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Revision of the genus *Pozziella* (Porifera: Poecilosclerida) with description of three new species from the eastern Pacific*

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Abstract

To date, the poecilosclerid sponge genus *Pozziella* Topsent, 1896 was represented by two species: *Pozziella clavisepta* Topsent, 1896 and *Pozziella aperta* (Topsent, 1920), which are presently redescribed. During the campaign SO 144-3a of the project PAGANINI in the Pacific Ocean between the Galapagos Archipelago and Central America, three new species were recovered and are described here: *Pozziella cerilla* sp. nov., *Pozziella neuhausi* sp. nov. and *Pozziella lueteri* sp. nov. The present study led to a revision of the genus and an attempt to resolve the relationships between the species, based on the likeness of spicule complements and biometric characters. A similarity analysis revealed that Atlantic and Pacific species clustered separately. In addition, a key to all species of the genus based on spicular characters is provided.

Key words: Porifera, revision, taxonomy, description, Cocos Ridge, *Pozziella*, new species

Introduction

This article deals with the revision of the genus *Pozziella* Topsent, 1896. Three new species from the campaign SO 144–3a are described and the two previously known species of the genus *Pozziella* are redescribed herein.

The suborder Mycalina Hajdu, Van Soest & Hooper, 1994, is characterized by having palmate chelae or derivatives of them (occasionally absent), and only one type of megascleres, generally styles with a slight subapical constriction (mycalostyles). Alternatively, the megascleres may occasionally be strongyles or oxeas. Additionally, sigmas or sigma derivatives are generally present. The skeleton is plumose or plumoreticulate. The suborder comprises nine families, of which the family Hamacanthidae Gray, 1872 is defined by having mycalostyles and derivatives of sigmancistras (cyrtancistras and diancistras). It comprises approximately 25 species distributed all over the world and includes eight nominal genera, of which only two are currently considered valid: *Pozziella* and *Hamacantha*.

The genus *Pozziella* Topsent, 1896 is characterized by having cyrtancistras, by a choanosome that is made up of plurispicular fascicula, and by a rather uniform layer of exotyles that make up the ectosome. According to Hajdu (2002), the cyrtancistras of *Pozziella* are undeniably related to the diancistras (characteristic of the genus *Hamacantha* Gray, 1867). Small diancistras, as e.g. in *Hamacantha acerata* Lévi, 1993, would represent an evolutive step of the typical forms as e.g. in *Hamacantha johnsoni* (Bowerbank, 1864). The cyrtancistras of *Pozziella* are interpreted as the most advanced form, in which most of the interior edge is reduced.

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The material for the present study was sampled during the campaign SO 144–3a, which was part of the German project PAGANINI. The campaign was conducted on board the RV *Sonne* in November and December 1999, moving between the Galapagos Archipelago and Central America. Two hundred and two specimens and sponge fragments were collected from 127 dredgings, stemming from depths between 600 and 3571 m.

Material and Methods

The new samples of *Pozziella* originate from the area of the Galapagos Volcanic System (GVS) (Fig. 19). Different rocky bottoms from most of the Cocos and Carnegie Ridges were sampled here, yielding the studied specimens from stations 32, 39 and 72 (Fig. 19).

Material was sorted on board and fixed in 4% formaldehyde and then preserved in 70% alcohol. For the study of clean spicules, tissue fragments were digested in nitric acid taken to boiling point, following Rützler (1978) and Uriz (1986). For the holotype of each species, 25 spicules of each type (except styles) were measured using a light microscope (Olympus BX41TF). In the case of styles, 100 spicules were measured in each holotype, to check whether one or two types of styles were present according to their length. From the results, frequency distribution histograms were obtained for the styles and the form index (width/height) of all spicule types was calculated. Spicule height was considered as the distance between both ends following a straight line. Spicules of all five described species were examined and photographed using the scanning electron microscopes (SEM) Leo 435vp and Leica 440. Small pieces of holotypes of the three new species were embedded in paraffin wax and cut into slices with a microtome (Microm HM 340 E). Then, permanent preparations were made, including slices of sponge in Canada balsam, to determine skeletal architecture. The classification system adopted in this work is that proposed in Systema Porifera (Hooper & Van Soest 2002). All descriptions of spicules and spicule arrangement are based on present observations. Other morphological descriptions are amended from original descriptions of the two existing species of *Pozziella* for which only preparations of clean spicules were available. The type specimens for the new *Poziella* species were deposited in the Museum für Naturkunde, Berlin (ZMB). The type material of *Pozziella clavisepta* Topsent, 1896 and *Pozziella aperta* (Topsent, 1920) was provided on loan by the Muséum National d'Histoire Naturelle (MNHN) of Paris.

A matrix with features of spicules as presence/absence data was devised to determine affinities among the five known species of *Pozziella*. From that matrix, similarities among species were determined by means of the Bray-Curtis similarity index. A classification of the species was done from the similarity matrix by cluster analysis based on the group-average sorting algorithm. Analyses were carried out with the software package PRIMER 5.2.3 (Clarke & Warwick 2001).

Taxonomy

Order Poecilosclerida Topsent, 1928
Suborder Mycalina Hajdu, Van Soest & Hooper, 1994
Family Hamacanthidae Gray, 1872
Genus *Pozziella* Topsent, 1896

Diagnosis. Hamacanthidae with cyrtancistras (Hajdu, 2002)

Type species. *Pozziella clavisepta* Topsent, 1896 (by monotypy)

***Pozziella clavisepta* Topsent, 1896**
(Figs. 1–3, 19)

Examined Material: *Pozziella clavisepta* (Syntype) MNHN no. 12 P.A 1895 (one preparation of clean spicules).

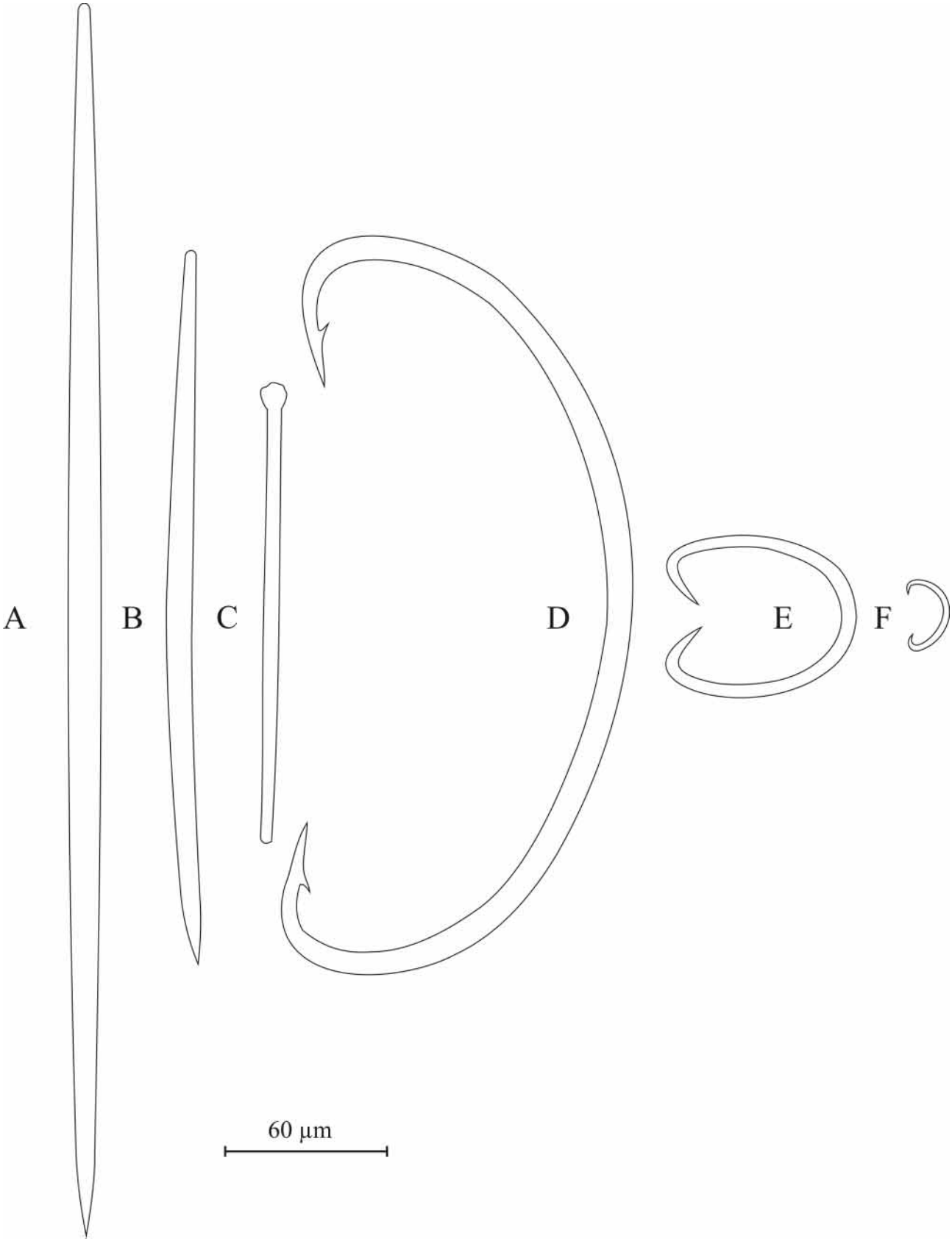

FIGURE 1. Spicules of *Pozziella clavisepta* (Syntype). A. Style I; B. Style II; C. Exotyle; D. Cyrtancistra I; E. Sigma I; F. Sigma II.

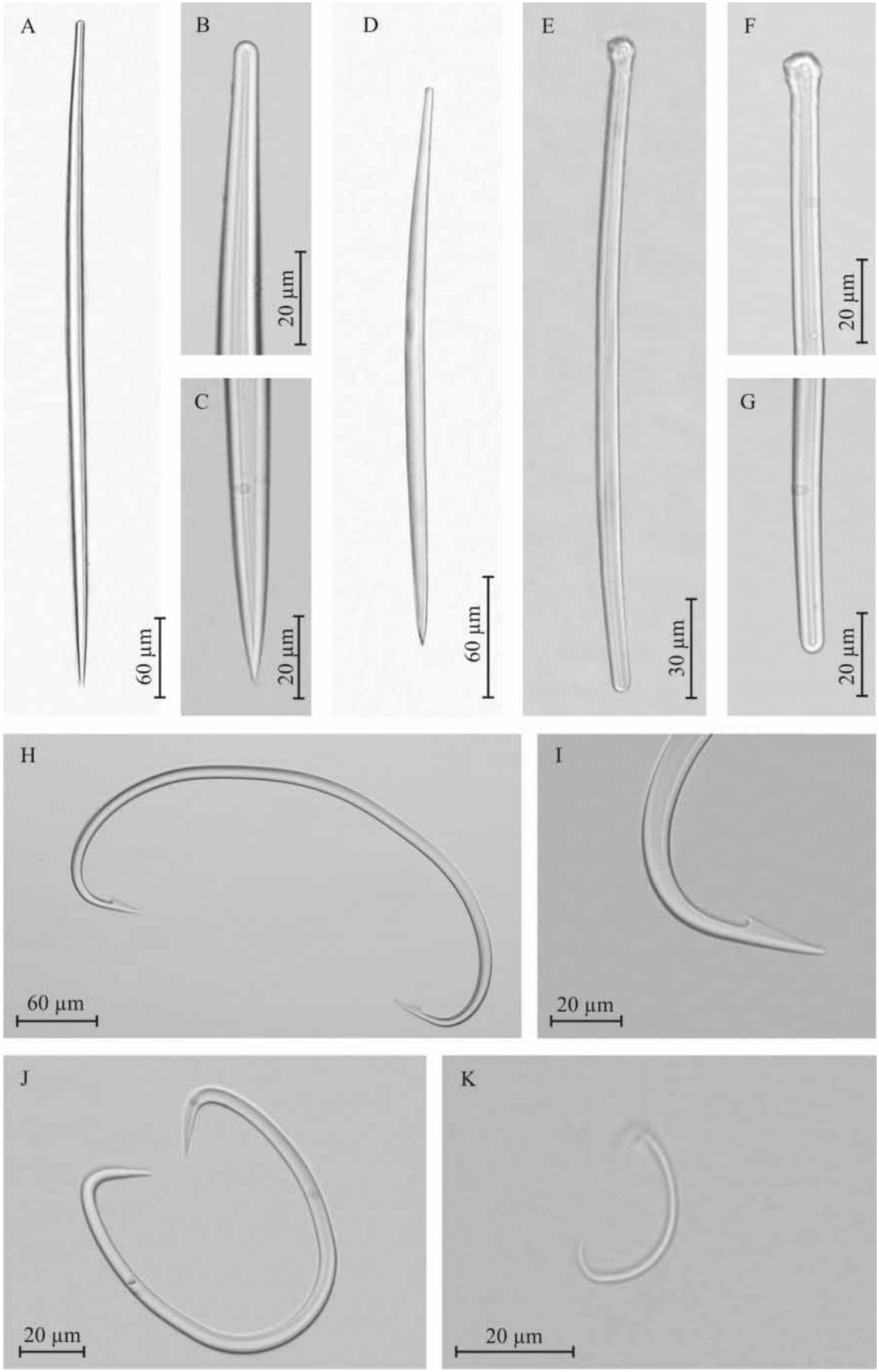

FIGURE 2. Spicules of *Pozziella clavisepta* (Syntype). A. Style I; B. Rounded end of a style I; C. Pointed end of a style I; D. Style II; E. Exotyle; F. Tyle of an exotyle; G. Rounded end of an exotyle; H. Cyrtancistra I; I. Lanceolate termination of cyrtancistra I; J. Sigma I; K. Sigma II.

Description

Habitus: Incrusting sponge, thin, forming more or less extensive patches. Tissue easily separable from substrate, soft. White or greyish ectosome. No visible orifices when viewed without magnification. Choanosome brownish-grey, cavernous and fibrous (Topsent, 1896).

Spicules

Megascleres: Smooth styles, fusiform, shaft straight or slightly curved (Fig. 1 A, B; 2 A–D), in two different size classes. Large styles (style I, Fig. 1 A) 460–550 µm in length (Mean (M.) ± Standard deviation (S.D.), 502.8 ± 24.41 µm) and 12.5–15 µm in width (M. ± S. D., 14.4 ± 1.09 µm) at mid-shaft, latter dimension decreasing towards rounded end to 5–7.5 µm (M. ± S. D., 6.2 ± 1.27 µm) (Fig. 2 A–C) (form index: 0.028). Smaller styles (style II, Fig. 1 B) 280–360 µm in length (M. ± S. D., 316.4 ± 17.77 µm) and 10–12.5 µm in width at mid-shaft (M. ± S. D., 11.5 ± 1.25 µm), latter dimension gradually decreasing to 2.5–5 µm at rounded end (M. ± S. D., 4.9 ± 0.50 µm) (Fig. 2 D) (form index: 0.036).

Exotyles straight or slightly curved, 210–250 µm in length (M. ± S. D., 228 ± 10 µm) and 9–12 µm in width (M. ± S. D., 10.36 ± 0.86 µm), smooth shafts with uniform diameter (Fig. 1 C; 2 E–G). Spherical tyle with width of 15–20 µm (M. ± S. D., 17.41 ± 1.49 µm), covered with small warts (Fig. 2 E, F) (form index 0.045).

Microscleres: Large cyrtancistras of uniform size (Fig. 1 D; 2 H), 310–400 µm in height (M. ± S. D., 355.2 ± 26.94 µm) and 7.5–12.5 µm in width (M. ± S. D., 10.6 ± 1.49 µm). Singular, distinctive, terminal hooks (Fig. 2 I) with smooth body (index form: 0.37). Numerous sigmas with variable curvature and in two size classes (Fig. 1 E, F; 2 J, K). Larger sigmas (type I) horizontally stretched C-shape, actines tending to be parallel, 190–320 µm in height (M. ± S. D., 232 ± 29 µm) and 1 µm in width (M. ± S. D., 1.0 ± 0.0 µm) (index form: 0.94). Smaller sigmas (type II) vertically stretched C-shape, 23–33 µm in height (M. ± S. D., 29.4 ± 2.61 µm) and 1 µm in width (M. ± S. D., 1.0 ± 0.0 µm) (index form: 0.43).

Skeleton

Skeletal arrangement: Styles arranged in long plurispicular fibres in choanosome, interweaved in no particular order in the ectosome. Exotyles inserted vertically in ectosome with tyle pointing outwards and making up the characteristic armour of the genus. Cyrtancistras hooked in fascicles along the choanosomic fibres of styles (Topsent, 1896).

Distribution: Only known from type locality. Azores archipelago, between San Miguel and Terceira. Between 550 and 1165 m depth (Topsent, 1896) (Fig. 19).

Remarks. *P. clavisepta* Topsent, 1896 is the type species of *Pozziella* and is clearly distinguishable from the other species by the presence of two different kinds of sigmas.

The existence of two types of styles is not mentioned in the original description of *P. clavisepta* Topsent, 1896. Topsent (1904) does, however, mention it superficially. Our examination of the syntype confirmed the presence of two types of styles of different length (Fig. 3).

***Pozziella aperta* (Topsent, 1920)**

(Figs. 3–5, 19)

Examined material: *Hamacantha clavisepta* var. *aperta* (Syntype) MNHN LBIM no. D.T 2155 (one preparation of clean spicules).

Description

Habitus: White and opaque crust. Beginnings of some choanosomic lines hanging from the inner surface of the ectosome. Exotyles standing out on the surface of the sponge, resulting in slightly hispid aspect (Topsent, 1920).

Spicules

Megascleres: Small styles (II), smooth, small, fusiform and slightly curved (Fig. 4 A; 5 A–C), 250–470

µm in length (M. ± S.D., 373 ± 70.29 µm) and 10–17.5 µm in width at mid-shaft (M. ± S.D., 14.40 ± 2.08 µm), latter dimension decreasing towards rounded end to 5–7.5 µm (M. ± S.D., 6 ± 1.25 µm) (form index: 0.04).

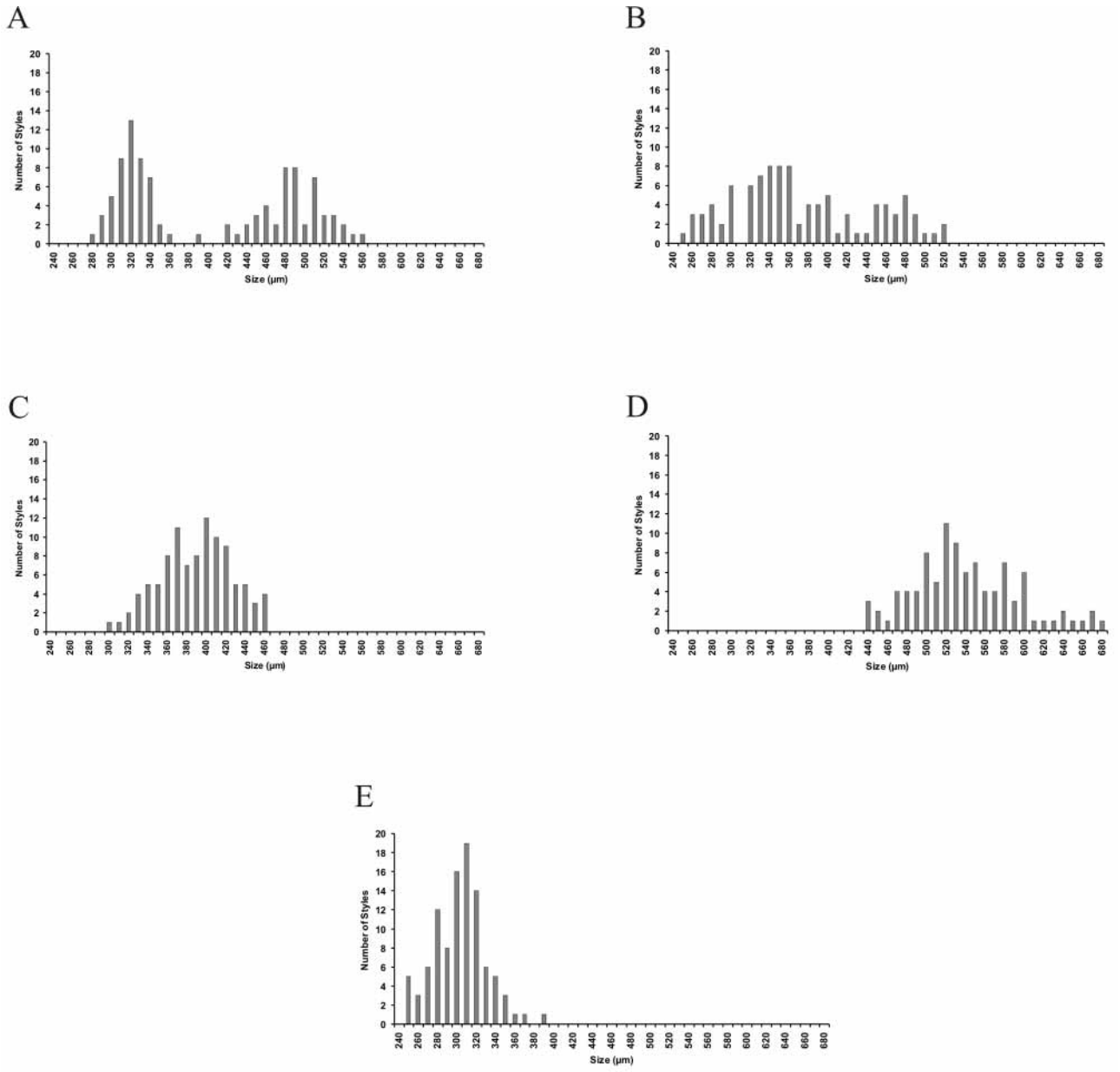

FIGURE 3. Size frequency distributions of styles of *Pozziella* species: A. *P. clavisepta*; B. *P. aperta*; C. *P. cerilla* sp. nov.; D. *P. neuhausi* sp. nov.; E. *P. lueteri* sp. nov.

Smooth exotyles, straight or slightly curved (Fig. 4 B; 5 D). Tyle in the shape of a spherical mace, covered by shapeless creases, opposite end rounded. Diameter of the spicule increasing towards the rounded end (Fig. 5 E, F), 165–197.5 µm in length (M. ± S.D., 186.30 ± 8.169 µm), 10–12.5 µm shaft width in mid-region (M. ± S.D., 11.4 ± 1.27 µm), tyle width of 10–20 µm (M. ± S.D., 16.40 ± 2.61 µm) (form index 0.088).

Microscleres: Smooth cyrtancistras of two different types. Larger cyrtancistras (type I) vertically stretched C-shape, 360–460 µm in height (M. ± S.D., 423.57 ± 31.77 µm) and 12.5–20 µm in width (M. ± S.D., 16.07 ± 2.72 µm) (form index: 0.35) (Fig. 4 C; 5 G, H). Smaller cyrtancistras (type II) C-shaped, with

strong angulation in middle and almost parallel arms, 102.5–157.5 µm in height (M. ± S.D., 131.25 ± 17.17 µm) and 3–5 µm in width (M. ± S.D., 4.29 ± 0.61 µm) (form index: 0.540) (Fig. 4 D; 5 I). Abundant small and strong type II sigmas (Fig. 4 E; 5 J), 18–26 µm in height (M. ± S.D., 21.68 ± 2.23 µm) and 1 µm in width (M. ± S. D., 1.0 ± 0.0 µm) (form index: 0.39).

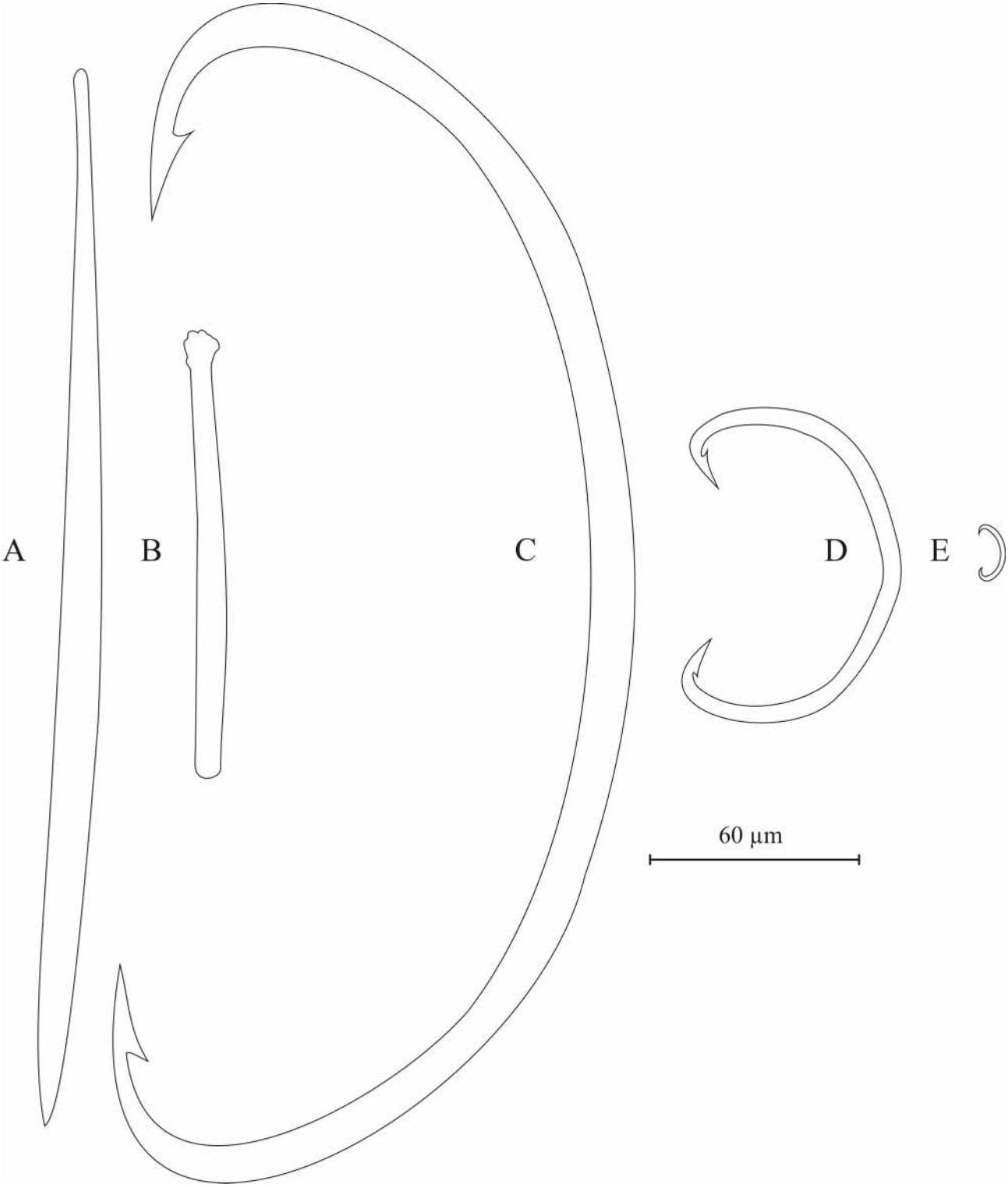

FIGURE 4. Spicules of *Pozziella aperta* (Syntype). A. Style II; B. Exotyle; C. Cyrtancistra I; D. Cyrtancistra II; E. Sigma II.

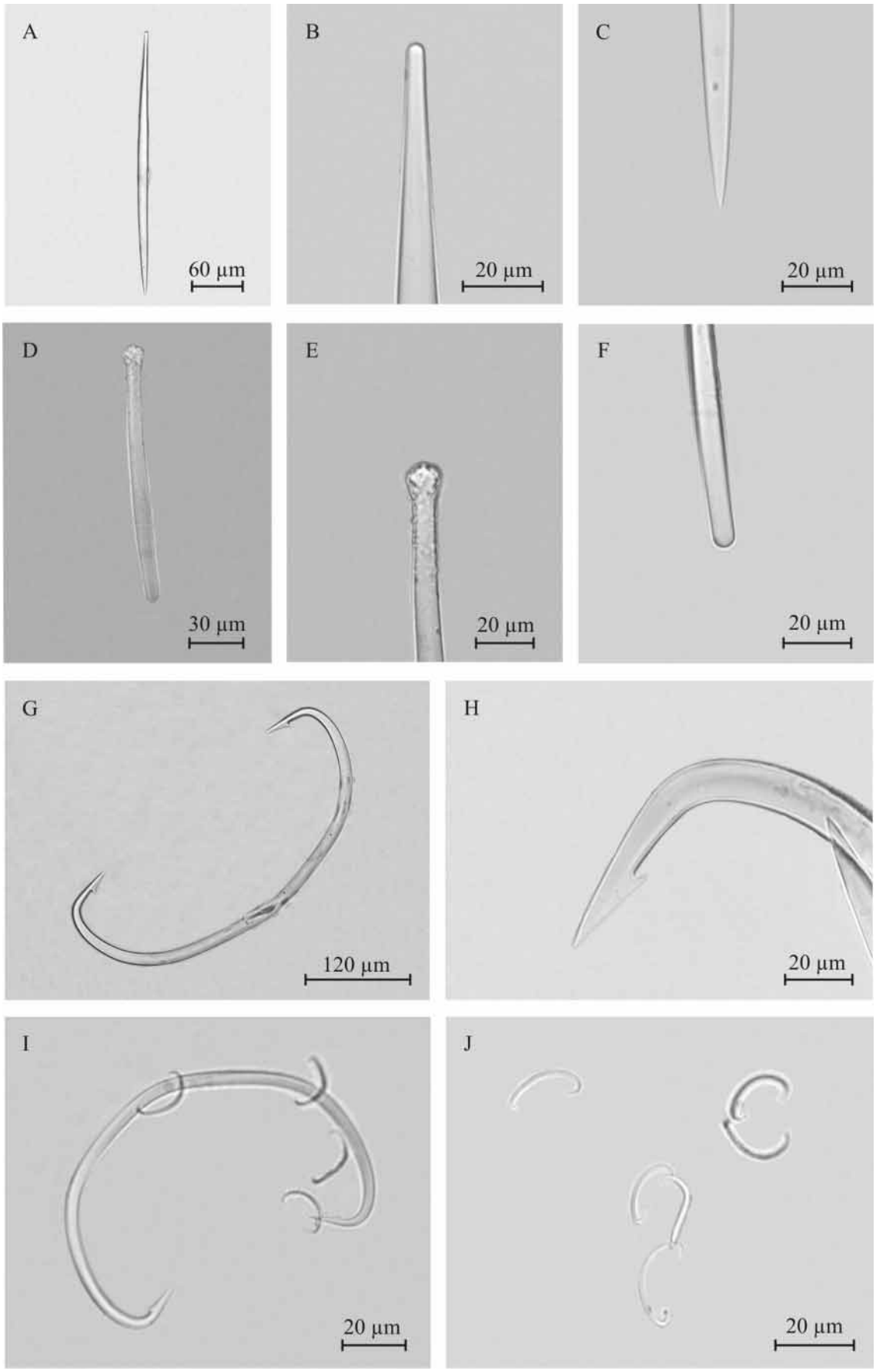

FIGURE 5. Spicules of *Pozziella aperta* (Syntype). A. Style II; B. Rounded end of a style II; C. Pointed end of a style II; D. Exotyle; E. Tyle of an exotyle; F. Rounded end of an exotyle; G. Cyrtancistra I; H. Lanceolate termination of cyrtancistra I; I. Cyrtancistra II; J. Sigma II.

Distribution: Only known from type locality. Caribbean Sea (Topsent, 1920) (Fig. 19).

Remarks: Hajdu (2002) considered Topsent's (1920) variety *Hamacantha clavisepta* var. *aperta* a valid species on its own: 'Topsent (1920) described *Hamacantha clavisepta* var. *aperta* from the West Indies. This is clearly a *Pozziella*, and is considered here a valid species, *Pozziella aperta*, on account of diagnostic morphological features and likely biogeographical isolation. It differs from the type species by the possession of a second category of much smaller cyrtancistras (larger ones up to 473 µm, smaller ones up to 167 µm)'. Hajdu's (2002) decision is here supported, as *P. aperta* has cyrtancistras typical of *Pozziella*, but not of *Hamacantha*, choanosomic plurispicular fascicula and a rather uniform layer of exotyles that make up the ectosome, what is also characteristic of the genus *Pozziella*.

P. aperta differs clearly from the other species of the genus because it is the only one that has two types of cyrtancistras, clearly distinguishable by their size and form, with the smaller type having an angle in mid-region. The exotyles of *P. aperta* have a tyle in the shape of a spherical mace similar to that of *P. clavisepta* and *P. neuhausi* sp. nov. However, in *P. neuhausi* sp. nov. the tyle is covered by a thin layer of granulae, whereas in *P. clavisepta* it shows irregular creases as those of *P. aperta*. In addition, *P. aperta* differs from the other two species by having longer and thinner exotyles with a form index of 0.088, whereas in the other two species the indices are 0.045 and 0.027 respectively. Moreover, the shaft of the exotyle of *P. aperta* is mace-shaped and its diameter wider in the mid and lower region than in the upper half, a characteristic which is not shared by the other species of the genus.

***Pozziella cerilla* sp. nov.**
(Figs. 3, 6–9, 19)

Examined material: Wet holotype ZMB Por. 12645 (preparations at O.M. deposited at ZMB). Type locality: Cocos Ridge; from 03º27.60 N, 090º37.00 W to 03º27.56 N, 090º36.63 W; depth 1224–1458 m; station 32; campaign SO 144–3a.

Description

Habitus: Incrusting, thin layer of 2–3 mm thickness, covering surface of 20 mm x 9 mm (Fig. 6 A, B). Yellowish white colour in alcohol. No oscula visible. Flexible and fragile consistency with rough texture. Base of specimen with sediment, small fragments from other sponges and remains of malacostracan crustacean inside a fold.

Spicules

Megascleres: Small, smooth, rectilinear and fusiform styles II, pointed ends slightly rounded; rounded end semispherical (Fig. 7 A; 8 A–C). Some styles with enlarged axial canal. Size: 300–450 µm in length (M. ± S.D., 389.7 ± 37.02 µm) and 7.5–12.5 µm in mid-region (M. ± S.D., 10.9 ± 1.42 µm), diameter decreasing towards rounded end to 2.5–7.5 µm (M. ± S.D., 5.3 ± 1.81 µm) (form index: 0.028).

Straight exotyles (Fig. 7 B; 8 D) with rounded end (Fig. 8 F) opposite the tyle. Latter in claviform shape, with irregular and rough surface (Fig. 8 E). Irregularities continue along shaft for ¼ of its length, lower ¾ of shaft smooth (Fig. 8 D–F). Shaft with uniform diameter. Exotyle size: length 125–165 µm (M. ± S.D., 147.4 ± 10.84 µm), width 2.5–5 µm (M. ± S.D., 4.6 ± 0.9 µm)and tyle width 7.5–12.5 µm (M. ± S.D., 9.6 ± 1.72 µm) (form index 0.065).

Microscleres: Large cyrtancistras I with semilanceolate ends (Fig. 8 H, I); spicule with very obtuse angle in mid-region (Fig. 7 C; 8 G). Some cyrtancistras with two denticles on lanceolate hooks (Fig. 8 H). Cyrtancistra size: height 490–640 µm (M. ± S.D., 593.2 ± 35.91 µm) and width 20–25 µm (M. ± S.D., 21.9 ± 1.66 µm) (form index: 0.41). Small, thick and strong type II sigmas, generally C-shaped(Fig. 7 D; 8 J): height 14–18 µm (M. ± S.D., 16.44 ± 1.33 µm) and width 1µm (M. ± S.D., 1.0 ± 0.0 µm) (form index: 0.59).

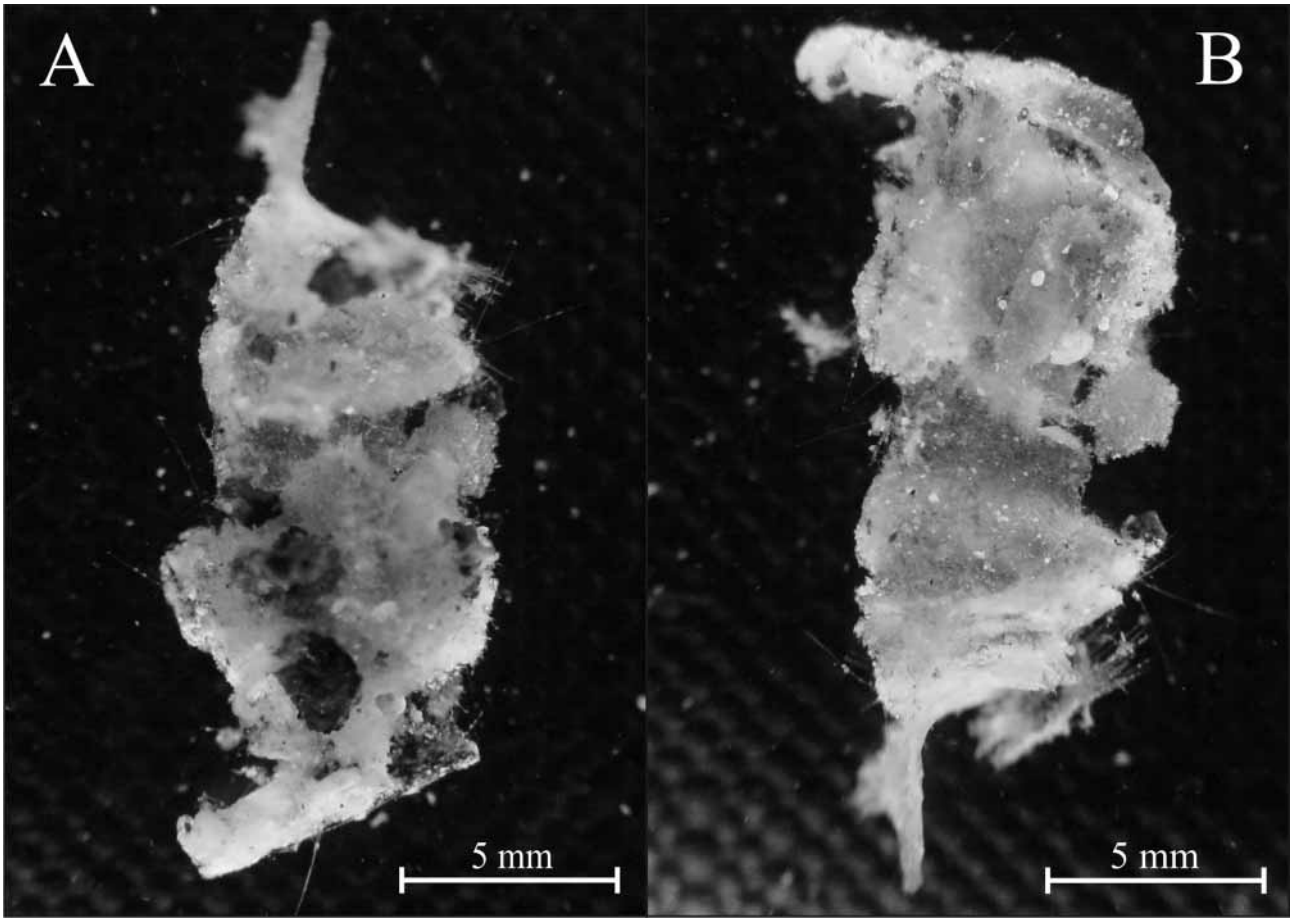

FIGURE 6. A, B. Habitus of *Pozziella cerilla* sp. nov.

Skeleton

Skeletal arrangement: Choanosomic plurispicular fascicula of styles arranged in bunches near ectosome (Fig. 9). Ectosome consisting of irregularly arranged tangential styles with free exotyles or exotyles forming hispid bunches of 4 or 5, with tyles pointing out. Cyrtancistras situated in ectosome underneath stylar layer. Very abundant sigmas arranged as ectosomal crust just beneath tangential styles.

Distribution: Galápagos archipelago, Cocos Ridge; from 03º27.60 N, 090º37.00 W to 03º27.56 N, 090º36.63 W; depth 1224–1458 m.

Derivatio nominis: The name of this species derives from the Spanish word for match, 'cerilla', as the shape of its exotyles resembles a match.

Discussion: *Pozziella cerilla* sp. nov. is characterized by having exotyles with a claviform tyle, which differs from *P. clavisepta*, *P. aperta* and *P. neuhausi* sp. nov., in which the tyles have a spherical shape. The shape of the exotylar tyle in *P. lueteri* sp. nov. is similar to that in *P. cerilla* sp. nov. However, the tylar irregularities of *P. lueteri* sp. nov. only occur on the tyle itself, whereas in *P. cerilla* sp. nov. they extend down to ¼ of the spicule shaft. *P. cerilla* sp. nov. additionally displays longer and thinner exotyles than *P. lueteri* sp. nov., as the form index of each species shows: 0.065 in *P. cerilla* sp. nov. and 0.154 in *P. lueteri* sp. nov. The exotyles in *P. cerilla* sp. nov. are arranged loosely in the ectosome or form bundles of 4 or 5 exotyles with the tyle pointing out. This arrangement is similar to that observed for *P. neuhausi* sp. nov., but in the latter the exotyles never form bundles. In the remaining species they create a uniform layer in the ectosome, with the tyles pointing out.

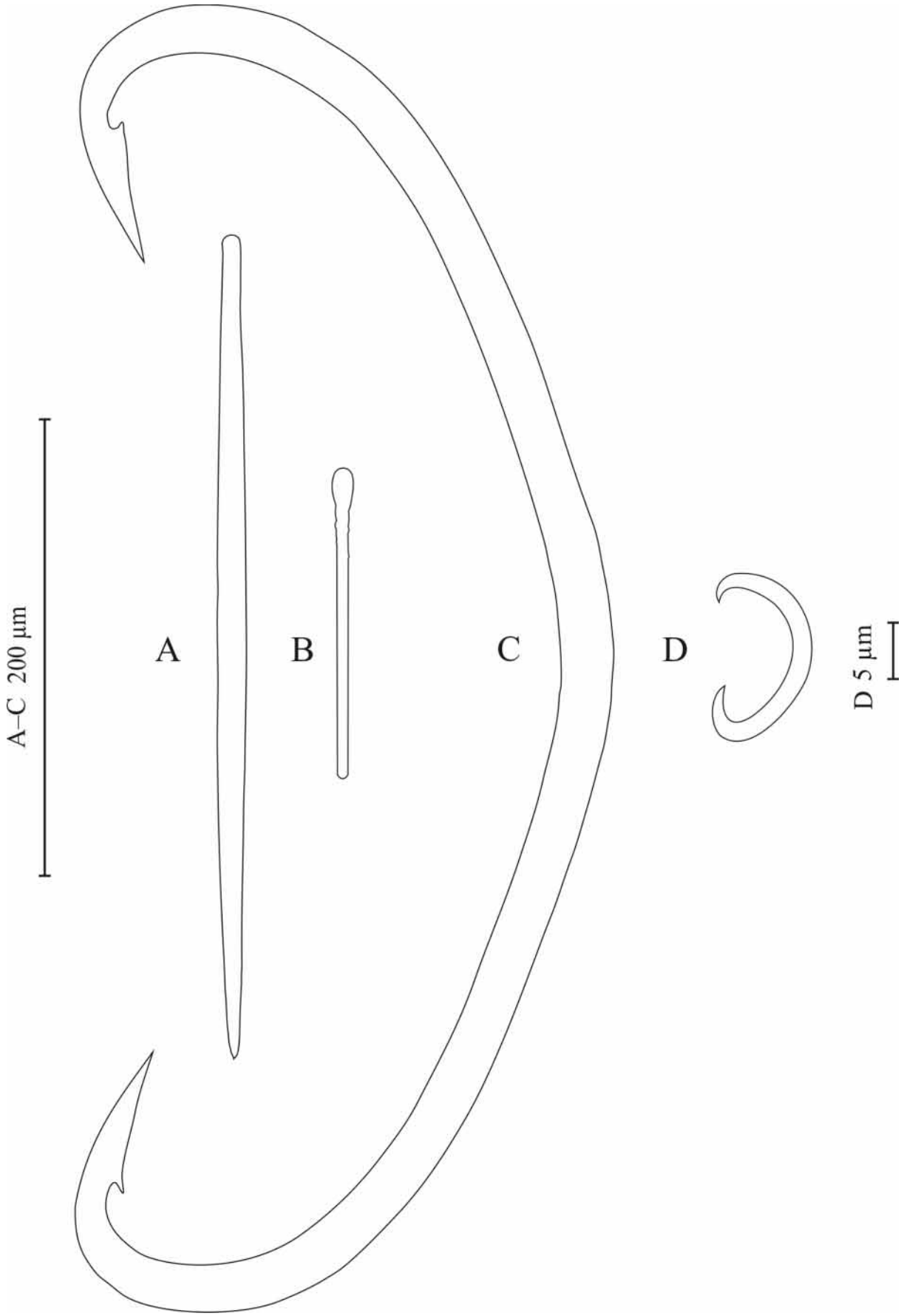

FIGURE 7. Spicules of *Pozziella cerilla* sp. nov. A. Style II; B. Exotyle; C. Cyrtancistra I; D. Sigma II.

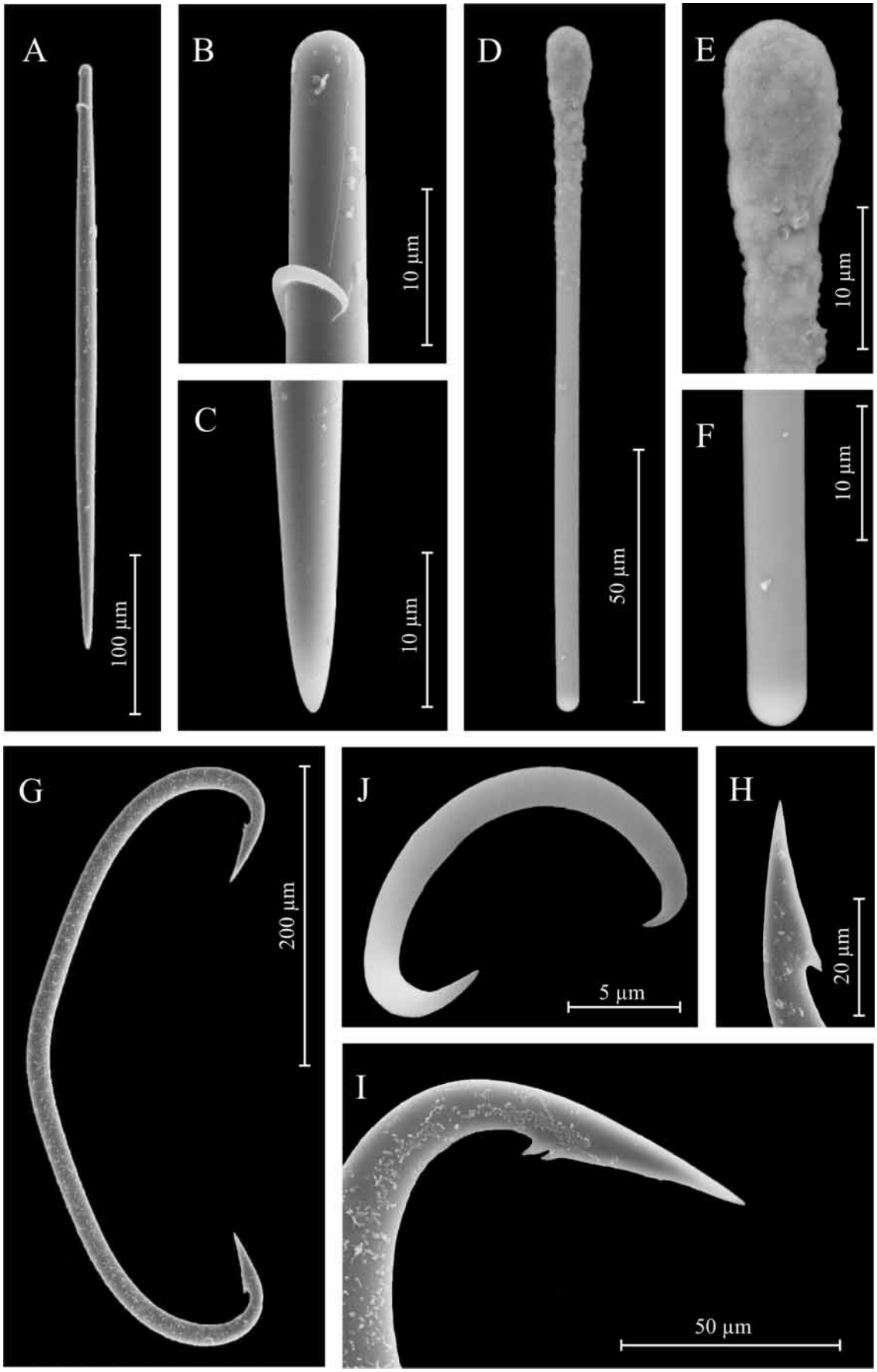

FIGURE 8. Spicules of *Pozziella cerilla* sp. nov. A. Style II; B. Rounded end of a style II; C. Pointed end of a style II; D. Exotyle; E. Tyle of an exotyle; F. Rounded end of an exotyle; G. Cyrtancistra I; H. Cyrtancistra I lanceolate termination with two denticles; I. Cyrtancistra I lanceolate termination with single denticle; J. Sigma II.

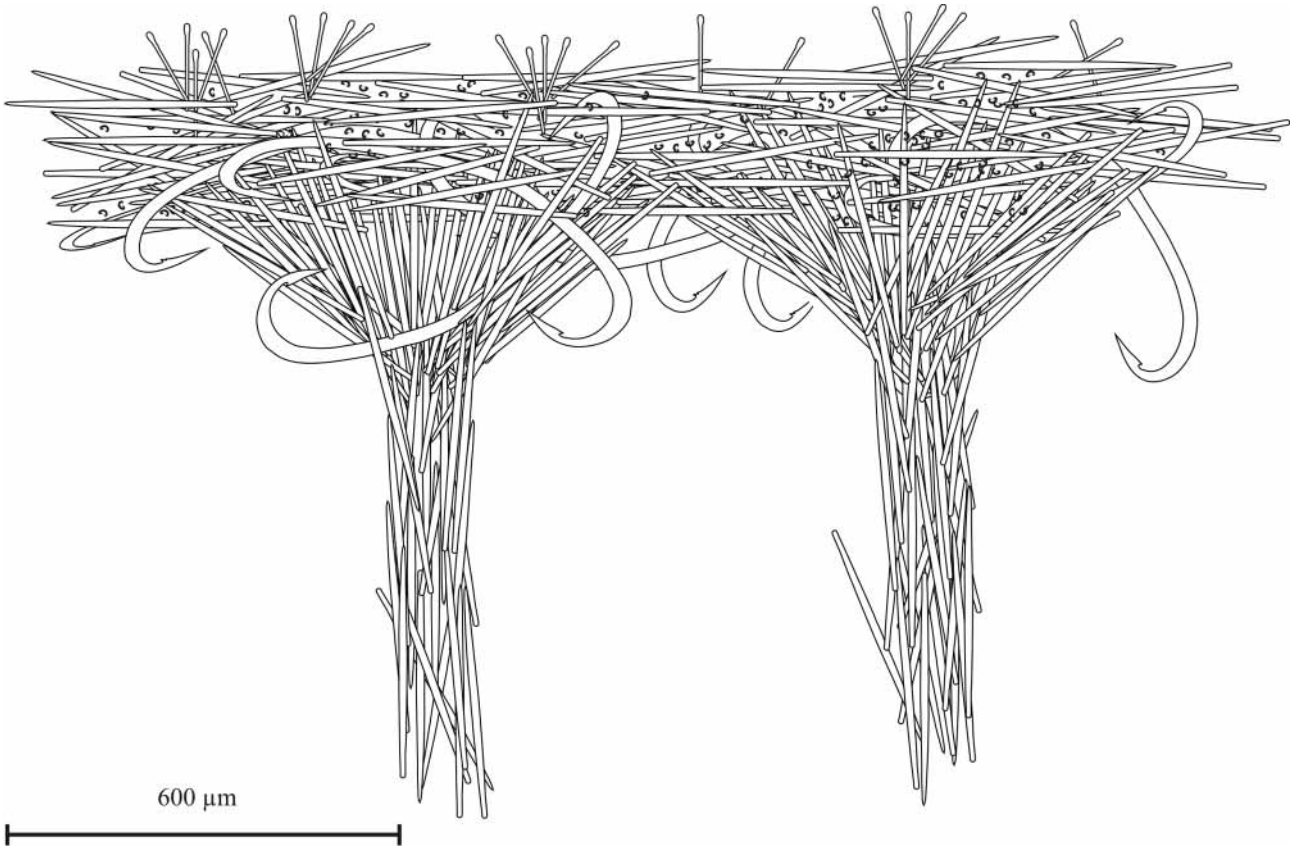

FIGURE 9. Skeletal arrangement of *Pozziella cerilla* sp. nov.

Pozziella cerilla sp. nov. differs from *P. clavisepta* by having only one type of sigma and cyrtancistras with an angular curvature. It differs from *P. aperta* because the latter has two types of cyrtancistras. Moreover, the largest cyrtancistras of *P. aperta* do not have the angulation of those of *P. cerilla* sp. nov.

P. neuhausi sp. nov. and *P. lueteri* sp. nov. have only one type of cyrtancistras and sigmas, similar to *P. cerilla* sp. nov. However, *P. cerilla* sp. nov. differs from *P. lueteri* sp. nov. by having angular cyrtancistras, and it differs from *P. neuhausi* sp. nov. by having cyrtancistras with a more pronounced angulation. In *P. cerilla* sp. nov. the cyrtancistras are situated in the ectosome under the tyles, whereas in *P. neuhausi* sp. nov. they are at the base of the sponge. The above characters distinguish *P. cerilla* sp. nov. from the other *Poziella* spp. and justify the creation of the new species.

***Pozziella neuhausi* sp. nov.**
(Figs. 3, 10–13, 19)

Examined material: Holotype ZMB Por. 12646 and Paratype, ZMB Por. 12647 (preparations at O.M. deposited at ZMB). Type locality: Cocos Ridge; from 04º30.84 N, 086º46.23 W to 04º30.73 N, 086º45.94 W; depth 1087–1164 m; station 39; campaign SO 144–3a.

Description

Habitus: Incrusting and thin with 2–4 mm thickness (Fig. 10 A, B), holotype covering surface of 16 mm x 16 mm and paratype 16 mm x 10 mm. Yellowish white colour in alcohol. Soft, slightly flexible and fragile consistency. Rough texture. No oscula visible. Bases of both specimens with embedded sediment. Paratype with enclosed hexactinellid spicules.

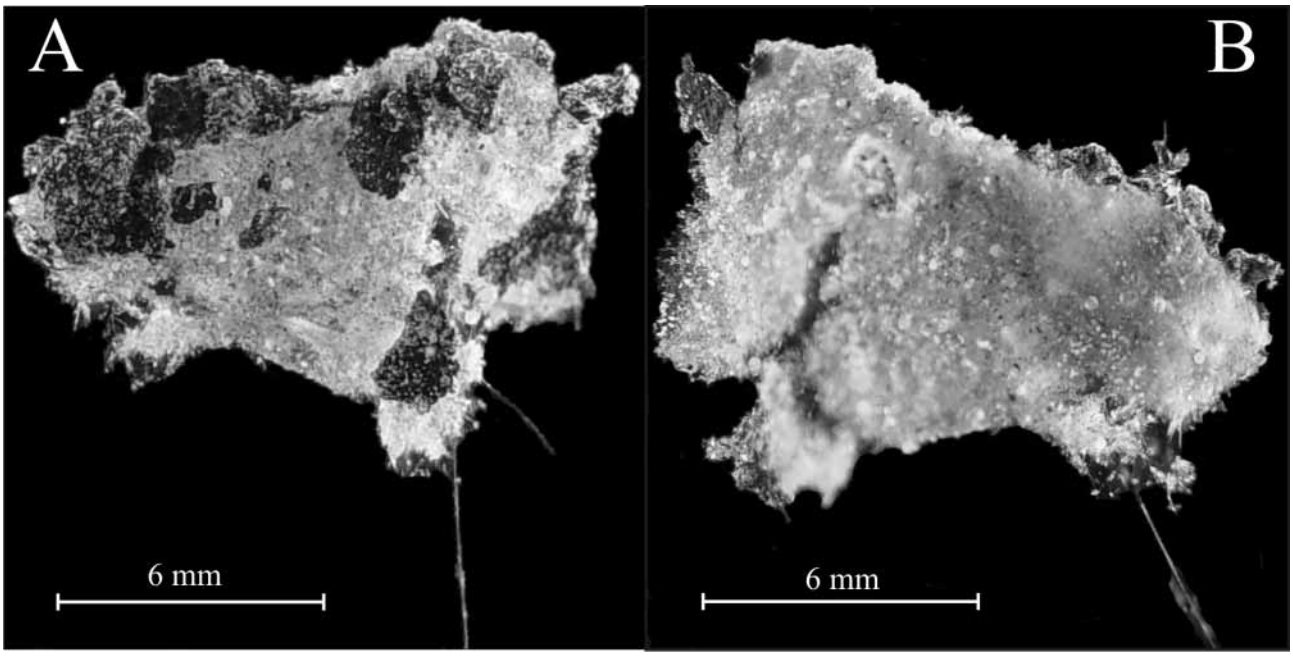

FIGURE 10. A, B. Habitus of *Pozziella neuhausi* sp. nov.

Spicules

Megascleres: Large styles I, smooth, fusiform and straight or slightly curved, pointed end slightly rounded, opposite end semispherical. Some styles with enlarged axial canal (Fig. 11 A; 12 A–C). Style size: length 480–600 µm (M. ± S.D., 541.9 ± 54.27 µm) and width 10–17.5 µm in mid-region (M. ± S.D., 13.4 ± 1.59 µm), decreasing gradually towards rounded end to 5–7.5 µm (M. ± S.D., 6.3 ± 1.3 µm) (form index: 0.025).

Very long exotyles, with spherical tyles with finely and uniformly granulated surface. Granulation extending from tyle down approximately ¼ of shaft. Rest of the spicule completely smooth. Shaft with uniform diameter and rounded lower end (Fig. 11 B; 12 D–F). Exotyle size: length 370–480 µm (M. ± S.D., 430.8 ± 24.48 µm), width 7.5–10 µm (M. ± S.D., 8.4 ± 1.22 µm) and tyle width 10–15 µm (M. ± S.D., 11.6 ± 1.75 µm) (form index 0.027).

Microscleres: Large, but not very abundant cyrtancistras I with semilanceolate ends with single denticle (12 H). Soft curvature with subtle angulation in the mid-shaft (Fig. 11 C; 12 G). Cyrtancistra size: height 560–760 µm (M. ± S.D., 683 ± 56 µm) and width 25–32.5 µm (M. ± S.D., 29.4 ± 2.22 µm) (form index: 0.25). Small, thick and strong type II sigmas, generally C-shaped (Fig. 11 D; 12 I): height 13–20 µm (M. ± S.D., 17 ± 1.9 µm) and width 1 µm (M. ± S.D., 1.0 ± 0.0 µm) (form index: 0.42).

Skeleton

Skeletal arrangement: Choanosomic plurispicular fascicula of styles arranged in bunches near ectosome (Fig. 13). Ectosome consisting of thick layer of irregularly arranged tangential styles. Exotyles widely spaced, vertically emerging from stylar layer, tyles pointing out, not forming bunches or uniform layer. Cyrtancistras at base of sponge forming layer near the substratum. Abundant sigmas in ectosome, scattered between styles.

Distribution: Galápagos archipelago, Cocos Ridge; from 04º30.84 N, 086º46.23 W to 04º30.73 N, 086º45.94 W; depth 1087–1164 m.

Derivatio nominis: This species is dedicated to Dr. Birger Neuhaus, who collected the specimens on board the RV *Sonne* and provided them to us for this study.

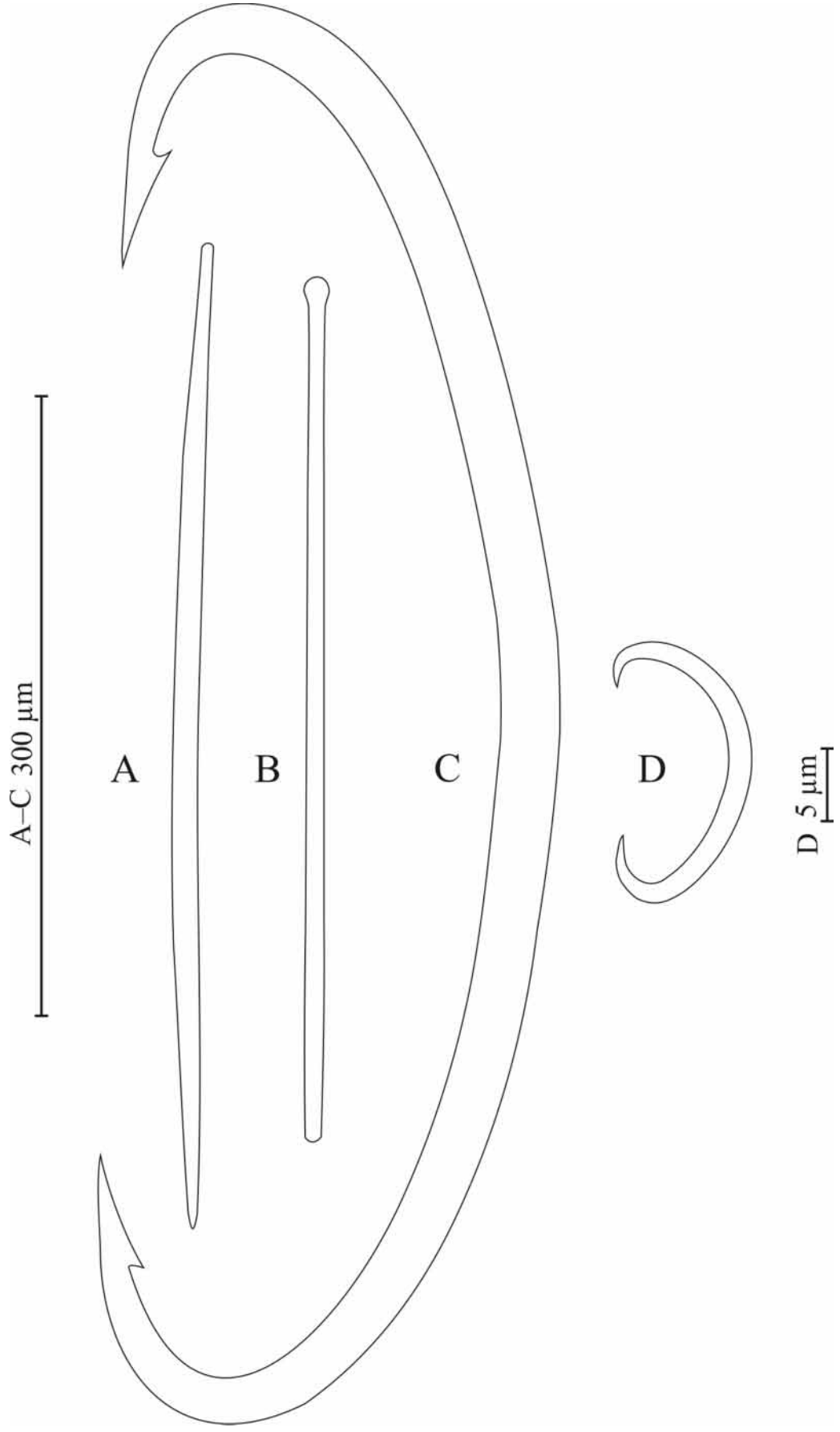

FIGURE 11. Spicules of *Pozziella neuhausi* sp. nov. A. Style I; B. Exotyle; C. Cyrtancistra I; D. Sigma II.

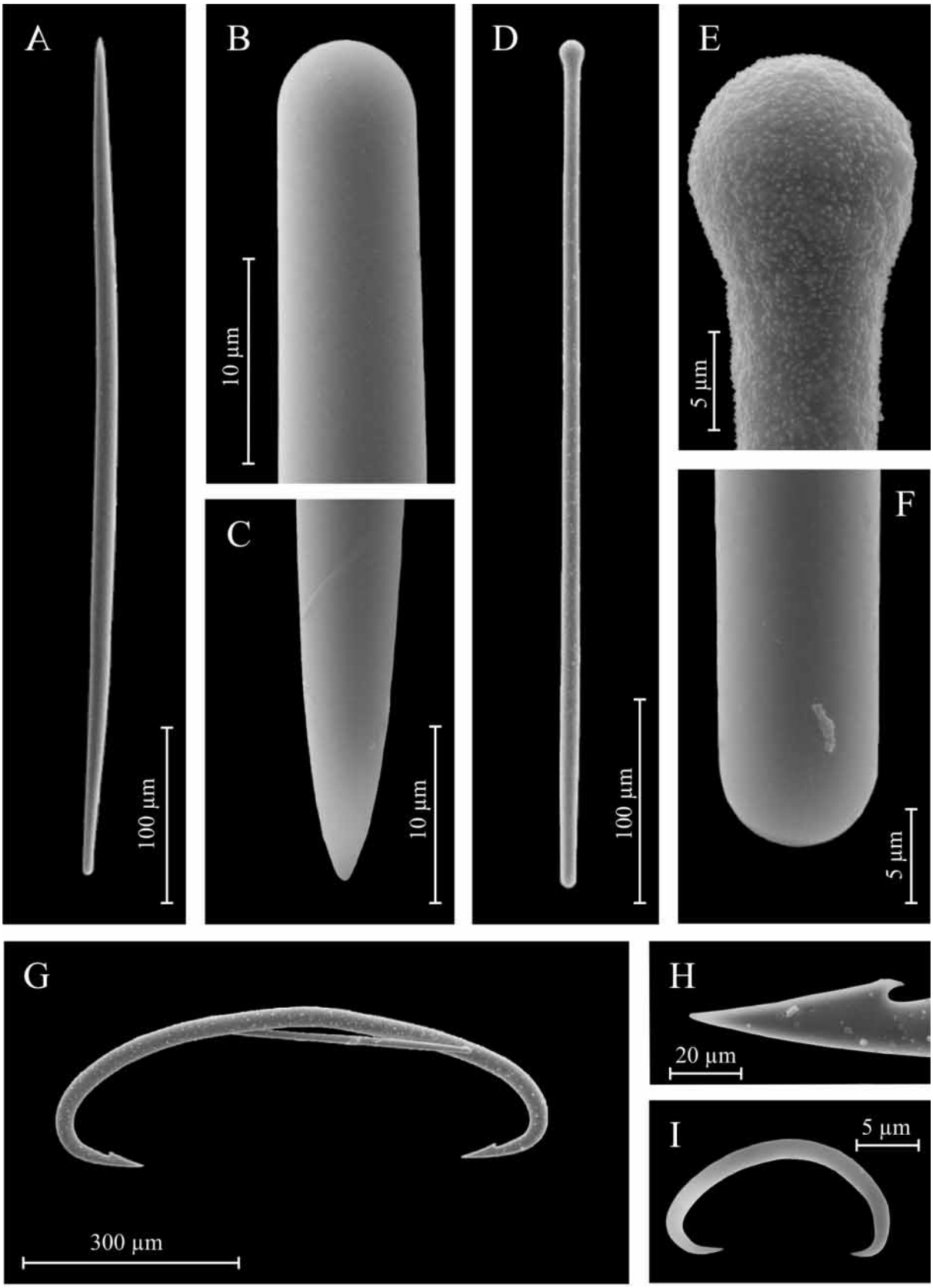

FIGURE 12. Spicules of *Pozziella neuhausi* sp. nov. A. Style I; B. Rounded end of a style I; C. Pointed end of a style I; D. Exotyle; E. Tyle of an exotyle; F. Rounded end of an exotyle; G. Cyrtancistra I; H. Lanceolate termination of cyrtancistra I; I. Sigma II.

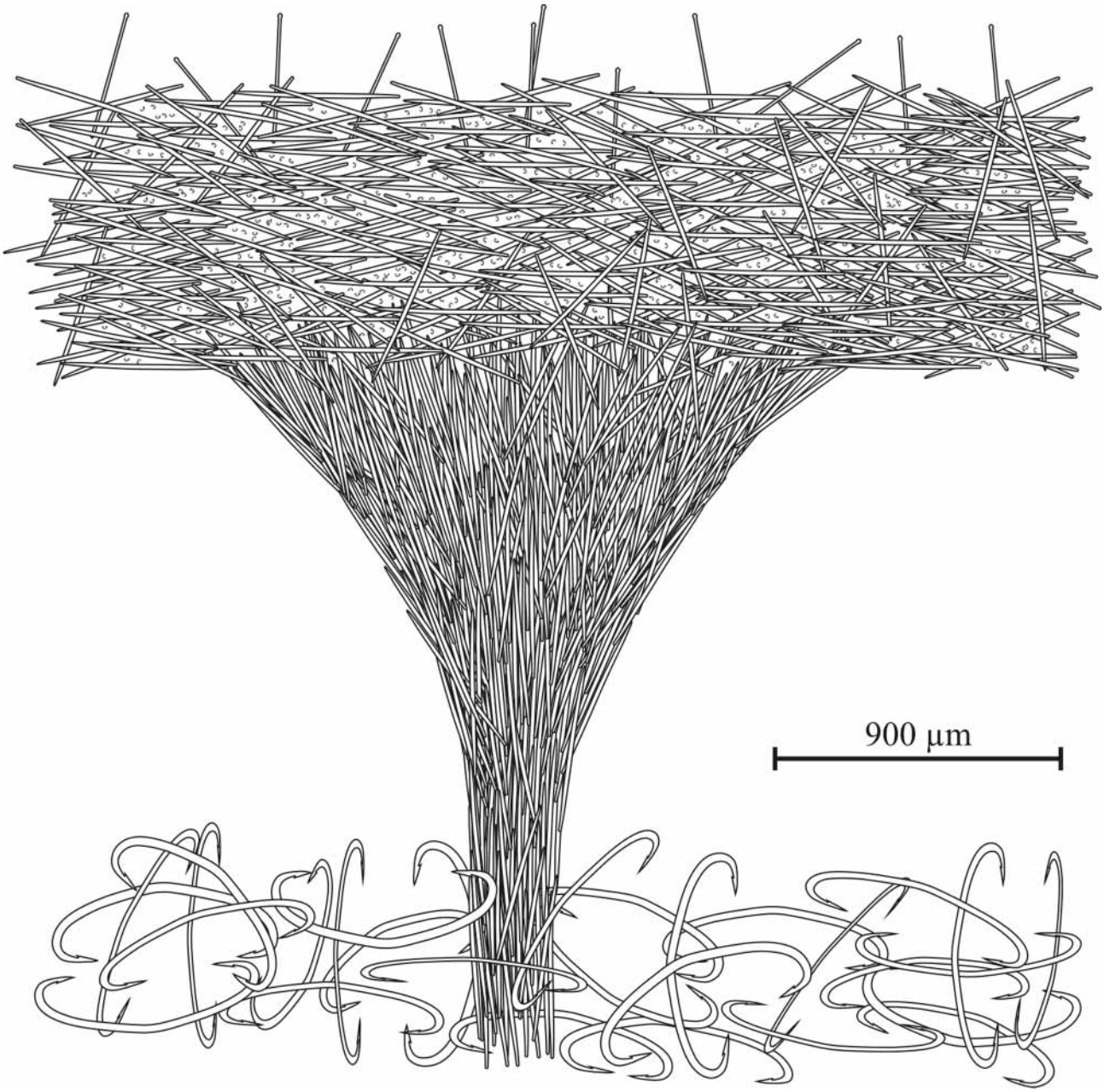

FIGURE 13. Skeletal arrangement of *Pozziella neuhausi* sp. nov.

Discussion: *P. neuhausi* sp. nov. has spherical tyles of the exotyles, which is shared with two other species of the genus: *P. clavisepta* and *P. aperta*, whereas the tyles of the remaining two species, *P. cerilla* sp. nov. and *P. lueteri* sp. nov. are claviform. The exotyles of *P. clavisepta* and *P. aperta* are much shorter and thicker than those of *P. neuhausi* sp. nov., which are the longest and most slender of the whole genus, shown by the form indexes: 0.027 for *P. neuhasi* sp. nov., and for *P. clavisepta* and *P. aperta* 0.045 and 0.088, respectively. Moreover, the tyle of *P. neuhausi* sp. nov. is covered with a thin layer of granulae, whereas the tylar surfaces of the other four species display irregularities occasionally resembling creases. The exotyles of *P. neuhausi* sp. nov. neither form a uniform layer nor are they arranged in bundles in the ectosome.

The cyrtancistras of *P. neuhausi* sp. nov. have, like those of *P. cerilla* sp. nov., an angle, but in *P. cerilla* sp. nov. it is much more pronounced. The remaining species of the genus lack this angulation, except *P. aperta*, but there it occurs only in the small cyrtancistras. *P. neuhausi* sp. nov. cyrtancistras are situated at the base of

the sponge, a characteristic that differentiates it from *P. cerilla* sp. nov., *P. lueteri* sp. nov. and *P. clavisepta*, in which they are dispersed in the ectosome. *P. neuhausi* sp. nov. clearly differs from the other four known species of *Pozziella*.

***Pozziella lueteri* sp. nov.**
(Fig. 3, 14–17, 19)

Examined material: Holotype ZMB Por 12648 (preparations at O.M. deposited at ZMB). Type locality: Cocos Ridge; from 05º52.11 N, 087º34.36 W to 05º51.82 N, 087º34.41 W; depth 760–968 m.; station 72; campaign SO 144–3a.

Description

Habitus: 1–3 mm thick body, incrusting and rounded (Fig. 14 A, B), covering surface of 9 x 8 cm. Orangey yellow colour in alcohol. Soft, flexible and fragile consistency. Rough texture. Osculum in centre lateral position. Sediment embedded in base of specimen.

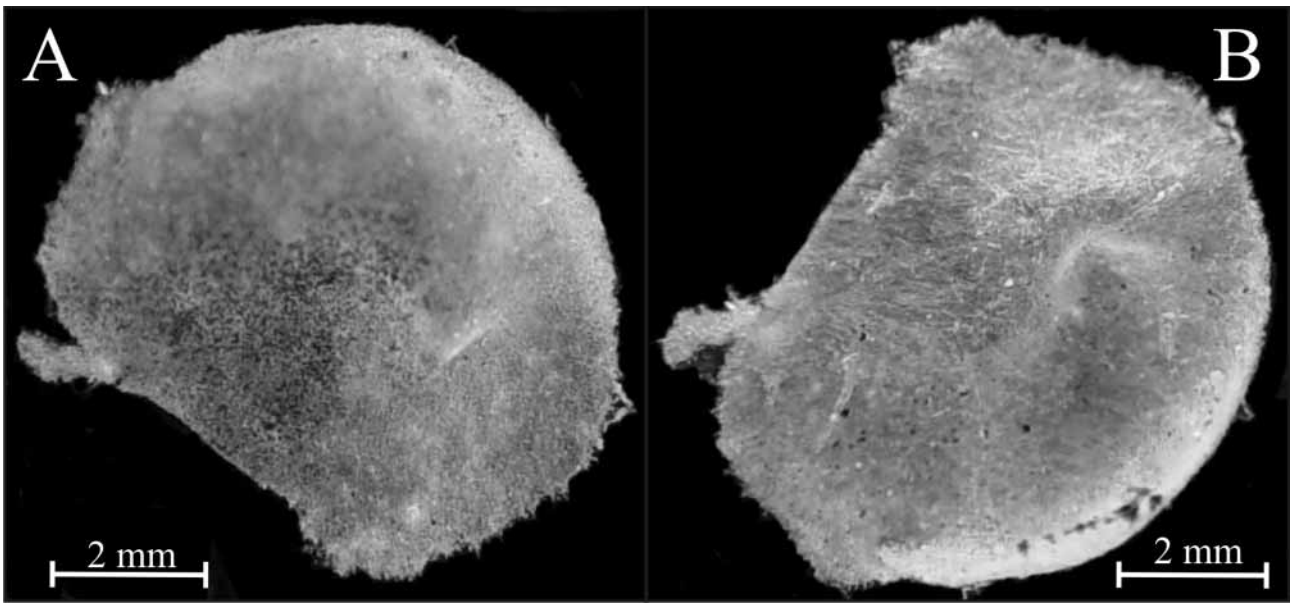

FIGURE 14. A, B. Habitus of *Pozziella lueteri* sp. nov.

Spicules

Megascleres: Small styles II, smooth, fusiform and slightly curved (Fig. 15 A; 16 A–C), short pointed ends acerate, opposite end rounded, length 280–360 µm (M. ± S.D., 303.5 ± 26.98 µm) and width 10–12.5 µm in mid-region (M. ± S.D., 11.60 ± 1.22 µm), decreasing towards rounded end to 2.5–7.5 µm (M. ± S.D., 5.20 ± 1 µm) (form index: 0.037).

Straight exotyles, short and strong. Tyle oval, drop-shaped with regular wart-like formations encrusting surface (Fig. 16 E). Diameter of exotyle shaft decreasing towards rounded end (Fig. 15 B; 16 D) and smooth end (Fig. 16 F). Exotyle length 145–172.5 µm (M. ± S.D., 153.40 ± 6.69 µm), width 10–15 µm (M. ± S.D., 12.6 ± 1.69 µm), tyle width 20–37.5 µm (M. ± S.D., 23.70 ± 3.76 µm) (form index: 0.154).

Microscleres: Large and scarce cyrtancistras, with semilanceolate ends (Fig. 15 C; 16 H), regularly curved and vertically elongated C-shape, with single denticle on each end (Fig. 16 G, H). Cyrtancistra size: height 490–620 µm (M. ± S.D., 555.71 ± 39.10 µm) and width 20–27.5 µm (M. ± S.D., 23.93 ± 2.44 µm) (form index: 0.41). C-shaped small and strong type II sigmas (Fig. 15 D; 16 I): height 16–20 µm (M. ± S.D., 17.88 ± 1.27 µm) and width 1 µm (M. ± S.D., 1.0 ± 0.0 µm) (form index: 0.38).

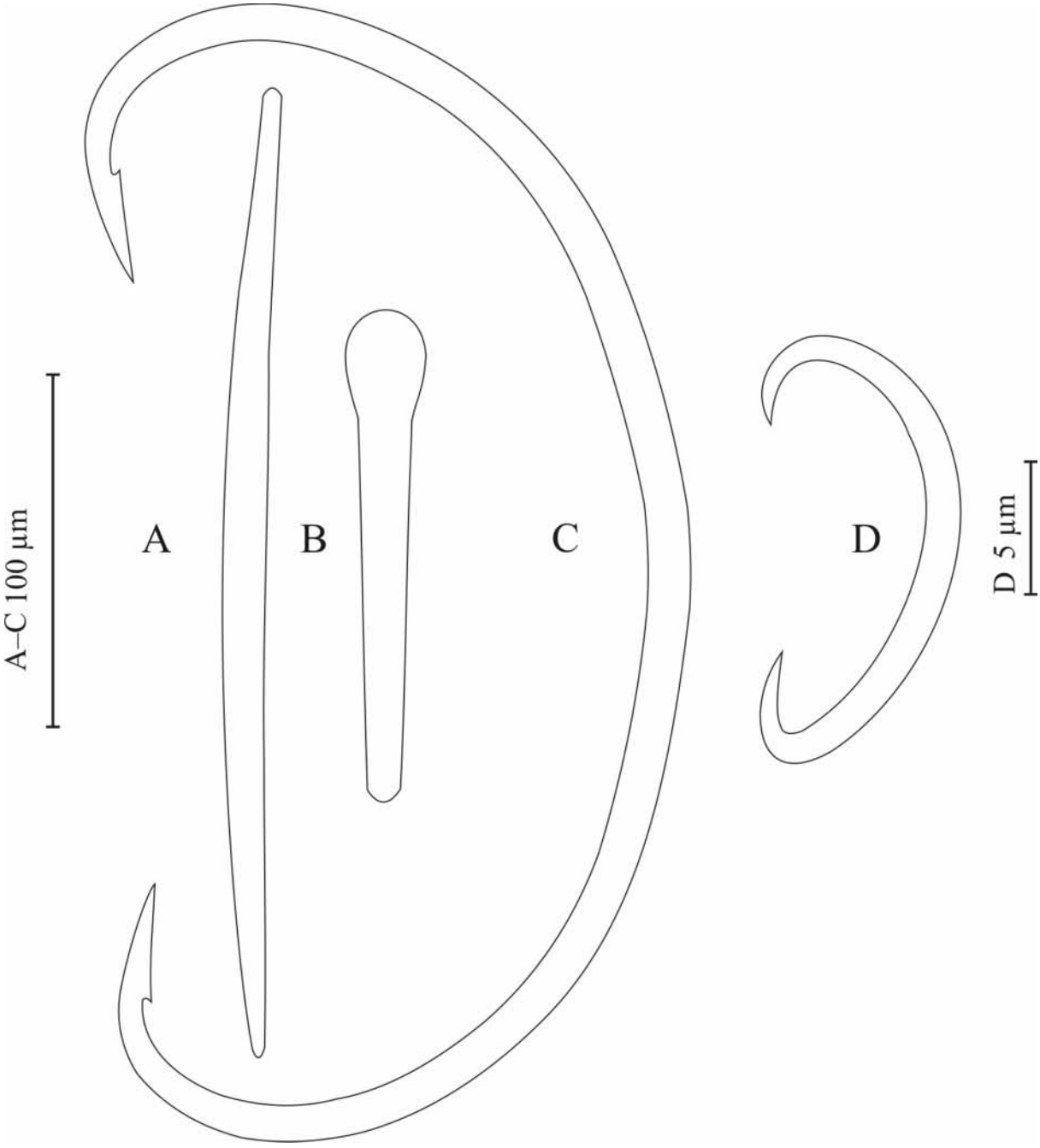

FIGURE 15. Spicules of *Pozziella lueteri* sp. nov. A. Style II; B. Exotyle; C. Cyrtancistra I; D. Sigma II.

Skeleton

Skeletical arrangement: Endosomal plurispicular fascicula of styles arranged in bunches near ectosome (Fig. 17). Ectosome consisting of a layer of irregularly arranged tangential styles and exotyles at right angles to surface, forming superficial, uniform crust with tyles pointing out. Cyrtancistras dispersed in ectosomal stylar layer with sigmas scattered in between.

Distribution: Galápagos archipelago, Cocos Ridge; from 05º52.11 N, 087º34.36 W to 05º51.82 N, 087º34.41 W; depth 760–968 m.

Derivatio nominis: This species is dedicated to Dr. Carsten Lüter for his kindness and providing the facilities to carry out this study.

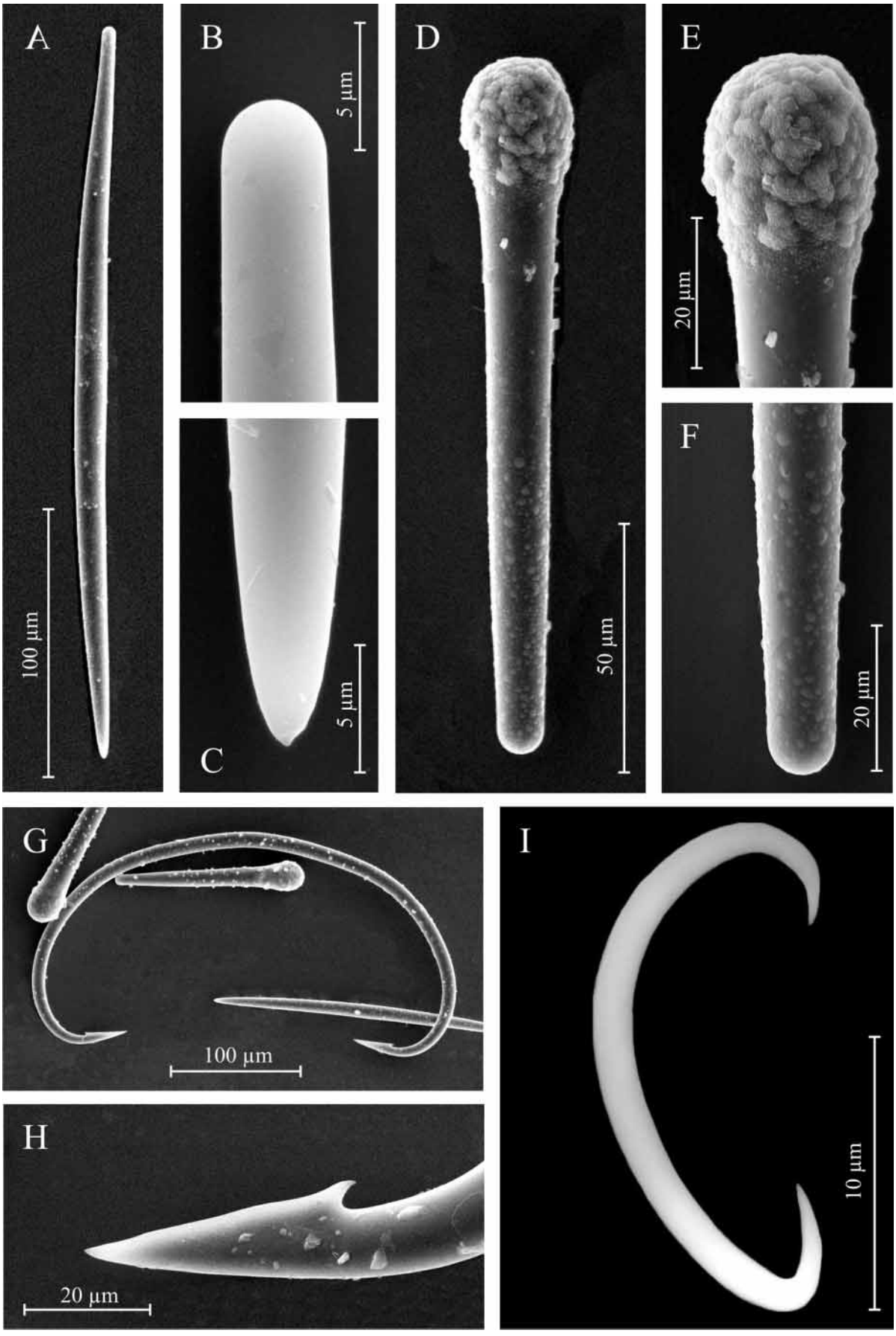

FIGURE 16. Spicules of *Pozziella lueteri* sp. nov. A. Style II; B. Rounded end of a style II; C. Pointed end of a style II; D. Exotyle; E. Tyle of an exotyle; F. Rounded end of an exotyle; G. Cyrtancistra I; H. Lanceolate termination of cyrtancistra I; I. Sigma II.

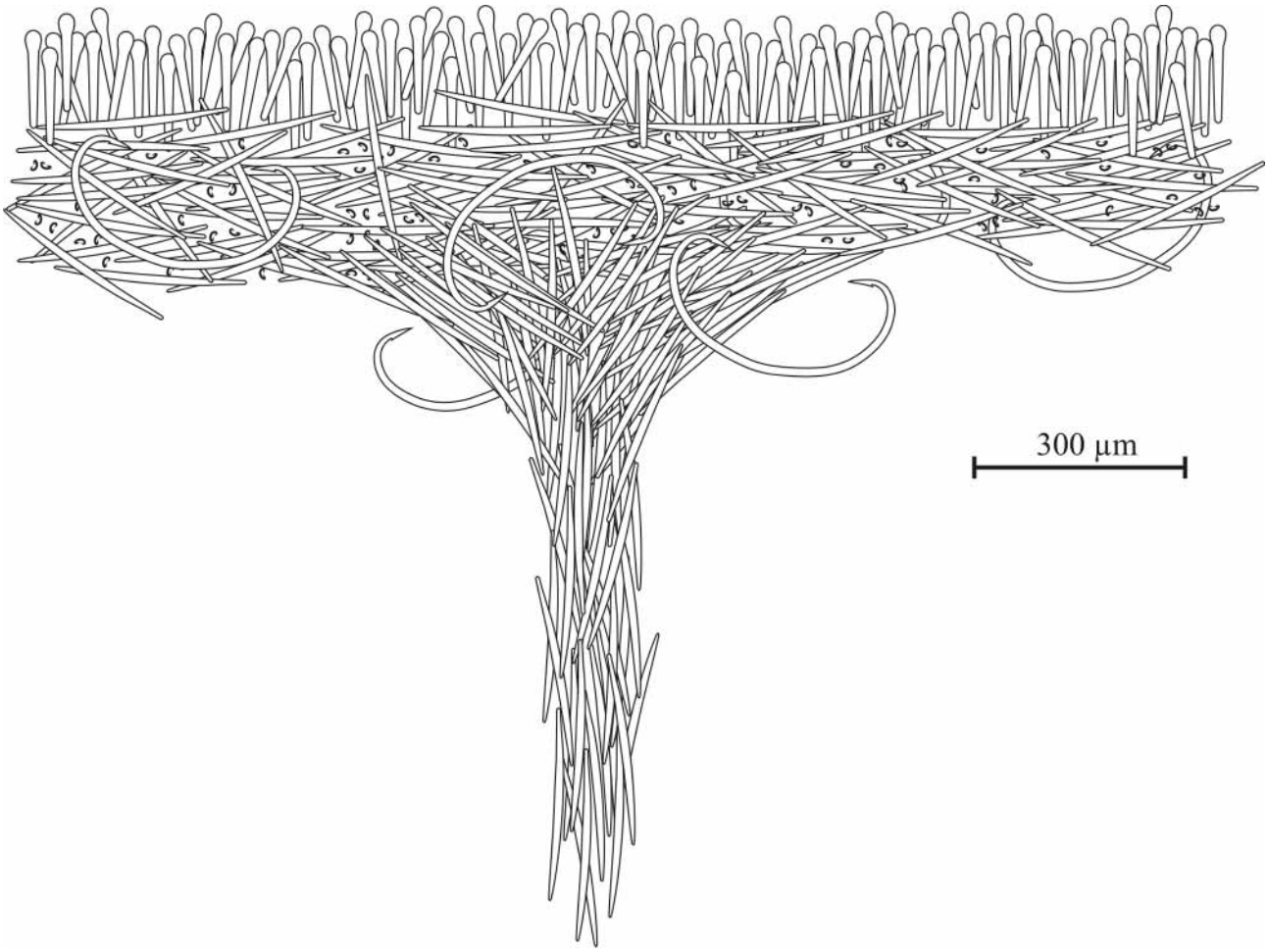

FIGURE 17. Skeletal arrangement of *Pozziella lueteri* sp. nov.

Discussion: *P. lueteri* sp. nov. clearly differs from the other species of the genus in the form and size of its exotyles with their oval, drop-shaped tyles. *P. cerilla* sp. nov. exotyles have similar tyles, but differ from those in *P. lueteri* sp. nov. because the tylar irregularities extend along ¼ of the shaft. Moreover, the exotyles of *P. lueteri* sp. nov. are the shortest and thickest of the whole genus, which makes this species very distinctive when comparing the form indexes, e.g. *P. lueteri* sp. nov. 0.154 and *P. cerilla* sp. nov. 0.065.

The arrangement of exotyles in the ectosome differs from all other species of *Pozziella* in forming a uniform layer.

The cyrtancistras of *P. lueteri* sp. nov., unlike those of *P. cerilla* sp. nov. and *P. neuhausi* sp. nov., are regularly curved, i.e. more similar to *P. clavisepta* and *P. aperta*, but with ends closer together than in the latter two species. *P. clavisepta*, *P. aperta* and *P. lueteri* sp. nov. are easily differentiated by the shape of their cyrtancistras and due to the fact that the first one has two types of sigmas, whereas the other two have only one type. According to arguments exposed above, *P. lueteri* sp. nov. is clearly a new species.

Similarity analysis

To compare the five species of *Pozziella*, a presence-absence matrix of several biometric and morphologic characters of the spicules was devised for a similarity analysis (Table 1). The similarity matrix shows that *P. neuhausi* sp. nov. is the most distinctive from the other species, and especially compared to *P. aperta* with

which it shares only 27.8% similarity (Table 2). *P. clavisepta* and *P. aperta* are the most similar species, with a similarity of 75%. The analysis furthermore shows two defined species pairs (Fig. 18): one consisting of *P. cerilla* sp. nov. and *P. lueteri* sp. nov., the other of *P. clavisepta* and *P. aperta*; *P. neuhausi* sp. nov. clusters separately. This classification agrees with the geographical distribution of the species, with the Atlantic species clustering together and two of the Pacific species closely associated to each other. The Pacific *P. neuhausi* sp. nov. clusters separately, but is closer to the Pacific species than to the Atlantic species.

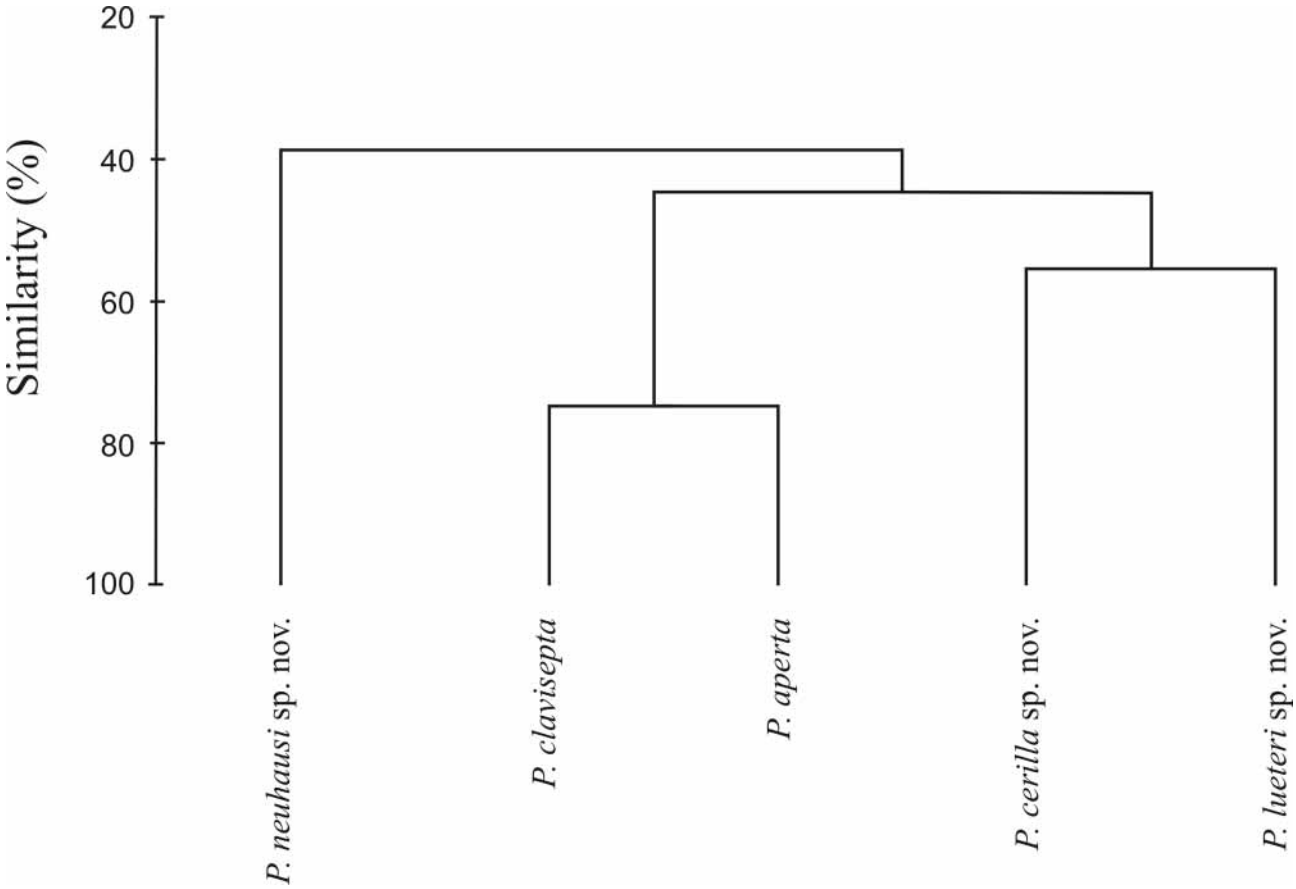

FIGURE 18. Dendrogram of Bray-Curtis similarities of the five known species of *Pozziella* according to spicular features.

TABLE 1. Spicular features of the five known species of *Pozziella* used in the similarity analysis**.**

	P. clavisepta	*P. aperta*	*P. cerilla* sp. nov.	*P. neuhausi* sp. nov.	*P. lueteri* sp. nov.
Style II occurs	1	1	1	0	1
Style I occurs	1	0	0	1	0
Style II form index >0.030	1	1	0	0	1
Style II form index <0.030	0	0	1	0	0
Style II is straight	0	0	1	0	0
Style II tends to be slightly curved	1	1	0	0	1

.....continued

TABLE 1 (continued)

	P. clavisepta	*P. aperta*	*P. cerilla* sp. nov.	*P. neuhausi* sp. nov.	*P. lueteri* sp. nov.
Style I straight or slightly curved	1	0	0	1	0
Exotyle length <250 µm	1	1	1	0	1
Exotyle length >250 µm	0	0	0	1	0
Exotyle form index <0.1	1	1	1	1	0
Exotyle form index >0.1	0	0	0	0	1
Straight exotyle	0	0	1	1	1
Exotyles tend to be slightly curved	1	1	0	0	0
Exotyle shaft smooth	1	1	0	0	1
Exotyle shaft partially irregular	0	0	1	1	0
Diameter of exotyle shaft uniform	1	0	1	1	0
Diameter of exotyle shaft decreasing away from mid-region	0	0	0	0	1
Spicular body of exotyle showing growing diameter towards rounded end	0	1	0	0	0
Exotyle with spherical tyle	1	1	0	1	0
Exotyle with oval tyle	0	0	1	0	1
Exotyle tyle with coarse irregularities	1	1	1	0	1
Exotyle tyle with fine irregularities	0	0	0	1	0
Exotyle tyle diameter <20 µm	1	1	1	1	0
Exotyle tyle diameter >20 µm	0	0	0	0	1
Cyrtancistra I large (>300 µm)	1	1	1	1	1
Cyrtancistra II small (<160 µm)	0	1	0	0	0
Cyrtancistra I without angle	1	1	0	0	1
Cyrtancistra with soft angle	0	0	0	1	0
Cyrtancistra with pronounced angle	0	0	1	0	0
Cyrtancistra I height <500 µm	1	1	0	0	0
Cyrtancistra I height >500 µm	0	0	1	1	1
Cyrtancistras I form index <0.30	0	0	0	1	0
Cyrtancistras I form index 0.30–0.40	1	1	0	0	0
Cyrtancistras I form index >0.40	0	0	1	0	1
Sigma I large (>180 µm)	1	0	0	0	0
Sigma II small (<30 µm)	1	1	1	1	1
Sigma II height <20 µm	0	0	1	1	1
Sigma II height 20–25 µm	0	1	0	0	0
Sigma II height >25 µm	1	0	0	0	0
Sigma II form index <0.40	0	1	0	0	1
Sigma II form index 0.40–0.50	1	0	0	1	0
Sigma II form index >0.50	0	0	1	0	0

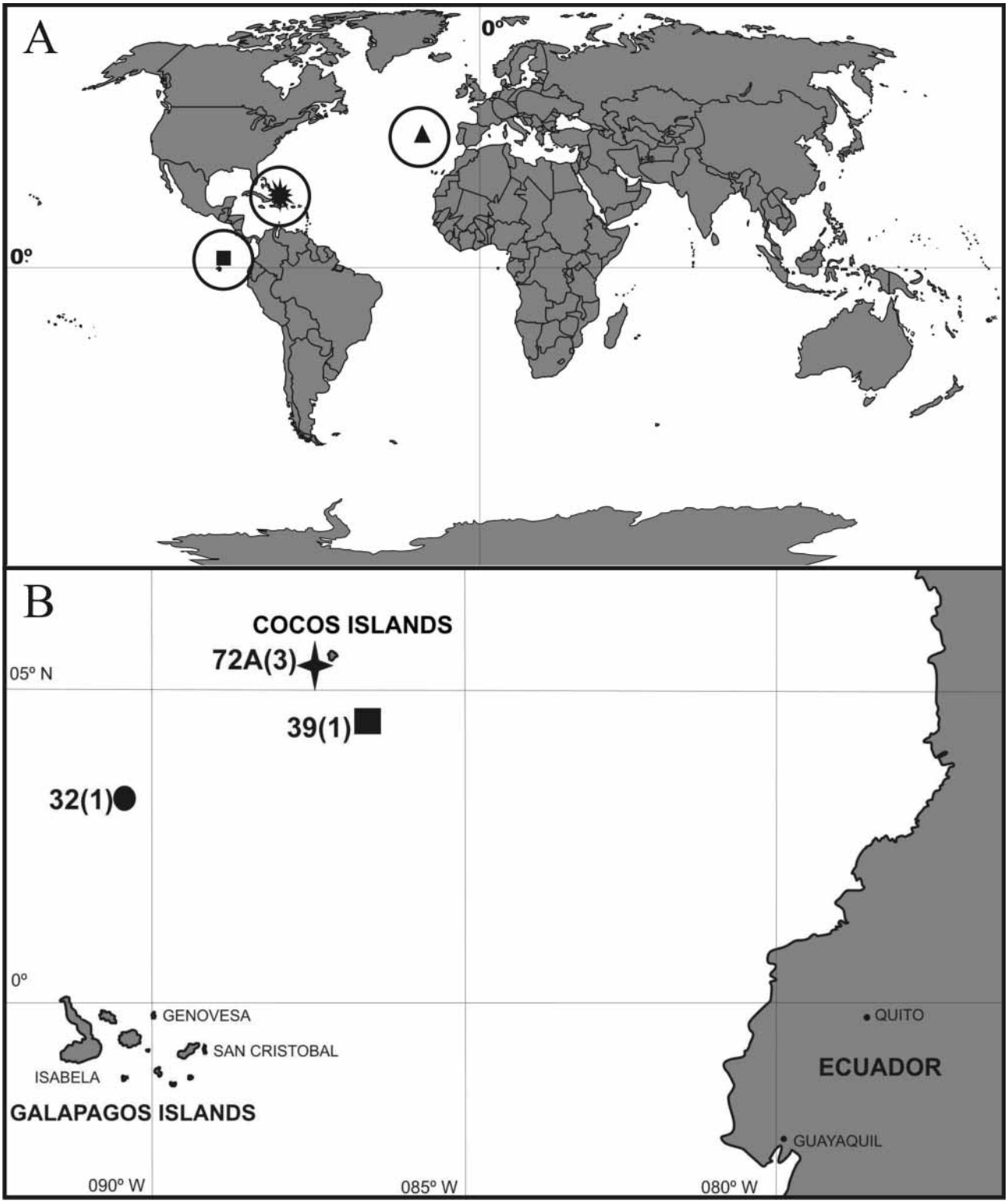

FIGURE 19. A. Known distribution of the genus *Pozziella* species: ▲ *P. clavisepta*, ✹ *P. aperta*, ■ *P. cerilla* sp. nov., *P. neuhausi* sp. nov., *P. lueteri* sp. nov. B. Map of the collecting stations of the genus *Pozziella* species: ■ *P. neuhausi* sp. nov., ● *P. cerilla* sp. nov., ✚ *P. lueteri* sp. nov.

The analysis depended on a number of key factors: *P. neuhausi* sp. nov. is the only species that has no small styles (type II). Although it shares a similar spicule compostion with *P. cerilla* sp. nov. and *P. lueteri* sp.

nov., its exotyles are much longer and have a different tyle shape and ornamentation compared to *P. cerilla* sp. nov. and *P. lueteri* sp. nov., resulting in the separate clustering of *P. neuhausi* sp. nov. Exotyles have a profound taxonomic value in the genus *Pozziella*. This pairing of *P. clavisepta* and *P. aperta*, and of *P. cerilla* sp. nov. and *P. lueteri* sp. nov. may be related to the similarity of the exotyles in each pair. Overall, the similarity between *P. clavisepta* and *P. aperta* is remarkable, differing only in: the presence of two types of styles in *P. clavisepta* and the fact that it has two types of sigmas, whereas *P. aperta* has two types of cyrtancistras. Regarding *P. cerilla* sp. nov. and *P. lueteri* sp. nov., they also differ in some spicular features: irregularities of the exotyle tyle and angulation of the cyrtancistras. Further differences derive from spicule shapes, as evidenced by the form indices of the styles, exotyles and sigmata.

TABLE 2. Matrix of Bray-Curtis similarities (%) of the five known species of *Pozziella* based on spicular features.

	P. clavisepta	*P. aperta*	*P. cerilla* sp. nov.	*P. neuhausi* sp. nov.	*P. lueteri* sp. nov.
P. clavisepta	–				
P. aperta	75.00	–			
P. cerilla sp. nov.	41.02	37.84	–		
P. neuhausi sp. nov.	47.37	27.78	51.43	–	
P. lueteri sp. nov.	46.15	54.05	55.55	28.57	–

Species key of the genus *Pozziella*

(1) Two cyrtancistra sizes ..... *Pozziella aperta*
One cyrtancistra size ..... (2)
(2) Two style and sigma sizes ..... *Pozziella clavisepta*
One style and sigma size ..... (3)
(3) Long exotyles (>370 µm). Spherical tyle, finely granulated ..... *Pozziella neuhausi* sp. nov.
Short exotyles (<370 µm). Claviform tyle, with thick creases ..... (4)
(4) Cyrtancistras with angle in mid-region ..... *Pozziella cerilla* sp. nov.
Cyrtancistras with regular curvature ..... *Poziella lueteri* sp. nov.

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