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The Reef Coral *Astreopora* (Anthozoa, Scleractinia, Astrocoeniidae): A Revision of the Taxonomy and Description of a New Species[1]

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ABSTRACT: The taxonomy of the Indo-Pacific reef coral *Astreopora* is reviewed. Eighteen nominal species are synonomized to nine, which are characterized. One new species, *A. scabra*, is described.

REEF CORAL TAXONOMY has never been an exact science and, from time to time, efforts of previous workers should be reviewed in light of recent methodology and/or with analysis of more extensive collections encompassing a greater geographic range than were previously available. For over two centuries, the binomial system of Linnaeus has been regarded as standard with some notable exceptions. Bernard, when cataloging the corals of the British Museum (1896–1906), began with *Turbinaria* and *Astreopora*, which supposedly had fewer species than did other genera. We can sense his problems, for whenever he encountered a specimen with a slightly different growth form, he erected a new species. Eventually, he recognized the futility of this approach. When he reached the genus *Porites*, he assigned only locality numbers to the various specimens, thus almost abandoning the binomial system. This tack was followed by Wood-Jones (1907), who concluded that all specimens of the genus *Pocillopora* were a continuum of growth forms, making species designations meaningless. Vaughan and Wells (1943) recognized the shortcomings of previous classifications and in their revision of the Order Scleractinia included factors other than skeletal elements. Although their generic classification was based primarily on the formation of skeletal septa, species delineation included mode of colony formation, form of corallum, modification of skeletal elements, and phylogeny of the groups.

Various adjunctive methods have been explored since then to clarify the species problem in reef coral identification: (1) large suites from many habitats (Laborel 1970, Wijsman-Best 1972); (2) specimens from different geographical areas (Wells 1966); (3) histological analysis of skeletal material (Chevalier 1975); (4) coral polyp ethology (Dustan 1975, Lang 1971); (5) chromosomal analysis (Wijsman and Wijsman-Best 1973); (6) numerical taxonomy (Powers 1970, Powers and Rohlf 1972); (7) informational analysis (Wallace 1974); and (8) protein electrophoresis (Lamberts 1979).

I am attempting to update and record present knowledge of the systematics of the coral genus *Astreopora*, relying primarily upon examination of a large suite of specimens from many habitats and from many geographical locations. There is obviously a continuum among the species of this genus. The majority of specimens show considerable intracolony growth variation such that some areas might be classified differently from the rest of the colony. In this way, one large specimen might be included under two, three, or more distinct designations. Recognizing this, I have attempted to identify the salient diagnostic features of each species listed and have classified the various colonies according to what, in my judgment, constitutes the most representative, or the largest, comparatively unstressed area of that particular colony.

REVIEW OF LITERATURE

The genus *Astreopora* was founded by de Blainville (1830) when he separated a number of species from Lamarck's (1816) genus *Astraea*. Included were *A. myriophthalma*, Lamarck; *A. pulvinaria*, Lamarck; *A. punc-*

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tifera, Lamarck; and *A. stellulata*, Lamarck. The last was actually a species of the genus *Turbinaria*, then considered a closely allied genus. Dana (1846) named his specimens *A. pulvinaria*, following Lamarck's suggestion by combining the new species with *A. myriophthalma*. He completed his classification by listing *A. punctifera* but identifying no specimen as such. He accepted the mislabeled *A. stellulata* and also listed *A. fungiformis*, Blainville (1830), apparently confusing *Gemmipora* (*Turbinaria*) for *Astreopora*. In 1849, Milne-Edwards and Haime listed only *A. myriophthalma*, believing it to be the only living species, and in 1850, they designated a genolectotype from the Red Sea. In 1860, they also listed *A. pulvinaria* and *A. punctifera*, restoring Blainville's classification. Verrill (1872), in reviewing Dana's specimens, renamed *A. pulvinaria* (non Lamarck) *A. profunda*. Brueggemann (1877) added *A. expansa*.

When Bernard began working with *Astreopora* (1896), he found thirty specimens in the British museum and classified them according to growth forms, dividing them into explanate, pulvinate, and globular types. He accepted four species and again combined *A. myriophthalma* Lamarck (1816), with *A. pulvinaria* Lamarck, (1816). He listed *A. punctifera* Lamarck (1816), *A. profunda* Verrill (1872), and *A. expansa* Brueggemann (1877). He redescribed a specimen of *A. myriophthalma* identified by Klunzinger (1879) as *A. ehrenbergi* and was left with eighteen unnamed specimens. These he divided into ten new species, eight being represented only by the holotypes.

Gardiner (1898) named three specimens he found in Rotuma and Funafuti as *A. tabulata*. Vaughan (1918) synonomized Bernard's *A. ovalis* and *A. kenti* with *A. ocellata* Bernard (1896). Hoffmeister (1925) redefined *A. profunda* Verrill (1872) but added no new species. Waugh (1936), after extensive reef studies, placed *A. ehrenbergi* Bernard (1896) in *A. myriophthalma* Lamarck (1816) and described the microscopic anatomy of the polyps. Yabe and Sugiyama (1941) described two new species, *A. elliptica* and *A. tayamai*.

Crossland (1952: 180), relying on considerable reef experience, recognized that museum classifications based on growth forms, such as Bernard's, were untenable. In his discussion on variation in colony form, he states, "such detached forms occur in almost any sort of coral and are purely environmental" and "indeed, of Bernard's 14 species it seems likely that no more than three or four are real." Wells (1954), in his Marshall Island study, listed six species of which two new ones, *A. suggesta* and *A. tabulata*, were obtained only by dredging. He later corrected this last entry, *A. tabulata* Wells, to non *A. tabulata* Gardiner (unpublished data, 1976). Nemenzo (1964) described four species from the Philippines, *A. stellae* being new. Lamberts (1980) added two new species, *A. cucullata* from Samoa and *A. randalli* from Guam, to bring the total of nominal species of *Astreopora* to eighteen.

MATERIALS

My collection of *Astreopora* (listed AEL) consists of 118 specimens selected from thousands of living colonies observed during the investigation of over one hundred Indo-Pacific coral reefs. *Astreopora* in the following museum collections were examined: National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C. (approximately 90 specimens); Yale University Peabody Museum (YPM), New Haven, Connecticut; Museum of Comparative Zoology (MCZ), Harvard University, Cambridge, Massachusetts; Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii; British Museum (Natural History) (BMNH; sometimes simply BM on specimen labels), London; University of Philippines (UP), Quezon City, Manila; Cambridge University Museum (CUM), Cambridge, England; and the Richard Randall coral collection, University of Guam (GUAM) (approximately 100 specimens). J. P. Chevalier kindly loaned me Lamarck's type specimens from the Muséum National d'Histoire Naturelle (NMHN), Paris.

METHODS

Live colonies were lifted from the substrate with a rock hammer and then transported to boat or laboratory in a plastic bucket, where a plastic numbered tag was attached with a plastic-coated wire. They were then either placed in a seawater table for further study or immersed in fresh water for a few days, cleaned of organic matter by spraying, and bleached with sodium hypochlorite solution and air-dried. Many specimens were photographed in color before cleaning. Each specimen was entered into a sequentially numbered data book with location of reef where it was taken, the date, water depth, quality, current flow, size of the entire colony, underwater color, general composition of the reef including percent coral cover, and a list of the genera and species of coral seen at the location. Specimens were later taken to my home laboratory for further study and will eventually be lodged in the Bernice P. Bishop Museum, Honolulu, Hawaii.

At the time of identification, data from each specimen were transcribed on a study card with the following entries: (1) my collection number or museum name and collection number; (2) sketch of specimen with dimensions, description of shape, dead areas, fractures, parasites, etc.; (3) gross appearance of mature calices, height of calical eminence if present, prominence of pseudocostae and septa; (4) depth of mature calices; (5) calculated number of mature calices per square centimeter in two or three representative 1-inch circles; (6) average maximum diameter of ten representative calices; (7) shape and structure of primary septa, degree of axial fusion; (8) secondary and tertiary septa evaluated; (9) pseudocostal ring evaluated; (10) exposed coenosteum assessed, reticulate or solid and degree of each; (11) echinulations, height, prevalence, and structure; (12) fracture areas, texture of coenosteum, etc.; (13) epitheca; (14) parasites, barnacles, worm tubes, mollusks, sponges, etc.; (15) special collection data; and (16) my identification. Similar cards were prepared for all museum specimens selected for special study. Many were photographed in black and white, using a 35-mm SLR camera equipped with a macro lens. Total number of *Astreopora* specimens studied in this series was 252.

ECOLOGY AND BIOLOGY OF *Astreopora*

The genus *Astreopora* is an Indo-Pacific coral found in most well-established reefs studied. The known extent of its distribution is as follows: northern range, 34°05′ N, Miyuki-Jima, Japan (R. Randall, personal communication, 1981); southern range, 31°36′ S, Lord Howe Island (Veron and Done 1979); 28° + S, Houtman's Albrohos (Wilson and Marsh 1979); western range, 34° W, Inhaca Island, S. Mozambique, 26° S (Boshoff 1969); eastern range, 124°47′ W, Ducie Atoll (Rehder and Randall 1975), 24°40′ S. *Astreopora* has also been reported from Wake Island, but not from Johnston Island or the Hawaiian chain. These limits follow approximately the isochryme, indicating a mean seawater temperature of 70°F (21°C) Stehli and Wells (1971).

Astreopora appears to thrive best in clear, fast-moving, tropical oceanic waters; however, it can grow well under adverse conditions where most corals do not survive. I found a large colony in a silty area of Ylig Bay, Guam, with only the colonizing, very hardy *Porites lutea* and *Pocillopora damicornis* anywhere near. It was also found on the impoverished reef on the north Pago Pago harbor entrance, American Samoa. It does not tolerate prolonged emersion, and I have not recorded it from reef flat areas uncovered in times of low waters. *Astreopora* has been found on virtually every suitable reef where I have searched. It may, nevertheless, be very rare.[3] *Astreopora myriophthalma* has been rarely reported from Palau (Belau); however, in nearby Guam, it is abundant on some reefs

[3] I considered a coral to be rare if I could not find it after a prolonged search, although it had previously been reported from a place, or if I found only one specimen after hours of searching.

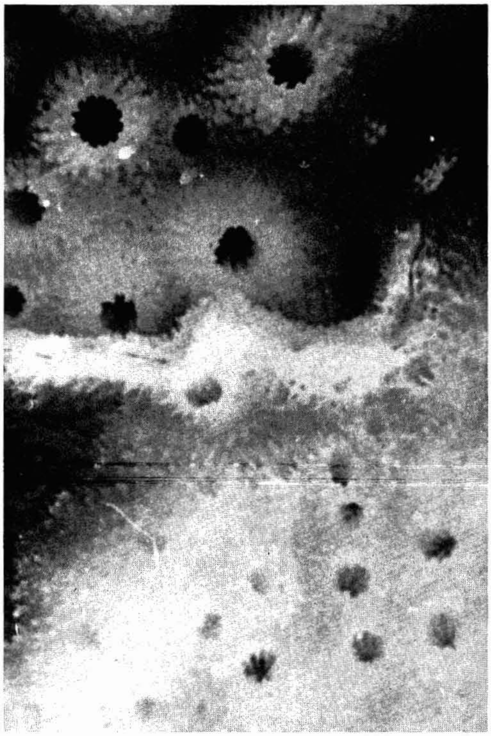

FIGURE 1. *Astreopora myriophthalma* abutting an *Astreopora randalli*, both forming an epitheca (Guam 10664, 10664), ×4.

and only occasionally found on others. On Rizal reef terrace, it was the third most common genus. This reef is on a rocky substrate with fast-moving water of 1–3-m depth. Coral cover was from 20 to 40 percent, with only *Porites* and *Montipora* more abundant. It was more abundant than *Acropora*, both in colony numbers and in total area covered. It was also abundant on deeper Galvez Banks off Guam but rare to absent on Taema Bank of similar depth off Tutuila, American Samoa, even before a heavy infestation by the coral predator *Acanthaster planci*, which began in 1978. The reasons for such discrepancies have not been ascertained. Because this genus has not been reported from a certain reef does not mean that it does not grow there. Scheer (1971) observed that the number of corals reported increases symptotically with the number of collectors and the hours spent.

Substrate preference or survival strategies in *Astreopora* are virtually unknown. However, when colonies are established, they are seldom encroached upon by other corals. They seem well able to protect themselves and generally have a free zone of several centimeters on every side. I have observed an instance in which *Acropora ceralis* (Dana) grew to within a millimeter of an *Astreopora listeri* with no apparent disturbance to the surface of either colony. I have also seen one instance where a *Montipora* sp. overgrew a small area of an *Astreopora scabra*. On two occasions, I have observed two colonies of *Astreopora* abutting each other without fusion. In one instance an *A. randalli* abutted an *A. myriophthalma*, both colonies forming an epitheca (see Figure 1). In another instance observed on Rizal terrace, Guam, and collected, an *A. randalli* produced an epitheca as it overgrew an *A. myriophthalma*, which did not. Both were diagnostically typical for the species.

Dispersal of *Astreopora* is by planula larva, although the larvae have not been described. Dispersal can also be accomplished by fragmentation. Pieces of live coral can be moved by wave action or transported by xanthid crabs (Lamberts and Garth 1977). The holotype of *A. kenti* collected by Saville-Kent is a large specimen with a typical crab hole, indicating that it had been transported by this means. Many free-rolling specimens of *Astreopora* have been collected. Often, when colony formation begins on a fragment of *Porites* or *Acropora*, with growth these begin to roll and form balls of living coral with no substrate attachment. This phenomenon was first described by Lamarck (1816) for *A. punctifera*, which he noted formed into spherical shapes like cannon balls. When these free-rolling balls reach a critical size, probably about 10 cm in diameter, they become too heavy to move. Continued growth is upward and outward; the calices at the bottom are smothered and die. The large hemispherical colonies found unattached to any substrate are likely the result of this phenomenon.

The color of *Astreopora* colonies, as in all reef corals, is due to a combination of the hue of the endosymbiotic algae, zooxanthellae, and certain inherent pigments. The zooxanthellae produce the colors ranging from light tan to deep brown. This color range can be partially correllated with ambient sunlight, the darker browns being found in shaded or deeper habitats. Other color patterns range from dull reds to orange and rust, and from shades of green to bright blue and magenta. Occasionally, an entire colony may be of a uniform tan or other color; more commonly, certain areas have color differences. These often are an intensification of the color, or a different tint, of one edge of a colony or one side of a group of calix elevations. Color variations are more common in *A. myriophthalma* than in other species examined.

Partially dead colonies of *Astreopora* are commonly encountered. Often, part of a colony has died and been overgrown once or many times by tissue from the parent colony. Pathological processes or causes of local death are unknown in most cases, but prolonged exposure to air is a likely cause, as this condition is most often found in shallow-water specimens. *Astreopora* is occasionally infested by polychaete worms. The worm growth often keeps pace with coral growth, so there may be isolated or multiple tube openings scattered about the surface coenosteum. Usually, these invaders do not provoke a deposition of epitheca by the coral. Most of the tubes are less than 1 mm in diameter. At times, the coral coenosteum may follow the accelerated upward growth of worm tubes, creating conical elevations of 2 or more cm in length and a basal diameter of 5–6 mm. X-ray studies of some of these have shown fine, evenly deposited coenosteal reticulum surrounding the tube and at times sealing off the terminus.

Barnacles of the subfamily Pyrgomatinae occasionally settle on a growing colony of *Astreopora* and become encased in coenosteum. These are very rare in American Samoa and Guam but relatively common in Enewetak, where some colonies are so distorted by such a multitude of these crustaceans that species identification is sometimes doubtful because too little undistorted surface is available for critical analysis. I know of no instances in *Astreopora* where such commensals have led to the description of more species than warranted. Mollusks rarely settle on *Astreopora* and have been engulfed by colony growth. I have seen little hindrance to growth by sponges. The usually catabolic or erosive agents, such as boring mollusks, sipunculids, and algae, found on all tropical coral reefs are also found on dead *Astreopora*. Coral tumors (Cheney 1975) have been found in several scleractinian genera, most commonly *Acropora* and *Montipora*; I have so far found none on *Astreopora*.

ANATOMICAL CHARACTERISTICS OF THE GENUS *Astreopora*

In the classification scheme of the Order Scleractinia proposed by Vaughan and Wells (1943) and Wells (1956), this major division of Zooantheria includes nearly all post-Paleozoic fossil and recent corals. Their extensive revision rests primarily on the observation of the fine microscopical skeletal patterns visible in thin-section preparations. Using these as a guide, the genus *Astreopora* may be defined as follows: massive to subramose hermatypic colonies formed by extratentacular budding, corallites small, synapticulo-thecate, pseudocostate, slightly differentiated from coenosteum, no axial corallite. Septa not or slightly exert, in two cycles formed by simple spiniform trabeculae projecting inward and upward from vertical mural trabeculae, commonly fusing to form laminae. Coenosteum reticular formed by outwardly inclined trabeculae, spinose surface. Dissepiments tabular. A columella is absent.

Living colonies of *Astreopora* appear as a mass of evenly spaced open-topped relatively small papules, so the surface has a pebbly appearance. Polyps extend nocturnally, rarely in subdued light, and are usually not visible during daylight hours on the reef. When observed, they appear semitransparent as cylinders protruding from each opening, each surmounted by a whorl of 24 flat petallike tentacles. At times, the mesentaries can be seen as vertical lines on the body wall. Six larger tentacles originate at the edge of the oral disk and are club-shaped. Between these and a little farther out from the center are six smaller tentacles. Together, they make up an upper ring. A second tier of twelve tentacles lie beneath and alternate with the upper series. They all lie horizontally and, when expanded, have an overall diameter of about twice that of the calix opening. The peristome is usually white, and the mouth edges may be purple or brown. When partially expanded, the living polyps appear as a cluster of round beads at the calix opening. The microscopic anatomy of the polyps is like most other genera of reef corals. It has been described and illustrated by Waugh (1936).

Once a colony has begun as a single parent polyp, the coenenchyme expands in all directions on a bed of epitheca. Satellite polyps appear in all directions. These have no connection with the parent polyp except through the canal systems traversing the coenenchyme. New polyps occur at regular intervals along the advancing edge and at times appear in orderly rows. With upward growth, the coenosteum thickens and, if this continues at an even rate, an incrusting colony results which reflects the contours of the surface it covers. More frequently, uneven growth occurs, and calix cylinders tend to bend outward. New polyps appear between them as though they were being pushed apart. Whenever an expanse of about 5 mm of surface coenenchyme emerges, a new polyp develops in the center. In some globular colonies, newly formed polyps may constitute half the total number of calices in any given area. Most growth of a colony appears to take place in the coenenchyme between the calices, thus further advancing the process. In some colonies, both tabular and globular growth forms exist.

Newly formed calices are smaller and the coenosteal pits over which they lie are shallow and have no septa. With upward growth of the polyps, the calicular pits become deeper, septa appear and, after a centimeter or more of upward growth, the calix assumes a mature appearance. The living coenenchyme occupies only the uppermost 7–8 mm of the colony surface and, when the calicular cylinder reaches this length, tabular dissepiments are formed in the calicular tube and the coenenchyme disappears from beneath them and from the deeper intracalicular areas. Fractures through this area may show a green tint immediately below the coenenchyme where algae have invaded, but deeper regions usually show only a clean coenosteum.

The skeletal surface shows evenly spaced monocentric corallites with a reticular coenosteum between. These corallites, when viewed in vertical cut section, appear as cylinders that taper at their beginning. They grow straight out in flat colonies and are often bowed outward in globular specimens with additional calices appearing at all levels. These cylinders are perforated by regular tiers of twelve evenly spaced round or oval openings between the construction pillars that constitute the vertical element, while the horizontal elements continue laterally into the coenosteum as the tabular floors and ceilings of the reticulum. Both the vertical and horizontal elements of the calix itself may be considerably thickened in the portion of the calix that protrudes above the general coenosteal level, as in the papules of *A. myriophthalma*. The living coral rests on and is surrounded by a skeletal domicile deposited in a pattern that is genetically determined but considerably altered by environmental factors.

The carbonate corallum of *Astreopora* is composed of aragonite crystals and their deposition is not entirely a passive process. Both deposition and reabsorption take place in some and probably in all species of *Astreopora*. Most of this seems to occur at the level of the calicular openings. Septal structures and surface configurations are changed, reshaping the outward characteristics of some species. *Astreopora cucullata*, *A. elliptica*, and, to some extent, *A. scabra* have an identifiable surface skeletal arrangement so that each presents a unique appearance. This is changed to a basic calicular pattern that is common to all the species. The architecture of the calicular cylinder and the coenosteum of all species, when examined in cross section at fracture lines or where sawed, show a pattern that is basically alike in all species. There are differences in the relative thickness of the elements and this may vary considerably even within one colony. Although this variation is most likely environmentally induced, the factors that influence these changes have not been determined.

The diameter of the calicular openings is

TABLE 1

CALIX DIAMETER AND FREQUENCY DISTRIBUTION IN *Astreopora*

SPECIES	NUMBER OF SPECIMENS	INTERNAL DIAMETER (mm)	STANDARD DEVIATION FROM MEAN	FREQUENCY OF CALICES (no./cm²)	STANDARD DEVIATION FROM MEAN
cucullata	9	1.54	0.28	7.6	1.3
elliptica	3	1.73	0.39	12.0	5.5
expansa	4	1.47	0.15	4.6	2.1
gracilis	26	1.71	0.47	4.6	1.5
listeri	46	1.72	0.24	7.0	1.9
myriophthalma	116	1.79	0.30	5.9	1.8
ocellata	10	2.51	0.10	4.8	1.4
randalli	5	1.45	0.31	9.0	2.4
scabra	23	1.82	0.37	5.3	2.4
suggesta	10	1.34	0.37	5.3	2.4
Totals and averages	252	1.73	0.29	6.36	2.2

TABLE 2

EXTREMES IN VARIATION OF CALIX FREQUENCY IN FOUR MOST COMMON SPECIES OF *Astreopora*

SPECIES	NUMBER OF SPECIMENS	MOST	AVERAGE	LEAST
gracilis	24	7.9	4.6	2.2
listeri	44	12.0	7.0	3.6
myriophthalma	109	14.6	5.9	3.1
scabra	23	8.3	5.5	3.3

NOTE: Values in table are number of calices per square centimeter, with number of colonies of each species evaluated.

remarkably similar among the various species, as is the distribution of calices. Table 1 lists the average maximum internal diameter of the several species of *Astreopora*. The data show that the calicular diameters of 80 percent of all specimens measured fall within 0.1 mm of 1.76 mm. The number of calices in every square centimeter of surface is also reasonably fixed for most specimens. The extremes for the most common species are given in Table 2, but the average for most specimens is about six calices per square centimeter, with considerable variation in some rarer species as *A. ocellata* and *A. randalli*. While most of any colony will fall within the limits described here, it is not unusual to find double calices or areas in which the calices are very crowded, and in these areas they may be unusually small or distorted. At times, the entire specimen may be so distorted that too few seemingly normal calices remain for positive identification.

Once established, calix diameter is not altered. With upward growth of the calicular cylinder, the inner architecture is developed. Septa appear at the surface as ridges; with inward growth, these converge on the axial line where they may fuse with one another at a depth of 4–5 mm from the growing margin. There are always six major septa, usually disposed equally at 60° intervals and normally of equal size. Directives are not apparent. These septa are thin and seldom perforate, and the edges are often undulating or irregular but not regularly dentate. Axial fusion occurs in various combinations and for varying distances but seldom for more than a few millimeters. Two adjoining septa may fuse; alternates, opposites, or various combinations have been found to fuse. This varies within each colony, but the depth of fusion varies little within the genus. There is no columella.

Six secondary septa are interposed at regular intervals between the primaries, similar to them but always less well developed. At times, these may reach as a maximum halfway to the axis line. At times, they are so poorly developed as to be almost invisible, and they do not fuse with the primaries. Tertiary septa occasionally occur in larger calices as vertical rows of toothlike projections interrupted by the thecal perforations.

As upward growth continues and the thecal cylinder lengthens to about 7 mm, tabular dissepiments appear and are then formed at intervals of about every millimeter. They may be as much as 2 mm or as little as 0.5 mm apart, with considerable variation in each calix. These dissepiments are thin partitions that include septa and completely close off the cylindrical compartment below. Apparently, the coenenchyme and mesenteries are drawn upward periodically, the new dissepiment is formed across the entire opening and, once formed, is not further thickened by additional sterome.

Coenosteum constitutes 75 percent or more of the bulk of any colony and is laid down concomitantly with the calicular structures. It consists of a succession of parallel horizontal floors (extrathecal dissepiments) supported by tiers of vertical rods. These floors are from 0.01 to 0.04 mm thick, although this may vary within any colony. They are sparsely perforated. Apparently, they are laid down near the surface coenenchyme and undergo no further increase in thickness once laid down.

Supporting elements formed as rods come off the thecal cylinder in a regular manner, about twelve at a time and all directed upward at about 30°; they appear to pass through successive dissepimental floors. They may bend to parallel the corallite axis, but more frequently they end by fusing with another rod which may continue on. Together, the vertical and horizontal elements give a reticular appearance that is visible without magnification. Cross-section studies show a general pattern of less heavy growth midway between the calices. This general pattern of coenosteal development is found in all *Astreopora*, and I found no consistent distinction among the various species to serve in species identification.

Species differences in *Astreopora* include size, shape, and distribution of the calices and the character of the structures surrounding the calicular openings. The coenosteum may pile up so the calix openings are atop mounds which are grossly apparent and often (as in *A. myriophthalma*) appear as papules 3–4 mm through the base and 1 mm high. The contour may also be gently sloping, with the base of the mound being about 5–8 mm (*A. suggesta*). In others, such as *A. listeri* and *A. randalli*, there is no appreciable elevation.

The calicular opening is surrounded by a ring of echinulations which are a continuation of the thecal cylinder and, for the most part, mark the position of the septa. These usually appear as blades or oblong rods with jagged tips. The calicular eminence may be densely covered with echinulations, forming a crown or rosette around the calix opening. These are perpendicular to the coenosteum through which they rise and may partially fuse with the rings of similar vertical rods mentioned above, forming what appear to be costae but are regarded as pseudocostae. These also are grossly visible, and the considerable variations among them are considered species characteristics.

The surface of the corallum, when viewed with magnification, may appear to be entirely reticular or solid. Dana (1846) thought this to be species specific, but it simply reflects the growth phase of the individual colony at the time of collection. The coenosteum has a profusion of echinulations, usually less crowded midway between the calices. These assume various shapes and may resemble solid, smooth, or fluted cones; blades; chisels; or flakes; and they may be up to a millimeter long. Most echinulations terminate in several sharp points, giving the tip a frayed appearance. Their form has some relation to the growth environment and, in general, the specimens of *Astreopora* collected in shallow or rough waters have stouter echinulations than those from deeper waters, which are more fragile and delicate. However, there are so many exceptions that I can only conclude that the forms of the echinulations have no diagnostic importance.

Not every colony of *Astreopora* has a visible epitheca. Lateral growth of a colony that encrusts a substrate resembles a forward rolling on a cushion of echinulations with an epitheca forming beneath, as when another species of coral is encountered. Occasionally, a small free segment of epitheca is seen where an irregularity produces an overhang that the colony growth does not follow. The holotype of *A. expansa* has an extensive epitheca. This is a shelflike specimen and the entire underside is covered with epitheca. Brueggemann (1877:416) described it as follows: "under surface covered to the very edge with a well developed concentrically striate epitheca." This extensive epitheca (Figures 2–4) is the only one of its kind I have seen, and most epithecae I have examined resemble a thin parchment closely adherent to the coenosteum.

FIELD IDENTIFICATION

At times, field identification of the genus *Astreopora* may be difficult. On the reefs, *Astreopora* may closely resemble a *Cyphastrea* or a *Leptastrea*, or vice versa. These latter two corals have true costae and a septal arrangement, which usually can be distinguished above water. Confusion may occur when small colonies of these various species are the only ones available to the collector. *Turbinaria* has much finer surface echinulations than does *Astreopora*, and a columella can usually be distinguished in situ. Growth patterns in *Turbinaria* are usually much different, and it forms large folia not found in *Astreopora*. Nor is *Astreopora* ever the mustard-yellow color commonly seen in *Turbinaria*.

TAXONOMIC KEY TO THE SPECIES

Vaughan (1918) wrote that all descriptive work is tentative, as are the following assignments. Giving a name to a coral specimen requires the designator to consider the salient characteristics and assign a relative comparative value to each. Positioning on a species curve involves discrimination that will differ with each examiner and will depend on experience and geographic breadth of observations as well as the resources at the examiner's disposal. The listing below is therefore tentative.

A. Colony form explanate, shelving. . . . . *A. expansa*
B. Colony form glomerate, not explanate
  I. Surface irregular
    a. Surface papillate
      1. Papillae directed outward
        (a) Calical openings 1.5–2 mm . . . . *A. myriophthalma*
        (b) Calical openings 2.5 mm + ... *A. ocellata*
      2. Papilla often leaning, not vertical. . . . . *A. gracilis*
    b. Surface undulating, calical openings on mounds. . . . . . *A. suggesta*
  II. Surface not papillate, smooth
    a. Calical openings round, regular
      1. Openings about 1.8 mm $\pm$ . . . . *A. listeri*
      2. Openings small, 0.1–0.14 mm . . . . *A. randalli*
    b. Calical openings other than above
      1. Openings elliptical. . *A. elliptica*
      2. Openings hooded . *A. cucullata*
      3. Rough surface, prominent septa . . . . *A. scabra*

SYSTEMATIC DESCRIPTIONS OF THE SPECIES

1. *Astreopora expansa* Brueggemann 1877

Figures 2–4

Astreopora expansa Brueggemann 1877, pp. 416
Bernard 1896, pp. 96, pl. 24 fig. 2, pl. 33 fig. 7
A. incrustans Bernard, Ditlev 1980, pp. 43, fig. 155

CHARACTERS: Distinguishing feature of this species is its mode of explanate growth. Three larger specimens examined all formed flat shelves and had inconspicuous calices above. All had fewer calices beneath and some epitheca. Upper surface was almost flat and grew horizontally; coenosteum solid and covered with fine bladelike echinulations. Calices not raised, no discreet pseudocostae; often in rows parallel to the growing edge. Primary septa poorly developed, at times only vertical rows

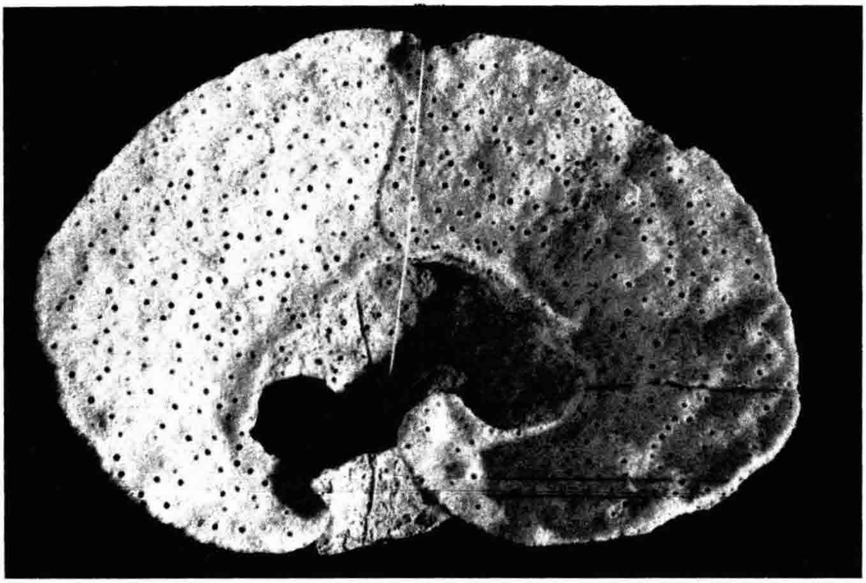

FIGURE 2. *Astreopora expansa*, Brueggemann: holotype BM 58-12-16-6, ½ natural size.

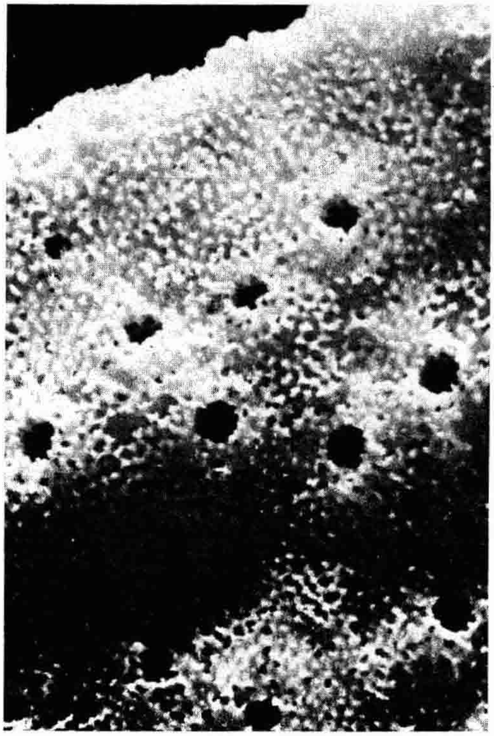

FIGURE 3. *Astreopora expansa*, Brueggemann: holotype BM 58-12-16-6, ×4.

FIGURE 4. *Astreopora expansa*, Brueggemann: holotype BM 58-12-16-6, epitheca, ×4.

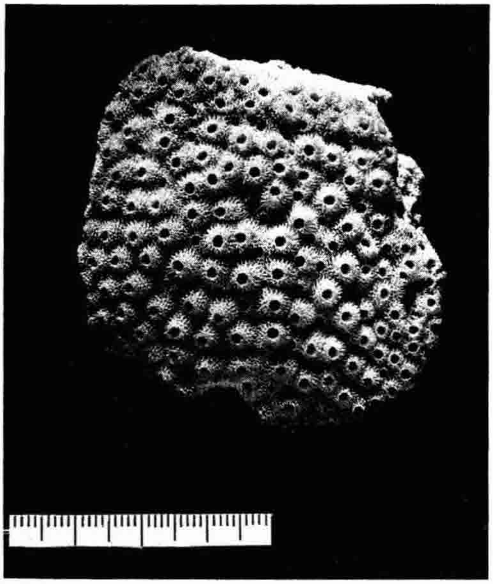

FIGURE 5. *Astreopora myriophthalma* (Lamarck): Lamarck's specimen 1, NMHN, labeled *A. pulvinaria* slightly reduced.

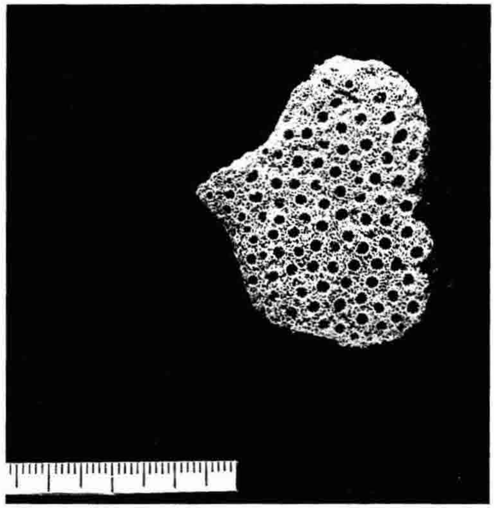

FIGURE 6. *Astreopora myriophthalma* (Lamarck): Lamarck's specimen 3, NMHN, labeled *A. myriophthalma*, slightly reduced.

of spines. In one specimen, primary septa fused irregularly. All specimens transmitted light, and calices appeared to reach the epitheca, which was often a broad band showing concentric rings. In the holotype, this was 12 cm wide with approximately 10 waves and 50 lines (Figure 4).

COLLECTION DATA: Specimen BM 1977-10-11-1 collected by P. Cornelius, N. Oman, 18 m, light brown above, lilac below. GUAM 334 collected by R. Randall in E. Taiwan: "Sandstone community, among *Goniopora* and *Leptoseris*. Other colonies of this species present but rare. Encrusting with explanate portions."

MATERIAL: 4 specimens. BMNH 58-11-16-6, holotype *A. expansa* type location unknown; Bottle labeled #185, Darros Island, BMNH 1977-10-11-1, N. Oman. GUAM 334, Taiwan.

2. *Astreopora myriophthalma* (Lamarck 1816)

Figures 5–7
Astrea myriophthalma Lamarck 1816, II, pp. 260

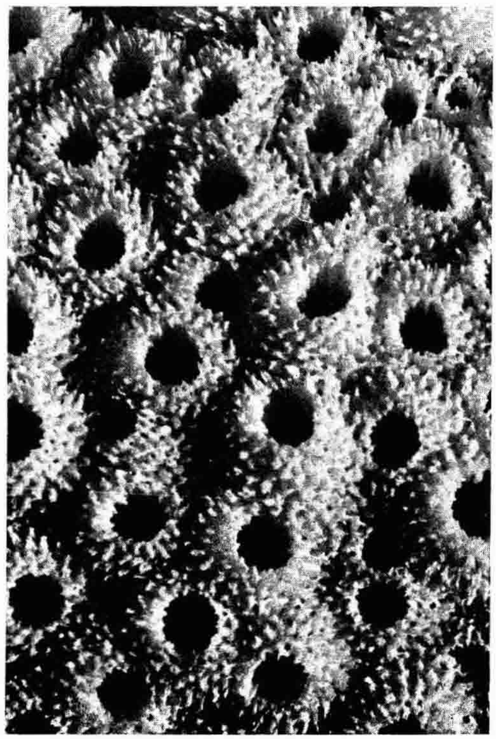

FIGURE 7. *Astreopora myriophthalma* (Lamarck): Crossland's specimen BM 1934-5-14-496, ×4.

Astrea pulvinaria Lamarck 1816, II, pp. 262
Astreopora myriophthalma (Lamarck), de Blainville 1830, pp. 383
A. pulvinaria (Lamarck), Dana 1846, pp. 416, pl. 29, fig. 3
A. myriophthalma (Lamarck), Milne-Edwards and Haime 1849, 29:259; Milne-Edwards and Haime 1860, pp. 168, pl. E2 fig. 4
A. profunda, Verrill 1872, pp. 333
A. myriophthalma (Lamarck), Klunzinger 1879, pp. 52, pl. 5 fig. 31
A. horizontalis Bernard 1896, pp. 87, pl. 25, fig. 3, 33 fig. 8
A. myriophthalma (Lamarck), Bernard 1896, pp. 87, pl. 25, 26, 33 fig. 9
A. incrustans Bernard 1896, pp. 89, pl. 27, 33 fig. 10
A. arenaria Bernard 1896, pp. 90, pl. 29, fig. 2, 33 fig. 11
A. ehrenbergii Bernard 1896, pp. 92, pl. 33, fig. 15
A. ovalis Bernard 1896, pp. 97, pl. 30, fig. 1, 33 fig. 17
A. kenti Bernard 1896, pp. 97, pl. 30, fig. 3, 33 fig. 19
A. profunda Verrill 1872, Bernard 1896, pp. 98, pl. 30, fig. 4, pl. 33, fig. 20
A. tabulata Gardiner 1898, pp. 264, pl. 23, fig. 4
A. myriophthalma (Lamarck), Vaughan 1918, pp. 146, pl. 60, fig. 5–5a
A. profunda Verrill 1872, Hoffmeister 1925, pp. 48
A. myriophthalma (Lamarck), Waugh 1936, pp. 922, fig. 7–9
A. myriophthalma (Lamarck), China Geol. Surv. 1937, pl. 2
A. myriophthalma (Lamarck), Ma 1937, pp. 181, pl. 100, fig. 2
A. myriophthalma (Lamarck), Yabe and Sugiyama 1941, pp. 83, pl. 89, fig. 2–2c, 92 fig. 1–2a, 3–3a
A. profunda Verrill 1872, Yabe and Sugiyama 1941, pp. 83, pl. 90, fig. 2–2c
A. tayamai Yabe and Sugiyama 1941, pp. 84, pl. 91, fig. 2–2c
A. myriophthalma (Lamarck), Wells 1950, pp. 40
A. myriophthalma (Lamarck), Crossland 1952, pp. 180
A. myriophthalma (Lamarck), Wells 1954, pp. 431, pl. 141
A. myriophthalma (Lamarck), Searle 1956, pp. 29, pl. 42
A. myriophthalma (Lamarck), Ma 1959, pp. 209, pl. 234, fig. 1
A. listeri Bernard 1896, Nemenzo 1964, pp. 218, pl. 11, fig. 1
A. stellae Nemenzo 1964, pp. 219, pl. 11, fig. 2
A. myriophthalma (Lamarck), Nemenzo 1964, pp. 220, pl. 11, fig. 3
A. myriophthalma (Lamarck), Domm 1969, pp. 46, pl. 47
A. myriophthalma (Lamarck), Phillipps 1978, pp. 101, pl. 6A
A. myriopthalma (Lamarck), Ditlev 1980, pp. 43, fig. 18, 156
A. myriophthalma (Lamarck), Campbell 1980, pp. 165, pl. 52

CHARACTERS: This species is identified by conspicuous corallite openings, 1.5–2 mm in diameter, evenly spaced and usually elevated 1–2 mm on papules. It is, by far, the most common *Astreopora* on most Pacific reefs and is found on the geographical extremes, Ducie Atoll and Miyuki-Jima, Japan. Found at all depths and in most color phases. Often green, blue, tan in shallow waters and gray or brown below 3 m. Most often found in globular masses 10–20 cm across but may form sheets a meter or more across. Septa narrow at calix orifice and flare at a depth of 3–4 mm. Calix elevation often covered with prominent pseudocostae. Secondary septa small. Coenosteum usually a continuous tabular surface covered with echinulations in the form of short heavy cones, tall fragile flakes, tall chisels or combinations of all of these.

MATERIAL: 116 specimens. AEL 36, 469, 564, 565, 583, 591, 600, 629, 678, 682, 683, 1148, 1150, 1210, 1233, 1250, 1346 (American Samoa); 654, 741, 775, 818, 840 (Enewetak); 1009, 1010, 1014, 1020, 1025, 1029, 1036 (Guam); 1056, 1066, 1067, 1098 (Fiji); 1111, 1112, 1113, 1114, 1115, 1126 (Aitutaki); 1421 (Sabah); 1504, 1505, 1514, 1522 (Solomon Island). BMNH 1849-9-28-4, type *A. arenaria* (Red Sea); 86-10-5-33, type *A. ehrenbergi* (Kosier); 1882-10-17-163, type *A. horizontalis* (Seychelles); 1893-7-1-18, type *A. incrustans*

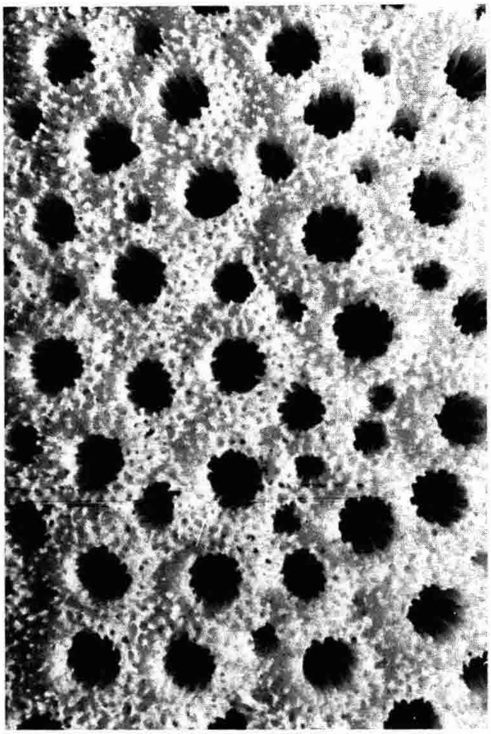

FIGURE 8. *Astreopora ocellata* Bernard: holotype BM 92-12-1-150, ×4.

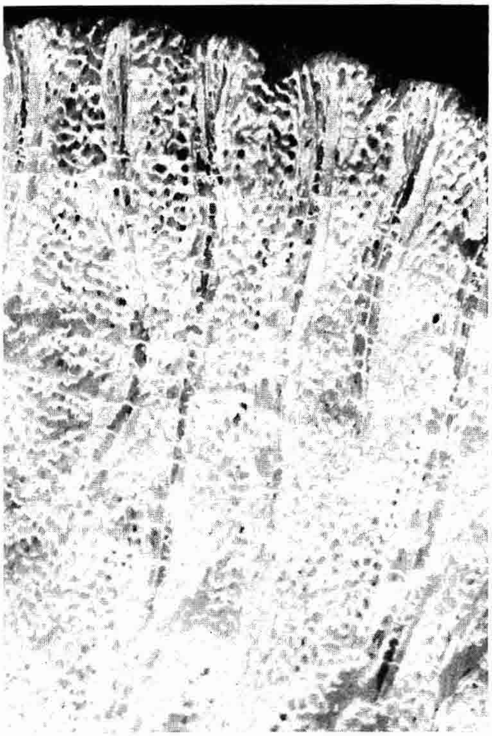

FIGURE 9. *Astreopora ocellata* Bernard: fracture section, AEL 749, ×4.

(origin unknown); 95-7-22-1, type *A. kenti* (King Sound, W. Australia); 1843-3-6-121, type *A. ovalis* (origin unknown); 1895-7-22-6 (Tongatabu); 1888-10-25-9 (Mauritius); 1934-5-14-496 (Ribbon Reef, G.B.R.E.); 92-12-1-558 (label says "Holotype *A. incrustans*"). CUM cotype *Astreopora tabulata* (part) Gardiner (Funafuti). NMHN specimens 1 and 2 Lamarck, labeled *A. pulvinaria*; specimen 3 labeled *A. myriophthalma* (specimen beachworn). BPBM 36, 383, 551, 1128, 1130, 1137, 1236, 1242, 1361, 1482, 1492, 1546, 2491, 2902, 2943 (Enewetak). USNM Tuamotus 204, 245 (Raroia Atoll); Fanning Island 12; Samoa 1, 2 (Mayor collection); Fiji 208 (Dana's specimen), type *A. profunda* Verrill; Caroline Islands 507, 508, 509, 510, 511 (Ifaluk); Philippines #1 (Steere collection); Red Sea 1, 4 (Ghardaga); Chagos 273012 (Diego Garcia). GUAM 11 (Taiwan); unnumbered (Yuan); 102, 115, 127, 217, 218, 1282, 2004, 2420, 4213, 4439, 8052, 9470, 9151, 10455 (Guam); 2941, 2943 (Maug); 3223 (Agrihan); 8774 (Truk); 10563, 10564, 10602, 10606, 10662, 10664 (Galvez Banks, Guam); two specimens unlabeled (Guam).

3. *Astreopora ocellata* Bernard 1896

Figures 8 and 9

Astreopora ocellata Bernard 1896, p. 95, pl. 29, fig. 4, 33 fig. 16

A. hirsuta Bernard 1896, p. 95, pl. 29, fig. 3, 33 fig. 16

A. ocellata Bernard, Vaughan 1918, p. 147, pl. 17, fig. 36, 37; Yabe and Sugiyama 1941, p. 83, fig. 1–2b; Ma 1937, p. 180, fig. 5, 6; Wells 1954, p. 432, pl. 140, fig. 5–6; Ma 1959, p. 234, fig. 3, 4

CHARACTERS: Calicular openings large, prominent, circular, and protruding 1 mm above the coenosteum. *Astreopora ocellata* is much like *A. myriophthalma*, but the surface features are on a larger scale. The two have been found growing next to each other and were readily distinguishable underwater by calix size, which in *A. ocellata* averages 2.5 mm in diameter in contrast with the 1.8-mm average for *A. myriophthalma*. Usually a well-developed collar of pseudocostae around the orifice. Calicular canal about 5 mm deep. Septa easily seen, primary septa narrow above, flare deep in calix, usually thicken deep and often fuse irregularly with one or more other septa. Secondaries vary from being almost as large as the primaries to being mere ridges in other specimens. Coenosteum usually a closed sheet, occasionally a heavy reticulum. Echinulations usually short, heavy, fluted cones surmounted by a cluster of spikes.

COLLECTION DATA: All specimens were collected in relatively shallow water without scuba equipment. Wells (1954) records this species as fairly common on windward flats of Bikini.

MATERIAL: 10 specimens. AEL 749 (Lankai Island, Sulawesi). BMNH 92-12-1-150, holotype *A. ocellata* (Warrier Island); 1892-12-1-157, holotype *A. hirsuta* (Rocky Island, both Australia). USNM 45504, 45505 (both Murray Island, described by Vaughan); Marshall Island #1 (Rangerik Atoll); #2, #3 (Bikini, described by Wells); Saipan collection #1 of P. E. Cloud.

4. *Astreopora gracilis* Bernard 1896

Figure 10

Astreopora gracilis Bernard 1896, p. 93, pl. 29, fig. 3, 33 fig. 14

A. tabulata Gardiner 1898, p. 264

A. gracilis Bernard 1896, Yabe and Sugiyama 1941, p. 83, pl. 88, fig. 3–4c, 92 fig. 1.2a; Wells 1954, p. 432, pl. 141, fig. 6, 7; Ma 1959, p. 234, fig. 5; Ditlev 1980, p. 43, fig. 17

CHARACTERS: The diagnostic character of *A. gracilis* was recognized by Bernard (1896: 93): "Calices well defined, circular (1.25 mm) opening in solid looking papillar projections (sometimes 3 mm high) very irregularly distributed; facing in all directions, crowded and confluent with deep valleys between." Most of the calices project 3–5 mm as papules tilted

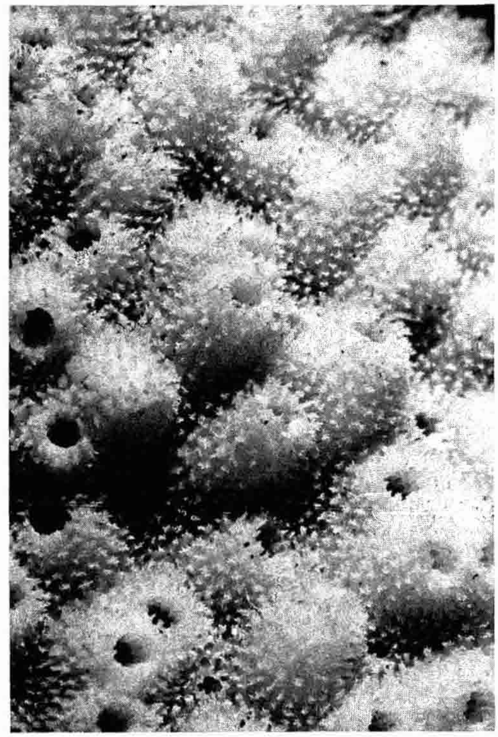

FIGURE 10. *Astreopora gracilis* Bernard: AEL 1015 (Guam), ×4.

toward the colony surface in a helter-skelter pattern. They may tend to lean toward the edge of the colony but almost never are vertical as are those of *A. myriophthalma*. There is no prominent ring of pseudocostae. Primary septa are prominent, well-developed, and fuse at about 3-mm depth. Secondaries may be present, seldom well-developed. Coenosteal surface usually a solid sheet.

COLLECTION DATA: Half the specimens examined were collected on Rizal reef terrace at a depth of about 2 m. Others from deeper water to 30 m. Echinulations from shallow-water specimens tended to be heavier and shorter, often forming cones with abraded tips. Those from deeper waters appeared longer and more fragile. Color of living specimens usually tan or brown, occasionally green, pink, or purple.

MATERIAL: 26 colonies. AEL 1006, 1011, 1015, 1016, 1021, 1023, 1031, 1033 (all Guam); 1483 (Sulig Island, Sabah, E. Malaysia). GUAM

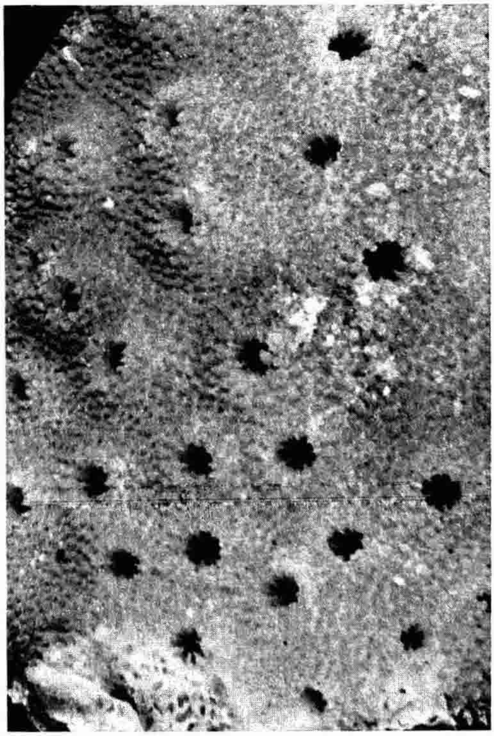

FIGURE 11. *Astreopora suggesta* Wells: holotype USNM 44703, ×4.

75 (Kwajelein); 710 (Palau); 1527, 1537 (Guam); 1862, 1888, 1900 (Enewetak); 2340 (Saipan); 3270, 4206, 4542, 4553 (Guam); 8716 (Truk); 10607 (Galvez Banks, Guam). CUM Gardiner's cotype *A. tabulata* (one piece). BMNH 1884-11-22-32, holotype *A. gracilis* (Dr. Guppy, Solomon Island).

5. *Astreopora suggesta* Wells 1954

Figure 11

Astreopora suggesta Wells 1954, p. 433, pl. 140, fig. 7–8

A. tabulata Wells 1954 (non Gardiner), p. cit. p. 432, pl. 140, fig. 3–4

CHARACTERS: *Astreopora suggesta* can be distinguished by the widely spaced small calices, each usually atop a mound 5–8 mm across the base, giving the surface an undulating appearance. Pseudocostae obscure. Septa inconspicuous and irregular, with some septal fusion at 3 mm from the calix opening. Secondary septa vary from being almost as large as the primaries to being barely discernible. Coenosteum usually a continuous plate with dense cover of short awllike spines, each ending in a cluster of jagged points. To the present, all specimens of *A. suggesta* have been collected on the reef fronts of Marshall Island atolls at 5–80 m. It is not known whether this depth has diagnostic significance.

COLLECTION DATA: All specimens taken with SCUBA or dredging. Color brown. Reported by Judy Lang, collector of BPBM 663 and 940, to be locally common on seaward slope of Bikan, Enewetak.

MATERIAL: 10 specimens. USNM 44703, holotype *A. suggesta*; 44702, paratype *A. suggesta*; 44704 (all dredged at Bikini); 44698, holotype *A. tabulata* Wells; 44699, paratype *A. tabulata* Wells. BPBM 663, 940 (Enewetak). GUAM 1912, 1913 (Enewetak).

6. *Astreopora listeri* Bernard 1896

Figure 12

Astrea punctifera Lamarck 1816, II, p. 260

Astreopora listeri Bernard 1896, p. 91, pl. 28, 29 fig. 1, 33 fig. 12

A. punctifera (Lamarck), Bernard 1896, p. 96, pl. 30, fig. 2, 33 fig. 18

A. punctifera (Lamarck, 1816), Yabe and Sugiyama 1941, p. 84, pl. 90, fig. 1–1f

A. listeri Bernard, Wells 1954, p. 432, pl. 141, fig. 1–2

A. listeri Bernard, Nemenzo 1964, p. 218

CHARACTERS: Colonies of *A. listeri* can usually be distinguished by their smooth contours without calicular elevations. The calix openings are round, regular, evenly spaced, 1.5–2 mm in diameter, sometimes partially surrounded by a half collar of pseudocostae. Primary septa well formed, narrow at the openings, flare at a depth of 2–3 mm. Fusion of septa incomplete and common. Secondary septa usually small. In twenty-six specimens the coenosteum was a solid sheet, in six it was partially solid, and in the rest it was an open reticulum. This seems to have no diagnostic significance.

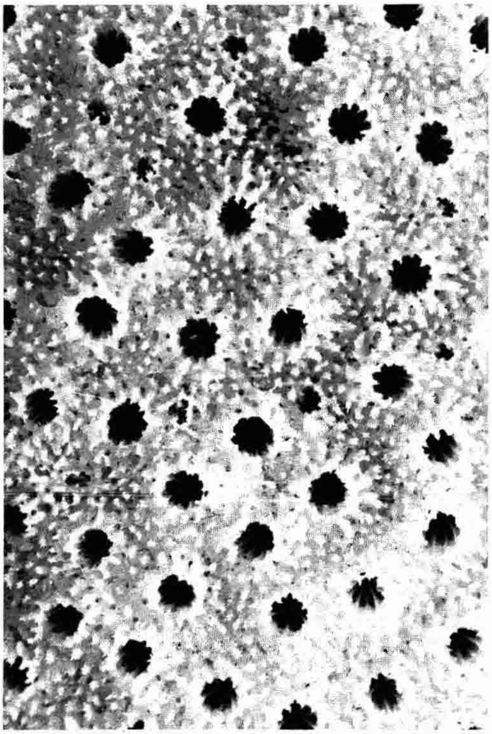

FIGURE 12. *Astreopora listeri* Bernard: holotype BM 1891-3-6-20, ×4.

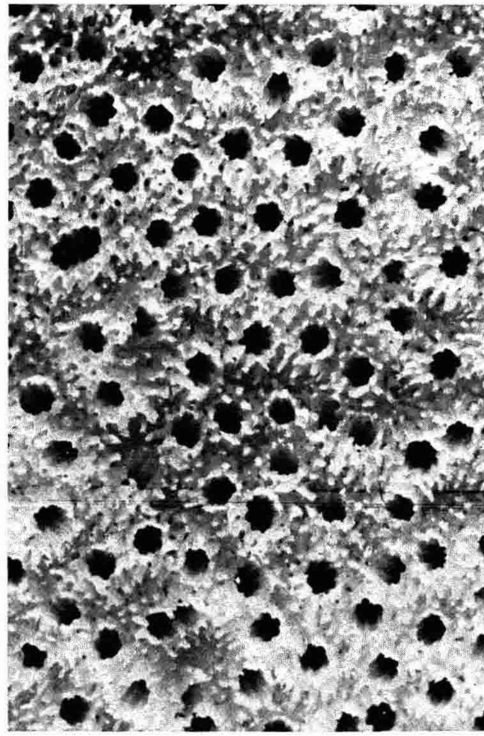

FIGURE 13. *Astreopora randalli* Lamberts: holotype BPBM SC 683, ×4.

COLLECTION DATA: Collected at all depths, exposed reef flats to 30 m. Usually tan colored, rounded masses.

ADDENDUM: Lamarck (1816) described *Astrea punctifera* as being spherical like a small cannon ball. Bernard recognized that this resembled his *Astreopora listeri* closely, but he rejected the synonomy because of differences in growth forms. Lamarck's specimen apparently has been lost, and Bernard's specimen *A. punctifera* is *A. listeri*. To the present, I have not found an unattached *Astreopora* that I could call *A. listeri*. Because of long usage, the name *A. listeri* is retained.

MATERIAL: 46 specimens. AEL 5, 9, 136, 674, 585 (American Samoa); 750 (Sulawesi); 751 (W. Java); 799, 818 (Enewetak); 1005, 1007, 1008, 1013, 1019, 1022 (Guam); 1110 (Aitutaki); 1089 (Fiji); 1395 (E. Sabah). BMNH 1891-3-6-20, holotype *A. listeri*; 1891-3-6-34, 1891-3-6-89 (collected by J. J. Lister, Tongatabu); 92-12-1-418, labeled *A. punctifera* (Saville-Kent, Great Barrier Reef). BPBM 800, 862, 1519, 1545, 1795 (Enewetak). USNM 45562 (Cocos-Keeling); Cabinet 241 (Tonga); Newell 131 (Raroia, Tuamotus). GUAM 53, 84 (Kwajelein); 1282, 1413, 1459a, 2654, 2654a, 3269, 9768, 10103, 10181, MD-T-CH, MD-T-CM (Guam); 2945, 2975 (Maug); Spec. 1 (Fagu Atoll, Caroline Islands).

7. *Astreopora randalli* Lamberts 1980

Figure 13

CHARACTERS: *Astreopora randalli* is differentiated by the large number of small calices not raised above the surface. Average 1.1 mm in diameter, usually nine or more per square centimeter, evently spaced, openings usually surrounded by a crown of flattened pseudocostae. Primary septa can barely be seen with unaided vision, descend regularly and flare at 2–3 mm. Axial fusion rare. Secondary septa poorly developed or absent. Coenosteal surface an open reticulum covered with short pencil-shaped echinulations.

COLLECTION DATA: Most colonies in situ had a velvety smooth appearance, bright jade green in Guam. There, *A. randalli* was one of four species of *Astreopora* growing in a mixed assemblage of corals on a reef terrace. Others included *A. myriophthalma*, *A. gracilis*, and *A. listeri*, the latter of which *A. randalli* resembled when cleaned. One colony found was an 18-inch pulvinate mass.

MATERIAL: 5 specimens. AEL 1027 (part of holotype); 1028, 1030 (Guam); 1109 (Aitutaki); 1579 (Mactan, Philippines). BPBM SC 683, holotype *A. randalli* (Guam).

8. *Astreopora elliptica* Yabe and Sugiyama 1941

Figure 14
Astreopora elliptica Yabe and Sugiyama 1941, p. 84, pl. 91, fig. 1–1c

CHARACTERS: The distinguishing feature of *A. elliptica* is the closely spaced calices, most of which have elliptical openings. All specimens seen are pulvinate and solid. A typical one (GUAM 1207) is subhemispherical, 14 × 9 × 5 cm. Calix rims not raised. Surface relatively smooth. Occasional calices round. These averaged 1.6 mm in diameter, whereas the elliptical ones averaged 2.26 × 0.9 mm. Septa not grossly apparent. Calices about 4.5 mm deep. Primary septa tend to fuse irregularly deep within the calicular cylinder. Secondaries weakly developed. Coenosteum at surface an open reticulum thickly covered with echinulations shaped like blades and flakes, tall in one specimen, short and frail in others.

The only specimen described by Yabe and Sugiyama was a "pillow shaped colony 19 × 10 × 7 cm" with other characteristics as described here. Collected at Nugal, Marshall Islands.

COLLECTION DATA: All collected by Richard Randall during SCUBA dives, at 10–20 m, Guam. No data on color of living colonies.

MATERIAL: 3 colonies. GUAM 127, 1207, one unnumbered.

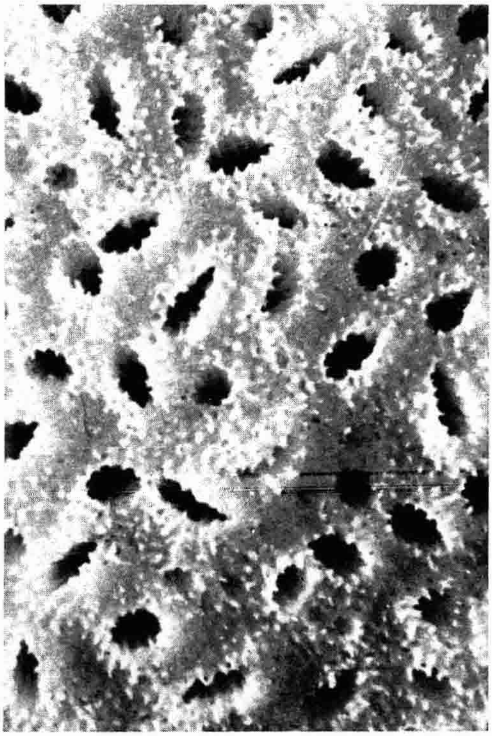

FIGURE 14. *Astreopora elliptica* Yabe and Sugiyama: GUAM 1207, ×4.

9. *Astreopora cucullata* Lamberts 1980

Figure 15
Astreopora cucullata Lamberts 1980, p. 261, fig. 1–4

CHARACTERS: *Astreopora cucullata* is distinguished by the cowled appearance of the coenosteum guarding the calicular openings. The corallites are evenly spaced, with calices that vary from circular to distorted ovals occasionally separated by a single thecal wall. Primary septa thin, poorly developed at upper end, descend unevenly, often appear warped. Axial fusion at 3–4 mm. Secondary septa small, weakly developed to absent. Coenosteal surface porous, densely covered with long, fluted, chisellike or blade-shaped echinulations. Coenosteum piled in distinctive hoods that virtually obscure half the calices. Hood openings usually directed downhill to the edge of the colony. Some corallite openings unprotected and others immersed.

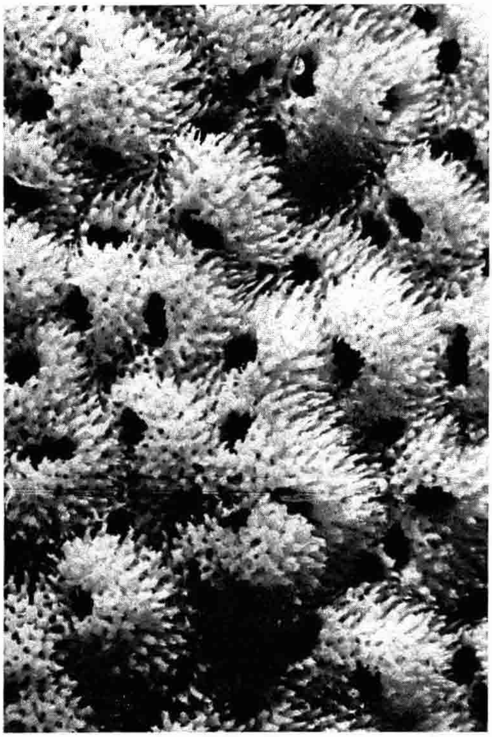

FIGURE 15. *Astreopora cucullata* Lamberts: holotype BPBM SC 682, ×4.

COLLECTION DATA: All specimens collected on reef slopes in semiprotected bay areas in mixed assemblages of coral. Tan to rust colored in situ. Growth form globular.

MATERIAL: 9 colonies. BPBM SC 682, holotype *A. cucullata* (Samoa); 1134 (Enewetak). AEL 512, 607, 608, 609, 688, 1141, 1142 (American Samoa).

10. ***Astreopora scabra*** species novum

Figures 16–20

Astreopora tabulata Gardiner 1898, p. 264

A. incrustans Bernard 1896, Yabe and Sugiyama 1941, p. 83, pl. 89 13, 2b; Ma 1959, p. 209; Nemenzo 1964, p. 219

CHARACTERS: Diagnostic feature of *Astreopora scabra* is the rough surface and the exert septa. Calices round, regular, and slightly elevated. There may or may not be a prominent collar of pseudocostae forming a rosette around the calix opening. Primary septa usually thick at the calix rim, becoming slightly exert and extending 3/4 distance to the axis. As they descend, they broaden more and fuse irregularly at 3–4 mm depth. Secondaries

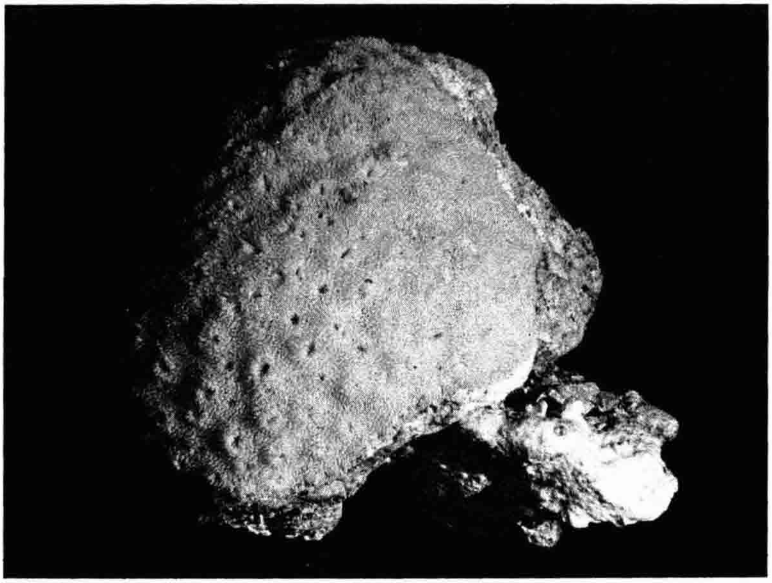

FIGURE 16. *Astreopora scabra* species novum: holotype BPBM SC 702, natural size.

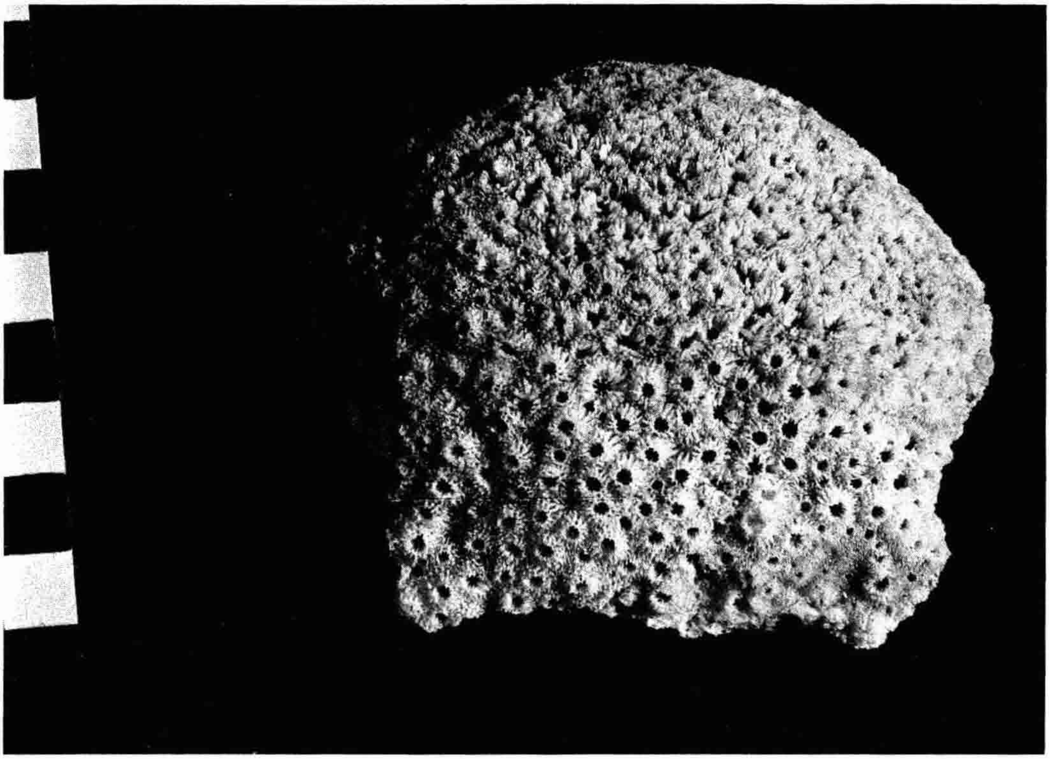

FIGURE 17. *Astreopora scabra* species novum: paratype BPBM SC 703, natural size.

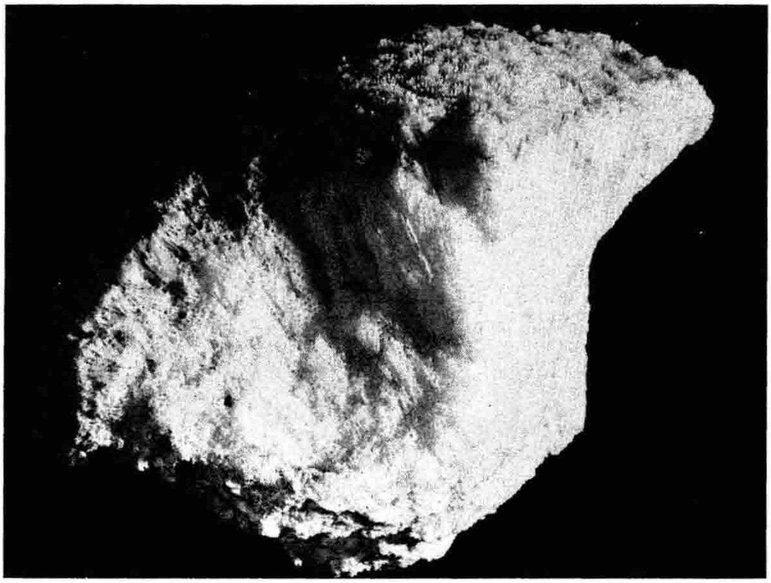

FIGURE 18. *Astreopora scabra* species novum: paratype BPBM SC 703, lateral view, natural size.

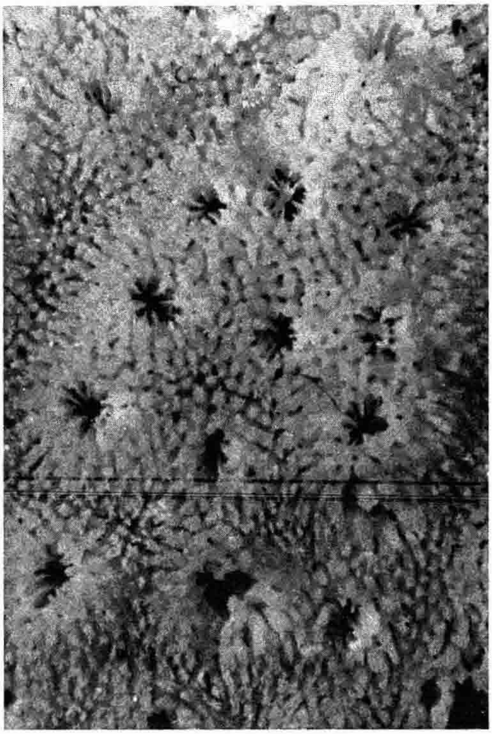

FIGURE 19. *Astreopora scabra* species novum: holotype BPBM SC 702, ×4.

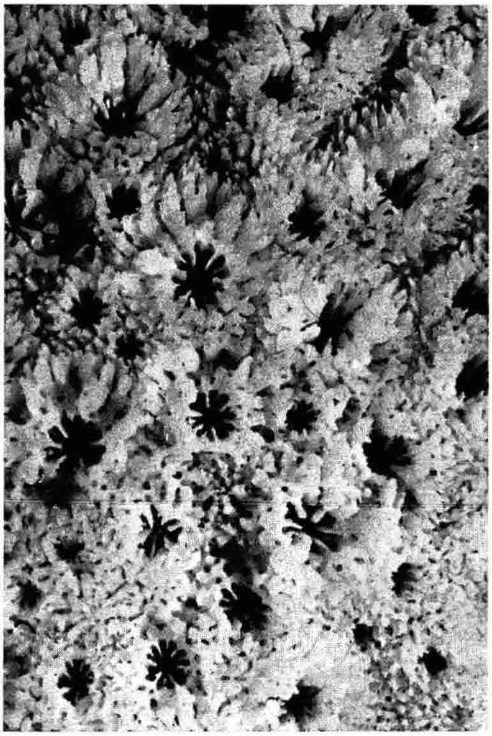

FIGURE 20. *Astreopora scabra* species novum: paratype BPBM SC 703, ×4.

resemble primaries and are often only slightly smaller and do not fuse with the primaries. Tertiary septa may be prominent, usually not. Coenosteum usually solid and appearing heavy. Echinulations may be so numerous coenosteum can hardly be seen beneath them. They are usually short, heavy cones with burr tips, occasionally blade- or flake-shaped.

Fracture sections show heavy coenosteum with both vertical and horizontal elements typical for the genus but heavily built. All specimens collected or examined were low, encrusting, unusually solid colonies.

COLLECTION DATA: Found in all reef conditions from virtually exposed reef flats to 40 m at Galvez Banks, Guam. Color tan or brown. One specimen (Samoa AEL 604) colored burnt orange.

MATERIAL: 23 specimens. AEL 604, 660, 1214 (American Samoa); 607 (Enewetak); 1001, 1002, 1017, 1038 (Guam); 1120 (Aitutaki). BMNH 1893-7-1-18 (Barrier Reef, Australia) *non A. profunda*, Verrill. CUM cotype *A. tabulata* Gardiner 1898 (Funafuti). BPBM 1120, 1146 (all Enewetak). USNM Samoa collection specimen labeled *Diploastrea heliopora* #2. GUAM 76 (Kwajelein); 913, 1589, M.O.T.C.H. (Guam); 4498 (Tinian); 10505, 10660, 10666 (Galvez Banks, Guam).

COLLECTION DATA AND MEASUREMENTS, SPECIES NOVUM: Holotype: BPBM SC 702. AEL collection 1017. Specimen collected 30 November 1977, Rizal reef terrace, Guam. Clear, fast-moving water among an assemblage of several species of *Astreopora*. Color brown, almost entire colony taken. Measures 8 × 5 × 7 cm, weight 145.5 g, volume 86.8 cm^3.

Paratype: BPBM SC 703. Enewetak collection 1102. Specimen collected 27 November

1976, at Bokinwotme, Enewetak Atoll. Windward lagoon terrace. This was a pyramid-shaped piece taken from a vertical surface on an outcrop in 2 m clear water. Mixed assemblage of corals including predominate *Acropora*; also *Montipora*, *Porites*, *Pavona*, *Psammocora*, *Fungids*, and *Astreopora myriophthalma*. Coral cover 25 percent, sand 75 percent. Original colony was an irregular crust 25 × 30 cm in size, red-brown color. Specimen measures 10 × 9 × 6 cm, weight 306.2 g, volume 210 cm^3.

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