A Revision of the Ahermatypic Scleractinia of the Galápagos and Cocos Islands

STEPHEN D. CAIRNS

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ABSTRACT

Cairns, Stephen D. A Revision of the Ahermatypic Scleractinia of the Galápagos and Cocos Islands. *Smithsonian Contributions to Zoology*, number 504, 44 pages, 12 plates, 4 tables, 1 map, 1991.—The ahermatypic Scleractinia of the Galápagos and Cocos islands are revised based primarily on the collections of the 1986 expedition of the *Johnson-Sea-Link I* research submersible. A historical review of the previous work on ahermatypic Scleractinia from the Galápagos and Cocos islands is given. Forty-two ahermatypic species from the Galápagos and 12 ahermatypic species from Cocos Island, including nine and five new records, respectively, are described and illustrated—because of overlap in distribution, a total of 44 species. One genus, *Pseudocyathoceras*, and nine species are described as new: *Cladocora pacifica, Oculina profunda, Caryophyllia perculta, C. solida, Concentrotheca vaughani, Crispatotrochus galapagensis, Anomocora carinata, Polymyces wellsi,* and *Dendrophyllia johnsoni. Crispatotrochus* Tenison Woods, 1878, is resurrected and designated the senior synonym of *Cyathoceras* Moseley, 1881. In order to facilitate comparisons within the subgenus *Caryophyllia (Caryophyllia)*, the 56 Recent species and subspecies are tabulated based on the nature of their base, septal symmetry, number of septa, and their distribution. The four species of Galapagan *Tubastraea* are also compared in a tabular key.

The zoogeographic affinities of both the Galapagan and Cocos Island ahermatypic Scleractinia are found to be consistent with other groups of marine invertebrates. The Galapagan fauna has a 41% endemic component, 21% Panamanian, 19% Indo-Pacific, 14% cosmopolitan, and 5% West Indian. The West Indian affinity is strengthened by the suggestion of two geminate species pairs: *Cladocora pacifica-C. debilis* and *Oculina profunda-O. varicosa.* The Cocos ahermatypic fauna has smaller endemic and larger Panamanian components, 17% and 33% respectively, the remaining species equally allied between the Indo-Pacific region and cosmopolitan species.

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Contents

A Revision of the Ahermatypic Scleractinia of the Galápagos and Cocos Islands

Stephen D. Cairns

Introduction

HISTORICAL RESUMÉ.—The first ahermatypic coral to be reported from the Galápagos was *Flabellum galapagense* Milne Edwards and Haime (1848a,b), a fossilized specimen from an unspecified island within the Galápagos archipelago and an unknown geologic age. This specimen is lost (Wells, 1983) and the species has not subsequently been found in the Galápagos.

Pourtalès (1875) reported seven scleractinians from the Galápagos collected on the beach during an expedition of the U.S.C.S. Steamer *Hassler* in 1872, including two shallow-water ahermatypes: *Oulangia bradleyi* and *Tubastraea coccinea*, the latter reported as *Astropsammia pedersenii*. Duncan (1876) also reported *T. coccinea* from the Galápagos as *Placopsammia darwini*, the specimen having been collected in 1835 by Charles Darwin.

Based on the dredging of the U.S.F.C. Steamer *Albatross* in 1891, Marenzeller (1904b) reported three deep-water corals from the Galápagos: *Madrepora oculata*, *D. cristagalli*, and *Oculina pacifica* (the latter reported as "Oculinidarum gen.? sp.?") and three species from Cocos Island: *Cladocora profunda* (reported as *C. arbuscula*), *Caryophyllia diomedeae* (reported as *Caryophyllia* sp.), and *Javania cailleti* (reported as *Flabellum* sp.).

In a similar publication based on the deep-water dredging of the U.S.F.C. Steamer *Albatross* in 1904–1905, Vaughan (1906) reported three new deep-water species from the Galápagos: *Madrepora galapagensis* (= *M. oculata*), *Desmophyllum galapagensis* (= *Javania cailleti*), and *Balanophyllia galapagensis*. Only the last two species were new records for the Galápagos. Both Marenzeller's (1904b) and Vaughan's (1906) specimens are deposited at the USNM.

On the expedition to the South Pacific of the S.Y. *St. George*, Crossland (1927) reported yellow and pink *Dendrophyllia* from Tagus Cove, Isabela, believed by Wells (1983) to be the first record of *D. gracilis* from the Galápagos.

The greatest addition to the Galapagan ahermatypic fauna was that of Durham and Barnard (1952), who reported 19 shallow-water species from the Galápagos and three from off Cocos Island, 13 and 1 new records, respectively, for these islands. These specimens were collected on board the *Velero III* and *Velero IV* between 1932 and 1949 and are deposited at the AHF. The 13 new Galapagan records were *Madracis asperula*, *M. pharensis* (reported as *Madracis* sp.), *Cladocora pacifica* (reported as *C. debilis*), *Astrangia browni* (reported as *A. gardnerensis*), *A. equatorialis*, *Caryophyllia perculta* (reported as *C. diomedeae*), *Polycyathus hondaensis* (reported as *Astrangia hondaensis*), *Phyllangia consagensis* (reported as *Lophosmilia wellsi*), *Sphenotrochus hancocki*, *Pseudocyathoceras avis* (reported as *Kionotrochus avis* and *K. hoodensis*), *Flabellum daphnense*, *Endopachys grayi* (reported as *E. vaughani*), and *Endopsammia pourtalesi*. The two new Cocos Island records were *Polycyathus hondaensis* and *Endopachys grayi*. Durham and Barnard (1952, table 1) also listed the 98 species then known from the eastern Pacific, including a separate category for the Galápagos species, making this a benchmark paper for the study of the taxonomy and zoogeography of the eastern Pacific coral fauna.

Six ahermatypic species were collected at the Galápagos and Cocos islands on the Galápagos-Expedition 1953–1954 of the International Institute for Submersible Research (Durham, 1962). The collections were made on the *Xarifa* and are now deposited at the Hessisches Landsmuseum, Darmstadt, and Museum of Paleontology, University of California, Berkeley. None of the four shallow-water species from the Galápagos was a new record but all three from Cocos Island were previously

Stephen D. Cairns, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

Review Chairman: C.W. Hart, National Museum of Natural History, Smithsonian Institution. Reviewers: John Wells, Cornell University, Ithaca, New York 14853; Helmut Zibrowius, Station Marine d'Endoume, F13007 Marseille, France.

unknown from that island: *Astrangia dentata, Rhizopsammia verrilli* (reported as *Balanophyllia scheeri*), and *Tubastraea coccinea* (reported as *T. tenuilamellosa*). Durham (1962, table 3) also tabulated a comprehensive list of all Scleractinia known from the Galápagos and Cocos islands, but because he overlooked the papers by Milne Edwards and Haime (1848a), Pourtalès (1875), Marenzeller (1904b), and Crossland (1927), the list was incomplete.

In a paper on the zoogeography of the eastern Pacific Scleractinia, Durham (1966, table 1) reiterated his lists of scleractinian species for the Galápagos and Cocos islands, this time including the paper by Pourtalès (1875), but no additional species were reported for either island group. Durham (1966, table 2) also reiterated his list of all 103 species known from the eastern Pacific, extracted primarily from Durham and Barnard (1952), and presented a brief historical resume of the corals previously reported from the Galápagos and Cocos islands.

The next addition to the scleractinian fauna of the Galápagos was that of Wells (1982), who described six new shallow-water ahermatypes: *Polymyces isabela, Balanophyllia eguchii, Rhizopsammia wellingtoni, Tubastraea faulkneri, T. tagusensis,* and *T. floreana*. The most recent addition to the Galapagan fauna was the annotated and illustrated checklist of Wells (1983), who listed five new records for the Galápagos: *Culicia rubeola, Caryophyllia solida* (reported as *C. diomedeae*), *Paracyathus humilis, Enallopsammia rostrata* (reported as *E. amphelioides*), and *Polymyces wellsi* (reported as *Javania pseudoalabastra*). As in his previous paper (Wells, 1982), most of the specimens on which this paper was based are deposited at the USNM, but some are also at the CAS and Charles Darwin Reserach Station, Santa Cruz.

Nine new records are reported herein from the Galápagos: *Caryophyllia diomedeae, Concentrotheca vaughani, Crispatotrochus galapagensis, Lophelia prolifera, Flabellum* sp. A, *Javania* sp. A, *Dendrophyllia johnsoni, D. californica,* and *Rhizopsammia verrilli*. This increases to 42 the number of ahermatypes known from the Galápagos Islands (Table 1). Combined with the 13 hermatypic species known from the Galápagos (Wells, 1983:215), a total of 55 species are thus known from the archipelago, including one exclusively fossil species.

Four new records are reported herein for Cocos Island: *Culicia rubeola, Desmophyllum cristagalli, Anomocora carinata,* and *Dendrophyllia californica*. This increases to 12 the number of ahermatypes known from off Cocos Island (Table 1). Combined with the 12 hermatypic species known from Cocos Island (Durham, 1966:125), a total of 24 species are thus now known from this island.

ABBREVIATIONS.—The following abbreviations are used in the text, primarily in the context of the "Material Examined" sections.

AB	R/V *Anton Bruun*
AHF	Allan Hancock Foundation, Los Angeles
ALB	U.S. Fish Commission Steamer *Albatross*
Cx, Px, Sx	Costae, pali, or septa (respectively) of cycle designated by numerical subscript
CAS	California Academy of Sciences, San Francisco
GCD : LCD	Ratio of greater calicular diameter to lesser calicular diameter
IRCZM	Indian River Coastal Zone Museum, Harbor Branch Oceanographic Institution, Ft. Pierce, Florida
JSL	*Johnson-Sea-Link I*, a research submersible owned by Harbor Branch Oceanographic Institution
USNM	Collections of the former United States National Museum, now in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.
YPM	Yale Peabody Museum, New Haven

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The *Johnson-Sea-Link I* submersible expedition to the Galápagos and Cocos islands, which provided the bulk of the new material reported in this report, was co-sponsored by Harbor Branch Oceanographic Institution; SeaPharm, Inc.; and the National Cancer Institute, Natural Products Branch (contract NO1-CM-67919). I am grateful to co-chief scientists K.L. Rinehart and S.A. Pomponi for the opportunity to participate in this cruise, and to J.K. Reed and P.M. Mikkelsen for facilitating the loan of specimens.

The scanning electron photomicrographs were taken in the SEM Laboratory of the National Museum of Natural History, Smithsonian Institution.

Material and Methods

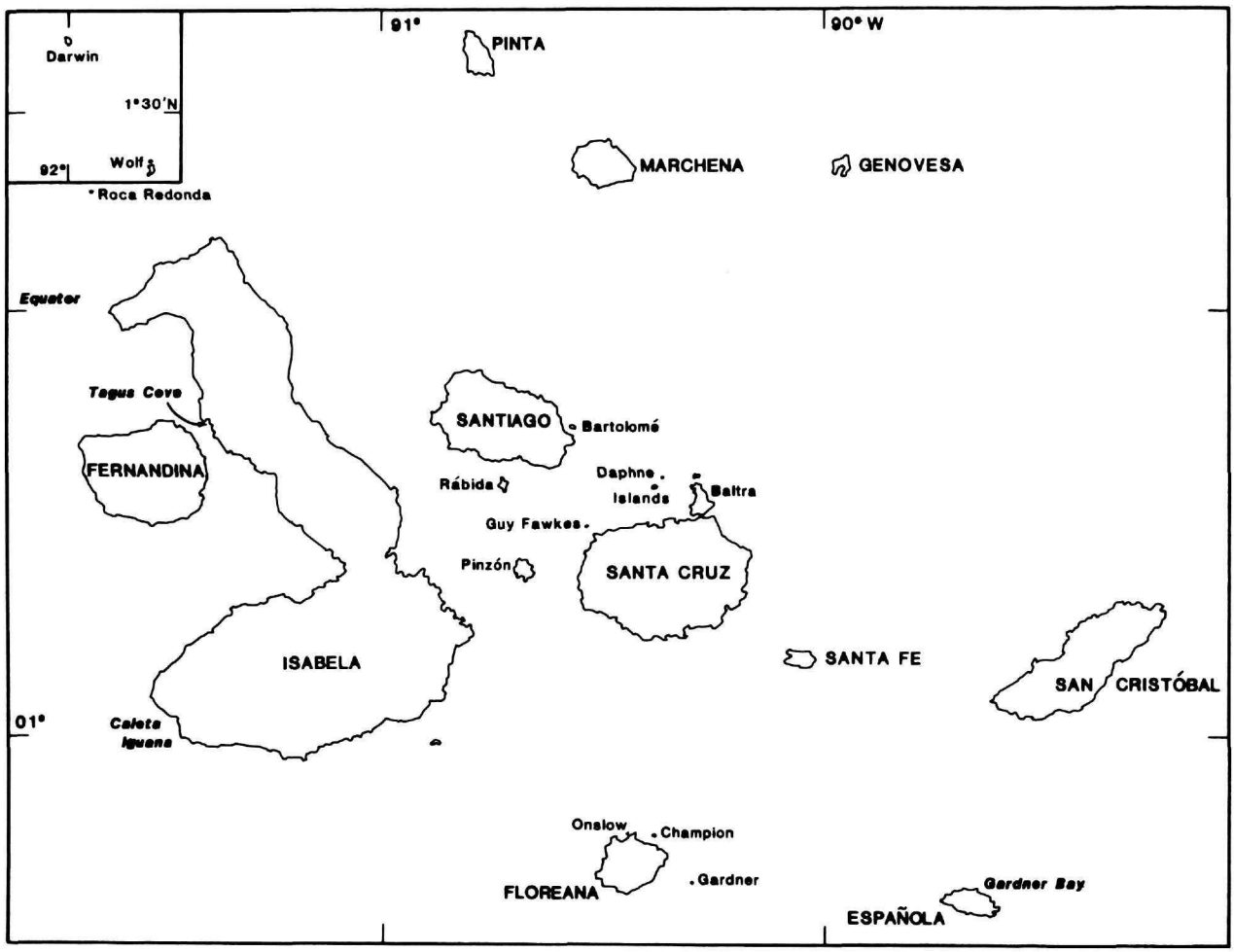
The new material on which this revision is based originated primarily from the *Johnson-Sea-Link I* submersible expedition to the Galápagos and Cocos islands in November to December of 1986. Ahermatypic Scleractinia were collected from 25 (see "Station List") of the 35 submersible dives, and 10 additional SCUBA dives in adjacent shallower waters. The use of a manned research submersible allowed selective collection of invertebrates and in situ observation and photography of living corals. Specimens were also examined from 14 *Albatross* stations, several *Anton Bruun* stations, several shallow-water stations made in 1974 by W.D. Hope in the Galápagos, and several shallow-water collections made by W.L. Schmitt in 1934 off Cocos Island. Much of the previously reported historical material from the Galápagos, Cocos Island, and eastern Pacific was also examined, including the specimens reported by Marenzeller (1904b), Vaughan (1906), Durham and Barnard (1952), and Wells (1982, 1983). Station data for the *Velero* stations reported by Durham and Barnard (1952) are found in volumes 1 and 6 of the *Allan Hancock Pacific Expeditions*.

Species synonymies are complete insofar as records from the Galápagos, Cocos Island, and eastern Pacific. If a species

TABLE 1.—General distribution and depth ranges of ahermatypic Scleractinia from Galápagos and Cocos islands. (S) indicates that species was considered as a predominantly shallow-water species in the zoogeographic analysis.

Species	Galápagos Islands	Cocos Island	Eastern Pacific	Indo-Pacific	West Indies	Bathymetric range of Galápagos–Cocos records (m)	
1. *Madracis* sp. cf. *M. asperula*	x				?	46–64	(S)
2. *Madracis* sp. cf. *M. pharensis*	x		?		?	30–343	(S)
3. *Cladocora pacifica*	x	x				45–603	
4. *Culicia* sp. cf. *C. rubeola*	x	x	x	x		0–27	(S)
5. *Astrangia browni*	x		x			0–5	(S)
6. *Astrangia equatorialis*	x					0–15	(S)
7. *Astrangia dentata*		?	x			8	(S)
8. *Oulangia bradleyi*	x		x			0–14	(S)
9. *Madrepora oculata*	x		x	x	x	15–806	
10. *Oculina profunda*	x		x			305–742	
11. *Caryophyllia diomedeae*	x	x	x			245–806	
12. *Caryophyllia perculta*	x		x			105–316	
13. *Caryophyllia solida*	x					373–488–?1160	
14. *Concentrotheca vaughani*	x					313–316	
15. *Crispatotrochus galapagensis*	x					84–806	
16. *Paracyathus humilis*	x		x			23	(S)
17. *Polycyathus isabela*	x					14–23	(S)
18. *Polycyathus hondaensis*	x	?	x			?	(S)
19. *Desmophyllum cristagalli*	x	x	x	x	x	373–806	
20. *Lophelia prolifera*	x		x	x	x	315–316	
21. *Phyllangia consagensis*	x		x			0–59	(S)
22. *Anomocora carinata*		x				614–785	
23. *Sphenotrochus hancocki*	x		x	x		18–273	
24. *Pseudocyathoceras avis*	x					91–183	
25. *Flabellum galapagense*	x					fossil	
26. *Flabellum* sp. A	x					441–717	
27. *Flabellum daphnense*	x					101	
28. *Javania cailleti*	x	x	x	x	x	245–576	
29. *Javania* sp. A	x					143	
30. *Polymyces wellsi*	x					391–813	
31. *Balanophyllia galapagensis*	x					18–462	
32. *Balanophyllia eguchii*	x		x	x		1–27	(S)
33. *Dendrophyllia gracilis*	x			x		0–12	(S)
34. *Dendrophyllia californica*	x	x	x			315–576	
35. *Dendrophyllia johnsoni*	x					373–462	
36. *Endopachys grayi*	x	x	x	x		20–183	
37. *Rhizopsammia verrilli*	x	x		x		6–20	(S)
38. *Rhizopsammia wellingtoni*	x					2–43	(S)
39. *Endopsammia pourtalesi*	x					?	(S)
40. *Enallopsammia rostrata*	x			x	x	717	
41. *Tubastraea coccinea*	x	x	x	x	x	1.5–54	(S)
42. *Tubastraea faulkneri*	x			x		3–5	(S)
43. *Tubastraea tagusensis*	x			x		1–43	(S)
44. *Tubastraea floreana*	x					2–5	(S)
Totals	42	12	20	14	8	20	S

ranges beyond the eastern Pacific, one or more references are included in the synonymy that summarizes these records. Efforts were made to verify most of the historical records by personal observation, but when specimens were not available for study and the published account was unclear, the synonymy and corresponding distributional records are queried. Representatives of 43 of the 44 species known from the Galápagos and Cocos islands were examined and illustrated; only the fossil *Flabellum galapagense* was not seen and is presumed to be lost.



MAP 1.—Galápagos Islands, illustrating all of the islands off which corals were collected.

Descriptions are provided for most species; however, when no additional specimens were collected of a particular species, then only a discussion is provided including emendations or additions to the previously published description. Conventional scleractinian terminology is used in describing the coralla (see Wells, 1956; Cairns, 1981, 1989). In two cases (i.e., subgenus *Caryophyllia* and *Crispatotrochus*) supraspecific taxa are discussed in order to facilitate comparisons of described species or to resurrect an older taxon.

In the "Material Examined" sections, the number of specimens from a station (if solitary) is enclosed in parentheses following the station number, itself followed by the museum catalog number and previous publication citation, if any. Additional reference material examined, not conspecific with the species being discussed, follows. Types of all new species are deposited in USNM.

If the species is widespread, bathymetric ranges are given for the Galápagos-Cocos records distinct from the entire known range. Spanish names are used for the individual Galápagos Islands (see Glynn and Wellington, 1983:5–7) and in the "Distribution" sections listed in a counterclockwise order beginning with Fernandina.

The scanning electron photomicrographs were done by the author on a Cambridge Stero Scan 100. In many cases stereo pairs are published in order to give a better appreciation of the depth of fossa and relative exsertness of septal cycles. Some specimens were dyed with red food color in order to improve their contrast for conventional photography.

Zoogeography

Unlike the Galapagan stylasterid corals, which are all endemic to that archipelago (Cairns, 1986), the Galapagan ahermatypic Scleractinia have more traditional faunistic affini-

ties as described by Ekman (1953) and Briggs (1974), that is: a high endemic component, followed by affinities with the Panamanian, Indo-Pacific, and West Indian regions, in that order. The relative percentages of these categories are given in Table 2. It should be noted that the shared possession of a species between the Galápagos and Cocos Island is considered as an endemic. The West Indian affinity is not only inferred by the shared possession of two species of *Madracis*, but also by the occurrence of *Oculina profunda* and *Cladocora pacifica*, which are extremely similar (geminate pairs) to the West Indian *Oculina varicosa* and *Cladocora debilis*.

It must be remembered, however, that marine zoogeographic patterns are based primarily on shallow-water (continental shelf) organisms, whereas the ahermatypes are predominantly a deep-water (continental slope) ecological group. Therefore, a further breakdown of faunistic affinities based on depth range is also presented in Table 2. A high majority of the endemic and cosmopolitan species from the Galápagos are deep water species, whereas all West Indian, most Indo-Pacific, and a majority of the Panamanian species are shallow water in distribution. Another result of analyzing a predominantly deep-water group of organisms is a relatively higher percentage of cosmopolitan species.

The only comparable analysis of the Galapagan ahermatypes was that of Wells (1983:217), based on 31 species. He listed a lower percentage (32%) of endemics, a slightly higher percentage of combined Indo-Pacific and cosmopolitan species (35%), a slightly lower percentage of Panamanian species (19%), and a much higher percentage of West Indian species (13%). These discrepancies can be explained by the higher number of species analyzed herein and the reidentification of several of Wells' species.

The affinities of the Galapagan ahermatypes differ from the affinities of the Galapagan hermatypes (Wells, 1983) by having a much higher percentage of endemic and cosmopolitan species and a much lower percentage of Indo-Pacific species.

The faunistic affinities of the relatively few (12 species) ahermatypes known from Cocos Island (Table 2) are also consistent with most other groups of marine invertebrates as summarized by Briggs (1974): a relatively low endemic component (17%), a high Panamanian component (33%), and lesser Indo-Pacific (25%) and cosmopolitan (25%) components. Cocos Island is therefore considered to be an outpost of the Panamanian Province. Ten of its 12 ahermatypic species are shared with the Galápagos.

TABLE 2.—Zoogeographic affinities of Galápagos and Cocos islands ahermatypic Scleractinia, emphasizing depth ranges. Percentages of shallow and deep divisions are expressed as a percentage of total component.

Component	Galápagos			Cocos		
	Total	Shallow	Deep	Total	Shallow	Deep
Endemic	17 (41%)	5 (29%)	12 (71%)	2 (17%)	0	2 (100%)
Panamanian	9 (21%)	5 (56%)	4 (44%)	4 (33%)	2 (50%)	2 (50%)
Indo-Pacific	8 (19%)	6 (75%)	2 (25%)	3 (25%)	2 (67%)	1 (33%)
Cosmopolitan	6 (14%)	1 (17%)	5 (83%)	3 (25%)	1 (33%)	2 (67%)
West Indian	2 (5%)	2 (100%)	0	0	0	0
Totals	42 (100%)	19	23	12 (100%)	5	7

Order SCLERACTINIA

Suborder ASTROCOENIINA Vaughan and Wells, 1943

Family POCILLOPORIDAE Gray, 1842

Madracis Milne Edwards and Haime, 1848

1. *Madracis* sp. cf. *M. asperula* Milne Edwards and Haime, 1850

PLATE 1*a*

Madracis asperula.—Durham and Barnard, 1952:14-15, pl. 1: fig. 2a,b.—Durham, 1962:46; 1966:125.—Wells, 1983:224.

DISCUSSION.—A delicately branched decameral species of *Madracis* is known from one specimen from the Galápagos, a branch fragment 26.6 mm long reported by Durham and Barnard (1952). Nothing is added to their description of this specimen. Until a revision of the genus is made (as recommended by Zibrowius, 1980), based, perhaps, on a detailed morphometric analysis or a molecular taxonomic approach (e.g., electrophoresis), the taxonomy of *Madracis* and the range of variation and taxonomic value of various characters will remain poorly known. Until then, I prefer to follow Durham and Barnard's (1952) tentative identification of this specimen as *M. asperula* even though the gross morphological characters of the Galapagan specimen are identical to those of *M. asperula* from the Atlantic.

Madracis asperula differs from the other Pacific branching *Madracis* (i.e., *M. kauaiensis* Vaughan, 1907, and *M. asanoi* Yabe and Sugiyama, 1936) by having very slender, delicate branches.

MATERIAL EXAMINED.—*Velero* 201-34 (1) AHF 1.1 (Durham and Barnard, 1952), Plate 1*a*.

DISTRIBUTION.—Galápagos: off Gardner Bay, Española;

46–64 m. Elsewhere (if identified as *M. asperula*): Caribbean, Madeira (type locality), Canary Islands, and Cape Verde Islands; 2–40 m (Zibrowius, 1980).

2. *Madracis* sp. cf. *M. pharensis* (Heller, 1868)

PLATES 1*b–e*, 11*g*

Madracis sp.—Durham and Barnard, 1952:15, pl. 1: fig. 1.—Durham, 1962:46; 1966:125.

Madracis pharensis.—Wells, 1973:19 [key to Atlantic species].—Zibrowius, 1980:18–20 [discussion of Atlantic species].—Wells, 1983:224, pl. 16: figs. 1, 5, 6.

DESCRIPTION OF SPECIMEN FROM JSL-1920.—Corallum small, colony consisting of five corallites encrusting the inner edges of several septa of a dead, heavily encrusted specimen of *Desmophyllum cristagalli*. Colony approximately 4.5 mm in diameter; individual corallites 1.5 mm in diameter; calices circular. Intercalicular coenosteum narrow (0.2 mm) and spinose. Corallum white. Septa decamerally arranged in one cycle with traces of 10 secondary septa in several corallites (10–20 septa per corallite). Primary septa exsert and relatively narrow, each separated by a deep notch from a small paliform lobe. Ten paliform lobes highly granular, their inner edges fusing to the central massive styliform columella. Fossa moderately deep.

DISCUSSION.—The specimen reported by Wells (1983) from Gardner Island, Floreana, is a much larger colony of approximately 60 corallites, having very thin, nonspinose walls and polygonal (pentameral or hexameral) corallites. Nonetheless, that specimen, as well as *Madracis* sp. of Durham and Barnard (1952) and the JSL specimen, are considered to represent the same encrusting species, but its identity as *M. pharensis* is unsure. Based on the large variation in colony shape and calicular features found in the Atlantic populations of *M. pharensis*, the paucity of characters to analyze in the genus, and the paucity of specimens from the Galápagos, I share the reservations of Durham and Barnard (1952), Wells (1954), and Zibrowius (1980) in assigning the Galapagan specimens to *M. pharensis*, even though their gross morphological characters do match those of the Atlantic species.

The Galapagan specimens differ from the Pacific *M. kauaiensis* and *M. asanoi* in being encrusting, not branching. It differs from the encrusting *Madracis* sp. reported by Wells (1954) from the Marshall Islands in having poorly developed secondary septa and narrow primary septa; the secondary septa of the Marshall Islands specimen are well developed.

MATERIAL EXAMINED.—JSL-1920 (1) USNM 84775, Plate 1*d,e; Velero* bottom sample 453 (1) AHF 2.1 (*Madracis* sp. of Durham and Barnard, 1952); Gardner Island, Floreana, CAS 66645 (Wells, 1983), Plate 1*b,c*, 11*g*. Reference Specimens: *Madracis* sp. from Bikini Atoll (1) USNM 44407 (Wells, 1954).

DISTRIBUTION.—Galápagos: Gardner Island, Floreana (Wells, 1983); off Kicker Rock, San Cristóbal; Gardner Bay, Española (Durham and Barnard, 1952); 30–343 m. Elsewhere (if identified as *M. pharensis*): ?Gorgona Island, Colombia (Durham and Barnard, 1952); eastern Atlantic; Caribbean; 5–150 m.

Suborder FAVIINA Vaughan and Wells, 1943

Family FAVIIDAE Gregory, 1900

Cladocora Ehrenberg, 1834

3. *Cladocora pacifica*, new species

PLATE 1*f–h*

Cladocora arbuscula.—Marenzeller, 1904b:76–79, pl. 1: fig. 1a–e.

Cladocora debilis.—Durham and Barnard, 1952:58, pl. 4: fig. 22a–e.—Durham, 1962:46; 1966:125.—Wells, 1983:231–232, pl. 14: figs. 9–10.

Cladocera debilis.—Hertlein, 1963:231.

DESCRIPTION.—Colonies consist of a scolecoid, cylindrical principal corallite, from which numerous extratentacular buds originate at right angles. Longest principal corallite 7 cm and 6.2 mm in diameter; secondary buds rarely exceed 1.5 cm in length; smaller tertiary buds not uncommon; quaternary buds rare. No attached coralla were found in the study material. Branches do not anastomose. Costae equal in width (about 0.35 mm), convex to slightly ridged, and coarsely granular. Intercostal striae narrow (about 0.10 mm) and shallow. Coralla light brown to white.

Septa hexamerally arranged in approximately four cycles, the number of septa increasing with increased calicular diameter. Corallites of 2.2–3.5 mm calicular diameter usually have 24 septa; 3.5–6.0 mm, 26–48 septa; and over 5.5 mm calicular diameter, 48–62 septa. Thirty-six septa is a common complement of septa for a corallite of average size, which includes one pair of S_4 in each system. S_1 larger and slightly more exsert (up to 1 mm) than other septa, having smooth, straight upper inner edges, but usually laciniate lower inner edges, the slender septal teeth merging with the columella. Larger paliform teeth or paliform lobes also present on lower inner edges of S_2, sometimes manifested as crispate fascicular laths. If S_4 flank S_3, paliform lobes also occur before the S_3, rising higher in the fossa than the P_2. Septal faces covered with fine pointed granules. Fossa relatively deep. Columella papillose, consisting of a small field of irregularly shaped crispate laths, often merging indistinguishably with lower paliform lobes.

DISCUSSION.—Three valid Recent species of *Cladocora* are known: *C. caespitosa* (Linnaeus, 1767)(eastern Atlantic, 0–50 m); *C. arbuscula* (Lesueur, 1821)(western Atlantic, 0–30 m); and *C. debilis* Milne Edwards and Haime, 1849 (eastern and western Atlantic, 28–100 m). Other species have been described from the western Pacific but have subsequently been assigned to other genera (see Zibrowius, 1980:28), resulting in the Galápagos and Cocos islands specimens being the only known occurrences of the genus outside the Atlantic, a

zoogeographic pattern not unlike that of *Oculina*. The presumably ahermatypic *C. pacifica* is most easily distinguished from the hermatypic species *C. arbuscula* and *C. caespitosa* by growth form: the two shallow-water species have dense, bushy colonies with highly coalescent branches. *Cladocora pacifica* is clearly most similar to *C. debilis* in growth form, and the two might be considered as a geminate species pair. *Cladocora pacifica* differs from *C. debilis* in corallite and branch size, number of septa, and number of paliform lobes: *C. debilis* has a typical calicular diameter of only 3.5 mm, only 24 septa per corallite, and only one crown of P_2, whereas *C. pacifica* has calicular diameters up to 7.0 mm, up to 62 septa per corallite, and paliform lobes before the S_2 and S_3. Some specimens of *C. debilis* from the Gulf of Guinea (Zibrowius, 1980) and St. Peter and Paul Rocks (USNM 80814) have large corallites with correspondingly more septa, not unlike those corallites of *C. pacifica*. These equatorial Atlantic specimens should be more carefully compared to typical *C. debilis* and *C. pacifica* to ascertain their status.

ETYMOLOGY.—Named *pacifica* because it is the only species of *Cladocora* known thus far from the Pacific Ocean.

MATERIAL EXAMINED.—Holotype: ALB-3367, USNM 84776, Plate 1*f-h*. Paratypes: ALB-3367 (10) USNM 22103; ALB-3368 (over 100) USNM 22104 (*C. arbuscula* of Marenzeller, 1904b); JSL-1939 (1) USNM 84777; "Galápagos," 100 m (3) USNM 46967 and 79106 (*C. debilis* of Wells, 1983). Other material: *Velero* 143-34 (4) AHF 22.1, 22.2, and 27.1.

TYPE LOCALITY.—5°31′30″N, 86°52′30″W (Cocos Island), 188 m.

DISTRIBUTION.—Galápagos: Gardiner Bay, Española; Wolf. Cocos Island; 45–274 m.

Family RHIZANGIIDAE d'Orbigny, 1851

Culicia Dana, 1846

4. *Culicia* sp. cf. *C. rubeola* (Quoy and Gaimard, 1833)

PLATE 1*i,j*

Culicia rubeola.—Wells, 1954:464–465, pl. 185: figs. 3–6 [synonymy and discussion]; 1983:232, pl. 11: figs. 1, 2.

DESCRIPTION.—Colonies increase by extratentacular budding from thin, encrusting stolons, each corallite originating only one or two stolons. Stolons often eroded or encrusted by other organisms, sometimes giving an impression that corallites are solitary. Because of the irregularities in the substrate and the lengths of stolons, corallites usually cover only about 50% of the substrate on which they occur. Corallites short (≤2.0 mm tall) and cylindrical; irregular, concentric bands of epitheca encircle each corallite. Corallum white.

Septa hexamerally arranged in four cycles, the fourth cycle incomplete ($S_1>>S_2>S_3>S_4$), the number of septa apparently a function of calicular diameter. Corallites 3.5–4.5 mm in diameter have 24–30 septa; a large corallite 5.0 mm in diameter may have 40 septa. Upper, outer edges of all septa join epitheca at same level, 0.3–0.5 mm below the calicular edge, which, in well-preserved corallites, produces a thin, nonseptate rim around the upper calice. Nevertheless, S_1 are exsert, their upper edges usually rising well above the calice in a narrow septal lobe. Inner edges of S_1 vertical and slightly dentate, laciniate near columella. All other septa nonexsert with laciniate inner edges that slope gradually toward the columella. In well-developed septal systems, pairs of S_4 fuse to adjacent S_3, and pairs of S_3 fuse to adjacent S_2. Fossa variable in depth, perhaps dependent on the turbulence of the environment, ranging from shallow to moderately deep. Columella papillose and large, consisting of a circular field of granular papillae, often indistinguishable in shape from the laciniate teeth of the higher cycle septa.

DISCUSSION.—As is the case with many of the shallow-water ahermatypic genera (e.g., *Madracis*, *Oculina*, *Astrangia*), the species of *Culicia* are in need of revision on a worldwide basis. Approximately 12 Recent species of *Culicia* have been described, probably only half of them valid. The genus was previously only known from shallow water of the Indo-West Pacific, especially common in the Australian and New Zealand temperate regions. In 1983, Wells reported *C. rubeola* from the Galápagos, which was the first record of the genus from the eastern Pacific. The genus is also known from off Hawaii (USNM 78497). Because I have not seen the types of *C. rubeola*, I share Wells' (1954) hesitation in assigning any specimen definitively to *C. rubeola*.

MATERIAL EXAMINED.—Onslow, USNM 78892-3 (Wells, 1983); Caleta Iguana, Isabela, USNM 79100 (Wells, 1983); Rábida, CAS 66643; Cousin's Rock, USNM 79101 (Wells, 1983); Santiago, CAS 66656; Genovesa, CAS 66649; Marchena, USNM 84779; Wolf, USNM 46954 (Wells, 1983). Cocos Island: JSL-30-XI-86-2, USNM 80849; JSL-1-XII-86-2, USNM 80850, Plate 1*i,j*; "Cocos Island," USNM 84780.

DISTRIBUTION.—Galápagos: off Isabela, Santiago, Cousin's Rock, Rábida, Santa Cruz, Onslow, Genovesa, Marchena, Wolf, and Darwin; 0–27 m. Cocos Island. Elsewhere (if identified as *C. rubeola*): widespread in central and South Pacific.

Astrangia Milne Edwards and Haime, 1848

5. *Astrangia browni* Palmer, 1928

PLATE 2*a,b*

Astrangia browni Palmer, 1928:27–29, pl. 1: figs. 1, 2.—Durham, 1947:26.—Wells, 1983:232, pl. 12: figs. 1, 3.

DESCRIPTION.—Colony ceriod to slightly plocoid, individual corallites closely spaced and project less than 1.0 mm above common basal coenosteum. A large corallum (USNM 46958) measures 58 × 32 mm in size, consisting of about 50 corallites encrusting a volcanic rock. Calices circular to irregular in

shape, 3.0–5.1 mm in diameter. Costae indistinct, very short or absent, the latter condition present in short corallites. Costae, when present, are equal in width, slightly rounded, and relatively smooth. Coenosteum and corallites white; polyps green.

Septa arranged in two size classes: 12 : 12 (24 septa) to 21 : 21 (42 septa), hexameral symmetry apparent only in those corallites with 24 septa. Primary septa slightly exsert, their edges coarsely dentate on the vertical upper half, and more finely dentate to laciniate on the lower almost horizontal half, the lower teeth merging indistinguishably with the columella. Secondary septa much smaller, sometimes rudimentary, with laciniate inner edges that sometimes fuse to an adjacent septum but never attain the columella. Fossa shallow. Columella quite large, consisting of a circular field of numerous papillae.

DISCUSSION.—Although I have not examined the type of *A. browni*, its description and illustrations match the Galapagan specimen, except that the corallites of the Galapagan specimens are larger (those of the type are only 2.5–3.0 mm) and have correspondingly more septa (corallites of the type have only 28–30 septa).

Wells' (1983) synonymy of *A. gardnerensis* with *A. browni* is difficult to understand and may represent an error of placement, because the type of *A. gardnerensis* is clearly more similar to *A. equatorialis* (in fact synonymous) than the Galapagan specimen he identified as *A. browni*.

MATERIAL EXAMINED.—Caleta Iguana, Isabela, USNM 46958 (Wells, 1983), Plate 2*a,b*. Reference Specimen: holotype of *A. gardnerensis*, AHF 30.1.

DISTRIBUTION.—Galápagos: Caleta Iguana, Isabela; 5 m. Elsewhere: west of Puerto Angel, Oaxaca, Mexico; intertidal (Palmer, 1928).

6. *Astrangia equatorialis* Durham and Barnard, 1952

PLATE 2*c-f*

?Astrangia browni Palmer, 1928:27–29, pl. 1: figs. 1, 2.

Astrangia equatorialis Durham and Barnard, 1952:69, pl. 6: fig. 29a,b.—Durham, 1962:46, 52; 1966:125.—Wells, 1983:232–233, pl. 12: figs. 1, 2.

Astrangia gardnerensis Durham and Barnard, 1952:70, pl. 5: fig. 27.—Durham, 1962:52; 1966:125.

DESCRIPTION.—Colonies plocoid: corallites closely adjacent and united basally by a thick, encrusting, common coenosteum. Individual corallites usually project above coenosteum as much as 2.5 mm. Largest colony examined 65 × 41 mm in size (Wells, 1983) consists of about 120 corallites that encrust a volcanic rock. Calices circular, elliptical, or irregular in shape; calices 2.5–3.5 mm in greater calicular diameter. Costae equal (about 0.25 mm wide), low, and rounded, covered by a very coarse granulation that extends to basal coenosteum. Intercostal striae shallow and often indistinct. About 1 mm below calicular edge there is often an epithecal ridge below which the costae are either encrusted or eroded. Coenosteum and corallites light brown to reddish brown; polyps pink.

Septa hexamerally arranged in four incomplete cycles (24–36 septa), apparently dependent on calicular diameter. S_1 slightly exsert and narrow, with vertical, highly dentate to laciniate inner edges. S_{2-4} progressively less wide, but having laciniate inner edges. Septal faces covered by large, pointed granules up to 85 μ tall. Fossa moderately deep, dependent on height of corallite. Columella consists of a tangle of 5–10 elongate septal teeth (paliform lobes?) of the S_1 and sometimes the S_2.

DISCUSSION.—Despite Durham and Barnard's (1952) separation of *A. equatorialis* and *A. gardnerensis* based on the characters of fossa depth and length of paliform lobes, a reexamination of the types (both from the same locality) and additional material from the Galápagos show these characters to be within the range of variation of one species. The synonymy of *A. gardnerensis* with *A. browni*, as implied by Wells (1983), is questioned. Although *A. browni* has calices of the same range of calicular diameters and a similar number of septa per corallite, its corallum is ceriod (not plocoid) and its septa are of only two size classes (not three or four size classes as in *A. equatorialis*). The type of *A. browni* was not examined.

MATERIAL EXAMINED.—Holotype of *A. equatorialis*, *Velero* 31-33, AHF 29.1, Plate 2*c;* holotype of *A. gardnerensis*, *Velero* 31-33, AHF 30.1; Caleta Iguana, Isabela, USNM 46958 (Plate 2*d*) and 78891 (Wells, 1983); "Galápagos," USNM 78890, Plate 2*e, f*.

DISTRIBUTION.—Galápagos: Caleta Iguana and Urvina Bay, Isabela; Onslow; Gardner Bay and Osborn Island, Española (Durham, 1962); Genovesa (Durham, 1962); Darwin (Wells, 1983); 0–15 m.

7. *Astrangia dentata* Verrill, 1866

PLATE 2*g*

Astrangia dentata Verrill, 1866:332; 1870:528–529.—Durham, 1947:28, pl. 5: fig. 6.—Durham and Barnard, 1952:10.—?Durham, 1962:46, 52.—?Hertlein, 1963:231.—Durham. 1966:125.

DISCUSSION.—Durham (1962) reported *A. dentata* from Cocos Island, but did not include a description or illustration of the specimen. It is presumed to be deposited at the Hessisches Landsmuseum, Darmstadt, Germany; however, it was not examined. For this reason, and because there are so many nominal species of *Astrangia* described from the eastern Pacific (see Durham and Barnard, 1952), this record is queried. The original description of this species (Verrill, 1866) has been reproduced by Verrill (1870) and Durham (1947).

MATERIAL EXAMINED.—Syntypes of *A. dentata*, YPM 5376, Plate 2*g*.

DISTRIBUTION.—?Cocos Island; 8 m (Durham, 1962). Elsewhere: Panama, Pearl Islands, San Salvador, Acapulco, La Paz; 0–15 m (Verrill, 1866).

Oulangia Milne Edwards and Haime, 1848

8. *Oulangia bradleyi* Verrill, 1866

PLATE 2*h,i*

Ulangia bradleyi Verrill, 1866:333; 1870:534-535, pl. 9: fig. 10.—Pourtalès, 1875:283.—Marenzeller, 1904b:75.

Oulangia bradleyi.—Durham and Barnard, 1952:77, pl. 18: fig. 39.—Durham, 1966:125.—Wells, 1983:233, pl. 12: figs. 4, 5.

DESCRIPTION.—Colonies increase by extratentacular budding from stolons, but isolated corallites also common. Intratentacular budding also occurs. Corallites short (rarely over 8 mm tall), and cylindrical, usually slightly greater in diameter at base. Base polycyclic, having up to five concentric theca. Calices circular to elliptical, up to 15×13 mm in diameter. Theca usually heavily encrusted with bryozoans and calcareous algae up to calicular edge; however, theca, when visible, consists of broad, slightly convex granular costae, separated by very shallow, narrow intercostal striae. Coralla light brown.

Septa hexamerally arranged in five cycles, the fifth cycle usually incomplete, the number of septa dependent on corallum size. Small corallites of 3.5-5.0 mm have 48 septa; 5.0-12.5 mm, 48-70 septa; and over 14 mm calicular diameter, 90-96 septa. S_1 exsert: their upper edges slightly dentate to smooth and project well into fossa; their inner edges vertical; their lower inner edges bearing laciniate teeth. S_2 only slightly smaller than S_1, both S_1 and S_2 extending to the columella. S_3 smaller than S_2 and bear thickened laciniate septal teeth along most of their margins. S_4 smaller still, bearing slender laciniate teeth along entire margin, pairs of S_4 often joined to adjacent S_3. S_5 rudimentary, with laciniate inner edges. Inner edges of S_{3-4} slope gradually toward columella and are sometimes porous. Septal faces bear sparse, pointed granules; granulation on septal teeth and columella slightly more prominent. Fossa moderately deep and evenly concave (bowl-shaped). Columella composed of a circular field of spiny papillae forming the concave base of the fossa.

DISCUSSION.—*Oulangia bradleyi* is easily distinguished from the numerous other eastern Pacific rhizangiids by its relatively large size and higher number of septa.

MATERIAL EXAMINED.—Off Punta Albemarle (8), Bahia Urvina (1), and Perry Isthmus (1), Isabela, USNM 46959 (Plate 2*h,i*), 78895, (Wells, 1983); Cowley Island, Isabela (1) CAS 66654; off Guy Fawkes Island, Santa Cruz (2) CAS 17911; unknown ALB-station (6) USNM 22075 (Marenzeller, 1904b); *Velero* 275-34 (1) AHF 39.1 (Durham and Barnard, 1952); Panama Canal, USNM 78841 (Wells, 1983); Playa Grande, Pearl Islands (1) USNM 81369; syntype of *O. bradleyi* from Pearl Islands (1) YPM 5374.

DISTRIBUTION.—Galápagos: off Isabela and Santa Cruz (see "Material Examined"); 0-14 m. Elsewhere: off Pacific Panama, Mexico (Durham and Barnard, 1952), and Ecuador (Wells, 1983); 0-64 m.

Family OCULINIDAE Gray, 1847

Madrepora Linnaeus, 1758

9. *Madrepora oculata* Linnaeus, 1758

PLATES 2*j*, 3*a-d*

Madrepora oculata.—Marenzeller, 1904b:79.—Durham, 1966:127.—Zibrowius, 1974a:762-766 [discussion and synonymy].—Cairns, 1979: 39-42 [discussion and synonymy]; 1982:15 [discussion and synonymy].

Madrepora galapagensis Vaughan, 1906:63-64, pl. 1: fig. 2, pl. 2: fig. 1, 1b.—Durham and Barnard, 1952:11.—Durham, 1962:46; 1966:125.—Wells, 1983:234, pl. 13: figs. 1, 2.

DISCUSSION.—*Madrepora oculata* is an extremely variable species, some of its variation described and illustrated by Zibrowius (1974a) and Cairns (1979, 1982). Zibrowius (1974a) synonymized or implied the synonymy of most of the Recent nominal species of *Madrepora*, including *M. galapagensis*, as *M. oculata*, which results in one species with a worldwide distribution and a range of 80-1500 m. Although I (Cairns, 1979) previously maintained the distinction of *M. galapagensis*, after seeing additional specimens from the Galápagos and Subantarctic (Cairns, 1982), I now concur with Zibrowius in considering *M. galapagensis* a junior synonym of *M. oculata*. I can not offer a full resolution to the species problem in the genus *Madrepora*, but in the context of this revision note that that there are four distinctive forms of *Madrepora* in the study material from the Galápagos. The forms are referred to as *M. oculata* forma *galapagensis* (Vaughan, 1906), forma *alpha*, forma *beta* (including Marenzeller's (1904b) specimens), and forma *gamma* (illustrated by Wells, 1983), and are briefly diagnosed below.

Madrepora oculata forma *galapagensis* is a bushy deep-water form (166-547 m) with dense brown coenosteum, bearing linear to reticulate intercostal striae. Calices are 3.6-4.0 mm in diameter. The septal formula is $S_1=S_2>S_3$, the inner edges of the S_{1-2} reaching the columella and often greatly thickened (especially the S_2), sometimes as paliform lobes. S_1 are quite exsert and S_3 are small to rudimentary. The fossa is moderately deep and contains dense stereome and a rudimentary, crispate columella.

Forma *alpha* is similar to forma *galapagensis*, being a bushy to encrusting deep-water (545-806 m) form with dense brown coenosteum. However, its C_{1-2} are slightly ridged and its corallites are much smaller (<2.5 mm in diameter). Septa are arranged $S_1>S_2>S_3$, both S_{1-2} reaching the columella but without inner paliform lobes. S_2 are well developed. The fossa is very shallow, with a massive columella.

Forma *beta* is an openly branching, flabellate, deep-water (545-806 m) growth form with dense, brown coenosteum. The coenosteum is relatively smooth, with no raised costae. Calices are circular, about 3.5 mm in diameter. This form is distinguished by its septal arrangement: all septa are nonexsert; only the six S_1 reach the center of the fossa; S_{2-3} are very reduced or missing. The lower, inner edges of the S_1 join to

form a rudimentary columella deep in the fossa, but there is no thickening of their inner edges. The fossa is deep and straight.

Forma *gamma* is the most distinctive of the forms, being a delicate, bushy, shallow-water (15–24 m) phenotype with a low-density corallum. The white coenosteum is highly granular and bears ridged C_{1-2}. Calices are 3.5–4.0 mm in diameter but often irregular in shape. Septal formula: $S_1>S_2>S_3$; S_1 exsert; S_3 rudimentary or missing. Inner edges of S_{1-2} not thickened, only the S_1 meeting at the base of the fossa. Fossa extremely deep and usually curved, obscuring base of fossa. Columella rudimentary or absent.

MATERIAL EXAMINED.—Forma *galapagensis:* ALB-4642 (types) USNM 68276 (Plate 2*j*) and 77275; JSL-1911, USNM 84782; JSL-1914, USNM 84783, Plate 3*b;* JSL-1924, USNM 84781; JSL-1926, USNM 84784; JSL-1935, USNM 84785.

Forma *alpha:* JSL-1916, USNM 84786, Plate 3*a;* JSL-1929, USNM 84787.

Forma *beta:* ALB-2818, USNM 36377, Plate 3*c;* ALB-3401, USNM 22085 (Marenzeller, 1904b); JSL-1915, USNM 84789; JSL-1916, USNM 84791; JSL-1921, USNM 84790; JSL-1929, USNM 84788.

Forma *gamma:* Tagus Cove, Isabela, USNM 46961 (Wells, 1983), Plate 3*d;* off Española, USNM 79099 (Wells, 1983).

DISTRIBUTION.—Forma *galapagensis:* off Fernandina, Santiago, Santa Cruz, Floreana, and Española; 166–547 m. Forma *alpha:* west of Española and Roca Redonda; 545–806 m. Forma *beta:* off Santa Cruz, San Cristóbal, Española, Genovesa, and Roca Redonda; 545–806 m. Forma *gamma:* Tagus Cove, Isabela and off Española; 15–24 m. Elsewhere: cosmopolitan except for off continental Antarctica (Cairns, 1982); 80–1500 m.

Oculina Lamarck, 1816

10. *Oculina profunda,* new species

PLATES 3*e–g,* 4*a,b*

"Oculinidarum gen.? sp.?".—Marenzeller, 1904b:79.

?*Oculina* sp.—Vaughan, 1917:361.—Palmer, 1928:27.—Durham, 1947:2, 4, 32, pl. 1: fig. 14; 1966:127.

Oculina pallens.—Keith and Weber, 1970:270.

DESCRIPTION.—Colony openly branched, with infrequent branch anastomosis. Colony size and attachment unknown; species known only from broken branch fragments, the largest (holotype) 7 cm long and 6 mm in greater branch diameter. Corallites distributed uniformly on branch, spaced 1.0–3.5 mm apart, being more crowded toward branch tips. Occasionally corallites at branch tips arranged in alternating, sympodial fashion. Corallites circular to elliptical, elliptical corallites more common at branch tips, about 2.6 × 3.7 mm in diameter, the greater diameter aligned with branch axis. Circular corallites 2.0–3.0 mm in diameter. Corallites slightly exsert (up to 1.0 mm), oriented at a right angle to larger-diameter branches but oriented apically on lesser-diameter branch tips. Coenosteum white and costate, bearing broad, low, slightly convex and coarsely granular costae 0.3–0.4 mm wide, separated by shallow, narrow intercostal striae 0.04–0.05 mm wide. Costal granules up to 40 μ tall.

Septa arranged in three complete cycles: $S_1>S_2>S_3$ (24 septa). All septa slightly exsert, with straight, entire inner edges and highly granular septal faces. Lower inner edges of S_1 bear a small, slender paliform lobe directly adjacent to columella. Inner edges of S_2 have a larger, thicker paliform lobe, which rises higher in the fossa than the P_1. S_3 about half the width of S_2, becoming rudimentary deeper in fossa. Fossa relatively shallow, containing a large, highly fused papillose columella.

DISCUSSION.—Of the approximately 20 nominal Recent species of *Oculina,* only four or five appear to be valid species (Zibrowius, 1974c; Wells, pers. comm., 1977), the genus being in need of taxonomic revision. All described Recent species occur in the western Atlantic with one exception: *O. virgosa* Squires, 1958 (Miocene to Recent, New Zealand). Therefore, the report of *O. profunda* from off California and the Galápagos is one of the first records of the genus for the eastern Pacific and only the second for the Indo-West Pacific. The other Pacific species, *O. virgosa,* differs from *O. profunda* in having heptameral symmetry and a considerably shallower depth range (44–101 m). Of the western Atlantic species, *O. profunda* is most similar to *O. varicosa* Lesueur, 1821, which forms ahermatypic thickets as deep as 101 m off the Florida coast (Reed, 1980). *O. profunda* differs in only minor characters, such as having less exsert corallites and less well-developed paliform lobes; it might be considered as a geminate pair along with *O. varicosa.*

Although not figured or described by Palmer (1928) and not examined by the author, the Pleistocene *Oculina* from Oaxaca, Mexico, may well pertain to *O. profunda.* This specimen was later figured by Durham (1947). Durham's (1962) listing of Recent *Oculina* from the eastern Pacific was based on Vaughan (1917). In turn, Vaughan's record was based on either Marenzeller's (1904b) "Oculinidarum" or the type series of *O. profunda,* which he undoubtedly saw while working at the USNM.

ETYMOLOGY.—Named *profunda* for the great depth at which this species was collected, far deeper than any other species in the genus.

MATERIAL EXAMINED.—Holotype: ALB-3170, USNM 84792, Plate 3*e.* Paratypes: ALB-3170 (22 branch fragments) USNM 36370; ALB-3174 (1 branch) USNM 36565; ALB-3187 (10 fragments) USNM 36373; ALB-3188 (14 fragments) USNM 36372, Plates 3*f,g,* 4*a,b;* ALB-3401 (1 dead fragment) USNM 22073 ("Oculinidarum gen.? sp.?" of Marenzeller, 1904b). Reference Specimen: Recent figured specimen of *Oculina virgosa* Squires, 1958, USNM 46820.

TYPE LOCALITY.—38°17′N, 123°29′W (off Bodega Bay, California), 305 m.

DISTRIBUTION.—Galápagos: southeast of San Cristóbal; 742 m. Elsewhere: off St. Lucia Range and off Bodega Bay,

California; 119-578 m. ?Pleistocene of Mexico (Palmer, 1928).

Suborder CARYOPHYLLIINA Vaughan and Wells, 1943

Family CARYOPHYLLIIDAE Gray, 1847

Caryophyllia Lamarck, 1801

DIAGNOSIS.—Corallum solitary, attached or free: if attached, corallum cylindrical, trochoid, or ceratoid; if free, corallum usually cornute with a nonreinforced pedicel. Calice circular, elliptical, or compressed; thecal edge spines or crests present on species having compressed coralla. Septal symmetry quite variable, including hexameral, octameral, decameral, and various multiples of 12-20; however, hexameral symmetry with four cycles of septa most common pattern. One crown of pali present before penultimate cycle of septa (usually S_3); pali rarely present before antipenultimate cycle. Columella fascicular, usually composed of one to several tightly twisted laths, but may also be composed of a field of rod-like papillae.

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

Subgenus *Caryophyllia (Caryophyllia)* Lamarck, 1801

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

DISCUSSION.—Wells (1956) listed three subgenera of *Caryophyllia:* nominate, *Acanthocyathus,* and *Premocyathus.* The latter is now considered as a separate genus and *Acanthocyathus* is easily distinguished by its edge spines or crests. Despite this parsing of the genus, the remaining nominate subgenus contains the greatest number of species of any ahermatypic genus: 56 valid Recent species and subspecies (Table 3) and approximately 185 nominal fossil species, many of the latter described as *Ceratocyathus* and undoubtedly including many junior synonyms. In view of the large number of Recent species of *Caryophyllia* and because three species of *Caryophyllia* are described from the Galápagos (two of them as new species), it was thought appropriate to examine the descriptions and reference specimens (if possible) of all Recent species and to devise a method of subdividing this subgenus in order to facilitate comparisons.

An easily observable and ecologically and morphologically fundamental difference among the species of *Caryophyllia* concerns whether or not the pedicel of the corallum is subsequently reinforced with stereome. If reinforced, the corallum is invariably attached to a substrate and stands upright in relation to the substrate. If the pedicel is not reinforced, the original attachment is usually broken, the corallum becomes free, and often (perhaps in an attempt to right itself) becomes cornute in shape. This character can be used to separate the Recent species into 41 "attached" species and subspecies and 15 "unattached" species and subspecies. Some authors (e.g., Chevalier, 1961) have employed the subgenus *Ceratocyathus* Seguenza, 1863, for the unattached, free species. Squires (1958) used this distinction to help characterize his five "groups" of Indo-West Pacific *Caryophyllia.* However, Zibrowius (1980) cautioned against using this character at the subgeneric level because of the intermediate nature of some species, the variation found within some species, and the difficulty of diagnosing this character in poorly preserved fossil species.

Another useful level of discrimination that usually represents a valid species-level character in the genus is that of septal symmetry. Sometimes the number of septa and apparent septal symmetry changes as the corallum increases in size, but usually the adult symmetry is fixed and can be determined. Septal symmetry varies greatly among the species of *Caryophyllia;* among the 41 attached taxa, 24 have hexameral symmetry, 4 octameral, 7 decameral, and 6 have symmetry that appears to change with calicular diameter. The same criterion can be applied to the unattached species (Table 3).

Among the 24 attached species and subspecies with hexameral symmetry, a third criterion, that of number of adult septal cycles, can be applied: 19 have four cycles (48 septa) and 5 have five cycles (96 septa). Squires (1958) also used this character in concert with the state of the corallum base to distinguish his five species groups. To further discriminate among the 19 attached hexameral species with four cycles of septa, characters such as relative septal exsertness and size, septal sinuosity, development of the columella, and corallum size and shape must be considered.

DISTRIBUTION.—Upper Jurassic to Recent, cosmopolitan, 0–3200 m (Keller, 1981).

11. *Caryophyllia diomedeae* Marenzeller, 1904

PLATE 4c–e

Caryophyllia diomedeae Marenzeller, 1904b:79-80, pl. 1: fig. 2.

?Caryophyllia sp. Marenzeller, 1904b:80.

Not *Caryophyllia diomedeae.*—Durham and Barnard, 1952:82, pl. 9: fig. 43 [= *C. perculta*].—Durham, 1962:46; 1966:125.—Wells, 1983:234-235 [= *C. solida*].

?Caryophyllia sarsiae Zibrowius, 1974d:779-782, pl. 3.

DESCRIPTION.—Corallum tall (up to 30 mm) and ceratoid, attached by a narrow pedicel 30%–40% diameter of calice. Calice elliptical: GCD : LCD ranging from 1.1–1.3; largest corallum (JSL-1933) 13.1 mm in greater calicular diameter. Costae alternate in width and expression: C_4 flat and broad (0.6–0.8 mm wide), C_{1-3} slightly ridged and often narrower (0.6 mm). Theca porcellaneous and milky white, not granular.

Septal formula: $S_{1-2}>S_3>S_4$, 48 being the typical complement of septa regardless of corallum size. Inner margins of $S_{1-2,4}$ straight; those of S_3 quite sinuous. P_3 broad (up to 1.4 mm wide), each separated by a deep and narrow notch from corresponding S_3. Septal face granules 0.2 mm tall; those of

TABLE 3.—Tabulation of 56 species and subspecies of Recent *Caryophyllia (Caryophyllia)* based on nature of attachment (A = attached; U = unattached), septal symmetry, number of septa, and geographic distribution (1 = Western Atlantic, 2 = Eastern Atlantic, 3 = Antarctic/Subantarctic, 4 = Eastern Pacific, 5 = Central Pacific, 6 = Australia/New Zealand Region, and 7 = Indo-West Pacific).

Species	Attachment	Septal symmetry	Number of septal cycles	Distribution
C. berteriana Duchassaing, 1850 = *C. formosa* Pourtalés, 1867	A	×6	4	1
C. polygona Pourtalés, 1878	A	×6	4	1
C. horologium Cairns, 1977	A	×6	4	1
C. corrugata Cairns, 1979	A	×6	4	1
C. parvula Cairns, 1979	A	×6	4	1
C. calveri Duncan, 1873	A	×6	4	2
C. sarsiae Zibrowius, 1974	A	×6	4	2,3,6,7
C. alberti Zibrowius, 1980	A	×6	4	2
C. atlantica (Duncan, 1873) = *C. laevicostata* Moseley, 1881 = *C. alcocki* Vaughan, 1907 = *?C. pacifica* Keller, 1981	A	×6	4	2, 5
C. antarctica Marenzeller, 1904	A	×6	4	3
C. arnoldi Vaughan, 1900	A	×6	4	4
C. diomedeae Marenzeller, 1904	A	×6	4	4
C. alaskana Vaughan, 1941	A	×6	4	4
C. lamellifera Moseley, 1881	A	×6	4	7
C. japonica Marenzeller, 1888	A	×6	4	7
C. ephyala Alcock, 1891	A	×6	4	7
C. panda Alcock, 1902	A	×6	4	7
C. sewelli Gardiner and Waugh, 1938	A	×6	4	7
C. sp. cf. *C. berteriana* sensu Gardiner, 1904	A	×6	4	7
C. cyathus (Ellis and Solander, 1786) = *M. calendula* Hermann, 1782 = *M. anthophyllum* Esper, 1791	A	×6	5	2
C. inornata (Duncan, 1878)	A	×6	5	2
C. eltaninae Cairns, 1982	A	×6	5	3
C. profunda Moseley, 1881	A	×6	5	3, 6
C. capensis Gardiner, 1904	A	×6	5	7
C. paucipalata Moseley, 1881	A	×5-6	4	1
C. barbadensis Cairns, 1979	A	×8	3	1
C. rugosa Moseley, 1881 = *C. paraoctopali* Yabe and Eguchi, 1942	A	×8	3	5
C. octopali Vaughan, 1907 = *C. octopali incerta* Vaughan, 1907	A	×8	3	5
C. marmorea Cairns, 1984	A	×8	3	5
C. antillarum Pourtalés, 1874	A	×10	3	1
C. zopyros Cairns, 1979	A	×10	3	1
C. abyssorum Duncan, 1873 = *C. inskipi* Duncan, 1873 = *C. vermiformis* Duncan, 1873	A	×10	3	2
C. perculta, new species	A	×10	3	4
C. hawaiiensis Vaughan, 1907	A	×10	3	5
C. quadragenaria Alcock, 1902	A	×10	3	7
C. scobinosa decapali Yabe and Eguchi, 1942	A	×10	3	7
C. solida, new species	A	×6-10	4	4
C. smithii Stokes and Broderip, 1828 = *T. borealis* Fleming, 1828 = *C. turbinata* Philippi, 1836 = *P. taxilianus* Gosse, 1860 = *P. thulensis* Gosse, 1860 = *P. pteropus* Gosse, 1860 = *P. monilis* Duncan, 1878 = *P. humilis* Duncan, 1878	A	×12-18	3	2
C. foresti Zibrowius, 1980	A	×12-18	3	2
C. paradoxus Alcock, 1898	A	×13-17	3	7
C. jogashimaensis Eguchi, 1968	A	×18	3	7
C. transversalis Moseley, 1881	U	×6	4	7
C. scobinosa scobinosa Alcock, 1902	U	×6	4	7
C. cultrifera Alcock, 1902	U	×6	4	7
C. epithecata sensu Gardiner, 1904	U	×6	4	7
C. squiresi Cairns, 1982	U	×6	4	3
C. clavus sensu Wells, 1958	U	×6	5	6
C. grandis Gardiner and Waugh, 1938	U	×6	5	7
C. mabahithi Gardiner and Waugh, 1938	U	×8	3	3, 7
C. cornuformis Pourtalés, 1868 = *C. pourtalesi* Duncan, 1873	U	×6-11	3	1, 2
C. pauciseptata Yabe and Eguchi, 1932	U	×11	3	7
C. ambrosia ambrosia Alcock, 1898	U	×14-18	3	1, 2
C. ambrosia caribbeana Cairns, 1979	U	×14-18	3	1
C. scillaemorpha Alcock, 1894	U	×15	3	7
C. seguenzae Duncan, 1873	U	×16-22	3	2
C. planilamellata Dennant, 1906	U	×20	3	6

Generic attribution of *C. gigas* van der Horst, 1931, uncertain, but thought to be a parasmiliid.

pali 0.3 mm tall. No carinae on septal or palar faces. Fossa moderately deep. Fascicular columella consists of 5–8 slender twisted laths recessed below level of pali.

DISCUSSION.—Durham and Barnard's (1952) records of *C. diomedeae* from the Galápagos and off Panama do not pertain to this species, as Wells (1983:235) implied for the Galapagan record. The specimen reported by Wells (1983) from ALB-2808 is too small and poorly preserved to accurately identify, but its costal granulation suggests an identity of *C. solida*.

The three specimens from Cocos Island are only tentatively identified as *C. diomedeae*. Two of the three specimens (Marenzeller's (1904b) *Caryophyllia* sp. and JSL-1938) are seemingly identical to *C. diomedeae* but are queried because of their poor preservation. The third specimen (JSL-1938) is well preserved and very similar to *C. diomedeae*, differing only in having granular and a much better developed costae. The skeletal variation of this species, known from less than a dozen specimens, is not yet adequate to determine accurate species limits.

In comparing *C. diomedeae* to the other 18 attached, hexamerally symmetrical species of *Caryophyllia* with four cycles of septa, it was found to be remarkably similar to *C. sarsiae* Zibrowius, 1974 (eastern Atlantic and Bermuda, 520–2200 m). The only differences noted were that the coralla of *C. sarsiae* attained a larger size and were more robust, and lacked the C_{1-3} costal ridges (Plate 4*f*).

Likewise, judging from the description and figures of Alcock

(1902), *C. ephyala* Alcock, 1891 (Andamans and Luccadive Sea, 402–1289 m) is also very similar; however, without comparative specimens it is not possible to synonymize these species. Yabe and Eguchi (1942) considered *C. ephyala* a junior synonym of *C. japonica* Marenzeller, 1888.

Marenzeller's (1904b) original description of *C. diomedeae* was apparently based on two specimens from ALB-3358, which must be considered as syntypes. His figured specimen is deposited at the USNM (22083); the deposition of the other syntype was not traced.

MATERIAL EXAMINED.—JSL-1916 (2) USNM 84793; JSL-1929 (1) USNM 84794; JSL-1933 (2) USNM 84795; JSL-1938 (1) USNM 84796, Plate 4*e;* JSL-1942 (1) USNM 84787; ALB-3358 (syntype) USNM 22083, Plate 4*c,d;* ALB-3370 (1) USNM 22082 (*C.* sp. of Marenzeller, 1904b). Reference Specimens: *Velero* 948-39 (1) AHF 43.2 (*C. diomedeae* of Durham and Barnard, 1952); ALB-2808 (1) USNM 36429 (*C. diomedeae* of Wells, 1973).

DISTRIBUTION.—Galápagos: off Fernandina, Española, Roca Redonda. Cocos Island; 245–806 m. Elsewhere: off Panama; 1043 m (Marenzeller 1904b).

12. *Caryophyllia perculta,* new species

PLATE 5*a,b,d*

Caryophyllia diomedeae.—Durham and Barnard, 1952:82 [part: *Velero* 948-39], pl. 9 fig. 43.

DESCRIPTION.—Corallum ceratoid, with a circular to slightly elliptical calice. Holotype 7.6 mm in calicular diameter (circular) and 12.6 mm tall; however, its slightly bent pedicel is broken above the point of attachment. Only upper 0.5–1.0 mm of theca covered by coenosarc, the lower part highly eroded, a yellowish brown in color. Nonetheless, faint intercostal striae can sometimes be seen on the theca, delimiting equal costae about 0.5 mm wide, uniformly covered by low, rounded granules 0.10–0.12 mm in diameter. Upper, intact theca glisteny white, that of holotype displaying concentric epithecal bands.

Septa decamerally arranged in three cycles (10 : 10 : 20=40 septa), even a specimen only 4.0 mm in calicular diameter having 40 septa and 10 pali. Ten primary septa moderately exsert (1.5 mm above calicular edge), with vertical, only slightly sinuous inner edges that attain about 85% distance to columella. Ten secondary septa less exsert (0.8 mm) and about $^2/_3$ width of primary septa (or extending about 57% distance to columella). Twenty tertiary septa, although less exsert than secondaries (0.5 mm), extend an equal or greater distance toward the columella (57%–67% of distance). Septal faces covered by blunt granules about 0.10 mm tall, the granulation replaced by long (up to 0.8 mm), low (0.1 mm), obliquely oriented carinae on the lower inner septal edges. A ring of 10 wide (0.75 mm) pali occurs before the secondary septa, each palus separated from its corresponding septum by a narrow gap of about 0.07 mm, i.e., $^1/_{10}$ the palar width. Palar edges highly sinuous, the palar faces bearing tall (0.25 mm) obliquely oriented carinae that completely traverse the pali, giving the pali the appearance of even greater sinuosity. Upper edges of pali terminate about 1 mm below calicular edge. Fossa relatively deep, the palar crown 1 mm deep and the columella about 2 mm deep within the fossa. Fascicular columella composed of up to six ornately twisted laths.

DISCUSSION.—Durham and Barnard's (1952) *C. diomedeae* from Bahia Honda, Panama, is clearly *C. perculta.* The other two specimens reported by Durham and Barnard as *C. diomedeae* from the Galápagos (*Velero* 170-34) were not examined.

Among the six other species of decamerally symmetrical attached *Caryophyllia, C. perculta* is most similar to *C. hawaiiensis* Vaughan, 1907, both species having coralla of about the same size and shape, and tertiary septa that are wider than the secondary. *Caryophyllia perculta* is distinguished by its ornately carinate septal and palar faces and lack of thecal granulation. *Caryophyllia perculta* also seems to be similar to *C. quadrageneria* Alcock, 1902 (East Indies, 112–281 m), based on the description; however, as in the case of *C. hawaiiensis, C. perculta* differs in its septal and palar ornamentation and lack of thecal granulation. Furthermore, both *C. hawaiiensis* and *C. quadrageneria* have a purplish brown upper thecal margin, an unusual character not shared with *C. perculta* and one that indicates a possible synonymy of the Hawaiian and East Indian species. Several other species of *Caryophyllia* have ornately carinate septal and palar faces, such as *C. vaughani; C. alberti* Zibrowius, 1980; *C. antarctica* Marenzeller, 1904a; and *C. rugosa* Moseley, 1881; however, the septal symmetry of these species is not decameral.

ETYMOLOGY.—The species name is from the Latin *perculta* (highly adorned), alluding to its ornately carinate septal and palar faces and twisted columellar laths.

MATERIAL EXAMINED.—Holotype: JSL-1937, USNM 84798, Plate 5*a,d.* Paratypes: JSL-1914 (1) USNM 84799, Plate 5*b;* JSL-1932 (1) USNM 84800; JSL-1939 (2) USNM 84801. Other Material: *Velero* 948-39 (1) AHF 43.2 (*C. diomedeae* of Durham and Barnard, 1952).

TYPE LOCALITY.—0°59.8′S, 91°27.1′W (off Caleta Iguana, Isabela), 315–316 m.

DISTRIBUTION.—Galápagos: off Caleta Iguana and Tagus Cove, western Isabela; Floreana. Cocos Island; 105–316 m. Elsewhere: Medidor Island, Bahia Honda, Panama; 54–64 m (Durham and Barnard, 1952).

13. *Caryophyllia solida,* new species

PLATE 5*c,e, f*

?Caryophyllia diomedeae.—Wells, 1983:234–235 [part: ALB-2808].

DESCRIPTION.—Corallum subcylindrical and short, firmly attached to substrate through a thick pedicel and thin encrusting base. Largest specimen (JSL-1926) 12.3 × 12.2 mm in calicular diameter and 19.8 mm tall; holotype 11.3 × 11.0 mm in

calicular diameter, 12.1 mm tall, and 8 mm in pedicel diameter. Pedicel thickened by solid dense layers of calcium carbonate, producing a stout, robust corallum. Only upper 1–2 mm of theca covered by coenosarc, the lower theca eroded and chalky in color and consistency, sometimes encrusted by other calcareous organisms. Upper theca smooth and glisteny-white, showing no intercostal striae or grooves. Costae flat, each about 0.70 mm wide, covered by very low, rounded granules 0.13–0.15 mm in diameter, which are often discernable on lower eroded theca.

Septa of nine specimens from JSL-1924 (including the holotype) decamerally arranged in three cycles (10 : 10 : 20), the largest, as well as a specimen only 5.5 mm in calicular diameter, having 40 septa and 10 pali. However, the other three specimens identified as *C. solida* are hexameral in symmetry, having 48 septa and 12 pali. Ten primary septa (or 12 S_{1-2}) moderately exsert (about 1 mm above calicular edge), with vertical, slightly sinuous inner edges that attain half the distance to columella. Ten secondary septa (or 12 S_3) and 20 tertiary septa (or 24 S_4) progressively less exsert and wide, reaching correspondingly less distance toward columella. Septa and pali porcellaneous in texture, covered only sparsely with low granules. A crown of 10 (or 12) tall (up to 3.0 mm), slender (0.4–0.5 mm) pali occurs before the secondary septa (or S_3), each palus separated from its corresponding septum by a wide gap equal to or greater than its own width (0.4–0.6 mm). Edges of pali slightly sinuous to straight, their inner edges fused to the columellar elements. Rounded upper edges of pali attain level of calicular edge. Fossa virtually nonextant, the upper edges of the pali and columellar elements all extending to upper calicular edge. Fascicular columella composed of 5 or 6 slender, twisted laths.

DISCUSSION.—It is difficult to categorize the symmetry of *C. solida* for comparative purposes because nine of the 12 known specimens are decameral (40 septa), while the remaining specimens are clearly hexameral with four cycles of septa, all other characters being the same. It is impossible to judge whether one or the other symmetries is typical and the other aberrant, or if both symmetries commonly prevail in the species. *Caryophyllia solida* is unusual in other ways, however, making it easy to distinguish from all other species: it has a subcylindrical corallum, virtually straight inner septal edges, extremely reduced septal granulation making the septa appear to be widely spaced, very thin pali, and virtually no fossa.

ETYMOLOGY.—The species name is from the Latin *solida* (solid), alluding to the solid, robust nature of the corallum.

MATERIAL EXAMINED.—Holotype: JSL-1924, USNM 84804, Plate 5*e, f*. Paratypes: JSL-1924 (8) USNM 84805; JSL-1926 (1) USNM 84806, Plate 5*c;* JSL-1935 (1) USNM 84807; ALB-2808 (1) USNM 36429 (*C. diomedeae* of Wells, 1983).

TYPE LOCALITY.—0°03.9′N, 90°19.2′W (seamount north of Santiago), 373–430 m.

DISTRIBUTION.—Galápagos: southeast of Fernandina; ?north of San Cristóbal (Wells, 1983); north of Santiago; 373–488–?1160 m.

Concentrotheca Cairns, 1979

14. *Concentrotheca vaughani*, new species

PLATE 4*g–i*

DESCRIPTION.—Corallum cylindrical, tapering little, if any, toward polycyclic base. Corallum firmly attached, having, in addition to the thick pedicel, a thin peripheral expansive base. Three of the seven coralla examined (including the holotype) show signs of rejuvenescence from a parent corallum of larger diameter. Calices circular to slightly elliptical. Holotype (largest specimen) 6.7 mm in calicular diameter and 9.9 mm tall; however, its pedicel is broken above point of attachment. Only upper theca covered by coenosarc, the lower theca eroded. Theca uniformly covered by small, low granules with no evidence of costae. Upper theca and septa light brown.

Septa hexamerally arranged in four cycles, the fourth incomplete: the largest specimen lacking one pair of S_4 (46 septa); a specimen with a greater calicular diameter of 5.8 mm lacks two pairs of S_4 (44 septa); and other specimens 3.4–4.3 mm in calicular diameter have 36–42 septa. Six S_1 moderately exsert (up to 1 mm), having vertical, straight to slightly sinuous inner edges. Upper edges of S_1 project deeply into fossa, creating a well-defined hexameral symmetry for each corallum; lower inner septal edges attain the columella. S_2 equally exsert as S_1 but their inner edges are not vertical; they slope slightly toward the columella and only attain 0.9 the distance to columella. S_{3-4} progressively less exsert and wide. Septal faces covered by small granules about 0.08 mm tall and, on higher cycle septa (S_{2-4}), low carinae are obliquely oriented on the lower inner septal edges (Plate 4*i*). Small P_3 (0.4–0.6 mm wide) occur deep in the fossa, forming an indistinct crown just above the columella. In half-systems lacking pairs of S_4, a palus is usually present before the S_2, maintaining the penultimate palar position. Owing to the great depth of the fossa of the holotype, the small P_3 are barely visible, appearing as small appendages to the extreme lower, inner septal edges, but, nonetheless, are well differentiated from the columellar elements. Pali highly sinuous and also covered with thick, elongate carinae. Fossa deep, approximately 4 mm in the holotype. Columella papillose, composed of a circular field of 10–15 irregularly-shaped rods, each 0.2–0.3 mm in diameter.

DISCUSSION.—The genus *Concentrotheca* is very similar to *Caryophyllia,* but differs primarily in having a polycyclic base and a papillose columella. Only one other species is known in the genus, the type species *C. laevigatus* (Pourtalès, 1871), which is known only from the western Atlantic and Azores (183–800 m). *Caryophyllia vaughani* differs from the type species in having consistently hexameral symmetry, a relatively thin thecal wall, carinate septal faces, and narrow notches separating pali from their corresponding septa.

ETYMOLOGY.—Named in honor of T.W. Vaughan (1870–1952) for his many contributions to scleractinian taxonomy (see Thompson, 1958), including the description of new species from the Galápagos (Vaughan, 1906).

MATERIAL EXAMINED.—Holotype: JSL-1937, USNM 84802, Plate 4*h*. Paratypes: JSL-1932 (6) USNM 84803, Plate 4*g,i*.

TYPE LOCALITY.—0°59.8′S, 91°27.1′W (off Caleta Iguana, Isabela), 315–316 m.

DISTRIBUTION.—Galápagos: off Tagus Cove and Caleta Iguana, Isabela; 313–316 m.

Crispatotrochus Tenison Woods, 1878

Crispatotrochus Tenison Woods, 1878:309.
Cyathoceras Moseley, 1881:156.

DIAGNOSIS.—Corallum solitary, ceratoid to turbinate, and firmly attached through a robust pedicel. Theca costate or porcellaneous. Septal symmetry hexameral (48–96 septa) or decameral (40 septa). Pali absent. Columella fascicular and usually robust, composed of 2–30 twisted laths.

DISCUSSION.—*Crispatotrochus*, as described by Tenison Woods (1878) and defined by the holotype of its type species (*C. inornatus*, off Port Stephens, N.S.W., Australia), clearly belongs to the same genus as those species subsequently described as *Cyathoceras*. Because *Crispatotrochus* has nomenclatural priority by three years, those species formerly placed in *Cyathoceras* must be transferred to *Crispatotrochus*. It should be noted that Chevalier (1987) considered *Crispatotrochus* as a subgenus of *Edwardsotrochus* Chevalier, 1961, separate from *Cyathoceras* but a senior synonym of *Labyrinthocyathus* Cairns, 1979.

A review of the literature reveals that 12 species can be assigned to *Crispatotrochus*, and, as with *Caryophyllia*, they may be grouped based on septal symmetry. Eight species have hexameral symmetry: *Crispatotrochus inornatus* Tenison Woods, 1878; *C. cornu* (Moseley, 1881); *C. rubescens* (Moseley, 1881) (= *Cyathoceras diomedeae* Vaughan, 1907); *C. tydmani* (Alcock, 1902) (? = *C. rubescens*); *C. niinoi* (Yabe and Eguchi, 1942); *C. foxi* (Durham and Barnard, 1952); *C. irregularis* (Cairns, 1982); and *C. galapagensis*, new species, and four species have decameral symmetry: *C. woodsi* (Wells, 1964); *C. squiresi* (Cairns, 1979); *C.* sp. cf. *C. cornu* (Cairns, 1979); and *C.* sp. A (Cairns, 1982). Four other species previously assigned to *Cyathoceras* have been transferred to other genera: *C. quaylei* Durham, 1947, and *C. kondoi* Wells, 1977, to *Labyrinthocyathus;* and *C. avis* and *C. hoodensis* (Durham and Barnard, 1952) to *Pseudocyathoceras*, a new turbinoliid genus described herein. In addition to septal symmetry, other characters of systematic value include number of septal cycles, relative exsertness of septal cycles, corallum size, and columella size.

TYPE SPECIES.—*Crispatotrochus inornatus* Tenison Woods, 1978, by monotypy.

DISTRIBUTION.—Recent: worldwide, excluding Antarctica; 82–2329 m.

15. *Crispatotrochus galapagensis*, new species

PLATE 5*g,h*

?Cyathoceras sp.—Durham and Barnard, 1952:90.

DESCRIPTION OF HOLOTYPE.—Corallum ceratoid: 7.6 × 7.1 mm in calicular diameter, 11.0 mm tall, and firmly attached to substrate through a pedicel 3.8 mm in diameter, which expands into an encrusting base approximately 6.5 mm in diameter. Costae indistinct, slightly incised only near calicular edge. Theca smooth, porcellaneous, and white, masking an underlying granulation.

Septa hexamerally arranged in four complete cycles (48 septa). S_{1-2} equal in size and highly exsert (up to 1.6 mm), with extremely sinuous, vertical inner edges that fuse to the columella at their lower edges. S_3 less exsert (up to 1.2 mm), with slightly less sinuous inner edges, extending about 0.8 distance to columella. S_4 quite small, extending only about one third distance to columella, and have slightly sinuous inner margins. Septal face granulation consists of sparse, low granules about 0.10 mm tall. Fossa nonextant, being entirely filled with a fascicular columella consisting of 6 or 7 broad, loosely twisted laths interconnected among themselves. Tips of columellar laths extend slightly above calicular edge.

DISCUSSION.—The three paratypes from JSL-1929 differ from the holotype in several characters, all of which are considered to fall within the range of variation for this species. These specimens have better-defined costae and tangible thecal granules about 0.08 mm in diameter. Their S_1 are slightly larger than the S_2 and their septal face granules are approximately twice the height (0.2 mm) as those of the holotype. Their columellae are not exsert, but recessed about 1 mm within the fossa.

Among the eight species of hexamerally symmetrical *Crispatotrochus*, most have in excess of four cycles of septa: either an incomplete fifth cycle (e.g., ≥60 septa) or a complete fifth cycle (96 septa). Only two species, the Australian *C. inornatus* and *C. galapagensis* have only four cycles of septa. They are differentiated on the basis of relative septal exsertness (S_{1-2} less exsert in *C. inornatus*), sinuosity of inner septal edges (straight in *C. inornatus*), and nature of the columella (over 30 narrow twisted laths in *C. inornatus* vs. 6–7 broad laths in *C. galapagensis*). Disregarding symmetry, *C. galapagensis* is remarkably similar to the western Atlantic decameral species *C.* sp. cf. *C. cornu* described by Cairns (1979).

ETYMOLOGY.—Named for the archipelago from which it was discovered, the Galápagos Islands.

MATERIAL EXAMINED.—Holotype: JSL-1931, USNM 84808. Paratypes: JSL-1911 (1) USNM 85222; JSL-1913 (1) USNM 84809; JSL-1929 (3) USNM 84810; JSL-1935 (1)

USNM 84811. Reference Specimen: holotype of *C. inornatus*, Macleay Museum, University of Sydney.

TYPE LOCALITY.—0°10.3'S, 91°24.7'W (off Tagus Cove, Isabela), 441-525 m.

DISTRIBUTION.—Galápagos: southwest of Fernandina; off Tagus Cove, Isabela; north of Floreana; off Santa Cruz; and off Roca Redonda; 84-806 m.

Paracyathus Milne Edwards and Haime, 1848

16. *Paracyathus humilis* Verrill, 1870

PLATE 6*a,b*

Paracyathus humilis Verrill, 1870:538.—Durham and Barnard, 1952:92, pl. 12, fig. 54a,b.—Wells, 1983:235-236, pl. 13: figs. 5, 6.

DESCRIPTION OF GALAPAGAN SPECIMENS.—Corallum ceratoid and firmly attached through a thick pedicel and polycyclic base. Illustrated specimen (Plate 6*a*) 5.5 mm in calicular diameter and 10.2 mm tall, with a pedicel diameter of 3.7 mm. Theca and all calicular elements light brown. Costae equal, rounded, and slightly granular; lower theca encrusted.

Septa hexamerally arranged in four incomplete cycles according to the formula $S_1>S_2>>S_3>S_4$, the largest specimen missing one pair of S_4 (46 septa). Inner edges of all septa straight. P_1 variable in width but usually slender yet still lamellar, forming the innermost palar crown directly adjacent to columella. Crown of six P_2 also slender, slightly recessed from columella, and rises higher in fossa than P_1. P_3 sometimes quite broad, rise higher in fossa and recessed farther from columella than P_2. P_3 sometimes have 2 or 3 very slender accessory paliform lobes on inner margins. Palar granulation much coarser than that of septa, but not carinate. Fossa shallow. Papillose columella composed of a field of 15-20 slender, irregularly shaped rods recessed within the palar crowns.

DISCUSSION.—Five species of *Paracyathus* are known from the eastern Pacific: *P. clathra* Verrill, 1869; *P. stearnsi* Verrill, 1869 (= *P. pedroensis* Verrill, 1903); *P. humilis* Verrill, 1870; *P. montereyensis* Durham, 1947; and *P. tiburonensis* Durham, 1947. Another undescribed species was alluded to by Durham (1957) from Clipperton Island. Only two of these species have four cycles or less of septa in the adult stage: *P. montereyensis* and *P. humilis*. *Paracyathus humilis* appears to differ from *P. montereyensis* in having brown theca and thinner pali.

MATERIAL EXAMINED.—Syntype of *P. humilis* (1) YPM 5377; *Velero* 137-34 (1) AHF 54.1 (Durham and Barnard, 1952), Plate 6*b;* Darwin Bay, Genovesa (4) USNM 46963 (Wells, 1983), Plate 6*a*.

DISTRIBUTION.—Galápagos: Darwin Bay, Genovesa; 23 m. Elsewhere: Sulphur Bay, Clarion Island, Pearl Islands (Durham and Barnard, 1952); 104 m.

Polycyathus Duncan, 1876

17. *Polycyathus isabela* Wells, 1982

PLATE 6*c-e*

Polycyathus isabela Wells, 1982:211, pl. 1: figs. 1-3; 1983:236, pl. 14: figs. 1-3.

DESCRIPTION.—Corallum colonial, cylindrical corallites arising from thin basal encrustation, often directly adjacent to base of parent corallite. Largest corallite of holotypic colony 6.5 mm in calicular diameter and 8.1 mm tall; calice elliptical. Costae equal and slightly convex, about 0.32 mm wide, and separated by distinct intercostal striae about 0.08 mm wide. Coenosteum light brown to white; costae covered by low, coarse granules.

Septa hexamerally arranged in four incomplete cycles according to the formula $S_1>S_2>S_3>S_4$: a corallite with a greater calicular diameter of 2.0 mm has only 24 septa; 2.8 mm, 32 septa; 3.0 mm, 36 septa; and 3.7-6.5 mm, 42 septa. Inner edges of S_{1-2} straight; edges of S_3 slightly sinuous; edges of S_4 lacerate. Six slender, crispate, twisted P_1 form a palar crown deep in fossa adjacent to columella. A second crown of six P_2, each palus equal in size to a P_1, occurs slightly higher in the fossa. A third crown of 12 P_3, each palus twice the size of a P_{1-2} but equally crispate, occurs still higher in fossa. Fossa moderately deep. Columella papillose, composed of 15-20 slender, irregularly shaped rods.

DISCUSSION.—According to Wells (1982), only two species of *Polycyathus* are known from the eastern Pacific, both known from the Galápagos. *Polycyathus isabela* differs from *P. hondaensis* (Durham and Barnard, 1952) by having larger corallites with an additional incomplete cycle of septa.

MATERIAL EXAMINED.—Holotype, USNM 49964, Plate 6*c-e;* no additional specimens are known of this species.

DISTRIBUTION.—Known only from the type locality: west of Punta Albemarle, Isabela; 14-23 m.

18. *Polycyathus hondaensis* (Durham and Barnard, 1952)

PLATE 6*f*

Astrangia hondaensis Durham and Barnard, 1952:72-73, pl. 6: fig. 32a-c.—Durham, 1962:46.—Hertlein, 1963:231.—Durham, 1966:125.
Polycyathus hondaensis.—Wells, 1982:211; 1983:236.

DESCRIPTION.—Corallum colonial, cylindrical to slightly ceratoid corallites arising from a basal coenosteal encrustation. Corallites up to 3.1 mm in greater calicular diameter and 3-9 mm tall; calices circular to elliptical. Granular costae equal and flat, separated by narrow intercostal striae.

Septa hexamerally arranged in three cycles (20-24 septa) according to the formula $S_1>S_2>S_3$. Inner edges of S_{1-2} straight, those of S_3, dentate. Twelve robust, crispate P_{1-2} occur in a tight crown before first two septal cycles. Septal and palar granulation ornate, composed of large, multi-tipped

granules and low, continuous carinae near inner septal edges. Fossa shallow, papillose columella composed of 10–15 slender, irregularly shaped rods.

DISCUSSION.—As previously discussed, *P. hondaensis* is distinguished from *P. isabela* by its smaller size and fewer septa; but, because immature corallites of *P. isabela* must also pass through the 24 septa stage, it is necessary to know the ontogenetic relationship between greater calicular diameter and number of septa to distinguish the two species. For instance, corallites of *P. isabela* 3.0–3.1 mm in diameter already have 36–38 septa, whereas corallites of *P. hondaensis* of the same diameter have only 24 septa. To this distinction may be added that *P. hondaensis* has ornately carinate septal faces (*P. isabela* has simple granules) and one crown of very large pali (*P. isabela* has three crowns of smaller pali).

MATERIAL EXAMINED.—Holotype of *A. hondaensis*, AHF 33.1, Plate 6*f*; "Galápagos," USNM 78887.

DISTRIBUTION.—Durham and Barnard (1952) questionably reported *P. hondaensis* from both the Galápagos and Cocos islands based on worn specimens; however, these specimens were not obtained from the AHF for verification. An additional specimen reported herein (USNM 78887) from the Galápagos partially substantiates their records. Elsewhere: Medidor Island, Bahia Honda, Panama; 55-64 m.

Desmophyllum Ehrenberg, 1834

19. *Desmophyllum cristagalli* Milne Edwards and Haime, 1848

PLATE 6*g-i*

Desmophyllum cristagalli.—Marenzeller, 1904b:81.—?Durham and Barnard, 1952:86–87, pl. 11: fig. 48.—Zibrowius, 1974a:758–761, pl. 3: figs. 1–10 [synonymy and discussion].—Cairns, 1979:29–30, pl. 8: figs. 9–12, pl. 9: figs. 1–3 [synonymy and discussion].—Wells, 1983:236–237.

DESCRIPTION.—Corallum solitary and variable in shape, ranging from subcylindrical to ceratoid to trochoid. Large coralla have flared calices. Corallum firmly attached through a thick pedicel and a thin expansive basal encrustation. Largest Galapagan corallum 43 × 28 mm in calicular diameter and 50 mm tall, with a pedicel diameter of 7.2 mm. Theca and septa yellowish brown to white. Theca variable in expression: usually finely granular with no evidence of costae except for thin, white striae corresponding to C_{1-3}; however, some specimens bear thin ridged C_{1-3} that extend to the base.

Septa hexamerally arranged in five complete cycles (96 septa), the fifth cycle completed between 14–17 mm calicular diameter. Relative sizes of septa: $S_{1-2}2>S_3>S_4>S_5$, all septa being highly exsert, up to 12 mm in the case of the S_{1-2}. Inner edges of all septa straight and vertical, the inner edges of opposing S_{1-2} coming within 1 mm of each other. S_3 extend about $^2/_3$ distance to center of fossa; S_4 extend about half distance to center of fossa; and S_5 about $^1/_5$ that distance. Although S_5 are clearly less wide than S_4, they are more exsert than the S_4, fusing to the exsert outer faces of adjacent S_{1-3}. Septal granulation inconspicuous, giving the appearance of smooth septal faces. Fossa extremely deep, not encumbered with pali or columella; however, observable in some small coralla are 1–4 slender, twisted columellar laths, similar to those of *Crispatotrochus*.

DISCUSSION.—Although cosmopolitan in distribution and common in collections, *D. cristagalli* was previously known from only five "dead" specimens dredged from two *Albatross* stations (Marenzeller, 1904b; Wells, 1983). Durham and Barnard's (1952) records of specimens from 12 fathoms (22 m) from off Cartago Bay, Isabela are queried based on their unusually shallow depth.

Desmophyllum cristagalli was the most commonly observed and collected ahermatypic coral on the *JSL* expedition, often found growing downward on the underside of overhangs or within cavities, a growth habit also observed for this species in the deep-water canyons off New York (B. Hecker, pers. comm.). This may explain why, despite their abundance, they were rarely collected by a surface vessel in the Galápagos.

MATERIAL EXAMINED.—JSL-1911, USNM 84814, Plate 6*g-i*; JSL-1915 (1) USNM 84815; JSL-1916 (6) USNM 84816; JSL-1922 (1) USNM 84817; JSL-1924 (4) USNM 84818; JSL-1927 (3) USNM 84819; JSL-1929 (46) USNM 84820; JSL-1938 (1) USNM 84821; JSL-1942 (4) USNM 84822; ALB-2818 (2) USNM 19146 (Wells, 1983); ALB-3401 (3) USNM 22086 (Marenzeller, 1904b).

DISTRIBUTION.—Galápagos: off Isabela, Santiago, Santa Cruz, San Cristóbal, Española, Marchena. Cocos Island; 373–806 m. Elsewhere: cosmopolitan except off continental Antarctica (Cairns, 1982); 35–2460 m.

Lophelia Milne Edwards and Haime, 1849

20. *Lophelia prolifera* (Pallas, 1766)

PLATE 6*j*

Lophelia californica Durham, 1947:36, pl. 1: figs. 13, 16, pl. 2: fig. 11.
Dendrosmilia nomlandi Durham and Barnard, 1952:85, pl. 10: fig. 47.
Lophelia prolifera.—Cairns, 1979:125–127, pl. 24: figs. 1–5 [synonymy and discussion]; 1982:30–31, pl. 9: fig. 6.
Lophelia pertusa.—Zibrowius, 1980:126–130, pl. 66: figs. A-L [synonymy and discussion].

DIAGNOSIS OF GALAPAGAN SPECIMENS.—Corallum increases by intratentacular budding. Corallites long and slender, the largest 4.3 × 3.8 mm in diameter and 14.0 mm long. C_{1-2} slightly ridged near calice; otherwise, theca uniformly granular and white. Three of four branch fragments possess irregularly shaped lateral thecal extensions, some of which adhere to an adjacent serpulid worm tube. Septal symmetry variable, the largest corallite having 11 primary and 11 secondary septa (22 septa), but septa of other corallites hexamerally arranged ($S_1>S_2>S_3$ = 24 septa). S_1 (or primary septa) exsert but not

very broad, extending only about 1/3 distance to center of fossa, and have straight inner edges. S_2 (or secondary septa) not exsert and only rudimentary in development. Septal granulation minute, making septal faces appear smooth. Fossa large because of the narrow septa, and quite deep, the bottom sometimes obscured from view by a slight curvature of the elongate corallite. Pali and columella absent. Tabular endothecal dissepiments sparse, found only deep within corallites; visible only in damaged coralla.

DISCUSSION.—In view of the great variation of colony and corallite size and shape, and septal symmetry as described in Atlantic populations (Cairns, 1979; *L. pertusa* in Zibrowius, 1980), it is suggested that the eastern Pacific specimens, including the Galapagan specimens, belong to the same widespread species. The growth form of the Galapagan specimens comes closest to the *gracilis* variety (Duncan, 1873), typified by slender, elongate corallites. Western Atlantic specimens are known that are virtually identical to the Galapagan coralla. The specimen described as *Dendrosmilia nomlandi* from off California approximates the more robust *brachycephala* variety (Moseley, 1881). If these synonymies are accepted, there is but one widely distributed Recent species in the genus.

MATERIAL EXAMINED.—JSL-1937 (4 fragments) USNM 84813, Plate 6*j*; holotype of *Dendrosmilia nomlandi* Durham and Barnard, 1952, AHF 47.1.

DISTRIBUTION.—Galápagos: off Caleta Iguana, Isabela; 315–316 m. Elsewhere: cosmopolitan, except off continental Antarctica (Cairns, 1982); 60–2170 m.

Phyllangia Milne Edwards and Haime, 1848

21. *Phyllangia consagensis* (Durham and Barnard, 1952)

PLATE 7*d*

Bathycyathus consagensis Durham and Barnard, 1952:79–80, pl. 8: fig. 40a–e, pl. 9: fig 40f.—Squires, 1959:422–423.—Durham, 1966:126.
Lophosmilia wellsi Durham and Barnard, 1952:90–91, pl. 12: fig. 52.—Durham, 1962:46; 1966:125.
Phyllangia consagensis.—Wells, 1983:233–234, pl. 12: figs. 6–7.

DESCRIPTION.—Colonies increase by extratentacular budding from wide, but thin, peripheral stolons. Coenosteum between corallites in center of colony eventually thickens and becomes continuous between corallites. Intercalicular coenosteum, as well as theca, smooth and cream to white in color, not bearing costae or intercostal striae. Corallites cylindrical and short, rising only 3–5 mm above basal coenosteum. Calices circular, elliptical, or irregular in shape; larger corallites 10–11 mm in greater calicular diameter.

Septa hexamerally arranged in four complete cycles (48 septa), occasionally with one or two pairs of S_5 in larger corallites (50–52 septa). All septa exsert; however, S_1 highly exsert (1.5–2.0 mm) with smooth, straight inner edges, sometimes slightly undercut in vicinity of columella. S_2 approximately half as exsert as S_1, but also reach the columella. S_3 half width of S_2, each bearing a paliform lobe of variable size on its lower inner edge, pairs of which sometimes fuse before the adjacent S_2 and extend to columella. S_4 small, becoming rudimentary lower in fossa. Fossa moderately deep. Columella large and variable in structure, ranging from papillose to an irregular fusion of calcium carbonate.

DISCUSSION.—Among the approximately seven Recent species of *Phyllangia*, only two are known from the eastern Pacific: *P. consagensis* and *P. dispersa* Verrill, 1864. The Panamic *P. dispersa* differs from *P. consagensis* in having smaller corallites (only up to 5 mm in calicular diameter), fewer septa (24–30), and a much smaller columella. According to Wells (1983), *P. papuensis* Studer, 1878, and *P. hayamaensis* (Eguchi, 1968), both from the western Pacific, are more similar to *P. consagensis* than *P. dispersa*.

MATERIAL EXAMINED.—JSL-20-XI-86-2, USNM 84823; AB 18-794, USNM 77271; Darwin Bay, Genovesa, USNM 79105 (Wells, 1983), Plate 7*d*; Bartolomé, USNM 46960 (Wells, 1983); Isabela, USNM 79102 (Wells, 1983); Darwin, USNM 79107 (Wells, 1983); holotype of *B. consagensis*, AHF 40.1; paratypes of *B. consagensis*: *Velero* 1062-40, AHF 40.3; *Velero* 1965-50, AHF 40.4; holotype of *Lophosmilia wellsi*, AHF 52.1.

DISTRIBUTION.—Galápagos: off Fernandina; Urvina Bay and Tagus Cove, Isabela; off Santiago; Bartolomé; San Cristóbal; Genovesa; Darwin; 0–59 m. Elsewhere: Gulf of California; 18–82 m.

Anomocora Studer, 1878

22. *Anomocora carinata*, new species

PLATE 7*a,b*

DESCRIPTION.—Corallum quasicolonial, larger corallites intratentacularly budding one or more smaller corallites at right angle to parent corallum, the daughter corallites breaking free of the parent before a third generation bud appears. Corallum ceratoid when young, becoming cylindrical with growth. Holotype consists of a corallite 5.8 × 4.7 mm in calicular diameter and 18.5 mm long, sporting six buds: one 8.5 mm long, the other five only represented by scars, the buds either previously detached or aborted early in ontogeny. Costae of primary septa carinate, sometimes ridged almost to base, and up to 1 mm tall near calicular edge. Secondary costae flat and slightly broader than primary costae. All costae covered by a fine granulation, the pointed granules about 0.10 mm in diameter. Theca pale brown. Irregularly shaped lateral thecal extensions, like those described for *Lophelia* from the Galápagos, also present on some specimens, linking adjacent corallites (buds) on one corallum or fusing a corallite to a serpulid worm tube.

Septal symmetry irregular, but 28 septa per corallite is most common: arranged 11 : 11 : 6 in the holotype, 9 : 9 : 10 in a

paratype. Primary septa slightly exsert and have straight inner edges extending about 2/3 distance to center of fossa. Secondary septa not exsert and much narrower, attaining only 1/5 to 1/4 distance to center of fossa. Tertiary septa rudimentary. Septal granules quite tall and slender, up to 0.20 mm tall and 0.05 mm in diameter. Thin tabular endothecal dissepiments common, especially in longer cylindrical coralla, spaced about every 1.0–1.5 mm, resulting in a corallum of low density. Fossa variable in depth depending on recency of dissepiment formation. Invariably a complete dissepiment or one in the process of formation can be seen from a calicular view. A columella was not noted in any specimen.

DISCUSSION.—Only one other species of *Anomocora* has been previously described, the type species *A. fecunda* (Pourtalès, 1871), known from the Atlantic Ocean from 73–567 m (Cairns, 1979). Reports of *Anomocora* are also known from the Red Sea (Gardiner and Waugh, 1939), off Sumatra (Marenzeller, 1904a), off Japan (Eguchi, 1968), and off the Hawaiian Islands (Cairns, 1984), the Pacific records representing (an) undescribed species. *Anomocora carinata* differs from all previously reported specimens in this genus by having highly carinate primary costae. In the study area, it might be confused with small branch fragments of *Lophelia prolifera*, both species having intratentacular budding, endothecal dissepiments, and thecal extensions. *Anomocora carinata* is distinguished by its prominent costae, taller costal spines, wider septa, and more conspicuous dissepiments.

ETYMOLOGY.—The species name is from the Latin *carinata* (keeled), alluding to the distinctively ridged primary costae.

MATERIAL EXAMINED.—Holotype: JSL-1938, USNM 84824, Plate 7*a,b*. Paratypes: JSL-1938 (12) USNM 84825.

TYPE LOCALITY.—5°24.5′N, 87°09.8′W (off Cocos Island), 614–785 m.

DISTRIBUTION.—Known only from the type locality.

Sphenotrochus Milne Edwards and Haime, 1848

23. *Sphenotrochus hancocki* Durham and Barnard, 1952

PLATE 7*c,e–g*

Sphenotrochus hancocki Durham and Barnard, 1952:94-95, pl. 13: fig. 57a,b.—Durham, 1962:46; 1966:125.—Wells, 1983:236.—Cairns, 1989, pl. 20: figs. a–h.

DESCRIPTION OF THE HOLOTYPE.—Corallum solitary, cuneiform, and highly compressed: 2.3 × 1.25 mm in calicular diameter and 4.0 mm tall. Costae equal in width (0.16–0.18 mm), separated by broad, shallow intercostal furrows. Costae rounded and smooth, lacking granulation. Costae continuous for most of thecal face but degenerating into isolated fragments in lower 1/5 to 1/4 of corallum face. Septa hexamerally arranged in three cycles according to the formula: $S_{1-2}>S_3$. Twelve S_{1-2} highly exsert and extend about 0.6 distance to columella, the 10 lateral S_{1-2} fusing with the columella low in fossa. S_3 rudimentary. Septal faces smooth. Columella lamellar and exsert, rising above calicular edge.

DISCUSSION.—This species was described and illustrated recently by Cairns (1989), where its affinities to other species were also discussed.

MATERIAL EXAMINED.—Holotype and paratype of *S. hancocki, Velero* 170-34, AHF 57.2, Plate 7*c*. Other Material Examined: ALB-5311 (Philippines), USNM 81897 (Plate 7*e–g*).

DISTRIBUTION.—Galápagos: Stephen's Bay, San Cristóbal; Wolf; 18–273 m. Elsewhere: Miocene of Costa Rica; Recent: Philippines, South China Sea, Lower California.

Pseudocyathoceras, new genus

Kionotrochus.—Durham and Barnard, 1952:88 [in part: *K. avis* and *K. hoodensis*].

Cyathoceras.—Cairns, 1982:22 [in part: *K. avis* and *K. hoodensis*].

DIAGNOSIS.—Corallum conical (ceratoid to trochoid), with a pointed base that invariably shows a scar of previous attachment; transverse division lacking. Wall imperforate; costae rounded and finely granular; intercostal grooves do not extend to epicenter. Septa decamerally arranged in three highly exsert cycles (40 septa). Pali absent. Columella fascicular, composed of numerous twisted laths.

DISCUSSION.—Durham and Barnard (1952) tentatively placed two Galapagan species in the genus *Kionotrochus* based on the characters of their corallum shape and nature of their costae. They also noted their resemblance to *Cyathoceras*, but argued against this placement. After seeing the types of these two species in 1979, I (Cairns, 1982) listed them, without explanation, as *Cyathoceras*. Wells (1983) followed suit and furthermore synonymized *C. hoodensis* with *C. avis*. After having recently reviewed and keyed the turbinoliid genera (Cairns, 1989), I now consider this species to represent a new genus of turbinoliid, *Pseudocyathoceras*, not *Kionotrochus*, as suggested by Durham and Barnard (1952). Although similar to *K. suteri* in costal shape and granulation, *Pseudocyathoceras* differs in having a fascicular columella, shorter intercostal grooves, a more conical corallum, and in lacking pali. *Pseudocyathoceras* is considered to be a turbinoliid based on its unattached corallum with costae extending to the epicenter, and relatively deep intercostal furrows (at least in the upper corallum). Among the 23 known turbinoliid genera (Cairns, 1989), it belongs to the group of seven imperforate, nonpaliferous genera. It is distinguished from these genera both by its conical corallum and fascicular columella.

ETYMOLOGY.—Although *Cyathoceras* is herein synonymized with *Crispatotrochus*, for a time (e.g., Cairns, 1982) *P. avis* was placed in *Cyathoceras*. Thus, *Pseudocyathoceras* is an allusion to its superficial similarity to *Cyathoceras*. Gender: neuter.

TYPE SPECIES.—*Kionotrochus avis* Durham and Barnard, 1952, herein designated.

DISTRIBUTION.—Galápagos; 91–183 m.

24. *Pseudocyathoceras avis* (Durham and Barnard, 1952), new combination

PLATE 7*h,i*

Kionotrochus (?) avis Durham and Barnard, 1952:88–89, pl. 11: fig. 50a,b, pl. 12: fig. 50a.—Durham, 1962:46; 1966:125.

Kionotrochus (?) hoodensis Durham and Barnard, 1952:89–90, pl. 12: fig. 51a–d.—Durham, 1962:46; 1966:125.

Cyathoceras avis.—Cairns, 1982:22.—Wells, 1983, pl. 13: figs. 3, 4.

Cyathoceras hoodensis.—Cairns, 1982:22.—Wells, 1983:235.

DESCRIPTION.—Corallum ceratoid to trochoid; free; calice elliptical. Corallum up to 10.3 × 8.4 mm in calicular diameter and 11.4 mm tall (USNM 46962). Costae continuous to epicentral scar, but separated by deep intercostal grooves in upper corallum only. Costae covered by fine, low, rounded granules.

Septa decamerally arranged in three cycles (i.e., 40 septa). Septa well spaced, separated from one another by 2–3 times thickness of a primary septum. Primary septa highly exsert (up to 1.7 mm), with sinuous vertical inner edges that attain the columella. Secondary septa also highly exsert (up to 1.2 mm), with sinuous vertical inner edges that extend about $^2/_3$ distance to columella. Tertiary septa extend about 0.9 mm above calicular edge and about $^1/_4$ distance to columella; they have relatively straight inner edges. Pointed granules 0.08–0.10 mm tall cover septal faces. Fossa shallow. Columella composed of 9–15 slender twisted laths, strongly interconnected among themselves.

MATERIAL EXAMINED.—Holotype and 2 paratypes of *K. avis*, AHF 50.1; holotype and paratype of *K. hoodensis*, AHF 51.1–2; "Galápagos," 100 m, V. and T. Williams (11) USNM 46962 (Wells, 1983), Plate 7*h,i*.

DISTRIBUTION.—Galápagos: off Floreana and Española; 91–183 m.

Family FLABELLIDAE Bourne, 1900

Flabellum Lesson, 1831

25. *Flabellum (F.) galapagense* Milne Edwards and Haime, 1848

Flabellum gallapagense Milne Edwards and Haime, 1848a, pl. 4: fig. 3; 1848b:264.—Wells, 1983:237.

DISCUSSION.—Little can be added to the description and figure of Milne Edwards and Haime (1848a,b) and the comments by Wells (1983). This species is known from only one fossil (?Pliocene) specimen that is now thought to be lost (Wells, 1983:237). As Wells suggested, the figure of the holotype looks very much like *F. thouarsii* Milne Edwards and Haime, 1848 (see Cairns, 1982:34–35); however, it should be remembered that *Flabellum* is a very speciose genus (Cairns, 1989), the nominate subgenus having 28 valid Recent species and the genus having an additional 144 nominal fossil species, none of which have been reported from the eastern Pacific. Even if the original specimen were available, comparisons to other species would be difficult.

The spelling of the species name is herein emended to *F. galapagensis* in accordance with Article 32c of the *International Code of Zoological Nomenclature*, the original intention of the authors clearly being to name the species for the Galápagos Islands.

DISTRIBUTION.—Known only from the ?Pliocene of the Galápagos, specific locality unknown.

26. *Flabellum (F.)* sp. A

PLATE 8*j,k*

Javania cailleti.—Wells, 1983:238 [in part: ALB-2818].

DESCRIPTION.—Corallum ceratoid, elongate, and usually irregularly bent (scolecoid). Largest corallum 7.9 mm in calicular diameter and 17.9 mm tall, with a nonreinforced pedicel 1.8 mm in diameter. Theca smooth and porcellaneous in texture; theca very thin and fragile, translucent; white.

Septa hexamerally arranged in three cycles with rudiments of several S_4 in upper calice of largest specimen, suggesting an adult complement of four cycles. Inner edges of S_1 slightly sinuous, extending about 0.8 distance to center of fossa. S_2 only slightly smaller than S_1. S_3 quite small, extending only 0.3 distance to center of fossa. Relative exsertness of septal cycles unknown because calicular edges of all specimens damaged. Septa as thin and delicate as theca, approximately 0.11 mm thick and widely separated from one another by as much as 0.70 mm, producing a very spacious fossa. Fossa deep. Rudimentary columella formed from contorted lower inner edges of S_{1-2}.

DISCUSSION.—The three juvenile specimens from ALB-2818 reported by Wells (1983) as *J. cailleti* are clearly a species of *Flabellum*, not *Javania*. Ontogenetic sequences of *J. cailleti* from the Galápagos show that at a greater calicular diameter as low as 5.7 mm, it has 48 thick septa, a straight corallum, and a reinforced pedicel. Coralla of *Flabellum* sp. A of an equivalent calicular diameter have only 24 very delicate septa, and a bent, nonreinforced pedicel.

Among the 28 Recent species of *Flabellum (F.)* listed by Cairns (1989), *Flabellum* sp. A most closely resembles two species with scolecoid coralla: *F. gracile* Studer, 1878, and *F. flexuosum* Cairns, 1982.

MATERIAL EXAMINED.—JSL-1931 (1) USNM 84826; ALB-2818 (4) USNM 19279, 77274 (*Javania cailleti* of Wells, 1983), Plate 8*j,k*.

DISTRIBUTION.—Galápagos: off Tagus Cove, Isabela and northeast of Santa Cruz; 441–717 m.

27. *Flabellum (Ulocyathus) daphnense* Durham and Barnard, 1952

PLATE 8*a,b*

Flabellum daphnense Durham and Barnard, 1952:96, pl. 13: fig. 58a,b.—Durham, 1962:46; 1966:125.—Wells, 1983:237–238.

DISCUSSION.—*Flabellum daphnense* is known from only one specimen, the holotype; its original description can be augmented accordingly. The finely "cobbled" theca is reddish brown in color. The specimen has an incomplete fourth cycle of septa, lacking pairs of S_4 from four lateral half-systems (40 septa). The upper calicular edge, although highly damaged, appears to be moderately jagged, the S_{1-2} forming exsert apices, which places this species in the subgenus *Ulocyathus*. The fossa is relatively shallow.

Of the 23 Recent and fossil species attributed to the subgenus *Ulocyathus*, Cairns (1989) placed *F. daphnense* in a subgroup of nine species characterized by having laterally compressed coralla. As Wells (1983) suggested, *F. daphnense* is similar to *F. aotearoa* Squires, 1964, in thecal granulation, as well as thecal color and having a moderately jagged calicular edge; however, *F. aotearoa* has a greater edge angle, edge crests, and five cycles of septa. No other species of *F. (Ulocyathus)* is known from the eastern Pacific.

MATERIAL EXAMINED.—Holotype of *F. daphnense*, AHF 58.1, Plate 8*a,b;* one worn specimen of *Flabellum* is reported (ALB-2808, USNM 36437), which, based on its fragmentary nature, could be *F. galapagense*, *F. daphnense*, or another species.

DISTRIBUTION.—Galápagos: known only from the type locality: southeast of Daphne Mayor (north of Santa Cruz); 101 m.

Javania Duncan, 1876

28. *Javania cailleti* (Duchassaing and Michelotti, 1864)

PLATE 8*c-e*

Flabellum sp.—Marenzeller, 1904b:81.

Desmophyllum galapagense Vaughan, 1906:63, pl.1: fig. 1-1b.—Durham and Barnard, 1952:11.—Durham, 1962:46; 1966:125.

Javania galapagensis.—Zibrowius, 1974b:17.

Javania cailleti.—Cairns, 1979:153-156, pl. 28: figs. 8-12, pl. 30: figs. 1, 4 [synonymy and discussion]; 1982:46-48, pl. 14: figs. 9-12 [discussion and distribution].

Not *Javania cailleti*.—Wells, 1983:238 [= *Flabellum* sp. A and *Javania* sp. A].

DESCRIPTION.—Corallum solitary, ceratoid, and firmly attached through a robust, stereome-reinforced pedicel and thin, expansive basal layer. Largest Galapagan specimen 16.2 × 14.1 mm in calicular diameter, 25.7 mm tall, and 5.3 mm in pedicel diameter, these specimens, in general, being smaller than those of Atlantic populations. Lower third of corallum, corresponding to area of pedicel reinforcement, dull white and smooth. C_{1-3} sometimes slightly ridged, C_3 more than others, but only near calicular edge.

Septa hexamerally arranged in four complete cycles (48 septa) even at a calicular diameter as small as 5.7 mm, according to the formula $S_{1-2}>>S_3>S_4$. S_{1-2} highly exsert, with straight, vertical inner edges that extend 0.8-0.9 distance to center of fossa. S_3 much less exsert, extending about half distance to center of fossa. S_4 only slightly exsert, thin and rudimentary, extending up to 0.2 distance to center of fossa. Exsert septa produce a jagged calicular margin. Septal granules pointed, up to 0.2 mm tall. Fossa deep and narrow. Columella an elongate, solid, smooth calcareous mass joined by the lower inner edges of the S_{1-2}.

DISCUSSION.—Zibrowius (1974b) was the first to realize that Vaughan's *Desmophyllum galapagense* was a *Javania*. Although previously reported from the Cocos and Galápagos islands by Marenzeller (1904b) and Vaughan (1906) as *Flabellum* sp. and *Desmophyllum galapagense*, respectively, *J. cailleti* was first verified as such from these localities by Cairns (1979). The new Galapagan specimens reported by Wells (1983) from ALB-2816 and 2818 pertain to a different species of *Javania* and *Flabellum*.

MATERIAL EXAMINED.—JSL-1911 (2) USNM 84827; JSL-1916 (6) USNM 84828; JSL-1924 (6) USNM 84829; JSL-1926 (2) USNM 84830; JSL-1931 (1) USNM 84831, Plate 8*c,e;* JSL-1932 (4) USNM 84852; JSL-1935 (3) USNM 84832; JSL-1941 (1) USNM 84833; JSL-1943 (6) USNM 84834, Plate 8*d;* JSL-1944 (2) USNM 84835; ALB-3370 (1) USNM 22084 (*Flabellum* sp. of Marenzeller, 1904b); ALB-4642 (1) holotype of *Desmophyllum galapagense*, USNM 68275.

DISTRIBUTION.—Galápagos: off Fernandina; off Tagus Cove, Isabela; Santiago; Santa Cruz; Española. Cocos Island; 245-576 m. Elsewhere: cosmopolitan, except for continental Antarctic and eastern Pacific (Cairns, 1982); 86-2165 m.

29. *Javania* sp. A

PLATE 8*g,h*

Javania cailleti.—Wells, 1983:238 [in part: ALB-2816].

DISCUSSION.—Cairns (1989) listed eight valid species of *Javania* (including three exclusively fossil species) and two as yet undescribed species from the Kermadec Islands and the Bering Sea—making a total of 10 species of *Javania*. Of the seven Recent species, three have four cycles of septa and four have five cycles of septa, the latter being *J. insignis* Duncan 1876; *J. lamprotichum* (Moseley, 1880); *J. antarctica* (Gravier, 1914); and an undescribed species from the Bering Sea (USNM 82019). The broken specimen of 27 mm calicular diameter reported by Wells (1983) from ALB-2816 is clearly a five-cycle species, and therefore not *J. cailleti*, which has four cycles. When directly compared to representatives of the four five-cycle species, the Galapagan specimen most closely resembles the Bering Sea species; however, the poor preservation of the Galapagan specimen does not allow a definitive identification.

MATERIAL EXAMINED.—ALB-2816 (2) USNM 19142: two decidedly nonjuvenile specimens pertain to this lot reported by Wells (1983). The "three juvenile specimens from the same haul" must refer to the small specimens he identified as *J. cailleti* from ALB-2818, not from ALB-2816.

DISTRIBUTION.—Galápagos: off western coast of Floreana (not Bartolomé, as stated by Wells, which is exactly 1° farther north); 143 m. Elsewhere: ?Bering Sea, ALB-4784; 247 m.

Polymyces Cairns, 1979

30. *Polymyces wellsi*, new species

PLATES 8*f,i*, 9*a,b*

Javania sp. cf. *J. pseudoalabastra*.—Wells, 1983:238.

DESCRIPTION.—Corallum solitary, ceratoid to trochoid, and firmly attached through a pedicel reinforced with pairs of contiguous hollow rootlets. Rootlets usually asymmetrical in development, first appearing as 2–4 contiguous hollow chambers near base of corallum, each chamber corresponding to one septum. Slightly higher on corallum each chamber subdivides into two smaller chambers, one corresponding to each half-system. Each of these smaller chambers (rootlets) communicates with the remainder of the polyp through a small pore or slit between an S_1 and adjacent S_2. The result is a compartmentalized contiguous ring encirling or partially encircling the lower pedicel. In larger specimens the chambers that constitute the 2–4 pairs of rootlets rise 6–7 mm from the base on one side of the corallum, but only 0–2 mm on the other side. Holotype 29.7 × 24.7 mm in calicular diameter and 32.6 mm tall, with an original pedicel diameter of 2.1 mm augmented to 5.3 mm by the rootlets. C_{1-2} slightly ridged for most of theca; C_3 ridged only near calice. Theca smooth and porcellaneous, streaked with reddish brown stripes corresponding to the C_{1-2} and upper C_3. This coloration also continues to the septal faces adjacent to theca.

Septa hexamerally arranged in four complete cycles, the fourth cycle already complete at a greater calicular diameter of 6.5 mm. Septal formula: $S_{1-2}>S_3>S_4$. S_{1-2} highly exsert (up to 5.0 mm), with slightly inclined straight inner edges extending about 0.8 distance to center of fossa. S_3 also exsert (up to 3.1 mm) and similar to the S_{1-2}, reaching about 0.6 distance to center of fossa. S_4 up to 1.5 mm exsert and reach about 0.4 distance to center. Exsertness of septa produces a jagged calicular edge. Septal granules blunt and tall, up to 0.25 mm in height. Fossa deep. Columella composed of an elongate, solid to porous, smooth mass of calcium carbonate joined to the lower inner edges of the S_{1-2}.

DISCUSSION.—Three previously described species belong to *Polymyces: P. fragilis* (Pourtalès, 1868), the type species; *P. montereyensis* (Durham, 1947); and *P. tannerensis* (Durham and Barnard, 1952). *Polymyces wellsi* is similar in thecal pigmentation and septal number to the *tulipa* form of *P. fragilis*, a species known only from the western Atlantic from 75–796 m (see Cairns, 1979), but differs in having irregular development of rootlets, straight septal edges, and much more exsert septa. *Polymyces montereyensis*, known only from off California from 82–110 m, differs in having five cycles of septa, 12 symmetrically arranged rootlets, and relatively nonexsert septa, resulting in a smooth calicular margin. *Polymyces tannerensis*, known only from the holotype from Tanner Bank, California at 82–84 m, is perhaps the most similar to *P. wellsi*, the two species having 48 highly exsert septa and straight inner septal edges. *Polymyces tannerensis* differs, however, in having S_4 more exsert than S_3 (in *P. wellsi* the S_3 are more exsert than the S_4), 12 symmetrically arranged rootlets, and a white corallum.

ETYMOLOGY.—Named in honor of John W. Wells, author of numerous papers on scleractinian taxonomy, including a revision of the Galapagan fauna (Wells, 1983).

MATERIAL EXAMINED.—Holotype: JSL-1916, USNM 84836, Plate 9*a,b*. Paratypes: JSL-1916 (5) USNM 84837, Plate 8*f*; JSL-1921 (2) USNM 84838; JSL-1928 (1) IRCZM; JSL-1935 (1) USNM 84839; ALB-2818 (2) USNM 77273 (*J. pseudoalabastra* of Wells, 1983), Plate 8*i*. Reference Specimens: holotype and paratype of *F. tannerense*, AHF 59.1; holotype of *F. montereyense*, USNM 547406.

TYPE LOCALITY.—1°18.7′S, 89°48.8′W (northwest of Española), 545–562 m.

DISTRIBUTION.—Galápagos: off Fernandina; east of Isabela; Santa Cruz; Española; Genovesa; 391–813 m.

Suborder DENDROPHYLLIINA Vaughan and Wells, 1943

Family DENDROPHYLLIIDAE Gray, 1847

Balanophyllia S.V. Wood, 1844

31. *Balanophyllia galapagensis* Vaughan, 1906

PLATE 9*c-g*

Balanophyllia galapagensis Vaughan, 1906:67–68, pl. 4: fig. 2–2b.—Durham and Barnard,1952:10.—Durham,1962:46; 1966:125.—Wells, 1983:239, pl. 14: figs. 4, 5.

Balanophyllia osburni Durham and Barnard, 1952:100–101, pl. 15: fig. 63a–d.—Durham, 1962:46; 1966:125.—Wells, 1983:239.

DESCRIPTION.—Corallum solitary, ceratoid, and firmly attached through a thick pedicel. Largest specimen examined (USNM 77277) 8.45 × 7.2 mm in calicular diameter, 12.3 mm tall, and 4.7 mm in pedicel diameter. C_{1-3} usually slightly broader than C_4, 0.36 mm vs. 0.25 mm, respectively. Costae slightly convex and granular, separated by deep, thin (0.11 mm) intercostal striae. A very thin epitheca masks the synapticulotheca for a variable percentage (5–85) of the corallum, most extensively developed on the holotype of *B. galapagensis*.

Septa hexamerally arranged in four complete cycles, the largest specimen having an additional pair of S_5 (50 septa) and the holotype of *B. osburni*, virtually the same size, having two pairs of S_5 (52 septa). S_{1-2} of approximately the same size, slightly exsert (up to 1.2 mm), and extend to columella. S_3 rudimentary, only about 0.4 mm exsert, and extend 0.2–0.3 distance to columella. S_4 more exsert (0.8 mm) and broader than S_3, fusing before the S_3 in a broad ($^1/_2$ calicular radius) paliform lobe, which projects slightly into the columella. Septa and pali covered with prominent pointed granules up to 0.08 mm tall. Fossa usually very shallow, containing a large compact elliptical columella composed of fused fascicular elements.

DISCUSSION.—*Balanophyllia galapagensis* and *B. osburni*

are both known from the Galápagos from approximately the same depth range. Durham and Barnard (1952) distinguished *B. osburni* by its deeper fossa, smaller columella, thinner septa, and smaller septal granules. In examining the types of both species it was found that the columellar and septal granules of both species are virtually identical. The fossa of *B. osburni* may be deeper and its septa thinner, but these characters are considered to be within the range of variation of *B. galapagensis*.

MATERIAL EXAMINED.—JSL-1911 (2) USNM 84840; JSL-1914 (5) USNM 84841; JSL-1936 (3) USNM 84842; ALB-4643 (1) holotype of *B. galapagensis*, USNM 68278, Plate 9*c, f;* holotype (Plate 9*e*) and paratype of *B. osburni*, AHF 63.2; AB 18-795 (4) USNM 77277, Plate 9*d,g;* off Onslow, USNM 46965 (Wells, 1983); west of Wolf (3) CAS 66655.

DISTRIBUTION.—Galápagos: off Isabela; Santa Cruz; Floreana; Onslow; Española; and Wolf; 18–462 m.

32. *Balanophyllia eguchii* Wells, 1982

PLATE 9*h-j*

Balanophyllia eguchii Wells, 1982:211-213, pl. 1: figs. 4-6 [synonymy]; 1983:239, pl. 14: figs. 6-8.

DESCRIPTION.—Corallum colonial, small clusters of corallites formed by extratentacular budding from basal coenosteum and directly from corallite theca, augmented by settlement of sexually produced planulae on the colonial coenosteum. Second generation buds not uncommon but third generation buds rare. Corallites cylindrical; calices elliptical to greatly elongate (e.g., 13.5 × 6.5 mm for one on holotypic colony). Theca of corallites covered by thin epitheca for 50%–95% of height, generations of bryozoa keeping pace as the receding edge zone lays the epitheca. Costae equal in width and bear spiny granules. Intercostal striae deep and porous.

Septa basically hexamerally arranged, but total number of septa depends on size of calice: at a greater calicular diameter of 4.0 mm there are 36 septa; 5.5 -7.0 mm, 48 septa; 10.0 mm, 64 septa; and the largest calice 13.5 mm in greater calicular diameter has 80 septa. In 48-septa corallites, S_{1-2} are equal in size, only slightly exsert, and have straight, vertical inner edges, laciniate deep in fossa. S_3 rudimentary and pairs of S_4 meet before the S_3 and extend to the columella but do not form paliform lobes. Inner edges of fused S_4 also laciniate. Fossa deep and elongate. Columella rudimentary, composed of small crispate elements attached to the lowest inner edges of the larger septa.

MATERIAL EXAMINED.—JSL-13-XI-86-1, IRCZM; JSL-16-XI-86-2, USNM 84843, Plate 9*i;* JSL-19-XI-86-4, IRCZM; holotype of *B. eguchii*, USNM 46966, Plate 9*h,j;* off Rábida, USNM 78888 and 79097 (Wells, 1982); "Galápagos," USNM 79096; Champion and Onslow Islands, Floreana, CAS 18927 and 18928 (Wells, 1982); Kaneohe Bay, USNM 79668 (Wells, 1982); off Japan, USNM 78646.

DISTRIBUTION.—Galápagos:off Santiago; Cousin's Rock; Rábida; Santa Cruz; Champion and Onslow, Floreana; Española; 1-27 m. Elsewhere: off Japan; Hawaii; off Queensland, Australia; Gulf of Panama; Malpelo; 7-85 m (Wells, 1982).

Dendrophyllia de Blainville, 1830

33. *Dendrophyllia gracilis* Milne Edwards and Haime, 1848

PLATE 10*a,b*

Dendrophyllia gracilis Milne Edwards and Haime, 1848c:100, pl. 1: fig. 13; 1860:119.—Wells, 1983:240-241, pl. 17: figs. 1-4 [complete synonymy].
?Dendrophyllia sp.—Crossland, 1927:541.

DESCRIPTION OF GALAPAGAN SPECIMENS.—Corallum colonial: small bushy colonies formed primarily by extratentacular budding from edge zone and probably from basal coenosteum, and, to a lesser extent, by equal intratentacular budding (Plate 10*a*). Second generation extratentacular buds not uncommon but third generation buds not observed. Corallites cylindrical, up to 36 mm tall and 13 mm in greater calicular diameter. Calices circular to irregularly elliptical in shape. Costae thin (about 0.14 mm) and "vermiculate," bearing small triangular teeth. Intercostal striae of equal width to costae and relatively deep. Theca porous and relatively thin, never epithecate.

Septa irregular in symmetry. Small corallites hexameral: $S_1 > S_2 > S_4 > S_3$; however, with increase in calicular diameter (e.g., 8–11 mm), pairs of S_5 are gradually added and concurrently the S_2 increase to a size equal to the S_1. Ultimately, a full five cycles are present at a calicular diameter of 13–14 mm, the higher cycle septa arranged in the Pourtalès Plan. Corallites with 8, 9, 10, and 11 primary septa (with a corresponding number of 64, 72, 80, and 88 septa) are therefore not unusual. Septa nonexsert or only slightly so, the higher cycle septa having laciniate inner edges. Inner edges of S_5 do not bear paliform lobes. Fossa extremely deep, containing an irregularly shaped spongy columella of variable size, ranging from quite small to massive.

MATERIAL EXAMINED.—JSL-20-XI-86-2, IRCZM; JSL-21-XI-86-5, IRCZM; off Cousin's Rock and Sullivan's Bay, Santiago, USNM 46971 (Plate 10*a,b*), 79103 (Wells, 1983); off Rábida, CAS 18925 (Wells, 1983); 7-12 m; off Palau, USNM 47223–47230, 46972, 78644; off Australia, USNM 78537; off Singapore, USNM 78531-2; Malaysia, USNM 78533, 78535.

DISTRIBUTION.—Galápagos: off Isabela (Crossland, 1927); Santiago; Rábida; Española (Wells, 1983); 0–12 m. Elsewhere: common throughout Indo-West Pacific, and off eastern Australia; 0–45 m (Wells, 1983).

34. *Dendrophyllia californica* Durham, 1947

PLATE 10*c-e*

Dendrophyllia californica Durham, 1947:37-38, pl. 10: figs. 2, 6.—Durham and Barnard,1952:101-102,pl. 15: fig. 65a,b.—Bythell, 1986:21, pl. 12: figs. e,f.

DESCRIPTION.—Corallum colonial; increase by regular (usu-

ally sympodial) extratentacular budding resulting in large, often uniplanar branches and colonies up to 1 meter tall. Large colonies supported by dense, thick basal branches up to 5 cm in diameter. Calices elliptical, up to 14 × 12 mm in diameter. Costae equal in width and height (approximately 0.6 mm wide), evenly convex and separated by thin intercostal striae. Costae and intercostae solid on branches; however, in vicinity of corallites, costae are vermiculate and intercostae are porous. Costae covered by tiny pointed granules about 0.10 mm in diameter and 0.15 mm tall, arranged in an irregular pattern 2–4 across costal width, producing a rough "sandpaper" texture to branch. Corallum white; coenosarc yellow.

Septa hexamerally arranged in five incomplete cycles, a common arrangement being one pair of S_5 in each half-system, resulting in 72 septa. S_{1-2} approximately equal in size, thin, and solid, their inner edges straight and entire or coarsely dentate. S_3 rudimentary, porous, and dentate. S_4 and S_5, depending on the half-system, also porous, pairs of septa meeting before adjacent lower cycle septa and extending to columella. Inner edges of S_{4-5} laciniate, occasionally having a paliform lobe. Fossa moderately deep (4–5 mm), containing a massive columella composed of an elliptical field of numerous small, swirled elements.

DISCUSSION.—Three nominal species of *Dendrophyllia* are known from the eastern Pacific: *D. oldroydi* Faustino, 1931; *D. californica* Durham, 1947; and *D. cortezi* Durham and Barnard, 1952. A comparison of topotypic specimens of *D. oldroydi* (USNM 38114) to the types of *D. cortezi* (AHF 66.1) show that they are identical, supposed differences cited by Durham and Barnard (1952) and Bythell (1986) notwithstanding. The character of having dentate or smooth S_3 inner edges (?or fused S_4) is variable. *Dendrophyllia californica*, as figured by Durham and Barnard (1952), differs in having less exsert corallites (usually less than 5 mm), which project perpendicular to the main branch, a larger columella, and a more robust corallum. The Galapagan specimens are most similar to *D. californica*, differing only in having larger corallites.

MATERIAL EXAMINED.—JSL-1911, USNM 84844, Plate 10*c–e;* JSL-1932, USNM 84845; JSL-1937, USNM 84846; JSL-1943, IRCZM; JSL-1944, IRCZM. Reference Specimens: topotypes of *D. oldroydi*, USNM 38114; types of *D. cortezi*, AHF 66.1; *Velero* 1254-41, AHF 65.6 (*D. californica* of Durham and Barnard, 1952).

DISTRIBUTION.—Galápagos: off Isabela, Santa Cruz; Cocos Island; 315–576 m. Elsewhere: off Lower California (26°–32°N), 100–228 m.

35. *Dendrophyllia johnsoni*, new species

PLATE 10*f–h*

DESCRIPTION.—Corallum colonial; increase by regular sympodial extratentacular budding. Colony size and pedicel diameter unknown: largest branch (holotype) 8.1 cm long, with 14 corallites. Branches thin and delicate, about 5.8–6.0 mm in diameter; calices round to slightly elliptical, about 6.5 mm in greater calicular diameter and standing 3.0–4.5 mm from main branch. Costae unequal in width and height: primary costae about 0.54 mm in width, others about 0.32 mm wide. Eight primary costae ridged on corallites, the two opposing, transversely oriented primary costae usually more exsert than other six. All costae convex, separated by deep, thin intercostal striae. Costae covered with small pointed granules, giving the coenosteum a rough texture. Costae and intercostal areas of branches solid; however, costae of corallite walls vermiculate, and intercostal areas quite porous. Corallum white.

Septa octamerally arranged in three complete cycles (32 septa). Primary septa slightly exsert, complementing the ridged primary costae: thin in the upper half of the fossa (e.g., 0.6 mm wide) but gradually or abruptly widening to about 1.6 mm halfway down the fossa. Secondary septa not exsert and also very narrow in upper fossa (e.g., 0.4 mm) but also broadening in lower fossa. Inner edges of primary and secondary septa reach the columella. Inner edges of primary septa entire to finely dentate; secondaries coarsely dentate to laciniate; and tertiaries laciniate. Tertiary septa rudimentary in upper fossa, but broadening and joining in pairs to adjacent secondary septa through a porous connection lower in fossa. Fossa relatively deep. Columella rudimentary, composed of several crispate processes fused to the lower inner edges of the primary and secondary septa.

DISCUSSION.—*Dendrophyllia johnsoni* is easily distinguished from the other eastern Pacific branching *Dendrophyllia* by its octameral symmetry, relatively few (32) septa per corallite, small diameter of branches and calices, and unusually shaped septa.

ETYMOLOGY.—Named in honor of Mr. Seward Johnson, Jr., chief executive officer of Harbor Branch Oceanographic Institution and cosponsor of the JSL Galápagos expedition.

MATERIAL EXAMINED.—Holotype: JSL-1911, USNM 84847, Plate 10*f–h*. Paratypes: JSL-1924 (5 branches) USNM 84848.

TYPE LOCALITY.—0°32.7′S, 90°07′W (northeast of Santa Cruz), 426–462 m.

DISTRIBUTION.—Galápagos: seamount north of Santiago, off Santa Cruz; 373–462 m.

Endopachys Lonsdale, 1845

36. *Endopachys grayi* Milne Edwards and Haime, 1848

PLATES 10*i,j*, 11*a,b*

Endopachys grayi.—Umbgrove, 1950:648–650, pl. 82: figs. 1–10, pl. 83: fig. 7 [synonymy and discussion].—Wells, 1983:241.

Endopachys vaughani Durham, 1947:39–40, pl. 11: figs. 6–8, 10, 11.—Durham and Barnard, 1952:103, pl. 16: fig. 67a,b.—Durham, 1962:46.—Hertlein, 1963:231.—Durham, 1966:125.

DESCRIPTION.—Corallum cuneiform and free, the original

scar of attachment usually overgrown by costae. Thecal faces gently rounded, meeting at acute angle at thecal edges, producing a calice lenticular in cross section. Thecal edges bear continuous crests up to 3.0 mm tall. Largest specimen examined (*Velero* 816-38) 40.2 × 16.5 mm in calicular diameter and 38.9 mm tall. Angle of thecal faces about 27°; edge angle, exclusive of crests, 55°–70°. Costae composed of one or two rows of short spines; costae of large coralla up to 0.45 mm wide and separated by shallow furrows about 0.35 mm wide. Thecal porosity only evident in intercostal furrows and exsert portions of S_{1-2}. Corallum white.

Septa hexamerally arranged in four or five cycles (48 or 96 septa) depending on size of calice. S_{1-2} equal in size, slightly exsert, and quite thick (up to 1 mm) at calicular edge. Inner edges of S_{1-2} vertical and entire, merging with columella. S_3 about half as thick and 3/4 as wide as S_{1-2}, also meeting the columella. In large specimens having five cycles of septa, S_4 are the smallest septa, each flanked by pairs of S_5 that are more exsert and wider than the S_4, often fused together before the S_4. The S_5 of each pair that is adjacent to each S_1 and S_2 is more highly exsert and strongly fused to its adjacent lower cycle septum above the calicular edge. Only these S_5 bear paliform lobes lower in fossa, the lobes not separated by notches from their septa. Inner edges of P_5 merge with columella. In smaller specimens having only four cycles of septa, pairs of S_4 merge before the S_3. Fossa deep and elongate. Columella rudimentary.

MATERIAL EXAMINED.—*Velero* 816-38 (1) AHF 67.4 (Durham and Barnard, 1952), Plate 10*i,j;* off Rábida (1) CAS 66652, Plate 11*a,b;* "Galápagos" (1) CAS 66651.

DISTRIBUTION.—Galápagos: Tagus Cove, Isabela; off Rábida; north of Española; 20–183 m; Cocos Island (Durham and Barnard, 1952). Elsewhere: throughout Indo-Pacific, including off California, Hawaii, Indonesia, Philippines, Japan, and Persian Gulf (Umbgrove, 1950); 36–658 m.

Rhizopsammia Verrill, 1870

37. *Rhizopsammia verrilli* van der Horst, 1922

PLATE 11*c–e*

Rhizopsammia verrilli van der Horst, 1922:64, pl. 8: figs. 1, 2.—Wells, 1982:213; 1983:241–242, pl. 15: figs. 1–4.

Balanophyllia scheeri Durham, 1962:46, 53–54, figs. 2b,c, 4, 7.—Hertlein, 1963:231.—Durham, 1966:125.

DESCRIPTION.—Corallites ceratoid to cylindrical; largest specimen examined (USNM 77410) 10.8 × 9.6 mm in calicular diameter, 15.2 mm tall, and 8.3 × 8.1 mm in pedicel diameter. Corallites well separated from one another, interconnected by cylindrical costate stolons 2.5–3.5 mm in diameter, 3 or 4 originating from the base of each corallite. Costae equal in width and coarsely granular; intercostae porous and almost as wide as costae.

Septa hexamerally arranged in five complete cycles, pairs of S_5 consistently developed only in half-systems adjacent to S_1 (well illustrated by Durham, 1962, fig. 2c), resulting in 72 septa per corallite. S_1 large and solid septa, with straight inner edges that project well into fossa and reach columella. S_2 much smaller, but also reach columella lower in fossa. Higher cycle septa arranged according to an exaggerated Pourtalès Plan, their inner edges dentate to laciniate (see Durham, 1962, fig. 2b). Septal faces covered by low pointed granules. Fossa moderately deep. Columella an elongate spongy mass.

DISCUSSION.—Although the type of *R. verrilli* was not examined, a specimen from Cocos Island (USNM 77410) closely matches the description and figures of the type, even to the dimensions of the calices. It is not surprising that Durham (1962) described this species as a *Balanophyllia*. As van der Horst (1922:65) noted, disassociated corallites are "not to be recognized from a *Balanophyllia;*" however, if the corallite base is intact, radiating stolons can usually be seen.

Rhizopsammia verrilli differs from *R. wellingtoni* in having larger and taller corallites, more septa per corallite (72 vs. 48), and isolated corallites united by stolons (vs. clumped corallites united by a basal coenosteum). The specimens of *R. verrilli* reported by Wells (1983) from the Galápagos have numerous pairs of S_5, characteristic of *R. verrilli* but the colonial habit of *R. wellingtoni*. They are tentatively identified as *R. verrilli*.

MATERIAL EXAMINED.—JSL-21-XI-86-3, USNM 84849; "Cocos Island," USNM 77410, Plate 11*c,d;* Marchena, USNM 46968 (Wells, 1983); Wolf, USNM 46933 (Wells, 1983); Floreana, USNM 78889 (Wells, 1983).

DISTRIBUTION.—Galápagos: off Santiago, Floreana, Marchena, Wolf; 6–20 m. Cocos Island; 7–10 m (Durham, 1962). Elsewhere: off Timor, Indonesia; 27–278 m.

38. *Rhizopsammia wellingtoni* Wells, 1982

PLATE 11*f–h*

Rhizopsammia wellingtoni Wells, 1982:213–216, pl. 2: figs. 1–3; 1983:242, pl. 15: figs. 5–7, pl. 16: fig. 1.

DISCUSSION.—No additional specimens of *R. wellingtoni* have been collected since its original description; however, examination of the type specimens allows several additional observations. Much of the extratentacular budding occurs from the lower edges of the corallites as well as from the basal coenosteum. Intratentacular budding also occurs but is rare. Intercostal striae are about half the width of the costae and are only occasionally porous, the theca otherwise being imperforate. Epithecal bands are present only on lower corallite bases, if at all. Inner edges of S_{1-2} entire and vertical; septal faces smooth. Inner edges of S_{3-4} laciniate; S_3 rudimentary, S_4 larger and porous.

Wells (1982) listed the other seven Recent species of *Rhizopsammia*, stating that *R. wellingtoni* is most similar to *R. chamissoi* Wells, 1954, from the Marshall Islands. Comparison of the types of these two species show that although they are similar in size, shape, and columellar structure, *R. chamissoi*

differs in having larger, thicker, and more exsert S_1 (which are perforate near the thecal edge) and coarsely granular costae. Large corallites of *R. chamisoi* have pairs of S_5 in some half-systems, but larger corallites of *R. wellingtoni* probably also have additional septa, the largest paratype corallite (greater calicular diameter = 9 mm) having two pairs of S_5.

MATERIAL EXAMINED.—Holotype (USNM 46969) and paratypes (USNM 46970, Plate 11*f-h*) of *R. wellingtoni;* Gardner Island, CAS 18851 (Wells, 1982), Plate 11*g*. Reference Specimens: types of *R. chamissoi* (USNM 45104-5); syntype of *R. pulchra* Verrill, 1869, YPM 5375.

DISTRIBUTION.—Galápagos: Tagus Cove, Isabela; off Floreana; Onslow; 2-43 m.

Endopsammia Milne Edwards and Haime, 1848

39. *Endopsammia pourtalesi* (Durham and Barnard, 1952)

PLATES 11*i*, 12*a*

Thecopsammia pourtalesi Durham and Barnard, 1952:104-105, pl. 16: fig. 68.—Durham, 1962:46; 1966:125.
Endopsammia pourtalesi.—Wells, 1983:242.

DISCUSSION.—No additional specimens of *E. pourtalesi* have been collected since its original description; however, based on an examination of the type specimens, two observations can be made. Durham and Barnard (1952) reported that the species had four cycles of septa with traces of a fifth; however, the type specimens clearly have only three cycles of septa with traces of a fourth. They also remarked that the S_1 were prominently exsert, but all septa of the types are nonexsert.

Wells (1983), who transferred this species to *Endopsammia*, suggested that it might prove to be a junior synonym of the widespread Indo-West Pacific species *E. philippinensis* Milne Edwards and Haime, 1848. Comparisons to typical *E. philippinensis* (see "Material Examined") show it to be quite different. *Endopsammia pourtalesi* forms quasicolonial coralla consisting of slender (4-6 mm calicular diameter), elongate (up to 2 cm) corallites, infilled with endothecal dissepiments. Coralla of *E. philippinensis* are solitary, relatively squat, and broader (calicular diameters to 8 mm), without endothecal dissepiments. Furthermore, *E. pourtalesi* has only three cycles of nonexsert septa, all about the same size, whereas *E. philippinensis* has up to four cycles of septa, the S_1 exsert and larger than the others.

MATERIAL EXAMINED.—Holotype (Plates 11*i*, 12*a*) and four paratypes of *T. pourtalesi*, AHF 68.1; topotypic specimens from *Velero* 12-32 (1) CAS 29319. Reference Specimens: *E. philippinensis* from Queensland (USNM 78574, 83006) and New Caledonia (USNM 78559).

DISTRIBUTION.—Known only from the type locality west of Baltra, Galápagos; depth unknown.

Enallopsammia Michelotti, 1871

40. *Enallopsammia rostrata* (Pourtalès, 1878)

PLATE 12*b*

Enallopsammia rostrata.—Cairns, 1982:57, pl. 18: figs. 1-4 [synonymy and discussion].
Enallopsammia amphelioides.—Wells, 1983:242-243.

DESCRIPTION.—Only one small branch fragment of this species is known from the Galápagos, reported by Wells (1983) as *E. amphelioides*. This terminal branch fragment consists of two corallites, the larger 2.93 mm in calicular diameter, the branch 6.48 mm long. Costae are equal (about 0.32 mm wide) and vermiculate, separated by thin (about 0.11 mm wide), porous intercostal striae. Corallites not rostrate. Septa hexamerally arranged in three cycles according to the formula $S_1>S_2>S_3$. S_1 not exsert and very thin, extending to base of fossa. S_2 and S_3 about same width in upper fossa, pairs of S_3 fusing with adjacent S_2 within system lower in fossa. Septal faces, especially lower inner edges, highly granular. Fossa deep and curved; columella rudimentary.

DISCUSSION.—*Enallopsammia rostrata* differs from the other three species in the genus (see Zibrowius, 1973) by having calices on only one side of the colony. Cairns (1982) synonymized *E. amphelioides* Alcock, 1902, with *E. rostrata* based on the wide range of variation of rostral development found in Subantarctic populations, a decision upheld based on a later examination of Hawaiian populations (Cairns, 1984). The small specimen from the Galápagos belongs to the nonrostrate (*"amphelioides"*) form of the species.

MATERIAL EXAMINED.—ALB-2818 (1) USNM 36465 (*E. amphelioides* of Wells, 1983), Plate 12*b*.

DISTRIBUTION.—Galápagos: northeast of Santa Cruz; 717 m. Elsewhere: Atlantic, Indo-West Pacific, Subantarctic, Hawaiian Islands (Cairns, 1984); 229-2165 m.

Tubastraea Lesson, 1829

41. *Tubastraea coccinea* Lesson, 1829

PLATE 12*c-e*

Tubastraea coccinea Lesson, 1829:93.—Wells, 1982:216; 1983:243-244, pl. 18: figs. 1, 2 [synonymy and discussion].—Prahl, 1987:230-231, fig. 8.
Astropsammia pedersenii Verrill, 1869:392.—Pourtalès, 1875:283.—Hertlein, 1939: 369.
Placopsammia darwini Duncan, 1876:441.
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.—Durham, 1962:46, 54.—Hertlein, 1963:232.—Durham, 1966:125.
Lobopsammia darwini.—Durham and Barnard, 1952:2, 11.—Durham, 1966:125.

DESCRIPTION.—Colonies roughly spherical, up to 12 cm in diameter, and firmly attached to substrate. Corallites closely spaced, for the most part originating extratentacularly from

TABLE 4.—Comparison of Galápagos *Tubastraea*.

Character	*T. coccinea*	*T. tagusensis*	*T. floreana*	*T. faulkneri*
Septal number and relative exsertness; fusion of septa	$S_{1-2}>S_4>S_3$ (48 septa); in well-developed corallites, pairs of porous S_4 unite before S_3	$S_{1-2}>S_3>S_4$ in small corallites, $S_{1-3}>S_4$ in larger corallites (48 septa); all septa straight	$S_{1-2}>S_3$ (24 septa); all septa straight	$S_1>S_2>S_4>S_3$ (48+ septa); pairs of S_4 join to S_3 in large corallites
Corallites: range of adult calicular diameter; exsertness from coenosteum; spacing	10–13 mm; up to 12 mm; closely spaced	7–10 mm; 3–20 mm; closely spaced	4–6 mm; 2–10 mm; variably spaced: close or widely separated	8–13 mm; 3–8 mm; widely spaced
Inner edges of larger septa	vertical and entire; 12 reach columella	vertical and entire, but with horizontal paliform lobes near columella; 12–24 septa attain columella	vertical, entire, or laciniate; 12 reach columella	vertical, slightly exsert and entire; 12–24 reach columella
Columella	large, spongy	variable in size: usually rudimentary but may be quite large	rudimentary	large
Fossa	moderately deep	deep	moderately deep	shallow

intercorallite coenosteum. Adult corallites 10–13 mm in greater calicular diameter and project up to 12 mm above coenosteum; calices elliptical. Costae equal in width and usually finely granular, separated by equally wide, porous intercostal grooves.

Septa hexamerally arranged in four complete cycles. S_{1-2} nonexsert and equal in size, much larger than other higher cycle septa, their inner edges vertical and straight, attaining the columella. Faces of S_{1-2} bear very fine granules and, at low magnification, appear smooth. S_3 rudimentary, with laciniate inner edges. S_4 approximately same size and shape as S_3, except in larger corallites, where pairs of larger S_4 unite before adjacent S_3 and extend toward columella as a porous lamella. Fossa moderately deep. Columella large, composed of a mass of slender, irregularly shaped, crispate elements.

DISCUSSION.—Table 4 compares the characters of the four species of *Tubastraea* known from the Galápagos. The species are most easily distinguished based on their number of septa and relative width and exsertness of various cycles. Other useful characters include corallite size, septal shape, columella size, and fossa depth. Costal ornamentation does not appear to be a distinguishing character. *Tubastraea coccinea* is most easily distinguished from the other Galapagan species by its large difference in size between the S_{1-2} and S_{3-4}, and by its relatively large corallites.

MATERIAL EXAMINED.—JSL-28-XI-86-1, USNM 84850; JSL-30-XI-86-2, IRCZM; JSL-30-XI-86-3, IRCZM; AB 16-66128, USNM 77267 (Wells, 1983); AB 16-66132, USNM 77264-5, Plate 12*c–e;* Sullivan Bay, Santiago, USNM 77259 (Wells, 1983); off Santa Fe, USNM 77263, 77266; Daphne Menor, USNM 77257 (Wells, 1983); Darwin, USNM 79104 (Wells, 1983); Tagus Cove, USNM 77258; Cousin's Rock, Bartolomé, USNM 46973 (Wells, 1983); Española, AHF 69.1 (*T. tenuilamellosa* of Durham and Barnard, 1952); Santiago, CAS 66640; Floreana, CAS 66648 (*T. tenuilamellosa* of Durham, 1947); Santa Cruz, CAS 66644; holotype of *Astropsammia pedersenii*, USNM 38354.

DISTRIBUTION.—Galápagos: Tagus Cove, Isabela; Pleistocene (Hertlein, 1939) and Recent of Santiago; Bartolomé; Santa Cruz; Baltra; Daphne Menor; Santa Fe; Floreana; Española; Wolf; Darwin; Cocos Island; 1.5–54 m. Elsewhere: circumtropical; 2–110 m (see Wells, 1983:243).

42. *Tubastraea faulkneri* Wells, 1982

PLATE 12*j*

Tubastraea faulkneri Wells, 1982:216, pl. 3: figs. 1-3 [synonymy]; 1983:244, pl. 19: figs. 1-4.

DISCUSSION.—Little can be added to the original description of Wells (1982) concerning this species, as no additional specimens have been collected. It is distinguished from the other Galapagan species (Table 4) by its larger corallites and its prominent, slightly exsert S_1.

MATERIAL EXAMINED.—Only one specimen of this species has been reported from the Galápagos (Wells, 1982), from 3–5 m in Tagus Cove, Isabela. This specimen was later illustrated by Wells (1983, pl. 19: fig. 4), as an in situ underwater photograph. The deposition of this specimen, if it was collected, is unknown and therefore confirmation of this species from the Galápagos is still needed. Other Material Examined: holotype (USNM 47145) from Palau and other specimens of *T. faulkneri* reported by Wells (1982) USNM 62570, Plate 12*j*.

DISTRIBUTION.—Galápagos: ?Tagus Cove, Isabela; 3–5 m. Elsewhere: Palau, Banda, Amboina, Philippines.

43. *Tubastraea tagusensis* Wells, 1982

PLATE 12*f,g*

Tubastraea tagusensis Wells, 1982:216-218, pl. 4: figs. 1-4 [synonymy]; 1983:244-245, pl. 20: figs. 1-6.
Tubastraea floreana Wells, 1982:218 [part: specimen from Pinzón].

DESCRIPTION.—Colonies roughly spherical in shape, up to 13 cm in diameter, and firmly attached to substrate. Corallites relatively closely spaced; intratentacular budding from intercorallite coenosteum. Large corallites 7-10 mm in greater calicular diameter and project up to 20 mm above coenosteum; however, some colonies have uniformly short (2-3 mm) corallites. Calices circular to slightly elliptical. Costae equal in width (C_{1-2} sometimes slightly ridged) and usually finely granular, separated by relatively thin, porous intercostal grooves.

Septa of smaller corallites arranged according to the formula $S_{1-2}>S_3>S_4$, the S_{3-4} having laciniate inner edges. S_3 of larger corallites accelerated to size of S_{1-2}, i.e., $S_{1-3}>S_4$, the S_4 having laciniate inner edges. Inner edges of S_{1-3} entire and vertical, except near columella where they expand into irregular horizontal paliform lobes. Inner edges of all septa straight; no fusion of higher cycle septa occurs. Fossa deep. Columella variable in size: usually rudimentary, composed of lower, inner edges of S_{1-3}, but occasionally robust.

DISCUSSION.—*Tubastraea tagusensis* is distinguished from the other Galapagan species by having four cycles of straight septa, irregular paliform lobes on the lower cycle septa, and corallites of intermediate calicular diameter (Table 4).

MATERIAL EXAMINED.—Holotype and paratype of *T. tagusensis*, USNM 46977 and 46979; numerous specimens from Tagus Cove, Isabela (USNM 77268-69, 78877-78, 80-84, 86, CAS 18996 (Wells, 1983), Plate 12*f,g;* Daphne Menor, USNM 77256 (Wells, 1982); Pinzón, USNM 19151 (*T. floreana* of Wells, 1982).

DISTRIBUTION.—Galápagos: Tagus Cove, Isabela; Santiago; Pinzón; Daphne Menor; 1-43 m. Elsewhere: Nicobar; Palau (Wells, 1982).

44. *Tubastraea floreana* Wells, 1982

PLATE 12*h,i*

Tubastraea floreana Wells, 1982:218, pl. 4: figs. 5, 6 [not specimen from Pinzón]; 1983:245, pl. 18: figs. 3-6.

DESCRIPTION.—Colonies irregular in shape, up to 10 cm in width, and firmly attached. Corallites closely spaced; intratentacular budding from basal coenosteum and, not infrequently, from sides of other corallites. Corallites 4-6 mm in greater calicular diameter and project 2-10 mm above coenosteum. Calices circular to slightly elliptical. Costae equal in width, separated by thin, porous intercostal furrows. Costae and coenosteum distinctly granular. Corallum white; polyps bright pink.

Septa hexamerally arranged in three cycles: $S_{1-2}>S_3$. Inner edges of S_{1-2} vertical, entire or laciniate, and straight, attaining the columella. S_3 rudimentary, with laciniate inner edges. Fossa moderately deep. Columella rudimentary.

DISCUSSION.—*Tubastraea floreana* is distinguished from the other Galapagan *Tubastraea* by having only three cycles of septa and relatively small corallites (Table 4).

MATERIAL EXAMINED.—Holotype of *T. floreana*, USNM 46974; Gardner Island, Española, USNM 78885, Plate 12*h,i;* off Floreana, USNM 46975; off Caleta Iguana, USNM 46976 and 78879 (all Wells, 1982); Buccaneer Cove, Santiago, USNM 77261.

DISTRIBUTION.—Galápagos: Caleta Iguana, Isabela; Santiago; Pinzón; Floreana; Española; 2-5 m.

Appendix

Station List

Station	Latitude	Longitude (°W)	Depth (m)	Date	Bottom temp. (°C)
		Johnson-Sea-Link I (JSL)			
1911	0°32.7′S	90°07.0′	426–462	12 Nov 1986	8.3–10.3
1913	1°32.7′S	90°25.8′	84–227	14 Nov 1986	13.5–14.5
1914	1°17.3′S	90°17.4′	166–172	15 Nov 1986	14.3–14.4
1915	1°17.2′S	89°48.7′	650–652	15 Nov 1986	7.4–10.8
1916	1°18.7′S	89°48.8′	545–562	16 Nov 1986	7.3–10.8
1920	1°46.6′S	89°30.8′	64–104	17 Nov 1986	
1921	0°17.0′N	89°59.8′	680–720	18 Nov 1986	6.0–6.7
1922	0°23.7′N	90°26.3′	475–578	19 Nov 1986	7.3–8.9
1924	0°03.9′N	90°19.2′	373–430	20 Nov 1986	
1926	0°15.5′N	90°32.5′	395–429	21 Nov 1986	9.2–9.4
1927	0°10.5′S	90°53.3′	708–784	21 Nov 1986	5.6–6.5
1928	0°15.2′S	91°06.9′	720–813	22 Nov 1986	5.0–7.5
1929	0°14.7′N	91°36.5′	806	23 Nov 1986	5.7–9.3
1931	0°10.3′S	91°24.7′	441–525	24 Nov 1986	7.9–8.0
1932	0°15.1′S	91°27.7′	313–315	24 Nov 1986	10.4–12.2
1933	0°17.1′S	91°40.2′	663–788	25 Nov 1986	6.0–7.0
1935	0°15.2′S	91°27.9′	252–308	25 Nov 1986	7.8–9.0
1936	0°40.7′S	91°24.0′	182–224	26 Nov 1986	12.5–14.4
1937	0°59.8′S	91°27.1′	315–316	27 Nov 1986	11.2–12.6
1938	5°24.5′N	87°24.5′	614–785	30 Nov 1986	5.8
1939	5°34.8′N	87°03.6′	105–158	30 Nov 1986	13.7–15.1
1941	5°33.4′N	87°06.3′	286–316	1 Dec 1986	11.2–12.1
1942	5°34.6′N	87°04.3′	606–628	2 Dec 1986	6.7–7.1
1943	5°26.1′N	87°08.0′	303–333	2 Dec 1986	11.9
1944	5°28.1′N	87°08.0′	293–576	3 Dec 1986	7.7–8.3
		SCUBA localities operating from JSL			
13-XI-86-1	1000 m east Daphne Menor		7.6	13 Nov 1986	
16-XI-86-2	Pt. Suarez, Española		9–21	16 Nov 1986	
19-XI-86-4	off NW Marchena		0–5	19 Nov 1986	
20-XI-86-2	N of Bartolomé		6–26	20 Nov 1986	
21-XI-86-3	Baldridge I., Santiago		6–20	21 Nov 1986	
21-XI-86-5	Perry Isthmus, Isabela		0–3	21 Nov 1986	
28-XI-86-1	Academy Bay, Santa Cruz		1–3	28 Nov 1986	
30-XI-86-2	Isla Manuelita, Cocos I.		27	30 Nov 1986	
30-XI-86-3	Chatham Bay, Cocos I.		15	30 Nov 1986	
1-XII-86-2	Islas Dos Amigos, Cocos I.		27	1 Dec 1986	
		U.S.F.C.S. *Albatross* (ALB)			
2808	0°36.5′S	89°19.0′	1159	4 Apr 1888	26.1
2816	1°17.0′S	90°31.5′	144	9 Apr 1888	
2818	0°29.0′S	89°54.5′	717	15 Apr 1888	6.6
3170	38°17.0′N	123°29.0′	305	28 Mar 1890	
3187	36°14.0′N	121°58.7′	545	3 Apr 1890	5.1
3188	36°08.3′N	121°49.7′	578	3 Apr 1890	7.2
3358	6°30.0′N	81°44.0′	1015	24 Feb 1891	4.5

U.S.F.C.S. *Albatross* (ALB)—continued.

3367	5°31.5′N	86°52.5′	183	28 Feb 1891	13.9
3368	5°32.8′N	86°54.5′	121	28 Feb 1891	14.6
3370	5°36.7′N	86°56.9′	245	28 Feb 1891	12.7
3401	0°59.0′S	88°58.5′	722	28 Mar 1891	6.6
4642	1°30.5′S	89°35.0′	549	7 Nov 1904	9.3
4643	1°29.0′S	89°48.5′	183	7 Nov 1904	19.5
4784	52°55.7′N	173°26.0′	108	11 Jun 1906	
		Anton Bruun (AB)			
16-66128	0°44.8′S	90°18.5′	12–14	23 May 1966	
16-66132	0°15.9′S	91°22.9′	1–15	24 May 1966	
18-794	0°12.0′S	90°51.0′	34	24 Sep 1966	
18-795	0°37.0′S	90°51.0′	78	24 Sep 1966	

Literature Cited

Alcock, A.

1902. Report on the Deep-Sea Madreporaria of the *Siboga*-Expedition. *Siboga-Expedition*, 16a: 52 pages, 5 plates.

Briggs, J.C.

1974. *Marine Zoogeography*. x + 475 pages. New York: McGraw-Hill Book Company.

Broderip, W.J.

1828. Description of *Caryophillia smithii* n. sp. *Zoological Journal*, 3:485–486, plate 13.

Bythell, J.C.

1986. A Guide to the Identification of the Living Corals (Scleractinia) of Southern California. *Occasional Papers of the San Diego Society of Natural History*, 16: 40 pages, 12 plates.

Cairns, S.D.

1979. The Deep-Water Scleractinia of the Caribbean Sea and Adjacent Waters. *Studies on the Fauna of Curaçao and other Caribbean Islands*, 180: 341 pages, 40 plates.

1981. Marine Flora and Fauna of the Northeastern United States: Scleractinia. *NOAA Technical Report, NMFS Circular*, 438: 14 pages, 16 figures.

1982. Antarctic and Subantarctic Scleractinia. *Antarctic Research Series*, 34(1): 74 pages, 18 plates, 14 maps.

1984. New Records of Ahermatypic Corals (Scleractinia) from the Hawaiian and Line Islands. *Occasional Papers of the Bernice Pauahi Bishop Museum*, 25(10): 30 pages, 5 plates.

1986. Stylasteridae (Hydrozoa: Hydroida) of the Galápagos Islands. *Smithsonian Contributions to Zoology*, 426: 42 pages, 27 figures.

1989. A Revision of the Ahermatypic Scleractinia of the Philippine Islands and Adjacent Waters, Part 1: Fungiacyathidae, Micrabaciidae, Turbinoliinae, and Flabellidae. *Smithsonian Contributions to Zoology*, 486: 136 pages, 3 figures, 42 plates.

Chevalier, J.-P.

1961. Recherches sur les Madréporaires et les formations récifales miocènes de la Méditerranée Occidentale. *Mémoires de la Société Géologique de France*, new series, 40(93): 562 pages, 203 figures, 26 plates.

1987. Ordre des Scléractiniaires: Systématique. *In* P.-P. Grassé, editor, *Traité de Zoologie*, 3(3):679–753, figures 400–418. Paris: Masson.

Crossland, C.

1927. Marine Ecology and Coral Formations in the Panama Region, the Galápagos and Marquesas Islands, and the Atoll of Napuka. *In* The Expedition to the South Pacific of the S.Y. *St. George*. *Transactions of the Royal Society of Edinburgh*, 55(2):531–554.

Duncan, P.M.

1873. A Description of the Madreporaria dredged up during the Expeditions of H.M.S. "Porcupine" in 1869 and 1870, Part 1. *Transactions of the Zoological Society of London*, 8(5):303–344, plates 39–49.

1876. Notices of Some Deep-Water and Littoral Corals from the Atlantic Ocean, Caribbean, Indian, New-Zealand, Persian Gulf, and Japanese &c. Seas. *Proceedings of the Zoological Society of London*, 1876:428–442, plates 38–41.

Durham, J.W.

1947. Corals from the Gulf of California and the North Pacific Coast of America. *The Geological Society of America Memoir*, 20: 68 pages, 14 plates.

1957. Additional Notes on the Invertebrate Fauna of Clipperton Island. Coelenterata. *In* L.G. Hertlein and W.K. Emerson, *American Museum Novitates*, 1859:7–8.

1962. Corals from the Galápagos and Cocos Islands. *Proceedings of the California Academy of Sciences*, (4)32(2):41–56, 9 figures.

1966. Coelenterates, Especially Stony Corals, from the Galápagos and Cocos Islands. *In* Bowman, editor, *The Galápagos—Proceedings of the Symposium of the Galápagos International Scientific Project*, 15:123–135. University of California Press.

Durham, J.W., and J.L. Barnard

1952. Stony Corals of the Eastern Pacific Collected by the *Velero III* and *Velero IV. Allan Hancock Pacific Expeditions*, 16(1): 110 pages, 16 plates.

Eguchi, M.

1968. *The Hydrocorals and Scleractinian Corals of Sagami Bay Collected by His Majesty the Emperor of Japan*. xv + 221 pages, 70 plates. Tokyo: Mazuren Company.

Ekman, S.

1953. *Zoogeography of the Sea*. xiv + 417 pages. London: Sidgwick & Jackson.

Gardiner, J.S., and P. Waugh

1939. Madreporaria Excluding the Flabellidae and Turbinolidae. *John Murray Expedition Scientific Reports*, 6(5):225–242, plates 1–2.

Glynn, P.W., and G.M. Wellington

1983. *Corals and Coral Reefs of the Galápagos Islands*. xvi + 330 pages. Berkeley: University of California Press.

Hertlein, L.G.

1963. Contribution to the Biology of Cocos Island, Including a Bibliography. *Proceedings of the California Academy of Science*, (4)32(8):219–289, 4 figures.

Hertlein, L.G., and A.M. Strong

1939. Marine Pleistocene Mollusks from the Galápagos Islands. *Proceedings of the California Academy of Sciences*, (4)23(24):367–380, plate 32.

Keith, M.L., and J.N. Weber

1970. Vital Effects on the Carbonate Isotopic Composition of Reef Communities. *In* E. Tongiori, editor, *Stable Isotopes in Oceanographic Studies and Paleotemperatures*, pages 267–284. Pisa, Italy.

Keller, N.B.

1981. Interspecies Variability of *Caryophyllia* in Connection with Their Environment. *Trudy Institute of Okeanology*, 115:14–25, 2plates. [In Russian.]

Lesson, R.P.

1829. *Voyage autour du monde sur La Coquille, pendant les années 1822, 1823, 1824, et 1825, Zoologie*, 2(2) Zoophytes. Paris: A. Bertrand.

Marenzeller, E. von

1904a. Steinkorallen. *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898-1899*, 7(3):261–318, plates 14–18.

1904b. Reports on the Dredging Operations off the West Coast of Central America to the Galápagos ... by the U.S. Fish Commission Steamer *"Albatross"* During 1891, Stein- und Hydro-Korallen. *Bulletin of the Museum of Comparative Zoology*, 43(2):75–87, 3 plates.

Milne Edwards, H., and J. Haime

1848a. Recherches sur les Polypiers, mémoir 1: Observations sur la structure et le developpement des Polypiers en general. *Annales des Sciences Naturelles, Zoologie*, series 3, 9:37–89, plates 4–6.

1848b. Recherches sur les Polypiers, mémoir 2: Monographie des Turbinolides. *Annales des Sciences Naturelles, Zoologie*, series 3, 9:211–

344, plates 7–10.

1848c. Recherches sur les Polypiers, mémoir 3: Monographie des Eupsammidae. *Annales des Sciences Naturelles, Zoologie*, series 3, 10:65–114, 1 plate.

1860. *Histoire naturelle des Coralliaires ou Polypes proprement dits*. Volume 3, 566 pages. Paris: Roret.

Moseley, H.N.

1881. Report on Certain Hydroid, Alcyonarian, and Madreporarian Corals Procured During the Voyage of *H.M.S.Challenger*, in the Years 1873–1876. *Report on the Scientific Results of the Voyage of H.M.S.Challenger During the Years 1873-76, Zoology*, 2: 248 pages, 17 figures, 32 plates.

Palmer, R.H.

1928. Fossil and Recent Corals and Coral Reefs of Western Mexico, Three New Species. *Proceedings American Philosophical Society*, 67(1):21–31, 3 plates.

Pourtalès, L.F.

1875. Corals of the Galápagos Islands. *American Journal of Science*, (3)10:282–283.

Prahl, H. von

1987. Corales ahermatípicos colectados en el Pacífico Colombiano. *Revista de Biologia Tropical*, 35(2):227–232.

Reed, J.K.

1980. Distribution and Structure of Deep-Water *Oculina varicosa* Coral Reefs off Central Eastern Florida. *Bulletin of Marine Science*, 30(3):667–677.

Squires, D.F.

1958. The Cretaceous and Tertiary Corals of New Zealand. *New Zealand Geological Survey Paleontological Bulletin*, 29: 107 pages, 16 plates.

1959. Results of the Puritan-American Museum of Natural History Expedition to Western Mexico, 7: Corals and Coral Reefs in the Gulf of California. *Bulletin of the American Museum of Natural History*, 118(7):371–431, 20 figures.

Tenison-Woods, J.E.

1878. On the Extratropical Corals of Australia. *Proceedings of the Linnaean Society of New South Wales*, 2:292–341, plates 4–6.

Thompson, T.G.

1958. Thomas Wayland Vaughan. *National Academy of Sciences Biographical Memoirs*, 32:398–437.

Umbgrove, J.H.F.

1950. Corals from the Putjangan Beds (Lower Pleistocene) of Java. *Journal of Paleontology*, 24(6):637–651, plates 81–84.

van der Horst, C.J.

1922. The Madreporaria of the *Siboga* Expedition, Part 3: Eupsammidae. *Siboga-Expeditie*, 16c:45–75, plates 7, 8.

Vaughan, T.W.

1906. Reports on the Scientific Results of the Expedition to the Eastern Tropical Pacific ... by the U.S. Fish Commission Steamer *"Albatross"* from October, 1904, to March, 1905, VI: Madreporaria. *Bulletin of the Museum of Comparative Zoology*, 50:61–72, 9 plates.

1917. The Reef-Coral Fauna of Carizzo Creek Imperial County, California and Its Significance. *United States Geological Survey Professional Paper*, 98T:353–387, plates 94–102.

Verrill, A.E.

1866. On the Polyps and Corals of Panama with Descriptions of New Species. *Proceedings of the Boston Society of Natural History*, 10:323–357.

1869. On New and Imperfectly Known Echinoderms and Corals. *Proceedings of the Boston Society of Natural History*, 12:381–396.

1870. Notes on Radiata in the Museum of Yale College, Number 6: Review of the Corals and Polyps of the West Coast of America. *Transactions of the Connecticut Academy of Arts and Sciences*, 1:377–558, plates 4–10.

Wells, J.W.

1954. Recent Corals of the Marshall Islands. *Geological Survey Professional Paper*, 260-I:382–486, plates 94–185.

1956. Scleractinia. *In* R.C. Moore, editor, *Treatise of Invertebrate Paleontology, Part F: Coelenterata*, F328–F444, figures 222–339. New York: Geological Society of America.

1973. New and Old Scleractinian Corals from Jamaica. *Bulletin of Marine Science*, 23(1):16–58.

1982. Notes on Indo-Pacific Scleractinian Corals, Part 9: New Corals from the Galápagos Islands. *Pacific Science*, 36(2):211–219, 4 plates.

1983. Annotated List of the Scleractinian Corals of the Galápagos. *In* P.W. Glynn and G.M. Wellington, *Corals and Coral Reefs of the Galápagos Islands*, pages 212–291, 21 plates.

Yabe, H., and M. Eguchi

1942. Fossil and Recent Simple Corals from Japan. *Science Reports of the Tôhoku Imperial University*, series 2 (Geology), 22(2):105–178, plates 9–12.

Zibrowius, H.

1973. Revision des espèces actuelles du genre *Enallopsammia* Michelotti, 1871, et description de *E. marenzelleri*, nouvelle espèce Bathyle à Large Distribution. *Beaufortia*, 21(276):37–54, 3 plates.

1974a. Scléractiniares des Îles Saint Paul et Amsterdam (Sud de l'Océan Indien). *Tethys*, 5(4):747–777, 3 plates.

1974b. Révision du genre *Javania* et considérations générales sur les Flabellidae (Scléractiniaires). *Bulletin de l'Institut Océanographique, Monaco*, 71(1429): 48 pages, 5 plates.

1974c. *Oculina patagonica*, Scléractiniaire hermatypique introduit en Méditerranée. *Helgoländer Wissenschaftliche Meersuntersuchungen*, 26:153–173.

1974d. *Caryophyllia sarsiae* n. sp. and Other Recent Deep-Water *Caryophyllia* (Scleractinia) Previously Referred to Little-Known Fossil Species (*C. arcuata, C. cylindracea*). *Journal of the Marine Biological Association of the United Kingdom*, 54:769–784, 3 plates.

1980. Les Scléractiniares de la Méditeranée et de l'Atlantique Nord-Oriental. *Mémoires de l'Institut Océanographique, Monaco*, 11: 284 pages, 107 plates.

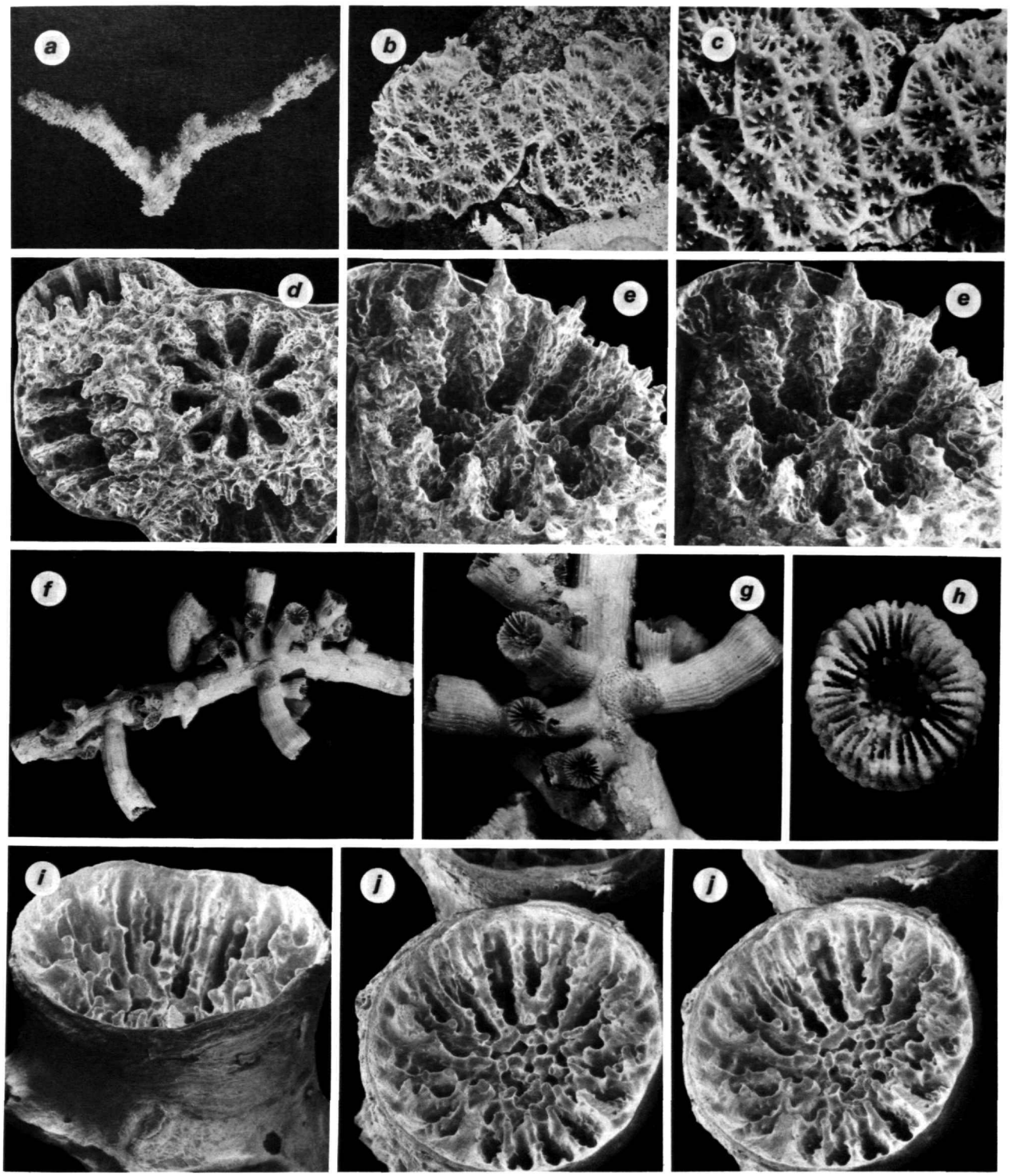


PLATE 1.—*a*, *Madracis* sp. cf. *M. asperula*, *Velero* 201-34, AHF 1.1 (see Durham and Barnard, 1952), terminal branch, ×2.2. *Madracis* sp. cf. *M. pharensis* (*b,c*, Gardner Island, Floreana, CAS 66645 (see Wells, 1983); *d,e*, JSL-1920, USNM 84775): *b,c*, enlargements of same colony, ×2.8, ×5.9, respectively; *d,e*, enlargements of same small colony, ×21, ×34, respectively (*e* is a stereo pair). *f-h*, holotype of *Cladocora pacifica*, new species (*C. arbuscula* of Marenzeller, 1904b), ALB-3367, USNM 84776, ×1.1, ×2.2, ×8.0, respectively. *i,j*, *Culicia* sp. cf. *C. rubeola*, JSL-1-xII-86-2, USNM 80850, lateral and stereo calicular views, ×18, ×15.5, respectively.

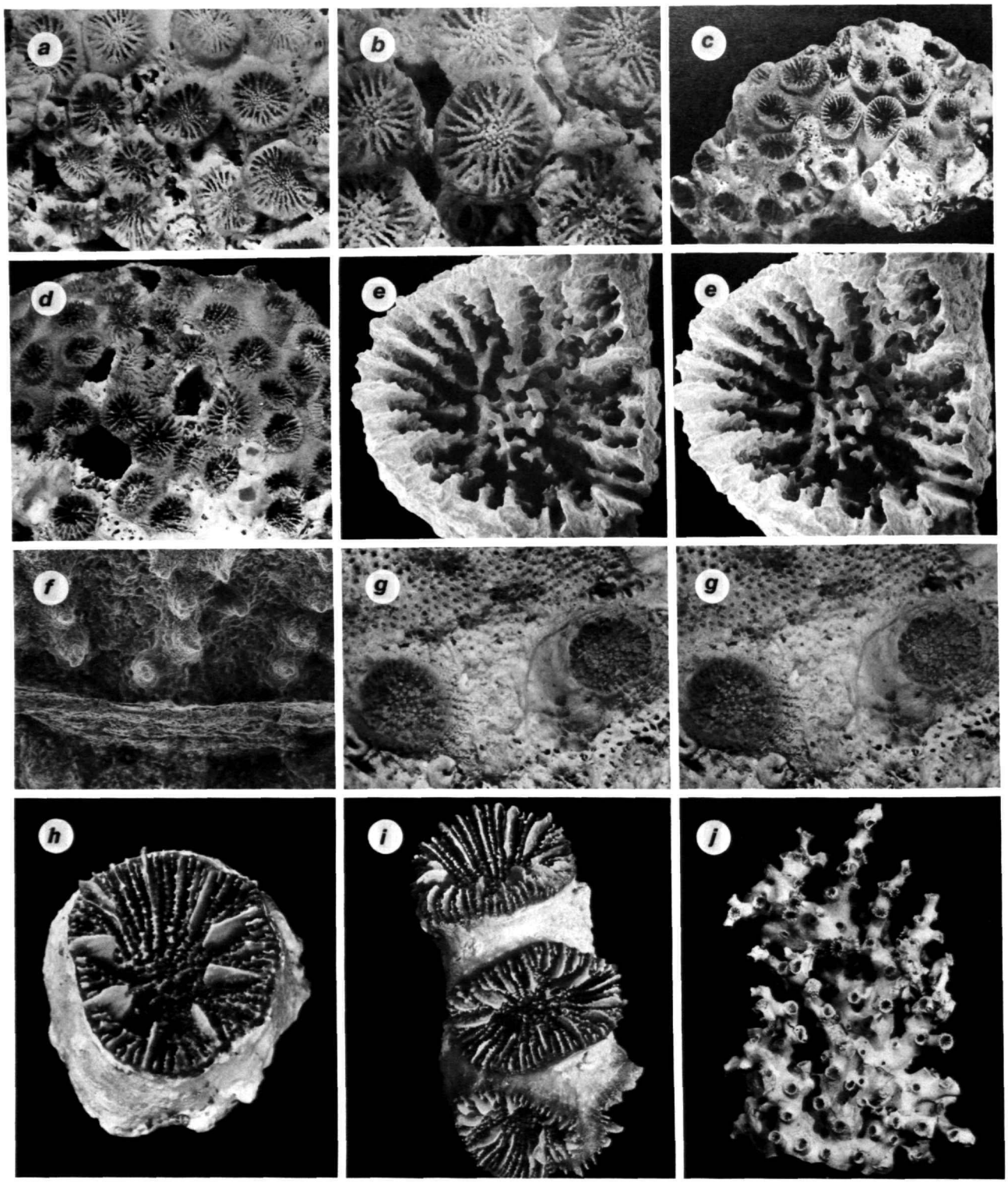


PLATE 2.—*a,b, Astrangia browni*, Caleta Iguana, USNM 46958 (see Wells, 1983), enlargements of same colony, ×2.9, ×4.1, respectively. *Astrangia equatorialis* (*c*, holotype of *A. equatorialis*, *Velero* 31-33, AHF 29.1; *d*, Caleta Iguana, also USNM 46958 (see Wells, 1983); *e, f*, "Galapagos," USNM 78890): *c,d*, corallites, ×2.2, ×3.0, respectively; *e*, stereo calicular view, ×17; *f*, border of lower epitheca with upper costae, ×87. *g*, *Astrangia dentata*, stereo view of syntypes, YPM 5376, ×7.3. *h,i*, *Oulangia bradleyi*, west of Punta Albemarle (see Wells, 1983), USNM 46959, ×3.6, ×2.8, respectively. *j*, syntype of *Madrepora galapagensis* (= *M. oculata* forma *galapagensis*), ALB-4642, USNM 68276, ×0.62.

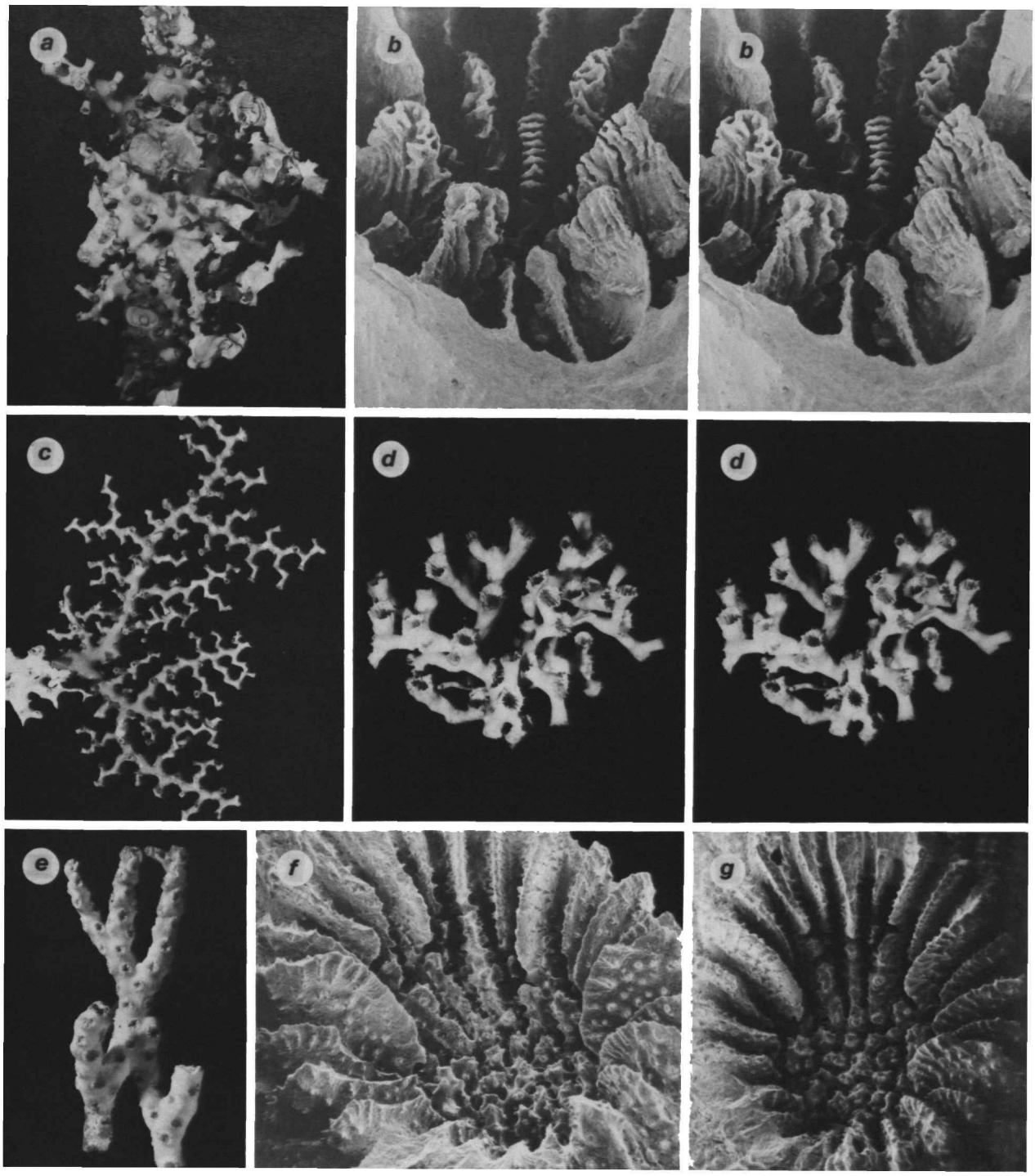


PLATE 3.—*a*, *Madrepora oculata* forma *alpha*, JSL-1916, USNM 84786, ×0.65. *b*, *M. oculata* forma *galapagensis*, JSL-1914, USNM 84783, broken calice revealing ornate P2, stereo pair, ×21.3. *c*, *M. oculata* forma *beta*, ALB-2818, USNM 36377, ×0.45. *d*, *M. oculata* forma *gamma*, Tagus Cove (*M. galapagensis* of Wells, 1983), USNM 46961, stereo pair, ×1.0. *Oculina profunda*, new species (*e*, holotype, ALB-3170, USNM 84792; *f,g*, paratype, ALB-3188, USNM 36372): *e*, holotype, ×0.87; *f,g*, calicular views, ×29, ×23, respectively.

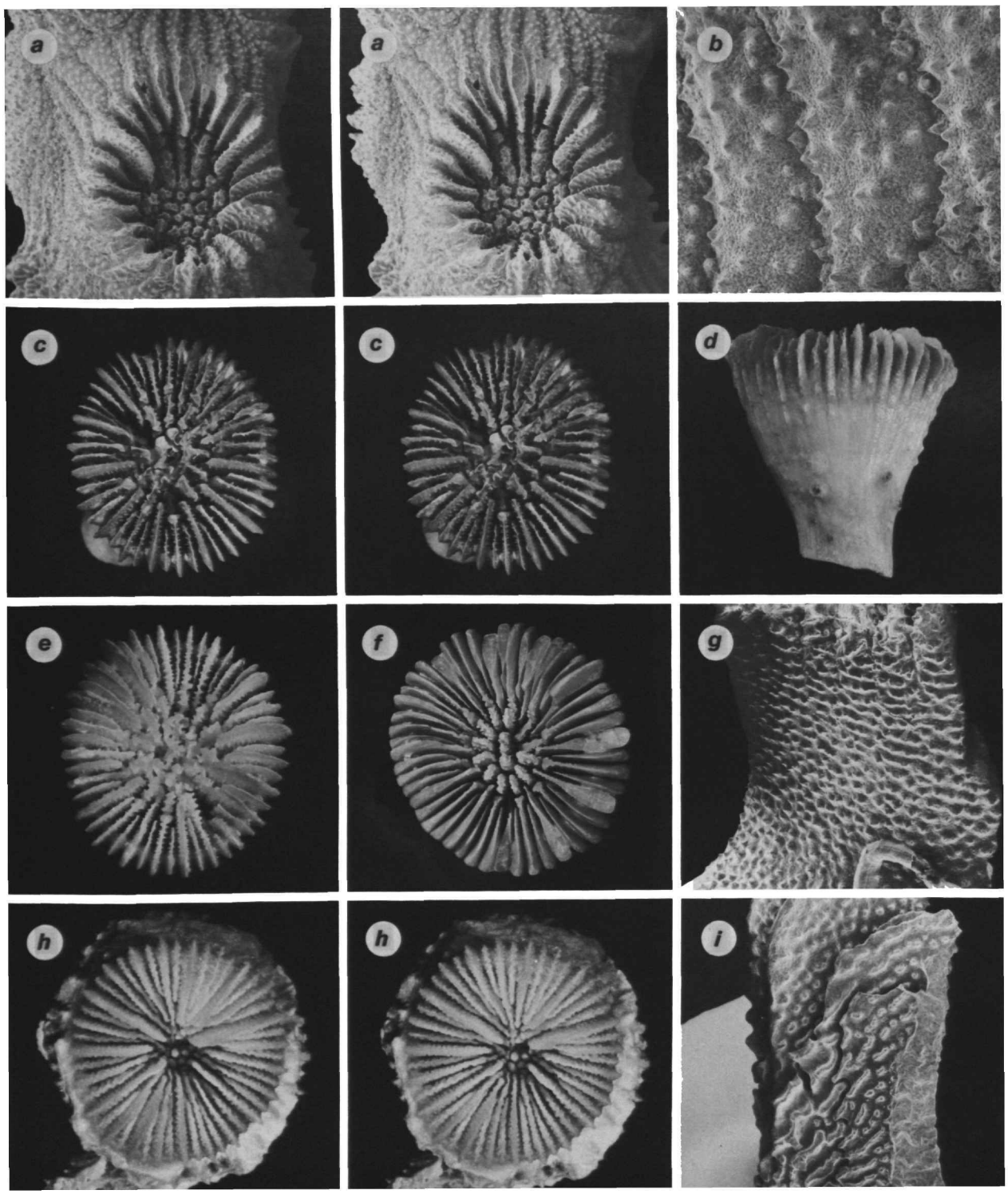


PLATE 4.—*a,b, Oculina profunda,* new species, paratype, ALB-3188, USNM 36372, stereo calicular view and granular costae, respectively, ×13.7, ×55. *Caryophyllia diomedeae* (*c,d,* originally figured syntype, ALB-3358, USNM 22083; *e,* JSL-1938, USNM 84796): *c,d,* stereo calicular and lateral views, ×3.7, ×3.1, respectively; *e,* calicular view, ×3.7. *f, Caryophyllia sarsiae, Thalassa* Z435 (48°39′N, 9°53′W, 1050 m), USNM 45743, ×2.25. *Concentrotheca vaughani* (*g,i,* paratype, JSL-1932, USNM 84803; *h,* holotype, JSL-1937, USNM 84802): *g,* granular theca, ×18.9; *h,* stereo calicular view, ×6.4; *i,* broken corallum revealing carinate septal and palar faces, ×17.5.

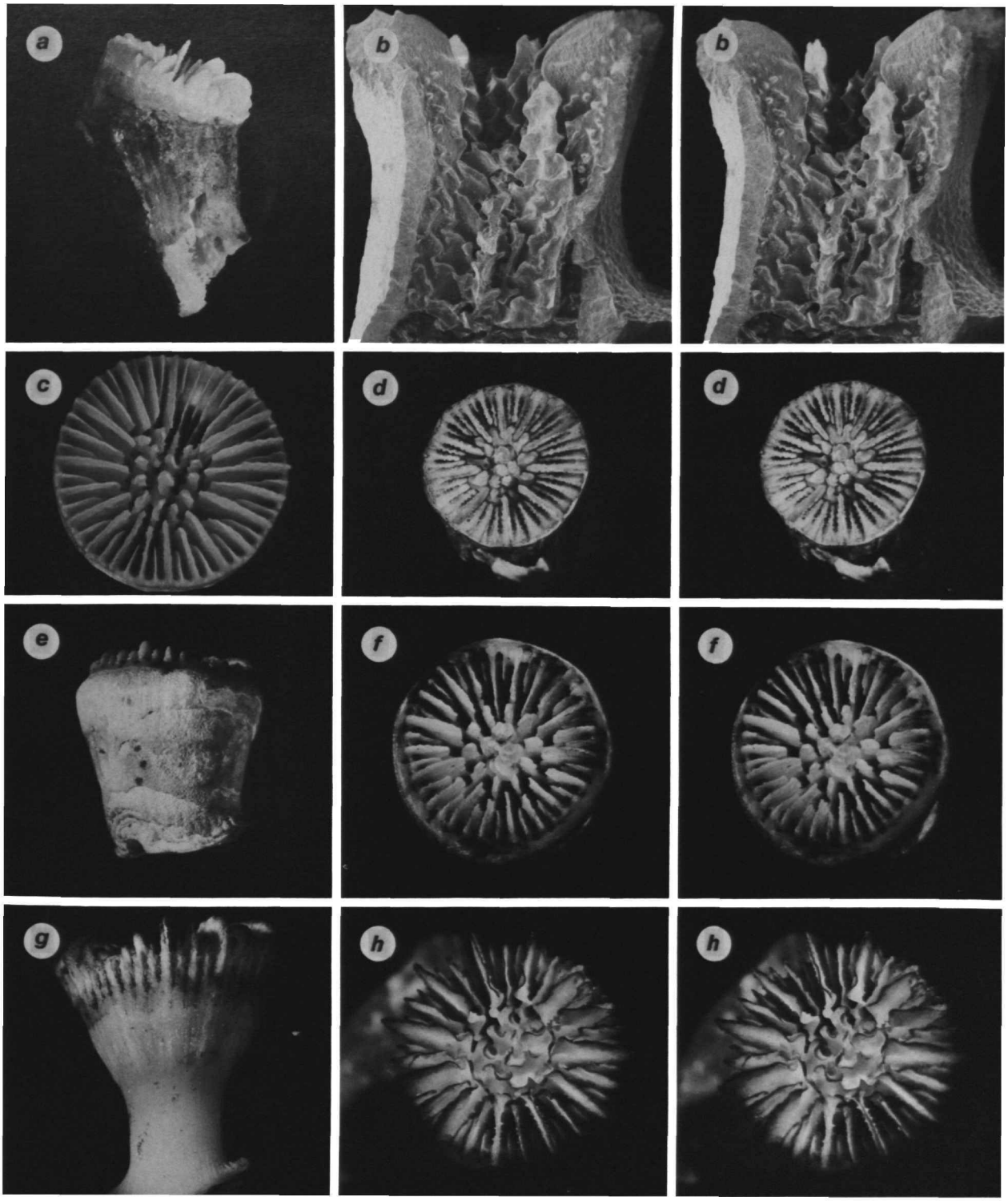


PLATE 5.—*Caryophyllia perculta*, new species (*a,d*, holotype, JSL-1937, USNM 84798; *b*, paratype, JSL-1914, USNM 84799): *a,d*, lateral and stereo calicular views, ×3.7, ×4.1, respectively; *b*, stereo view of broken corallum revealing carinate septal and palar faces, ×15.5. *Caryophyllia solida*, new species (*c*, paratype, JSL-1926, USNM 84806; *e, f*, holotype, JSL-1924, USNM 84804): *c*, calice, ×3.5; *e, f*, lateral and stereo calicular views of holotype, ×2.9, ×3.7, respectively. *g,h*, holotype of *Crispatotrochus galapagensis*, new species, JSL-1931, USNM 84808, lateral and stereo calicular views, ×5.0, ×5.2, respectively.

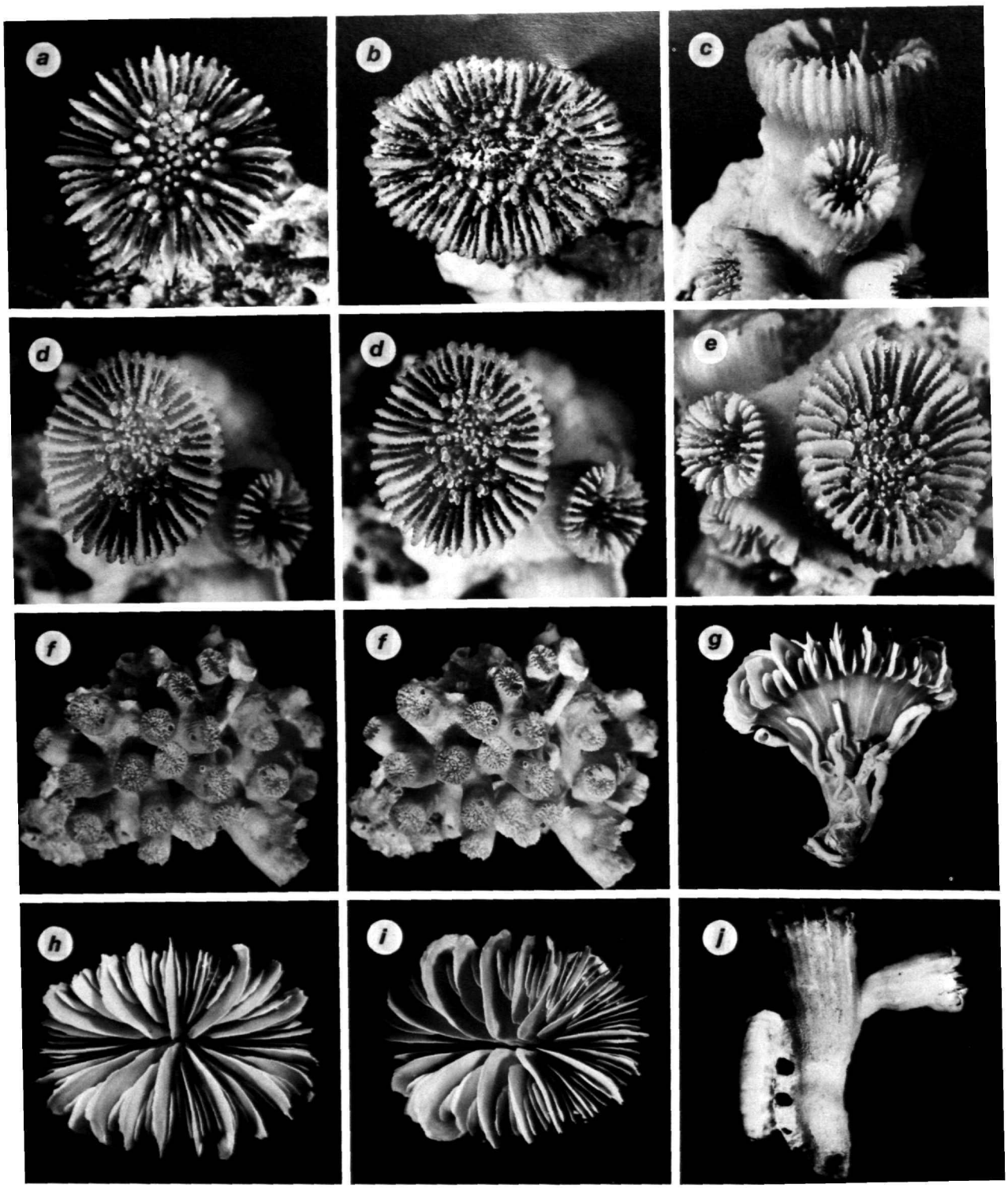


PLATE 6.—*Paracyathus humilis* (*a*, Darwin Bay, Genovesa (see Wells, 1983), USNM 46963; *b*, *Velero* 137-34 (see Durham and Barnard, 1952), AHF 54.1): *a,b*, calicular views, ×6.3, ×5.6, respectively. *c–e*, *Polycyathus isabela*, USNM 49964, lateral and calicular views of holotype, ×5.3, ×6.1, ×6.5, respectively (*d* is a stereo pair). *f*, holotype of *Polycyathus hondaensis*, *Velero* 948-39, AHF 33.1, stereo view, ×2.5. *g–i*, *Desmophyllum cristagalli*, JSL-1911, USNM 84814, lateral, calicular, and oblique calicular views, ×0.85, ×1.0, ×1.0, respectively. *j*, *Lophelia prolifera*, JSL-1937, USNM 84813, ×3.6.

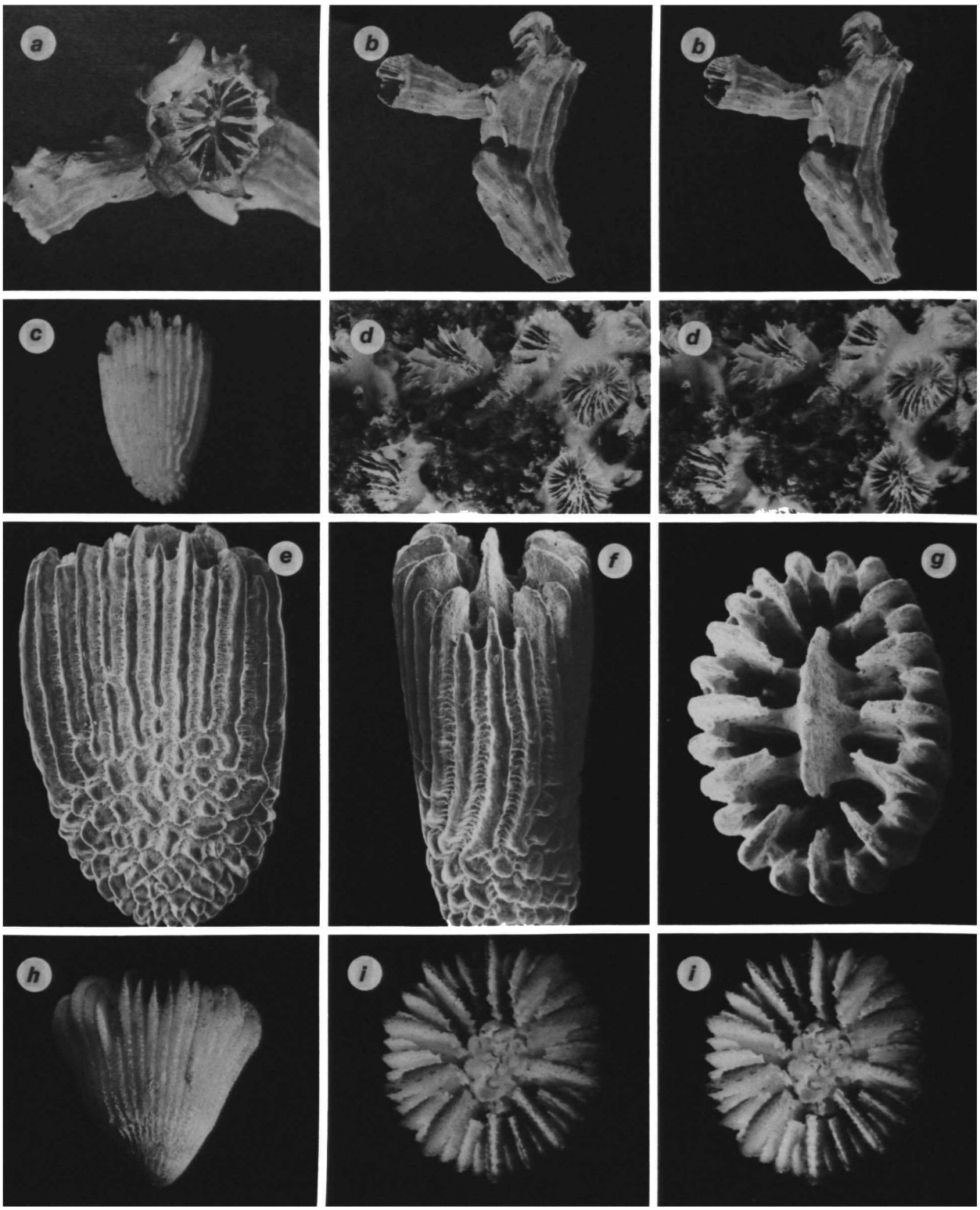


PLATE 7.—*a,b, Anomocora carinata,* new species, holotype, JSL-1938, USNM 84824, calicular and lateral stereo views, ×3.5, ×2.2, respectively. *Sphenotrochus hancocki* (*c,* holotype, *Velero* 170-34, AHF 57.2; *e-g,* ALB-5311 (see Cairns, 1989), Philippines, USNM 81897): lateral, edge, and calicular views, ×17.5, ×18.5, ×25, respectively. *d, Phyllangia consagensis,* Darwin Bay, Genovesa (see Wells, 1983), USNM 79105, stereo view of corallites interconnected by stolons, ×1.6. *h,i, Pseudocyathoceras avis,* "Galapagos" (see Wells, 1983), USNM 46962, lateral and stereo calicular views, ×4.5, ×5.5, respectively.

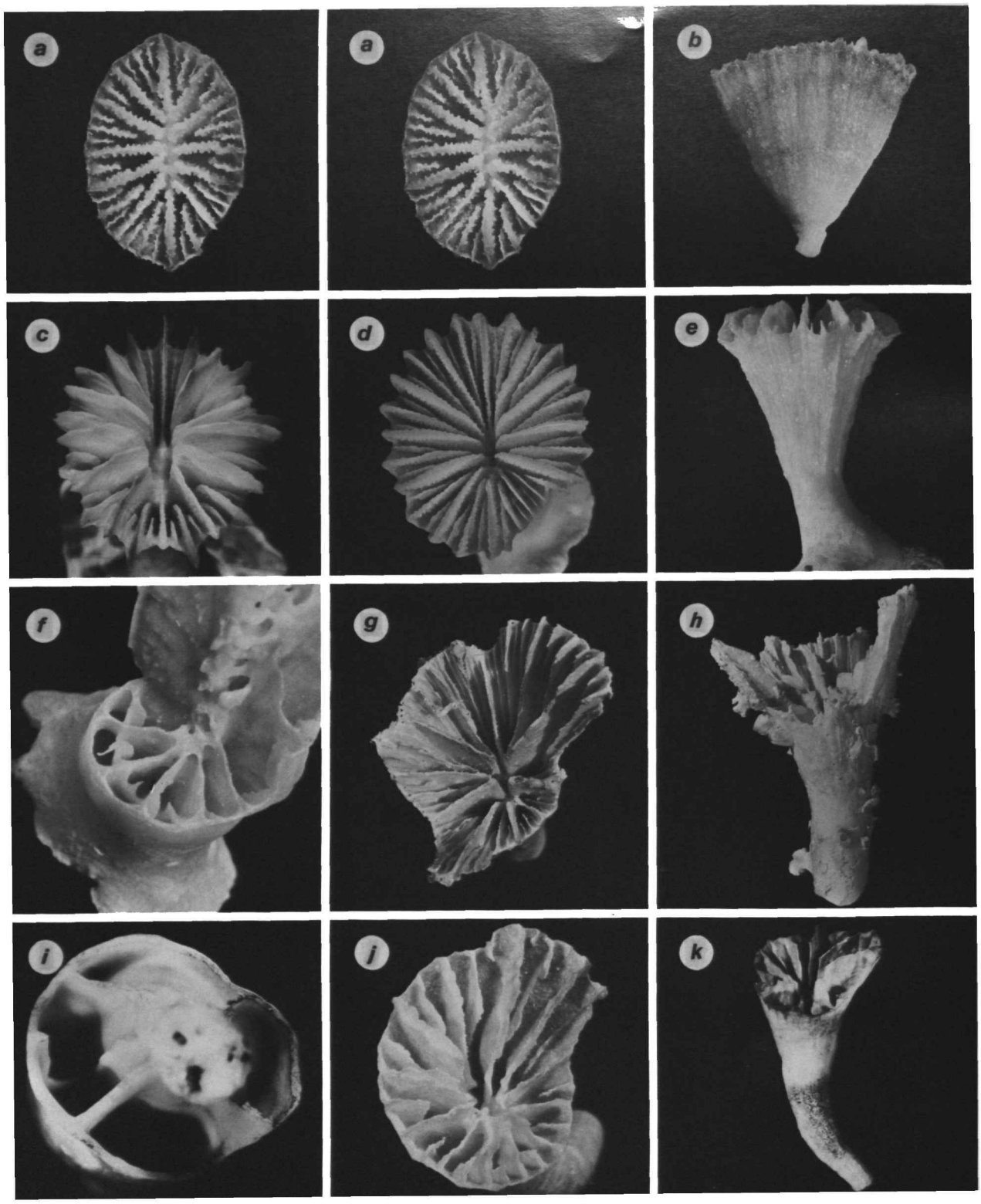


PLATE 8.—*a,b, Flabellum daphnense*, holotype, *Velero* 788-38, AHF 58.1, stereo calicular and lateral views, ×4.1, ×3.7, respectively. *Javania cailleti* (*c,e*, JSL-1931, USNM 84831; *d*, JSL-1943, USNM 84834): *c–e*, calicular and lateral views, ×3.1, ×3.2, ×2.0, respectively. *Polymyces wellsi*, new species (*f*, paratype, JSL-1916, USNM 84837; *i*, paratype, ALB-2818, USNM 77273 (*Javania pseudoalabastra* of Wells, 1983)): *f*, broken corallum revealing upper region of rootlets, ×5.7; *i*, broken basal region of corallum revealing asymmetrical development of rootlets, ×7.9. *g,h, Javania* sp. A, ALB-2816, USNM 19142 (*Javania cailleti* of Wells, 1983), calicular and lateral views, ×2.1, ×1.5, respectively. *j,k, Flabellum* sp. A, ALB-2818, USNM 77274 (*Javania cailleti* of Wells, 1983), calicular and lateral views, ×7.9, ×6.1, respectively.

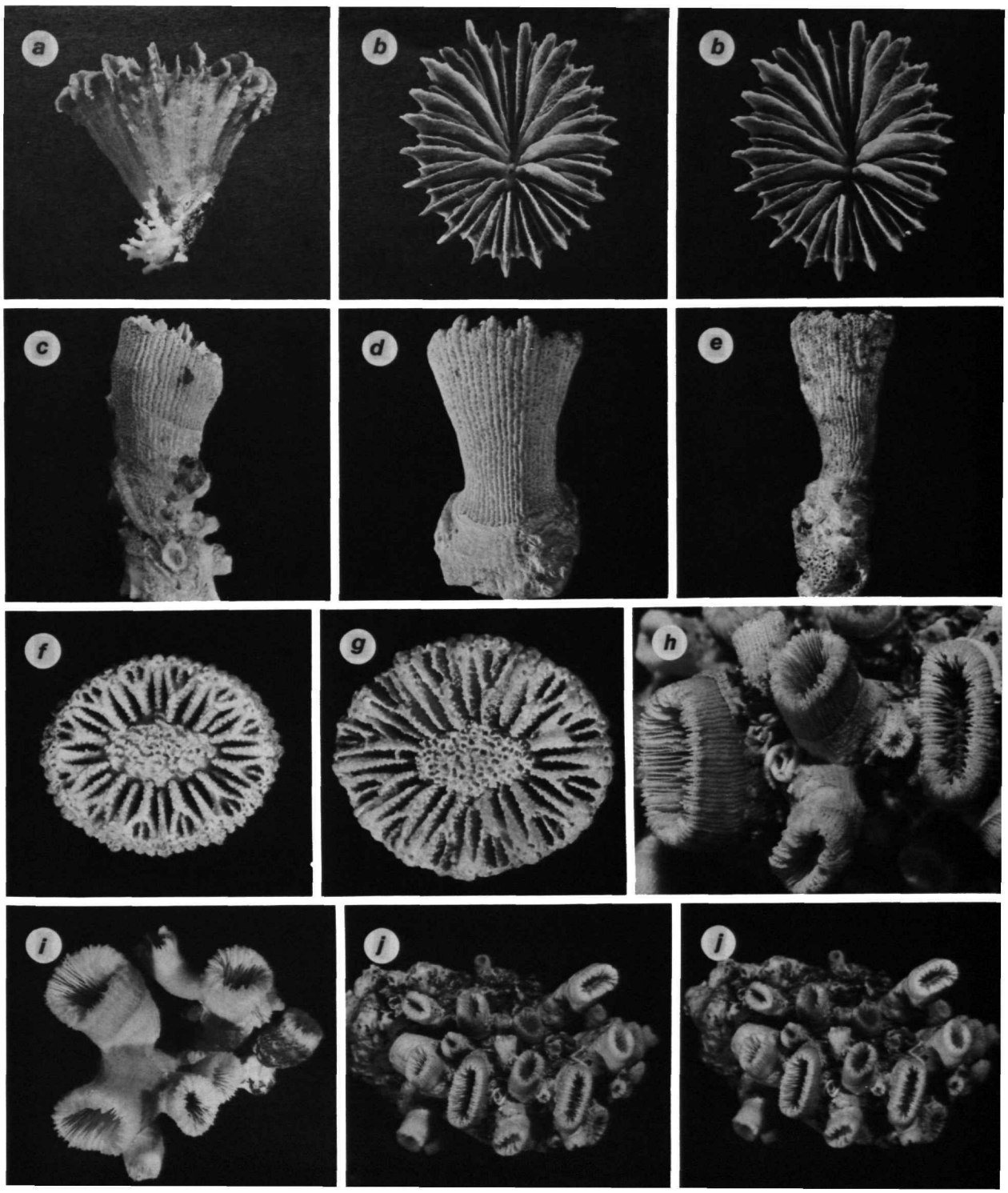


PLATE 9.—*a,b, Polymyces wellsi*, new species, holotype, JSL-1916, USNM 84836, lateral and stereo calicular views, ×1.25, ×1.3, respectively. *Balanophyllia galapagensis* (*c, f*, holotype of *B. galapagensis*, ALB-4643, USNM 68278; *d, g, Anton Bruun* 795, USNM 77277; *e*, holotype of *B. osburni*, AHF 63.2): *c–e*, lateral views of coralla, ×2.7, ×3.3, ×2.3, respectively; *f,g*, calicular views, ×6.4, ×6.0, respectively. *Balanophyllia eguchii* (*h,j*, holotype, USNM 46966; *i*, JSL-16-xI-86-2, USNM 84843): *h*, elongate corallites, ×2.3; *i,j*, two colonies, ×1.6, ×0.95, respectively.

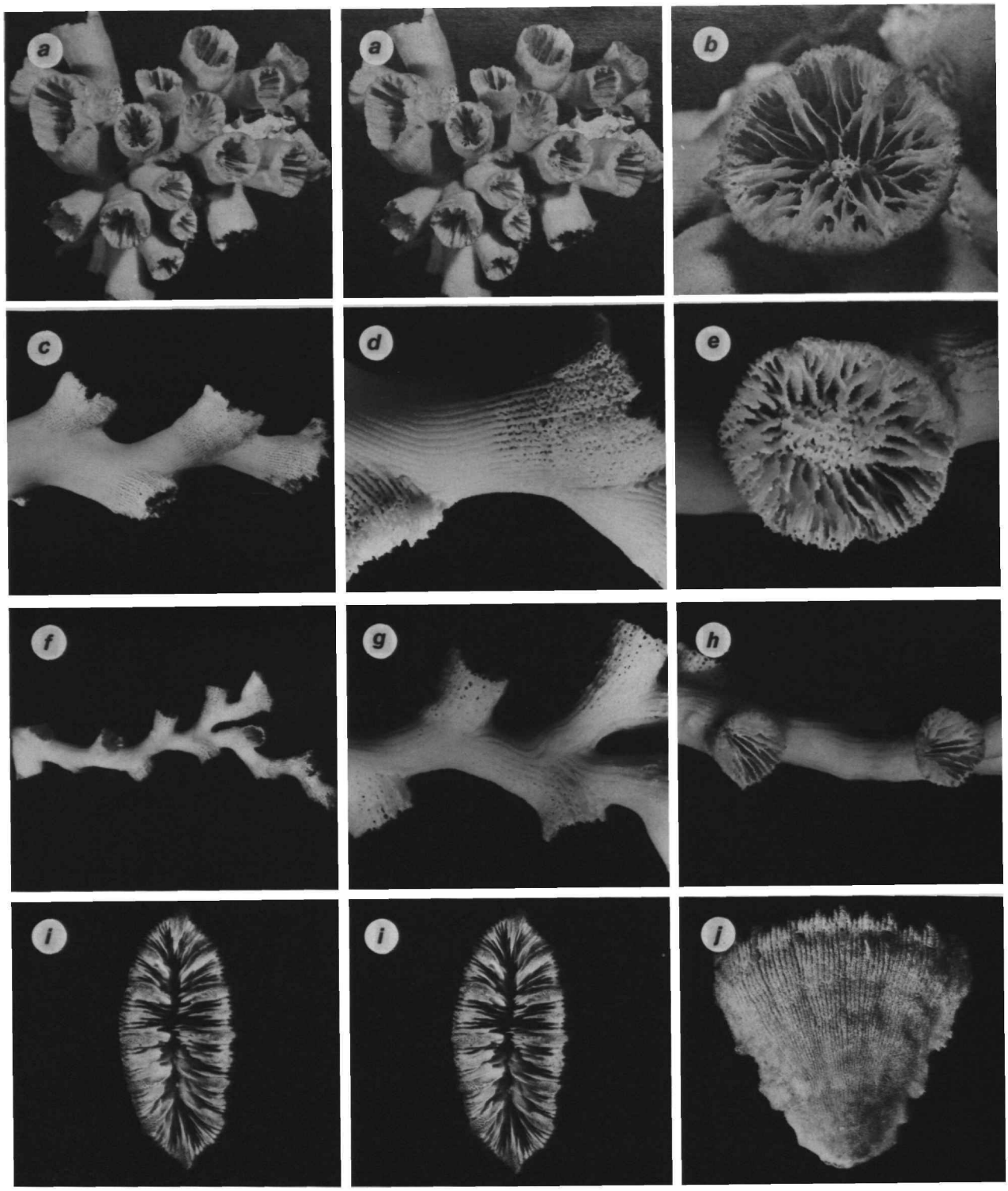


PLATE 10.—*a,b, Dendrophyllia gracilis,* Galapagos (see Wells, 1983), USNM 46971, stereo calicular and calicular views, ×0.85, ×3.5, respectively. *c-e, Dendrophyllia californica,* JSL-1911, USNM 84844, lateral and calicular views, ×0.85, ×2.2, ×2.9, respectively. *f-h, Dendrophyllia johnsoni,* new species, holotype, JSL-1911, USNM 84847, lateral and edge views of corallum, ×0.7, ×2.1, ×2.1, respectively. *i,j, Endopachys grayi, Velero* 816-38, AHF 67.4 (*E. vaughani* of Durham and Barnard, 1952), stereo calicular and lateral views, ×1.25, ×1.3, respectively.

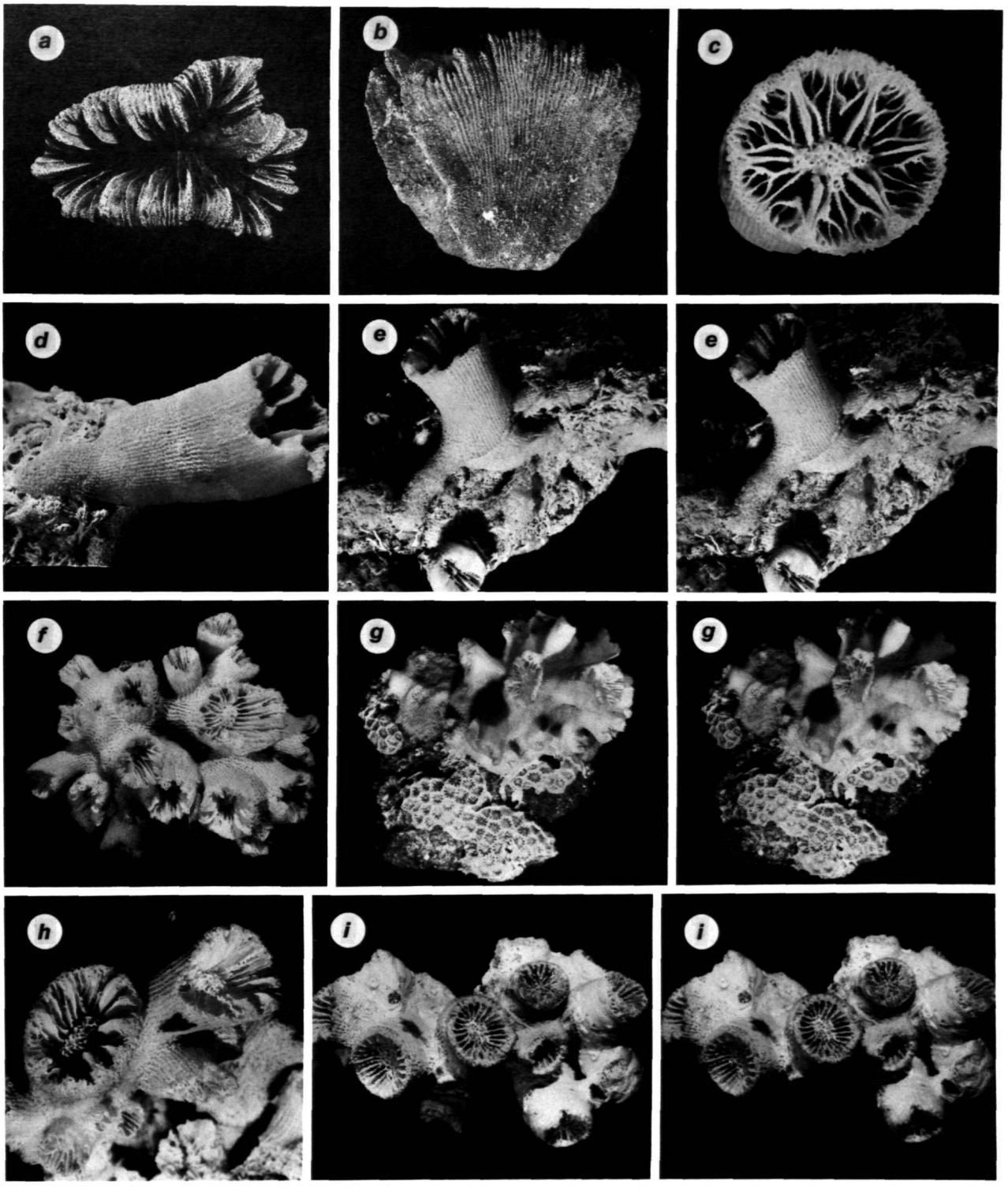


PLATE 11.—*a,b, Endopachys grayi,* Ráabida, CAS 66652, calicular and lateral views, both ×1.7. *Rhizopsammia verrilli,* Cocos I., USNM 77410: *c,d,* calicular and lateral views of a corallite, ×4.0, ×2.5, respectively; *e,* stereo view of a corallite with several stolons, ×2.8. *Rhizopsammia wellingtoni* (*f,h,* paratype, Tagus Cove, USNM 46970 (see Wells, 1983); *g,* Floreana, CAS 18851 (see Wells, 1983)): *f-h,* various coralla, ×1.7, ×1.5, ×3.4, respectively, figure *g* a stereo pair and includes *Madracis* sp. cf. *M. pharensis* on base. *i, Endopsammia pourtalesi,* holotype, *Velero* 12-32, AHF 68.1, stereo view of colony, ×1.7.

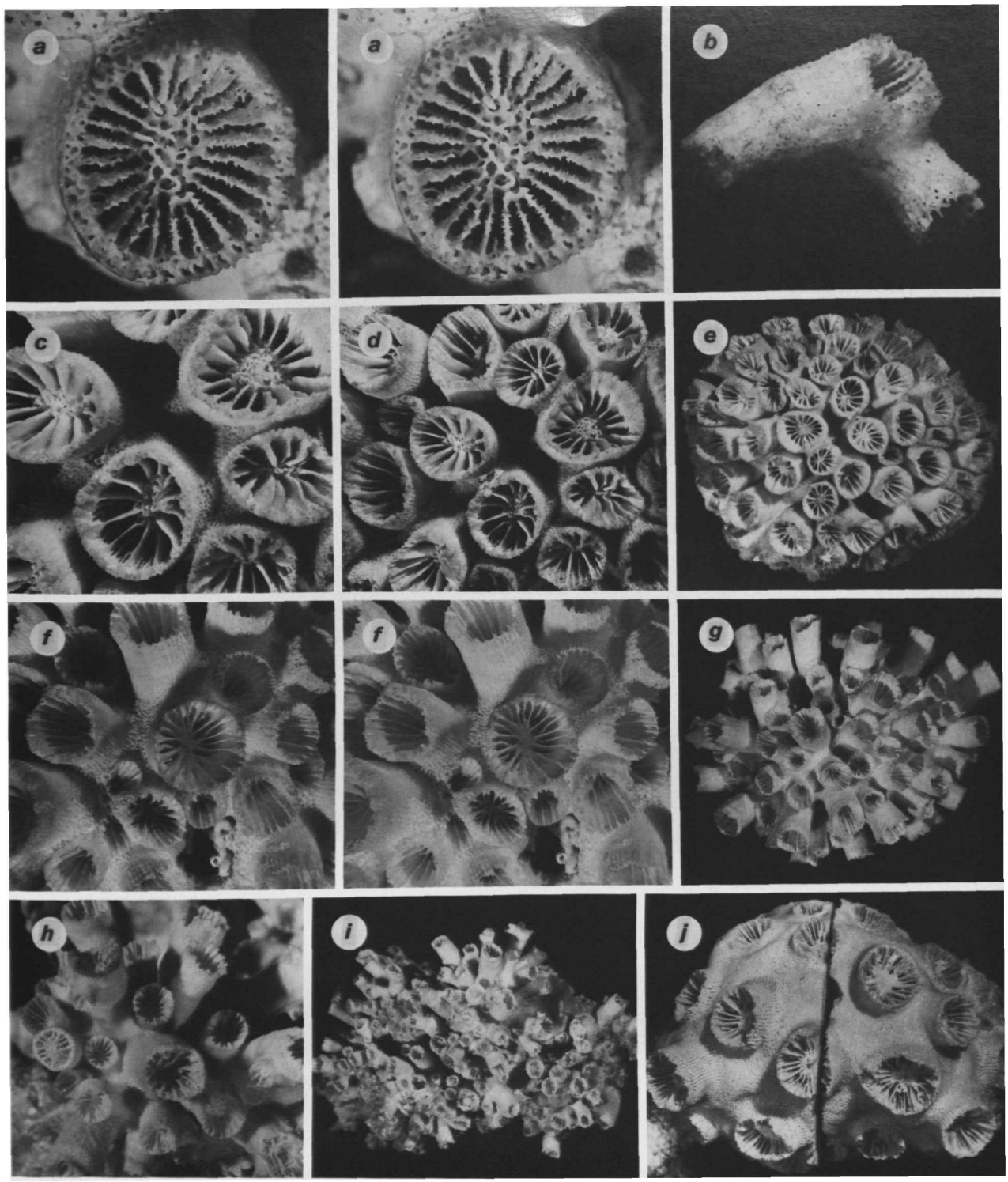


PLATE 12.—*a*, *Endopsammia pourtalesi*, holotype, *Velero* 12-32, AHF 68.1, stereo view of largest calice, ×8.0. *b*, *Enallopsammia rostrata* ALB-2818, USNM 36465 (*E, amphelioides* of Wells, 1983), ×5.6. *c–e*, *Tubastraea coccinea, Anton Bruun* 66132, USNM 77264, calicular and whole corallum views, ×2.1, ×1.5, ×0.65, respectively. *f,g*, *Tubastraea tagusensis*, Tagus Cove, USNM 7883 (see Wells, 1983), stereo calicular and calicular views, ×1.7, ×0.70, respectively. *h,i*, *Tubastraea floreana*, Gardner Island, Española, USNM 78885 (see Wells, 1983), ×1.9, ×0.68, respectively. *j*, *Tubastraea faulkneri*, Goenoeng, Api, Banda Islands, USNM 62570 (see Wells, 1982), ×0.80.

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Front matter (preceding the text) should include: **title page** with only title and author and no other information, **abstract** page with author, title, series, etc., following the established format; table of **contents** with indents reflecting the hierarchy of heads in the paper; also, **foreword** and/or **preface**, if appropriate.

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Center heads of whatever level should be typed with initial caps of major words, with extra space above and below the head, but no other preparation (such as all caps or underline, except for the underline necessary for generic and specific epithets). Run-in paragraph heads should use period/dashes or colons as necessary.

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Taxonomic keys in natural history papers should use the aligned-couplet form for zoology and may use the multi-level indent form for botany. If cross referencing is required between key and text, do not include page references within the key, but number the keyed-out taxa, using the same numbers with their corresponding heads in the text.

Synonymy in zoology must use the short form (taxon, author, year:page), with full reference at the end of the paper under "Literature Cited." For botany, the long form (taxon, author, abbreviated journal or book title, volume, page, year, with no reference in "Literature Cited") is optional.

Text-reference system (author, year:page used within the text, with full citation in "Literature Cited" at the end of the text) must be used in place of bibliographic footnotes in all Contributions Series and is strongly recommended in the Studies Series: "(Jones, 1910:122)" or ". . . Jones (1910:122)." If bibliographic footnotes are required, use the short form (author, brief title, page) with the full citation in the bibliography.

Footnotes, when few in number, whether annotative or bibliographic, should be typed on separate sheets and inserted immediately after the text pages on which the references occur. Extensive notes must be gathered together and placed at the end of the text in a notes section.

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