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Taxonomy of Sponges (Porifera) Associated with Corals from the Mexican Pacific Ocean

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José Antonio Cruz-Barraza and José Luís Carballo (2008) Taxonomy of sponges (Porifera) associated with corals from the Mexican Pacific Ocean. *Zoological Studies* **47**(6): 741-758. In this paper we describe 6 sponge species living on pocilloporid corals from the Mexican Pacific Ocean: *Callyspongia californica*, *Chalinula nematifera*, *Haliclona caerulea*, *Mycale* (*Carmia*) *cecilia*, *M.* (*C.*) *magniraphidifera*, and a new species of the genus *Amphimedon*, which constitutes the first record of this genus from the East Pacific Ocean. These are the only species overgrowing live coral frameworks known so far from the Mexican Pacific Ocean. *Amphimedon texotli* sp. nov. is a cushion-shaped to massive digitate blue sponge, with a skeletal structure typical of the genus *Amphimedon*. The new species was found growing on different substrata, but its distribution seems to be restricted to coral reef ecosystems. *Chalinula nematifera* was exclusively found on corals, and *H. caerulea* and *C. californica* were found as much on corals as on other types of substrata. *Mycale* (*Carmia*) *cecilia* and *M.* (*C.*) *magniraphidifera* were less common species overgrowing live corals, yet were found on other types of substrata. Our specimens constitute the first record of *M.* (*C.*) *magniraphidifera* from the Pacific Ocean. We present the distinctive characteristics of these species for the development of later ecological studies, related to the ecological role of these sponges in coralline ecosystems from the Mexican Pacific coast.
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Key words: Taxonomy, Sponges, Coral reef, Mexican Pacific Ocean, Interactions.

Coral reefs are recognized for their high biological diversity and concentrated biomass within benthic communities, in addition to their importance to fisheries, tourism, coastal protection, geological processes, and esthetic wonder (Jaap 2000). Sponges, one of the most diverse and abundant groups of marine benthic communities around the world (Harman 1977), are also an important biotic component of coral reef ecosystems (Reswig 1973, Wulff 2006). Their coverage is often similar or higher than those of stony corals (Rützler 1978, Zea 1993), and their diversity may even exceed that of corals (Wulff 2001). In fact, they are far more diverse than corals in many areas (Diaz and Rützler 2001, Wulff 2006). Sponges are relatively well-known in some coral reefs from different regions of the world (see Rützler 2004), where they play many important roles binding live corals to the reef frame, facilitating regeneration of broken reefs and harboring nitrifying and photosynthesizing microbial symbionts, or intervening in erosion processes (Diaz and Rützler 2001, Wulff 2001 2006).

However, sponges are important competitors for space (Suchanek et al. 1983, Aerts and van Soest 1997, Rützler 2002) and are able to damage corals by producing active substances even in non-contact situations (Suchanek et al. 1983, Sullivan et al. 1983, Porter and Targett 1988). Thus, competitive interactions between sponges and

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corals often result in the overgrowth and death of the coral (Macintyre et al. 2000, Rützler 2002). Some of these species are extremely aggressive and successful, particularly in environments stressful for corals (Vicente 1978, Aerts and Kooistra 1999, Macintyre et al. 2000, Rützler 2002), where they are capable of occupying large reef areas at the expense of corals (Vicente 1978, Rützler and Muzik 1993). For example, the species *Mycale grandis* is considered a strong space competitor with corals on some Hawaiian coral reefs (Coles et al. 2006). Also there are documented cases of mutualism, as the Caribbean sponge *M. laevis* which lives in association with several massive coral species. In this association, the coral is protected from bioerosion by other boring sponge species, while *M. laevis* benefits from an expanding substratum free of competitors (Goreau and Hartman 1966).

Eastern Pacific coral communities are distributed between 30°N and 5°S (Glynn and Ault 2000). Specifically, the Mexican Pacific littoral comprises 46% of their total distributional range (López-Perez et al. 2004). However, despite the great importance of coral reefs and their considerable presence in the Mexican Pacific Ocean, ecological interactions between corals and sponges remain poorly known, with the exception of boring sponges (Carballo et al. 2004, Carballo and Cruz-Barraza 2005, Bautista et al. 2006, Carballo et al. 2007).

The goal of the present paper was to describe species of non-boring sponges living in association with live corals in the Mexican Pacific Ocean. We described a new species, and carried out a systematic actualization of species already known. We also included some aspects of overgrowth competition between sponges and corals, as a 1st step in studying ecological interactions between these organisms.

MATERIALS AND METHODS

Specimens were collected by scuba diving at 14 coral reef locations that cover the entire coral reef distribution in the Mexican Pacific Ocean (Fig. 1). Specimens were fixed in 4% formaldehyde and transferred to 70% alcohol after 24 h. Spicule preparation followed the techniques described by Bautista et al. (2006) for light and scanning electron microscopy (SEM). Spicule

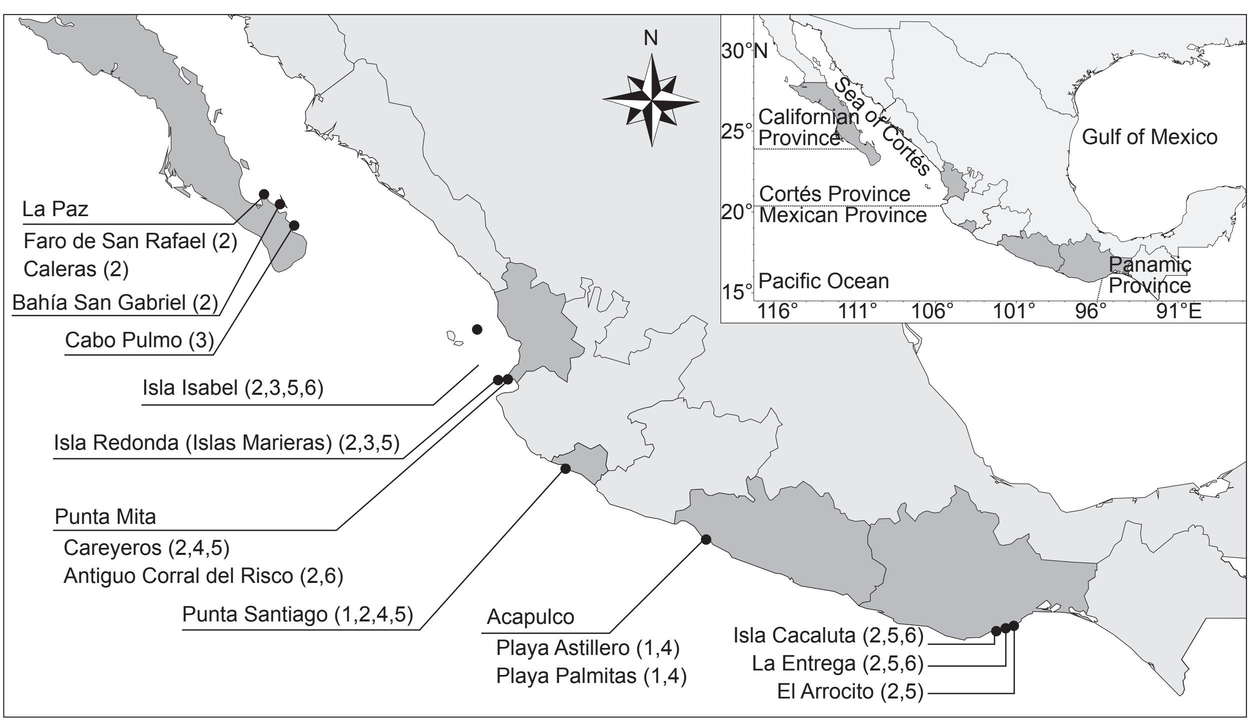

Fig. 1. Sampling localities and distribution of sponges living on corals along the Mexican Pacific Ocean. Numbers correspond to different species: (1) *Amphimedon texotli* sp. nov., (2) *Callyspongia californica*, (3) *Chalinula nematifera*, (4) *Haliclona caerulea*, (5) *Mycale* (*Carmia*) *cecilia*, (6) *M.* (*C.*) *magniraphidifera*.

measurements were obtained from a minimum of 25 spicules chosen at random for each specimen. The measurements (length, shaft width, and head width of tylostyles) are given in micrometers, and numbers in parentheses in some descriptions are the average.

The material was deposited in the Colección de Esponjas del Pacífico mexicano (LEB-ICML-UNAM), of the Instituto de Ciencias del Mar y Limnología, UNAM, Mazatlán, México. The type material of *Amphimedon texotli* sp. nov. was deposited in the Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN) and in the British Museum of Natural History (BMNH), London.

RESULTS

SYSTEMATICS DESCRIPTION

Order Haplosclerida Topsent, 1928

Suborder Haplosclerina Topsent, 1928

Family Niphatidae van Soest, 1980

Genus *Amphimedon* Duchassaing and Michelotti, 1864

Diagnosis: Irregularly massive, lamellate, flabelliform, branching growth forms, with numerous oscules linearly distributed on rims or scattered on branches. Ectosomal skeleton a tri-dimensional tangential network of secondary fibers with rounded meshes, covered by a fine membrane. Choanosomal skeleton an irregular, diffuse, radially plumose network of primary, ramified multispicular fibers, irregularly connected by secondary multispicular fibers. Sponging abundant. Megascleres oxeas often with modified or strongylote apices. Microscleres absent (Desqueyroux-Faúndez and Valentine 2002).

***Amphimedon texotli* sp. nov.**
(Figs. 2, 3, 7A; Table 1)

Material examined. *Holotype*: MNCN 1.01/364, Punta Santiago (Manzanillo, Colima) 19°05'41"N, 104°25'22"W, 2 m depth, 11 Oct. 2001. Paratypes: BMNH 2008.4.2.2, Punta Santiago (Manzanillo, Colima) 19°05'41"N, 104°25'22"W, 2 m depth, 11 Oct. 2001. LEB-ICML-UNAM-1096, La Entrega (Huatulco, Oaxaca), 15°44'34"N, 96°07'35"W, 3 m depth, 5 Apr. 2005. LEB-ICML-UNAM-1318, Playa Astillero (Acapulco, Guerrero), 16°50'10"N, 99°53'25"W, 3 m depth, 15 Apr. 2006. LEB-ICML-UNAM-1319, Playa Palmitas (Acapulco, Guerrero), 16°50'04"N, 99°55'22"W, 4 m depth, 18 Apr. 2006.

Description: Cushion-shaped sponge covering areas from 7 cm in diam., to massive globular, subcylindrical, lobate, palmate, or digitate forms, covering areas up to 15 cm in diam. (Fig. 2). Oscules circular oval-shaped, 0.2-1.0 cm in diam. Conspicuous and abundant, slightly elevated from surface, sometimes with tubules arising from base, and with oscules scattered on branches, sometimes linearly distributed on rims. Surface smooth, translucent, with a punctuate appearance due to subectosomal spaces (0.5-1.5 mm in diam.) distributed regularly over sponge. Species slightly rough and bumpy to touch. Ostial orifices 100-300 μm in diam. Consistency firm and relatively compressible, somewhat hard, but very fragile and easy to tear. After preservation, superficial membrane lost, and terminal tracts from choanosomal skeleton overdraft like minute projections on surface, giving it a hispid aspect. Ectosome a translucent membrane, not easily detachable. Choanosomal channels circular or oval, 0.5-1.2 mm in diam.; abundant and converging in atrium of oscular projections. Color in life sky blue; after preservation, dark brown or black. Alcohol typically also turning dark brown or black. Species commonly found overgrowing bases of live coral colonies, where tubular projections arise from coral structure (Fig. 2).

Skeleton: Ectosomal skeleton a tridimensional tangential reticulation of uni-paucispicular (1-4 spicules) or multispicular tracts (up to 9 spicules), 10-60 μm in diam., producing rounded meshes 100-400 μm in diam., covered by a fine membrane (Fig. 3A), which is lost in preserved specimens (Figs. 3B, C). Choanosomal skeletal architecture a regular anisotropic reticulation of pauci-multispicular primary ascending tracts (10 spicules), interconnected by irregular secondary pauci- sometimes multi-spicular tracts or individual spicules, forming triangular, quadrangular, or polygonal meshes 80-160 μm in diam. (Figs. 3D, E). Sponging not abundant, but always present cementing tracts and joining free spicules.

Spicules: Species presenting large, robust oxeas, almost fusiform (Fig. 7A), lightly curved at center, with symmetrical ends. Spicules with blunt-tipped styles, strongyles commonly present. Slender, probably immature oxeas also present, but rarely. Spicules measuring 100-200 (157.6) μm long, and 5-8 (6) μm wide (Table 1).

Etymology: The term “texotli” comes from Nahuatl and means blue, which refers to the typical color of the species.

Taxonomic remarks

Amphimedon texotli sp. nov. is a common sponge in coral reef ecosystems from the southern Mexican Pacific coast and constitutes the first record of the genus from the East Pacific.

The closest species is the Australian *A. queenslandica* Hooper and van Soest, 2006. Both species are similar in external morphology and color, although *A. queenslandica* is also green, while *A. texotli* sp. nov. is always blue. Both species differ principally in the skeletal composition and organization. *Amphimedon queenslandica* has a compressible, but firm, and resistant consistency, quickly returning to its initial shape due to a moderately well-developed thick spiculo-fiber skeleton (Hooper and van Soest 2006). In contrast, *A. texotli* sp. nov. has a firm consistency, but it is very fragile and easily tears, because the only sponging in the skeleton is restricted to joints of the spicules’ tracts. In addition to the choanosomal anisotropic skeletal reticulation, *A. queenslandica* has a thinner uni-paucispicular secondary skeleton, which forms an isodyctial reticulation within a larger fiber network. This characteristic is not present in *A. texotli* sp. nov. Finally, the spicule size and shape also differ. *Amphimedon queenslandica* has thinner and

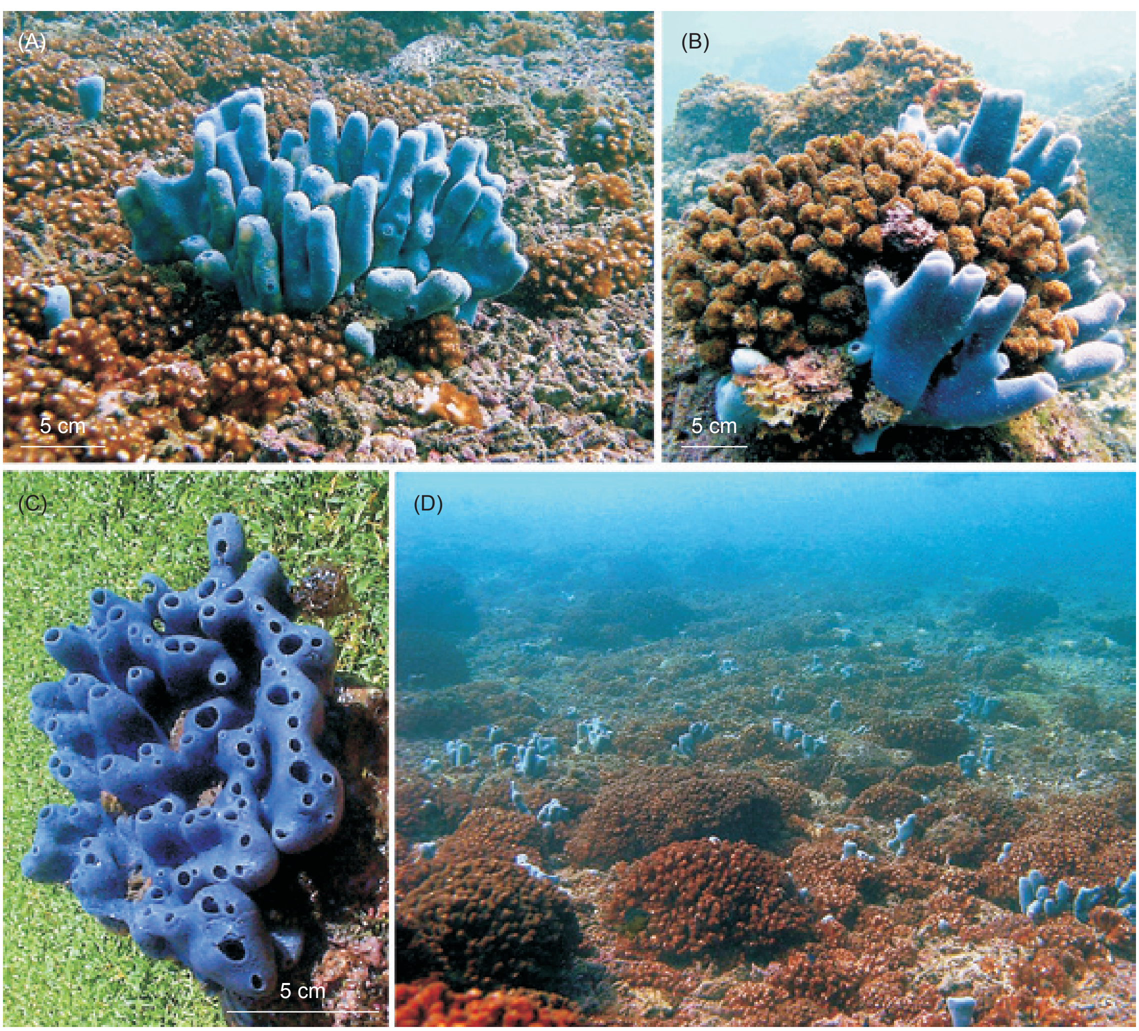

Fig. 2. External morphology of *Amphimedon texotli* sp. nov. (A, B) Branching specimens living between branches of pocilloporids corals; (C) fresh holotype taken out of the water; (D) coralline ecosystem where it is possible to appreciate the abundance of the species.

smaller oxeas of 55-118 (83) x 1.5-4.5 (2.3) μm than *A. texotli* sp. nov., which has oxeas (derivative oxeote styles and strongyles) of 100-200 (157) μm long, and 5-8 (6) μm wide (Table 1).

Another close species is the Caribbean *A. viridis* (Duchassaing and Michelotti, 1864). However, both species principally differ in external morphology and color. *Amphimedon viridis* is incrusting to massive or amorphous, with a tendency to become ramous or adopt the shape of a cock's comb, with a typical green color, while *A. texotli* sp. nov., is a cushion-shaped to

Table 1. Comparative data for the dimension of spicules (μm), distribution, and other characteristics of *Amphimedon* species in the Pacific Ocean and Caribbean Sea. Dimensions of the spicules are given as length by width of the shaft. Values in parentheses are means

Known *Amphimedon* species	External characteristics	Spicules	Distribution
	Amphimedon species from the Pacific Ocean		
A. texotli sp. nov. Holotype MNCN 1.01/364	Massive-digitiform blue sponge	Oxeas, styles, strongyles: 100-200 (157.6) x 5-8 (6)	Tropical Mexican Pacific
A. texotli sp. nov. LEB-ICML-UNAM-1096	Incrusting to cushion-shaped blue sponge	115-200 (1.60) x 3-7.5 (5.8)	Tropical Mexican Pacific
A. texotli sp. nov. LEB-ICML-UNAM-1318	Massive-digitiform blue sponge	147.5-175 (159.75) x 2.5-5 (4.2)	Tropical Mexican Pacific
A. texotli sp. nov. LEB-ICML-UNAM-1319	Massive-digitiform blue sponge	132.5-200 (172) x 3.75-3.75 (6.15)	Tropical Mexican Pacific
A. alata Pulitzer-Finali, 1996	Inconspicuous, creeping on rock, dark brown, softly resilient	Oxeas: 100-130 x 7-11.5 Toxas: 11-50	Papua New Guinea
A. conferta Pulitzer-Finali, 1996	Sub-cylindrical branching brown sponge	Oxeas: 140-160 x 7-9	Laing I., Papua New Guinea
A. cristata Pulitzer-Finali, 1996	Sub-cylindrical with a laterally projecting crested outgrowth, violet sponge, rigid no resilience	Oxeas (blunt points): 230-370 x 11-18	Laing I., Papua New Guinea
A. lamellata Fromont, 1993	Undulated spreading fan or erect lamellate pale-pink or mauve sponge	Oxeas: 11-130 (122) x 2.5-4.4 (3.6)105-126 (113) x 1.3-2.1 (1.8)	Australia
A. paraviridis Fromont, 1993	Incrusting to ramose olive-green sponge	Strongyloxeas: 109-135 (120) x 1.3-2.6 (2)131-151 (142) x 3.9-8 (6)	Australia
A. queenslandica Hooper and van Soest, 2006	Incrusting-lobate grayish-blue to green sponge	Oxeas: 55-118 (83) x 1.5-4.5 (2.3)	Australia
A. rudis Pulitzer-Finali, 1996	Part of a laminated sponge moderately resilient violet-brown sponge	Oxeas with rounder points: 360-420 x 10-2.5	Papua New Guinea
A. strongylata Pulitzer-Finali, 1996	Subcylindrical gray sponge Consistency is tough scarcely resilient	Strongyles (with centrotilote spicules): 170-200 x 14	Papua New Guinea
A. sulcata Fromont, 1993	Small globular massive live sponge	Oxeas: 122-153 (139) x 3-5.5 Thin oxeas: 94-140 x 1.6-2.6	Australia
	Amphimedon species known from the Caribbean Sea		
A. caribica (Pulitzer-Finali, 1986)	Palmate violet, greenish-gray or gray sponge	150-205 x 6.5-10.5	Puerto Rico
A. complanata (Duchassaing, 1850)	Massive to ramose with tendency towards a flabelliform habit (apparently) dark purple to black	Thin strongylote: 70-120 x 0.5-3	Caribbean
A. compressa Duchassaing & Michelotti, 1844	Ramose to flabelliform, pinkish to brownish-red live sponge	Oxeas a few styles-strongyles: 116-174 (146.5) x 2.5-7.5 (4.8)	Caribbean
A. viridis Duchassaing & Michelotti, 1864	Rounded masses with thick branches, (dark) green live and spirit	Oxeas: 115-180 (153) x 2-12 (6.8)	Caribbean

lobate, palmate, or digitate sponge, with typical blue color (Wiedenmayer 1977, Pinheiro et al. 2005). *Amphimedon texotli* sp. nov. differs from other Pacific and Caribbean species principally by morphological characters such as form, color, consistency, and spicule size and morphology (see table 1).

The closest species in the Eastern Pacific Ocean seems to be *Xestospongia trindania* Ristau, 1978 from the California coast (USA) (Ristau 1978). This species has been suggested to be included in the genus *Amphimedon* (World List of Extant Porifera), but a formal synonymy has not been given. *Xestospongia trindania* is a dark-brown incrusting or erect lobate sponge, with a lightly hispid surface (which gives it a conulose aspect), a firm and hard consistency, although it is slightly compressible, and 2 oxea size categories (115-200 x 2-8 and 240-260 x 18-20). *Amphimedon texotli* sp. nov. differs in the light blue color, smooth surface, and 1 oxea size category. In Ristau's description, an ectosomal membrane was observed, but ectosomal skeleton specialization was absent, while *A. texotli* sp. nov. has a tangential ectosomal reticulation. The choanosomal skeleton of *X. trindania* is an anisotropic reticulation typical of the genus *Amphimedon*, but also of the suborder Haplosclerina. *Amphimedon* differs from niphatid genera such as *Pachychalina*, *Cribrochalina*, and *Niphates* by having a more or less smooth surface and a rounded isotropic arrangement of spicule tracts at the surface (Desqueyroux-Faúndez and Valentine 2002, Helmy and van Soest 2005). Due to the absence of ectosomal skeleton specialization, we prefer to consider that

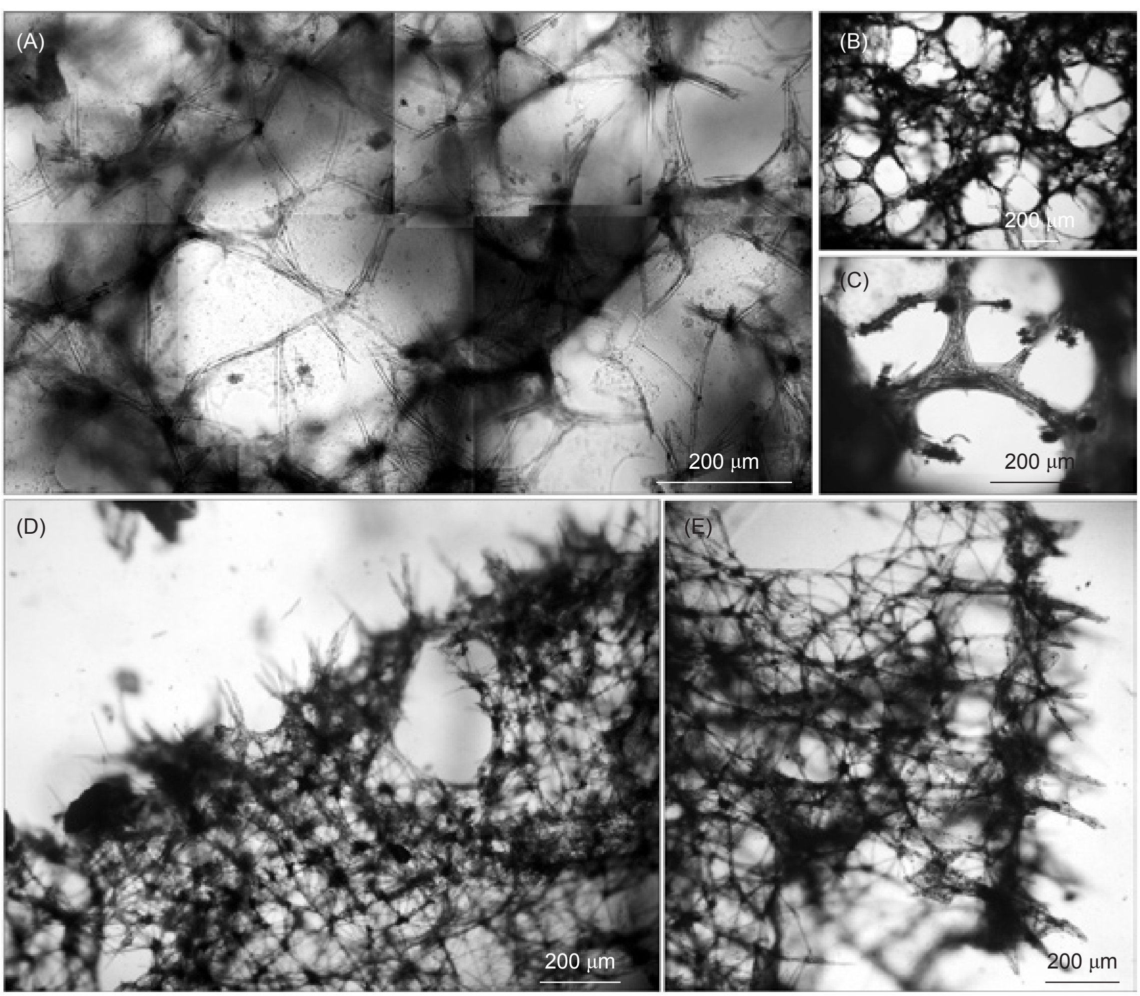

Fig. 3. Skeletal characteristics of *Amphimedon texotli* sp. nov. (A) Tangential reticulation of rounded meshes covered by a fine membrane; (B, C) details of the ectosomal skeletal structure; (D) choanosomal skeletal structure in the sponge body; (E) choanosomal skeletal structure of sponge branches.

the *Amphimedon* status of *X. trindania* is uncertain until the material type is revised for a future re-assignation.

Distribution and ecology

Amphimedon texotli sp. nov. is a common and abundant shallow-water sponge in coral reef ecosystems from the southern Mexican Pacific Ocean (Figs. 1, 2D), where it overgrows branches and bases of live coral colonies of the genus *Pocillopora*. The sponge forms typical tubular projections, which commonly protrude over the coral structure (Figs. 2A-C). The species can also be found overgrowing dead coral and rocks, at 2-4 m in depth.

Family Callyspongiidae de Laubenfels, 1936a

Genus *Callyspongia* Duchassaing and Michelotti 1864

Callyspongia californica, Dickinson, 1945

(Figs. 4, 7B)

Synonymy

Callyspongia californica Dickinson, 1945. *Callyspongia californica*.- Sim and Bakus 1986.

Description: Incrusting to cushion-shaped sponge (0.4-0.8 mm thick) frequently overgrowing base of live branched corals (Figs. 4A-C). Species

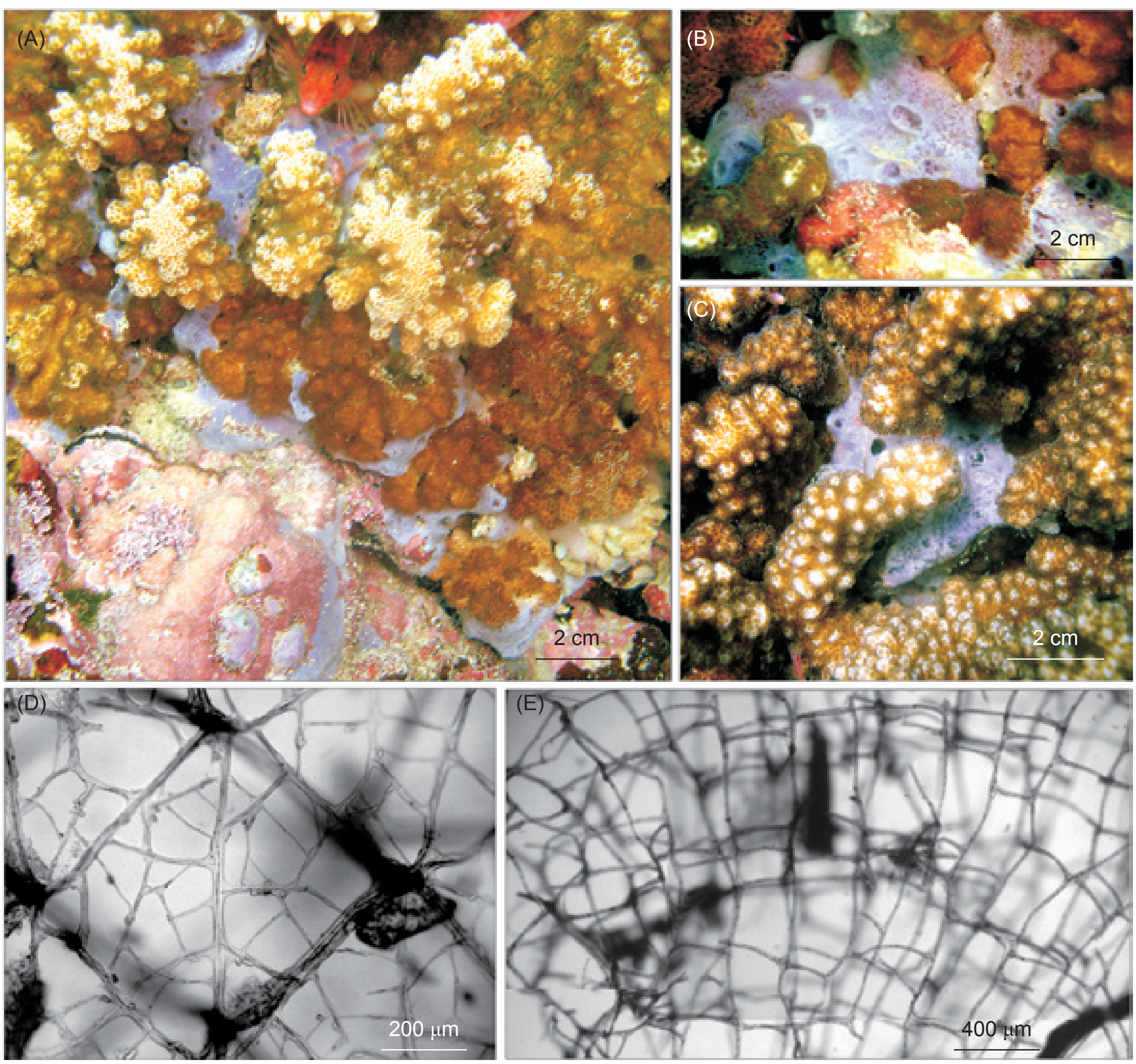

Fig. 4. External morphology and skeletal characteristics of *Callyspongia californica* Dickinson, 1945. (A) Specimen overgrowing coral and rock; (B, C), details of the species between branches of *Pocillopora* sp.; (D) tangential view of ectosomal skeletal structure; (E) cross-section of choanosomal skeletal reticulation.

with small, oscular, volcano-shaped elevations, or small tubular-oscular projections. Surface even and smooth, although slightly rough to touch. Subectosomal spaces 200-800 μm in diam. visible to naked eye and regularly distributed on sponge surface. Ostial spaces 25-50 μm in diam. inside ectosomal reticulum. Circular-shaped oscules 1-5 mm in diam., situated at summit of surface elevations, abundant and regularly distributed along surface. Consistency compressible, elastic, and very resistant, returning to initial shape quickly when compressed. Ectosome not easy detachable. Some specimens presenting sand grain and shell remains in ectosome and choanosome. Color in life light violet or blue to almost white. Preserved specimens turning light brown or losing color and becoming partially translucent.

Skeleton: Ectosomal skeleton formed by a tangential reticulation of primary, secondary, and tertiary spicule-fibers, sustained by ends of ascending choanosomal fibers (Fig. 4D). Multispicular primary fibers 10-50 μm in diam. formed by 5-35 spicules, forming polygonal meshes 450-900 μm wide, subdivided by pauci-multispicular secondary fibers (1-8 spicules) of 5-30 μm in diam., which form triangular to polygonal meshes 200-650 μm wide. Uni-paucispicular tertiary fibers 2.5-15 μm in diam. sometimes present inside secondary fibers, which form meshes 100-200 μm wide. Coanosomal skeleton formed by a square reticulation of primary fibers of 10-50 μm in diam. (Fig. 4E), formed by 5-16 spicules. Opening of meshes varying 120-660 μm wide and 130-1000 μm high.

Spicules: Thin and small oxeas lightly curved toward center of shaft, with asymmetrical ends and sharp or lightly rounded tips (Fig. 7B). Measurements: 52-117 (73) μm long, 1.3-5.0 (2.4) μm wide.

Taxonomic remarks: Our specimens agree well with the original description in external morphology and skeletal structure, but the spicules are slightly larger in Dickinson's specimens (up to 150 x 5 μm) (Dickinson 1945).

Distribution and ecology

The species was described in Oaxaca, Mexico (Dickinson 1945), and later cited in California, USA (Sim and Bakus 1986). Sim and Bakus (1986) believed that Dickinson (1945) found this species in the Gulf of California. However, the locality type and the geographical position given by Dickinson is Tangola Tangola Bay, located on Tangola I. in the state of Oaxaca, southern Mexico, and not in the Gulf of California.

Callyspongia californica is a common sponge in coral reef ecosystems (Fig. 1), growing both on live and dead coral, rocks, and shells. When it overgrows live coral of the genus *Pocillopora*, it spreads from the base towards the branches of the colony (Figs. 4A-C). The oscular elevations never stand out of the surface since they are always protected by the coralline structure. They are distributed from the intertidal to 15 m in depth.

Family Chalinidae Gray, 1867

Genus *Chalinula* Schmidt, 1868

***Chalinula nematifera* (de Laubenfels, 1954)**

(Figs. 5, 7C)

Synonymy

Nara nematifera de Laubenfels, 1954: 76; fig. 46.

Description: Thinly incrusting to semi-incrusting cushion-shaped sponge (1-4 mm thick), spreading on colony base and branches of live *Pocillopora* spp. (Figs. 5A-D). On base, specimens covering a maximum area of 4.0 x 2.5 cm and on branches can be up 15 cm long. Surface smooth to naked eye, but soft and slightly shaggy to touch. Small ectosomal pores 50-150 μm in diam. present in dermis, giving it a punctuate appearance. Subectosomal spaces 0.7-1.6 mm in diam. distributed regularly on sponge's surface. Oscules 2.5-7.0 mm in diam. abundant (more than 40 in 1 specimen), and regularly distributed over surface; oval or circular, situated at summits of volcano-shaped elevations 0.5-1.5 mm high. Consistency soft and compressible, somewhat elastic, but live specimens with much mucous. Color in life violet. Pale threads parallel to surface evident only in some specimens, never very conspicuous. Preserved specimens with a light-brown color or somewhat translucent.

Skeleton: Without ectosomal skeletal specialization. Ectosomal membrane supported by end of chonosomal unispicular ascending fibers, which sometimes cross membrane, ending at surface in a fine hispidation. Choanosomal skeleton showing a regular reticulation of ascendant unispicular, rarely bispicular, lines (13-25 μm in diam.) crossed by transverse lines (5-15 μm diam.), generally with 1 or 2 spicules in length, forming triangular or square sometimes polygonal meshes 100-200 μm wide (Figs. 5E, F).

Spicules: Small and very slender oxeas, slightly curved with asymmetric ends and a sharp point (Fig. 7C). Measurements: 87.5-112.5 (98.7) x 2.5-5.0 (4.4) μm.

Taxonomic remarks: Our specimens agree with the original description (as *Nara nematifera*) in spicule size and typical mucous consistency (de Laubenfels 1954). They also agree well with the skeletal structural description given in Systema Porifera (de Weerdt 2002). However, *Chalinula nematifera* has been described as containing very conspicuous and abundant threads which are probably a symbiotic fungus (de Weerdt 2002); these were not always evident in our specimens.

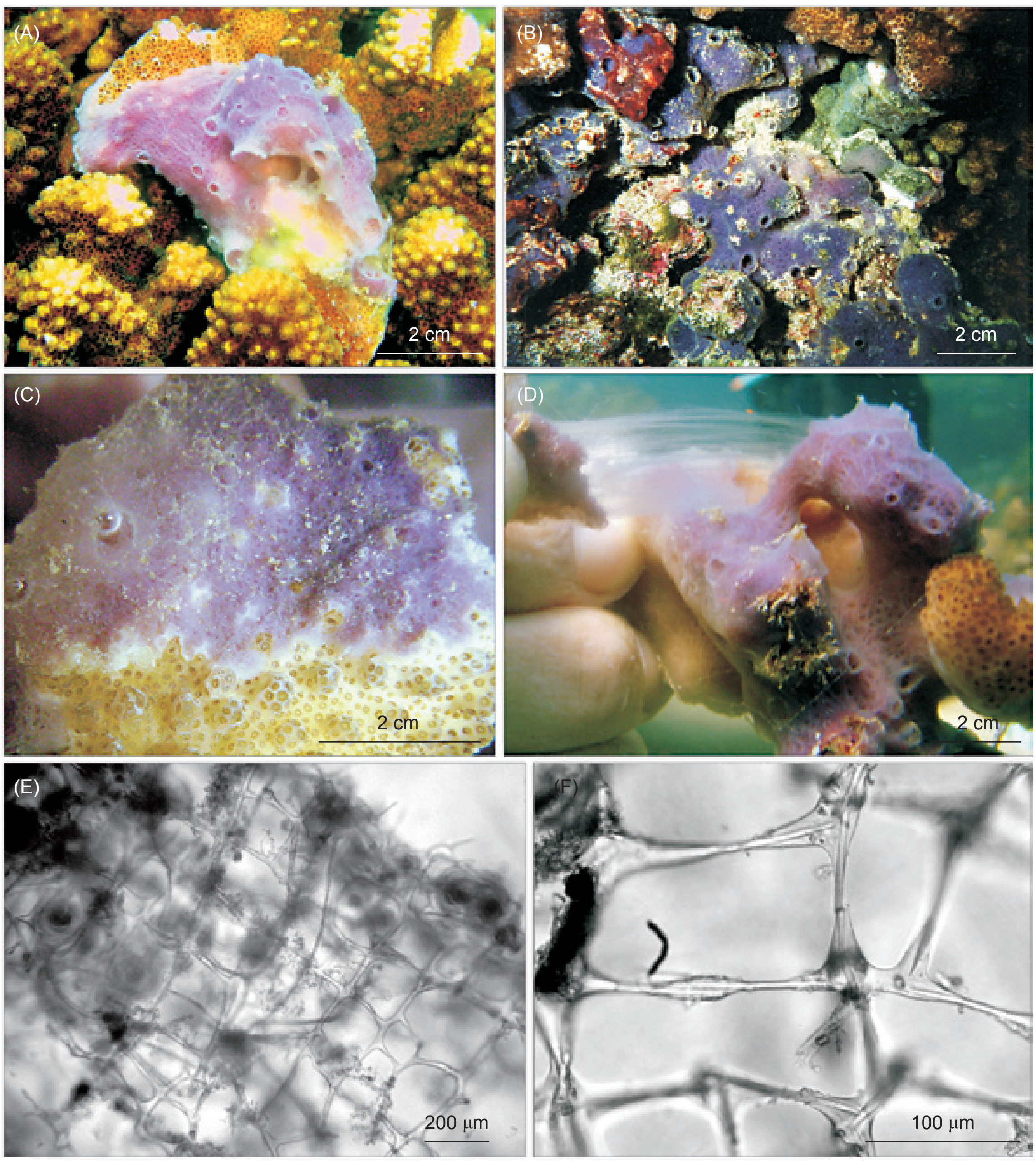

Fig. 5. External morphology and skeletal characteristics of *Chalinula nematifera* de Laubenfels, 1954. (A-D) Details of the species overgrowing live corals of the genus *Pocillopora*; (E) cross-section of choanosomal skeletal reticulation; (F) details of meshes formed by transversal lines 1 or 2 spicules long.

Distribution and ecology

The species was described in Central Pacific coral reefs (de Laubenfels 1954), and later considered extremely common growing on live coral throughout the tropical Indo-West Pacific Ocean (Weerdt 2002). In the East Pacific, the species is found on live corals from the Isla Isabel and Cabo Pulmo National Parks (México), (Fig. 1), where *C. nematifera* is relatively common overgrowing live coral colonies of 3 coral species: *Pocillopora damicornis* Linnaeus, *Poc. capitata* Verrill, and *Poc. verrucosa* Ellis and Solander). It is found from the intertidal to 15 m in depth, but it is more common at 5 m in depth where live corals are more abundant.

Genus *Haliclona* Grant, 1836

Haliclona caerulea (Hechtel, 1965)

(Figs. 6, 7D)

Synonymy

Sigmadocia caerulea Hechtel, 1965: 30, fig. 5, pl. 3, fig. 4. *Sigmadocia coerulea*. (erroneous spelling of *caerulea*) van Soest 1980: 21, fig. 7, pl. 2 fig. 4; Green and Gómez, 1996: 292, figs. 58-60. *Sigmadocia caerulea*. Zea 1987: 69, fig. 16, pl. 7 fig. 7. *Reniera coerulescens*. de Laubenfels, 1936 (not *Reniera coerulescens* Topsent, 1918). *Haliclona caerulea*. Wulff, 1996: 167. fig. 3.; Lehnert and van Soest 1998: 91.

Description: Lives in association with calcareous alga, *Jania adherens*, and found overgrowing live branches of coral colonies. Sponge varying from cushion-shaped to massive lobate (2-15 cm high), with mountainous forms and elevated oscules at top of lobules (Figs. 6A, B). Surface even to smooth to lightly rough, with fistular projections 0.2-1.0 cm high, 0.3-0.8 mm in diam. Ostial pores 0.2-0.8 mm in diam., abundant. Circular or oval-shaped oscula, 1.3-5.0 mm in diam., situated on summit of surface lobules and projections. Each oscule surrounded by an elevated translucent membrane, several millimeters high, which allows skeletal structure to be seen. Consistency lightly compressible, but very easily broken. Ectosomal membrane so translucent that it is possible to observe algae. Choanosome containing numerous aquiferous channels 0.2-1.0 mm in diam. Color in life varying from light blue to beige or white; preserved specimens beige.

Skeleton: Ectosomal skeleton a regular, tangential, unispicular, isotropic reticulation formed by oxeas, joined at nodes by sponging (Fig. 6C). Choanosomal skeleton somewhat confusing, but a reticulation of pauci-multispicular (4-8 spicules), ascending primary lines 50-90 μm in diam. visible, interconnected by secondary unispicular lines or single spicules. Sometimes chonosomal skeleton difficult to see because skeleton developed among ramifications of calcareous algae that live in symbiosis with sponge (Fig. 6D).

Spicules: Robust or slender oxeas slightly curved with asymmetrical extremes, sometimes fusiform with hastate extremes (Fig. 7D). Tip generally sharp, sometimes rounded. Measurements: 82.5-210.0 (177.3) μm long, 2.5-11.3 (5.9) μm in shaft diameter. Microscleras thin C-shaped sigmas (Fig. 6E), 17.5-30.0 (21.6) μm long.

Taxonomic remarks: Our specimens agree with the original description in size and form of spicules and skeletal arrangement (Hechtel 1965). According to this author, *H. caerulea* has a unispicular network ectosomal tangential skeleton, which is similar to our specimens. However, although the choanosome was described as a confusing pattern of vague tracts, scattered spicules, and a largely unispicular sponging-bound network, in our specimens, there is a reticulation of pauci-multispicular ascending primary tracts interconnected by secondary unispicular lines or single spicules.

Distribution and ecology: *Haliclona caerulea* was described in Jamaica (the Caribbean) (Hechtel 1965) and then cited from different Caribbean locations (see de Weerdt 2000), the Pacific side of Panama (Wulff 1996), and Mazatlán, Mexico (see Ávila and Carballo 2004). *Haliclona carulea* is a common sponge in shallow waters of the Mexican Pacific Ocean (Fig. 1), usually living in association with the red alga, *Jania adherens*. The association was found overgrowing the upper part of coral colonies of the genus *Pocillopora* (Figs. 6A, B), but it has also been found on other substrata such as dead coralline structures and over mollusk shells; found from the intertidal to 6 m in depth. Specimens of the Pacific side of Panama were also found to be associated with the bases of branching corals of the genus *Pocillopora* (Wulff 1996).

Order Poecilosclerida Topsent, 1928
Family Mycalidae Lundbeck, 1905
Genus *Mycale* Gray, 1867
Subgenus *Carmia* Gray, 1867
Mycale (*Carmia*) *cecilia* de Laubenfels, 1936b
(Fig. 8)

Synonymy

Mycale cecilia de Laubenfels 1936b: 447, fig. 41; de Laubenfels 1951: 24, fig. 15; Desqueyroux-Faúndez and van Soest 1997: 450, figs. 185-188. *Mycale microsigmatosa* Green and Gómez 1986: 284, figs. 37-40; Salcedo et al. 1988: 81 (not *Mycale microsigmatosa* (Arndt, 1927). *Mycale angulosa* Dikinson 1945: 23, pls. 37, 38 (not *Mycale angulosa* (Duchassaing and Michelotti, 1964).

Description: Incrusting to cushion-shaped sponge 1-5 mm thick, overgrowing base and branches of live *Pocillopora* spp., where it reaches 7 cm long and 3 cm wide (Fig. 8A). Surface smooth, soft. Ectosomal membrane flexible and resistant in live specimens; after preservation, membrane commonly lost. Subectosomal

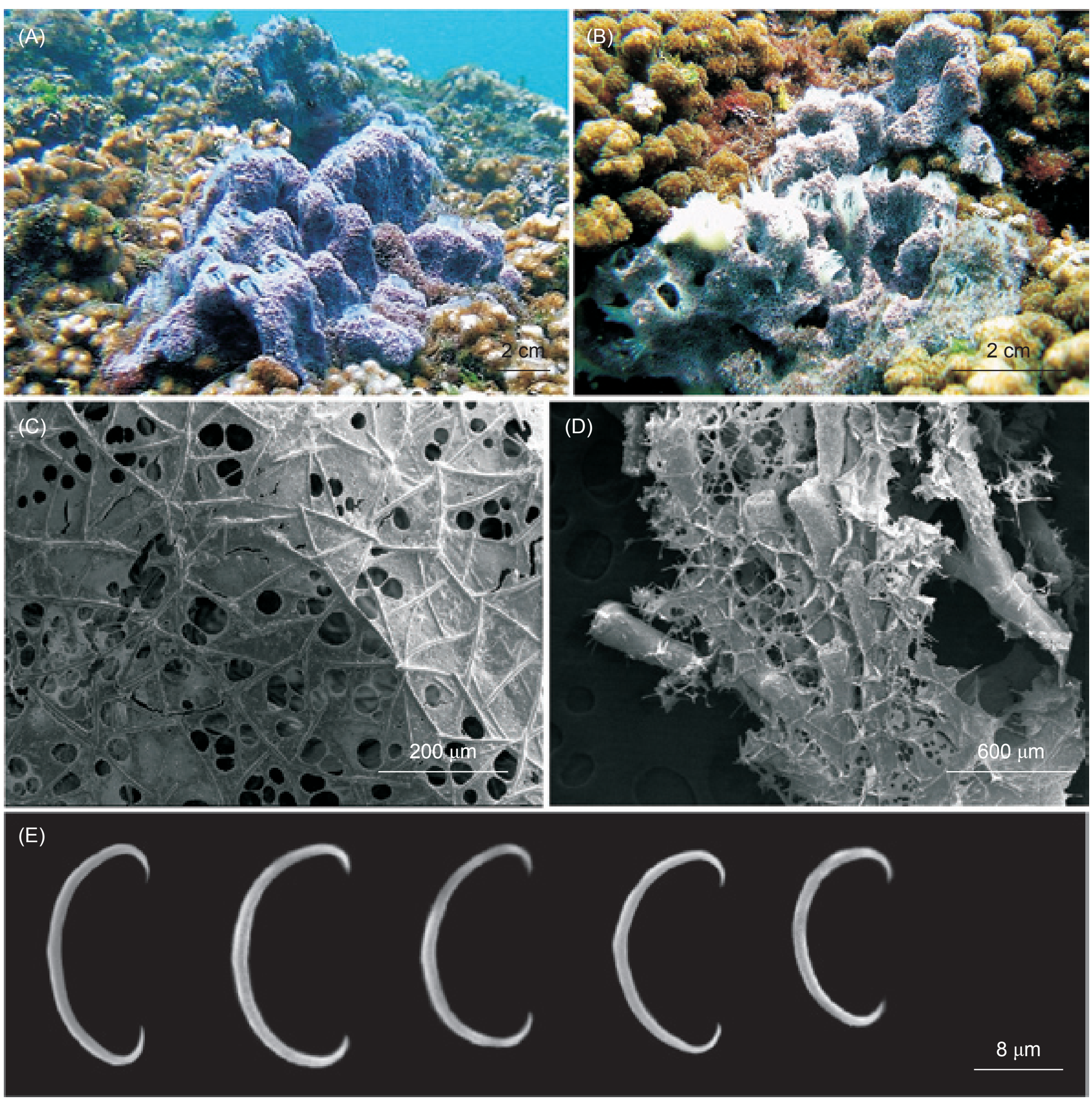

Fig. 6. External morphology and skeletal characteristics of *Haliclona caerulea* (Hechtel, 1965). (A, B) *Haliclona caerulea* growing on branches of pocilloporids corals; (C) tangential view of ectosomal skeletal reticulation; (D) details of choanosomal skeleton between algae branches; (E) microscleres sigmas.

channels 150-850 μm in diam. converging to oscula. Subectosomal spaces 20-759 μm, common, regularly distributed on surface. Very small ectosomal pores about 33.2 μm in diam., also observed on surface of sponge. Oscules circular to oval, 0.5-4.0 mm in diam., and commonly elevated from surface about 3 mm by a translucent dermal membrane. Consistency very soft, firm, resistant, but fragile and easy to tear after preservation. Live color highly variable; specimens commonly red to reddish-orange, or green with yellow, or almost blue, but always with distinctive small orange patches. Preserved specimens ochre or light brown.

Skeleton: Ectosomal membranes without skeletal specialization, but sometimes free tylostyles arranged tangentially. Free microscleras sigmas and anisochelae also distributed throughout surface (Fig. 8F). Ectosomal membrane supported by end of chonosomal multispicular ascending

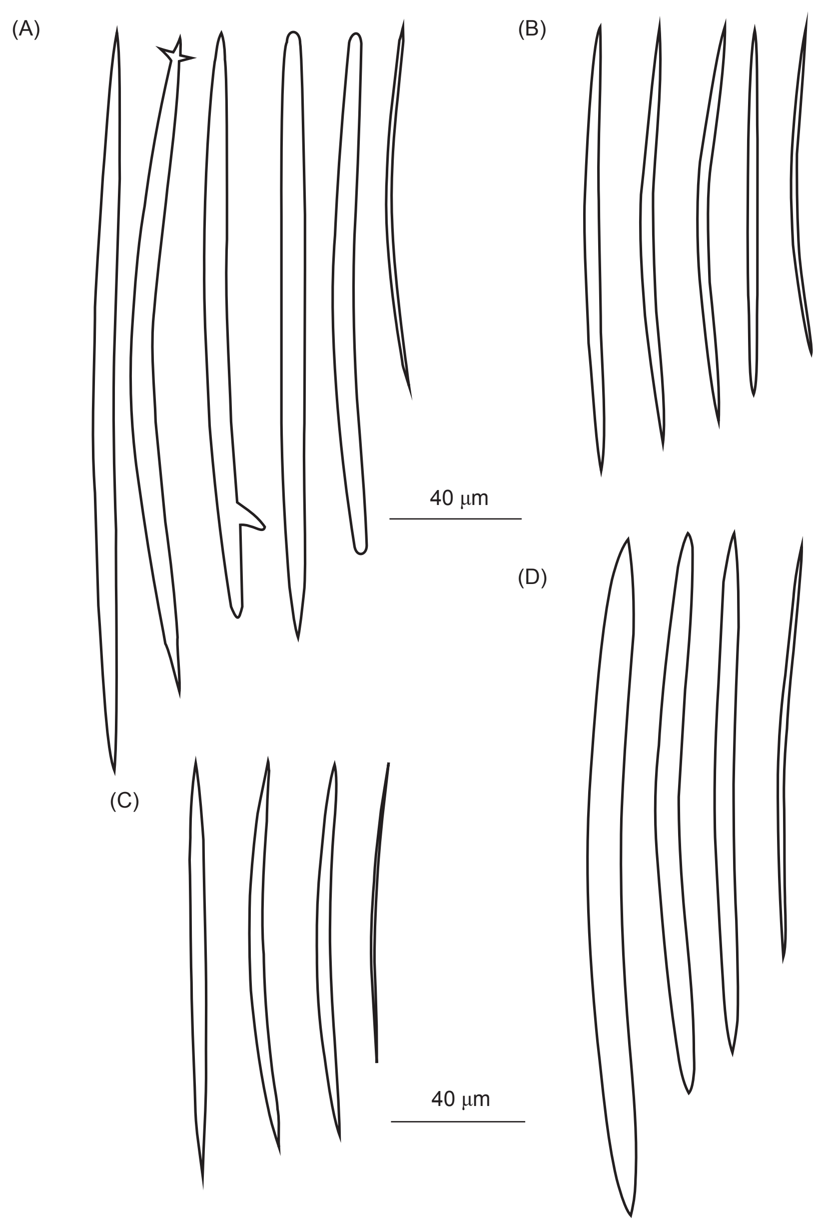

Fig. 7. Drawings of oxea morphologies. (A) *Amphimedon texotli* sp. nov.; (B) *Callyspongia californica* Dickinson, 1945; (C) *Chalinula nematifera* (de Laubenfels, 1954); (D) *Haliclona caerulea* (Hechtel, 1965).

tracts of mycalostyles 30-300 μm in diam., which slightly diverge into brushes when approaching surface (Fig. 8G). In some places, a few of these choanosomal tracts 30-150 μm in diam. continuing tangentially over surface. Microscleres, anisochelae, and sigmas common all over sponge.

Spicules: Megascleres mycalostyles straight, with sharp or blunt points and with a characteristic faintly marked oval head (Figs. 8B, E). Mycalostyle measurements: 130-302 (240) x 2.1-8.8 (5.2) μm;

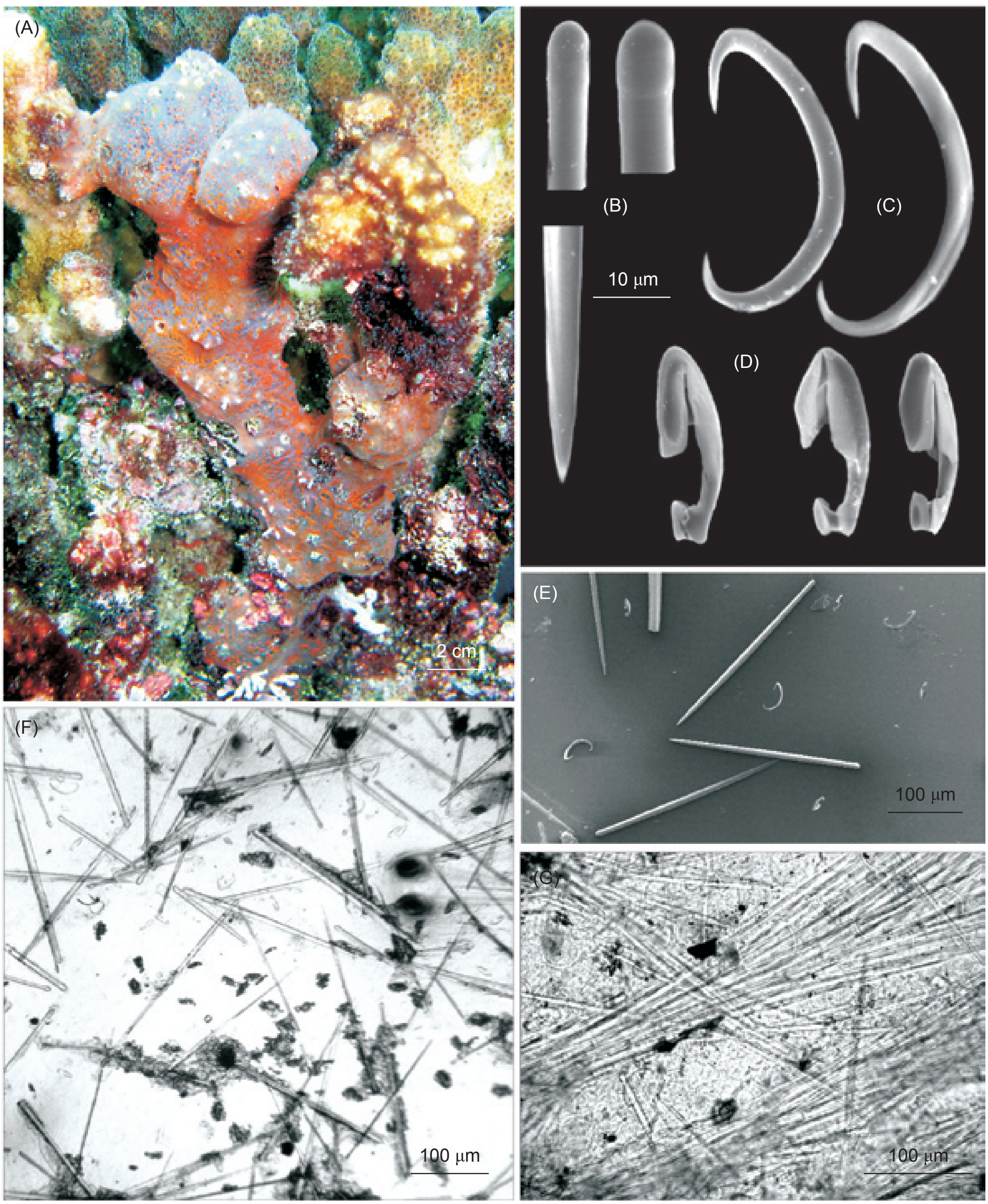

Fig. 8. External morphology and skeletal characteristics of *Mycale* (*Carmia*) *cecilia*. (A) Specimen overgrowing live branches of pocilloporid corals; (B-D) SEM picture of spicules; (B) details of the mycalostyle heads and points; (C) sigmas; (D) anisochelae; (E) general view of different spicules; (F) tangential view of ectosomal skeleton; (G) details of the choanosomal skeleton.

style diameter: 2.5-10.0 (5.9) μm. Microscleres C-shaped sigmas (Fig. 8C) and anisochelae (Fig. 8D). Sigma measurements: 15-50 (37) μm. Anisochelae measurements: 12.5-27.5 (20.2) μm.

Distribution and ecology

Mycale (*Carmia*) *cecilia* was described in Panamá (de Laubenfels 1936b), then widespread in the tropical East Pacific from the Hawaiian Is. (de Laubenfels 1951) to the Galapagos Is. (Desqueyroux-Faúndez and van Soest 1997). Particularly in the Mexican Pacific coast, the species was cited by Dickinson (1945) (as *M. angulosa*), Green and Gómez (1986), and Salcedo et al. (1988) (as *M. microsigmatosa*).

Mycale (*Carmia*) *cecilia* is a common sponge in shallow waters of the Mexican Pacific Ocean (Fig. 1). Our specimens were found overgrowing the base or branches of live corals of the genus *Pocillopora*. It has also been found on other substrata such as dead corals, rocks, and seaweeds; found from the intertidal to 10 m in depth.

***Mycale* (*Carmia*) *magnirhaphidifera* van Soest, 1984**
(Fig. 9)

Synonymy

Mycale (*Carmia*) *magnirhaphidifera*, van Soest 1984: 27; pl. 2, fig. 7. *Mycale* (*Carmia*) *magnirhaphidifera* Hajdu and Rützler 1998: 755; figs. 10, 11, 17e. Carballo and Hajdu 2001: 211; figs. 20-29.

Description: Thinly incrusting sponge 0.5-2.5 mm thick, growing on colony's base and branches of live *Pocillopora* spp., where it reaches 13 cm long and 2.5 wide (Figs. 9A, B). Surface smooth, but very soft and fragile, acuiferous system very conspicuous to naked eye. Subectosomal channels 0.6-1.2 mm in diam., commonly converging in a starry pattern to oscula. Subectosomal spaces 150-500 μm, abundant and regularly distributed on surface. Over them, possible to discern very small ectosomal sieve-like pores 33-70 μm in diam. Oscules 0.3-1.0 μm in diam., slightly elevated from surface by a translucent dermal membrane. Color in life most frequently deep-purple to bluish-purple; cream to orange-yellow in shaded zones. Preserved specimens ochre or cream.

Skeleton: Ectosomal skeleton consisting mainly of raphidotoxas arranged tangentially without defined structure. Rosettes of anisochelae -I and some other free anisochelae and sigmas also present (Fig. 9K). Choanosome formed by sinuous ascending tracts of megascleres mycalostyles 15-75 μm in diam., which diverge slightly into brushes when approaching surface (Fig. 9L). Microscleres anisochelae-II and -III, and sigmas common all over sponge.

Spicules: Megascleres mycalostyles straight, with blunt or sharp points and characteristic irregular-oval heads (Figs. 9G, H). Mycalostyle size: 225-260 (241) x 2.5-5.0 (3.8) μm; style diameter: 3.8-5.0 (4.8) μm. Microscleres anisochelae in 3 size categories (Figs. 9C-E); large anisochelae I size: 32.5-40.1 (36.9) μm, anisochelae II size: 20-25 (22) μm, anisochelae III size: 10-15 (13) μm. Raphidotoxas very thin, straight, or slightly bent with a sharp point (Fig. 9J), 315-367.5 (333) μm; C-shaped sigmas not very abundant (Fig. 9F). Measurements: 27.5-32.5 (30) μm; raphides, short and fusiform (microxea-like), with a sharp point (Fig. 9I). Measurements: 10.5-25 (15.4) μm.

Distribution and ecology

Mycale (*Carmia*) *magniraphidifera* is widespread in the tropical Western Atlantic, with a single report from subtropical northwestern Atlantic waters (Carballo and Hajdu 2001). In coral reef ecosystems of the Mexican Pacific Ocean, the species is found overgrowing the base or branches of live corals of the genus *Pocillopora* (Fig. 1). It is distributed at 2-10 m in depth, but is more common at 5 m in depth where live corals are more abundant. Our specimens constitute the first record of *M.* (*C.*) *magniraphidifera* from the Pacific Ocean.

DISCUSSION

Sponges are important and abundant organisms in coral reef environments (Reswig 1973, Wulff 2006), where they compete for space with other invertebrates (Rützler 2004, Voogd et al. 2004), and overgrow corals by displacing coral tissues (Rützler 2004).

Most of these interactions are between sponges and massive corals, and they have been mostly reported from the Caribbean, Indo-Pacific, and Central Pacific areas (see Rützler 2002), where coral-sponge interactions often result in the overgrowth and death of corals (Macintyre et al. 2000, Rützler 2002). However, although massive corals of the genera *Pavona* and *Porites* are common and abundant along the Mexican Pacific coast, so far we have only observed sponges overgrowing live specimens of the genus *Pocillopora*.

Amphimedon texotli sp. nov. lives exclusively in coral reef areas from the southern Mexican

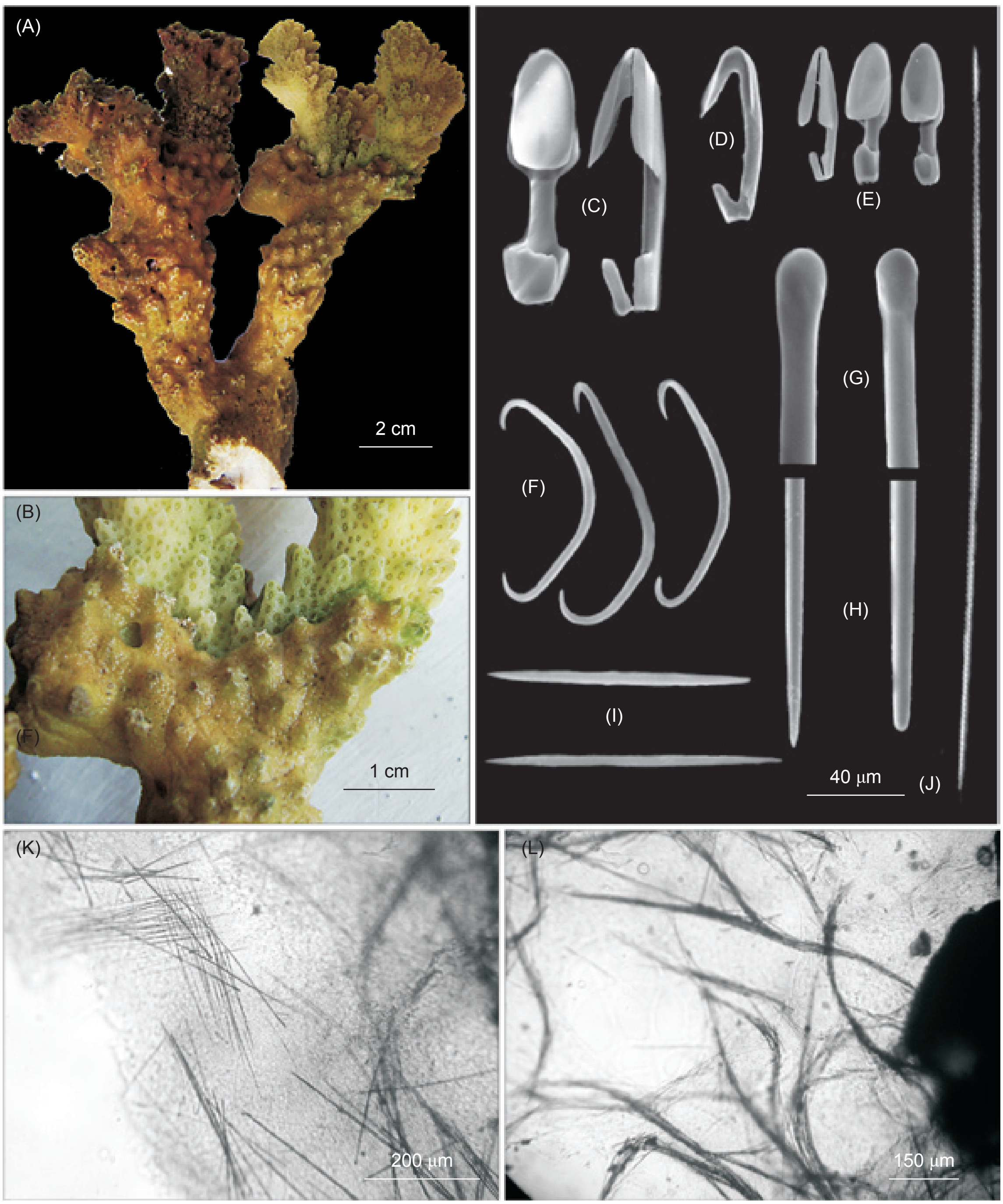

Fig. 9. External morphology and skeletal characteristics of *Mycale* (*Carmia*) *magniraphidifera*. (A, B) Specimen overgrowing live branches of pocilloporid corals; (C-J) SEM picture of spicules; (C) anisochelae I; (D) anisochelae II; (E) anisochelae III; (F) sigmas; (G) details of the mycalostyle heads; (H) details of the mycalostyle points; (I) raphids; (J) raphidotoxa; (K) details of ectosomal raphidotoxas; (L) cross-sectional details of choanosomal tract of mycalostyles.

Pacific Ocean (Mexicana Province), where it is so abundant that it can cover up to 6.85% of the total substrata available on some reefs (Fig. 2D). This sponge can grow over coral and other hard substrates. *Chalinula nematifera* has been found in 3 localities from Cortés Province which exclusively colonizes pocilloporid corals. *Callyspongia californica*, *H. caerulea*, *M.* (*C.*) *cecilia*, and *M.* (*C.*) *magniraphidifera* are widely distributed along the Mexican Pacific coast, and they are very common species, both in coralline and non-coralline environments. *Callyspongia californica* was found interact with corals in 11 localities, while *M.* (*C.*) *cecilia* was found in 7 localities, and *H. caerulea* was only found in 5 localities. *Mycale* (*Carmia*) *magniraphidifera* is the least common species overgrowing live corals, and it was found in 4 localities.

Probably the most aggressive species are *Chalinula nematifera* which was also found in the superior end of live branches and *A. texotli* sp. nov. which stands principally on the surface of coral colonies, mainly toward the lateral part and at intersections among several colonies.

The mechanisms through which these sponges compete with corals for space are unknown. However, studies of coral-sponge interactions suggest that sponges use toxins to overgrow live corals (de Voogd 2004). Surprisingly, most of the species found overgrowing live coral in the Mexican Pacific are haplosclerids (Demospongiae, Porifera), known for producing a variety of secondary metabolites (Erickson et al. 1997, Devijver et al. 2000, among others).

Coral reefs are currently struggling with a multitude of impacts (bleaching, sediments, and organic pollution) that have weakened their resilience and pushed them away from equilibrium. As a result, it is necessary to focus more attention on coral ecology. Ecological interactions between sponges and corals remain poorly known in the East Pacific Ocean, and this study can be considered preliminary. However, we present the distinctive characteristics of these species which we consider very interesting for the development of later studies related to the ecological roles of these sponges in coral reef ecosystems of the Mexican Pacific coast.

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