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East Pacific Mexican *Tethya* (Porifera: Demospongiae) with descriptions of five new species

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Abstract.—Seven species of Tethyidae (Porifera: Demospongiae: Hadromerida) inhabiting the Pacific waters of Mexico, including the Gulf of California, were studied. Five of them, *Tethya ensis, T. mexicana, T. ovum, T. paroxeata,* and *T. socius* are new species. The remaining two, *T. taboga* De Laubenfels and *T. californiana* De Laubenfels, are new records for the area.

This is the first published report on species of the genus *Tethya* (Porifera: Demospongiae) coming from the Pacific coast of Mexico. A total of 242 collected *Tethya* specimens yielded five new species and two other species recorded for the first time. *Tethya taboga* (De Laubenfels) was known only for the Pacific coast of Panama, and *T. californiana* De Laubenfels, 1932, redescribed by Sarà & Corriero (1993), is recorded here for a more southern site in Mexico. Only four species of *Tethya* were previously known for the whole Pacific coast of America: *T. californiana* De Laubenfels from California, *T. taboga* (De Laubenfels) from Panama, *T. papillosa* Thiele from Calbuco (Chile) and *T. sarai* Desqueyroux-Faúndez & van Soest, 1997 from the Galápagos Islands. This small number of American Pacific species, now amounting to nine, is probably due both to a real scarcity of species and to the poverty of records from this area. *Donatia multifida* Carter, 1882 from Acapulco (Mexico), examined by Sarà (1994) on spicular slides of the British Museum of Natural History (BMNH) is currently regarded as incertae sedis, given the scarcity of the material. Moreover, it is impossible to know if it belongs to a species of the *Tethya seychellensis* group or if it should be considered as representative of a new genus of Tethyidae.

Materials and Methods

Samples of *Tethya* (242 individuals) represent part of several collections obtained along the Pacific coast of Mexico, including the Gulf of California at different depths (Table 1, Fig. 1). Sponges were collected with SCUBA diving and with a trawl aboard the R/V *El Puma*. Thirty-eight trawls, covering almost all the Gulf of California from 31°15′9″N, 114°21′7″W to 20°49′N, 105°42′W, from 22 to 120 m depth, were performed in March, July, August, and October of 1985. Several dives off the coast of Mazatlán took place from 23°15′N, 106°29′W to 23°11′30″N, 106°25′W in May 1981 and June 1987 at a depth of 0 to 15 m. Trawls and dives from Guerrero were performed in February (Winter) and April (Spring) of 1982, in the continental shelf, from the coastline to the beginning of the continental slope, at 200 m depth (102°15′N, 98°W), including the Balsas river delta. Sponges, once aboard, were preserved first in 95% alcohol and then in 70%. Techniques to analyze internal structures follow Sarà (1992), and scanning electron microscopy (SEM) follow Gómez

(1998). Spicular data reported are based on 50 measurements from each spicular trait. Main and auxiliary megascleres, generally, strongyloxeas, were distinguished by a conventional 1000 μm length figure. For two species, a third category of "sword" strongyloxeas was considered. Micraster nomenclature is traditionally based on observations taken at the light microscopic level. Yet, the difference between oxyasters, strongylasters and tylasters (Sarà 1994) is only partially due to the ray shape. It depends largely, as shown by SEM micrographs, on the distribution and strength of the spines. The holotypes are deposited in the Natural History Museum of Genoa (Italy) (MSNG), some paratypes are deposited in Laboratorio de Ecología de Bentos ICML collection of Mazátlan (Mexico).

Study area.—The Gulf of California belongs to the subtropical regime with marked fluctuations in climatic conditions all year long. It is positioned between two dry continental environments that cause wide ranges in temperature, low humidity, and high evaporation rate. The yearly mean temperature value at the surrounding coast is 24°–26°C. Rainfall is abundant at the east coast of the Gulf as well as in the south, whereas at the west coast rainfall is lower. Maximum rainfall is from June to October, becoming dry at winter and at the beginning of spring. This brings about coastal upwelling along the western side in summer and at the eastern side in winter (INEGI 1984, Molina-Cruz 1986). Mazatlán is located at the mouth of the Gulf of California, in a tropical and subtropical semi-humid climate, bathed by the Gulf of California current and causing different water changes according to the nearby inlets, islands, and breakwaters. Yearly mean temperature is from 25°C to 28°C, yearly mean rainfall reaches 850 mm (Álvarez-León 1980). Guerrero has a tropical semi-humid climate, yearly mean temperature of 27.5°C, yearly mean rainfall 1117 mm, and a permanent influx of freshwater in Petacalco Bay that

Table 1.—Sampling stations of *Tethya* species along the Pacific coast of Mexico. Collecting parameters.

	Gulf of California			Mazatlán		Guerrero
Locality	Puerto Libertad	Cabo San Miguel	Punta Arboleda	Punta Chile	Petacalco Bay & Pta. Maldonado
Coordinates	29°59′0″N 112°45′0″W	28°10′2″N 112°48′2″W	26°51′9″N 110°00′9″W	23°12′28″N 106°25′50″W	17°55′N, 102°01′W 16°13′N, 98°44′W
Depth (m)	Intertidal	25	22	5 & 8	45 both
Collecting date	Oct 1985	Mar 1985	Jul 1985	May 1981 & Jun 1987	Feb & Apr 1982
Temperature (°C)	17	14	29.5	22	21.7 & 23.5
Oxygen (ml/l)	6.16	4.0	4.8	3.5	2.97
Salinity (‰)	35.56	35.3	35.5	34.4	34.2
Bottom	Sand	Rock-sand	Irregular	Rock	Sandy-mud, clay

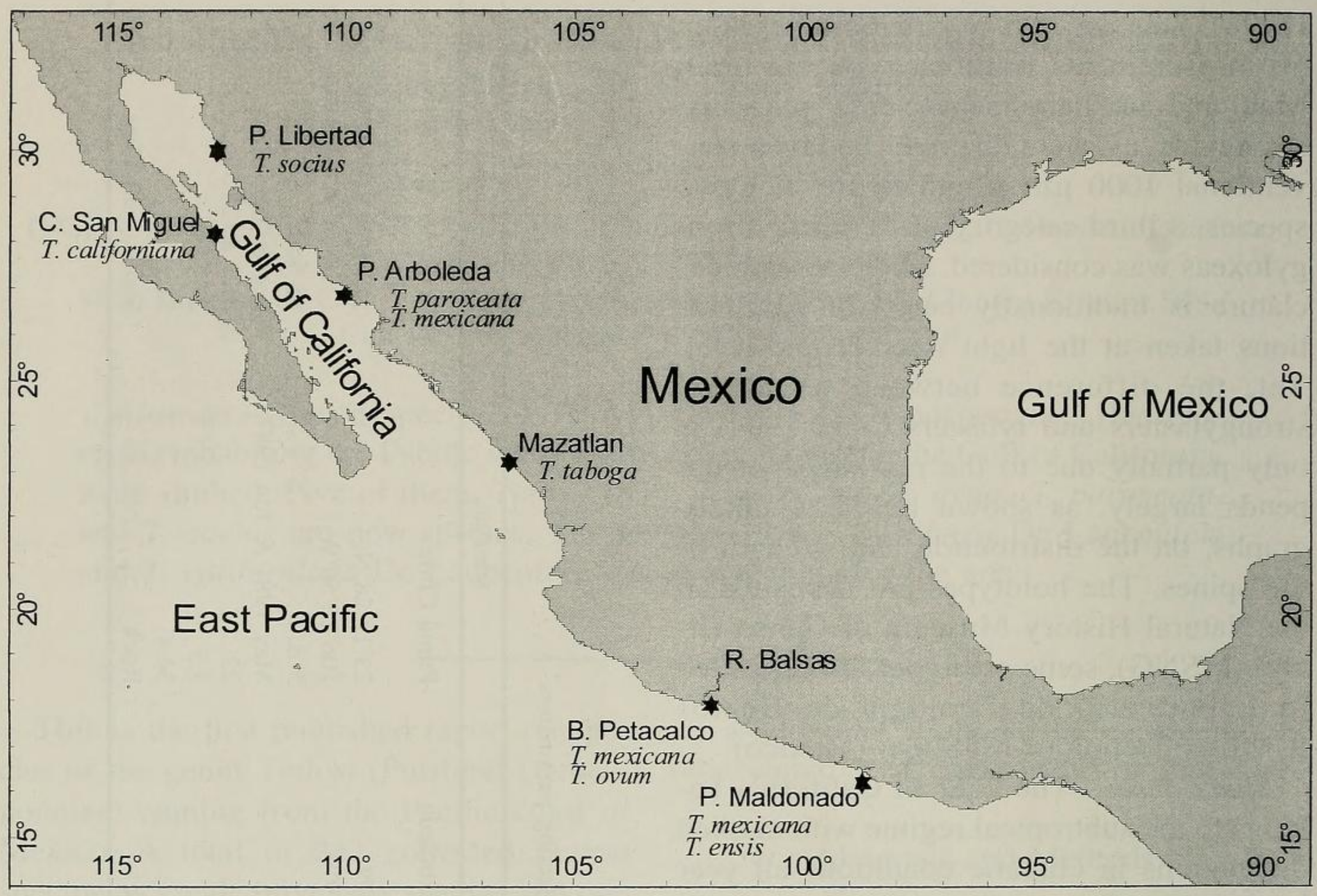


Fig. 1. Map of collecting areas and distribution of *Tethya* species: Puerto Libertad, Cabo San Miguel and Punta Arboleda inside the Gulf of California, Mazatlán at the mouth, and Petacalco Bay as well as Punta Maldonado at Guerrero, southern Mexico, tropical East Pacific.

comes from the Balsas river (Amezcua-Linares 1996).

The study area, except the Gulf of California, represents the transition zone between the mixture from the North Californian current and the South Perú current with the North equatorial counter-current, it marks the limits between the Californian Province with the Panamic one, now subdivided in Cortez Province, Mexican Province, and Panamic Province (Hendrickx 1995).

Systematics

Order Hadromerida Topsent, 1900
Family Tethyidae Gray, 1867
Genus *Tethya* Lamarck, 1815

Type species.—*Tethya aurantium* Pallas, 1766.

Diagnosis.—Spherical or subspherical body not supported by a stalk, well developed cortex distinct from the choanosome, megascleres bundles radiate from the center of the sponge ending in tubercles on the surface. Main and auxiliary megascleres are usually strongyloxeas, auxiliary may be also styles, megasters are spherasters or oxyspherasters, microsters are tylasters, strongylasters (chiasters) or oxyasters; these two are distributed in the cortex as well as in the choanosome (Sarà 1994).

Tethya ensis, new species
Figs. 2A, B, 3, 4, 15A, Table 2

Material examined.—Holotype: MSNG 50191; paratype: LEB-ICML 255; 46 specimens Punta Maldonado (Guerrero), Feb 1982, 45 m depth.

Description.—The type has an elongated hemispherical shape, 1.5 by 2.5 cm, with the irregular flattened basis covered by robust filamentous stolons. On the whole, the

shape is elongated hemispherical (Fig. 2A, B), 0.8–2.6 by 0.7–3 cm. Two specimens were attached to the next *Tethya* species described herein. Color: not recorded in vivo, creamy white in ethanol. Consistency slightly compressible. Surface sparsely and irregularly tuberculate, partially smooth. The best distinguished tubercles are finely hispid, flattened, 1–2 mm in diameter, 1 mm in height (Fig. 2A), sharp and stout filamentous stolons on the basis and the edges of the sponges are 2 cm long. Some tubercles on the edge of the sponges produce also 3 mm elongated buds. Cortex thickness, without tubercles, 0.5–1 mm.

Skeleton.—Megasclere bundles radiate from center to cortex sometimes in a coiled way as in the holotype. Bundles, 245–325 μm in diameter, ending in compact cortical fans without subdivisions (Fig. 3A). Megasters regularly distributed in the middle and, more densely, in the lower cortex, forming a belt around the choanosome. Some smaller megasters in the outer choanosome (Fig. 15A).

Spicules.—Table 2 summarizes measurements taken from 5 specimens. Megascleres (Figs. 3B, D, 4A) are: main strongyloxeas (maximum size 2312 by 47 μm), peculiar shortened fusiform strongyloxeas ("sword" like) in the cortical fans and among the subcortical interstitial megascleres, 225–965 μm, with a slender head 4–8 μm thick and a thickness of generally 15–25 μm, in the central and distal parts of the spicule and auxiliary megascleres, from slender strongyloxeas to thin styles.

Megasters (Figs. 3D, 4D): Spherasters heterogeneous in size and shape, with some slight differences among the specimens and a main size range 50–90 μm (maximum diameter 115 μm). The R/C main range is 0.5–0.9, sometimes in the larger spicules it is 1–1.1. Ray number: 14–16.

Microasters (Figs. 3C, 4B, C): Mainly strongylasters but variable from slightly knobbed tylasters to slightly tylote oxyasters 9–13 μm in diameter (minimum 5.9 and maximum 16.5 μm) with 12 thin spiny rays. Similar in the cortex and in the choanosome.

Etymology.—From Latin *ensis* = sword, in reference to the sword-like appearance of the short fusiform strongyloxeas; here used as a noun in apposition.

Remarks.—*Tethya ensis* is characterized by a peculiar shape and the occurrence in the cortex of the sword shortened fusiform strongyloxeas. The species is akin to a group of Mexican species subsequently described herein and to *T. californiana* De Laubenfels, 1932 (Sarà & Corriero 1993). *Tethya ensis* differs from *T. californiana* in body shape and cortical structure and in some significant spicular traits: the megascleres are strongyloxeas instead of anisostrongyles (but a Mexican population of *T. californiana* subsequently described herein also has strongyloxeas); the occurrence of peculiar sword shortened strongyloxeas which are absent in *T. californiana*; and the larger size and the lower R/C of its megasters that are spherasters instead of oxyspherasters.

Tethya mexicana, new species
Figs. 2C–G, 5–7, 15C, Table 3

Material examined.—Holotype: MSNG 50192; paratype: LEB-ICML 256; 75 specimens from Punta Maldonado (Guerrero), Feb 1982 and 10 specimens from Petacalco Bay (Guerrero), Apr 1982, 45 m depth. Adhered to bryozoans and calcareous fragments on sand and sand-mud-clay bottom; 43 specimens from Punta Arboleda (Gulf of California), Jul 1985, 22 m depth.

Description.—The type is irregularly ellipsoidal, cushion-like, with two opposite faces 3 by 2 cm, both covered by irregularly rounded tubercles, 1–3 mm in diameter, 0.5–2 mm in height. The thickness of the cushion is 1.5 cm. Long filamentous rooting processes are at one side of the faces, suggesting that in life the specimen was erect 2 cm high and 3 cm broad. Some elongated tubercles with spear like buds are on the top. On the whole, body variable in shape,

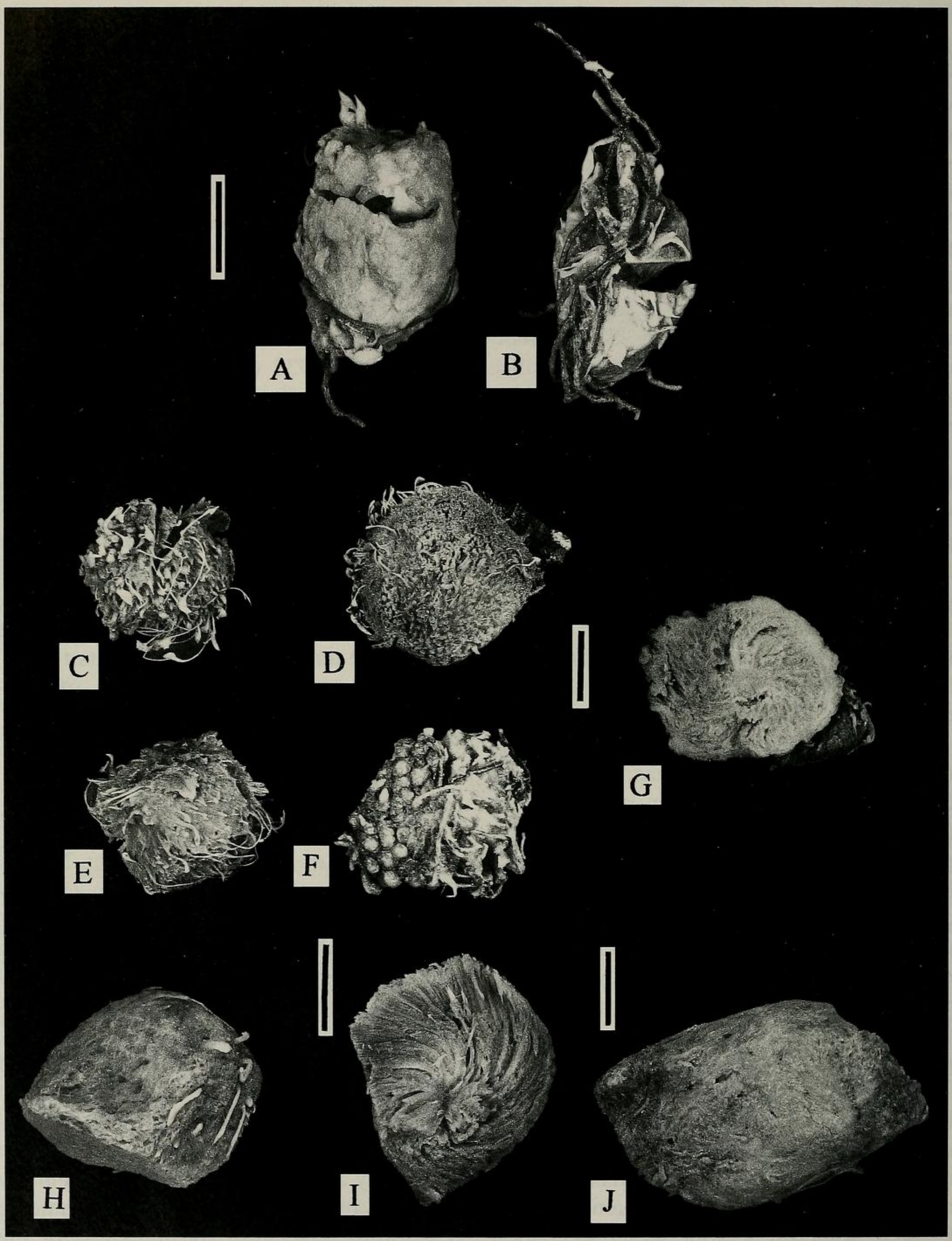
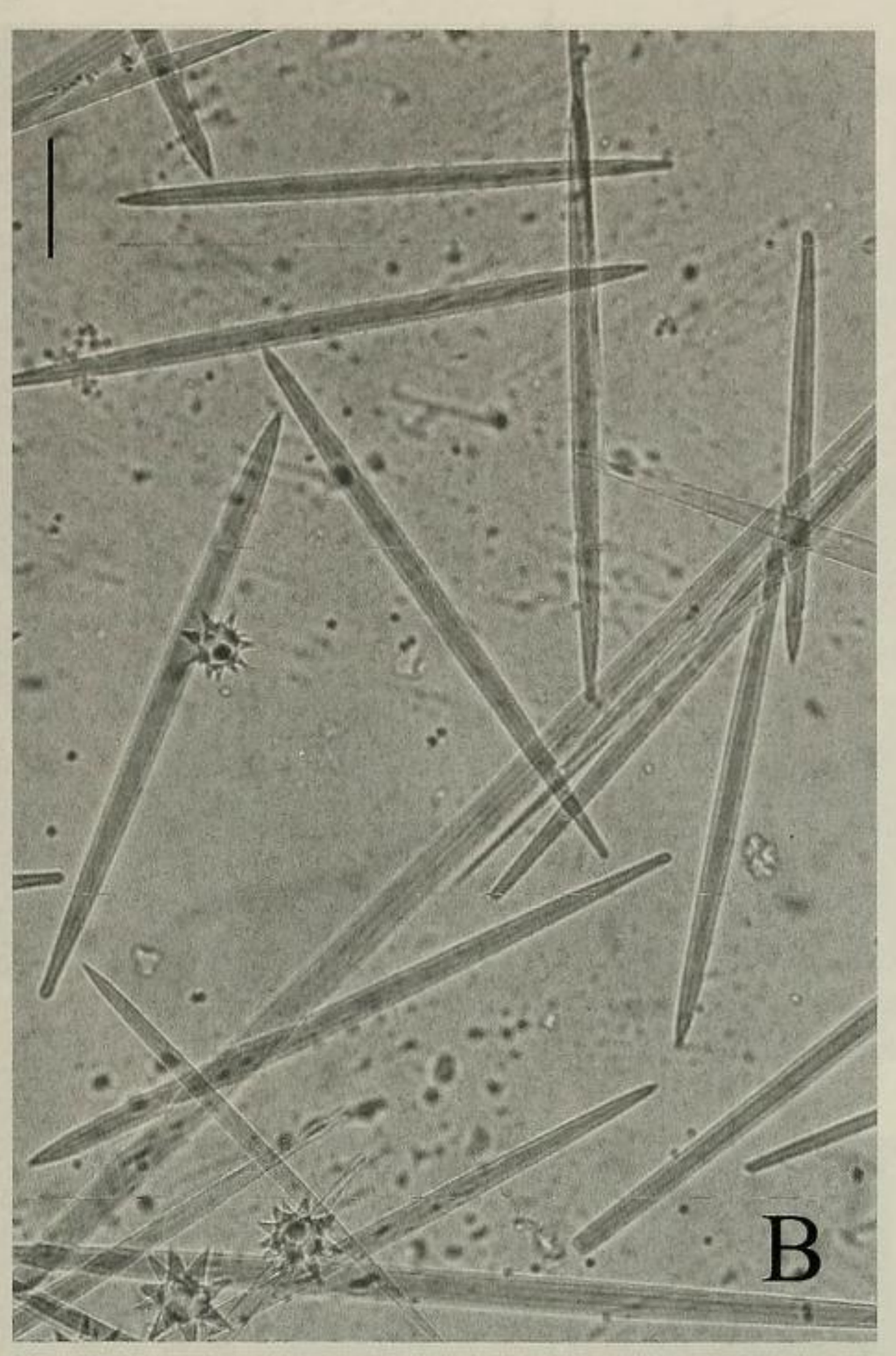
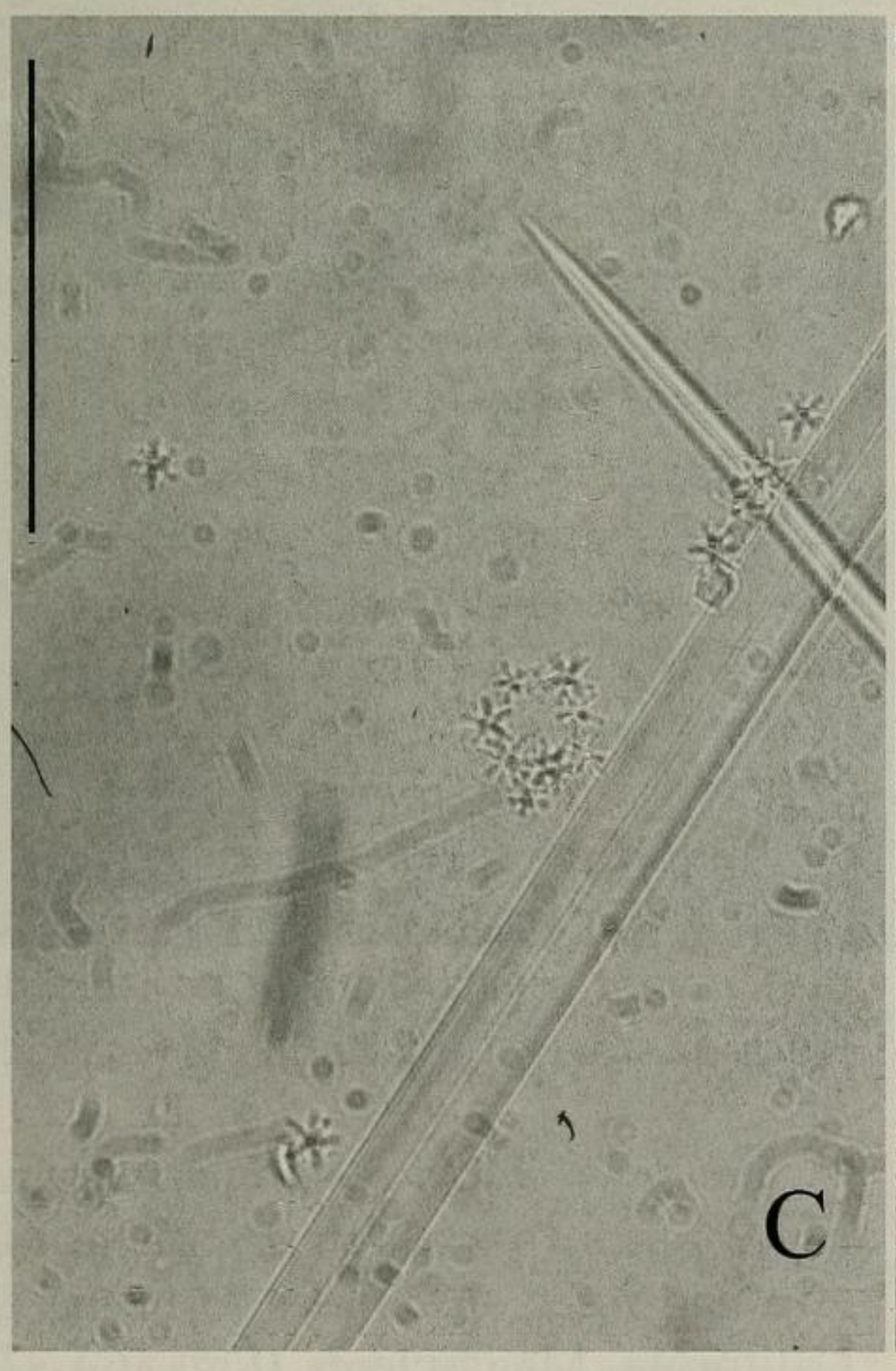


Fig. 2. A, B: *Tethya ensis,* new species. A, Holotype; B, Paratype. C–G: *Tethya mexicana,* new species. C–E, Three specimens from Gulf of California; F, Holotype from Guerrero; G, Transverse section of another specimen from Guerrero showing coiled skeleton and a central nucleus. H–J: *Tethya paroxeata,* new species. H, Holotype lateral view; I, Holotype, transverse section showing a coiled skeleton radiating from an asymmetrical center; J, Another specimen, lateral view. Scale bars = 1 cm.





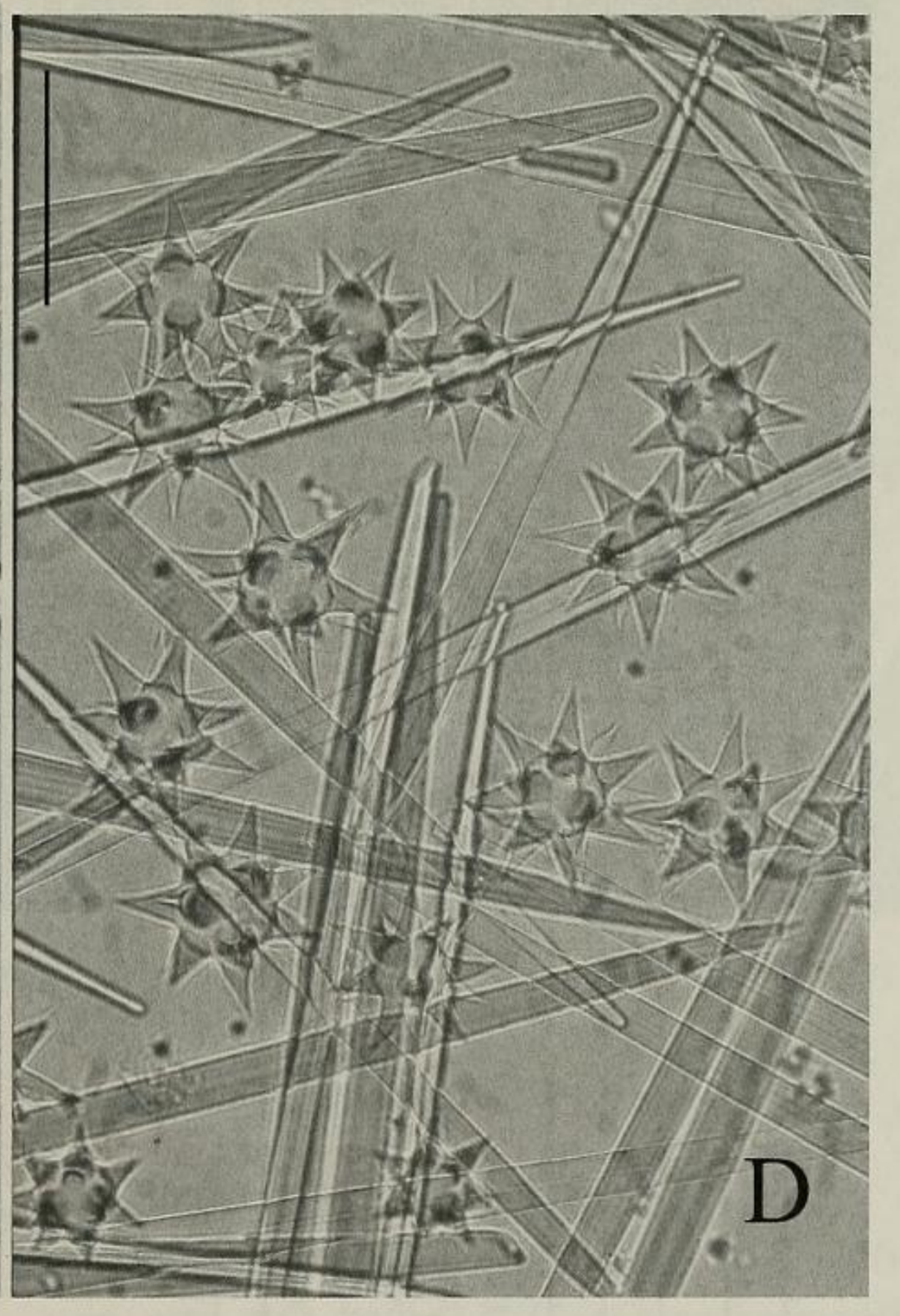


Fig. 3. *Tethya ensis,* new species. Light microscopic photographs. A, Skeletal structure of tubercle; B, Fusiform strongyloxeas and some megasters; C, Micrasters; D, Megasters and megasclere endings. Scale bars = 100 μm.

Table 2.—Measurements of spicules of specimens of *Tethya ensis* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres						Megasters		Micrasters Diameter
	Main		"Sword" strongyloxeas		Auxiliary				
	Length	Width	Length	Width	Length	Width	Diameter	R/C	
1 (Holotype)	1056-1611-2115	15-30-47	319-443-609	12-17-26	381-571-972	3-12-28	37-81-106	0.4-0.7-1.0	5.9-10.5-16.5
2	1006-1623-2312	8-24-45	364-510-720	11-17-24	318-603-980	3-9-22	27-87-115	0.4-0.6-0.8	8.3-11.6-15.3
3	1005-1586-2280	6-26-36	270-493-780	10-15-22	300-545-970	4-8-20	42-77-106	0.5-0.7-1.1	9.0-12.1-14
4	1342-1714-2290	18-29-35	247-513-777	10-16-21	260-551-990	4-7-13	46-76-98	0.4-0.6-0.9	10.0-11.9-13.5
5	1000-1599-2100	10-27-36	225-472-965	10-15-23	390-735-985	4-10-23	34-67-106	0.4-0.6-0.8	8-11.6-13

with irregularly hemispherical, ellipsoidal or polyhedral specimens, 0.8–4 cm in diameter and 0.5–2.5 cm in height (Fig. 2C–G). Color orange when alive, dirty white or brownish in ethanol. Consistency firm, slightly compressible. Surface tuberculate, with irregularly rounded or roughly polygonal tubercles 1–3 mm in diameter, 0.5–2 mm in height irregularly spaced and unevenly developed in Guerrero specimens, sometimes flattened, sometimes papillose, covered by sand in the Gulf of California specimens, others are scarcely visible with a surface covered by several stalked buds 2 cm long, and several with visible oscules. Specimens from Guerrero, as in the type, have on the basis and edges of the body flattened or filamentous rooting processes 10–16 mm long by 1–10 mm wide. Cortex (Fig. 5C, D), including tubercles, 2–4 mm thick. Spicular tufts hispidating the tubercles supported by bundles of strongyloxeas with a diameter of 300–480 μm in the cortex and 350–950 μm in the choanosome.

Skeleton.—The megasclere tracts branch at different levels of the choanosome (Fig. 5B). The interstices among the tracts in the upper part of the choanosome are filled with bundles of auxiliary megascleres. Megasters are placed densely in the central and lower parts of the cortex that shows several lacunes (Fig. 15C), although it is less lacunar than *Tethya californiana.* In some specimens the megasclere tracts are coiled and sometimes they depart from a central nucleus (Fig. 2G). The nucleus, about 5 mm in diameter, is made up of an irregular network of small styles and subtylostyles (Fig. 5A).

Spicules.—Table 3 summarizes measurements taken from three specimens of Guerrero and three specimens from the Gulf of California. Megascleres (Figs. 6A, 7B) are main strongyloxeas and auxiliary (cortical) strongyloxeas with intermediates among the two categories. Maximal length is 2130 μm and thickness 41 μm. The nucleus of some specimens presents heterogeneous styles

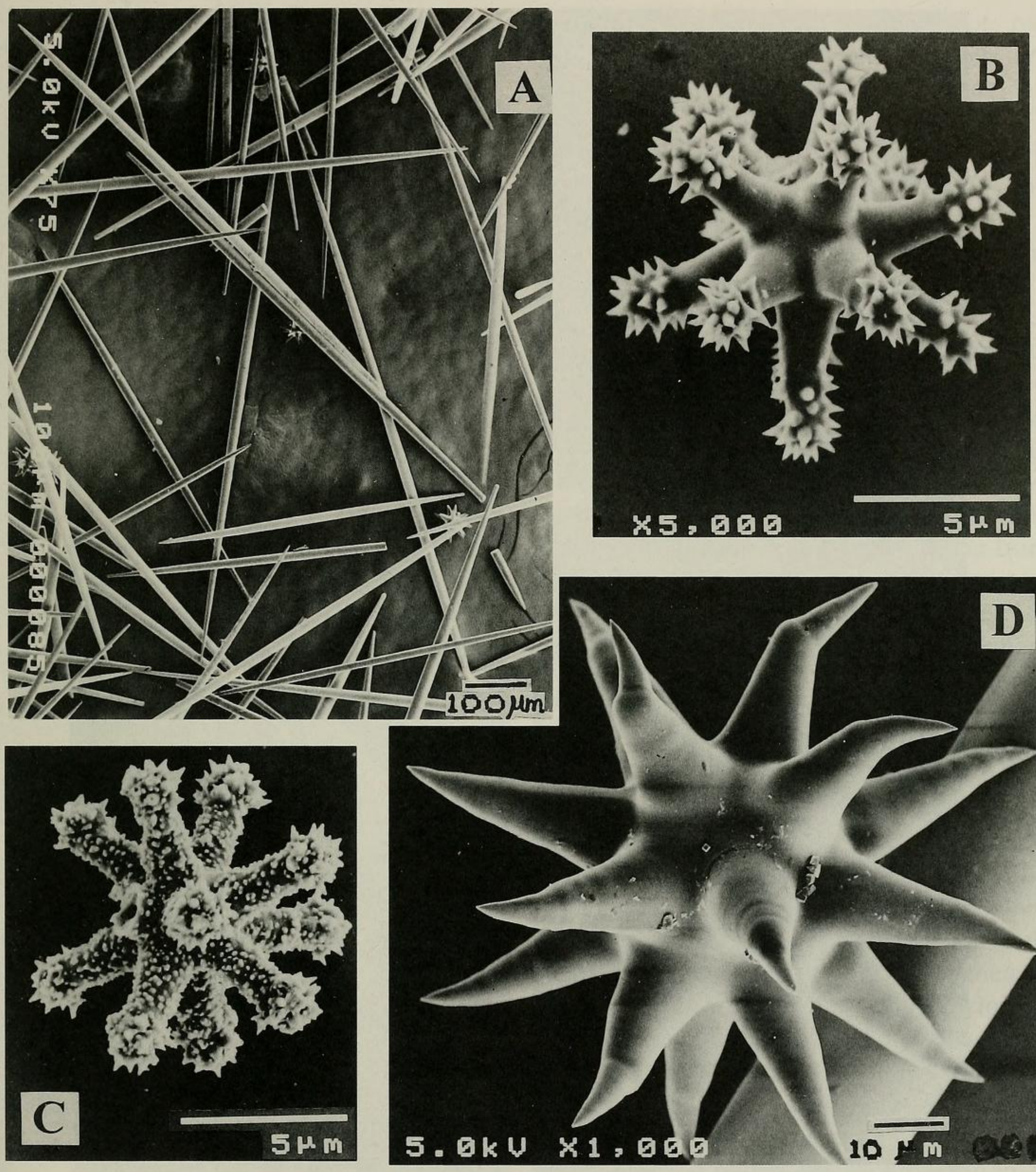


Fig. 4. *Tethya ensis,* new species. SEM micrographs. A, Megascleres and some megasters; B, Tylaster (more frequent); C, Chiaster (less frequent); D, Spheraster.

and subtylostyles frequently somewhat curved, 300–800 by 10–18 µm.

Megasters (Figs. 6A, 7C) are spherasters-oxyspherasters: heterogeneous in size and shape, they vary also among the species. The main size range is 70–120 µm (maximum 128 µm) and R/C range 0.7–1.2 (maximum 1.4). Two specimens from Punta Arboleda (Gulf of California) show sharp differences. The main size range is 60–75 µm and the main R/C range respectively, 0.5–0.7 and 0.7–0.9. Ray number 16–18, frequently bent, sometimes twisted or forked.

Microasters: Mainly strongylasters (chiasters) but variable from slender tylasters with

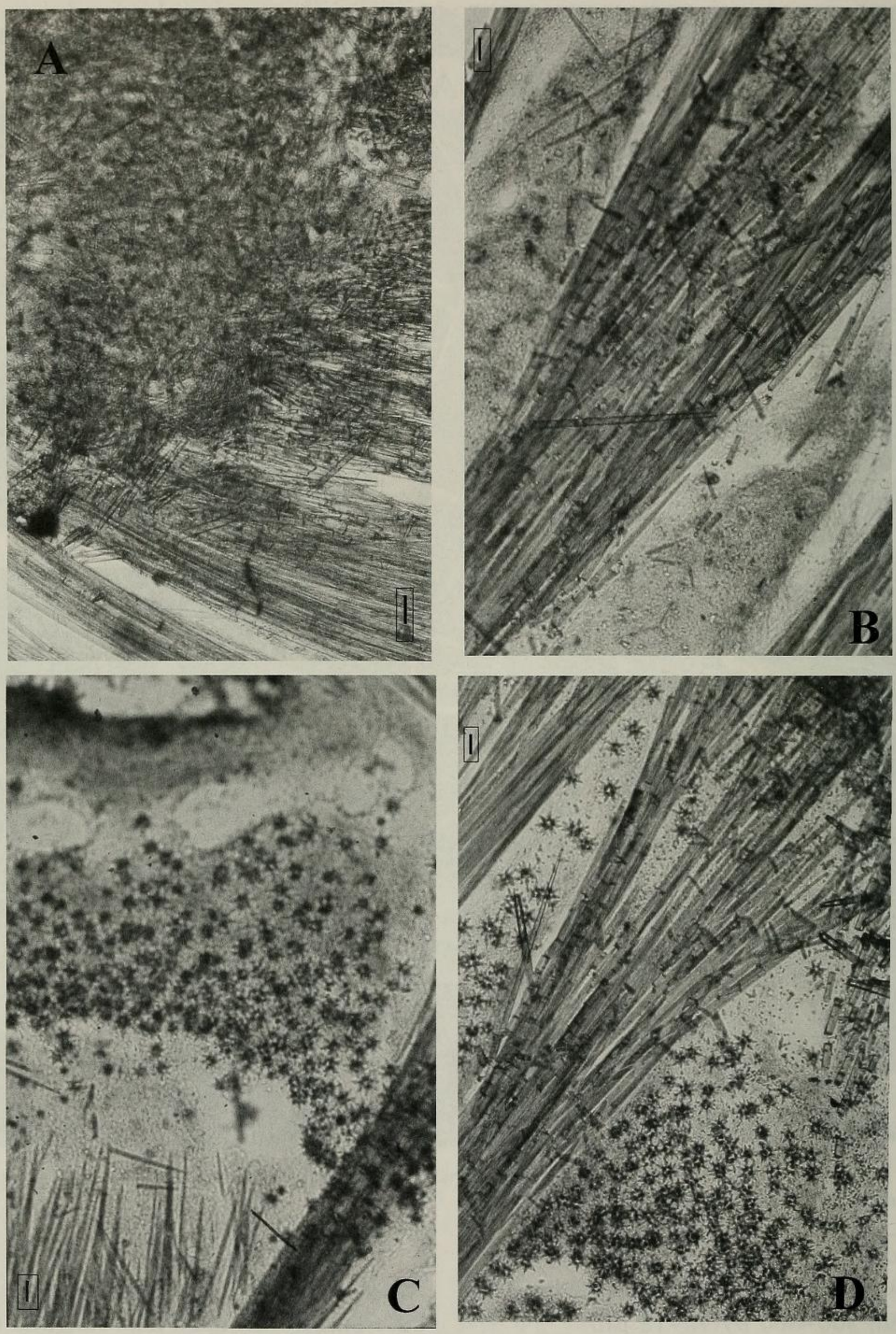


Fig. 5. *Tethya mexicana,* new species. Details of structure. A, Nucleus skeleton; B, Branching of a megasclere bundle in the choanosome; C, Cortical structure; D, Cortical structure with megasclere fans. Scale bars = 100 μm.

Table 3.—Measurements of spicules of specimens of *Tethya mexicana* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres				Micrasters Diameter
	Main		Auxiliary		
	Length	Width	Length	R/C	
1 (Holotype)	1020-1339-2010	14-23-40	339-547-971	0.5-0.8-1.2	6.8-11.4-15.5
(Guerrero)	1000-1522-2070	14-26-36	359-670-990	0.7-1.0-1.4	8.0-11.6-15.5
2 (Guerrero)	1033-1428-1820	18-29-39	360-656-985	0.6-0.9-1.4	8.5-11.6-15.5
3 (Guerrero)	1000-1564-2105	16-29-41	347-745-990	0.3-0.6-1.0	8.0-11.3-15.0
4 (P. Arboleda)	1000-1568-2130	9-28-39	250-725-978	0.5-0.7-1.1	8.0-11.3-15.0
5 (P. Arboleda)	1002-1340-2021	10-20-34	494-808-999	0.6-0.9-1.3	5.2-8.7-12.5
6 (P. Arboleda)					

Specimens	Megasters Diameter	Megasters R/C
1 (Holotype)	48-97-127	0.5-0.8-1.2
(Guerrero)	36-85-108	0.7-1.0-1.4
2 (Guerrero)	70-102-130	0.6-0.9-1.4
3 (Guerrero)	49-64-78	0.3-0.6-1.0
4 (P. Arboleda)	23-59-93	0.5-0.7-1.1
5 (P. Arboleda)	59-99-128	0.6-0.9-1.3
6 (P. Arboleda)		

slightly knobbed rays to slightly tylote oxyasters. Sometimes with a more or less developed center. They are in the cortex and in the choanosome alike, generally 8–13 μm in diameter (maximum 15.5 and minimum 5.2), with 8–14, generally 12, thin rays (Figs. 6B, 7A, D).

Etymology.—Named after its origin, the Mexican waters.

Remarks.—*Tethya mexicana* is characterized by a variable, generally depressed, body shape, uneven tuberculate cortex, sometimes with long stolons as in *T. ensis,* sometimes with buds, large and variable in size, spherasters-oxyspherasters with rays frequently bent, micrasters similar in the cortex and in the choanosome varying from a slightly tylote oxyaster to strongylaster shape or true slender tylasters. There is some intraspecific variability in spiculation, with differences especially among the specimens of Guerrero and Punta Arboleda. One of the Arboleda specimens (6) is characterized by smaller megascleres and micrasters (Table 3). The general structure and the spicular traits have several affinities with *T. ensis* but also some remarkable differences: the body shape even if variable, is not elongated hemispherical as in *T. ensis*; the skeletal structure shows a branching of megasclere tracts and interstitial strongyloxeas which are absent in *T. ensis*; the sword-like strongyloxeas of *T. ensis* are lacking in *T. mexicana*; the megasters (spherasters-oxyspherasters) are considerably larger in *T. mexicana* and with a greater R/C than in *T. ensis. Tethya mexicana* is also similar to *T. californiana* but differs in some important traits: the body shape is not spherical, has uneven tubercles and different cortical structure; the denser distribution of megasters in the lower cortex; the presence of strongyloxea instead of anisostrongyle type of megasclere; a greater size, lower R/C and lower ray number of its megasters; the more slightly tylote oxyaster type of its micrasters; and the lack of spherules.

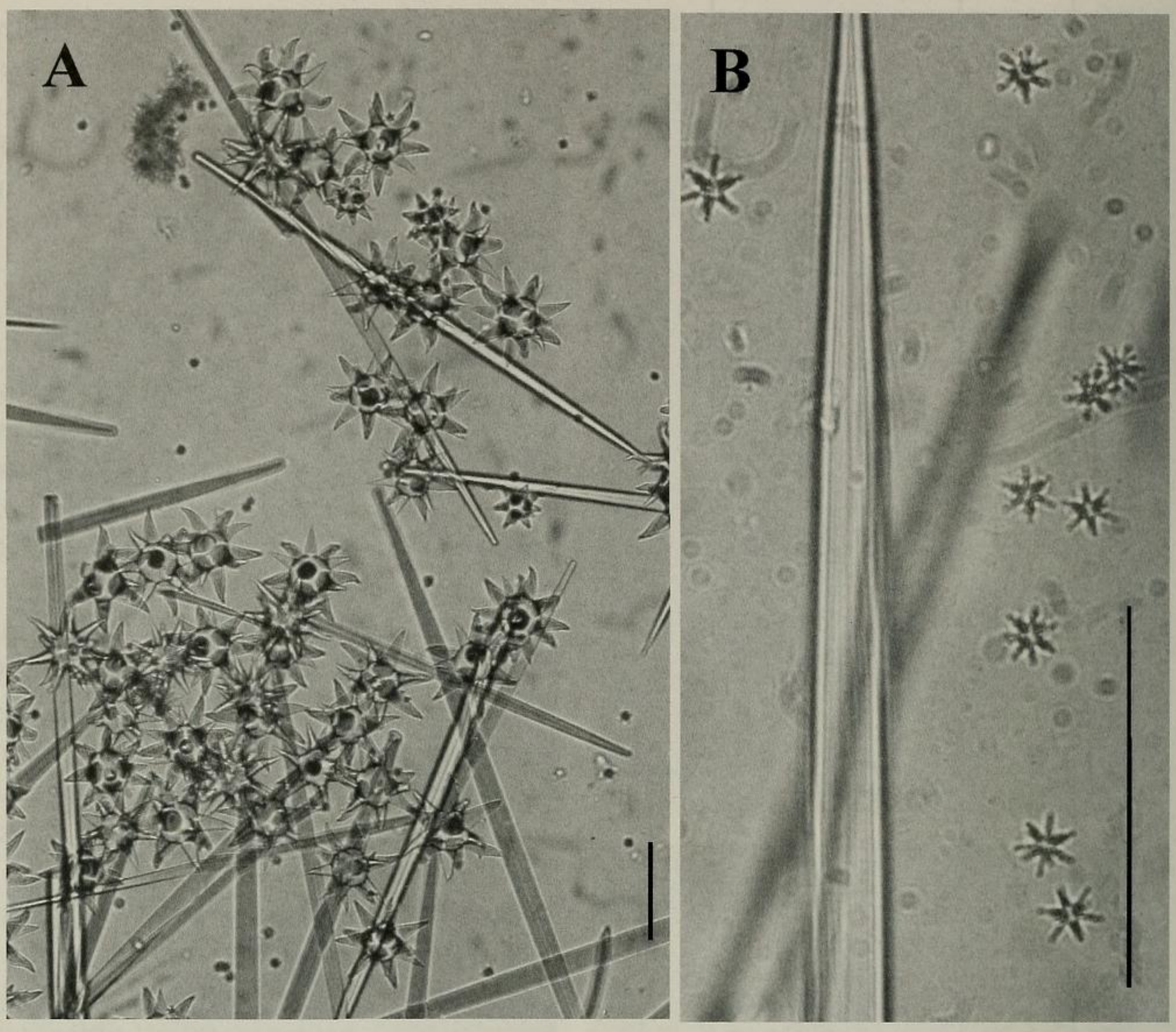


Fig. 6. *Tethya mexicana,* new species. Light microscopic photographs. A, Megasters; B, Microsters. Scale bars = 100 μm.

Tethya ovum, new species
Figs. 8A, B, 9, 10, 15B, Table 4

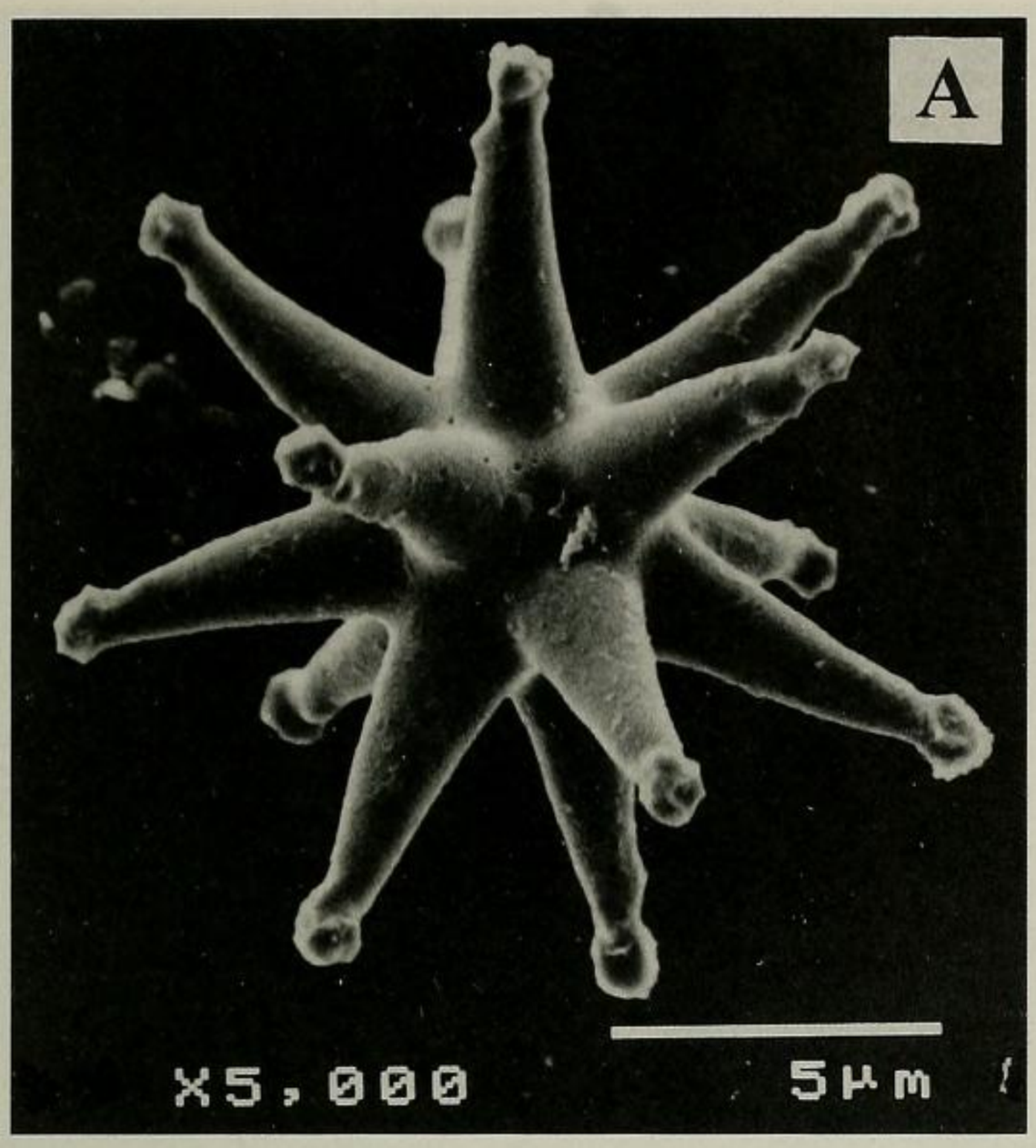
Material examined.—Holotype MSNG 50193; paratype: LEB-ICML 257; 4 specimens from Petacalco Bay (Guerrero), Apr 1982, 45 m depth.

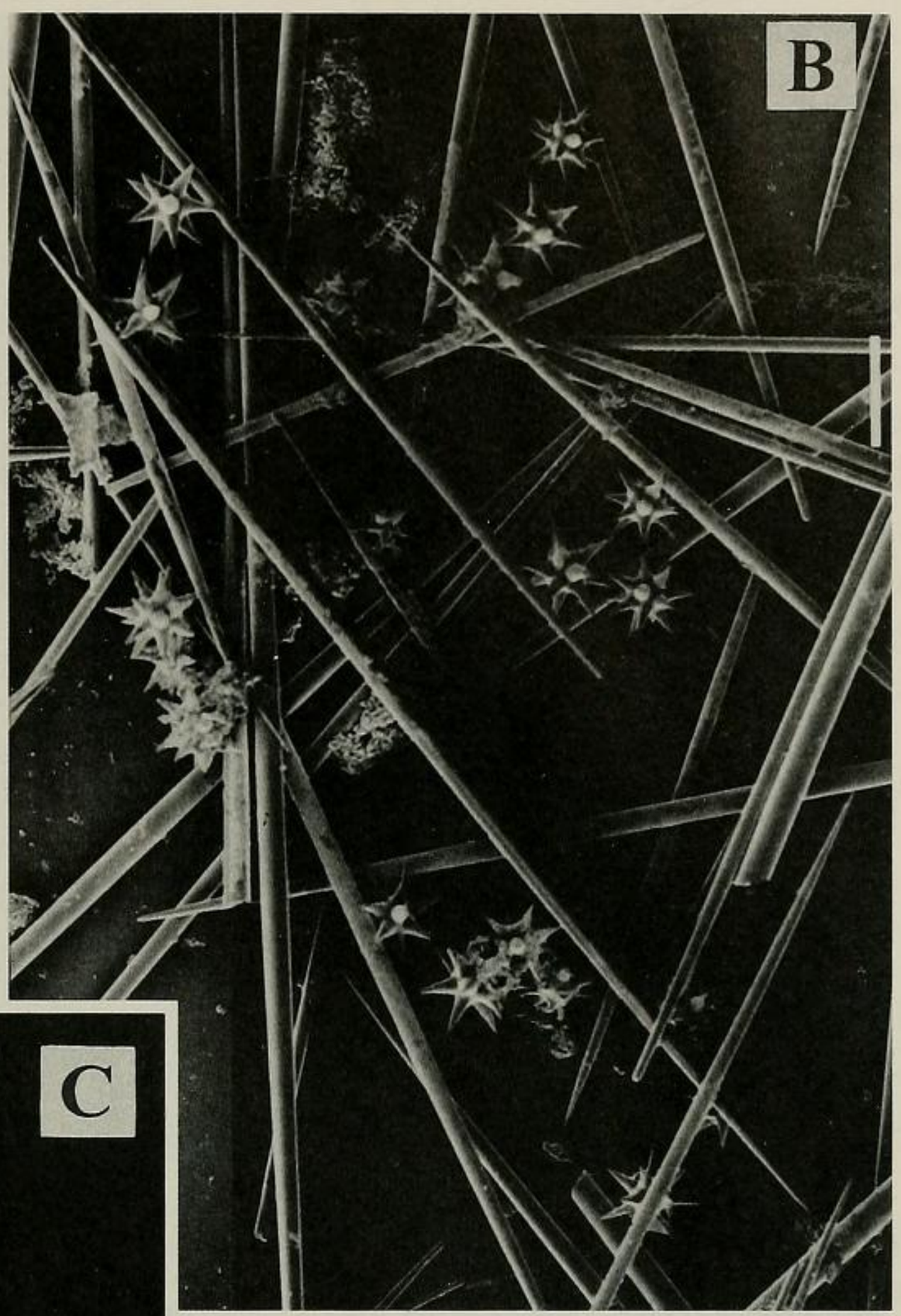
Description.—The type is ovoidal 11 mm in diameter and 17 mm in height. On the whole, 10–17 mm in diameter, 15–25 mm in height (Fig. 8A). Color, not recorded alive, dirty white in ethanol. Consistency hard. Surface strongly tuberculate, tubercles irregularly spaced, uneven, microhispid, sometimes smooth: 1–4 mm in diameter, 1–2 mm in height. Cortex, including tubercles, 3–4 mm thick.

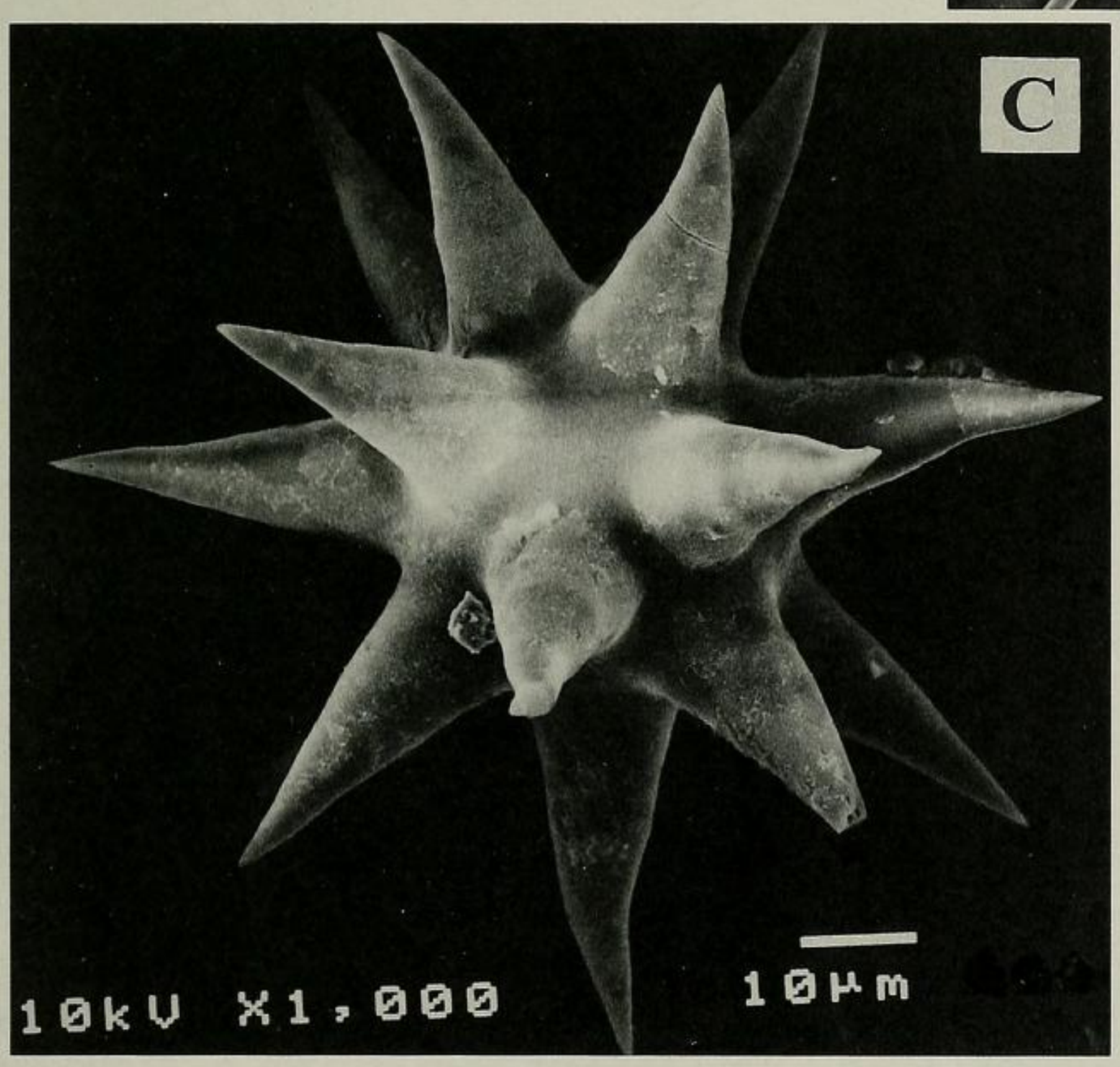
Skeleton.—Megasclere bundles less than 500 μm in diameter, sometimes a little coiled, radiating from the center to the cortex (Fig. 8B). Smaller fusiform subtylote strongyloxeas occur in the tubercle fans. Megasters are placed mainly in the lower cortex as a narrow continuous belt around the choanosome (Fig. 15B). Microsters are similar in the cortex and in the choanosome.

Spicules.—Table 4 summarizes measurements taken from two specimens. Main and auxiliary megascleres are slightly subtylote strongyloxeas. Maximum size of main megascleres is 1885 by 39 μm. Shortened cortical sword-like megascleres are fusiform, with the head 8–10 μm thick and the greater thickness 10–27 μm, in the central and distal parts of the spicule (Figs. 9A, 10A).

Megasters: Spherasters and oxyspheras-







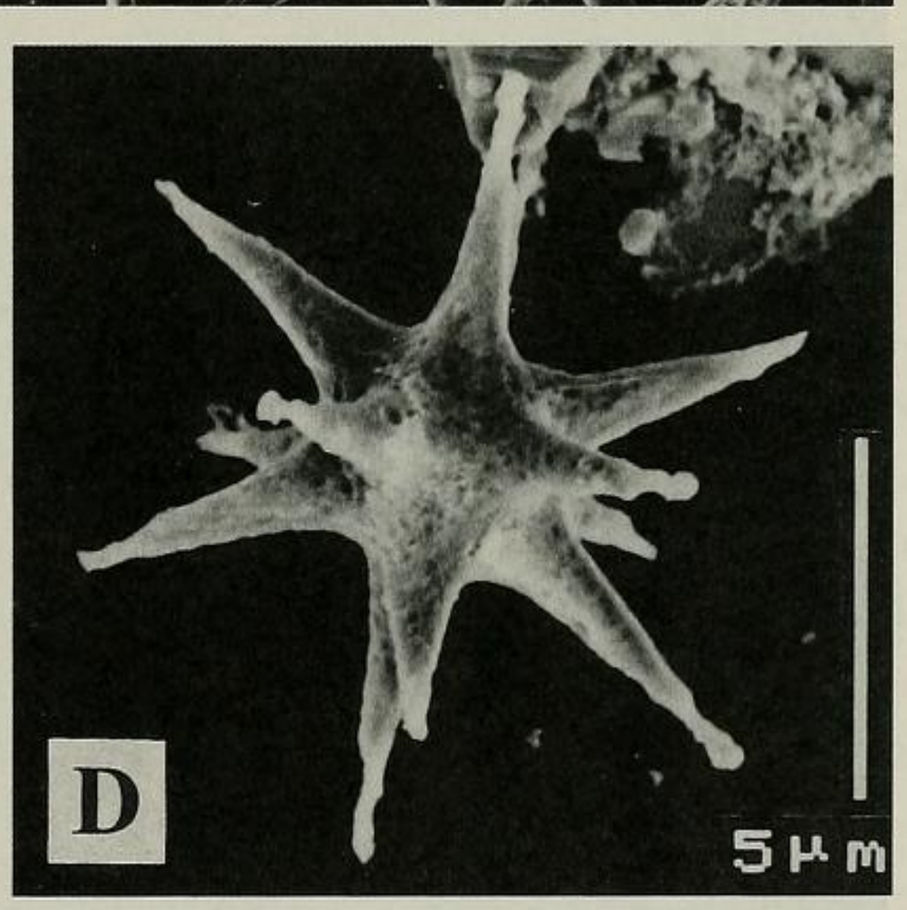


Fig. 7. *Tethya mexicana,* new species. SEM micrographs. A, D. Oxyasters with slightly tylote ends (more frequent); B, Megascleres and several megasters; C, Megaster.

ters show a main size range of 75–100 µm (maximum 110 µm), and R/C 0.7–1.2 (maximum 1.5), with about 18 rays generally bent and frequently spined or bifid (Figs. 9B, 10D).

Microasters: Mainly strongylasters (chiasters), but they vary from slender tylasters with slightly knobbed rays to slightly tylote oxyasters. Size: 8–13 µm in diameter, with about 12 thin rays, in the cortex and choanosome alike (Figs. 9C, 10B, C).

Etymology.—From latin *ovum* = egg, in reference to the ovoid shape of the body, an unusual character in *Tethya;* here used as a noun in apposition.

Remarks.—*Tethya ovum* is similar to *T.*

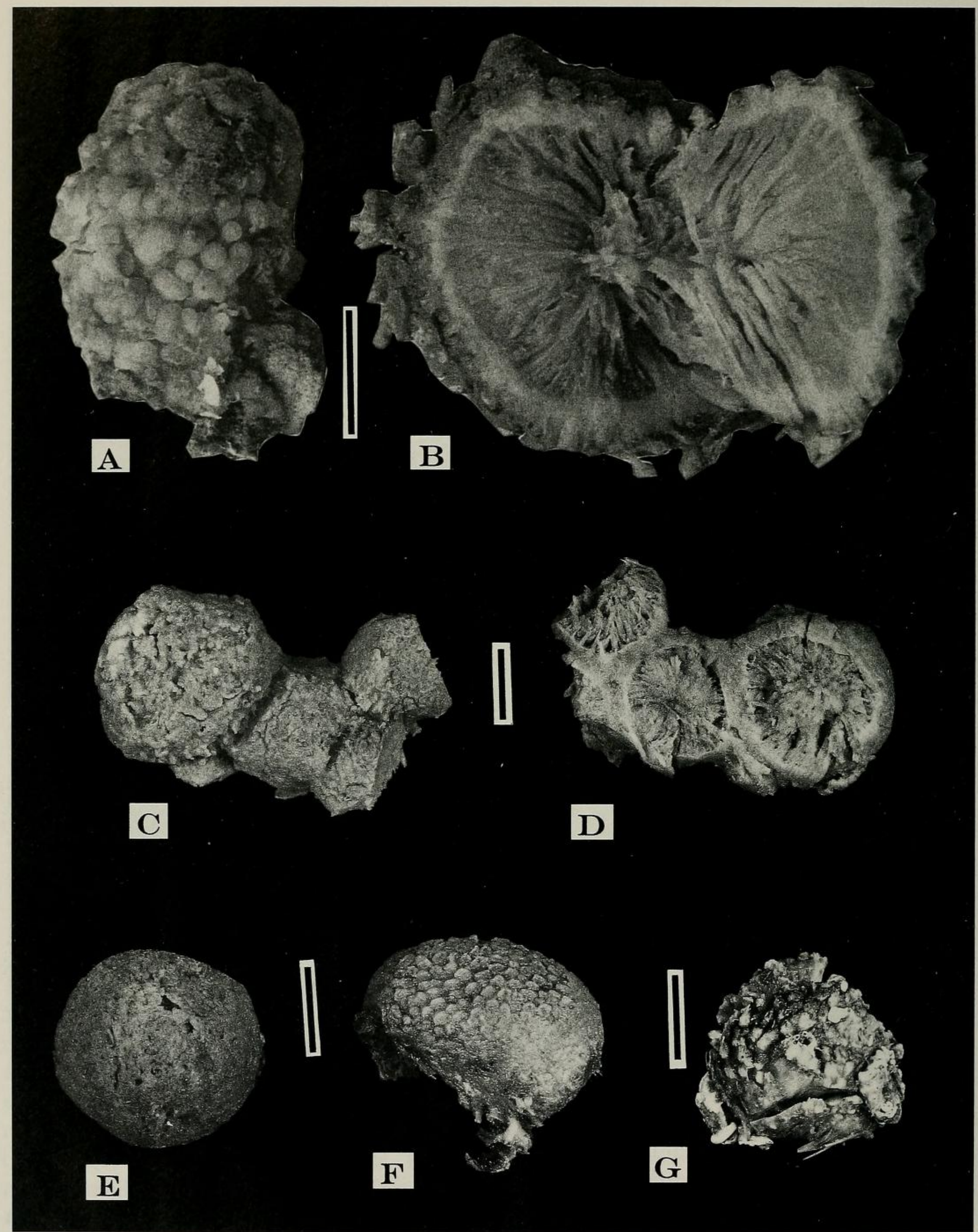


Fig. 8. A, B: *Tethya ovum,* new species. A, Lateral view of paratype; B, Transverse section of the same. C, D: *Tethya socius,* new species. C, Upper view of holotype; D, Basal view of the same. E, F: *Tethya californiana* De Laubenfels, two specimens showing differences of tuberculate surface. G: *Tethya taboga* (De Laubenfels) upper view. Scale bars = 1 cm.

Table 4.—Measurements of spicules of specimens of *Tethya ovum* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres: Main Length	Main Width	"Sword" strongyloxeas Length	"Sword" strongyloxeas Width	Auxiliary Length	Auxiliary Width	Megasters Diameter	Megasters R/C	Micrasters Diameter
1 (Holotype)	1007-1375-1693	8-23-36	357-573-996	10-15-23	400-696-996	2-7-10	28-77-106	0.2-0.8-1.2	6.3-9.7-13.2
2	1005-1490-1885	14-30-39	385-649-960	10-19-27	754-814-875	8-8-8	70-92-110	0.7-1.0-1.5	8.0-11.1-13.0

ensis and to *T. mexicana* but is well characterized by its ovoidal shape and strongly tuberculated surface. It shares with *T. ensis* the sword-like category of strongyloxeas, but these are clearly distinct because their head diameter is 8–10 μm instead of 4–8 μm. The megasters are spherasters-oxyspherasters similar to those of *T. mexicana* but generally bent and frequently adorned by forks and spines while the skeleton structure is more alike to *T. ensis*. *Tethya ovum* differs from *T. californiana* in all the traits discussed for *T. ensis* and *T. mexicana*.

Tethya paroxeata, new species
Figs. 2H–J, 11, 12, 15D, Table 5

Material examined.—Holotype MSNG 50194; paratype LEB-ICML 258; 6 specimens from Punta Arboleda (Gulf of California), Jul 1985, 22 m depth.

Description.—The type is irregularly polyhedral 2 cm high with flattened basis and six faces, 2 by 2 cm. The origin of the radiate bundles of the megascleres is a central nucleus near the surface of a lateral face, and the bundles are then strongly coiled towards the opposite face (Fig. 2I). In other four specimens, the body shape is irregularly polyhedral 1.5–3 cm at the base, 1–2.5 cm in height (Fig. 2H,J), and in two specimens hemispherical with a diameter of 2.5 cm. Color orange when alive. Consistency compact but not hard. Surface with small flattened and contiguous tubercles, 1–1.5 mm in diameter in two specimens, larger (2 mm) but more flattened and surface nearly smooth in the other three specimens. Many sand particles on the surface. With stalked buds (stalks 1 cm long). Tubercles 0.5 mm high, cortex (without tubercles) 1.5 mm thick, very lacunar under the sponge surface (Fig. 15D).

Skeleton.—Megasclere tracts, 280–630 μm thick, run compact to the tubercles forming little-developed fans (Figs. 11A, 15D). Some tracts, however, branch in the inner part of the choanosome. Auxiliary

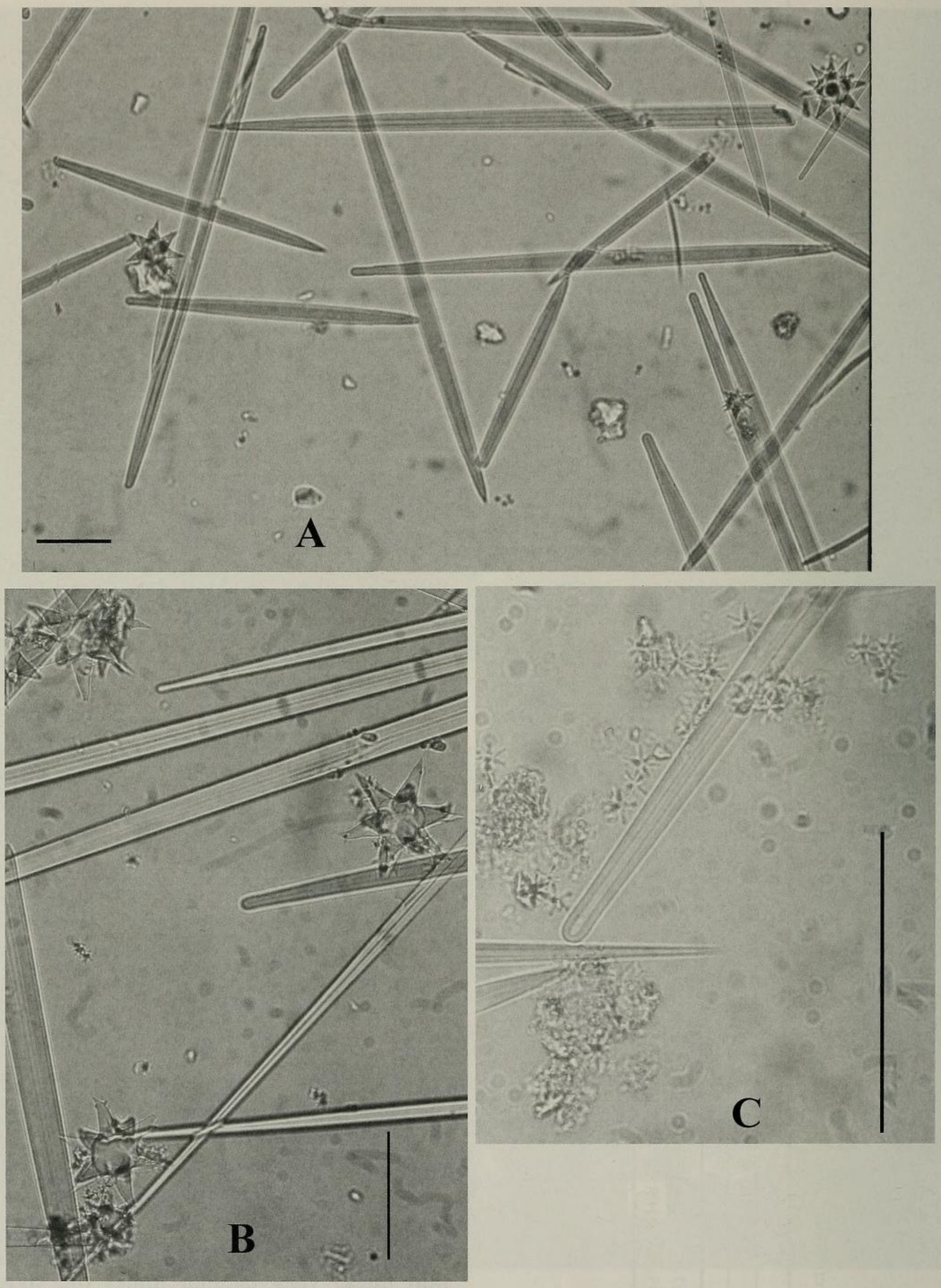
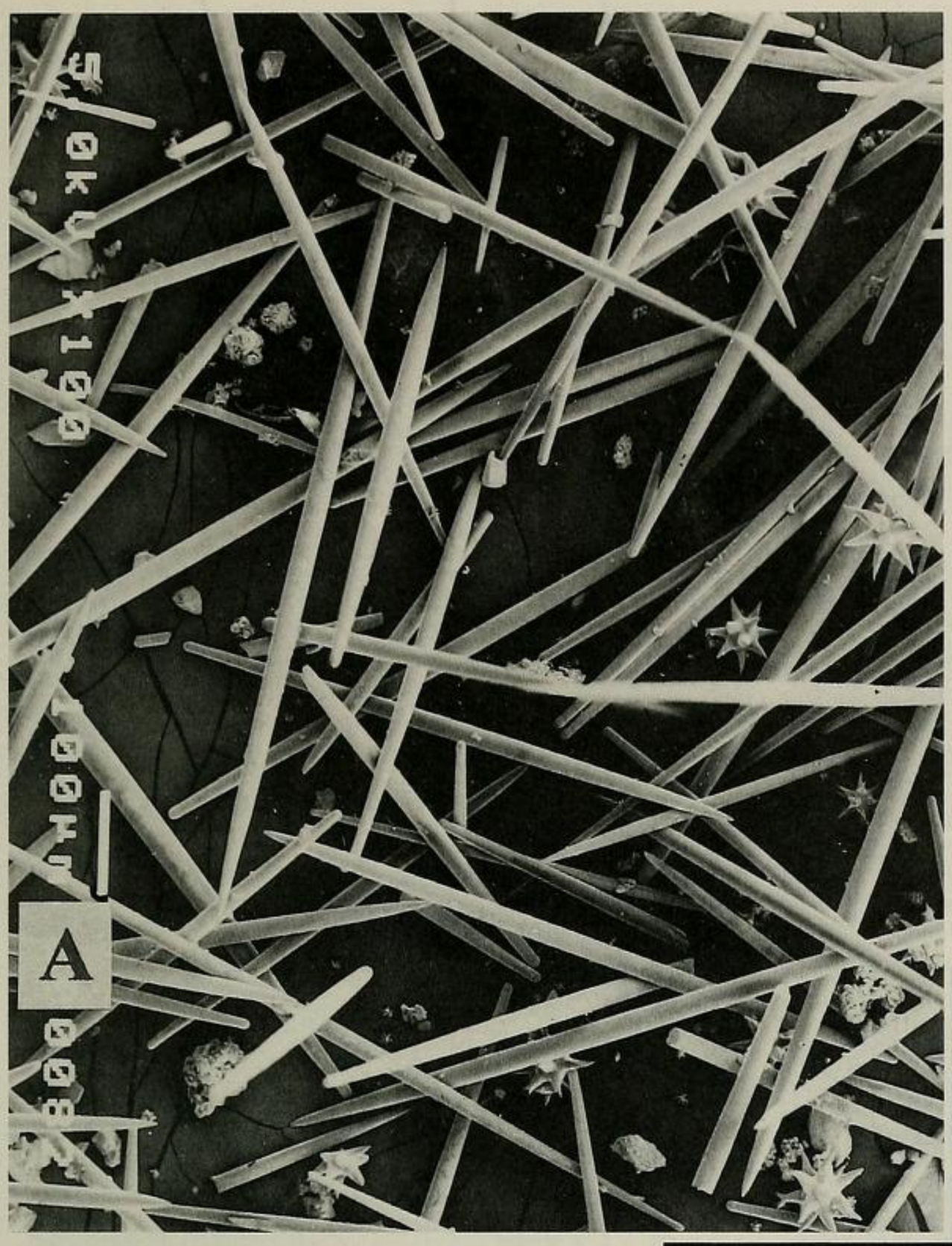
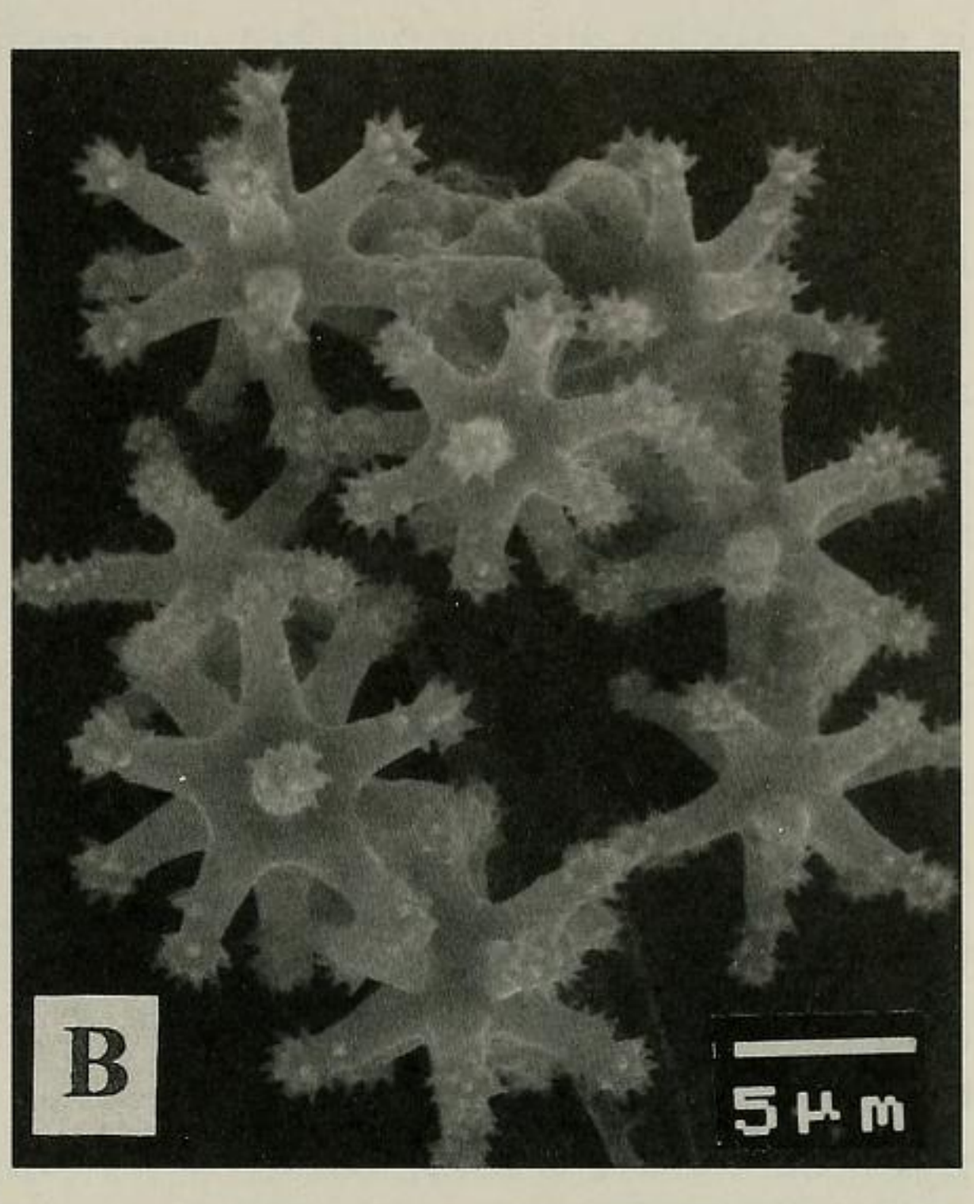
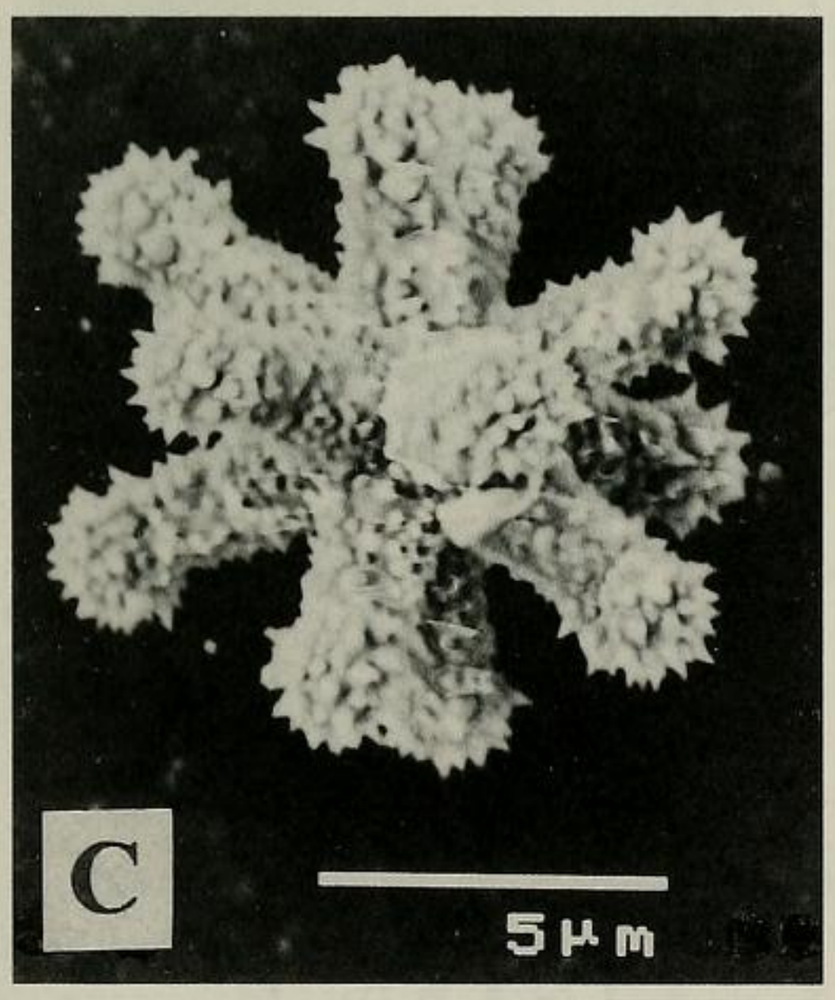


Fig. 9. *Tethya ovum,* new species. Light microscopic photographs. A, Fusiform strongyloxeas and three megasters; B, Spined and forked megasters with parts of megascleres; C, Micrasters and points of megascleres. Scale bars = 100 μm.







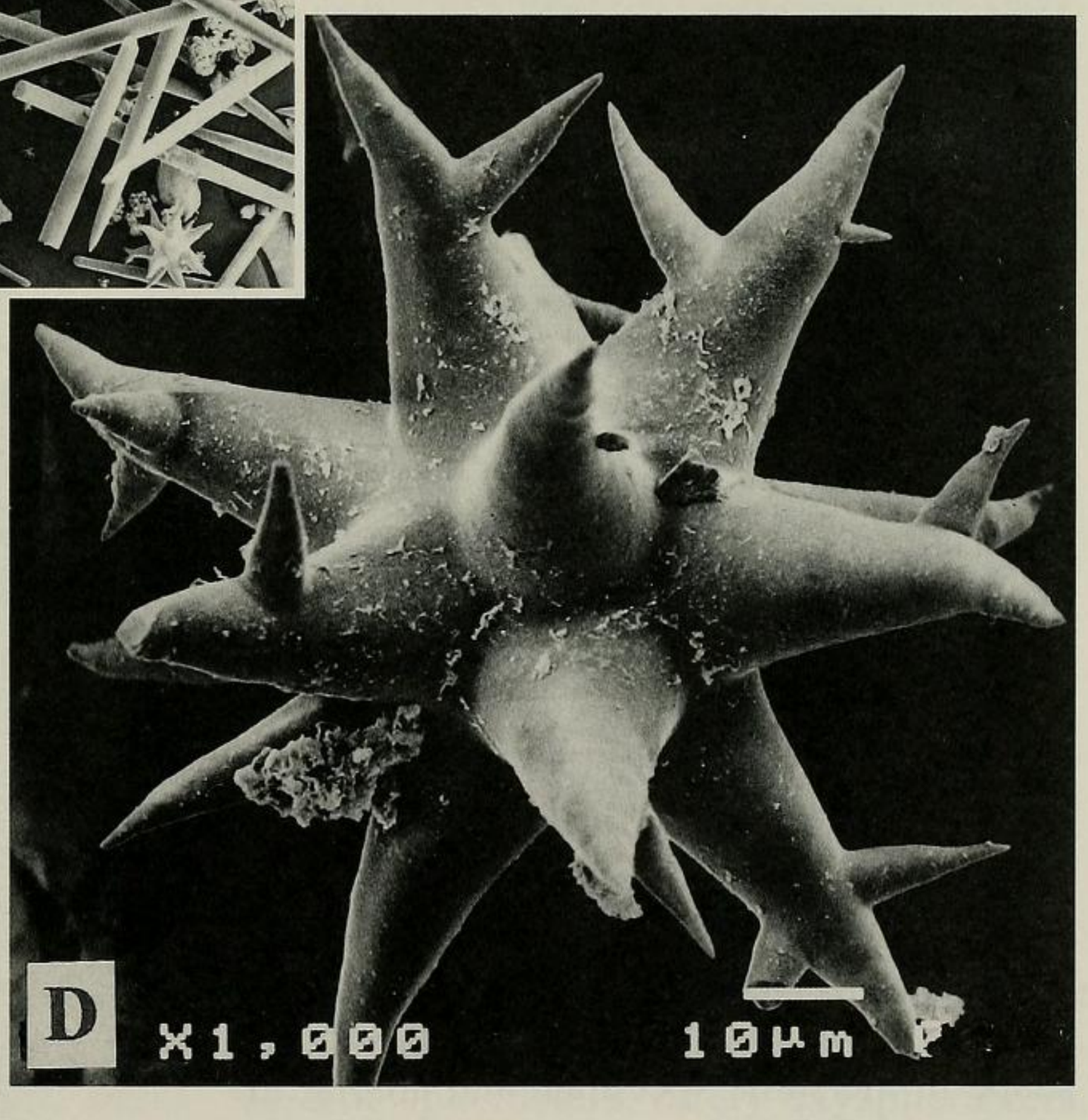


Fig. 10. *Tethya ovum,* new species. SEM micrographs. A, Megascleres and megasters; B, Tylasters (more frequent) with one chiaster at middle left; C, Chiaster (less frequent); D, Megaster.

megasclere bundles occur in the upper choanosome in some interstices among the main megasclere tracts. Megasters are irregularly and not densely distributed in the middle and inner cortex, more dense in the middle part (Fig. 15D). The surface is coated with a dense layer of microscleres.

Spicules.—Table 5 summarizes measurements taken from five specimens. Megascleres are fusiform strongyloxeas. Several middle-sized (1000–1300 by 10–20 µm), and the great majority of the small (300–1000 by 1–20 µm) megascleres are oxeiform with a very thin (0.5–3.5 µm thick)

rounded or tylote head (Figs. 11C, 12B). It is not easy to distinguish between main and auxiliary megascleres because there is a continuous range in their length (283–2620 μm), thickness (1–50 μm) and head width (0.7–22 μm), and these parameters are not always correlated. Moreover, large and small megascleres are associated in the same bundle. Some measurements (head thickness in brackets): 2620 by 45 μm (15), 2500 by 45 μm (18), 2250 by 50 μm (20); 1880 by 40 μm (10); 1840 by 40 μm (10); 1550 by 38 μm (22); 1240 by 10 μm (2), 950 by 20 μm (5); 900 by 7 μm (1.5); 830 by 8 μm (2.5); 770 by 6 μm (1); 670 by 5 μm (1). There are also strongyles, (one with the rounded head of the transformed strongyloxea a little tylote, 1050 by 35 μm (20), another 1135 by 35 μm (15) and anisotrongyles. The measurements reported in Table 5 refer to a conventional figure to distinguish between main and auxiliary megascleres at a length of 1000 μm. The larger megascleres (maximum size 2620 by 50 μm) have a head generally slightly tylote thick 10–22 μm, and a distal end generally well pointed, sometimes slightly rounded. In contrast, the middle-sized and smaller megascleres are also fusiform, but looking like oxeas for their very thin (0.5–3.5 μm) and generally slightly tylote head.

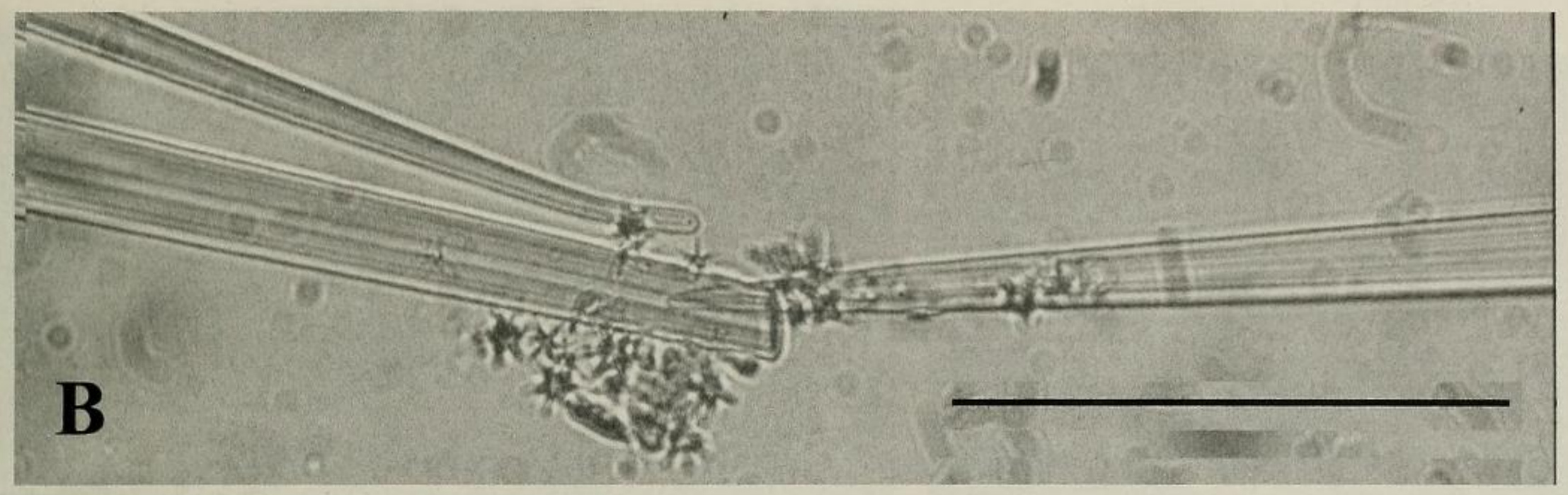
Megasters (Figs. 11D, 12A): Spherasters, sometimes oxyspherasters, with the main range 40–70 μm (maximum 91 μm) in diameter. R/C range, more frequently 0.6–1 (maximum 1.5). Ray number: 16–20, rays sometimes slightly bent or bifid. Spherasters, not abundant, are variable in size and shape in the same specimen and among the specimens.

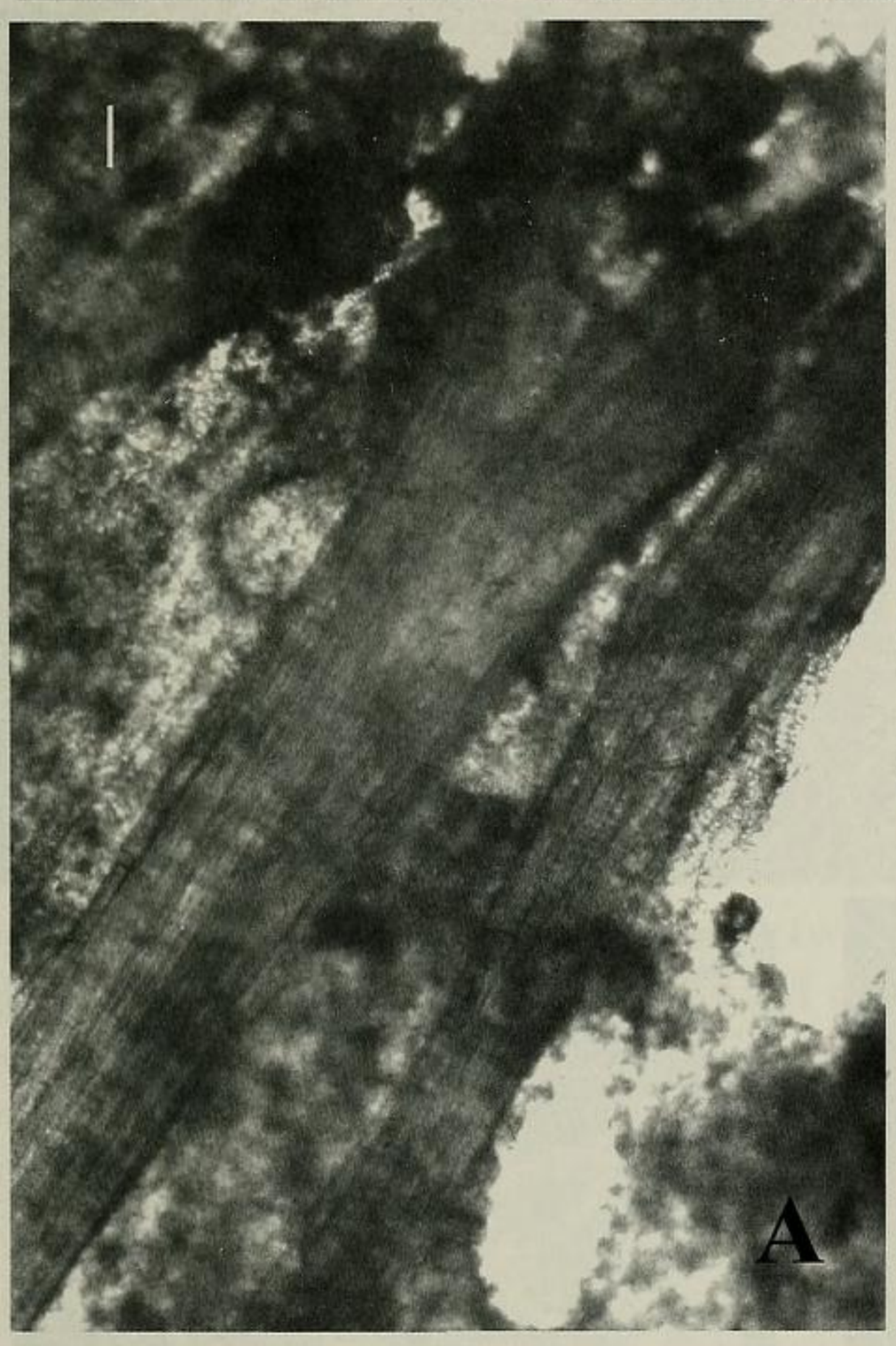
Microsters (Figs. 11B, 12C, D): Similar in the cortex and in the choanosome. Mainly strongylasters (chiasters) but variable from tylasters with slightly knobbed rays to slightly tylote oxyasters. Size: 8–13 μm (minimum 4, maximum 15.5 μm) in diameter. Ray number: 12–14. Often a center is more or less developed.

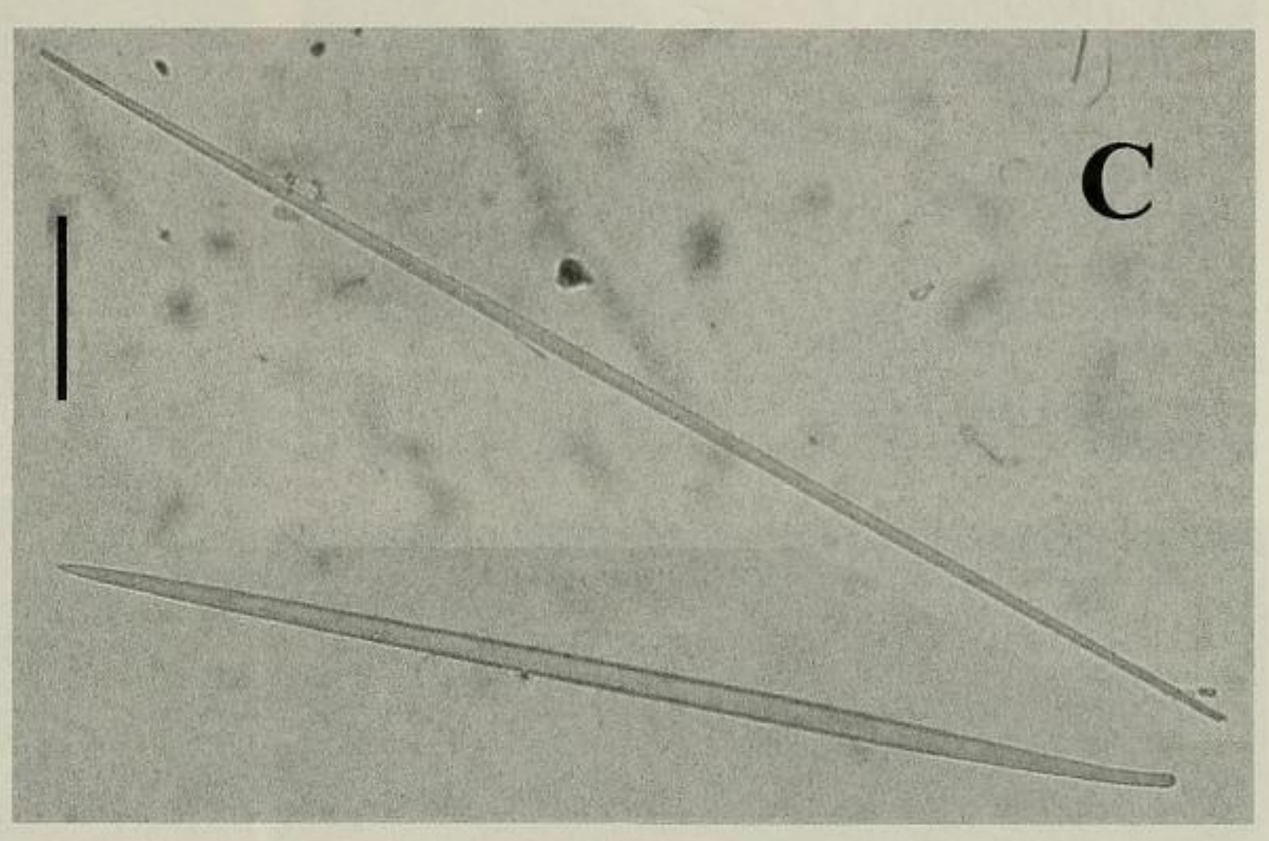
Etymology.—From the Greek prefix *para*

Table 5.—Measurements of spicules of specimens of *Tethya paroxeata* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres				Megasters		Microsters
	Main		Auxiliary				
	Length	Width	Length	Width	Diameter	R/C	Diameter
1 (Holotype)	1010-1369-2620	10-21-50	315-682-998	1-7-20	19-50-71	0.4-0.8-1.1	4.7-8.9-13.5
2	1014-1344-1963	9-20-32	419-718-982	6-11-18	26-55-69	0.3-0.7-1.0	4.0-7.6-11.8
3	1000-1616-2289	8-31-48	420-687-980	8-14-23	26-53-83	0.5-0.6-1.0	8.0-11.9-15.5
4	1000-1572-2280	8-28-43	400-733-995	5-13-24	28-53-70	0.5-0.8-1.3	8.0-11.5-15.0
5	1000-1513-2120	21-27-36	283-678-990	5-12-21	27-62-91	0.5-0.8-1.5	8.0-11.6-15.0







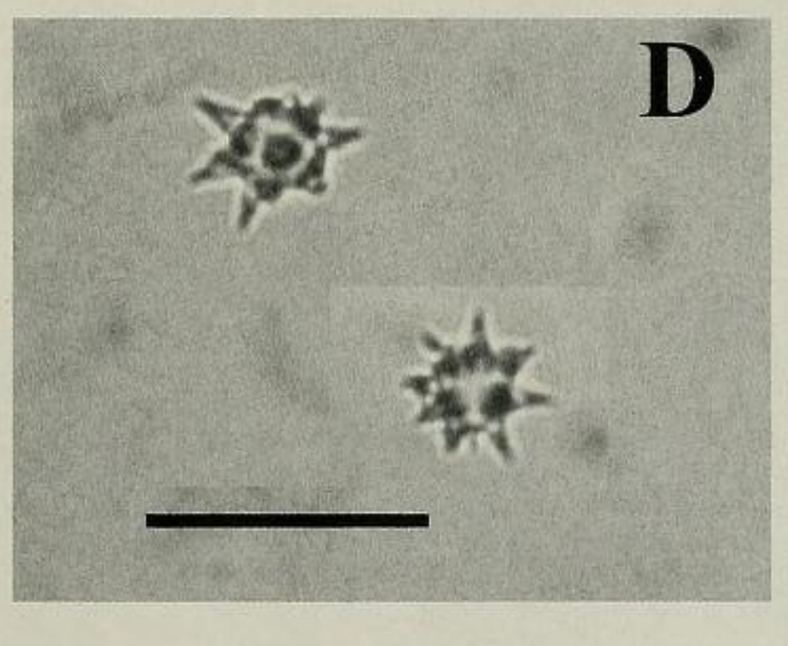


Fig. 11. *Tethya paroxeata,* new species. Light microscopic photographs. A, Cortical structure; B, Micrasters; C, Slender strongyloxeas; D, Megasters. Scale bars = 100 μm.

= beside, nearby + *oxeata* = relating to an oxea, Neolatin from Greek *oxys* = sharp, in reference to the ends, both thin, of the small megascleres.

Remarks.—Tethya paroxeata is similar to *T. ensis, T. mexicana* and *T. ovum* but is clearly distinguished by its peculiar polyhedral shape and even surface. The same type of shape and surface may occur rarely in some specimens of *T. mexicana* from the same locality (Punta Arboleda) but less pronounced. *Tethya paroxeata* is clearly distinguished from similar species by the peculiar oxeiform shape of the greater majority of the shorter megascleres. The spherasters, rarely oxyspherasters, are smaller than in *T. ensis, T. mexicana* and *T. ovum.* Spicular intraspecific variability is shown by specimen two which is characterized by smaller micrasters (Table 5). *Tethya paroxeata* differs from *T. californiana* in body shape, cortical surface and structure and occurrence of the oxeiform megascleres, in addition to the other traits listed for *T. ensis, T. mexicana* and *T. ovum.*

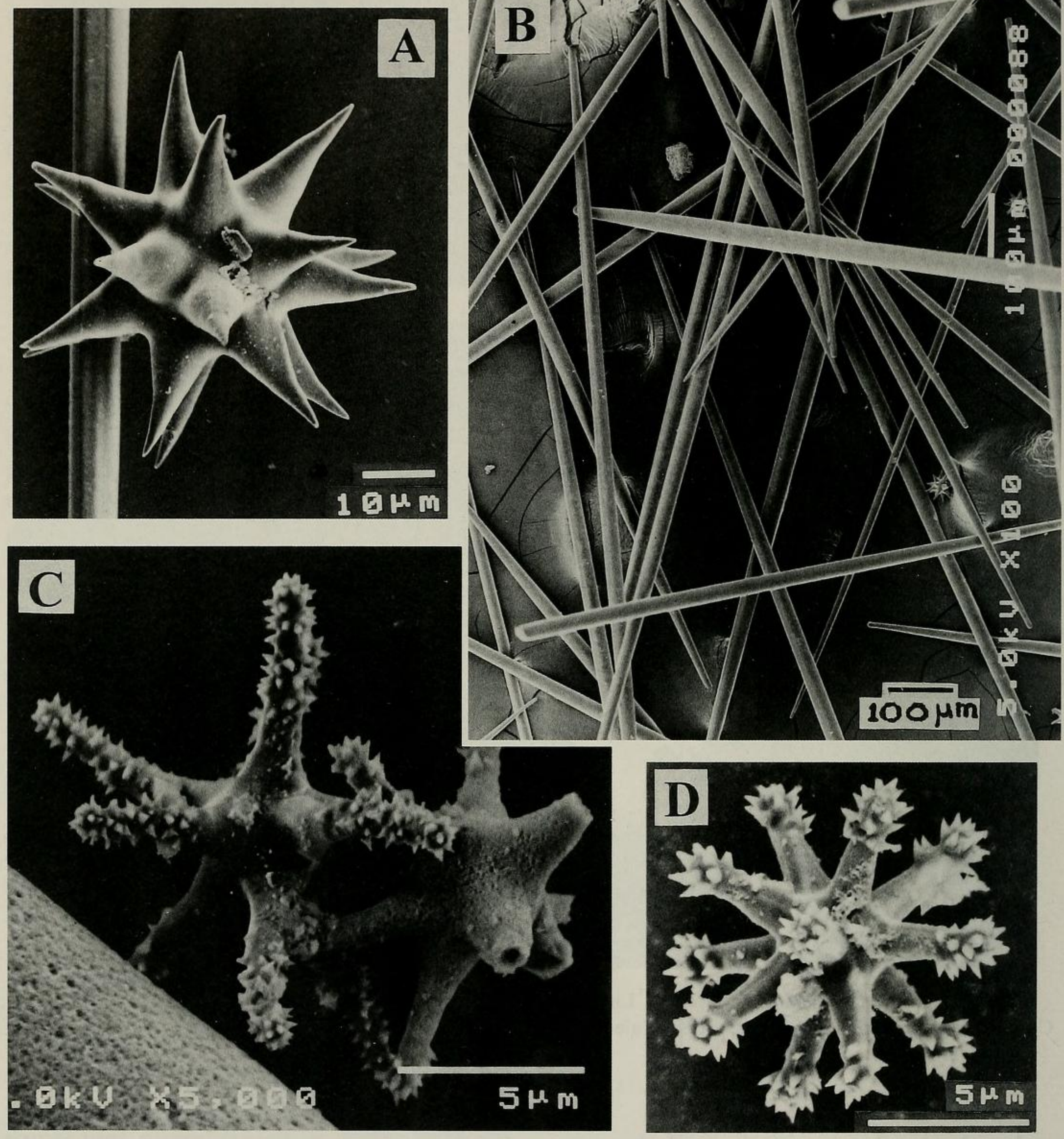


Fig. 12. *Tethya paroxeata,* new species. SEM micrographs. A, Megaster; B, Megascleres; C, Strongylasters (less frequent); D, Tylaster (more frequent).

Tethya socius, new species
Figs. 8C, D, 13, 14, 15E, Table 6

Material examined.—Holotype MSNG 50195; 1 specimen (composed of 4 fused individuals) from Puerto Libertad (Gulf of California), Oct 1985, intertidal.

Description.—The type is made by 4 fused spherical depressed individuals of 2, 1.5, 1.2 and 1 cm in diameter and 1–1.2 cm in thickness. On the whole, the specimen measures 4 by 3 by 1–1.2 cm in thickness (Fig. 8C, D). Color: pale pink in ethanol. Consistency soft, rather compressible. Lacunes in the outer cortex and in the outer choanosome under the cortex (Fig. 15E). Surface with contiguous tubercles of irreg-

ular shape and different size, 1–3 mm wide, flattened and with slightly winding outlines. Cortex with the tubercles, 2–2.5 mm thick. The body of all the individuals has a strong central nucleus, about 6 mm in diameter, from which the megasclere bundles radiate.

Skeleton.—The megasclere tracts may split, as in *T. mexicana,* before reaching the cortex. Different megasclere bundles may also support the same tubercle. Terminal fans are little developed. Auxiliary megasclere bundles fill the interstices among the main tracts in the upper choanosome. Spherasters are distributed in all the cortex, more densely in the basal part, especially at the boundary with the choanosome. Some smaller megasters are in the outer part of the choanosome. The skeleton of the nucleus is made by a dense and irregular network of small styles and subtylostyles (Fig. 15E).

Spicules.—Table 6 summarizes measurements taken from the holotype. Megascleres (Fig. 14A): strongyloxeas little fusiform without a clear distinction between the main and auxiliary. In the table the two categories are conventionally separated on the basis of a 1000 μm length figure. Some measurements (head thickness in brackets): 1700 by 30 μm (10); 1350 by 18 μm (10); 1315 by 18 μm (10); 1250 by 22 μm (12); 1040 by 8 μm (5); 1030 by 18 μm (5); 700 by 2 μm (1). An anisostrongyle: 1460 by 28 μm (15; 10). Maximal sizes 1700 μm in length and 30 μm in thickness, on the whole: 440–1700 μm by 2–30 μm (1–12). In the center small styles or subtylostyles heterogeneous in length and thickness and sometimes with the basal third a little curved: 150–400 by 5–20 μm.

Megasters (Figs. 13B, C, 14B, D): Oxyspherasters: generally 60–100 (max. 118 μm in diameter); R/C generally 1.2–1.7 (max. 1.8, min. 0.7). Ray number: about 14, frequently bent, twisted, blunt, bifid or with spines on the rays.

Microsters (Figs. 13B, 14C): Mainly strongylasters but variable from slightly knobbed tylasters to slightly tylote oxyasters. They are similar in the cortex and in

Table 6.—Measurements of spicules of one specimen of *Tethya socius* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres								Microsters Diameter
	Main				Auxiliary				
	Length		Width		Length		Width		
1 (Holotype)	1003-1206-1700		8-18-30		439-768-992		2-9-19		6.5-10.1-14.6

Megasters			
Diameter		R/C	
20-71-118		0.7-1.3-1.8	

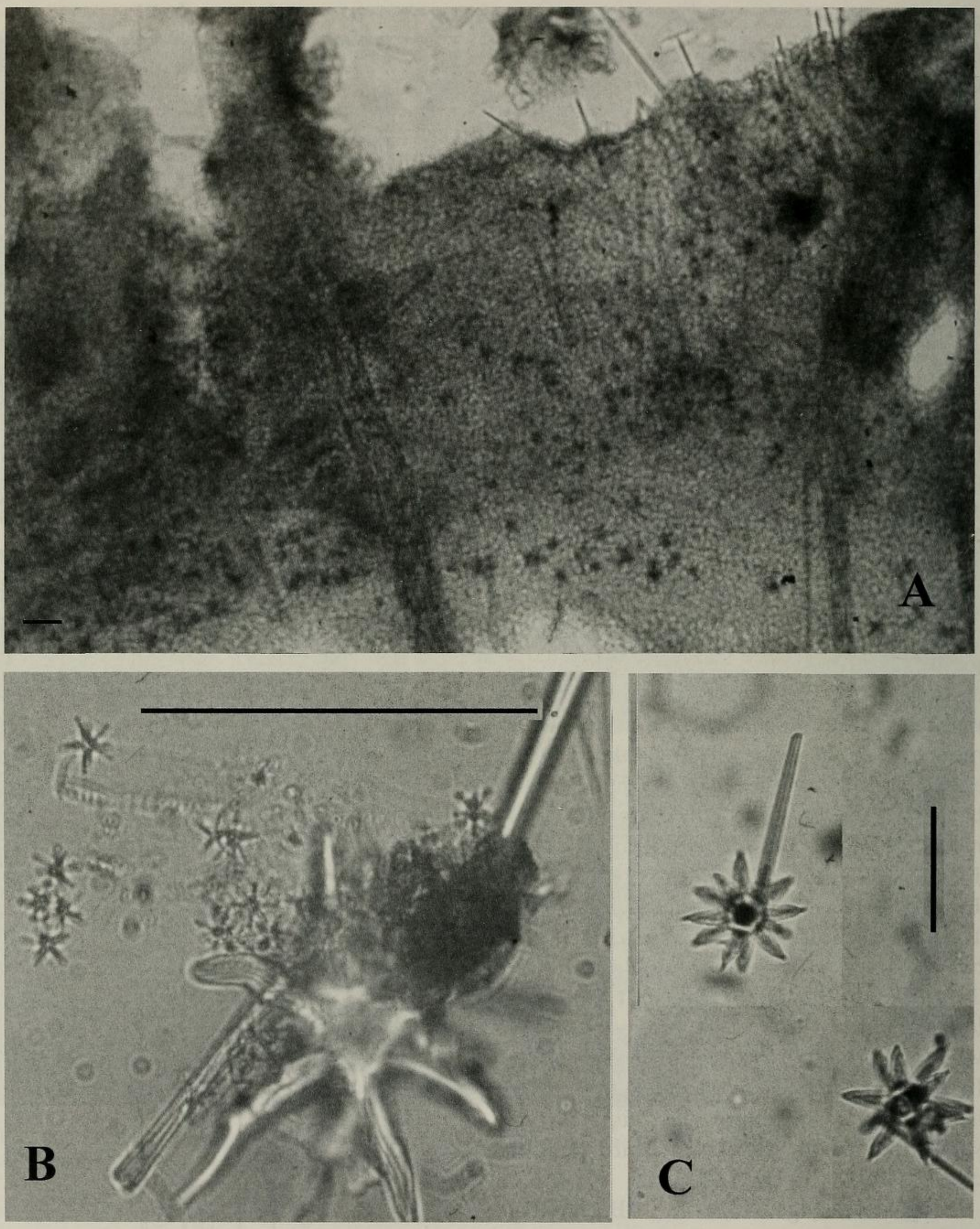


Fig. 13. *Tethya socius,* new species. Light microscopic photographs. A, Cortical structure; B, Micrasters and one megaster; C, Megasters. Scale bars = 100 μm.

the choanosome, generally 8–12 μm in diameter. Ray number 10–14.

Etymology.—From Latin *socius* = companion, in reference to the fusion of different individuals to form one specimen, unusual in *Tethya*; here used as a noun in apposition.

Remarks.—*Tethya socius* is well distinguished from the other Mexican species here described for the smaller size of the

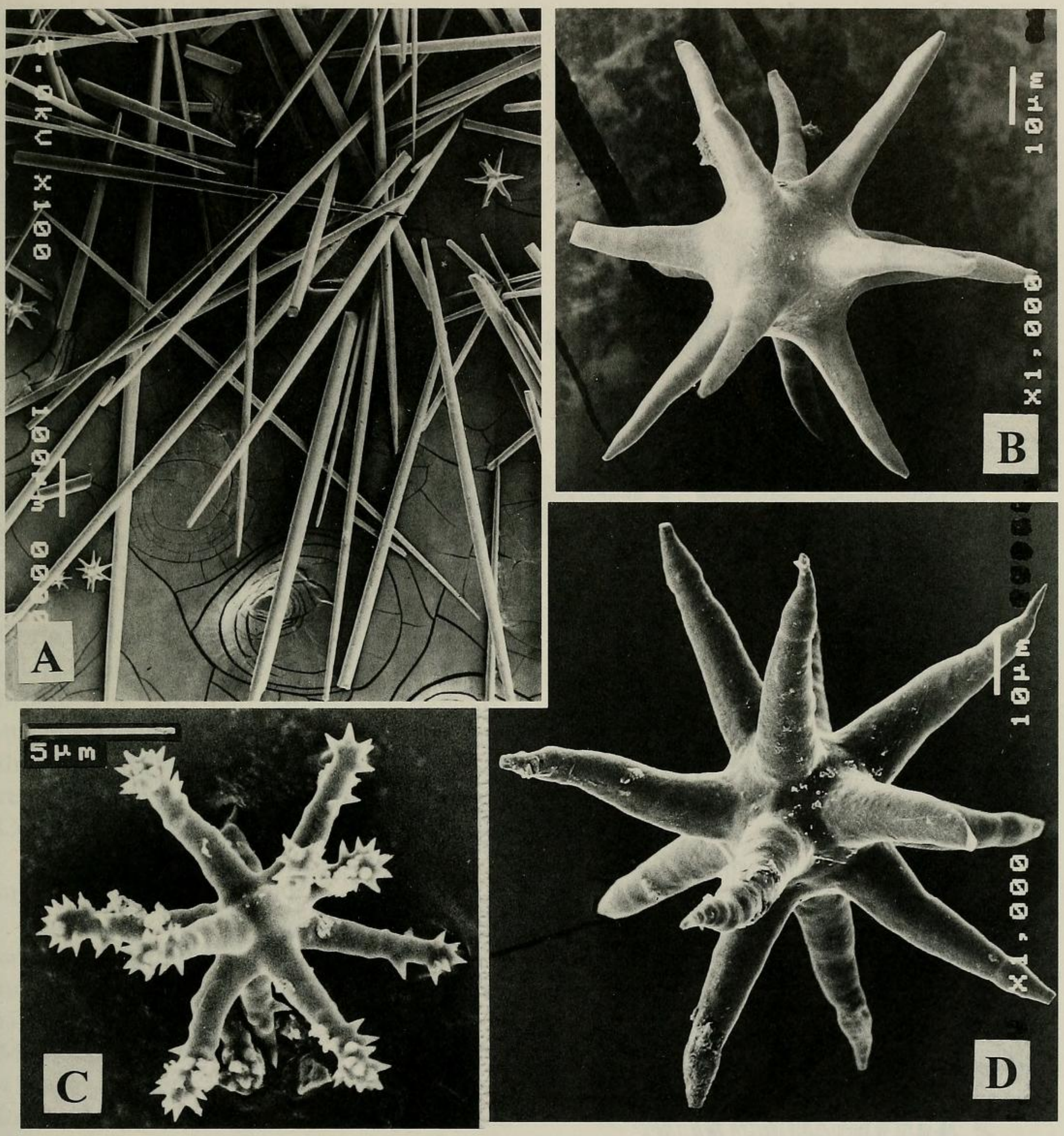


Fig. 14. *Tethya socius,* new species. SEM micrographs. A, Megascleres; B, Megaster; C, Micraster (more frequent); D, Megaster.

megascleres, the very high R/C of its oxyspherasters with rays frequently twisted, bent, blunt, bifid or with spines. Only the microsters, similar in the cortex and in the choanosome as in the other Mexican species, are roughly alike to those of *T. ensis, T. mexicana, T. ovum,* and *T. paroxeata.* The frequent oxyasters with a small swelling at the ray tips, which occur in all these Mexican species and also in *T. californiana,* may be compared to a similar trait in the eastern Indian Ocean *T. affinis* Kirkpatrick, 1900 and to the western Pacific *T. deformis* Thiele, 1905. Yet, in *T. affinis* the rays are longer and slenderer, and in *T. deformis* the microsters have a well developed center. Other spicular traits of both these species are clearly different by the Mexican

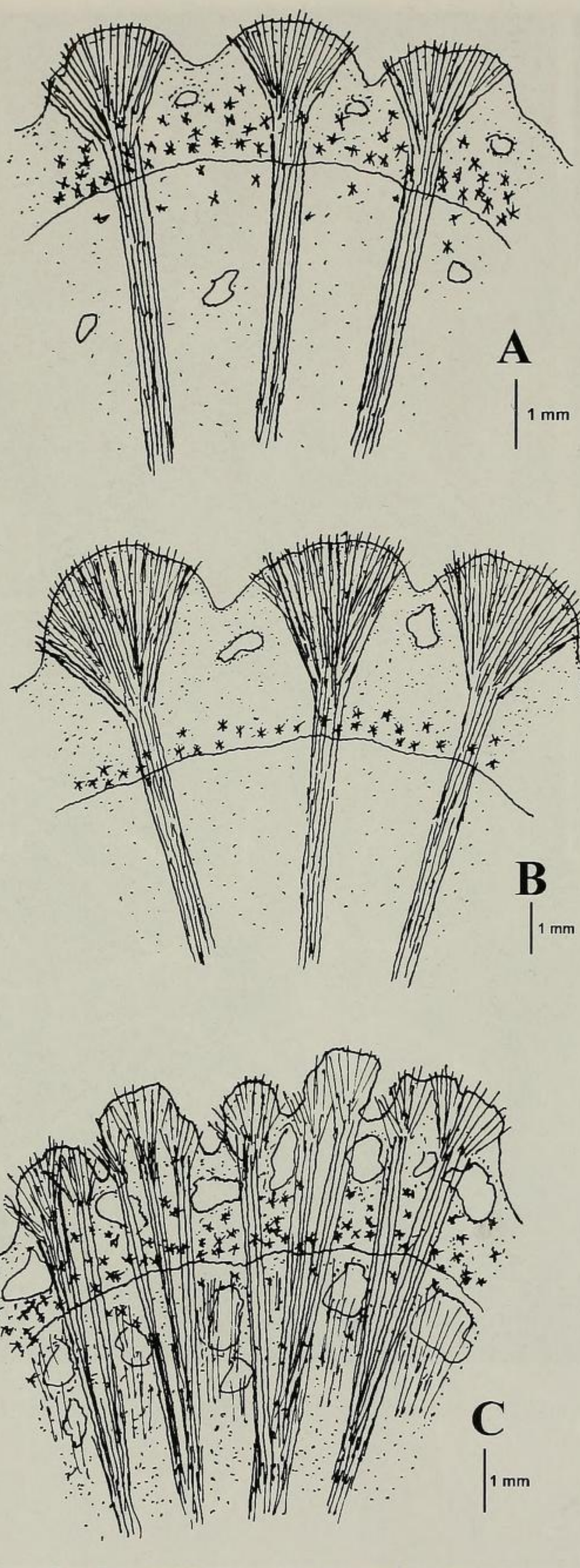


Fig. 15. Reconstruction of skeletal patterns from transverse sections of the new species of *Tethya*. A, *T. ensis*; B, *T. ovum*; C, *T. mexicana*; D, *T. paroxeata*; E, *T. socius*.

species. *Tethya socius* is also characterized by the fusion of the subspherical individuals which show a well marked central nucleus. A similar fusion of individuals is found in *T. communis* Bergquist & Kelly-Borges, 1991 from S.E. Australia. But *T. communis* lacks the central nucleus and has oxyspherasters with shorter rays and polyrhabds, absent in *T. socius,* among the microscleres. A central nucleus has been

found also in some specimens of *T. mexicana.*

Tethya californiana De Laubenfels, 1932
Fig. 8E, F, Table 7

Tethya aurantia var. *californiana* De Laubenfels, 1932:44
Tethya californiana.—Sarà & Corriero, 1993:204

Material examined.—54 specimens from Cabo San Miguel (Gulf of California), Mar 1985, 25 m depth.

Description.—Body shape spherical or sub-spherical, 0.6–3.8 cm in diameter. Surface smooth due to the very even tubercles. Color ochre yellow to orange when alive. Some specimens have round to irregular oscules on top. Consistency soft in ethanol. Cortex including the tubercles 2–2.5 mm thick. Tubercles 0.5–1.5 high, 1–3 mm broad. The irregular outlines of tubercles and the lacunar structure of the cortex and the choanosome correspond to those in the redescription of *T. californiana* in Sarà & Corriero (1993).

Megasclere bundles 300–800 μm in diameter.

Spicules.—Measurements of 5 specimens are summarized in Table 7. Megascleres are main and auxiliary strongyloxeas with intermediates between the two categories. Maximal size of strongyloxeas is 2375 by 43 μm. Medium-sized and small strongyloxeas have often the proximal part (head and neck) a little bent on the axis of the spicule.

Megasters: are mostly spherasters with a wide range in size and in R/C, even in the same specimen. Generally measuring between 45 and 60 μm, but minimal and maximal diameters are 20 and 83 μm. R/C generally between 0.6 and 0.8 but minimal and maximal R/C are 0.3 and 1.2. The conical rays about 24, are sometimes bifid or blunt.

Micrasters: similar in the cortex and in the choanosome are mainly microspined strongylasters, frequently as a strongylaster-oxyaster type, with moderately pointed

Table 7.—Measurements of spicules of specimens of *Tethya californiana* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres				Megasters		Micrasters
	Main		Auxiliary		Diameter	R/C	Diameter
	Length	Width	Length	Width			
1	1053-1373-2017	12-21-36	407-725-983	1-4-18	25-50-68	0.4-0.7-1.2	7.9-11.3-14.8
2	1010-1742-2375	7-26-43	286-686-976	1-7-22	23-51-66	0.4-0.7-1.1	6.7-10.0-13.5
3	1000-1402-2090	10-26-40	270-738-995	3-11-22	26-54-83	0.4-0.6-1.0	8.0-11.8-15.5
4	1000-1576-2340	10-26-40	307-698-990	3-11-18	21-54-78	0.4-0.7-1.1	9.0-12.3-15.5
5	1000-1604-2100	10-29-40	270-777-995	4-13-28	20-55-75	0.3-0.6-0.09	7.5-11.7-15.0

Specimens	Spherule Diameter
1	8.0-10.2-13.0
2	8.0-11.0-13.0
3	8.0-10.2-13.0

rays, and, less frequently, as a strongylaster-tylaster type, with slightly knobbed rays. Ray number 10–14 and, sometimes, a small center. More frequent size: 10–13 μm (max. 15.5 and min. 6.7).

Spherules 8–13 μm, are present in the cortex.

Remarks.—The Mexican population was identified as *Tethya californiana* after comparison with the type material of the species. However, it differs considerably in two traits: the megascleres are strongyloxeas instead of anisostrongyles and the megasters are generally spherasters, with R/C lower than 1, instead of oxyspherasters. Yet, some oxyspherasters with R/C = 1–1.2 occur also in the Mexican population. Other slight differences between the Mexican population and the Pacific *T. californiana* are the smaller body size, the smoother surface, and the greater spherule diameter. These differences may be due to the different geographic location of the samples. The type material comes from the Pacific coast of California, north of Los Angeles, whereas the ones described here are from the Mexican coast of the Gulf of California.

Tethya taboga (De Laubenfels, 1936)
Fig. 8G, Table 8

Taboga taboga De Laubenfels, 1936:452
Tethya aurantia sensu Green & Gomez, 1986:284

Material examined.—Punta Chile (Mazatlán), 7 specimens, May 1981, 8 m depth, 2 specimens, Jun 1987, 5 m depth.

Description.—Body shape hemispherical, 2.5 cm in diameter, 1.5 cm in height. Surface with rounded tubercles 1–1.5 mm high and broad. Cortex including the tubercles, 2–2.5 mm thick.

Megasclere bundles are sometimes coiled from the center to the cortical surface.

Spicules.—Measurements of three specimens are summarized in Table 8. Megascleres are generally strongyloxeas, sometimes with stepped ends. Maximal size found for strongyloxeas is 1680 by 34 μm.

Table 8.—Measurements of spicules of specimens of *Tethya taboga* (μm). Underlined numbers indicate mean values.

Specimens	Megascleres				Megasters		Oxyasters	Micrasters
	Main		Auxiliary					
	Length	Width	Length	Width	Diameter	R/C	Diameter	Diameter
1	1000-1355-1680	16-27-34	182-698-980	4-14-30	30-57-70	0.3-0.5-0.8	11.5-45.6-67.5	8.5-10.4-12.5
2	1002-1329-1641	12-18-28	262-587-987	2-9-19	19-48-65	0.2-0.4-1.0	22.3-42.9-58.5	6.6-9.5-13.4
3	1026-1309-1602	9-23-32	323-600-987	1-12-25	42-62-74	0.2-0.4-0.6	22.2-39.2-55.0	6.3-8.7-12.7

Table 9.—Comparison among the Pacific Mexican *Tethya* (depth in meters, spicule measurement in μm, size ranges restricted to the more frequent values; spicular types not dominant in brackets.

	T. ensis	*T. mexicana*	*T. ovum*	*T. paroxeata*	*T. socius*	*T. californiana*		*T. taboga*	
Geographic distribution	Mexico	Mexico	Mexico	Mexico	Mexico	Mexico	(Type) California (USA)	Mexico	(Type) Panama
Depth (m)	45	22–45	45	22	Intertidal	25	Intertidal–15	5–8	Intertidal
Body shape	Elongated hemispherical	—Ellipsoidal —Hemishpherical —Polyhedrical	Ovoidal	Polyhedral	Subspherical used individuals	—Spherical —Subspherical	—Hemispherical to oval stipulate	Hemispherical	Subspherical
Megascleres	Strongyloxeas Max. Size 2312 × 47 ''Sword'' strongyloxeas 225–965 × 10–25 Head Diam. 4–8	Strongyloxeas Max. Size 2130 × 41 (Some specimens: center with small styles and subtylostyles)	Strongyloxeas Max. Size 1885 × 39 ''Sword'' strongyloxeas 357–995 × 10–27 Head Diam. 8–10	Strongyloxeas Max. Size 2620 × 50 ''Oxeiform'' strongyloxeas 300–1300 × 1–20 Head Diam. 0.5–3.5	Strongyloxeas Max. Size 1700 × 30 (Center with small styles and subtylostyles)	Strongyloxeas Max. Size 2375 × 43	Anisostrongyles Max. Size 2200 × 40	Strongyloxeas Max. Size 1680 × 34 (Anisostrongyles)	Anisostrongyles Max. Size 1670 × 30 (Strongyles)
Megasters	Spherasters	Spherasters	Oxyspherasters	Spherasters (Oxyspherasters)	Oxyspherasters	Spherasters	Oxyspherasters	Spherasters	
	50–90 (Max. 115)	70–120 (Max. 128)	75–100 (Max. 110)	40–70 (Max. 91)	60–100 (Max. 118)	45–60 (Max. 83)	50–75 (Max. 80)	40–60 (Max. 74)	50–80 (Max. 80)
	R/C 0.5–0.9 (Max 1.1) Ray Nr. 14–16	R/C 0.7–1.2 (Max. 1.4) Ray Nr. 16–18	R/C 0.7–1.2 (Max. 1.5) Ray Nr. 18	R.C 0.6–1 (Max. 1.5) Ray Nr. 16–20	R/C 1.2–1.7 (Min. 0.7–Max. 1.8) Ray Nr. 14	R.C. 0.6–0.8 (Min. 0.3–Max. 1.2) Ray Nr. 24	R/C 1–1.2 (Min. 0.8) Ray Nr. 24	R.C 0.3–0.6 (Max. 1) Ray Nr. 16–20	R/C 0.3–0.5 (Max. 0.5) Ray Nr. 16–20
	Alike (in cortex and choanosome) Strongylasters/Tylasters/Oxyasters							Different (in cortex and choanosome) Cortex Tylasters	
Microsters	9–13 Ray Nr. 12	8–13 Ray Nr. 8–14	8–13 Ray Nr. 12	8–13 Ray Nr. 12–14	8–12 Ray Nr. 10–14	8–13 Ray Nr. 10–14	8–13 Ray Nr. 10–12	8–12 Ray Nr. 3–8	8–12 Ray Nr. 3–8
								Choanosome Oxyasters	
						Spherules 8–13	Spherules 4–8	25–55 Ray Nr. 4–8	25–60 Ray Nr. 4–8

There are also some strongyles which measured 490 by 16 μm, 1090 by 28.5 μm, 1123 by 27 μm, 1268 by 25 μm and 1450 by 30.5 μm. Several thinner styliform strongyloxeas are slightly sinuous.

Megasters are spherasters, generally 40–60 μm in diameter, 0.3–0.6 in R/C and 16–20 conical rays.

Microsters are small tylasters in the cortex and larger oxyasters in the choanosome. Cortical tylasters are stout, generally 8–12 μm in diameter with 4–8, sometimes 3, frequently irregular, microspined knobbed rays. Choanosomal oxyasters, generally 25–55 μm in diameter, with 4–8 smooth or spined rays, frequently bent, bifid or twisted.

Remarks.—The identification of the Mexican *T. taboga* specimens has been made by comparison with the type material. The two samples of Mazatlàn differ slightly in the spheraster diameter and R/C between them and more considerably with the Panama type. The megasters of the type have a greater size, generally 50–80 μm and a lower R/C (0.3–0.5). Microsters, tylasters and oxyasters, are alike in Mexican and type specimens.

General remarks

The Mexican Pacific species of *Tethya* here recorded, with the exception of *T. taboga,* represent a homogenous group, as indicated by the very similar microster type. This microster is mainly a slender strongylaster, variable, also in the same specimen, from a slightly knobbed tylaster to a slightly tylote oxyaster. This group of species may be called "californiana" from the first described species *T. californiana* De Laubenfels, 1932 and does not show any evident relationship with *Tethya* species of other regions.

Table 9 summarizes the distinctive and similar traits of these species as well as the differences with *T. taboga.* This last species belongs to the "seychellensis" group, characterized by two types of microsters, cortical tylasters and larger choanosomal oxyasters.

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