

## NEW RECORDS OF SPONGES OF THE GENERA *PETROSIA* AND *XESTOSPONGIA* (DEMOSPONGIAE: HAPLOSCLERIDA: PETROSIIDAE) FROM THE COLOMBIAN CARIBBEAN

Jaime Andrés Silva<sup>1</sup> and Sven Zea<sup>2</sup>.

1 Universidad Nacional de Colombia – Sede Bogotá – Facultad de Ciencias – Departamento de Biología, Ciudad Universitaria, Bogotá DC – Colombia. [jasilvab@unal.edu.co](mailto:jasilvab@unal.edu.co)

2 Universidad Nacional de Colombia – Sede Caribe – Instituto de Estudios en Ciencias del Mar – CECIMAR, c/o INVEMAR, Calle 25 2-55, Rodadero Sur, Playa Salguero, Santa Marta – Colombia. [sezeas@unal.edu.co](mailto:sezeas@unal.edu.co) (autor de correspondencia)

### ABSTRACT

Sponges (Porifera) are important constituents of littoral habitats in the Caribbean Sea. The knowledge of their biodiversity is fundamental to carry out ecological, managerial and utilitarian research. Their taxonomy is complex, but in the Caribbean in general, and in Colombia in particular, there are important advances. With this work, some sponge species of the genera *Petrosia* and *Xestospongia* are recorded and described for the first time from the Colombian Caribbean. *Petrosia* (*Strongylophora*) *davilai*, *Xestospongia arenosa*, *Xestospongia deweerdtiae* and *Xestospongia purpurea* are described and illustrated. The number of records of *Petrosia* and *Xestospongia* for the Colombian Caribbean are now three and four species, respectively. In all species, the specimens from continental localities had larger spicule sizes than those from insular localities, apparently owing to a greater availability of dissolved silicon in the former. The existence in *Xestospongia deweerdtiae* of free-living and *Plakortis*-associated lifestyles was documented for new areas of the Caribbean.

**KEY WORDS:** Porifera, Caribbean, Colombia, Taxonomy, New records.

### RESUMEN

**Nuevos registros de esponjas de los géneros *Petrosia* y *Xestospongia* (Demospongiae: Haplosclerida: Petrosiidae) para el Caribe colombiano.** Las Esponjas (Porifera) son constituyentes muy importantes de los ambientes litorales del mar Caribe. El conocimiento de su diversidad es fundamental para desarrollar investigaciones ecológicas, de aprovechamiento y de manejo. Su taxonomía es compleja pero en el Caribe en general y en Colombia en particular se vienen haciendo avances importantes. En el presente trabajo se registran y describen por primera vez para el Caribe colombiano algunas especies de esponjas de los géneros *Petrosia* y *Xestospongia*. Se describen e ilustran *Petrosia* (*Strongylophora*) *davilai*, *Xestospongia arenosa*, *Xestospongia deweerdtiae* y *Xestospongia purpurea*. Con ello, se llega a tres registros del género *Petrosia* y a cuatro del género *Xestospongia* para el Caribe colombiano. En todas

las especies, los especímenes de localidades continentales tenían las espículas más grandes que los que se encontraban en localidades insulares, aparentemente por haber una mayor disponibilidad de silicio disuelto en las primeras. Se documentó para nuevas áreas del mar Caribe la existencia en *Xestospongia deweerdtiae* de hábitos de vida libre y asociado a *Plakortis*.

**PALABRAS CLAVES:** Porifera, Caribe, Colombia, Taxonomía, Nuevos registros.

## INTRODUCTION

Sponges are ubiquitous components of Caribbean ecosystems, especially coral reefs, rocky shores and mangroves (Rützler and Feller, 1987/1988; Díaz and Rützler, 2001). Sponge taxonomy is complex, owing to paucity and ambiguity of characters, local and regional variability in morphology, and scarcity of comprehensive regional and local guides and catalogues (Cárdenas *et al.*, 2012). About 350 species of sponges are estimated to inhabit littoral habitats (down to about 40 m depth) of the Colombian Caribbean, including the continental coast of South America and the San Andrés and Old Providence Archipelago in the SW Caribbean (Zea, 1998 and unpublished updates). However, only about 150 species have been formally recorded and described. Sponges of the family Petrosiidae are common, large coral reef sponges with a generally firm to hard consistency, and a skeleton made up of monaxonic megasclere spicules (oxeas or strongyles), organized in a scaffold-like reticulation of single spicules or tracts (Desqueyroux-Faúndez and Valentine, 2002). This family contains the two genera that are the subject of this study, *vis.* *Petrosia* Vosmaer, 1885 and *Xestospongia* de Laubenfels, 1932. The genus *Petrosia* (with its two subgenera, *Petrosia* and *Strongylophora* Dendy, 1905), is characterized by having megasclere spicules of two or three size categories, being oxeas in the subgenus *Petrosia*, and strongyles in the subgenus *Strongylophora*; their ectosome is a tangential reticulation of single spicules or spicule tracts, to which a small category of oxeas (microxeas) is added (Desqueyroux-Faúndez and Valentine, 2002). There are 66 valid species described for *Petrosia*, nine of them occurring in the Caribbean (van Soest *et al.*, 2016a). The genus *Xestospongia* is distinguished from *Petrosia* by having only one category of megascleres, oxeas or strongyles, and no small spicules (microscleres) in the ectosome, and was separated from the genus *Neopetrosia* de Laubenfels, 1949 by spicule size, reaching 300–400  $\mu\text{m}$  in the former but only up to about 200  $\mu\text{m}$  in the latter (Desqueyroux-Faúndez and Valentine, 2002). *Xestospongia* contains 34 species worldwide and 11 in the Caribbean (van Soest *et al.*, 2016b).

For Colombia, two species of *Petrosia* have been recorded and described by Zea (1987), *vis.* *Petrosia* (*Petrosia*) *pellasarca* (de Laubenfels, 1934) and *P.*

(*Petrosia*) *weinbergi* van Soest, 1980, and only one species of *Xestospongia*, vis. *X. muta* (Schmidt, 1870). Other species previously placed in *Xestospongia* and described by Zea (1987), i.e., *X. proxima* (Duchassaing and Michelotti, 1864), *X. rosariensis* Zea and Rützler, 1983, *X. subtriangularis* (Duchassaing, 1850) and *X. carbonaria* (Lamarck, 1814) (placed under genus *Pellina* by Zea, 1987), fall now under the definition of *Neopetrosia*. In this paper, we add to Colombia the records and descriptions of *Petrosia* (*Strongylophora*) *davilai* (Alcolado, 1979), *Xestospongia arenosa* van Soest and de Weerd, 2001, *Xestospongia deweerdtiae* Lehnert and van Soest, 1999, and *Xestospongia purpurea* Rützler, Piantoni, van Soest and Díaz, 2014.

## MATERIALS AND METHODS

Sponges were collected by skin and SCUBA diving during taxonomic and ecological expeditions carried out throughout the Colombian Caribbean, covering the continental coast (South America) and the San Andrés and Old Providence Archipelago in the SW Caribbean (Figure 1). The areas are described and specific sites are mapped in Zea (1987). Specimens from the Bahamas, Martinique, Panama (Bocas del Toro) and Belize (Pelican Cays), were included for comparisons. Depending on the size, whole specimens or fragments were collected by cutting with a diving knife. Samples were fixed and preserved in 96 % ethanol, or fixed in 10 % formalin buffered with boric acid or methenamine (20 g L<sup>-1</sup>), then stored in 70 % ethanol after 2–3 days. Underwater photos were taken with Nikonos IV and V 35 mm film cameras equipped with strobe and close-up or macro lenses, and with Nikon Coolpix 5000 and Canon G9 and G16 Powershot digital cameras in watertight housings. Permanent mounts of clean spicules and thick sections were made as described in Zea (1987), but in a few cases digestion of tissue was carried out in commercial bleach instead of in boiling nitric acid; digestion was done overnight and in a circular shaker. Spicule and skeletal architecture photos were taken with a Zeiss AxioCam ERc5s camera mounted on an AxioLab A.1 compound microscope, and processed with Photoshop. About 25 of each spicule type were measured from digital photos with the program AxioVision SE64, rel. 4.91. Data are presented as minimum–*mean*–maximum length by width in  $\mu\text{m}$ .

Colombian material was deposited at Instituto de Investigaciones Marinas y Costeras – INVEMAR – Makuriwa Museo de Historia Natural Marina de Colombia Porifera collection in Santa Marta (acronym INV-POR). Foreign material is kept in the personal collection of S.Z. Other collection acronyms are ZMA.POR (Zoological Museum, University of Amsterdam, now located at Naturalis Biodiversity Center in Leiden, The Netherlands), and PorTol (project “Porifera Tree of Life” material, which is deposited in the National Museum of Natural History Museum, Smithsonian Institution, Washington, DC, USA).



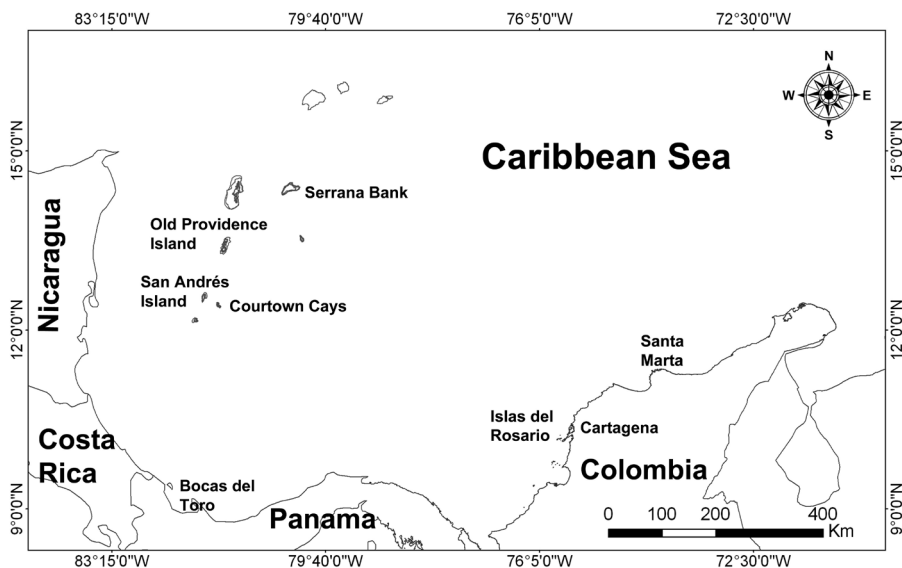


Figure 1. Map of the Colombian Caribbean with geographical areas where sponges were collected, including Bocas del Toro in Panama. Belize, Bahamas and Martinique localities are not included.

## RESULTS

### Systematics

Phylum Porifera Grant, 1836

Class Demospongiae Sollas, 1885

Subclass Heteroscleromorpha Cárdenas, Perez and Boury-Esnault, 2012

Order Haplosclerida Topsent, 1928

Family Petrosiidae van Soest, 1980

Genus *Petrosia* Vosmaer, 1885

Subgenus *Strongylophora* Dendy, 1905

#### *Petrosia (Strongylophora) davilai* (Alcolado, 1979)

Figure 2, Plate 1A-C; Table 1

*Strongylophora davilai* Alcolado, 1979: 1, Fig. 1; Rützler *et al.*, 2000, Table 1.

*Petrosia (Strongylophora) davilai*; Zea *et al.*, 2014.

**Studied material.** San Andrés and Old Providence Archipelago: INV-POR 1284, San Andrés Island, Bocatora Hole, windward fore reef terrace slope, 15 m, coll. S. Zea, 19 May 1992; INV-POR 1285, Courtown Cays, lagoon patch reef, 10 m, coll.

S. Zea, 24 May 1994; INV-POR 1286, Serrana Bank, lagoon patch reef, 10 m, coll. S. Zea, 10 May 1995. Cartagena–Islas del Rosario: INV-POR 1287, Pajarales, Isla Pretelt, lagoonal reef, 6 m, coll. S. Zea, 31 January 1983; INV-POR 1288, Isla Pavitos, south, reef slope, 10.5 m, coll. S. Zea, 14 August 2014. Cartagena–Cartagena Bay: INV-POR 1289, Varadero, reef, 4 m, S. Zea, 05 March 2015. Bahamas: uncatalogued fragment 401, Grand Bahama, Sweetings Cay, deep reef, coll. S. Zea, 18 July 2001. Belize: uncatalogued tissue slide SZ18, Pelican Cays, Manatee Cay, reef, coll. S. Zea, 05 July 1997.

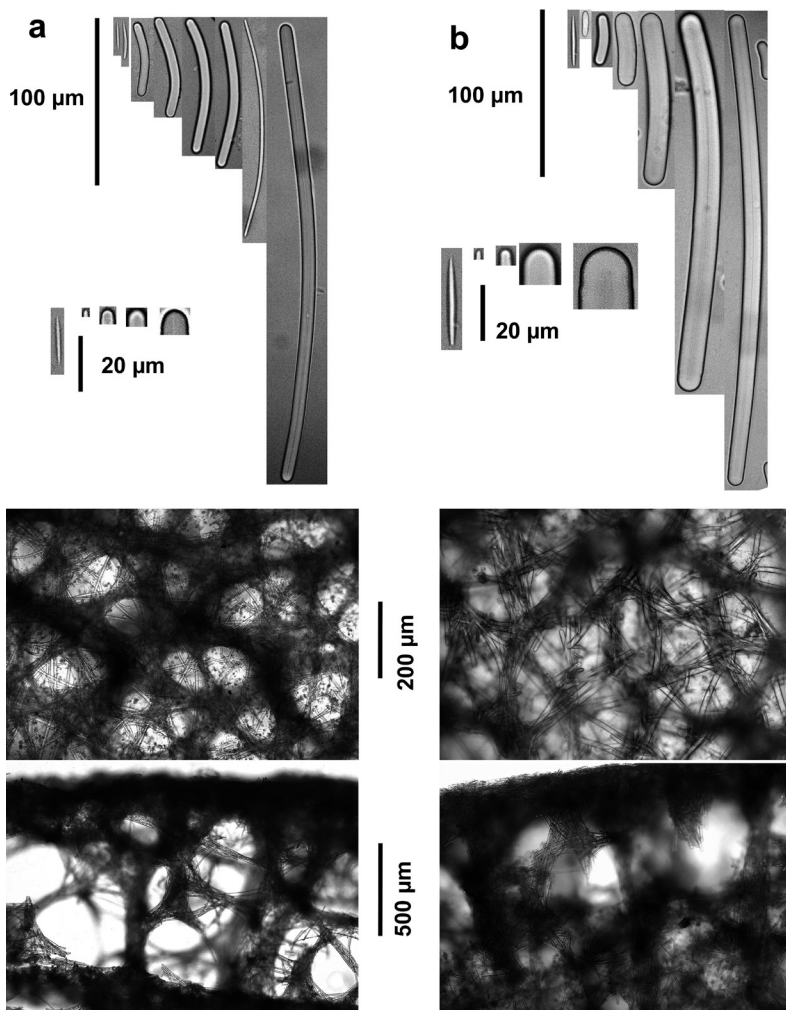


Figure 2. Microphotographs of the skeleton of *Petrosia davilai* comparing the studied material from the San Andrés and Old Providence Archipelago (a, left) and from Cartagena (b, right). From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface showing the ectosome and the upper choanosome (lower panel).

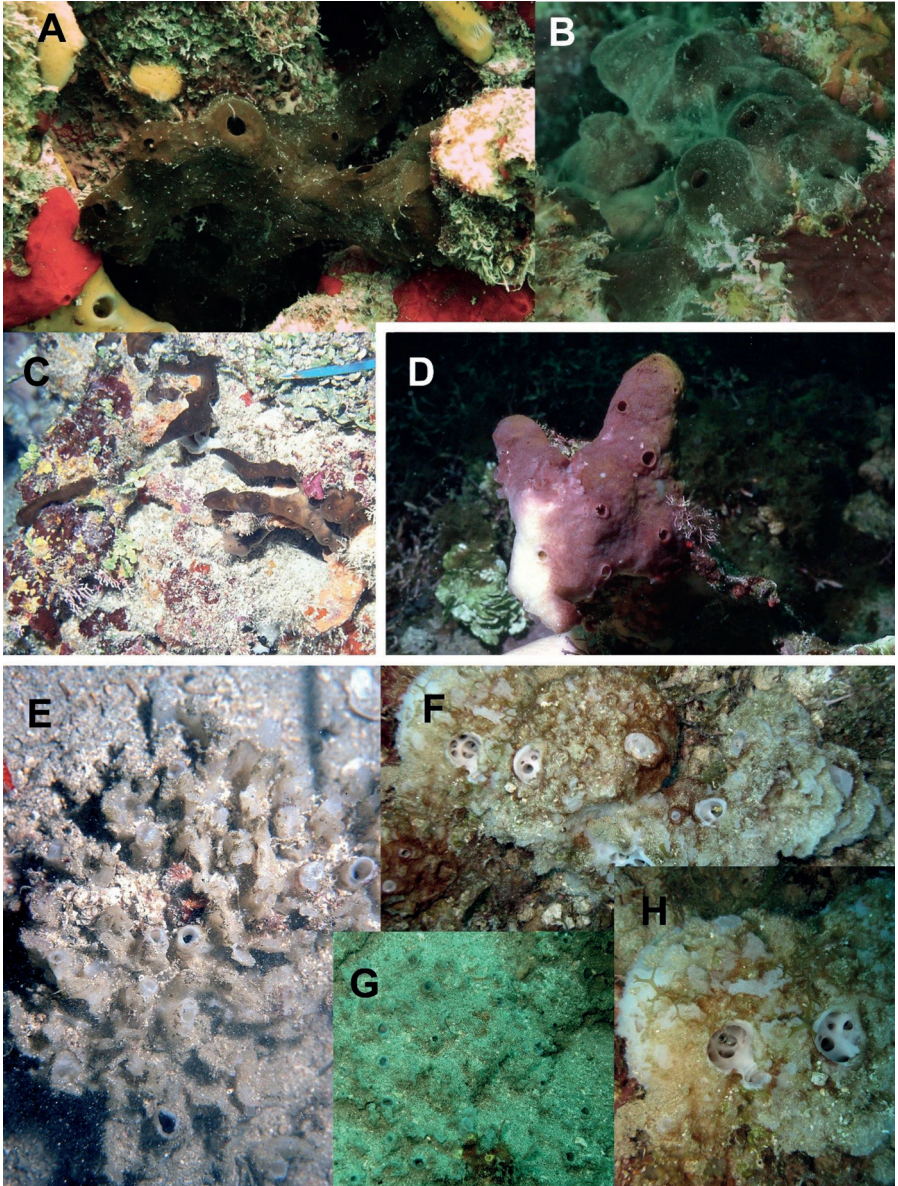


Plate 1. Underwater *in situ* photographs of species described herein. A, B, C: *Petrosia davilai* (A, B: Cartagena, C: San Andrés). D: *Xestospongia purpurea* (Cartagena). E, F, G, H: *Xestospongia arenosa* (E, G: Santa Marta, F, H: Martinique).

Table 1. Size of spicules of *Petrosia davilai* by geographical area. Measurements in  $\mu\text{m}$  (minimum–mean– maximum). L=length, W=width. Cuban type material (data from Alcolado, 1979); categories of strongyles were not discriminated; raphids  $72\text{--}230 \times 1\text{--}2 \mu\text{m}$  are here interpreted as developmental stages of strongyles.

Area		Strongyle I	Strongyle II	Microxea
Cuba	L		29–311	19–29
	W		3–9	1.5–2.0
Bahamas	L	30–115–198	232–249–280	19–30–43
	W	3.1–4.8–6.6	4.1–6.1–7.5	0.7–2.2–3.4
San Andrés	L	5.9–88–182	186–237–296	13–21–43
	W	3.4–6.8–10.3	4.4–8.5–13.3	0.9–2.0–3.8
Cartagena	L	13–74–195	135–231–277	10–27–33
	W	2.8–10.0–18.4	4.7–15.6–22.6	1.9–2.6–4.0

**Description.** Shape, color and consistency: creeping branches that arise from an encrusting base; branches 1-3 cm in diameter, and from 2 cm to about 20 cm in length. There are parts or whole individuals that are massive, sometimes with tubular lobes about 2 cm in height. Oscules 1-9 mm in diameter, on top of lobes and along branches. Color olive green, greenish dark brown; color along sides and underneath branches fades to cream. Consistency hard, stony; can be broken with some force.

**Skeleton:** the ectosomal skeleton is a plurispicular tangential reticulation of strongyle megascleres, 3-7 spicules thick, forming meshes 30–250  $\mu\text{m}$  in diameter; there are abundant microxeas around the strongyles. The most superficial reticulation is supported by a thicker, subectosomal reticulation with tracts 40–450  $\mu\text{m}$  thick and meshes 200–1000  $\mu\text{m}$ . Together, they conform a kind of cortex 200–500  $\mu\text{m}$  thick. The choanosomal skeleton is an isotropic reticulation, being more anisotropic towards the surface where it forms accretive growth layers. Ascending primary tracts are 4–20 spicules thick and 70–400  $\mu\text{m}$  wide; secondary interconnecting tracts are 4–10 spicules thick, producing polygonal to rounded meshes with well-defined edges, 180–800  $\mu\text{m}$  in diameter. Spicules: (1) strongyles of a wide range of sizes, separable into two classes, slightly curved, often slightly bent in two or three sections; thin forms with slightly pointed ends seem to be developmental stages of strongyles; a few are modified to styles. (2) Microxea, thin and pointed. Sizes are given in Table 1. Notice a greater length and thickness of spicules from Cartagena, in comparison to those of San Andrés and the Bahamas.

**Ecology.** Shallow and deep reef zones, on sides of live coral or on dead coral; also on overhanging walls; 4–10 m in depth in Colombia, 21 m in the Bahamas.

**Distribution.** Cuba (Alcolado, 1979); Bahamas (Zea *et al.*, 2014); Belize (also Rützler *et al.*, 2000); Colombia (San Andrés and Old Providence Archipelago, Cartagena).

**Remarks.** The species was initially described under genus *Strongylophora*, which was later placed as a subgenus of *Petrosia* by Desqueyroux-Faúndez and Valentine (2002). In the original description (Alcolado, 1979), raphids are mentioned as a spicule type, but judging by their size and shape, these seem to correspond to developmental stages of strongyles (see Table 1). A similar species in spicule types and sizes, and in the structure of the skeleton is *Petrosia (Strongylophora) dendyi* (Hechtel, 1969), from Barbados, but its external shape is just a flat encrustation and its color is cream. This latter species was also recorded from Jamaica by Lehnert and van Soest (1999) as a hemispherical sponge, orange brown. It would be necessary to review the material of these two records to confirm if they are different from each other and from *P. (S.) davilai*. The two other species of *Petrosia (Strongylophora)* known from the Caribbean are from deep water and clearly different from *P. (S.) davilai*. *Petrosia (Strongylophora) hartmani* (van Soest, 1980) is a semiglobular sponge without oscules and possesses an irregular and dense skeleton of very thick strongyles and two categories of thin oxea. *Petrosia (Strongylophora) stoneae* (van Soest and Stentoft, 1988) is a dark brown, pear-shaped sponge with an apical oscule; the ectosome is made up of tangential, thin oxea, and the choanosome is a regular isotropic reticulation of thick strongyles. In *P. (S.) davilai* there is greater thickness of spicules in the material from the Continental coast of Colombia, as compared with oceanic island locations like San Andrés and Old Providence Archipelago and the Bahamas (Table 1).

Genus *Xestospongia* de Laubenfels, 1932

***Xestospongia arenosa* van Soest and de Weerdt, 2001**

Figure 3, Plate 1E–H; Table 2

*Xestospongia arenosa* van Soest and de Weerdt, 2001: 110, Figs. 1–3; Rützler *et al.*, 2014: 91

*Xestospongia* sp.-“whitish thick encrustation”; Zea *et al.*, 2014.

**Studied material.** Santa Marta: INV-POR 1283, Bahía de Santa Marta, Punta de Betín, reef base, 24 m, coll. S. Zea, 18 February 1999. Bahamas: uncatalogued fragment 402, Grand Bahama, Sweetings Cay, deep reef, 22 m, coll. S. Zea, 16 July 2011. Martinique: uncatalogued fragment SZ-26, Les Anses d’Arlet, Grande Anse, Pointe Lezarde, littoral slope, 20 m, coll. S. Zea, 06 December 2013.



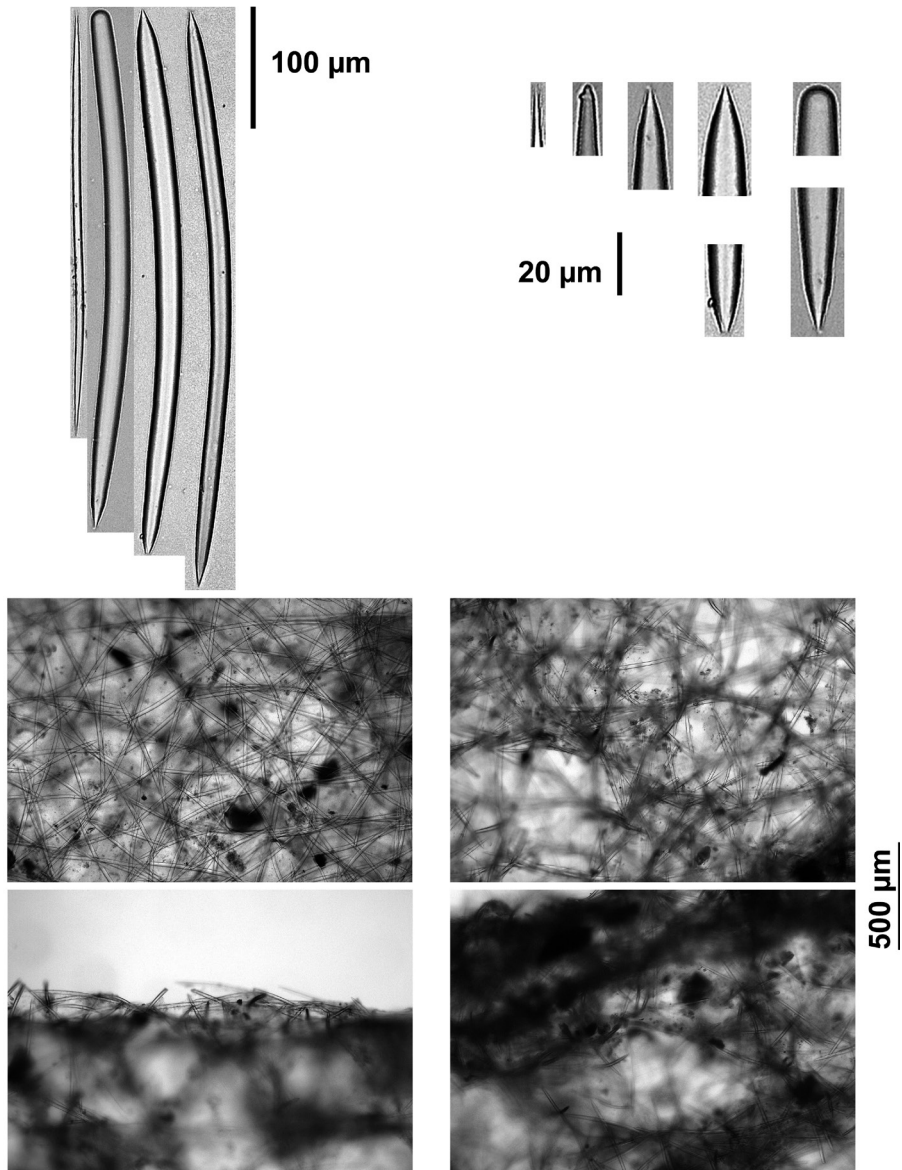


Figure 3. Microphotographs of the skeleton of *Xestospongia arenosa* of the studied material from Santa Marta. From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface showing the ectosome and the upper choanosome (lower panel).

Table 2. Size of spicules of *Xestospongia arenosa* by geographical area. Measurements in  $\mu\text{m}$  (minimum–mean–maximum). L=length, W=width. Curaçao type material (data from van Soest and de Weerd, 2001).

Area		Oxeas
Bahamas	L	300–378–437
	W	16.8–22.3–29.2
Martinique	L	401–441–501
	W	13.0–19.6–27.6
Curaçao	L	342–431–508
	W	7–10.1–14
Santa Marta	L	358–436–501
	W	10.6–19.9–26.8

**Description.** Shape, color and consistency: massive, reaching 20–30 cm in diameter, often partly buried in sand and rubble; surface generally with elevated digitations and fistules several cm long and up to 0.6–1 cm in diameter. Oscules 3–9 mm in diameter, over digitation or dispersed throughout the surface. Spaces between digitations usually filled with sand in buried specimens. The Bahamian specimen was a thick encrustation of about 20 x 10 cm in size, attached to a wall in a reef crevice, with an even surface (no digitations) fouled by zoanths and provided with interspersed oscules with transparent collars. Color dirty white, with greenish tinges in places. Consistency firm but friable.

**Skeleton:** The ectosome shows a tangential unispicular isotropic reticulation, with triangular meshes 130–320  $\mu\text{m}$  in diameter, overlying a coarser sub-superficial reticulation of spicule tracts, 1–4 spicules and 40–100  $\mu\text{m}$  thick and enveloped, by spongin in some sections, forming polygonal meshes 200–700  $\mu\text{m}$  in diameter. The combined tangential and sub-superficial reticulation have a thickness of about 40–200  $\mu\text{m}$ . The choanosomal skeleton is loose, consisting of a reticulation of ascending primary spicular tracts, up to eight spicules and 60–200  $\mu\text{m}$  thick, cemented by spongin, interconnected by unispicular secondary tracts, forming polygonal meshes 200–700  $\mu\text{m}$  in diameter. Spicules are hastate oxeas, slightly curved, with conical, short endings, sometimes mammiform; a few styles and strongly oxeas occur as well. Sizes are given in Table 2.

**Ecology.** Partly buried in sand and rubble among corals or in sandy reef valleys, or attached to rock in reef crevices, 20–24 m in depth.

**Distribution.** Curaçao (van Soest and de Weerd, 2001); Belize (Rützler *et al.*, 2014); Bahamas (Zea *et al.*, 2014); Martinique; Colombia (Santa Marta).

**Remarks.** Partly buried specimens clearly correspond to the original description by van Soest and de Weerd (2001), from their whitish semitransparent digitations and fistules arising from a buried mass. Also, our material coincides with the original in the large oxeas and the rather sparse choanosomal skeleton, which produce

a brittle consistency. The specimen from the Bahamas coincides in color, consistency, spiculation and skeleton but it may have not formed digitations owing to its location on a vertical wall; these fistules and digitations may be outgrowths to counteract the gradual burying as more and more sand is deposited. The loose skeleton, the large spicules (several surpassing 500  $\mu\text{m}$  in length), distinguish this species from others of the genus *Xestospongia* in the Caribbean. Van Soest and de Weerdt (2001) compared *X. arenosa* to *X. wiedenmayeri* van Soest, 1980, which also has a loose skeleton, but is brown in color, with spicules slightly shorter and thicker, and dwelling among mangrove stilt roots. We have not yet found this latter species in Colombia. Spicules of *X. arenosa* are shorter and thinner in the Bahamas in comparison with Martinique and Colombia (Table 2).

***Xestospongia deweerdtae* Lehnert and van Soest, 1999**

Figs. 4–6, Plate 2; Table 3

For synonymy see Vicente *et al.* (2016).

**Studied material.** This species occurs in two morphotypes, one free-living and the other in epizoic symbiosis (henceforth called associated) with sponges of the genus *Plakortis* (Vicente *et al.*, 2014, 2016); below it is indicated to which morphotype every specimen belongs. San Andrés and Old Providence Archipelago: INV-POR 1290 (associated), San Andrés Island, Bocatora Hole, windward fore reef terrace slope, 20–25 m, coll. Sven Zea, 19 May 1992; INV-POR 1291 (associated), Courtown Cays, leeward fore reef terrace slope, 20–30 m, coll. S. Zea, 27 May 1994; INV-POR 1292 (associated), Old Providence, east of Crab Cay, windward fore reef terrace, 25 m, coll. S. Zea, 18 October 1994; INV-POR 1293 (fragment ZMA.POR 5140) (associated), Old Providence, west of Fresh Water Bay, leeward fore reef terrace slope, 12–14 m, coll. S. Zea, 10 December 1980. Cartagena-Islas del Rosario: INV-POR 1294 [free living, but partly growing over the sponge *Mycale (Grapelia) unguifera* Hajdu, Zea, Kielman and Peixinho, 1995], Pajarales, Isla Pretelt, channel slope with coral *Acropora cervicornis*, 6 m, coll. S. Zea, 31 January 1983. Panamá-Bocas del Toro: PorTol P12X375 (S.Z. code PPA31) (associated), Isla Bastimentos, Punta Delfín, rocky terrace, 12 m, coll. S. Zea, 8 August 2012; PorTol P12X354 (S.Z. code PPA19) (free living), Isla Colón, Punta Caracol, fringing reef, 7 m, coll. S. Zea, 7 August 2012. Bahamas: uncatalogued fragment PBH16 (associated), Little San Salvador, shelf slope, 24 m, coll. S. Zea, 29 July 2000; uncatalogued fragment 349 (associated), Little San Salvador, shelf slope, coll. Tadeusz, Molinsqui, 16 June 2008; uncatalogued fragment 411 (free living), San Salvador, shelf slope, 29 m, coll. S. Zea, 20 June 2012. Martinique: uncatalogued fragment SZ-25 (free living), Les Anses d’Arlet, Grande Anse, Pointe Lezarde, littoral slope, 20 m, coll. S. Zea, 06 December 2013.



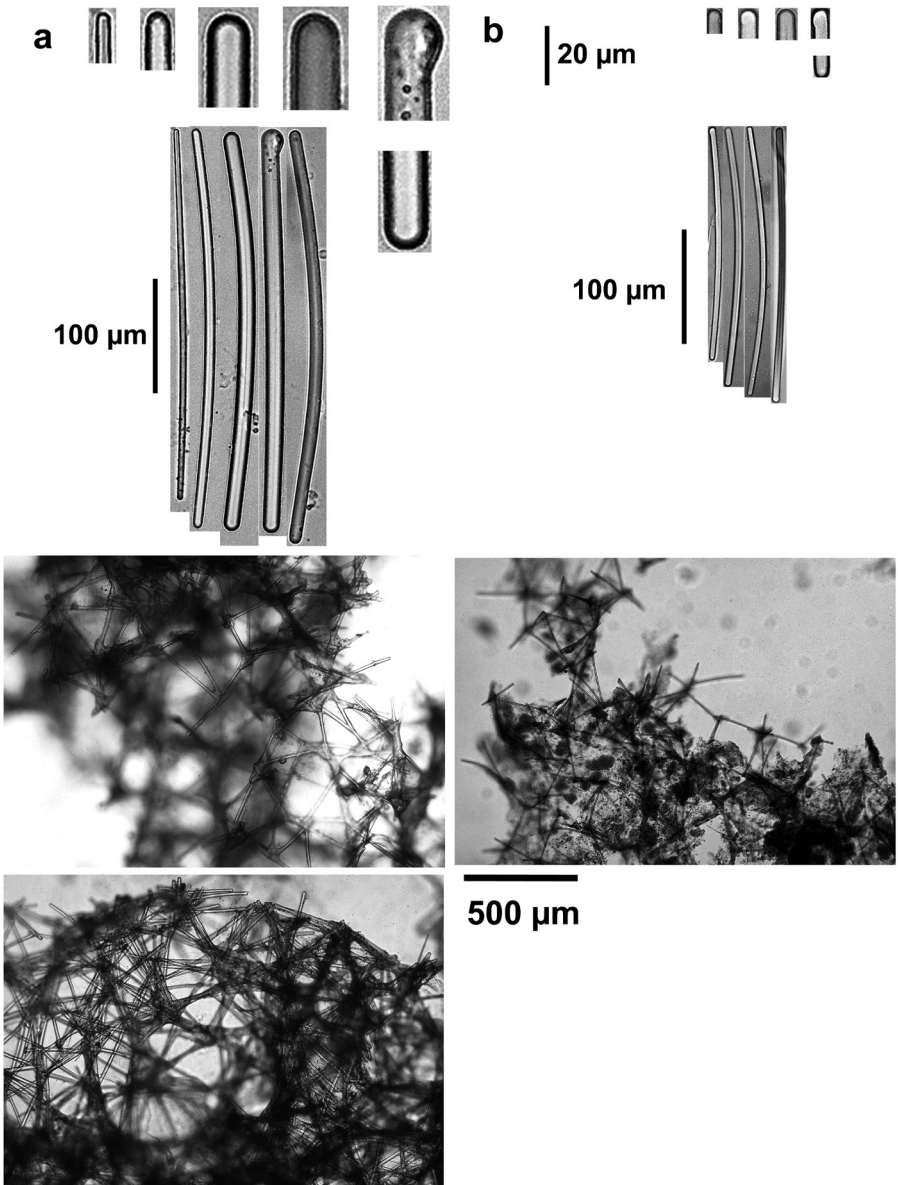


Figure 4. Microphotographs of the skeleton of *Xestospongia deweerdtiae* comparing free living (a, left) and *Plakortis*-associated (b, right) studied specimens from the Bahamas. From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface (lower panel). Notice the marked differences in size of spicules for the two forms in the same geographical area.

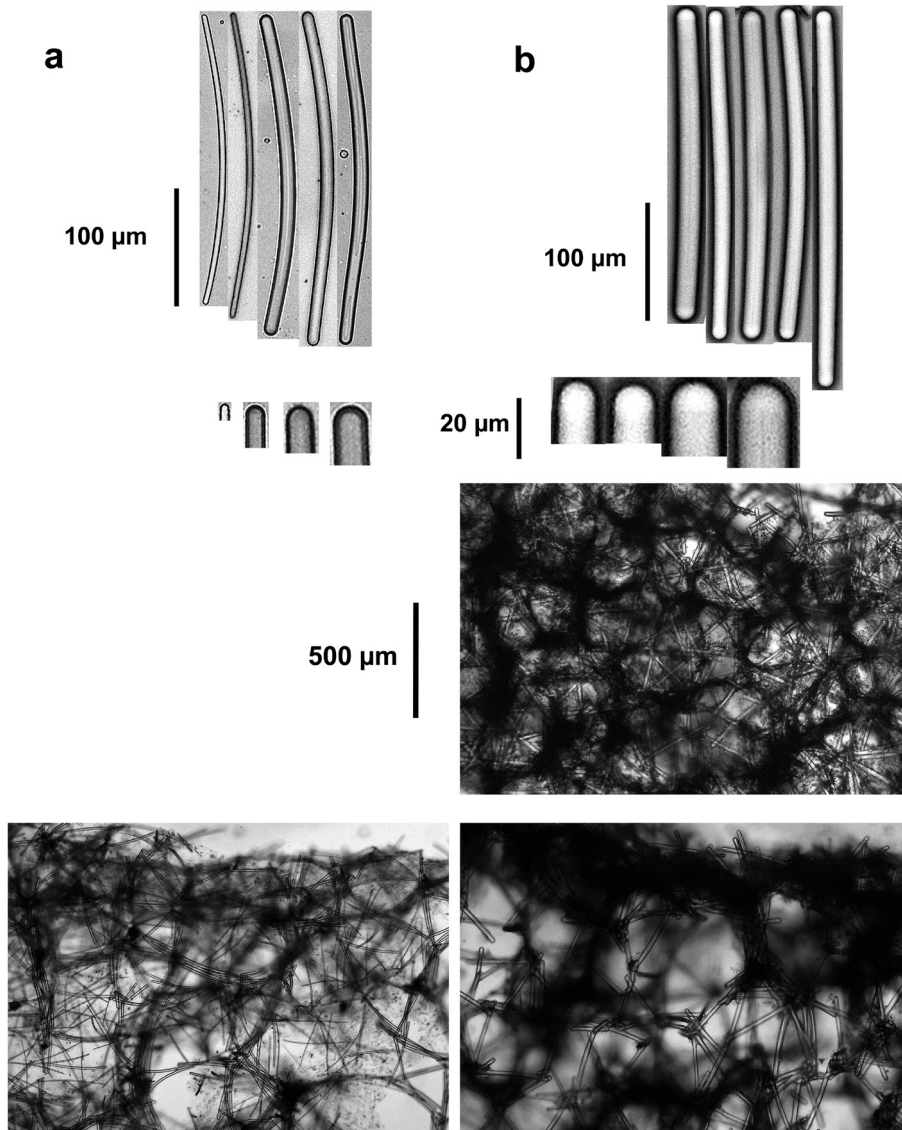


Figure 5. Microphotographs of the skeleton of *Xestospongia deweerdtiae* associated to *Plakortis*, comparing studied material from San Andrés (a, left) and Panama (b, right). From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface (lower panel). Notice the marked difference in size of spicules with locality, showing geographical differences for the same (associated) form.

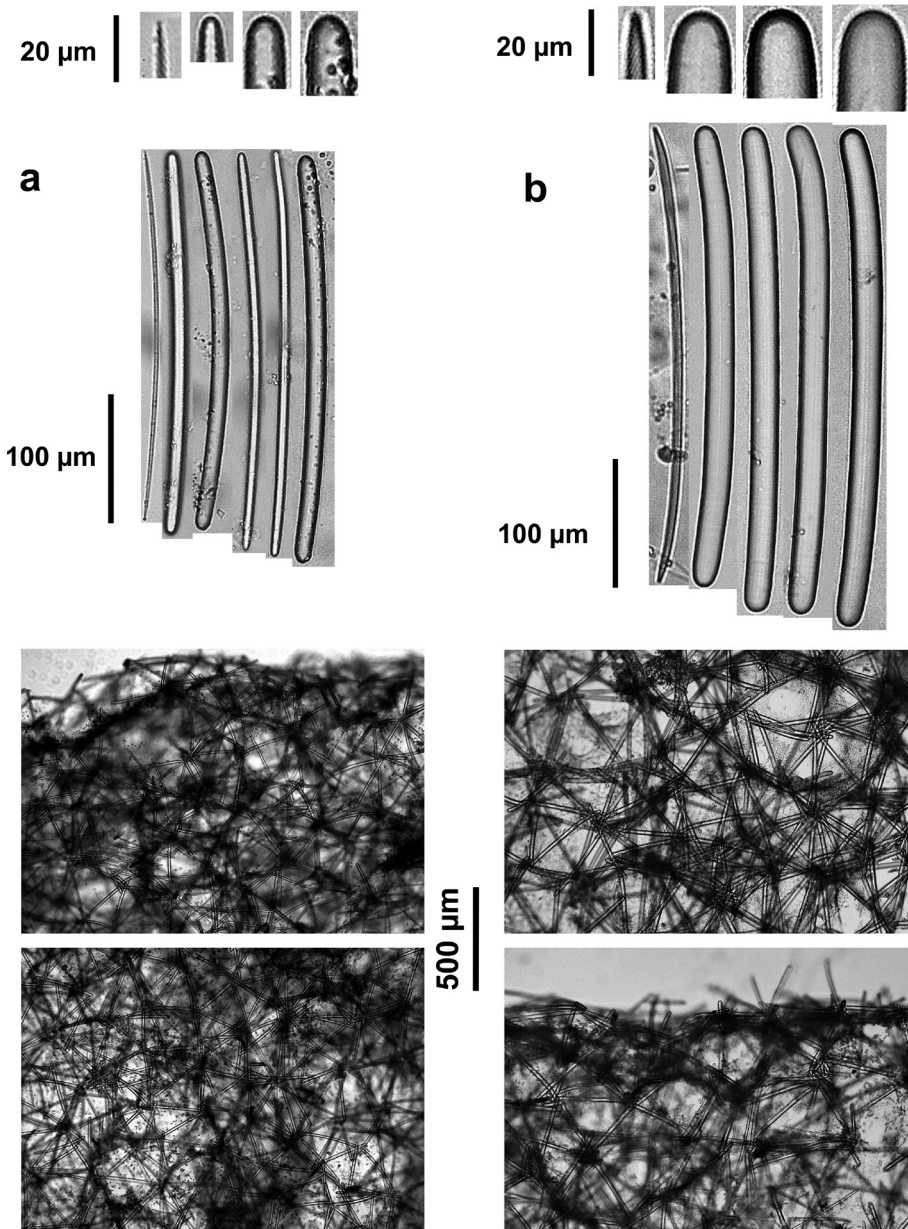


Figure 6. Microphotographs of the skeleton of free living *Xestospongia deweerdtiae*, comparing studied material from Martinique (a, left) and Cartagena (b, right). From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface (lower panel). Notice the marked difference in size of spicules with locality, showing geographical differences for the same (free living) form.

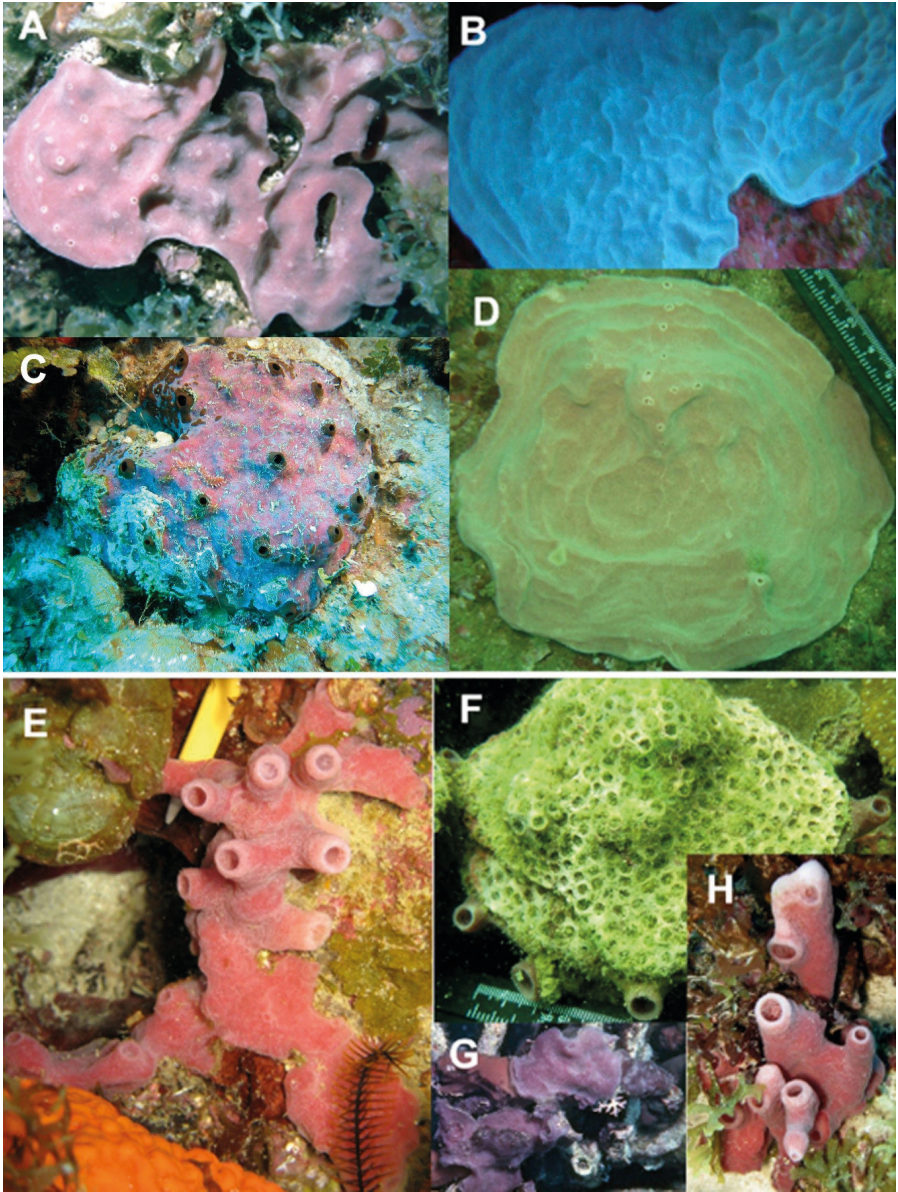


Plate 2. Underwater in situ photographs of species described herein. A, B, C, D: *Xestospongia deweerdtiae* associated with *Plakortis* spp. (A, B: San Andrés, C: Bahamas, D: Panama); E, F, G, H, D: free-living *X. deweerdtiae* (E, H: Martinique, F: Panama, G: Cartagena).

Table 3. Size of spicules of the material of *Xestospongia deweerdtiae* studied here by geographical area and comparing free-living and *Plakortis*-associated forms. Measurements in  $\mu\text{m}$  (minimum–mean–maximum). L=length, W=width. For further detailed comparisons see also Vicente *et al.* (2014, 2016)

Area		Free-living	<i>Plakortis</i> -associated
Bahamas	L	307–347–395	118–223–283
	W	12.0–18.9–24.9	7.0–12.6–16.6
San Andrés	L		186–283–335
	W		6.0–18.0–30.0
Martinique	L	153–295–342	
	W	10.9–17.7–23.7	
Cartagena	L	292–402–437	
	W	7.8–22.7–28.9	
Panama	L	327–383–428	230–302–350
	W	27.8–35.7–41.8	22.0–29.2–35.5

**Description.** Shape, color and consistency: the studied material, as redescribed by Vicente *et al.* (2014, 2016) occurs two forms, one free and the other living associated in epizotic symbiosis with a sponge of the genus *Plakortis*. The free form in the studied material is massive or a sheet-like, up to 5–10 cm in diameter, from which tubular projections arise, sometimes aligned in a row, 1–4 cm high, 1–2 cm in diameter, slightly thicker at the base, with the upper edge flat, surrounding oscules of 1–4 mm diameter. The base can be irregular and have creeping portions from which new tubes arise. The associated form grows as a thin encrustation (up to 3–5 mm thick), overgrowing specimens of *Plakortis*, partly or fully. If it totally covers the basal sponge, it may appear flabellate or laminated; if not, it may consist of irregular patches, or cover all the basal sponge but its oscular cones. Proper oscules, 2–4 mm in diameter, are rarely seen; if present, they occur in a small group or in a line, often just in a single portion of the sponge. Color is pink to pinkish gray or light brown; light brown in spirit. Once fixed, associated specimens are stained by the dark purple exudate of the *Plakortis*. Consistency somewhat fragile, crumbly.

**Skeleton:** The ectosomal skeleton is a tangential, unispicular, isodictyal reticulation with triangular meshes, 160–350  $\mu\text{m}$  in diameter. Spicules are cemented by spongin at the nodes. Overlaying this reticulum, one can observe the pinacoderm, transparent and with inhalant pores. Below it, there is a thicker reticulum, made up of 1–2 spicules that too are cemented by spongin, with meshes 180–900  $\mu\text{m}$  in diameter; both layers are 30–100  $\mu\text{m}$  thick. The choanosomal skeleton too is made up of an isodictyal reticulation, 2–8 spicules thick, 30–120  $\mu\text{m}$  in diameter, forming polygonal meshes. It is wider (200–820  $\mu\text{m}$ ) for free-



living specimens than for associated ones (230–470  $\mu\text{m}$ ). Spicules: strongyles in a single size class, considerably larger in free-living individuals than in associated ones. Within each form, strongyles are thicker in individuals from continental locations of South America than those from insular oceanic locations. There are a few fusiform oxeas that we interpret as developmental stages of strongyles. Sizes are given in Table 3.

**Ecology.** Our material was found in coral and rocky reefs, from shallow to deep (12–30 m), more common in deeper locations and in cryptic sites (caves, overhanging walls, lower surfaces of corals). We did not notice habitat segregation between free-living and *Plakortis*-associated forms. Overall, it has been found from 2 m to 80 m depth (see review in Vicente *et al.*, 2016).

**Distribution.** From records given by Vicente *et al.* (2016), this species occurs in the Bahamas, Jamaica, Puerto Rico, México (Cozumel, Banco Chinchorro), Serrana Bank (Colombia), Belize (record of Rützler *et al.* 2014), Panama (Bocas del Toro) and Curaçao. In addition to Bahamas and Panama, we herein record material from Martinique and from other localities in Colombia (San Andrés, Old Providence and Cartagena).

**Remarks.** Zea *et al.* (2009) separated the two sponge forms as different species, the free-living as *Xestospongia deweerdtiae* sensu stricto, and the associated one as *Xestospongia* sp., “thin pink sheet over *Plakortis*”. However, Vicente *et al.* (2014) demonstrated, by molecular phylogeny, that even though the two forms have different spicule sizes, they are conspecific. Further detailed work by Vicente *et al.* (2016) showed that differences in spicule size also occur across geographical localities within each lifestyle. These inter-lifestyle and geographical differences in spicule size were also evident in our material (Table 3). In the geographic component, our specimens from continental localities, such as Cartagena and Panama, have slightly larger and considerably thicker spicules than in oceanic localities, such as the Bahamas and the San Andrés and Old Providence Archipelago. Vicente *et al.* (2014) hypothesized that the association of this species with *Plakortis* spp. is a mutualistic symbiosis, in which *Plakortis* is possibly favored by tissue extensions of *X. deweerdtiae* that grow downward into *Plakortis*, which may facilitate ventilation to and from the basibiont. Also, *X. deweerdtiae* could be favored by investing less energy in building its skeleton with smaller spicules, thanks to the thinly encrusting form it adopts, which may need less skeletal support (Vicente *et al.* 2014), although if under limited silicon availability one species may deprive the other of this nutrient (Vicente *et al.*, 2016). Interestingly, the only free living specimen we have so far found in Colombia (INV-POR 1294, Islas del Rosario, Plate 2G), was thickly encrusting,

partly growing over another sponge, *Mycale (Grapelia) unguifera*, instead of a *Plakortis*; however, we did not have a *Plakortis*-associated specimen from the same area to check whether the spicule sizes differed. *Xestospongia deweerdtiae* is distinguished from other Caribbean *Xestospongia* by its shapes and the rose color, and by having strongyles as spicules. Another Caribbean haplosclerid species with strongyles organized in an isodictyal skeleton is *Haliclona strongylophora* Lehnert and van Soest, 1996, but these are considerably shorter (up to 200  $\mu\text{m}$ ). We have not yet done detailed work on the species identity of the basibiont *Plakortis* of our material; it could either be *P. deweerdtaphila* or *P. symbiotica* as both species are known to be associated with *X. deweerdtiae* (Vicente *et al.*, 2016).

***Xestospongia purpurea* Rützler, Piantoni, van Soest and Díaz, 2014**

Fig. 7, Plate 1D; Table 4

*Xestospongia purpurea* Rützler, Piantoni, van Soest and Díaz, 2014: 92, Figs. 4f, 4i.

**Studied material.** Cartagena: INV-POR 1282, Isla Barú, bank in front of Mohana, patch reef, 9 m, coll. 9 m, S. Zea, 3 January 1998.

**Description.** Shape, color and consistency: the only specimen collected was a mass about 5 cm in diameter, with two digitiform projections as primordial branches, 2-4 cm in length, up to 2 cm thick at their base. Surface even. Oscules relatively large, dispersed, 1-4 mm in diameter, with a slightly elevated edge. Color milky purple, with basal parts cream. Consistency hard, brittle.

**Skeleton:** The ectosome is about 400  $\mu\text{m}$  thick and comprises an upper tangential reticulum of oxeas I (thinner), somewhat confused, paucispicular (1-4 spicule tracts), forming meshes 60-150  $\mu\text{m}$  in diameter, supported by a subsuperficial reticulum of thicker tracts of oxeas II (3-7 spicules, 30-120  $\mu\text{m}$  thick), with meshes 200-500  $\mu\text{m}$  in diameter. The choanosomal skeleton is an isodictyal rather confused reticulation, although ascending and interconnecting tracts can be discerned, 8-14 spicules and 240-260  $\mu\text{m}$  thick, forming meshes of 300-700  $\mu\text{m}$  diameter, built by both types of oxeas. Near the sponge surface, growing layers are clearly distinct, but the skeleton becomes more dense and confused as one goes deeper. The tracts have spongin cementing the spicules. Spicules: oxeas in two size classes, (1) oxeas I, fusiform, slightly curved, with sharp points, 192-242.4-326 x 9.5-12.3-18.7  $\mu\text{m}$ ; (2) oxeas II, hastate, larger and thicker, with ending slightly blunt and sometimes mammiform or telescopic, or asymmetric turning into strongyloxeas and styles, 347-278.5-503 x 13-24.3-33.2  $\mu\text{m}$ . For comparison of sizes with the type material see Table 4.

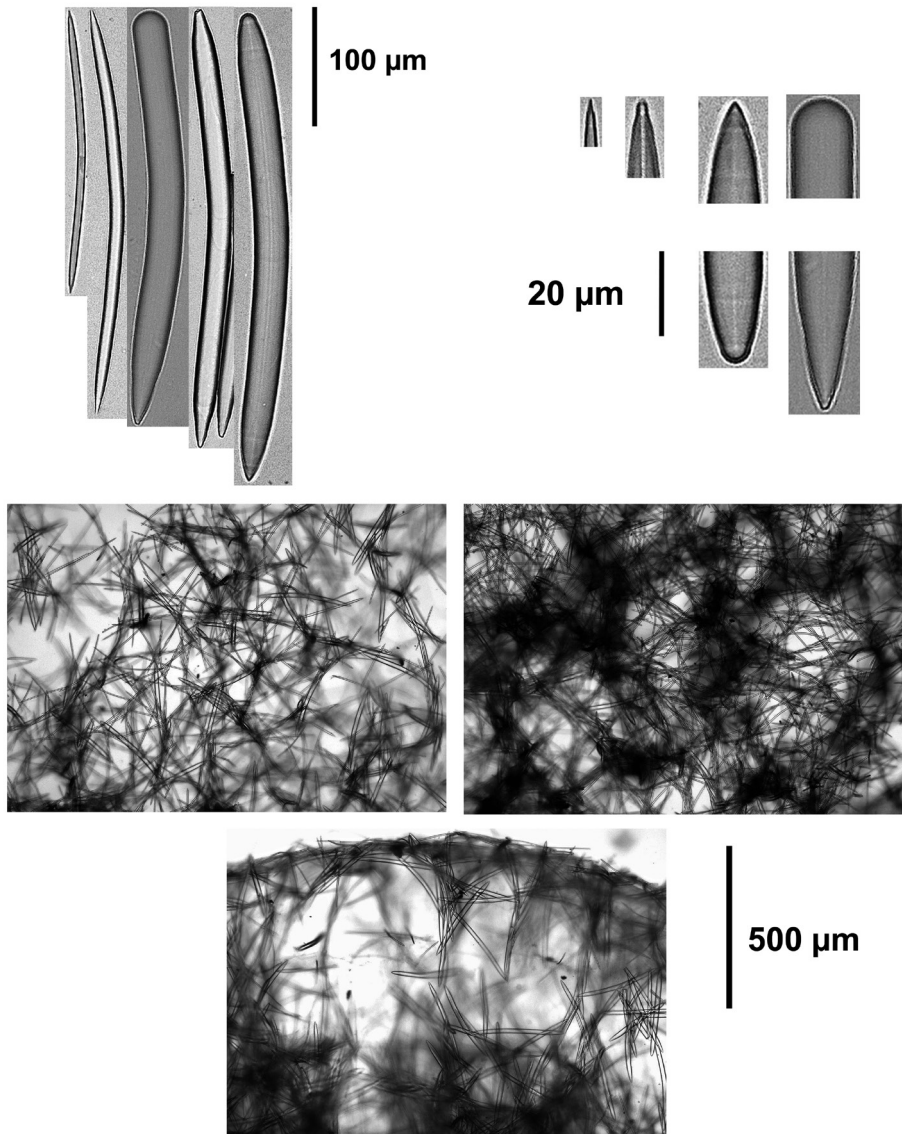


Figure 7. Microphotographs of the skeleton of studied material of *Xestospongia purpurea* from Cartagena. From top to bottom, spicules (upper panel), tangential view of the ectosome (middle panel), and perpendicular section of the choanosome at the surface showing the ectosome and the upper choanosome (lower panel).

Table 4. Size of spicules of *Xestospongia purpurea* by geographical area. Measurements in  $\mu\text{m}$  (minimum–mean–maximum). L=length, W=width. Belize type material (data from Rützler et al., 2014; Hol=holotype, Par=paratype).

Area		Oxeas I	Oxeas II
Belize (Hol)	L	240–316–350	340–383–420
	W	4–6–8	15–17–20
Belize (Par)	L	*	370–387–400
	W	*	18–21–24
Cartagena	L	192–242–326	347–279–503
	W	9.5–12.3–19	13–24.3–33

**Ecology.** On reefs, at mid depth (9 m), living in the base of foliose corals.

**Distribution.** Belize (Rützler *et al.* 2014); Colombia (Cartagena, Isla Barú).

**Remarks.** When collecting the specimen, we thought it belonged to a branching *Neopetrosia proxima* (Duchassaing and Michelotti, 1864), but upon spicule examination it became clear, from the larger spicule size, that we dealt with a species of *Xestospongia*. Only when it was described we could assign the proper name to it. The original material from Belize, found in cryptic habitats (1-18 m depth), was encrusting to cushion shaped, with a knobbed surface and dispersed oscules, purple in color on top, with cream sides and base (Rützler *et al.*, 2014). In addition to having the same two size classes of oxea, our specimen agrees with the Belizean original ones in color; its branch-like protuberances could be equivalent to the knobs of the Belizean specimens but with a greater growth. Interestingly, and to add to the variability of the species, in our specimen the first layer of the ectosome is built up exclusively of the thinner, smaller oxea. Perhaps new layers of growth were built up very fast in our specimen, so that spicules were not yet fully grown at the surface, whereas in deeper layers there were mature, large spicules, to which thinner, smaller ones, are being continuously added. By its shape, color, and the two spicule size classes, this species is clearly distinct from the other *Xestospongia* species in the Caribbean.

## DISCUSSION

Previous records of *Petrosia* and *Xestospongia* from the Caribbean coast of Colombia were *Petrosia (Petrosia) weinbergi* (van Soest, 1980), *Petrosia (Petrosia) pellarca* (de Laubenfels, 1934) and *Xestospongia muta* (Schmidt, 1870) (Zea 1987). With this work, *Petrosia (Strongylophora) davilai*, *Xestospongia arenosa*, *Xestospongia deweerdtiae* and *Xestospongia purpurea* are added, increasing to three the known species of *Petrosia* and to four those of *Xestospongia*, the overall sponge

list to 154. According to the “World Porifera Database” (<http://www.marinespecies.org/porifera>, see van Soest *et al.*, 2016a, b), there are currently eight valid species of *Petrosia* in the Greater Caribbean, vis. *Petrosia (Petrosia) cretacea* (Schmidt, 1870), *Petrosia (Petrosia) incrustata* (Alcolado and Gotera, 1986), *Petrosia (Petrosia) massiva* Lehnert and van Soest, 1996, *Petrosia (Petrosia) pellasarca* (de Laubenfels, 1934), *Petrosia (Petrosia) weinbergi* van Soest, 1980, *Petrosia (Strongylophora) davilai* (Alcolado, 1979), *Petrosia (Strongylophora) dendyi* (Hechtel, 1969), *Petrosia (Strongylophora) hartmani* (van Soest, 1980) and *Petrosia (Strongylophora) stoneae* (van Soest and Stentoft, 1988). Regarding *Xestospongia*, there are nine species, vis. *Xestospongia caminata* Pulitzer-Finali, 1986, *Xestospongia deweerdtiae* Lehnert and van Soest, 1999, *Xestospongia grayi* (Hechtel, 1983), *Xestospongia menzeli* (Little, 1963), *Xestospongia muta* (Schmidt, 1870), *Xestospongia portoricensis* van Soest, 1980, *Xestospongia purpurea* Rützler, Piantoni, van Soest and Diaz, 2014, *Xestospongia rampa* (de Laubenfels, 1934) and *Xestospongia wiedenmayeri* van Soest, 1980. *Xestospongia rampa* was synonymized with *X. muta* by Zea (1987) after re-examination of their types. This view was followed by van Soest and Stentoft (1988), but it was apparently later ignored, as some authors have maintained *X. rampa* as a valid species (e.g., Lehnert and van Soest 1996; Rützler *et al.* 2014). Several of the species listed above have only been found and described once, thus their identity still needs to be reassessed. Among the shallow-water littoral and reef species (<40 m in depth), these are *P. incrustata* from Cuba, *P. dendyi* from Barbados, *X. caminata* from Jamaica and Puerto Rico, *X. menzeli* from the Northern Gulf of Mexico, *X. portoricensis* from Puerto Rico and *X. wiedenmayeri* from Curaçao. *Petrosia cretacea* from the Northeastern Gulf of Mexico and Florida is also only known from the original record but its depth of collection is unknown (Rützler *et al.*, 2009). We have here confirmed the status and expanded the geographical range of *P. davilai* and of *X. purpurea*, although for the former there are previous records from Belize (Rützler *et al.*, 2014) and Bahamas (Zea *et al.*, 2014) of which we are sure, as we examined the material which was the basis of these records.

In Tables 1, 2 and 3, a trend of larger and thicker spicules in specimens from the continental coast, in comparison to those from oceanic localities, is noticeable. This trend was first described by Zea (1987) and corroborated by Valderrama and Zea (2013) and Zea *et al.* (2014); it is assumed to be caused by greater silicon availability in continental localities brought about by rivers that flow from the mountainous interior. Here we have confirmed the finding of Vicente *et al.* (2016) that this trend even occurs within each of the forms of *Xestospongia deweerdtiae* that have different spicule size, dependent on their free-living state or association with *Plakortis* spp. (Vicente *et al.*, 2014).

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