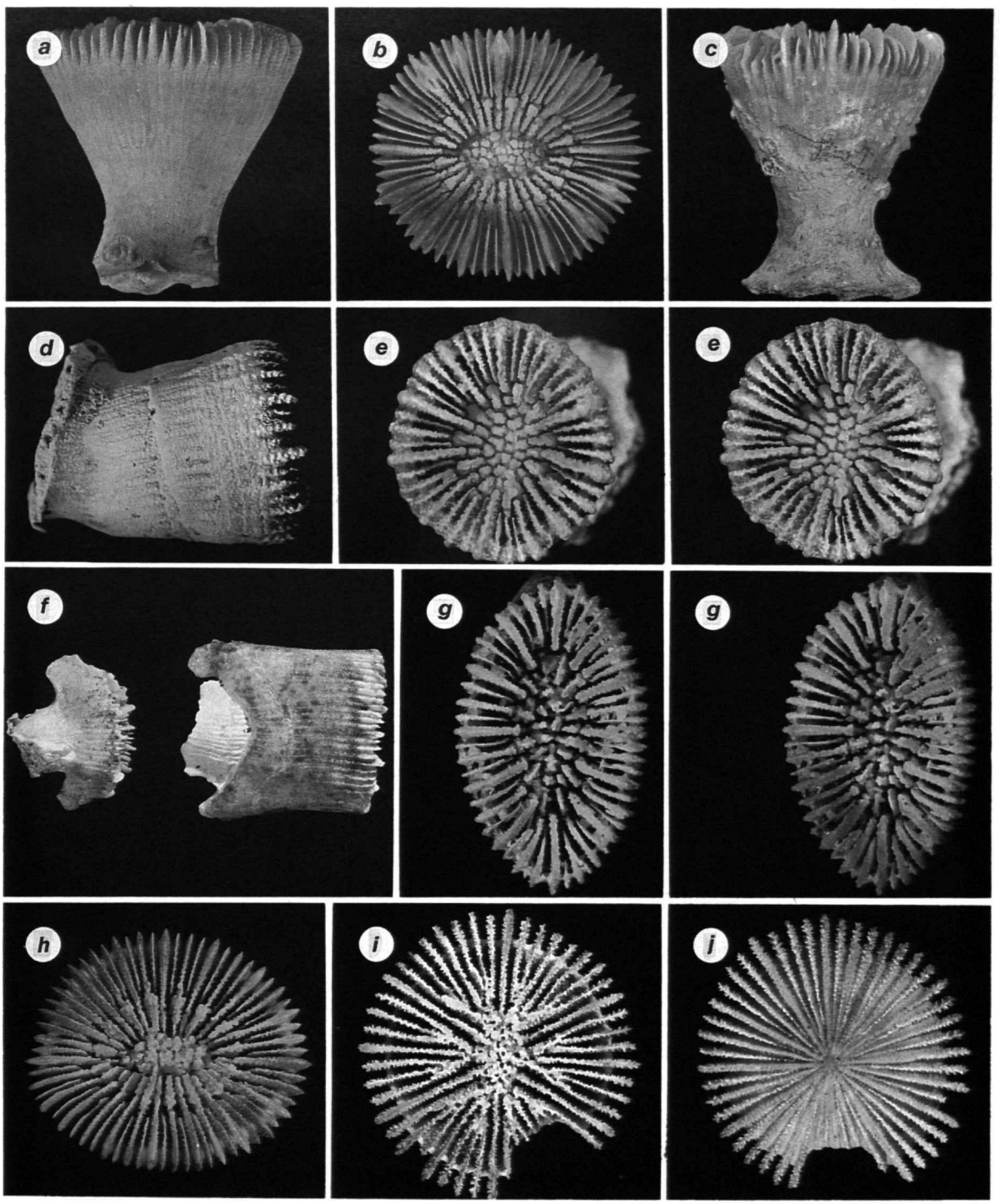

PLATE 23.—*Trochocyathus caryophylloides* (*a,h*, Alb-4891, CAS 74940; *b,c*, syntype, *Siboga*-253, ZMA Coel. 1324): *a,h*, lateral and calicular views, both × 3.2; *b,c*, calicular and lateral views of a syntype, × 2.7, × 2.3, respectively. *Trochocyathus decamera d,e*, holotype, USNM 92693, lateral and stereo calicular views, × 5.7, × 7.0. *Trochocyathus cooperi* (*f,g*, TM (KT9202, YT1), USNM 92691): *f*, anthocaulus and anthocyathus, × 3.0; *g*, stereo view of anthocyathus calice, × 5.8. *Deltocyathus vaughani: i,j*, calicular and basal views of holotype, USNM 19391, both × 2.6.

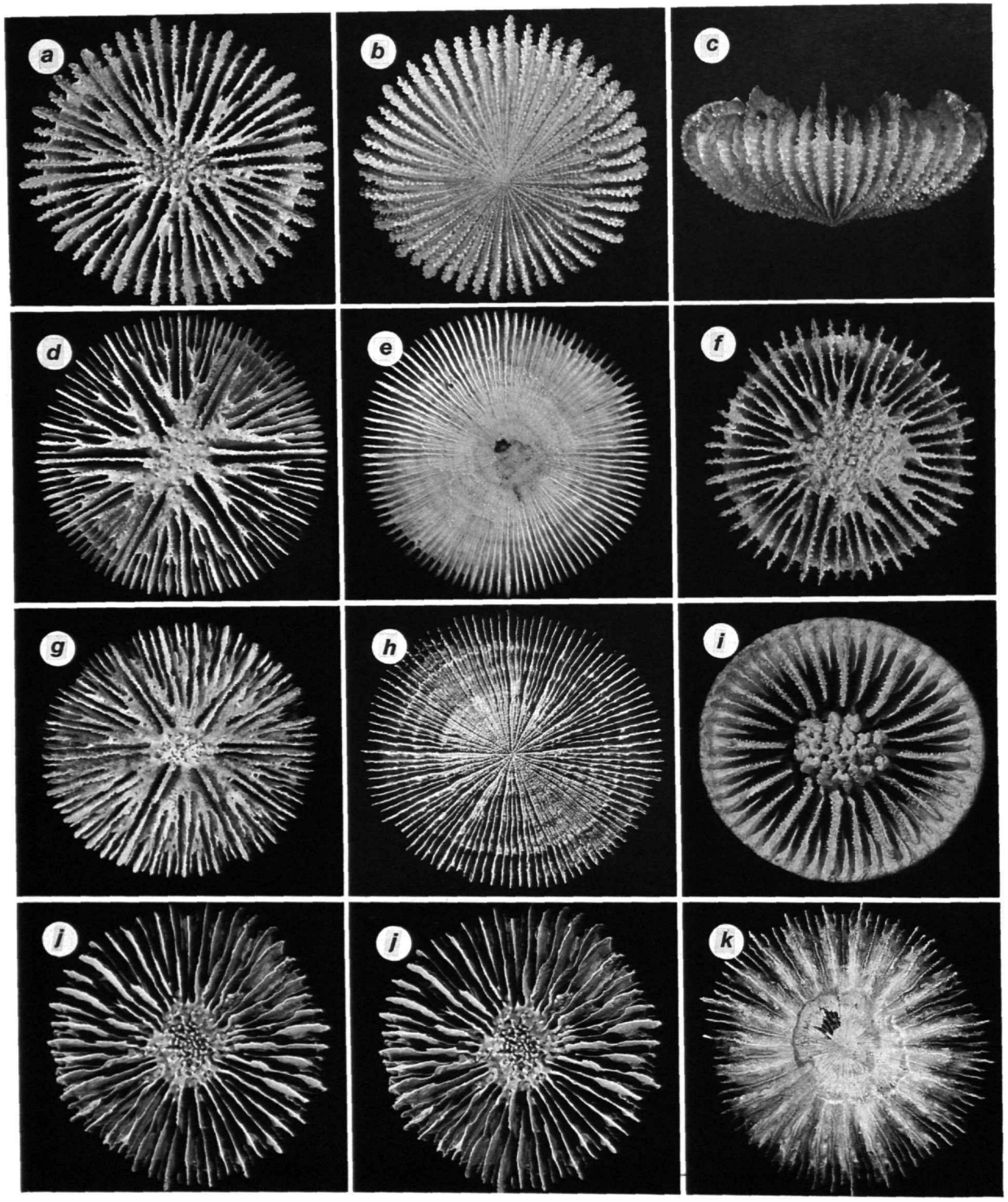

PLATE 24.—*Deltocyathus vaughani* (*a–c*, Alb-5088, USNM 92721; *f*, TM (KT7811, OT4), USNM 92723): *a–c*, calicular, basal, and lateral (edge) views of a specimen, × 2.7, × 2.6, × 2.7, respectively; *f*, specimen with ascothoracid gall in right portion of columella, × 3.3. *Deltocyathus magnificus* (*d,e*, syntype, *Challenger*-192, BM; *g,h*, Tsuchida-102, USNM 92730): *d,e*, only remaining syntype, both × 2.5; *g,h*, a Japanese specimen, × 1.6, × 1.8, respectively. *Conotrochus funicolumna*: *i*, *Soyo Maru*-268, TIUS 50243, calice, × 4.0. *Deltocyathus rotulus*: *j,k*, stereo calicular and basal views of specimen from Alb-5079, USNM 92726, both × 1.7.

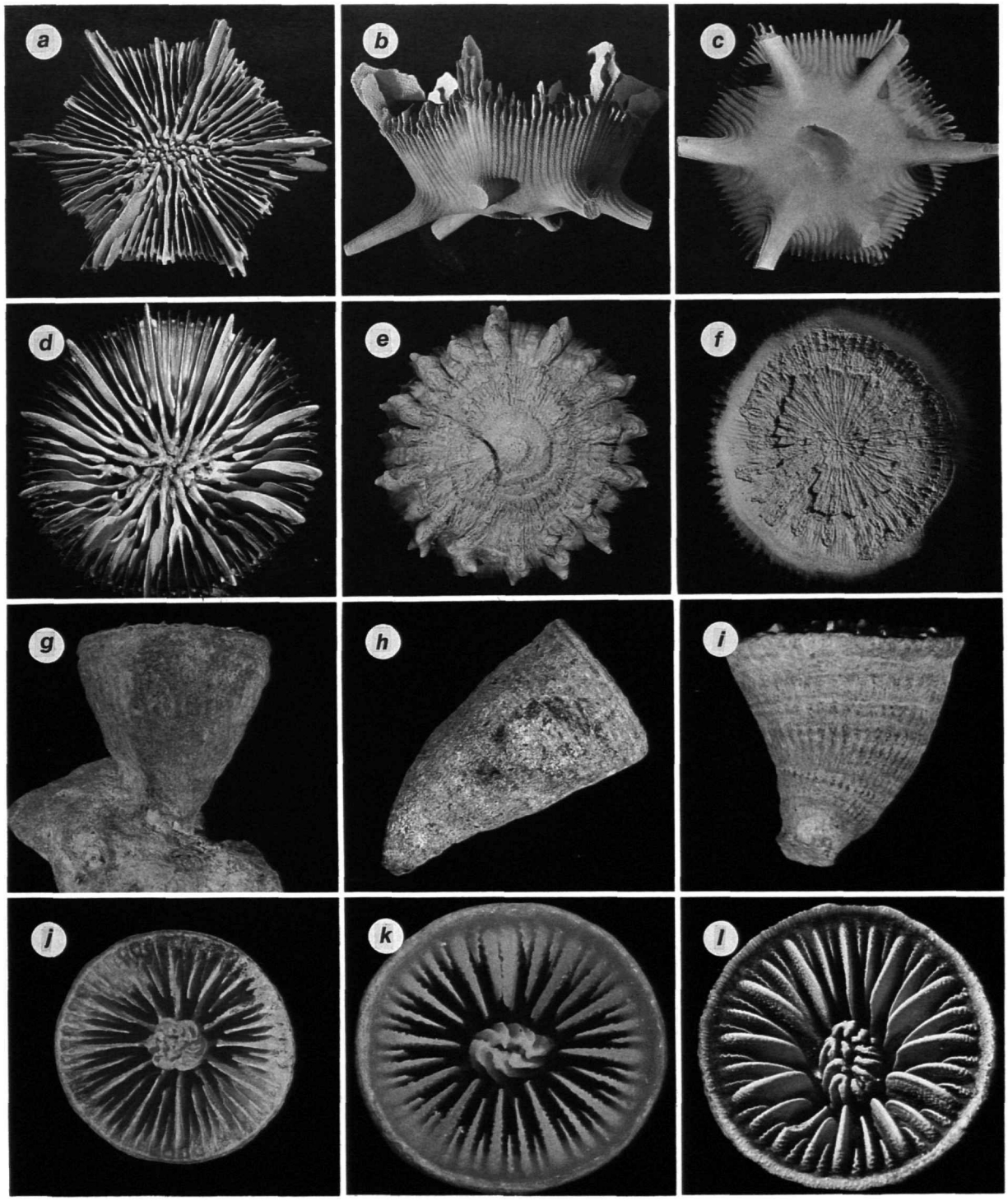

PLATE 25.—*Stephanocyathus spiniger: a–c*, calicular, lateral, and basal views of a specimen from Tosa Bay, USNM 92733, all × 1.1. *Stephanocyathus weberianus* (*d,f*, Alb-4958, USNM 92737; *e*, TM (KT9202, YT6), USNM 92743): *d,f*, specimen having an eroded base, both × 1.4; *e*, specimen having a strongly tuberculate base, × 1.4. *Conotrochus funicolumna* (*g,j*, syntype, *Siboga*-95, ZMA Coel. 709; *h,k*, *Soyo Maru*-323, TIUS 59174, syntype of *Conotrochus parahispidus; i*, *Soyo Maru*-268, TIUS 50243; *l*, off Misake, USNM 92700): *g, j*, × 2.6, × 3.6, respectively; *h,k*, × 2.9, × 5.5, respectively; *i*, × 3.8; *l*, × 4.1.

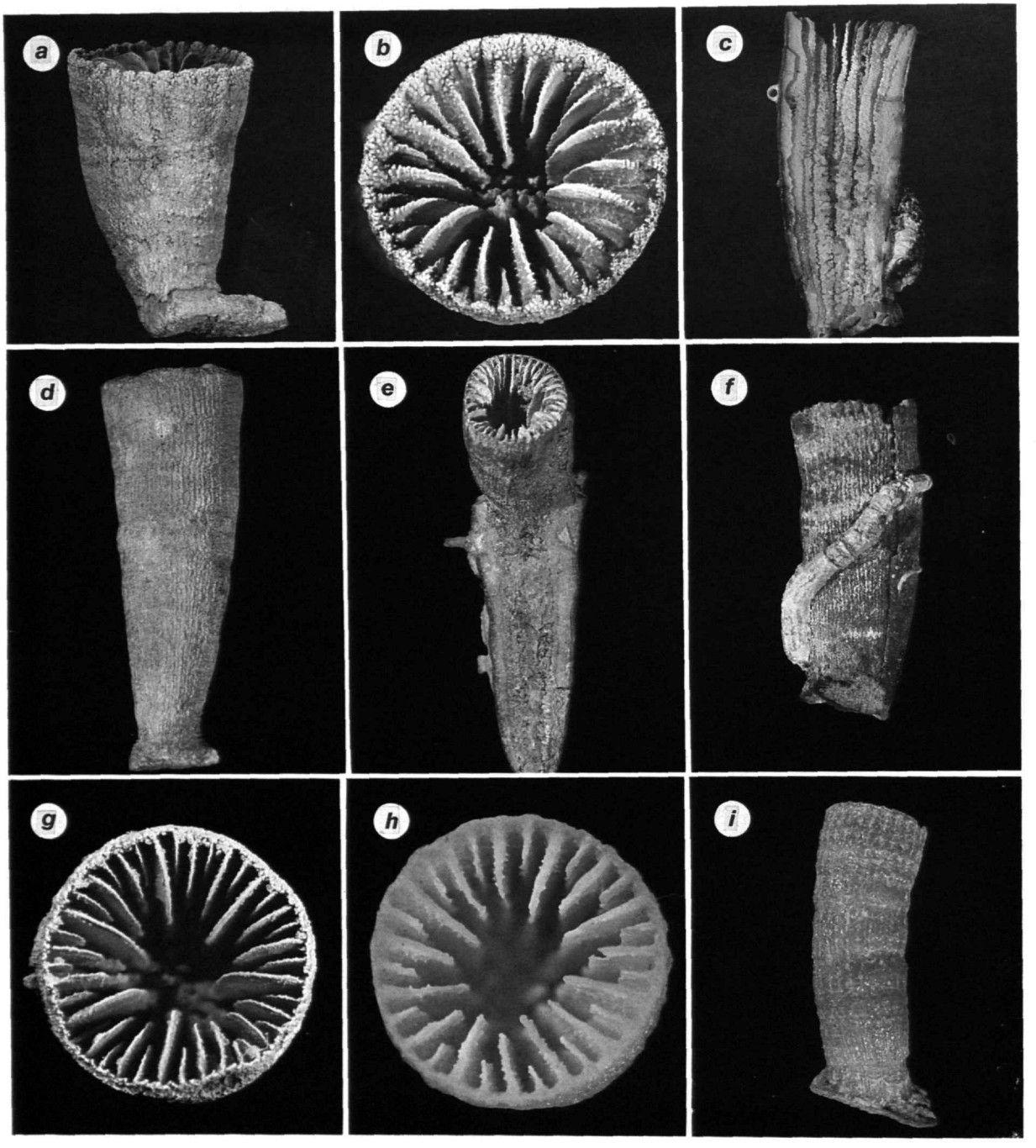

PLATE 26.—*Aulocyathus recidivus: a,b,* lateral and calicular views of a specimen from Alb-4958, USNM 92704, × 3.7, × 6.4, respectively. *Aulocyathus matricidus* (*c,e,f,* syntypes, BM 1862.7.16.72; *d,g,* TM (KT7802, Z4), USNM 92703): *c,f,* both sides of a longitudinally fractured specimen, both × 2.7; *e,* small corallum budded from parent fragment, × 2.6; *d,g,* lateral and calicular views of a specimen, × 4.1, × 7.7, respectively. *Aulocyathus juvensecens: h,i,* syntypes, ZMB 5064, calice and corallum, × 15, × 5.2, respectively.

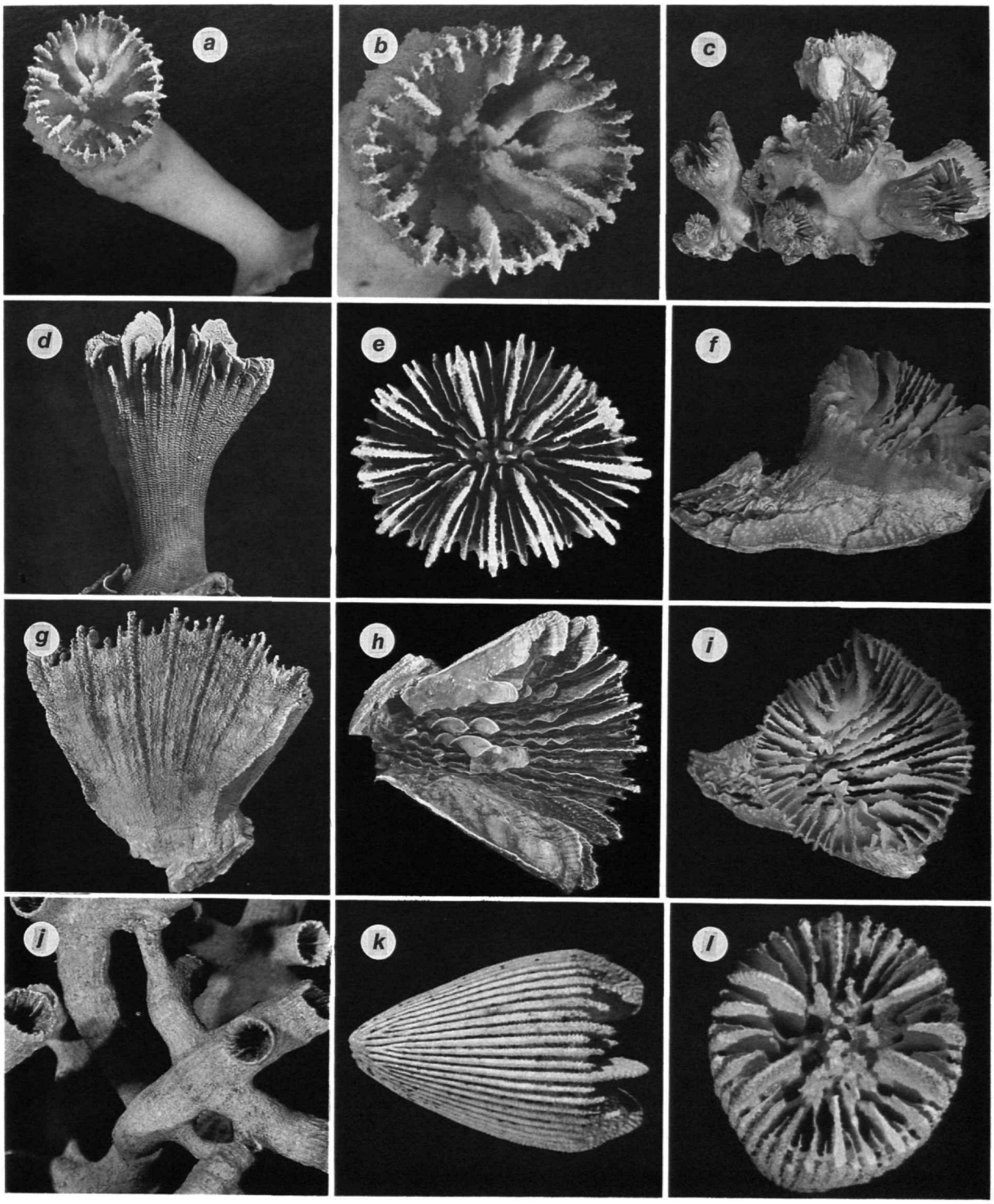

PLATE 27.—*Coenosmilia* sp. cf. *C. arbuscula: a,b,* calicular views of specimen from TM (KT9202, YS2), USNM 92709, × 3.3, × 6.2, respectively. *Rhizosmilia sagamiensis* (*c–e*, Alb-4944, USNM 92705): *c*, small phaceloid corallum, × 1.4; *d,e*, lateral and calicular views of an individual corallite, × 2.6, × 4.0, respectively. *Dasmosmilia pacifica: (f,i*, YO70-1009, ORI; *g,h*, Alb-3738, USNM 92710): *f, i*, regenerated corallum budded from parent corallum, × 3.1, × 3.3, respectively; *g,h*, corallum fragment illustrating costae and fascicular columella, both × 2.9. *Goniocorella dumosa: j*, colony fragment from Sagami Bay, USNM 92708, × 2.3. *Notocyathus venustus: k,l*, lateral and oblique calicular views of a corallum from TM (KT9015, BS2), × 5.0, 7.3, respectively.

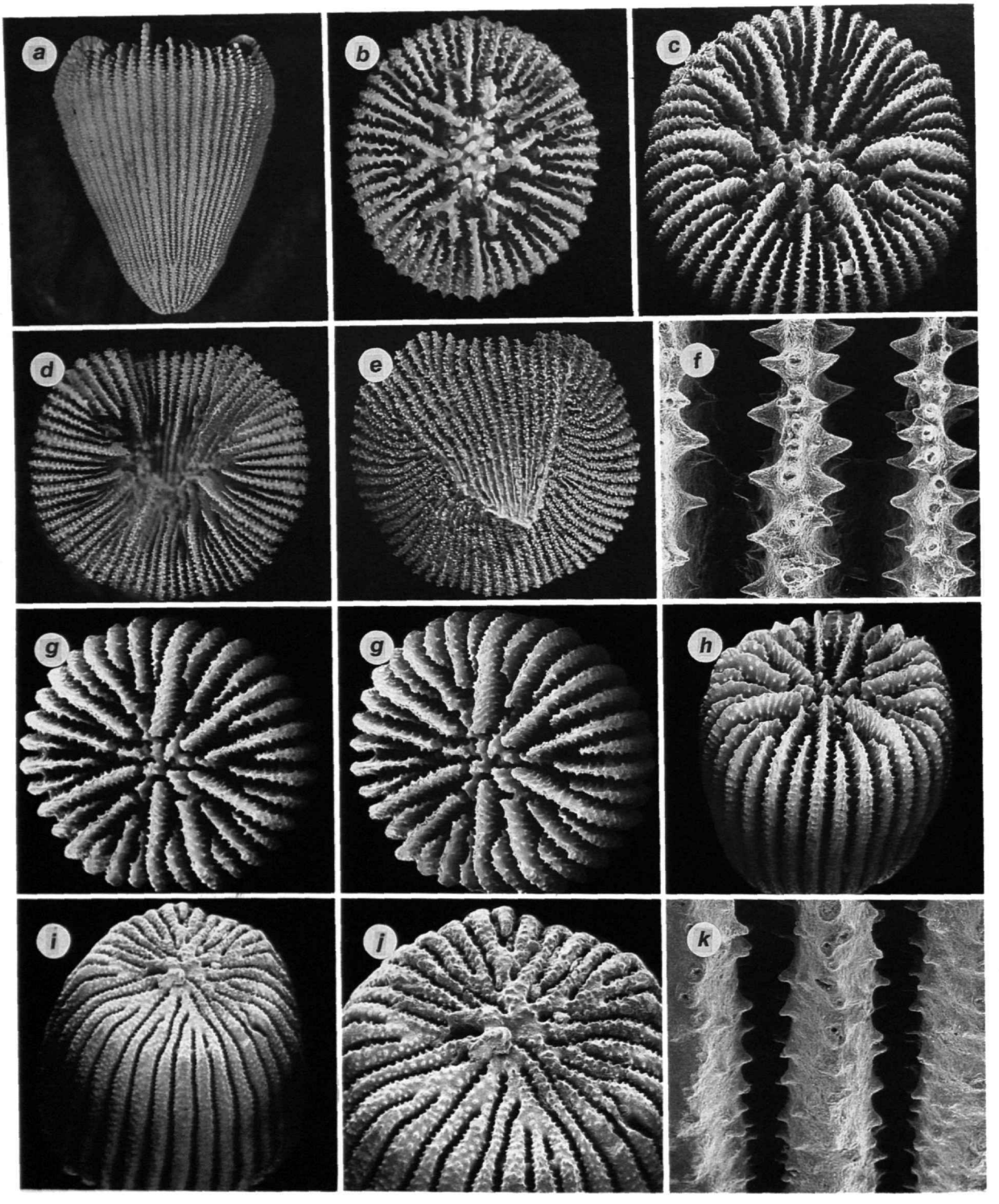

PLATE 28.—*Notocyathus conicus*: *a,b*, lateral and calicular views of specimen from TM (KT9015, CB1-2), USNM 92777, × 6.7, × 9.1, respectively. *Peponocyathus australiensis* (*c, f*, TM (KT9015, HK5), USNM 92766; *d,e*, TM (KT7414, B4), USNM 92917): *c,f*, calice and costae of typical form, × 9.8, × 66, respectively; *d,e*, calice and basal costae of form *japonicus*, both × 4.1. *Peponocyathus folliculus* (*g–k*, TM (KT9015, CB1-2), USNM 92774): *g,h*, oblique calicular views (*g* is a stereo pair), × 11, × 10, respectively; *i,j*, enlargements of flat base, × 11, × 18, respectively; *k*, costae, × 58.

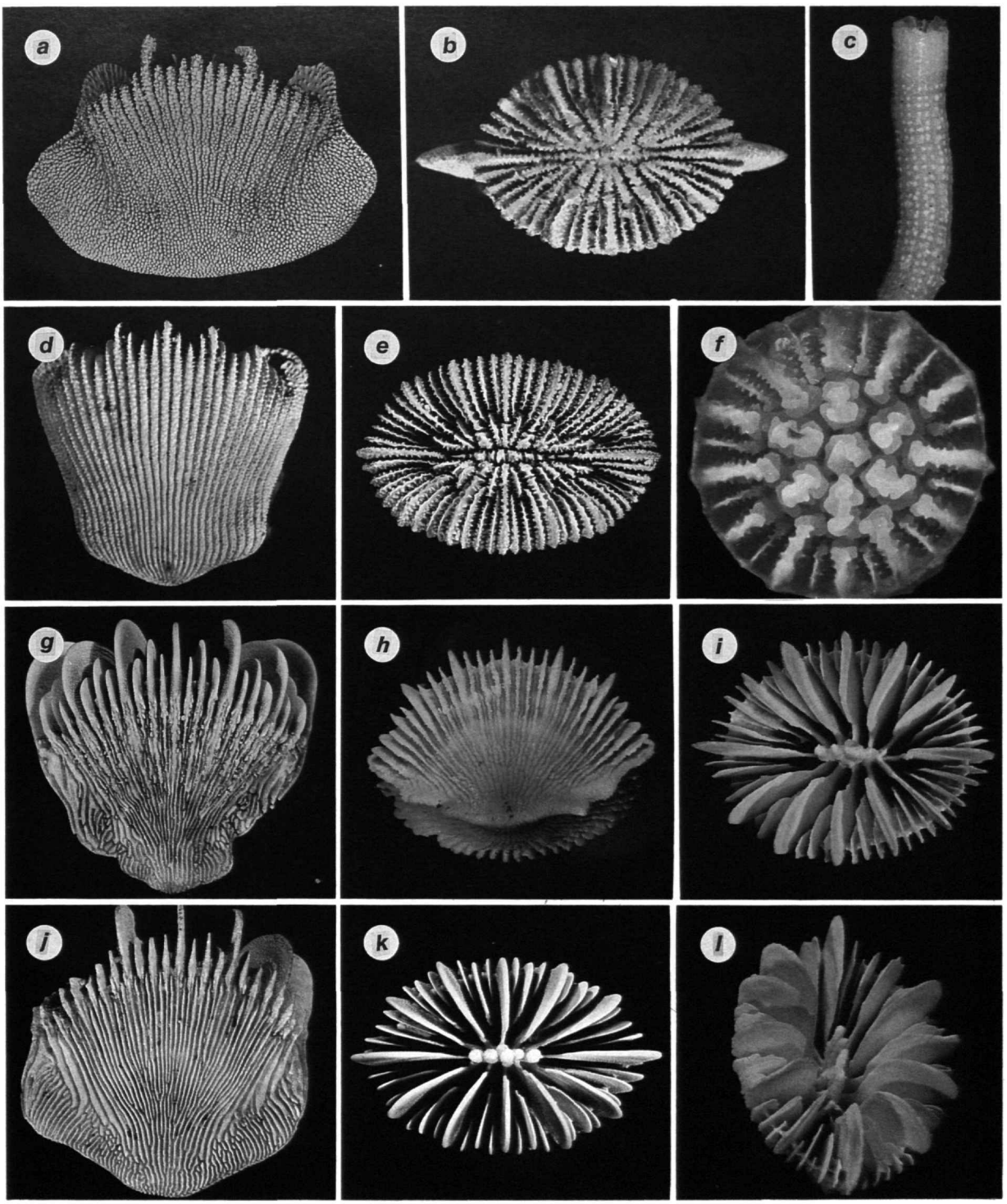

PLATE 29.—*Tropidocyathus lessoni: a,b,* lateral and calicular views of a specimen from TM (KT9202, YT2), USNM 92779, × 4.6, × 4.9, respectively. *Stenocyathus vermiformis* (*c*, 27°24'N, 79°26'W, USNM 46646; *f*, *Pillsbury*-861, USNM 46649): *c,f,* lateral and calicluar views of western Atlantic specimens, × 3.1, × 20, respectively. *Tropidocyathus pileus: d,e,* lateral and caliclular views of a specimen from TM (KT9015, BS2), USNM 92781, × 3.5, × 3.9, respectively. *Alatotrochus rubescens* (*g,j,k*, TM (KT9015, BS2), USNM 92776; *h,i,l*, syntype, *Challenger*-192, BM 1880.11.25.163): *g,k,* lateral and calicular views of a specimen, × 3.2, × 3.5, respectively; *h,i,l,* oblique basal, calicular, and oblique calicular views of a paratype, all × 2.6; *j,* lateral view of a specimen showing the distinctive costal development, × 3.5.

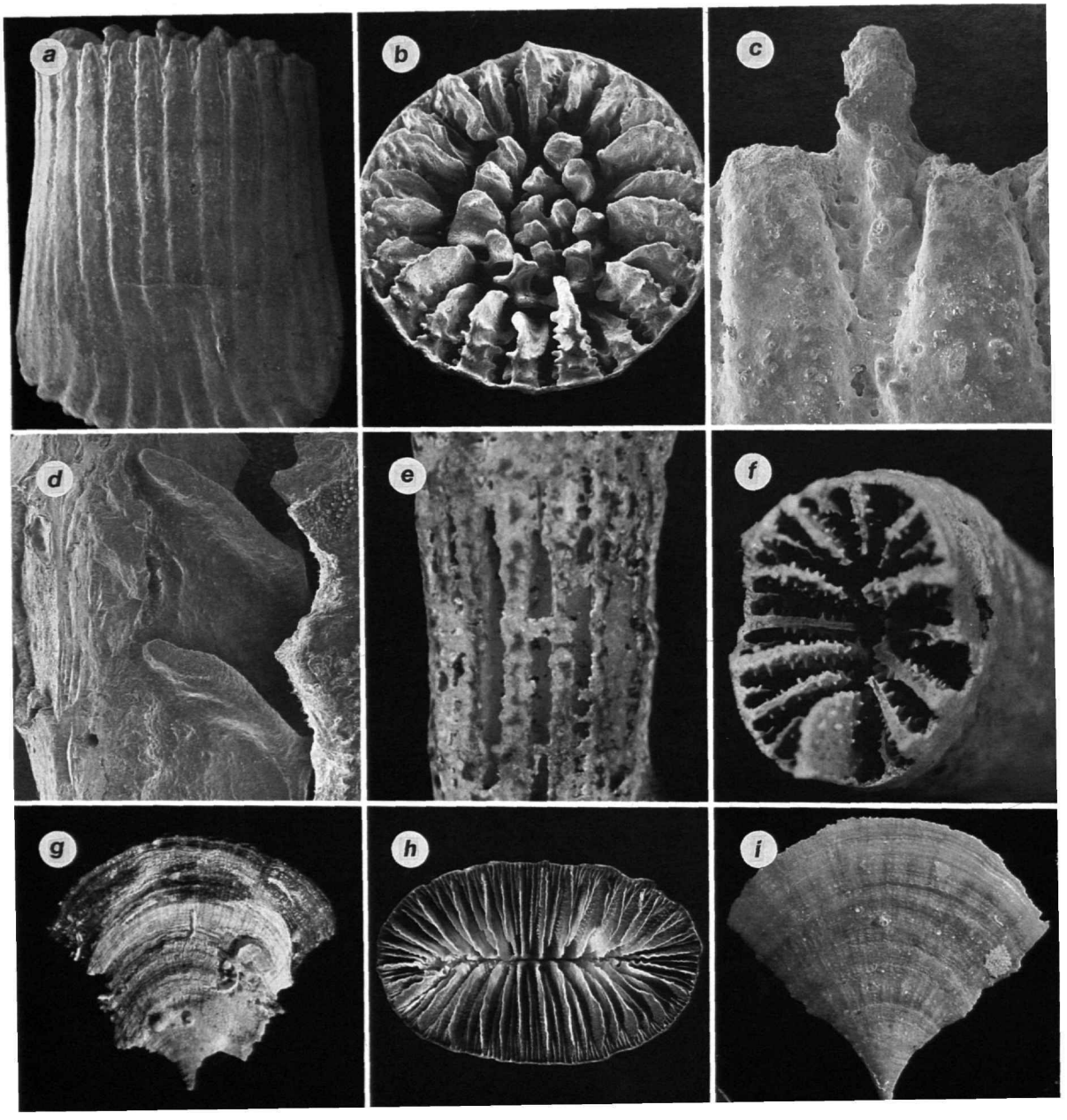

PLATE 30.—*Idiotrochus kikutii* (*a–d*, Philippine specimen from MUSORSTOM 2-33, USNM 81911): *a,b*, lateral and calicular views, × 20, × 18, respectively; *c*, calicular edge showing alternation of costae and septa, × 125; *d*, carinae on septal faces, × 60. *Truncatoguynia irregularis*: *e,f*, lateral and calicular views of a specimen showing characteristic thecal weathering, × 8.2, × 10, respectively. *Flabellum pavoninum* (*g–i*, specimens reported as *F. distinctum* by Yabe and Eguchi, 1942a): *g,h*, Sagami Bay, *coalitum* form, TIUS 43409, × 1.3, × 1.5, respectively; *i*, *Soyo Maru*-429, TIUS 39732, × 1.4.

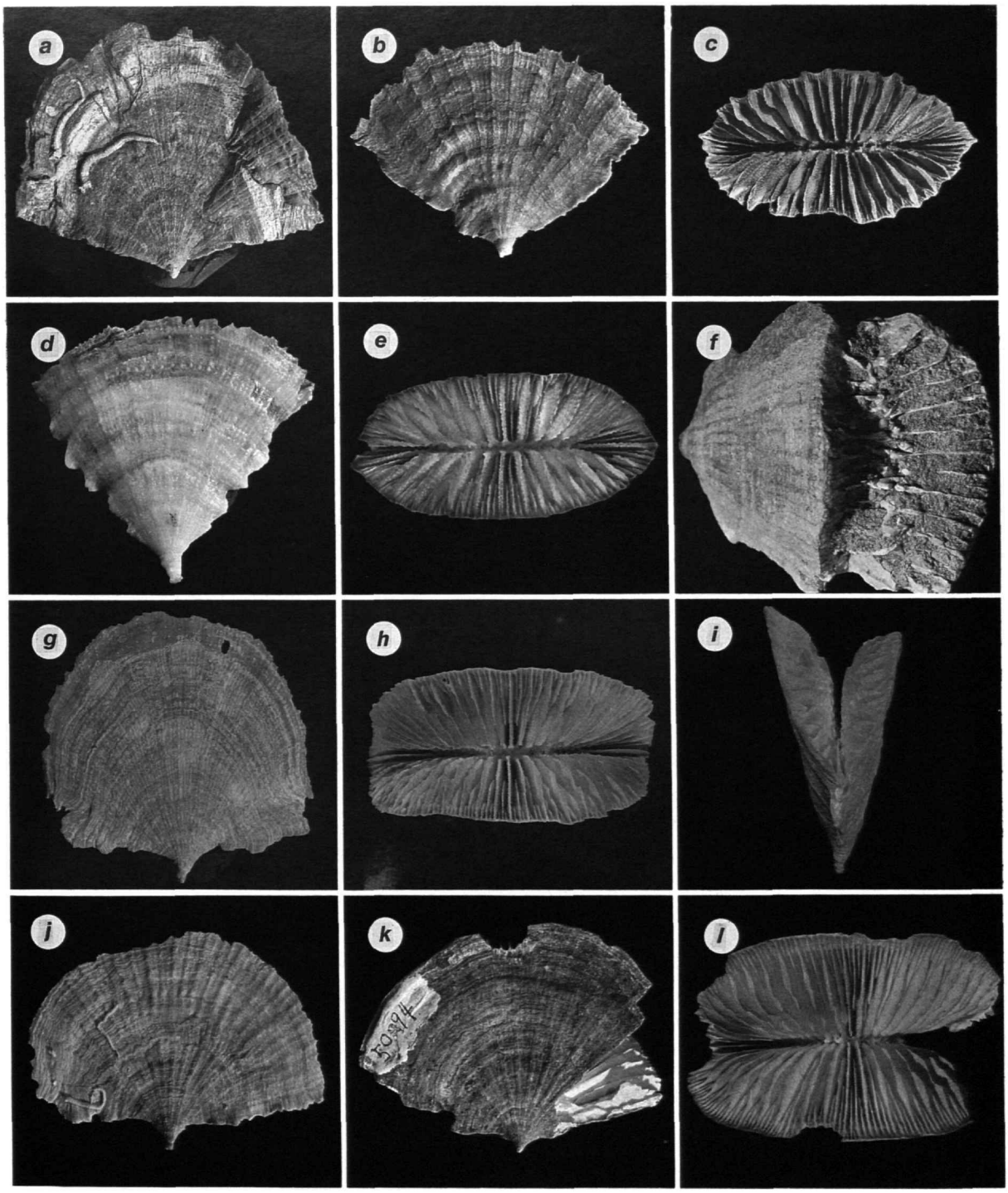

PLATE 31.—*Flabellum pavoninum* (*a–e*, Marenzeller's (1888a) Japanese specimens): *a*, "off China," NMW 8201, × 1.1; *b,c*, "off Japan," "*F. distinctum*," NMW 8197, both × 1.1: *d.e*, holotype of *F. coalitum*, "off Japan," NMW 8196, × 1.6, × 1.7, respectively. *Flabellum angustum*: *f*, syntype, TIUS 43436, Pliocene of Shikoku, × 2.3. *Flabellum patens*: *g–i*, specimen from YO70-770, USNM 92814, lateral, calicular, and edge views, × 1.2, × 1.2, × 1.4, respectively. *Flabellum magnificum* (*j*, *F. pavoninum* of Yabe and Eguchi, 1942a, *Soyo Maru*-437, TIUS 43448; *k.l*, *Soyo Maru*-416, TIUS 50094): *j*, × 1.1; *k,l*, × 0.7, × 0.8, respectively.

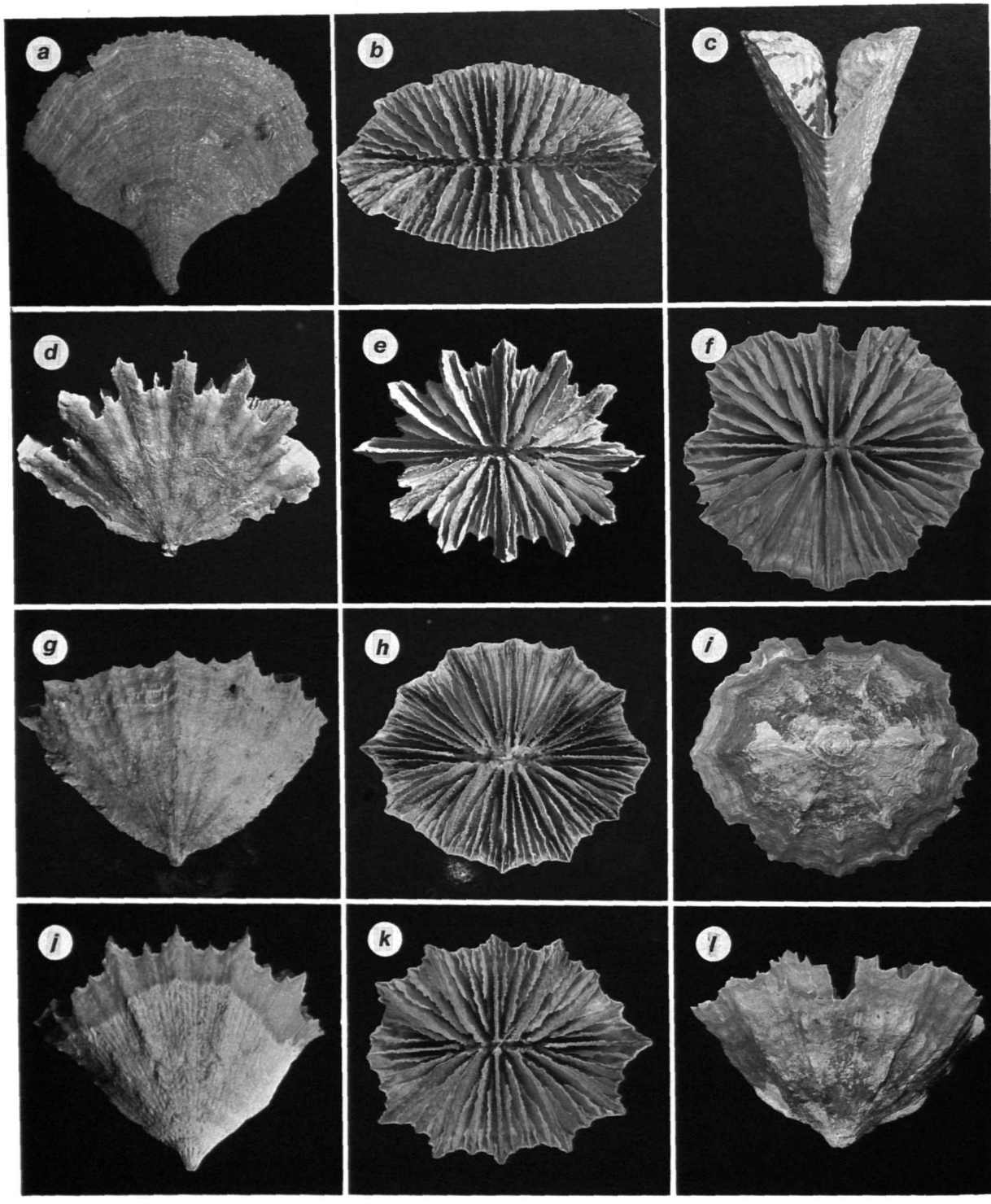

PLATE 32.—*Flabellum politum*: *a–c*, lateral, calicular, and edge views of specimen from Alb-4903, USNM 40735, all × 2.7. *Flabellum deludens*: *d,e*, lateral and calicular views of a specimen from Alb-5094, USNM 40761, both × 1.2. *Flabellum japonicum*: *g,h*, lateral and calicular views of a specimen from YO69-3, USNM 92828, × 1.05, × 0.95, respectively. *Flabellum apertum borealis* (*f,i,l*, holotype, USNM 40710; *j,k*, paratype, Alb-5083, USNM 40709): *f,i,l*, calicular, basal, and lateral views, all × 1.5; *j,k*, lateral and calicular views, both × 1.5.

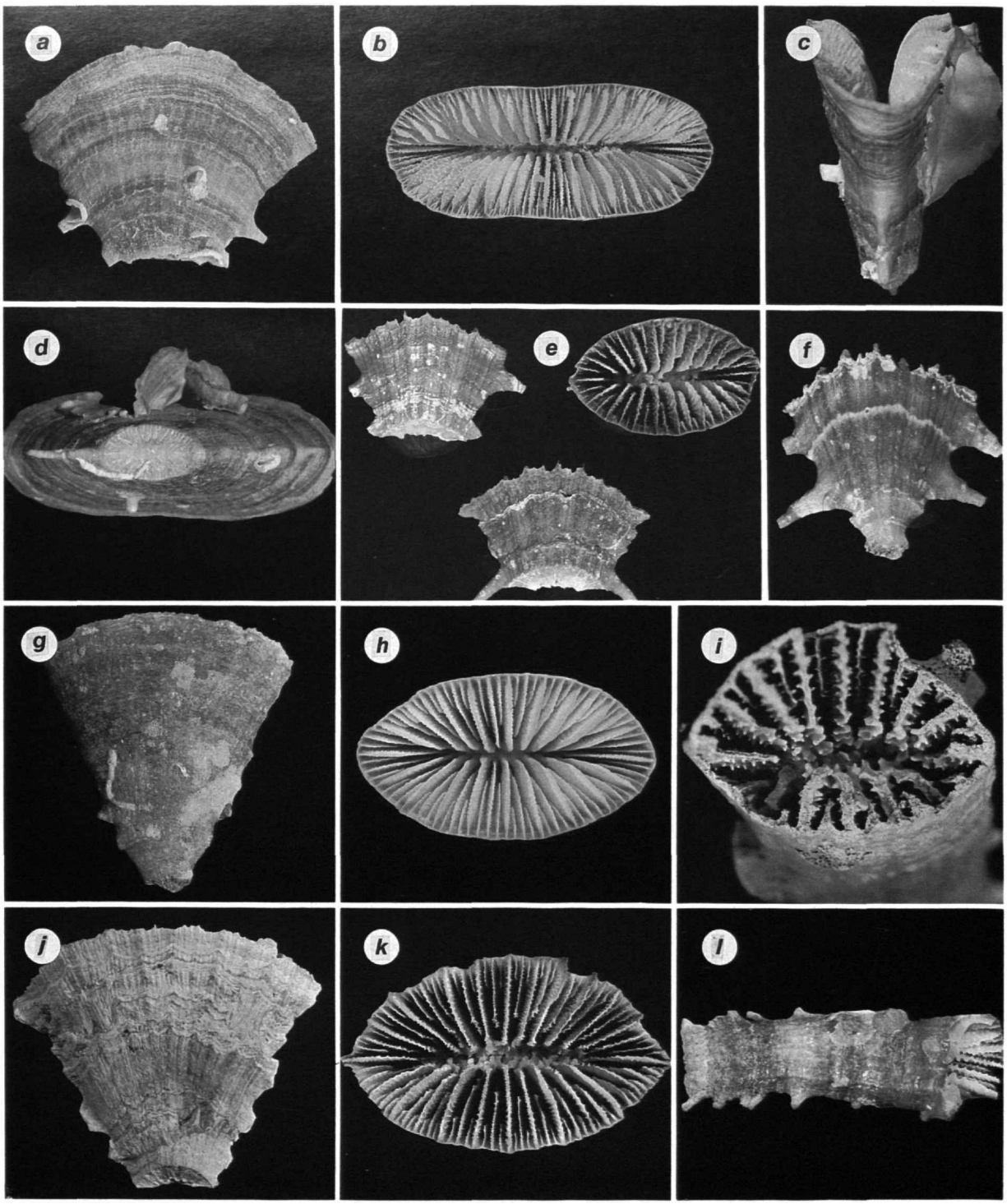

PLATE 33.—*Truncatoflabellum spheniscus: a–d*, TM (KT9015, HK2), USNM 92799, lateral, calicular, edge, and basal views of a specimen, × 1.8, × 1.9, × 2.3, × 2.6, respectively. *Truncatoflabellum candeanum* (*e*, *Soyo Maru*-465, TIUS 50229, *F. rubrum* (in part) of Yabe and Eguchi, 1942a; *f*, TM (KT9015, HK3), USNM 92802): *e*, three anthocyathi, × 2.7; *f*, anthocaulus with short anthocyathus still attached, separated by thin white crescent one-quater distance from top of corallum, × 3.9. *Truncatoflabellum formosum: g,h*, lateral and calicular views of a specimen from TM (CR7918), USNM 92804, × 1.7, × 2.0, respectively. *Truncatoflabellum* sp. B: *i,l*, calicular and lateral views of a specimen from TM (KT9202, YT1), USNM 92811, × 10.1, × 3.2, respectively. *Truncatoflabellum carinatum: j–k*, lateral and calicular views of a specimen from Pescadores Islands, Formosa Strait, USNM 92806, × 2.1, × 2.2, respectively.

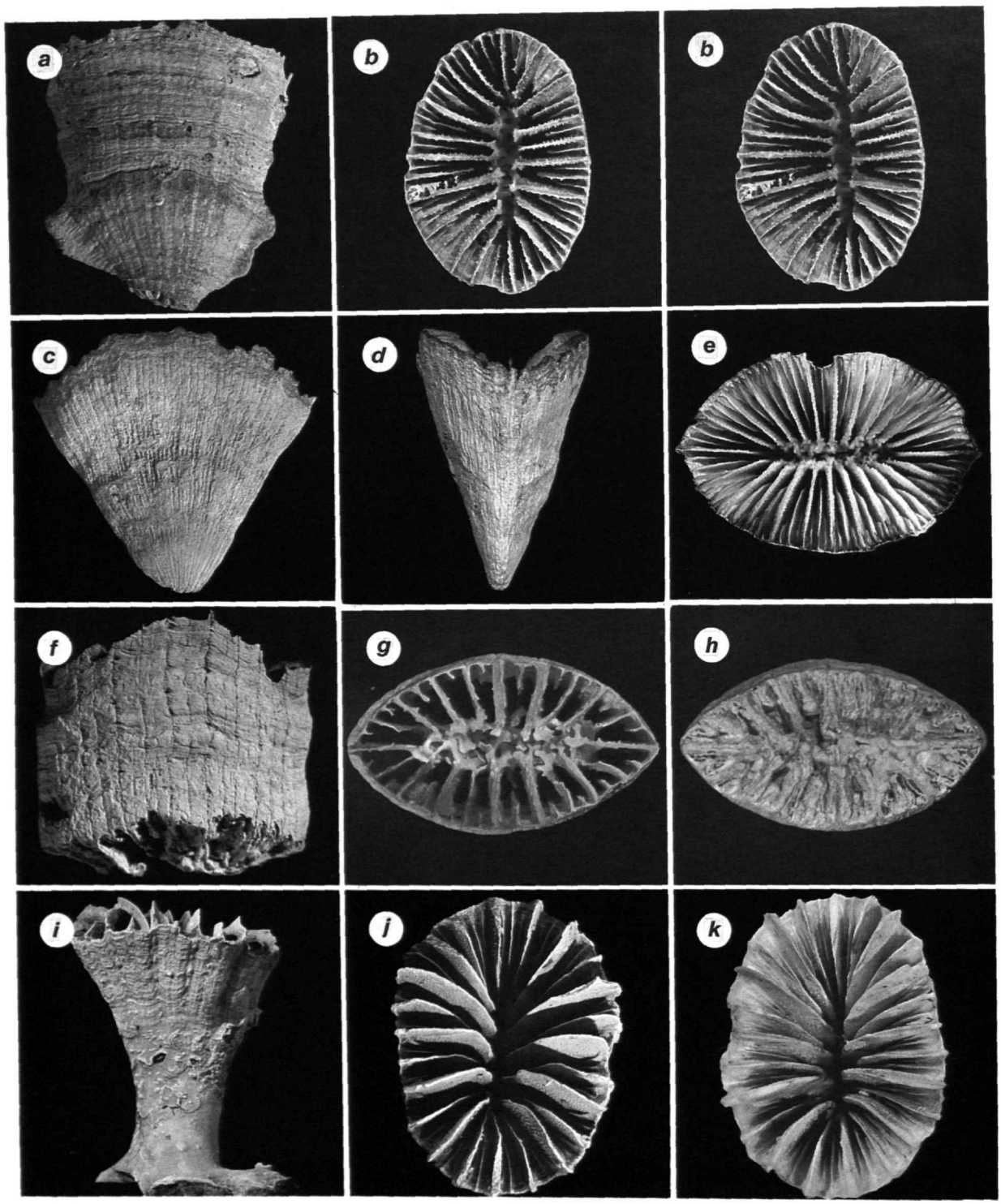

PLATE 34.—*Truncatoflabellum gardineri: a,b*, lateral and stereo calicular views of specimen from TM (KT9202, OS3), USNM 92809, × 2.6, × 3.0, respectively. *Truncatoflabellum* sp. A: *c–e*, lateral, edge, and calicular views of specimen from TM (KT9202, YT6), USNM 92810, all × 1.3. *Placotrochides scaphula: f–h*, lateral, calicular, and basal views of specimen from TM (KT7911, OT4), USNM 92748, × 5.1, × 5.9, × 6.2, respectively. *Javania insignis: i–k*, lateral and calicular views of a specimen from off Jogashima, Sagami Bay, USNM 92746, × 1.6, × 2.4, × 2.4, respectively.

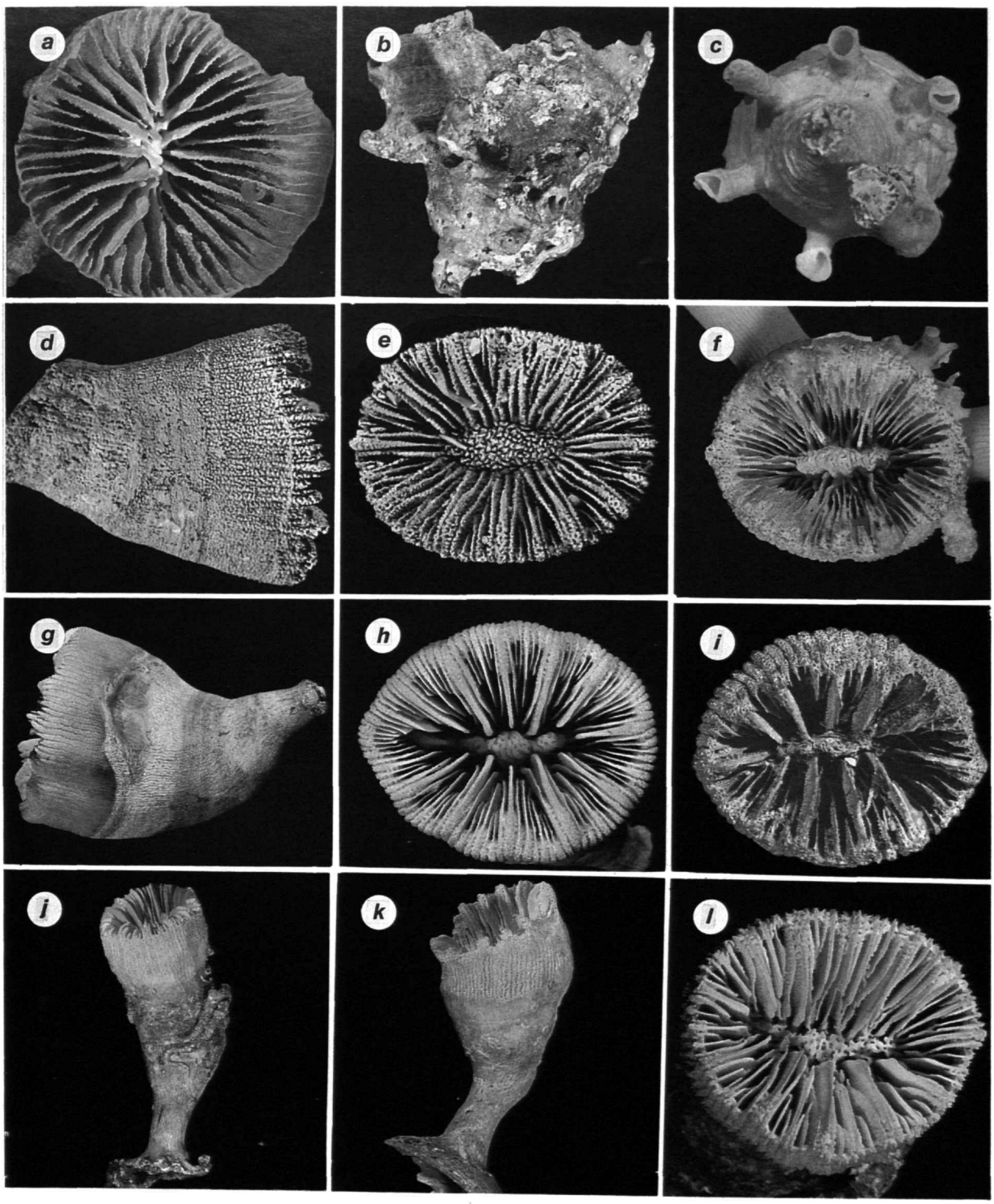

PLATE 35.—*Rhizotrochus typus* (*a,b*, Sagami Bay, USNM 92751; *c*, Okinose, Sagami Bay, ZMC): *a,b*, calicular and lateral views of a specimen, × 3.2, × 2.7, respectively; *c*, basal view showing pedicel and ring of six rootlets, × 3.5. *Balanophyllia cumingii*: *d,e*, lateral and calicluar views of TM (KT9015, HK2), USNM 92887), × 4.7, × 5.5, respectively. *Balanophyllia cornu* (*f,i*, syntypes, *Challenger*-306, BM 1880.11.25.143; *g,h*, Formosa Strait, CAS 74991): *f, i*, calices of syntypes, × 2.5, × 2.4, respectively; *g,h*, lateral and calicular views of a specimen, × 1.5, × 2.3, respectively. *Balanophyllia gigas* (*j,l*, Alb-5070, USNM 92882; *k*, holotype, BM 1876.10.11.23): *j,l*, lateral and calicular views of a specimen, × 0.7, × 1.9, respectively; *k*, holotype, × 0.8.

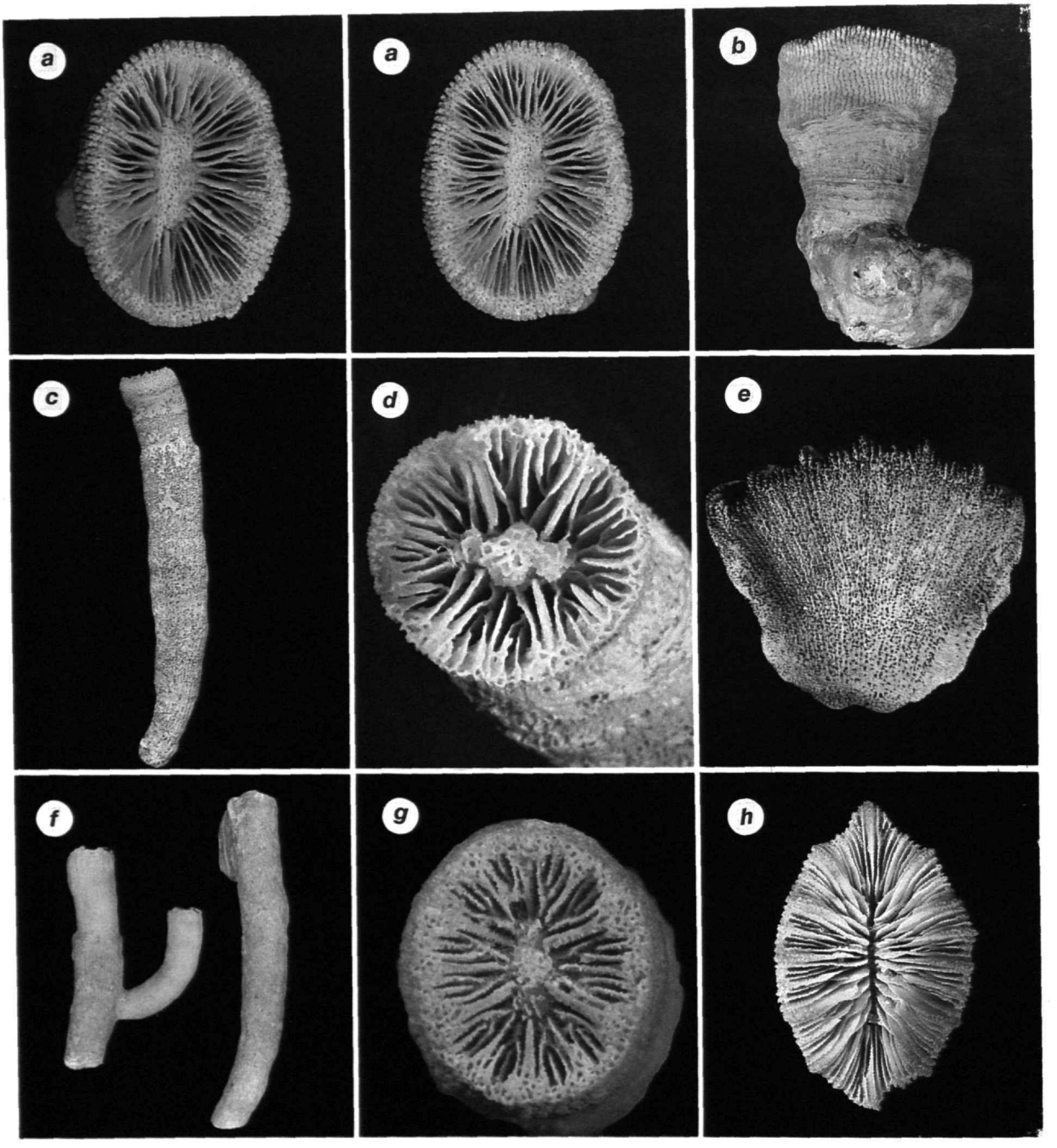

PLATE 36.—*Balanophyllia ponderosa: a,b,* stereo calicular and lateral views of holotype, BM 1939.7.20.62, × 2.1, × 1.2, respectively. *Balanophyllia teres* (*c*, holotype, USNM 92888; *d*, Alb-4903, USNM 92889): *c,d,* corallum and calice, × 2.4, × 7, respectively. *Endopachys grayi: e,h,* lateral and calicular views of a specimen from Alb-2999 (Gulf of California), USNM 19221, both × 2.0. *Eguchipsammia fistula: f,g,* lateral and calicular views of syntypes from *Siboga*-105, ZMA Coel. 564, × 1, × 6.4, respectively.

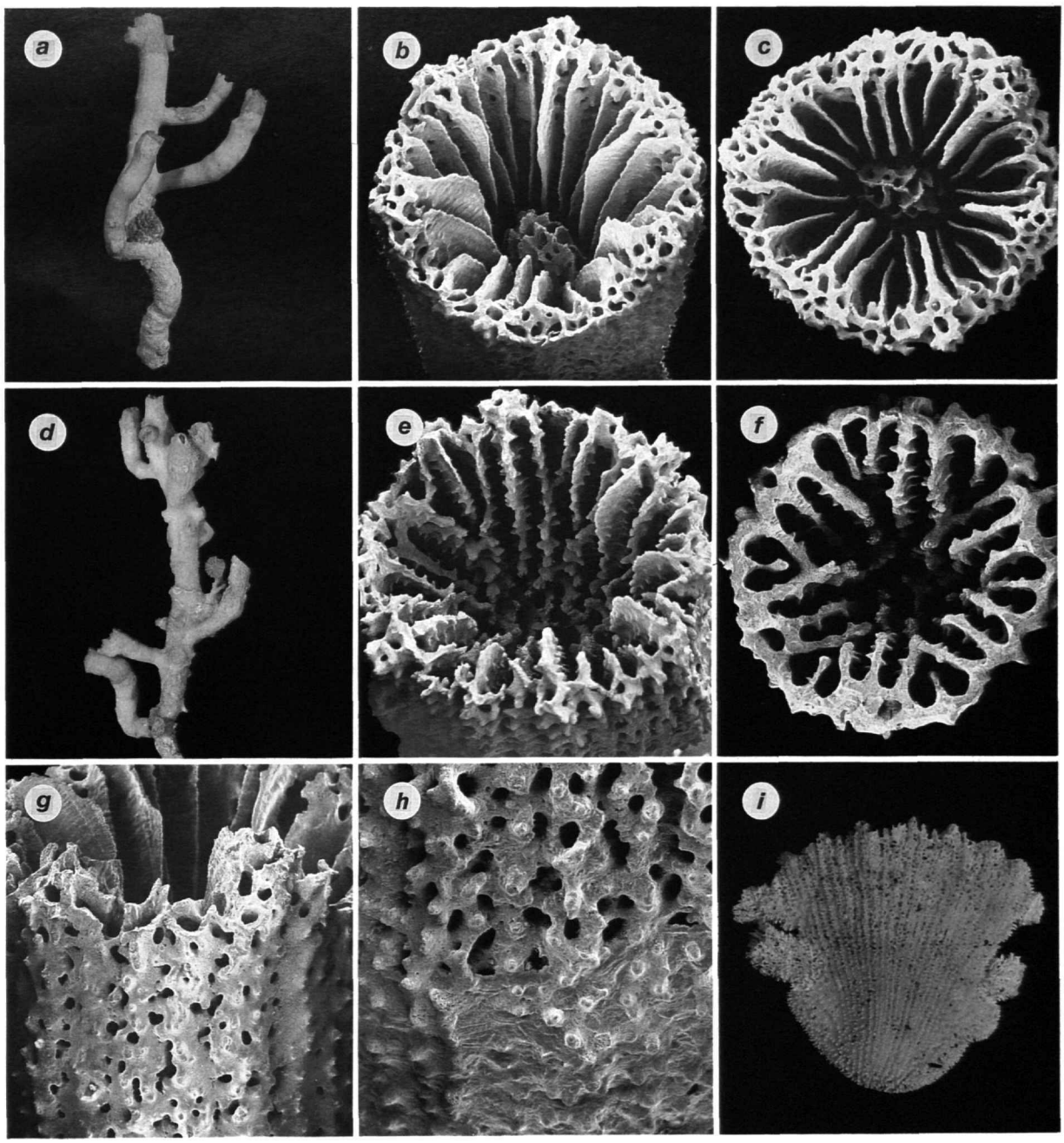

PLATE 37.—*Eguchipsammia wellsi* (*a–c, g*, Okinose, Sagami Bay, 110 m, USNM 92897): *a*, colony, × 1.1; *b,c*, calicular views, × 14, × 13, respectively; *g*, synapticulotheca, × 22. *Eguchipsammia gaditana* (*d–f,h*, Okinose, Sagami Bay, 110 m, USNM 92894): *d*, colony, × 1.2; *e–f*, calicular views, × 18, × 32, respectively; *h*, synapticulotheca covered by epitheca on lower half, × 35. *Endopachys grayi: i*, TM (KT9015, BS1), USNM 92866, corallum with five buds on thecal edges, × 2.7.

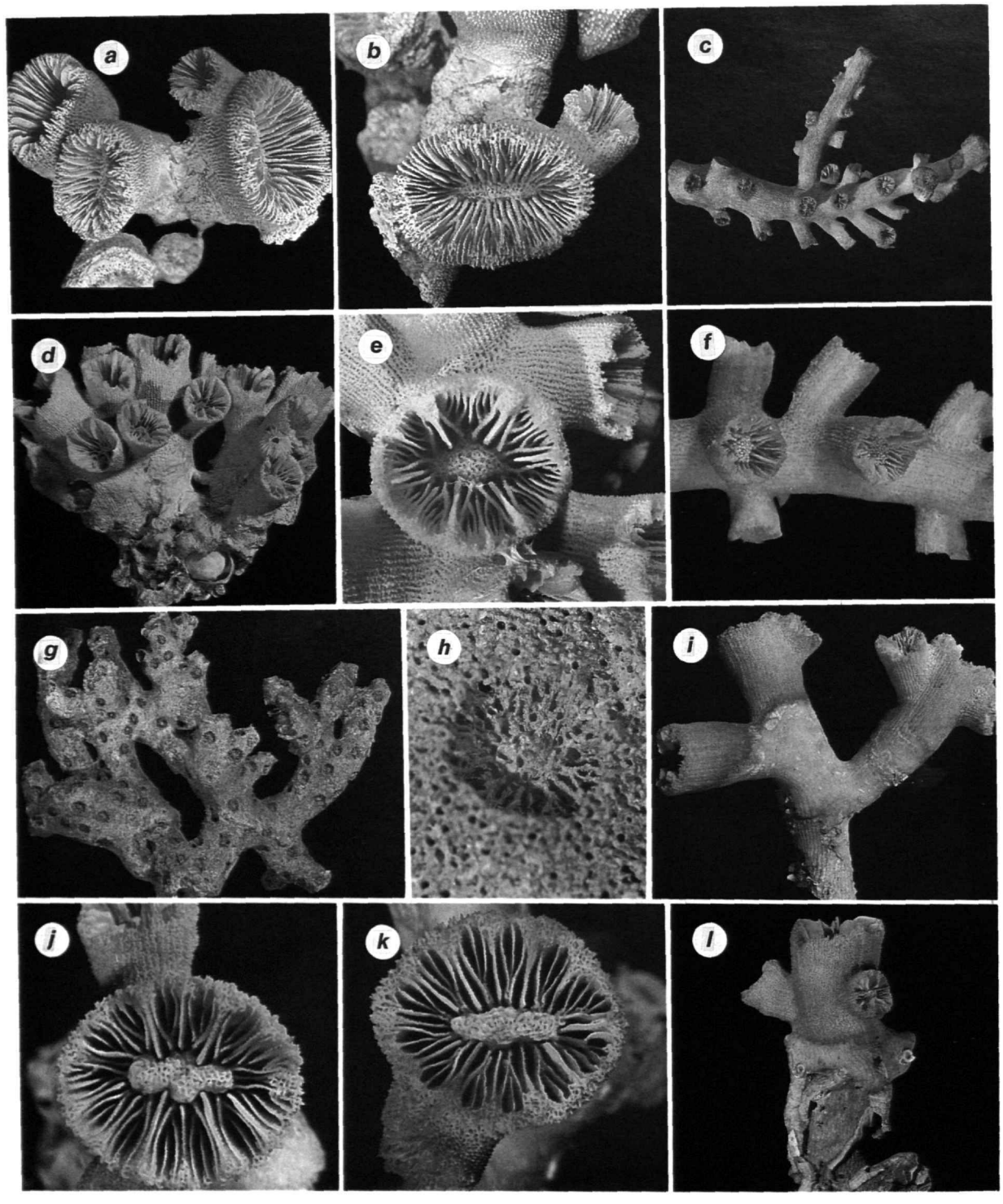

PLATE 38.—*Cladopsammia eguchii: a,b,* calices from colony off Shirahama, USNM 78646, × 2.1, × 2.8, respectively. *Dendrophyllia ijimai: c,f,* Moroisa, Sagami Bay, USNM 92872, colony and calices, × 0.65, × 1.9, respectively. *Cladopsammia gracilis: d,e,* off Shirahama, USNM 92870, colony and a calice, × 1.1, × 3.0, respectively. *Dendrophyllia cribrosa: g,h,* larger syntype, RMNH 9212, colony and one worn corallite, × 0.43, × 12.2, respectively. *Dendrophyllia arbuscula* (*i–l*, Alb-3707, USNM 22057): *i,l,* colonies, × 1.2, × 1.3; *j,k,* calices, × 3.4, × 3.3, respectively.

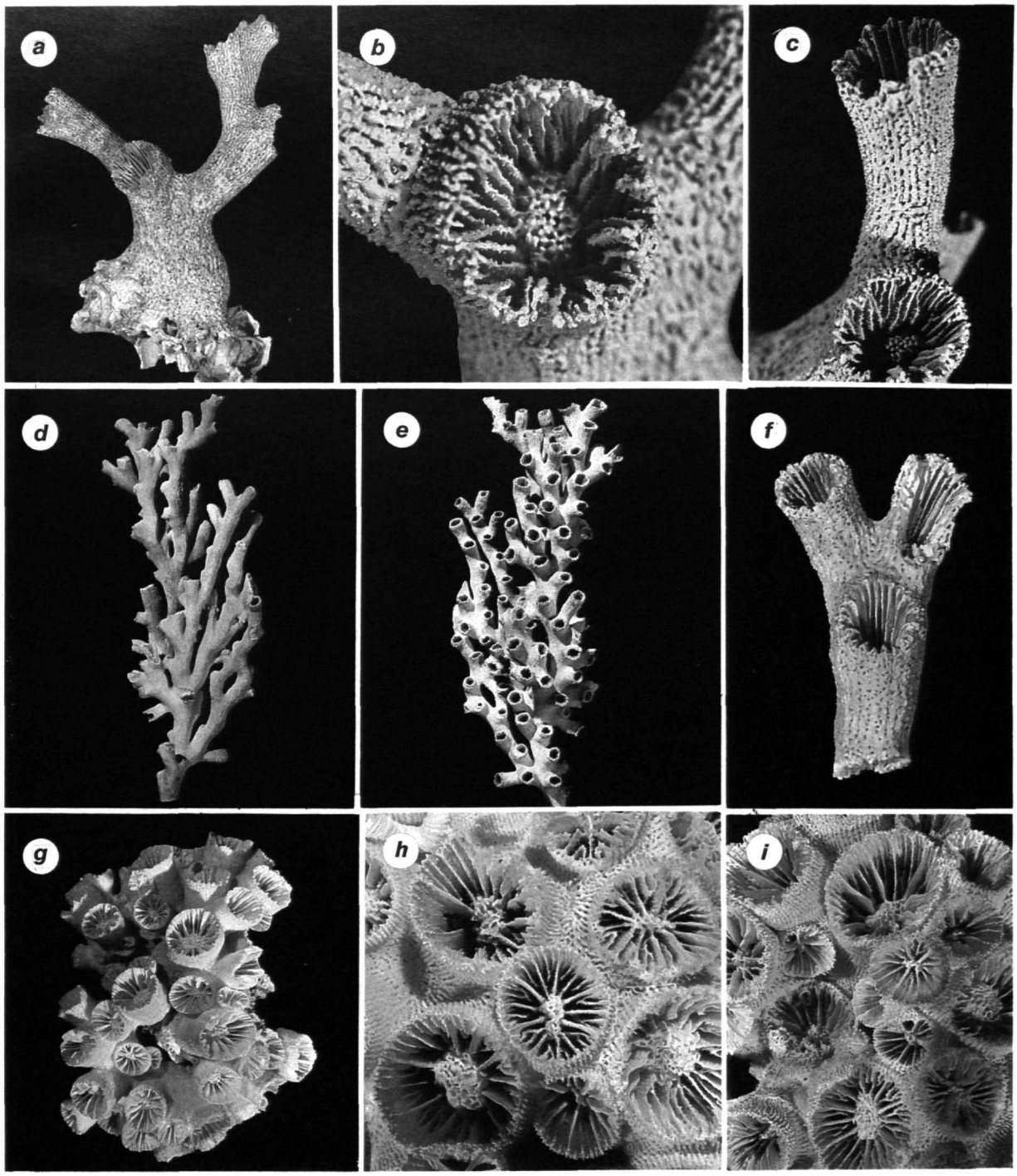

PLATE 39.—*Dendrophyllia florulenta: a–c*, TM (KT9015, CB2-2), USNM 92877, colony and calicular views, × 1.6, × 7.6, × 3.9, respectively. *Enallopsammia rostrata* (*d,e*, Alb-4892, USNM 92850; *f*, Alb-4891, USNM 92849): *d,e*, acalicular and calicular sides of a colony, × 0.48; *f*, three calices, × 2.7. *Tubastraea coccinea* (*g*, off Partida Island, Gulf of California, USNM 91428; *h,i*, off Misake, ZMC): *g*, colony, × 0.72; *h,i*, calices, both × 1.9.

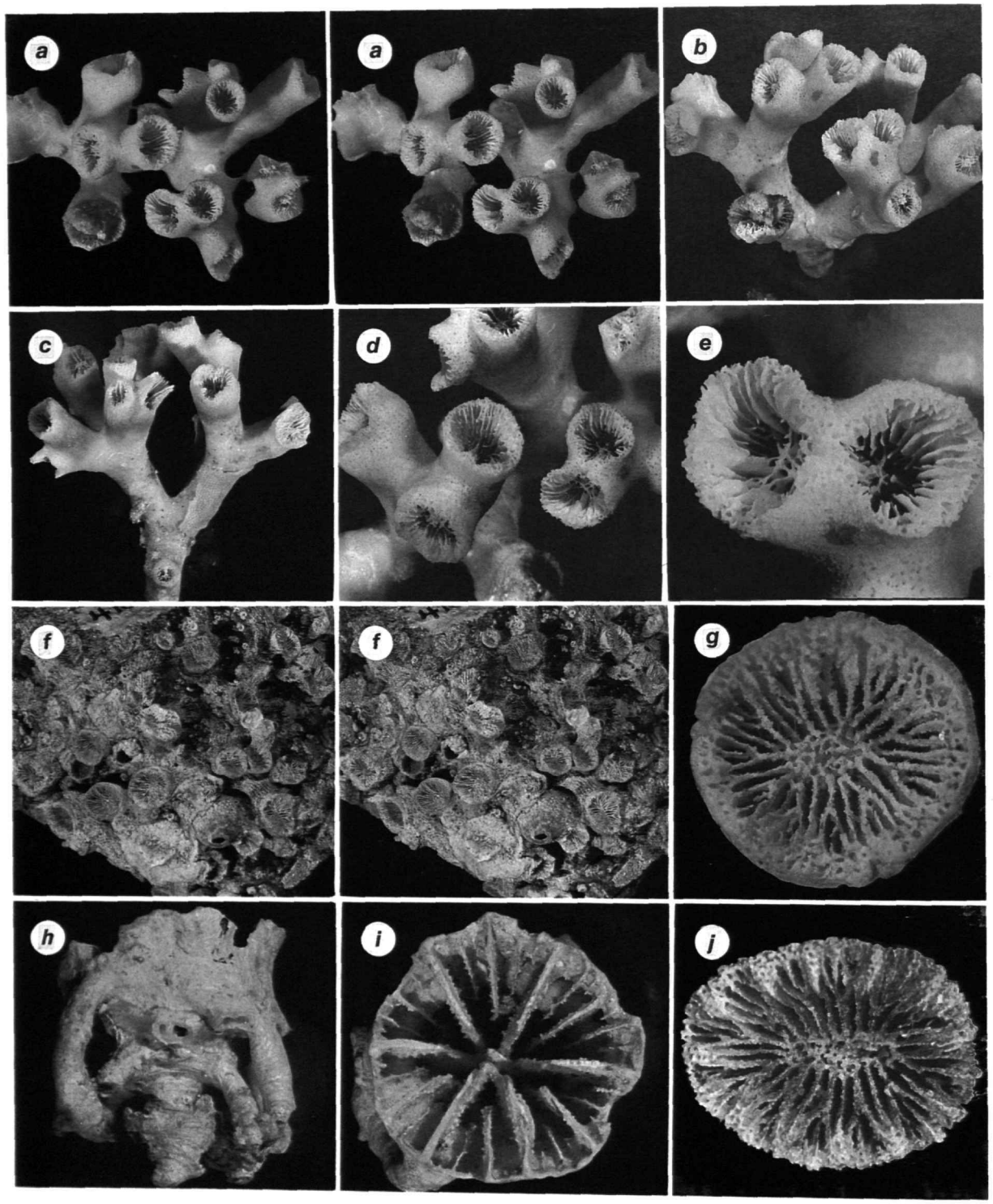

PLATE 40.—*Schizopsammia songae* (*a–e*, holotype, USNM 15847): *a*, stereo pair of colony, × 1.4; *b,c*, two other views of holotype, × 1.4, × 1.3, respectively; *d,e*, calices in process of intratentacular division, × 2.3, × 5.4, respectively. *Rhizopsammia minuta mutsuensis* (*f–g*, holotypic colony, TIUS 41391): *f*, stereo view of section of reptoid colony, × 1.3; *g*, a calice, × 9.3. *Rhizotrochus niinoi* (*h,i*, holotype, TIUS 60820): *h,i*, lateral and calicular views, × 5.0, × 5.3, respectively. *j*, *Balanophyllia* sp. A sensu Yabe and Eguchi (1942b), *Soyo Maru*-647, TIUS 59163, × 5.3.

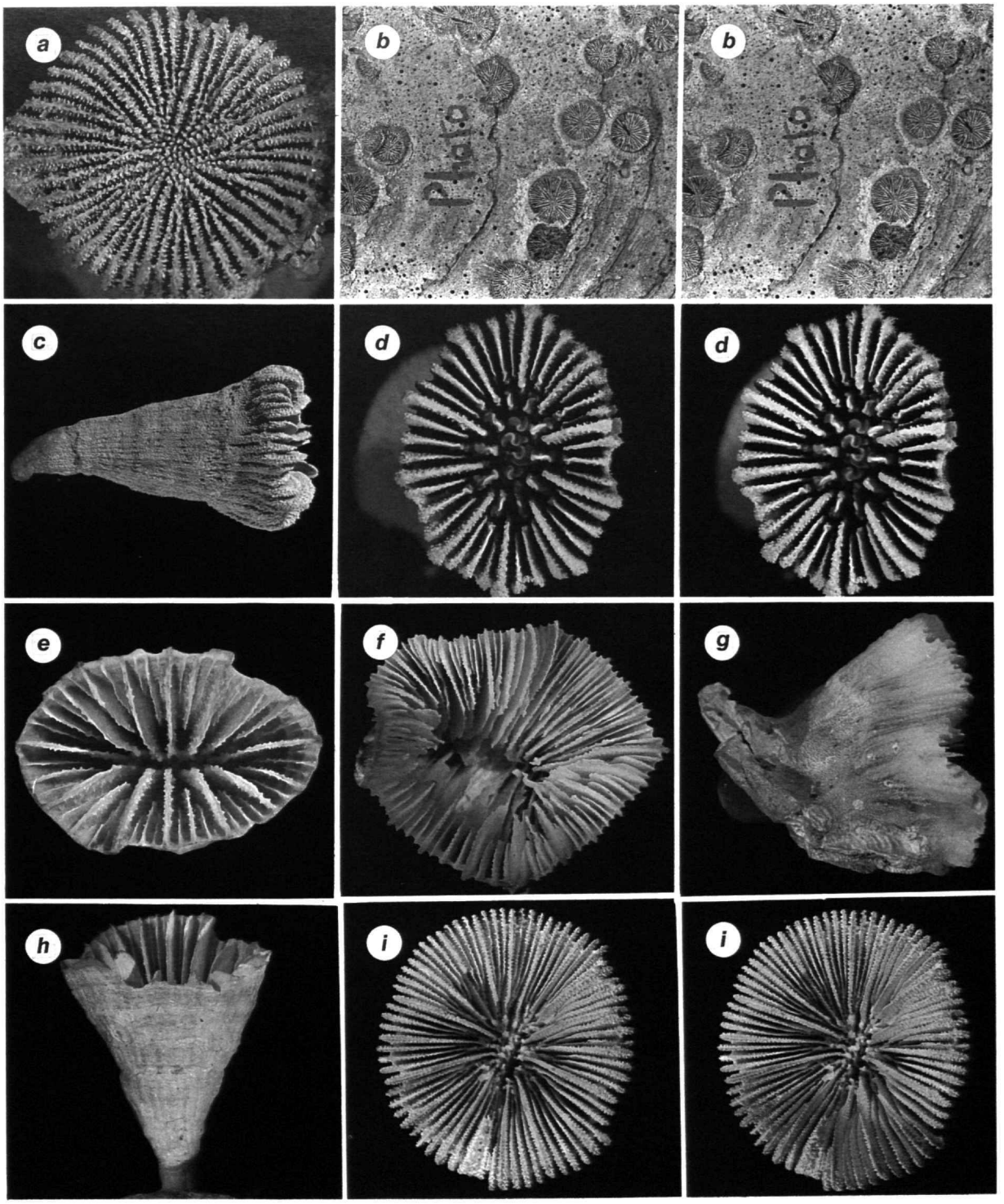

PLATE 41.—*Oulangia stokesiana miltoni* (*a,b*, syntypes, TIUS 41051): *a*, a well-preserved corallite, × 5.9; *b*, stereo view of corallites attached to an oyster shell, × 1.2. *Caryophyllia scobinosa decapali* (*c,d*, holotype, *Soyo Maru*-210, TIUS 53640): *c*, corallum, × 2.9; *d*, stereo view of calice, × 5.3. *Flabellum transversale conicum* (*e,h*, syntype, TIUS 39727): *e*, calice, × 4.2; *i*, corallum, × 2.9. *Goniocyathus pacificus* (*f,g*, syntype, TIUS 50086): *f*, calice, × 3.4; *g*, lateral view of same corallum, × 3.2. *i*, stereo calicular view of holotype of *Deltocyathoides japonicus*, TIUS 50091, × 3.4.

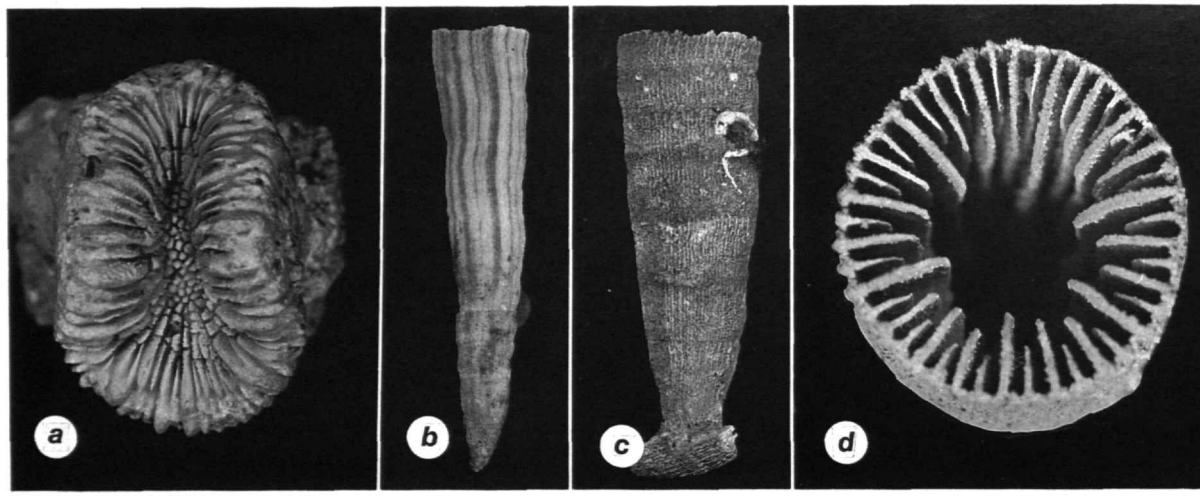

PLATE 42.—*a, Paracyathus pruinosus, Soyo Maru*-235, TIUS 53681, × 3.1. *Fragilocyathus conotrochoides* (*b,* holotype, TIUS 50084; *c,d,* TIUS 58223): *b,* lateral view showing thecal stripes, × 2.2; *c,d,* lateral and calicular views of a specimen, × 3.2, × 8.0, respectively.

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