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New Species of *Thalamoporella* (Ectoprocta) from Hawaii, Examined by Scanning Electron Microscopy

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INTRODUCTION

The ectoproct bryozoan genus *Thalamoporella* has not previously been reported as occurring in the Hawaiian Islands, probably because of the limited investigations conducted on the bryozoan fauna in that area prior to the recent studies by the authors (Soule and Soule, 1967, 1968). In the present paper, three new species of the genus *Thalamoporella* are described: *Thalamoporella verrilli, T. delicata,* and *T. hawaiiana.* One species, *T. stapifera,* is recorded from Hawaii that has been known previously only from the Indo-Pacific.

The minute calcareous spicules unique to the family Thalamoporellidae were examined by scanning electron microscopy and found to be smooth, dense, and uniform in size and configuration. A Japan Electron Optics Laboratory Company instrument was used, at an accelerating voltage of 25 kilovolts. Spicules and small portions of colonies to be examined were air dried and vapor coated with a 300 Ångstrom thick layer of 100 per cent gold in a vacuum evaporator, model JEE-4B.

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Examinations and photomicrographs were made at corrected magnifications of 76 times for colonies. The spicules were photographed at 760 and 7600 times, except where spicules exceeded field size; magnification was then reduced to 530 or 380 times. Light optics photomicrographs were taken with a Wild M-5 dissecting microscope, with a semi-automatic Nikon Microflex camera and adapter tube. All photomicrographs were made on 35 mm. film and enlarged to uniform size.

Acknowledgments

Field collecting and investigations in Hawaii and subsequent studies at the Allan Hancock Foundation have been supported in part by National Science Foundation Grants GB 5208 and 7723, since 1966.

Dr. William K. Emerson, Chairman of the Department of Living Invertebrates of the American Museum of Natural History, made available specimens of unidentified bryozoans collected by A. E. Verrill in Hawaii in the 1920's and donated to the museum by Verrill's family. Collections from the Bernice P. Bishop Museum in Honolulu were made available through the kindness of Drs. Lucius Eldredge and Dennis Devaney. Dr. Sidney Townsley of the University of Hawaii made his departmental collections available, and with Drs. Philip Helfrich and John Maciolek, aided the authors greatly in making field arrangements. Extensive diving was done by University of Hawaii graduate students; James McVey and Stanley Swerdloff assisted the authors in collecting the species discussed in the present paper. The type of *Thalamoporella distorta* was lent us for comparisons by Dr. David Pawson of the United States National Museum, Smithsonian Institution.

Scanning electron microscopy was done through the co-operation of Dr. Henry Lee, president of the Epoxylite Corporation, South El Monte, California; Malcolm Kateley performed the technical services on the scanning instruments.

Abbreviations

A.H.F., Allan Hancock Foundation, Los Angeles
A.M.N.H., the American Museum of Natural History, New York
B.P.B.M., Bernice P. Bishop Museum, Honolulu
U.S.N.M., United States National Museum, Smithsonian Institution, Washington, D.C.
S.E.M., Scanning electron microscopy
S- followed by numbers, represents a collecting site established by the present investigators; the last two digits of such numbers represent the year the collection was made

SYSTEMATIC ACCOUNTS

ORDER CHEILOSTOMATA

SUBORDER ANASCA

FAMILY THALAMOPORELLIDAE

Thalamoporella verrilli, new species

Figures 1A–G; 5A–C.

DIAGNOSIS: Thalamoporellid species unique in having strong, proximally facing avicularia with hourglass-shaped mandibles. Zooecia modified hexagonal in shape, with opesiules generally unequal in size and position. Zooecial cryptocyst resembles large, fused glass beads with regularly spaced, medium-sized pores. Aperture elevated, with strong, raised distal rim and adoral tubercles. Operculum heavily chitinized and bends down from proximal sclerite to meet rising thin proximal lip. No ovicells seen. Spicules include short, medium, and long compasses; no calipers found.

HOLOTYPE: A.H.F. Bryozoan No. 157.

PARATYPES: A.M.N.H. No. 2233; B.P.B.M., No. K440.

TYPE LOCALITY: Kukuiula Harbor breakwater, south coast of Kauai, Hawaiian Islands; Station S-803-67, at 13–16 meters. Collected by McVey, Swerdloff, and the Soules.

DESCRIPTION: The colonies were common in the type locality, forming unilaminar incrustations on breakwater rubble and on nullipores in relatively shallow waters. The zooecia are thick walled and sturdy looking, and have the typical subhexagonal vase shape of the thalamoporellid. Lateral zooecial rims and the cryptocyst are translucent but heavy, resembling a fusion of rows of glass beads. The cryptocyst bears regularly spaced, medium-sized pores, and slopes downward toward the opesiules from which it rises to the elevated aperture (fig. 1A).

The aperture has a heavy arched distal rim, with an inner oral shelf and with adoral tubercles; the proximal edge is a wide sinus, lowered and not rimmed. The operculum is tan, heavily chitinized, with a rim sclerite and a proximal sclerite arched across at the level of the tubercles. The operculum is bent downward below the proximal sclerite in order to meet the thin proximal lip.

Basal wall insertions are varied. The opesiules are usually unequal, and both may reach the basal wall, where they close upon the lateral walls. One or more circular scars are located between the opesiule insertions or distal to them.

The avicularia are unusual among the thalamoporellids, facing proximally, with heavy hourglass-shaped mandibles. There are also a few avic-

ularia that have a long pointed mandible, also directed proximally. The avicularium has a depressed, beaded cryptocyst with a single median opesiule or with two opesiules, and with a small arched aperture. The avicularium rostrum is arched upward and inward along the sides, and descends to the level of the parent zooecium at the tip. The mandible tips curve closely around the edge of the operculum of the next proximal zooecium or parent. The mandible is reinforced along the edges with a chitinous rim. There is an internal lucida in the center of the mandible corresponding to the shape of the avicularian aperture; two short stout muscles originating on the proximal aperture rim are inserted on the edge of the lucida (see also fig. 5A–C).

Where two rows of zooecia are formed from a parent zooecium, the so-called sister zooecium of an avicularium is almost twice as long as the avicularium, and is oriented parallel to it. Spicules are numerous, and include small, medium, and extra long compasses; no calipers were found (fig. 1A, B, C, and G show comparative compass sizes; table 1 gives measurements). Figures 1E and F show the precise configuration of the "hinge" area and the sharp tip of the spicules, respectively.

The only species of *Thalamoporella* found in the literature that has proximally facing avicularia is *T. gracilis,* which Maplestone (1900) described and figured in his paper on Tertiary deposits in Victoria, Australia. Stach (1936) also recorded that species from the lower Pliocene of Victoria. *Thalamoporella gracilis* differs greatly from the new species in having ovoid avicularia, and in the merging of the two opesiules into one in the zooecia. It forms a much more fragile, erect colony. The apertural area of *T. verrilli* and the steeply rising cryptocyst at the proximal lip resemble that of *T. gothica* var. *indica* as described by Harmer (1926), in which species he included Levinsen's *T. rozieri* var. *labiata.*

DISTRIBUTION: The type specimen was collected July 3, 1967 at station S-803-67, Kauai. Also collected at S-522-67, Pokai Bay, western Oahu, Hawaiian Islands, at 21 meters, on July 6, 1967.

One specimen of *T. verrilli* (A.M.N.H. No. 2233) was found in material that had been collected by A. E. Verrill on Kauai; no date or additional information was given on his label. This is a part of a small Hawaiian collection made by A. E. Verrill and donated by his family to the American Museum of Natural History.

The type locality is an area of heavy surf, for which the sturdily constructed *T. Verrilli* seems well adapted. It is outside a tiny harbor that receives heavy fresh-water runoff from rainfall and much red soil from adjacent cane fields. No doubt the heavy surf outside the breakwater keeps the colonies free of silt and excessive fresh-water dilution.

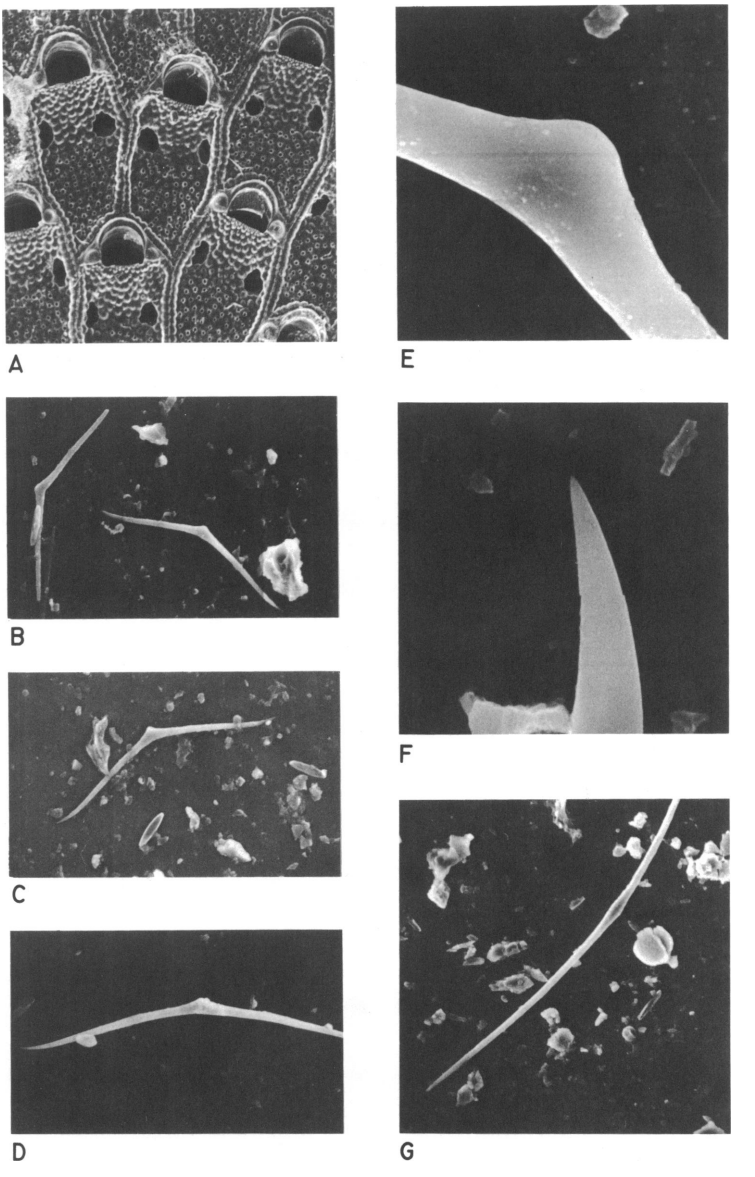

FIG. 1. *Thalamoporella verrilli,* new species. A. Portion of a colony. B–D. Compasses, photographed at ×760. E, F. "Hinge" and tip of small compass, photographed at ×7600. G. Extra long compass, photographed at ×380.

Thalamoporella hawaiiana, new species

Figures 2A–G; 5D, F.

DIAGNOSIS: Avicularium with a raised rostrum and a spathulate mandible; avicularian cryptocyst extensive, with small opesiules. Sister zooecium curved, with aperture directed toward avicularium. Spicules short, medium, and long compasses, calipers wicket-shaped. Zooecia subhexagonal with moderate-sized opesiules, equal or unequal in size and position. Cryptocyst raised, with small pores. Colonies, incrusting.

HOLOTYPE: A.H.F. Bryozoan No. 156.

PARATYPE: B.P.B.M. No. K441.

TYPE LOCALITY: Station S-522-67, Pokai Bay, western Oahu, Hawaiian Islands, an artificial reef 1 mile offshore at 21 meters. Collected July 6, 1967 by McVey, Swerdloff, and the Soules.

DESCRIPTION: The colonies are usually unilaminar and incrusting; the zooecia are oblong rectangular or widened laterally, at the level of the opesiules, to a subhexagonal shape. The aperture is arched, rounded distally, and straight or slightly curved upward proximally with beaded proximal rim (fig. 2A). The operculum fits the aperture and has a chitinous rim; short or medium lateral sclerites, or a complete chitinous bar, reinforce the operculum at the level of adoral tubercles. The proximal part is sometimes missing. Adoral tubercles are hollow, and some are raised into tiny, blunt spines. The cryptocyst is raised centrally, and is shiny and granular with tiny perforations. The opesiules are large, and may be unequal or nearly equal in size. Both descend to the basal wall forming large C-shaped closings with the lateral wall. Strong, calcified muscle attachments show clearly at the proximal edges of the suture lines. Some kenozoids, with or without apertures, appear at the margin of the colonies.

The avicularium is large, usually longer than the sister zooecium, which has its aperture twisted toward the avicularium mandible. The avicularian cryptocyst is extensive and granular, with two very small opesiules visible. The rostrum is narrowed and raised centrally, and expanded distally. The mandible is spathulate, reinforced with long triangular sclerites which have lateral hinge projections at the base (fig. 5D).

Spicules are short, medium and long compasses, and the calipers are wicket-shaped with hooked tips (table 1; fig. 2B–G). Zooecia are variable in size from colony to colony but uniform within a single colony, apparently depending upon the growing room available to the unilaminar colonies.

The ooecia are similar in size to the zooecia, but the cryptocyst is

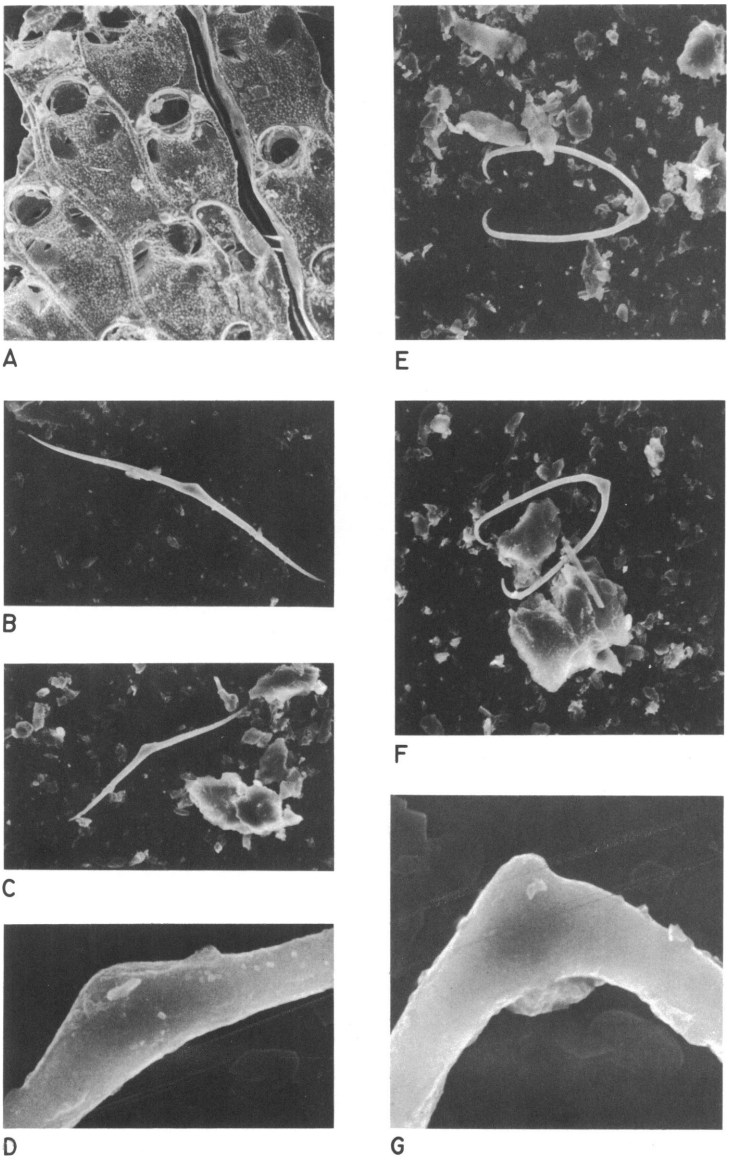

FIG. 2. *Thalamoporella hawaiiana,* new species. A. Portion of a colony. B, C. Compasses, photographed at ×760. D. "Hinge" of small compass, photographed at ×7600. E, F. Calipers, photographed at ×760. G. "Hinge" of caliper, photographed at ×7600.

shorter and descends directly from the proximal wall instead of being raised centrally (fig. 5F). The aperture and ovicell occupies about half of the zooecial space. The aperture is closed by its operculum, and the ovicell is closed by a long, thick, tonguelike operculum; these fuse at their bases and articulate with the aperture by lateral projections. The imperforate ovicell consists of two double-layered, rounded halves that fuse into a suture line in the center. The interior dividing projection is short.

The colony from B.P.B.M. Lot 312 is well calcified, but the colony from B.P.B.M. Lot 336 has more heavily calcified ovicells with a small lip rising at the suture line and arch in some individuals. Calcification of the older cryptocysts appears to take place by deposition of granular material, leaving the pores clear.

Thalamoporella hawaiiana resembles *T. stapifera* (Levinsen) somewhat, in the general shape of the zooecia and avicularia. However, *T. hawaiiana* has very small pores in the cryptocyst, and the descending walls of the opesiules are inserted in a closed pattern (see Levinsen, 1909, pl. VI, fig. 5, for comparison). The compass spicules are similar, but the calipers of *T. hawaiiana* are wicket shaped, with arms almost parallel and a small hinge area thickening. They are also taller than wide, but are larger than those of *T. stapifera* (table 1; figs. 2E, F; 4F).

Thalamoporella hawaiiana resembles *T. distorta* Osburn (U.S.N.M. No. 11848) in having the polypide tube and aperture of the sister zooecium next to the avicularium torqued laterally toward the avicularium, and in having small opesiules in the avicularian cryptocyst. *Thalamoporella distorta* lacks compass-shaped spicules, and its calipers are wide open, wider than high; its basal insertions are not closed. *Thalamoporella mayori* Osburn (1940) has larger avicularia with larger opesiules, and the sister zooecia are not torqued toward the avicularia. Both compasses and calipers of various sizes are found in *T. mayori,* according to Osburn (1940). Osburn's two species were described from the Caribbean. Cook (1964) recorded *T. mayori* from West Africa also.

Thalamoporella granulata Levinsen, as limited by Harmer (1926), has similarly asymmetrical sister zooecia facing the avicularia. The avicularian cryptocyst of *T. granulata* is reduced and the mandible more spoon-shaped than that of *T. hawaiiana. Thalamoporella granulata* has large cryptocystal pores and no adoral tubercles. The latter has been reported from Torres Straits and Victoria, from Japan and the Philippine Islands.

DISTRIBUTION: The type locality at Pokai Bay, western Oahu, is on an artificial reef placed by the Bureau of Sport Fisheries, Hawaii Cooperative Fishery Unit, at the University of Hawaii. Also found in B.P.B.M.

Lot 312, collected offshore Oahu, September 28, 1944, at 9 meters; B.P.B.M. Lot 315, offshore Oahu, April 28, 1944, at 14 meters; B.P.B.M. Lot 316, offshore Oahu, April 28, 1944, at 18 meters; B.P.B.M. Lot 336, offshore Oahu, on January 24, 1944, at 9 meters. A specimen sent by E. R. Long of the U. S. Oceanographic Office, collected off Oahu at 30 meters in May, 1968, appears to belong to this species.

Thalamoporella delicata, new species

Figures 3A–G; 4A, B; 5E.

DIAGNOSIS: Zooecia rectangular, lightly calcified; Cryptocyst thin and translucent with many small pores. Opesiules large, descending irregularly to basal wall, with attachments open distally. Avicularium spathulate with open opesium area in cryptocyst, proximal to mandible. Sister zooecium not modified. Spicules include short, medium, and long compasses, and three sizes of wide open calipers. Colonies, incrusting.

HOLOTYPE: A.H.F. Bryozoan No. 158.

TYPE LOCALITY: North Pokai Bay, western Oahu, Hawaiian Islands, ½ mile offshore opposite the "pill box," at 8 meters; S-518-67. Collected by McVey, Swerdloff, and the Soules, August 1, 1967.

DESCRIPTION: The colonies are unilaminar, incrusting, and very lightly calcified. The zooecia are oblong, with the cryptocyst thin, bearing numerous small pores (fig. 3A). The porous area extends distal to the opesiules in a well-marked arch. Opesiules are large, sometimes almost merged into one above the polypide tube. Both opesiules generally reach the basal wall. The insertions are irregular open hooks; in a few zooecia they almost meet back to back in the center, but they are commonly separated.

The aperture is a rounded arch distally with lateral edges almost parallel and bordered by a rim which ends in raised tips in the condyle area; adoral tubercles are absent. The proximal aperture is rounded and low. The operculum is reinforced by a distal chitinous rim and small lateral sclerites at the condyles; the operculum is very thin and continuous with the thin frontal membrane, similar to the situation in membraniporines.

The avicularium is slightly narrower than the zooecia but is similar in length. It is spathulate with the tip overhanging the next distal zooecium. The avicularian cryptocyst covers the proximal third of the frontal or less, and extends along the lateral walls to form an open opesium area proximal to the mandibular articulation. The rostrum is elevated centrally, descending at the distal end. The wall of the next distal zooecium can be seen beneath the transparent rostrum tip. The

mandible is lightly chitinized, with long sclerites that form a narrow distal arch and a basal sclerite that articulates with the condyles (fig. 5E).

The ooecium has a short cryptocyst and large opesiules; the ovicell hood is imperforate, of two fused halves, and is typically thalamoporellid. The operculum of the polypide aperture is continuous with the frontal membrane and is reinforced by a marginal sclerite. This articulates with the bordering sclerite of the ovicell operculum, which is also thin and not distinctly separated from the frontal membrane.

Thalamoporella delicata, the most fragile-appearing Hawaiian species, carries the greatest array of spicules. Included are very short, medium, long, and extra long compasses, as well as small, medium, and large wide open calipers (table 1; figs. 3B–G, 4A, B).

Thalamoporella delicata seems most similar to *T. lioticha* from Japan, as figured by Ortmann (1890), Levinsen (1909), and Silén (1938), particularly in the structure of the avicularia. The cryptocyst and opesiules are also similar. *Thalamoporella lioticha* forms incrusting colonies or erect, prismatic branching colonies, whereas *T. delicata* is very thin, unilaminar, and incrusting. This difference cannot be considered definitive however, since *T. californica* and *T. gothica* from California, and *T. granulata* are known to form either incrusting or erect colonies, depending upon substrate and growing conditions. Zooecia of *T. delicata* are wider than those of *T. lioticha* and the cryptocyst of the former has well-defined, perforate proximal areas. The apertural arch is more pronounced and less circular than that of *T. lioticha.* The basal insertions of *T. delicata* opesiules are open irregular hooks and do not form a complete line across the wall as they do in *T. lioticha,* although they may come close to meeting back to back in a few zooecia. The lack of distinct separation of the operculum from the frontal membrane is unusual also.

DISTRIBUTION: In addition to specimens collected at the type locality (S-518-67) at Pokai Bay, Oahu, one specimen was found in the B.P.B.M. Lot 313, collected on September 26, 1944, offshore Oahu at 18 meters.

Thalamoporella stapifera (Levinsen), 1909

Figure 4C–G.

Thalamoporella granulata var. *stapifera* LEVINSEN, 1909, p. 188.
Thalamoporella stapifera LEVINSEN: HARMER, 1926, p. 297.

Thalamoporella stapifera colonies collected correspond closely to Levinsen's figures (1909, pl. 6). The zooecia are subhexagonal. The granular cryptocyst is more or less level and bears numerous pores; the mural rim is beaded. Opesiules are unequal in size and position. The basal in-

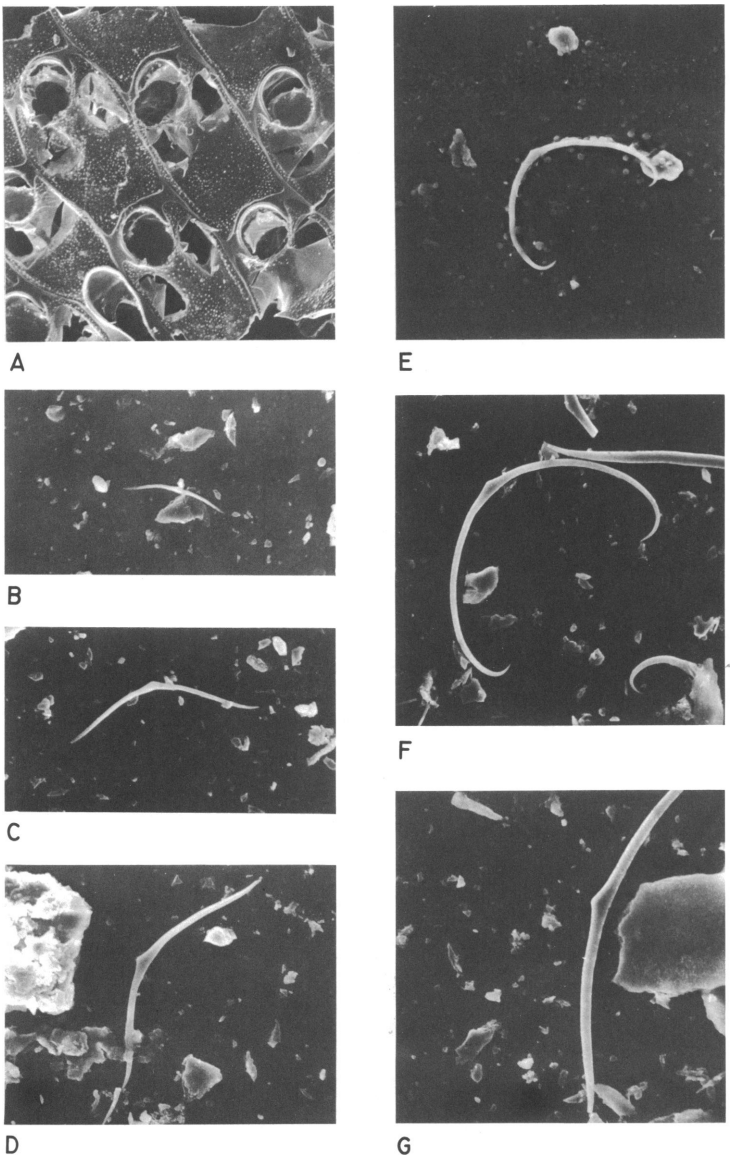

FIG. 3. *Thalamoporella delicata,* new species. A. Portion of a colony. B–D. Compasses, photographed at ×760. E. Caliper, photographed at ×760. F. Large caliper, small caliper, part of a compass, photographed at ×760. G. Extra large compass, photographed at ×760.

sertions are open distally, hook- or L-shaped. The aperture is arcuate distally with pronounced condyles and a wide, curved proximal sinus. The operculum is thin, with a distal marginal rim and two small lateral sclerites that divide the operculum into two parts.

The avicularia are shorter than the zooecia, and most have little or no cryptocyst; a few more heavily calcified colonies show the opesial area partially filled in. The avicularian mandible bears a strong basal sclerite and two long sclerites which may unite at the tip. Mandibles are triangular. The rostrum is elevated centrally and distally, overhanging the next zooecium like a pouring lip in most cases. The parent zooecium that initiates two new rows, one of which begins with an avicularium, is smaller than the other zooecia. The sister zooecium is within the normal size range of zooecia, and curves away slightly from the avicularium. Ooecia are rare. The ovicell hood is imperforate and large; it occupies more than half the ooecium and overhangs adjacent zooecia. The ooecial cryptocyst is short and granular, and has medium-sized pores. It descends directly from the mural rim, and the polypide tube is deep set. Spicules include long, medium, and numerous short compasses plus distinctive small calipers that are stirrup-shaped, higher than wide, with bowed arms and tipped ends (table 1; fig. 4E, F).

The Hawaiian *T. stapifera* differs from Levinsen's only in minor ways. Levinsen described the cryptocyst as being "tuberculous," and with closely set pores and gave the zooecial size as 790–930 microns, whereas the present material is smaller, ranging from 580 to 740 microns. Levinsen's measurements do not agree with his illustrations if the magnification is times 40 as stated; these show zooecial size about 500 microns if the scale is correct. Levinsen also mentioned the presence of small, round "acropetal spines" in the adoral areas, but these are lacking in the material from Hawaii.

Harmer (1926) indicated that the *Siboga* specimen had "adoral areas usually vestigial," and the cryptocyst was "much granulated, with large pores." These differences do not seem worthy of erecting a new species, especially since the avicularia and spicule size and shape agree well. The calipers of *T. stapifera* are somewhat similar in shape to those of *T. hawaiiana,* but are smaller and very rare.

DISTRIBUTION: *Thalamoporella stapifera* was collected at Barking Sands Beach, S-802-67, western Kauai, on July 2, 1967, at 6–9 meters; water temperature was 26° C. The substrate was rough coral rubble and nullipores so that the colonies were irregular, with numerous large and small kenozoids, especially at the growing edges. Most kenozoids had no cryptocysts. Brown bodies were common in the older portions of the colonies.

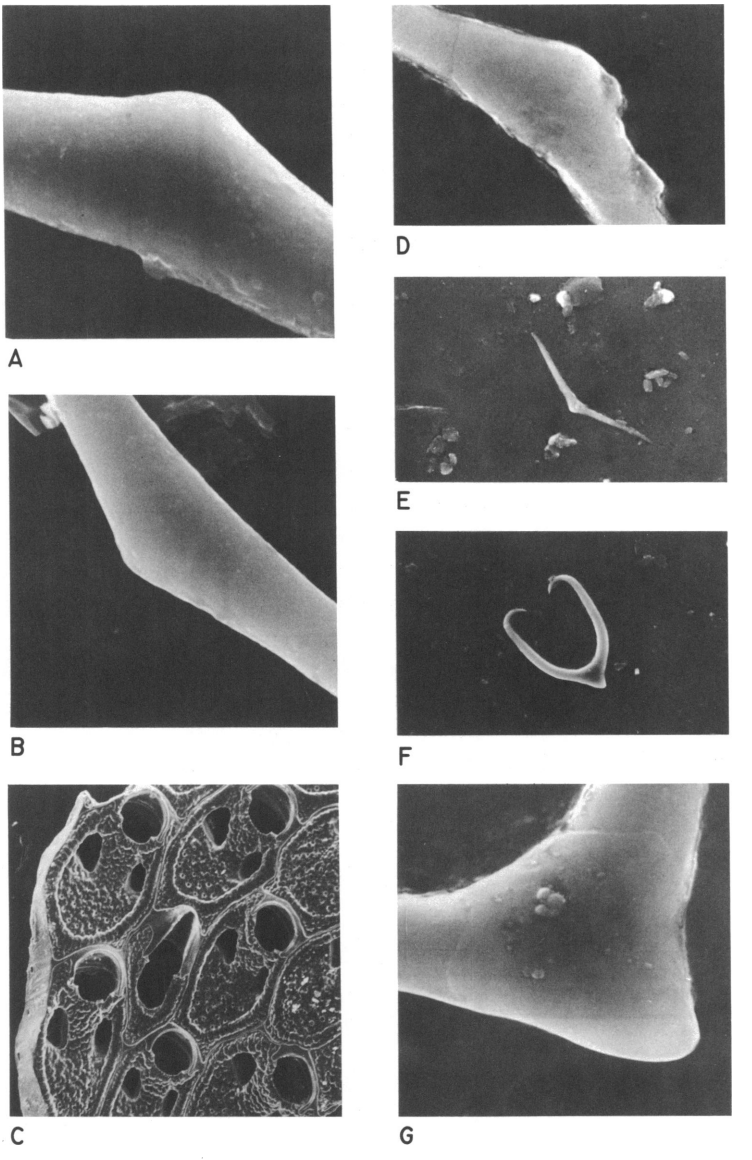

FIG. 4. A, B. *Thalamoporella delicata,* new species. A. "Hinge" of large compass. B. "Hinge" of large caliper, photomicrographs at ×7600. C–G. *Thalamoporella stapifera* (Levinsen). C. Portion of a colony. D. "Hinge" of small compass, photographed at ×7600. E. Small compass, photographed at ×760. F. Stirrup-shaped caliper, photographed at ×760. G. "Hinge" of caliper, photographed at ×7600.

It was also found in B.P.B.M. Lot 319, collected at "Oahu, 1937." In the University of Hawaii collections were specimens, identified by A. E. Blagg as *T. rozieri,* Nos. 17, 19, and 23, from Kahala and Waikiki (southern Oahu) with no other data. Harmer's illustrations (1926, pl. 19) show *T. rozieri* to have a short spathulate mandible on the avicularium, the basal insertions closed, and the calipers wide open; all in contrast to *T. stapifera,* to which Blagg's material belongs.

Levinsen's original specimens were small and the collecting site was uncertain; they were either from the Andaman or Nicobar Islands. Harmer had a small fragment on a sponge from Timor in the *Siboga* collection. Androsova (1963) reported *T. stapifera* from the South China Sea. All are tropical, Indo-Pacific locations.

DISCUSSION

Thalamoporella spicules, first described by Levinsen (1909), are minute calcareous structures with the shapes of compasses or of calipers. These have been found scattered beneath the frontal membrane, lying on the cryptocyst or in the opesiules, and within the body cavity. No histological or histochemical studies to show the cellular origin or function of the spicules have yet been made. Harmer (1926, pp. 295, 304) speculated that they represented temporary deposits of calcareous material, later used in building zooecial walls. He noted the mass of tissue at the growing margin of the colony in which numerous spicules were imbedded, and implied that this was the site of spicule development.

The minute size of most of the spicules and their location in living colonies makes their study difficult. Scanning electron microscopy offers a means of examining the spicules in dried material at very high magnifications. Observation by S.E.M. showed numerous spicules partially imbedded in the walls of opesiules and extended into the opesiule cavities like bristles. One possible interpretation of the role of the spicules is for defense against small parasitic or predatory invertebrates. The thin frontal membrane, large apertural and opesiular openings all offer easy access to the zooecial cavity.

In one colony of *T. hawaiiana,* thin calcareous erect and recumbent tubules formed by an unknown organism were found underlying the colony and penetrating some of the marginal zooecia. Another colony of that species, apparently a mature one with adoral spines and two or three layers of zooecia, had been invaded by an organism that constructed multiple blackish, chitin-like tubules in the apertures and opesiules. Some tubules could be traced to the lateral wall rosette plates or to the distal walls; as many as six tubules occupied a single aperture.

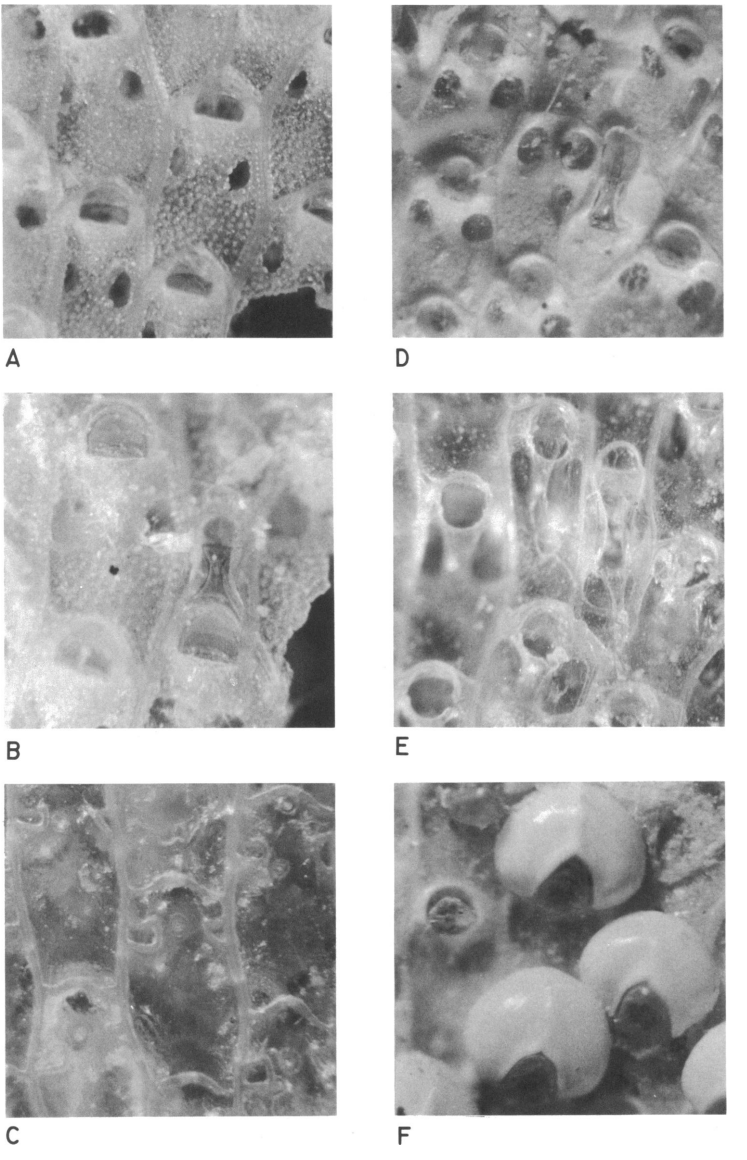

FIG. 5. Light microscope. A–C. *Thalamoporella verrilli,* new species. A. Portion of a colony. B. Proximally directed avicularium. C. Basal wall view. D. *Thalamoporella hawaiiana,* new species, avicularium and torqued sister zooecium. E. *Thalamoporella delicata,* new species, open avicularium. F. *Thalamoporella hawaiiana,* new species, ovicell.

Still other colonies of thalamoporellids showed penetration of the cryptocyst as though by a small punch. Since many small invertebrates, such as polycheates, crustaceans, and echinoderms can be observed browsing on the colonies, it may be assumed that some species are capable of puncturing the zooecia and feeding on the polypides.

The spicules are seen under the S.E.M. to be of dense material and to be very sharply pointed (fig. 1F). Apertures measuring roughly 150–200 microns had up to six of the foreign tubules in that diameter; this brings the spicules well within the size range of the foreign tubules, to offer possible resistance to potential invaders.

Levinsen (1909, p. 189, pl. 6a) described and figured *T. granulata* var. *tubifera,* which contained thin, calcareous tubules extending from the orifice to the distal wall and to the lateral rosette plates. Harmer (1926, pp. 299–301) also found such growths on *T. tubifera* and on *T. expansa.* Both he and Levinsen considered them to be secondary growth, regenerative or degenerative, and not normal, primary components of the thalamoporellids. It seems possible that these might also have been formed by invading organisms.

Harmer's postulation of the spicules as extracellular calcium deposits does not agree well with known instances of calcium deposition. These are usually in the form of amorphous mounds or concentrically deposited layers in globules. Certainly this differs greatly from the structurally exact, species specific forms of the thalamoporellid spicules. Sea water is usually saturated with calcium carbonate, so that deposition of crystalline reserves for wall building would not seem necessary. Protection of the growing edges of the colony, on the other hand, would be vital to the continued existence of the colony. These matters offer intriguing areas for further investigation.

The sizes and shapes of spicules and the structure of the avicularia continue to be two of the most definitive characters for recognition of the species. Zooecial size is significant, but is subject to variation according to the irregularity of the substrate and amount of space and competition. Field observations also suggest that the thalamoporellid size and shape vary according to the amount of pollution; the few colonies found in less well-circulated waters were notably distorted. Bryozoans generally do not tolerate silting, and colonies are situated on the sides or underneath rocks, pipes, coral colonies and shells where they will not be covered.

The degree of calcification apparently varies with the age of the colony and is sometimes enhanced frontally by depositions of coralline algae. The thick walls of *T. verrilli* contrast greatly with those of *T. delicata*

TABLE 1

MEASUREMENTS (IN MICRONS) OF ZOOECIA, AVICULARIA, AND SPICULES IN SPECIES OF *Thalamoporella*

	T. delicata	*T. hawaiiana*	*T. stapifera*	*T. verrilli*
Zooecium				
Length	700–800	550–900	580–740	800–910
Width (maximum)	350–480	300–430	325–490	420–500
Avicularium				
Total length	850–880	625–800	450–590	400–510
Width (maximum)	270–300	220–280	250–300	220–270
Caliper Width				
Small	25–30	42–47	32–38	—
Medium	60–85	—	—	—
Large	100–140	—	—	—
Caliper Height				
Small	22	60–80	48–62	—
Medium	50	—	85	—
Large	70–85	—	—	—
Compass length and angle of arms				
Short	50–115	50–65	50–75	95–105
	135°	140°	145°	140°
Medium	160–240	80–100	90–150	120–170
	150°	150°	150°	155°
Long	270–340	150–200	190–205	320–400
	155°	160°	155°	165°

when viewed basally, but are not different in size from those of *T. stapifera.* Among the specimens of *T. hawaiiana* differences in calcification are apparent, with adoral tubercles forming spines in the heavily calcified colonies.

Thalamoporellid ovicells are distinctive and show only a small amount of variation among the species for which they are known. There are a number of species of *Thalamoporella* in which no ovicells have ever been found, but this may be due to sparse collecting or the smallness of fragments of colonies collected.

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