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Excavating Sponge Species from the Indo-Pacific Ocean

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Barbara Calcinai, Giorgio Bavestrello, and Carlo Cerrano (2005) Excavating sponge species from the Indo-Pacific Ocean. *Zoological Studies* **44**(1): 5-18. Six excavating sponge species from the Indo-Pacific area (North Sulawesi, Indonesia, and the Philippines) are described here. Four of these species recorded in Indonesia are new (*Cliona albimarginata*, *Cliona favus*, *Cliona liangae*, and *Cliona utricularis*); for *Cliona dichotoma*, collected in Indonesia and the Philippines, this is the 2nd record which enlarges its geographic distribution and allowed us to describe its skeletal arrangement. A redescription of the skeletal arrangement and spicule features of *Cliona mucronata* is given. http://www.sinica.edu.tw/zool/zoolstud/44.1/5.pdf

Key words: Excavating sponges, Coral reefs, Porifera, Indonesia, Philippines.

In this paper, a collection of excavating sponge species from the Bunaken Marine Park (North Sulawesi, Indonesia) and the Philippines is described. The area of the Pacific Ocean comprising the Indonesian Archipelago, the Philippines, the Malaysian Peninsula, and New Guinea is considered a center of evolutionary radiation, where the highest marine biodiversity in the world is present (Sheppard and Wells 1988, Roberts et al. 2002) due to its geographic position, geological history, and wide habitat diversity (Tomascik et al. 1997). Unfortunately these areas are also poorly explored in comparison to other areas of the world.

Regarding the Indonesian Archipelago, in recent years new marine genera and species have been described (Ng and Tomascik 1994, Kott 1995, Lourie and Randall 2003), and the number of new records could increase as a large part of the material collected during past scientific expeditions, (e.g., the Siboga expedition and Snellius II expedition) still remains to be classified (Tomascik et al. 1997).

The Indonesian spongofauna is considered to be composed of almost 830 species (with probably some synonymies) (Van Soest 1989), with a high rate of dissimilarity existing among different areas (Amir 1992). Tomascik et al. (1997) reported a list of boring sponges made by Van Soest of the Zoological Museum of Amsterdam, including 16 species belonging to the family Clionaidae, order Hadromerida (including the genera *Cliona* and *Cliothosa*), 17 species belonging to the family Spirastrellidae, order Hadromerida and 5 species of *Aka* belonging to the family Ploeodictyidae, order Haplosclerida (under revision at the Zoological Museum of Amsterdam). After a recent revision made by Rützler (2002), some species, assigned to the family Spirastrellidae may now be included in the Clionaidae.

Regarding Philippine sponges only 16 papers are reported Gomez (1980). Some of those are derived from the study of collections by important expeditions such as the *Challenger* (Ridley and Dendy 1886, Ridley and Dendy 1887, Schulze 1887, Sollas 1888) and *Albatros* (Wilson 1925). The most recent by Lévi and Lévi (1989) reports on results of the Campaigns Musorstom 1 and 2 in the Philippines. In 2000, Hooper et al. produced a checklist of sponges in which the following exca-

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vating species are reported from the Philippines: *Cliona* sp. from *Luzon*, *S. inconstans* from Zambamga, *S. vagabunda* from Puerta Galera, *Spirastrella* (*Cliona* ?) spp. from the Bohol Sea, and *Aka* sp. from Cebu.

This paper deals with the results of the study of a large collection of boring sponges from the Bunaken Marine Park (North Sulawesi, Indonesia) and from the Philippines and represents a 1st contribution to improving the knowledge of the excavating sponges present in these poorly investigated areas.

MATERIALS AND METHODS

Indonesian samples were collected during expeditions conducted in Aug. 1999, Mar. 2000, and May 2002 in the area of the Bunaken Marine Park (North Sulawesi), in the framework of cooperative programs with Sam Ratulangi University (Manado). In this area, sponges were collected by diving from the tidal zone to a depth of 25 m. Sample sites are shown in figure 1. The material was preserved in 4% formalin-seawater or in 70% alcohol, or was dried. Samples from the Philippines were found into stony corals illegally imported into Italy and confiscated by the Italian Corpo Forestale dello Stato who assigned them for scientific purposes to the University of Genoa, Italy. No information about the collection sites was available for this material. This material was preserved dry.

For the study of spicules, small fragments of sponge tissue were heat-dissolved in nitric acid, rinsed in water, and dehydrated in ethanol, and then the spicules were mounted on microscope slides. The same method was followed for the scanning electron microscopic (SEM) observations. Spicules were put on stubs and sputtered with gold. Tissues present in the chambers and in the papillae were separately treated. Where the sponge dimensions were too exiguous, spicule preparations were made directly on the slide to avoid losing microscleres.

For the group of species described herein (*Cliona dichotoma* Calcinai et al., 2000, *C. mucronata* Sollas 1878 , and *C. liangae* sp. nov.), morphometric analysis of the megascleres was performed to clarify the dubious presence of 2 kinds of megascleres. The dimensions (width and length) of 100 spicules of 1 specimen were taken for each species. Data used to prepare the size-frequency distribution diagrams were obtained by the program of image processing and analysis in Java (ImageJ). Results were compared to *Cliothosa* (*Cth.*) *hancocki* (Topsent 1888), collected in Indonesia, but not described in this paper and with the type material of *C. aurivilli* (Lindgren 1897) (Swedish Museum of Natural History: SMNH 1190-1189-1187-23).

Attention was devoted to the study and characterization of the macroscopic erosion pattern considered to be an important feature for species discrimination (Rützler 1974, Bromley and D'Alessandro 1984).

The microscopic erosion of the excavation walls was studied by SEM. Small pieces of eroded

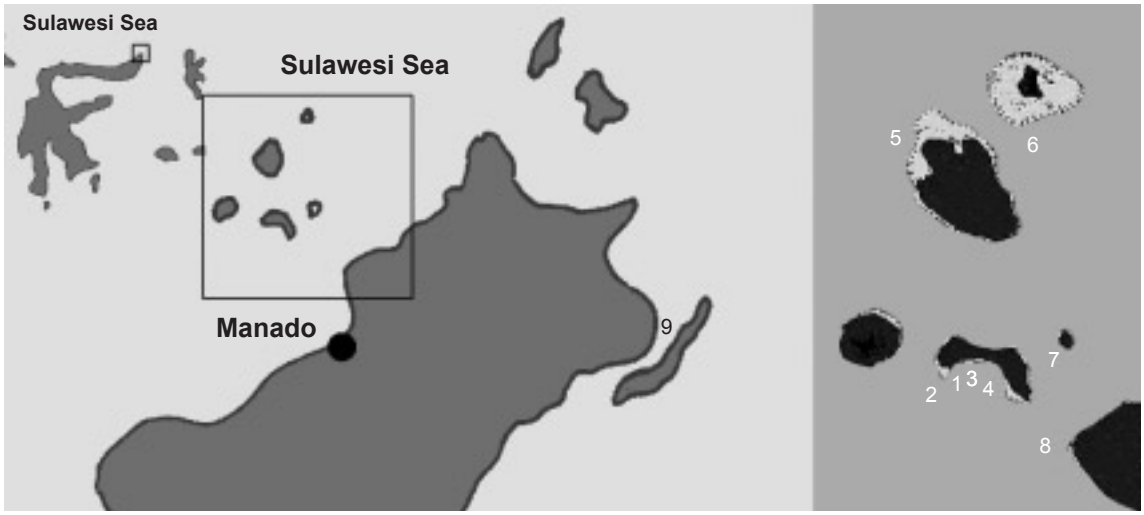

Fig. 1. Sampling sites in the area of Bunaken Marine Park (North Sulawesi, Indonesia). 1, Alung Banua; 2, Fukui; 3, Liang; 4, Likuan II; 5, Manteaghe; 6, Nain; 7, Siladen; 8, Tanjung Pisok; 9, Lembeh Strait

substrata were cleaned from the tissue by boiling in hydrogen peroxide, washing in water and alcohol, and drying.

For some specimens, it was not possible to take particular measures of the spicules because of their paucity in the sample or their absence; in such cases, they were not reported. Regarding spiraster measurements, "i.s." indicates that the measure includes the spines, while "e.s." on the contrary indicates that the spines were excluded.

Holotypes of the new species are deposited in the Museum of Natural History of Genoa (MSNG), Italy; paratypes are deposited in the 1st author's personal collection.

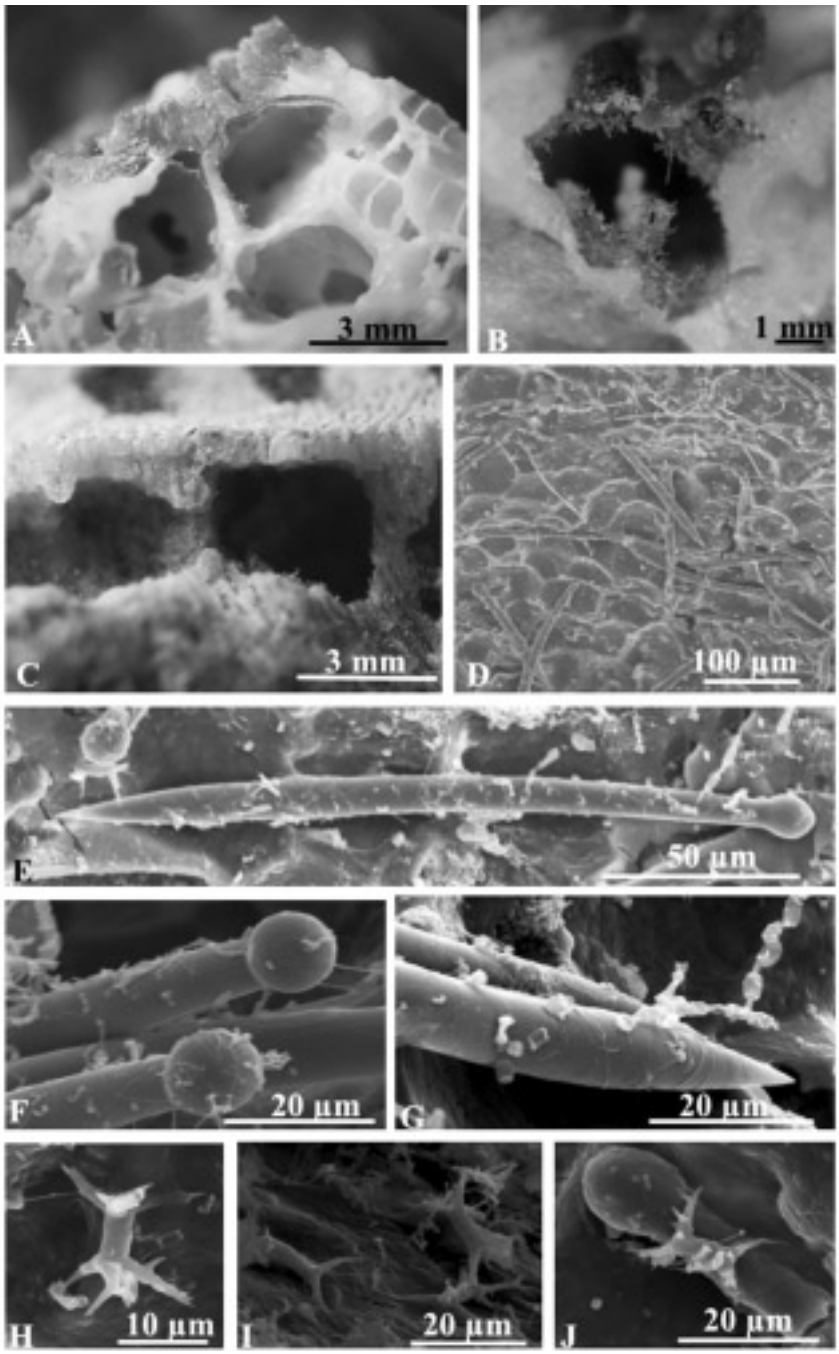

Fig. 2. *Cliona dichotoma*. (A-C) Boring chambers; (B) boring chamber lined by sponge tissue and connected to the exterior by a short papillar canal; (D) erosion scars on the chamber wall; (E) ensiform tylostyle; (F, G) details of the heads and of tips of the ensiform tylostyles; (H-J) branched amphiasters.

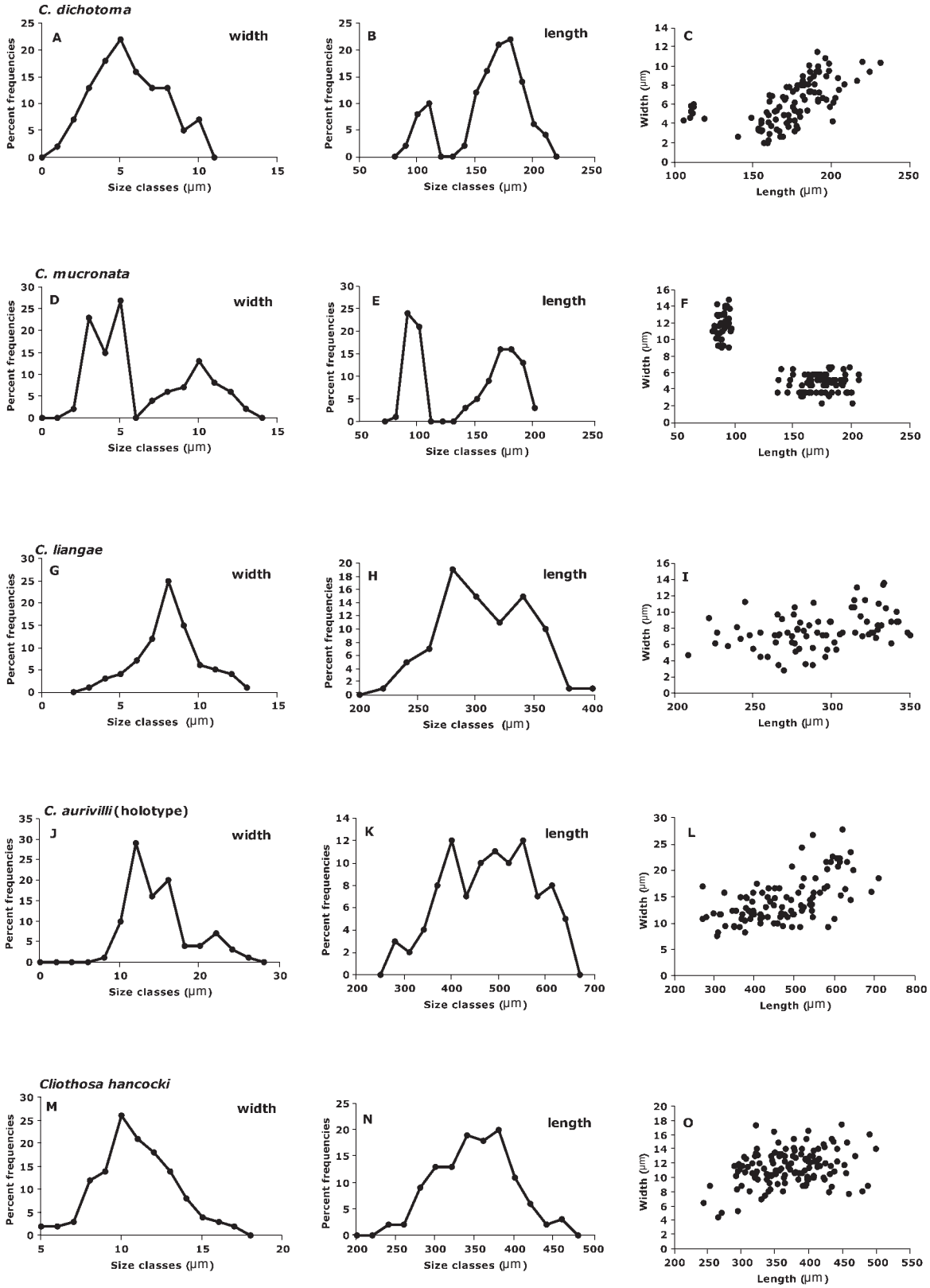

Fig. 3. Size-frequency distributions of tylostyle lengths and widths and length vs. width diagrams referring to the Indonesian species characterized by branched amphiasters.

RESULTS

Family Clionaidae
Genus *Cliona* (Grant)
Cliona dichotoma Calcinai, Cerrano, Sarà, Bavestrello, 2000

Examined material: Indonesian material: MTR, Liang, Aug. 1999, tidal zone; Philippine material: Phil 10, Phil 28, Phil 45, Phil 59, Phil 66.

Substrate: *Tridacna* sp.; *Pocillopora verrucosa*, and *Heliopora coerulea*.

Description: An elusive excavating sponge only recorded in the alpha form. Very small papillae, sometimes merging (1-2 mm), not easily recognizable (Fig. 2A, B). In dry preserved material, tissue color yellowish-brown.

Erosion pattern: Very short papillar canals connecting papillae to boring chambers below the surface. Chambers irregularly ovoid, sometimes sub-spherical or polygonal, 1-3 mm wide (Fig. 2A-C). Erosion scars on chamber wall smooth and rounded, 25-86.3 (average, 52) µm in diameter (Fig. 2D).

Skeleton: Tylostyles in papillae regularly arranged in a palisade pattern, with tips toward the exterior. In choanosomal tissue, tylostyles irregularly arranged with dispersed spirasters. In forami-

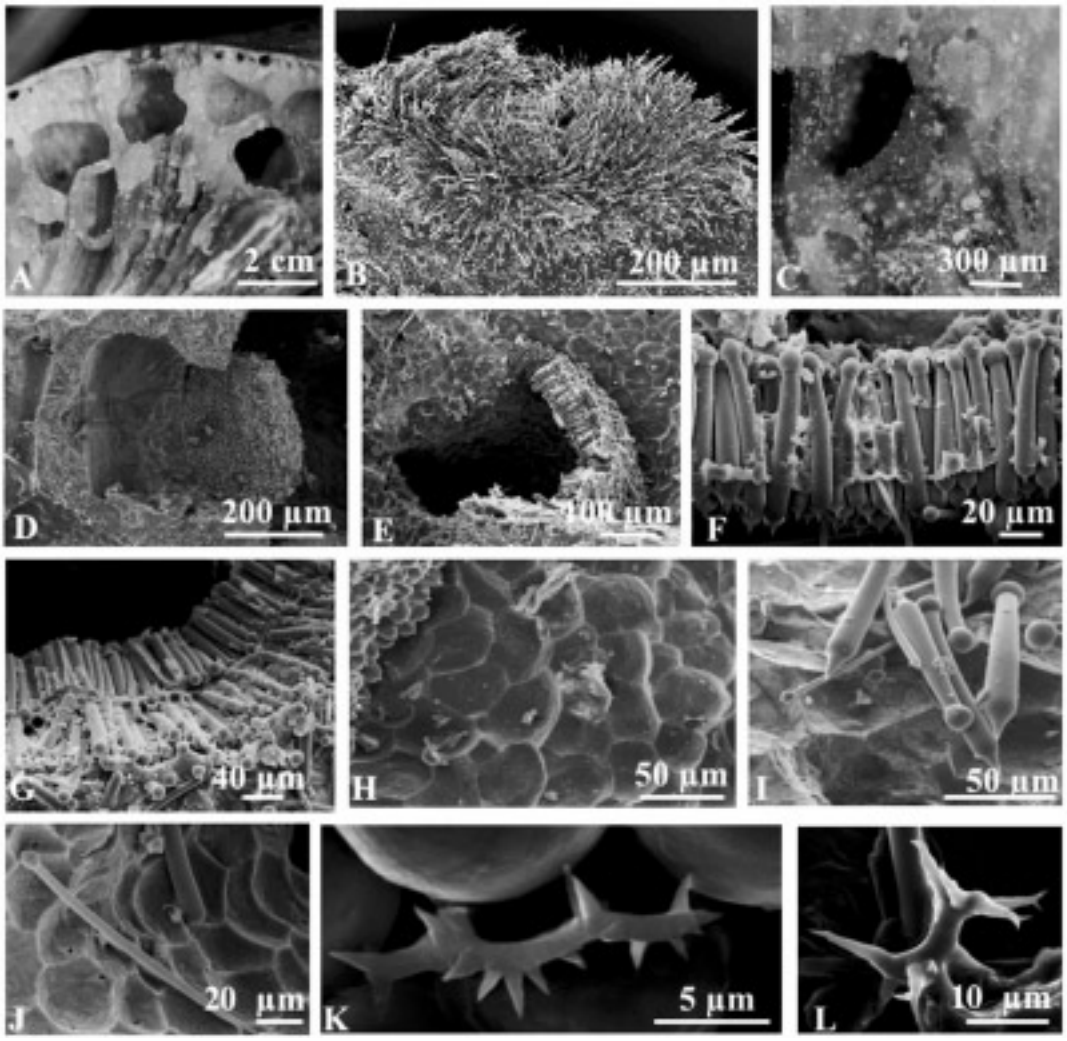

Fig. 4. *Cliona mucronata*. (A) Boring chambers in a madreporian coral; (B) arrangement of the thin tylostyles in an inhalant papilla; (C, D) regular arrangement of tylostyles in a foramina connecting 2 boring chambers; (E) skeletal structure of the sponge tissue lining a boring chamber showing the regular arrangement of mucronate tylostyles with the heads adherent to the chamber wall and the tips toward the center; (F) magnification of the previous image showing the palisade of mucronate tylostyles; (G) detail of a portion of sponge tissue composed of a double layer of mucronate tylostyles; (H) erosion scars on the chamber wall; (I) mucronate tylostyles; (J) thin tylostyle; (K) spiraster showing the spiralate arrangement of the spines; (L) spiraster transformed in a branched amphiaster.

na connecting chambers, tylostyles arranged in tracts.

Spicules: Megascleres. Short, ensiform, slightly curved tylostyles with hastate tips (Fig. 2E, G) Phil 59: 157-202.5 (178.9 ± 13.3) x 5-12.5 (9.6 ± 2.3) µm; MTR: 150-205 (190.4 ± 12.1) x 7.5-12 (10.4 ± 1.6) µm. Heads generally spherical, sometimes with lateral outgrowths (Fig. 2E, F) Phil 59: 8.7-15 (12.2 ± 2) µm; MTR: 10-12.5 (12.1 ± 1.5) µm. Numerous smaller tylostyles, similar in shape to those previously described, are present.

Microscleres: Amphiaster like spirasters, with long, dichotomically branched spines (Fig. 2H-J) Phil 59: 12.5-20 (17.5 ± 2.3) s.i. x 2.5 µm; MTR: 15-18.7 (18.4 ± 1.6) s.i. x 2.5 µm. Some with bent axes or with spines in central part of axis.

Remarks: This is the 2nd record of this species originally described from the Maldives (Calcinai et al. 2000). These records from the Philippines and Indonesia increase the geographical distribution of *C. dichotoma* from the Indian Ocean to the Pacific area. In the Indonesian sample, *C. dichotoma* shared the substratum in association with other species such as *Pione carpenteri* and *Thoosa latellieri*.

The spicule length of this species shows a bimodal size frequency distribution (Fig. 3A) undetectable in the spicule widths (Fig. 3B). The length/width diagram separates a small group of little spicules from a larger one characterized by a common pattern of growth (Fig. 3C). Although the microscleres of *C. dichotoma* are only branched amphiasters, the tips of the spines are always simple, without the verticils of hooks of *Cth. hancocki*.

Cliona mucronata Sollas, 1878

Examined material: Indonesian material: BU 16 bis, Alung Banua, 17 Mar. 2000, 21 m; BU 79, Lekuan II, 22 Mar. 2000, 5 m; BU 501, Manteaghe, 29 May 2002, 5 m. Philippine material: Phil 2, Phil 4, Phil 16, Phil 24, Phil 30, Phil 52.

Substratum: *Porites* sp., *Diploria* sp., *Heliopora coerulea*, and *Pocillopora verrucosa*.

Description: This species recorded in both the Indonesian and Philippine samples, but with very elusive presence in small cavities. Papillae, only rarely detected, small (300-800 µm), circular, and close to one another (Fig. 4A, B). Dried samples yellowish-beige to brown.

Erosion patterns: Erosion chambers small in diameter (0.9-2.5 mm Bu 501; 0.6-1.5 Phil 16) (Fig. 4A), and ovoid, often with main axis parallel to substrate surface and connected to papillae by short papillar channels (< 1 mm long) (Fig. 4A). Polygonal chips, derived by sponge erosion and observed in chambers are small about 16 µm. Erosion scars on chamber walls 26-63 (average, 41) µm in Indonesian samples and 30-65 (average, 46) µm in Philippine samples (Fig. 4H).

Skeleton: In papillae, thin mucronate tylostyles regularly arranged in a palisade with tips toward exterior. Only tips of thin tylostyles visible in intact papillae (Fig. 4B). Around chamber walls a layer of mucronate tylostyles is present. The spicules are arranged side by side with their heads toward chambers walls and tips toward center (Fig. 4C, E, F). This organization also present in foramina connecting chambers (Fig. 4C, D). Double layer of mucronate tylostyles sometimes observed (Fig. 4G).

Spicules: Megascleres. Two types of tylostyles. Type I (Fig. 4F, G, I): straight, short, stout tylostyles with spherical heads and mucronate tips BU 79: 82.5-97.5 (89.16 ± 4.2) x 10-15 (12.5 ± 1.7) µm; Phil 24: 62.5-77.5 (69 ± 3.3) x 10-15 (12.5 ± 1.3) µm.

Type II (Fig. 4B, I, J): straight, thin tylostyles with oval or spherical heads and hastate tips BU 79: 145-215 (182.2 ± 17.9) x 7.5-10 (9 ± 1.1) µm; Phil 24: 112-212.3 (143.5 ± 33) x 2.5 µm.

Microscleres. Spirasters with long, very thin triangular spines (Fig. 4K), sometimes amphiaster-like (Fig. 4L) BU 79: 12.5-30 (17.1 ± 4.7) s.i. x 2.5 µm.

Geographic distribution: Molucche Is., Amboine Is., Gulf of Mannar, Mergui Archipelagos, Tulear, Vietnam, Nicobar, and Andaman Is.

Remarks: *Cliona mucronata* is characterized by 2 kinds of tylostyles, as indicated by the size frequency distributions of length and width (Fig. 3D, E) and by the length/width diagram (Fig. 3F) showing 2 different patterns of growth. Moreover, the skeletal organization of the tidy palisade of the mucronate tylostyles in the boring chambers (Fig. 4E-G) is peculiar. This organization was not believed to be present in species of the family Clionaidae that were considered to be characterized by a scattered arrangement of the tylostyles which became arranged in tracts in the gamma-stage (Rützler 2002).

In the specimens described in the literature, spirasters are very rare and were only reported by Sollas (1878) and later by Vacelet et al. (1976). In our material, spirasters are very abundant allowing us to use SEM analysis. Although several of them are branched amphiasters, the spiralate axis is always evident, and the spine tips are simple,

avoiding any confusion with those of *Cth. hancocki*.

***Cliona albimarginata* sp. nov.**

Examined material: Indonesian material: Holotype (MSNG 51937), BU 237, Manteaghe, 13 May 2001, 7-12 m, preserved in formalin; paratype Bu 50, Manteaghe, 20 Mar. 2000, 25 m.

Substratum: *Porites* sp.

Description: Beta form of this species exclusively observed (Fig. 5A, B). It covered wide area

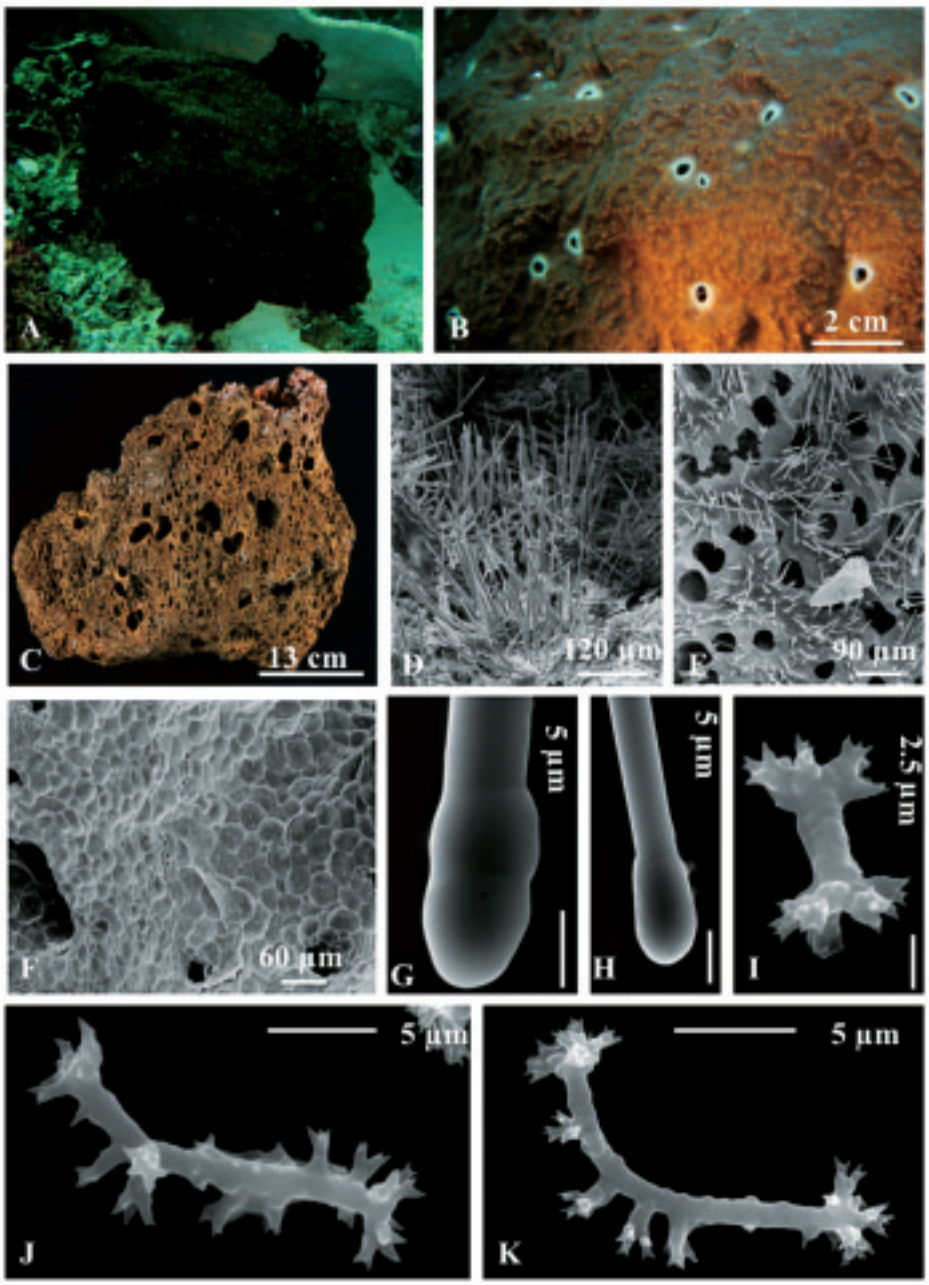

Fig. 5. *Cliona albimarginata* sp. nov. (A) Field image of a specimen; (B) enlargement showing the oscules characterized by the whitish rings and corallite septa visible beneath the sponge's pinacoderme; (C) section of a coralline rock completely invaded by the sponge (paratype); (D) particular of the sponge pinacoderme with ectosomal subtylostyles perpendicularly arranged and with their tips ispidating the surface; (E) arrangement of subtylostyles among the inhalant pores; (F) erosion pits on the chamber wall; (G, H) details of subtylostyles heads; (I) amphiaster; (J, K) spirasters.

up to 20-25 m^2. The sponge spreads over coral with thin stratum of tissue, and corallite septa visible beneath pinacoderme (Fig. 5B). When dried, tissue collapses, and it is impossible to detach it (Fig. 5C). Oscular openings, 6-10 mm in diameter, spread over sponge surface and characterized by a white ring (Fig. 5B). In single osculum, some exhalant canals merged. Inhalant openings, 50-80 µm in diameter, gathered in inhalant areas. In living specimens, ectosome dark olive-brown caused by symbiotic zooxanthellae (Fig. 5A, B); choanosome light yellow. When dried, sponge ocher-beige (Fig. 5C).

Erosion pattern: Substrate completely pervaded by sponge which occupies natural pores of corals and produces irregular, spherical or elliptic erosion chambers, 0.3-0.7 cm in diameter; minute chambers possibly merging to form chambers 2-3 cm wide. Erosion activity high, and possibly extending deep into coral: outgrowths of coral, 10 cm thick, observed to be completely excavated. Pits of chamber walls rounded, 23-45 µm in diameter (Fig. 5F).

Skeleton: In ectosome, tylostyles perpendicularly arranged with tips toward surface that is consequently slightly hispid (Fig. 5D, E). In choanosome, spicules regularly arranged in parallel tracts.

Spicules: Megascleres. Subtylostyles with long, slightly pronounced heads (Fig. 5G, H) 222-336.7 (288.1 ± 26.8) x 3.4-5.7 (4.6 ± 0.6) µm. Sometimes a secondary, annular outgrowth present under head. Tips acerate.

Microscleres: Two categories existing. Type I: amphiasters (Fig. 5I) with rough axis and terminal spines arranged in bouquets 9.2-20.7 (12.9 ± 3) µm e.s. x 2 µm. Type II: straight or curved spirasters, sometimes "C" -shaped with long spines arranged in bouquets (Fig. 5J, K) 9.2-20.7 (12.8 ± 3) µm e.s. x 1 µm; when axis is curved, spines concentrated on convex side.

Etymology: The specific name refers to the whitish rings lining the oscules.

Remarks: *Cliona albimarginata* is diffusely distributed in Bunaken National Park: it was observed also in Likuan II and Tanjunk Pisok at between 4 and 12 m in depth and deeper (Manteaghe, 25 m) in strong currents. The parrotfish, *Bolbometopon* sp., was observed feeding on it.

Cliona albimarginata can be considered to belong to the *C. viridis* complex due to the shape of the tylostyles and spirasters and to the greenish color which is due to the occurrence of symbiotic zooxanthellae (Schönberg 2002). This complex includes *C. varians* (Duchassaing and Michelotti 1864), *C. caribbaea* Carter 1882, *C. nigricans* (Schmidt 1862), *C. orientalis* (Thiele 1900), *C. viridis* (Schmidt 1862), *C. parenzani* Corriero and Scalera-Liaci 1997, and *C. copiosa* Sarà 1959.

In particular, this species can be confused with *C. orientalis* in its beta form and with *C. varians* forma *incrunstans*. Spicule features show important elements differentiating *C. albimarginata* from those 2 species: styles or subtylostyles show frequent head deformations in *C. albimarginata*, while on the contrary, tylostyles show well-formed spherical heads (Schönberg, 2000) in *C. orientalis* and *C. varians*. The latter has tylostyles that can be up to 500 µm long (Pang 1973). Spirasters of the Indonesian species are similar to the ones of *C. orientalis* in the bouquet-like spination, but *C. albimarginata* is also characterized by amphiasters and long, straight spirasters. In this new species "C" -shaped spirasters are less frequent than in *C. varians* (Schönberg 2002). Moreover, the macroscopic excavation pattern is different: in *C. orientalis*, erosion chambers are limited to the 1st 3 cm of depth in the substrate (Schömberg 2000), and also in *C. varians*, the large cavities are in the upper part of the coral (Pang 1973).

The microscleres of *C. albimarginata* are similar to those of *Spirastrella punctulata* (Ridley 1884) which has spirasters with spines on the convex side and anfiasters; nevertheless, the tylostyles differ in shape and size (480-530 µm).

Cliona favus sp. nov.

Examined material: Indonesian material: Holotype (MSNG 51938), BU 54, Manteaghe), 20 Mar. 2000, 10 m, dried; paratype BU 473, Fukui, 27 May 2002, 7-9 m.

Other examined material: BU 11, Fukui, 16 Mar. 2000, 5 m; MG 3, Liang, Aug. 1999.

Substratum: Dead parts of *Porites solida*, also on *Tubastrea* sp.

Description: This sponge recorded exclusively in alpha stage. Dried material dark brown (Fig. 6A), while in live material, inhalant and exhalant papillae reddish-orange and choanosome orangish-yellow (Fig. 6B). Papillae small, 1-5 mm in diameter, generally separated (Fig. 6A), but sometimes close papillae merged.

Erosion pattern: Papillar canals 4-7 mm long, connecting papillae to boring chambers (Fig. 6A), variable in diameter from 5 to 15 mm. These chambers, polygonal or ovoid in shape, resembling

honeycomb-alveolar organization (Fig. 6A, B). Chambers close to each other and separated by septum of substrate 1-4 mm thick; foramina -1 mm in diameter connecting adjacent chambers. Erosion scars irregularly polygonal (Fig. 6C) 20.7-52.9 (average, 36.4) µm; chips also rarely observed in boring chambers (Fig. 6D).

Skeleton: In papillae, tylostyles arranged in palisade with tips directed toward exterior. In choanosome, spicules irregularly arranged.

Spicules: Megascleres. Tylostyles straight, with oval trilobate heads and astate tips (Fig. 6E, F) BU 54: 200-350 (231.5 ± 21.9) x 5-11.2 (7.9 ± 1.3) µm; BU 11: 245-300 (274 ± 17.2) x 6.2-10 (8 ± 0.98) µm. Deformations along shaft common. Thinner tylostyles (2.3-3.7 µm wide) common.

Microscleres: Spirasters with long conical, sometimes forked spines, quiet variable in shape and in spine number and arrangement (Fig. 6G, H). Many straight, amphiaster-like, with spines concentrated at extremities (Fig. 6G right) BU 54: 15-37.5 (25 ± 6.3) s.i. x 2.5-3.8 (2.8 ± 0.6) µm; BU 11: 17.5-35 (24.7 ± 5.9) s.i. x 2.4-3.6 (2.6 ± 0.5) µm.

Etymology: The name refers to the honeycomb appearance of the erosion; it is derived from Latin *favus* meaning honeycomb.

Remarks: This species is very characteristic for its peculiar, honeycomb pattern of erosion and the spicular features. The particular boring chamber shape also makes the species easily recognizable in the field.

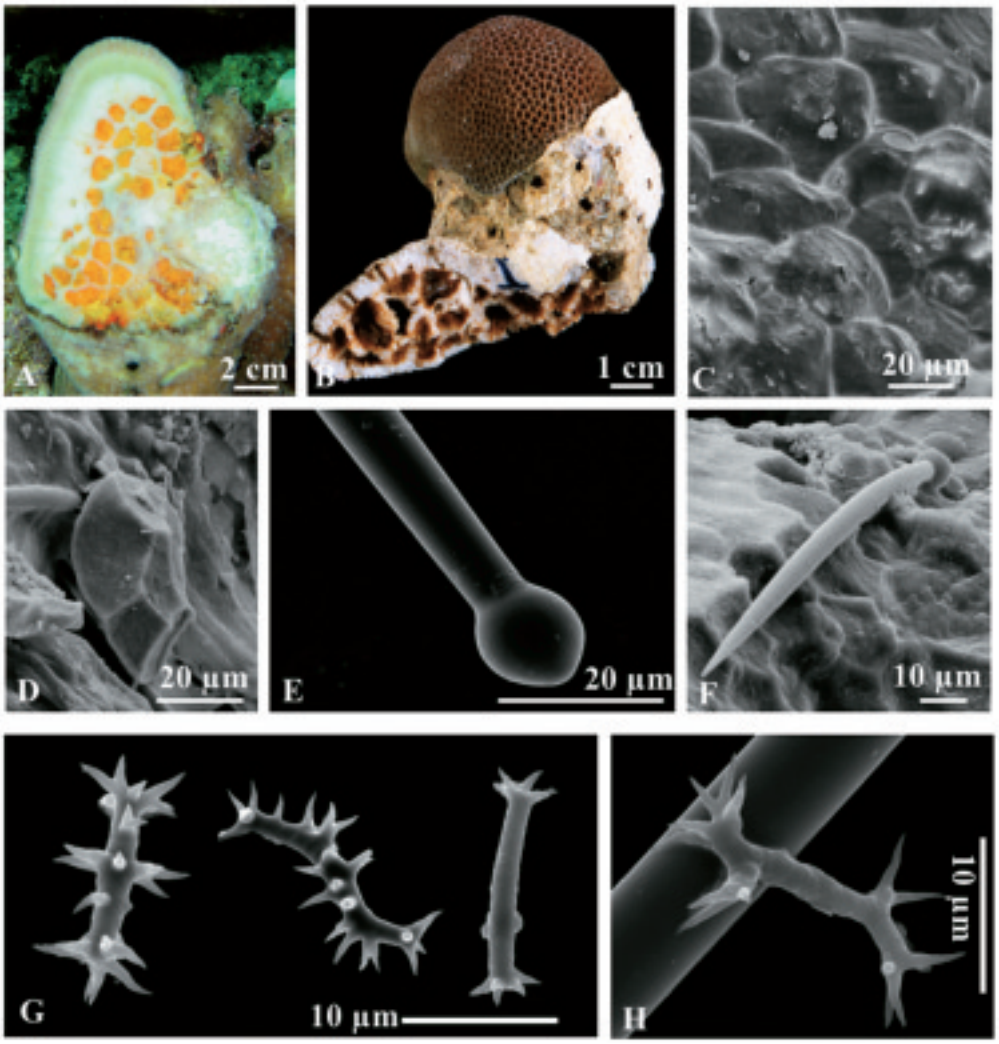

Fig. 6. *Cliona favus* sp. nov. (A) Field image showing the reddish-orange live sponge tissue; (B) honeycomb boring pattern of the holotype into a colony of *Porites solida*; (C) erosion scars on the chamber wall; (D) a partially detached calcareous chip on the chamber wall; (E) tylostyle head; (F) tylostyle; (G, H) spirasters.

Cliona liangae sp. nov.

Examined material: Indonesian material: Holotype (MSNG 51939), MG 1 bis, Liang, Aug. 1999, tidal zone, dried.

Substratum: *Acropora* sp.

Description: This species recorded in small fragment of coral. Small, circular, and regular papillae 0.5-1 mm in diameter and a single chamber visible. Color of dried specimens yellowish-brown.

Erosion pattern: Papillae of aquiferous system connected to boring chambers, irregularly shaped (10 x 7 mm), through short papillar channels (2-3 mm long).

Skeleton: As usual, tylostyles arranged in palisade in papillae and irregularly in choanosome.

Spicules: Megascleres. Tylostyles variable in size 206.9-397.8 (296.7 ± 38.3) x 2.8-13.6 (7.7 ± 2.1) μm; straight or slightly curved (Fig. 7A), with variable heads which are subterminal, trilobate, sometimes spherical or rounded (Fig. 7B, C).

Microscleres (Fig. 7D-H): Flexuous, slender, often bent spirasters with long, conical spines, rarely forked at tip 31.2-46.8 (37.22 ± 4.3) x 1.3-2.5 (2 ± 0.4) μm s.e. Straight forms amphiaster-like due to tufts of long branched spines at extremities of axis (Fig. 7G, H). In bent forms, spines (5.2-10.4 μm) also present in convex part (Fig. 7D-F).

Etymology: The name refers to the place of collection, Liang Point, Indonesia.

Remarks: This species is similar to *C. aurivilli* (Lindgren 1897) due to its flexuous spirasters with contorted axes (Lindgren 1898 fig. 22c'') sometimes transformed in amphiasters; *C. liangae* differs from *C. aurivilli* because it lacks the other, smaller category of spirasters, present in *C. aurivilli*, and has shorter tylostyles. Moreover, an analysis of the type material of Lindgred (SMNH 1187-23) showed that while the microscleres of *C. liangae*

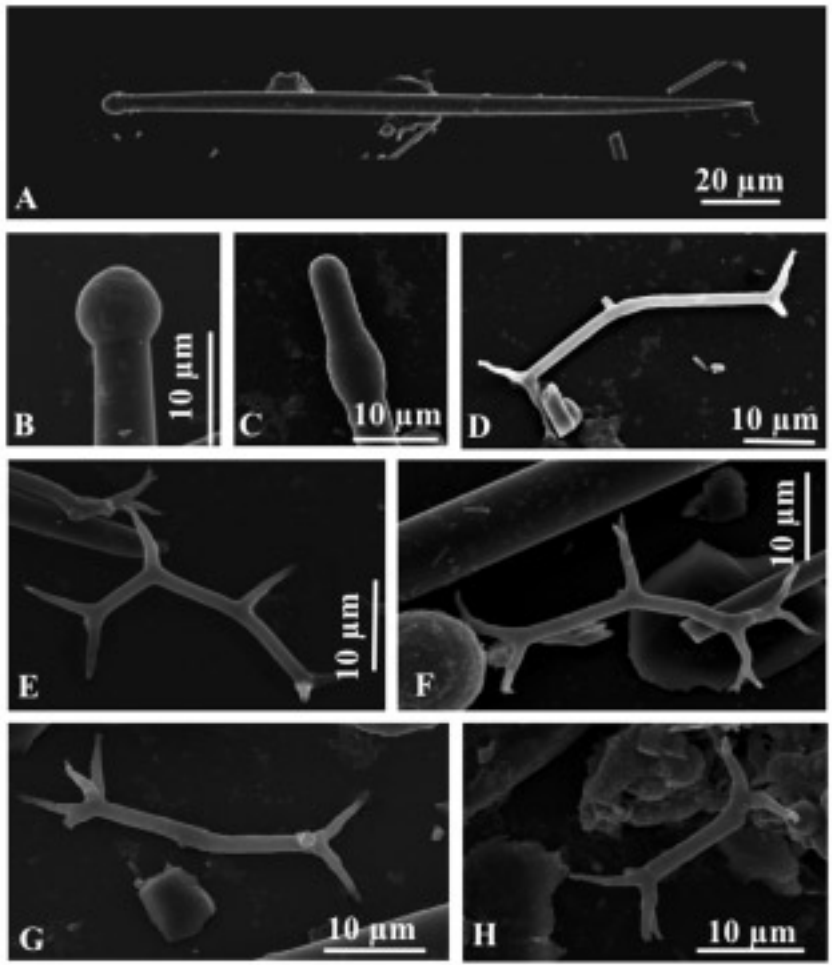

Fig. 7. *Cliona liangae* sp. nov. (A) Tylostyle; (B, C), details of the tylostyle heads; (E, F) spirasters; (D, G, H) spirasters transformed in branched amphiasters.

have generally simple or more rarely forked, branched tips (Fig. 8 G-I), those of *C. aurivilli* end with verticils of hooks (Fig. 8J, K).

In *C. liangae*, the size frequency distribution of tylostyle width is strongly unimodal with a mode in the class 8-9 µm (Fig. 3G), while the spicule length is slightly bimodal (with modes in the classes 260-280 and 340-360 µm) (Fig. 3H). The length-width diagram does not allow inclusion of evidence of the 2 groups of spicules characterized

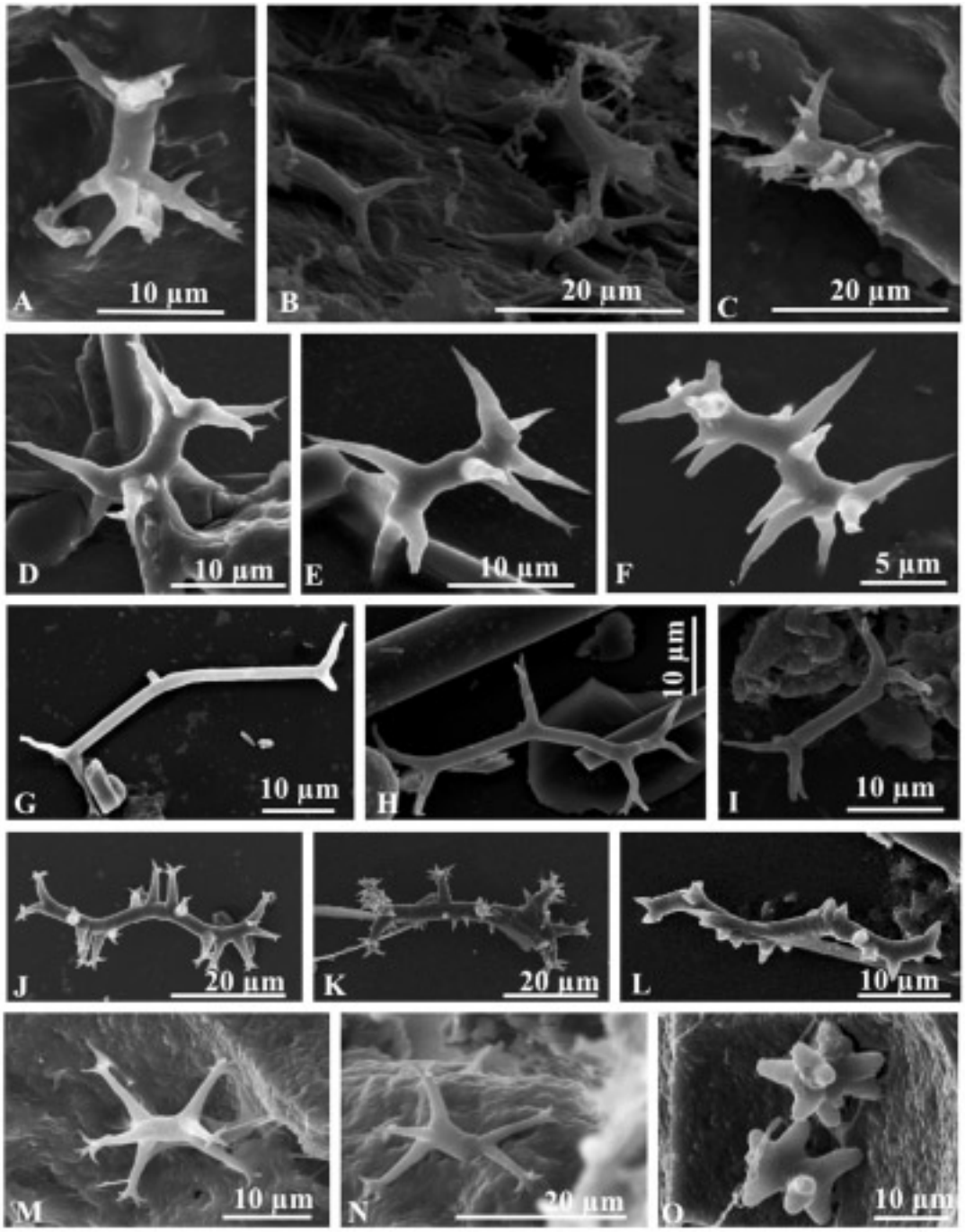

Fig. 8. Comparative table showing the microscleres of the Indonesian species characterized by branched amphiasters. (A-C) *Cliona dichotoma*; (D-F) *C. mucronata*; (G-I) *C. liangae*; (J, L) spirasters from the holotype of *C. aurivilli*; (M, N) branched amphiasters of *Cliothosa hancocki* characterized by the straight axis and unbranched spines ending in a verticil of hooks; (O) nodulose amphiasters of *Cth. hancocki*.

by different patterns of growth (Fig. 3I).

Cliona utricularis sp. nov.

Examined material: Indonesian material: Holotype (MSNG 51940), BU 31, Fukui, 18 Mar. 2000, 7 m, 2 pieces, dry and alcohol preserved; paratype MTR bis, Liang, Aug. 1999, tide level.

Other material: BU 13, Fukui, 16 Mar. 2000, 10-30 m; BU 60, Nain sud, 20 Mar. 2000, 16 m; BU 115, Fukui, 24 Mar. 2000, 10 m; BU 145, Lembeh, 29 Mar. 2000, 5 m; BU 474, 27 May 2002, 12 m; BU 482, Siladen, 28 May 2002, 15 m; BU 500, Manteaghe, 25 May 2002, 13 m; BU 505, Nain, 29 May 2002, 5 m.

Description: This species present in alpha stage. In live material, papillae brilliant reddish-orange (0.2-7 mm in diameter), circular (Fig. 9A, B), sometimes partially merged.

Tissue covering short papillar canals about 5 mm long, same color as papillae (Fig. 9B). In live material, choanosome clearly distinguishable from papillae by its yellowish-orange color (Fig. 9B). In dried specimens, both papillae and choanosome dark brown.

Erosion pattern: Erosion chambers wide, bagpipe-like, about 1-4 cm in diameter. Some papillar canals converging in same large chamber (Fig. 9B). Pits on chamber walls irregularly ovoid (27.7-65.5 µm), (Fig. 9C,D).

Skeleton: Megascleres in tracts in papillae, while irregularly arranged in chambers.

Spicules: Tylostyles curved BU 13: 290-490 (395.7 ± 45.2) x 8.7-21.2 (15.4 ± 2.8) µm, BU 31:

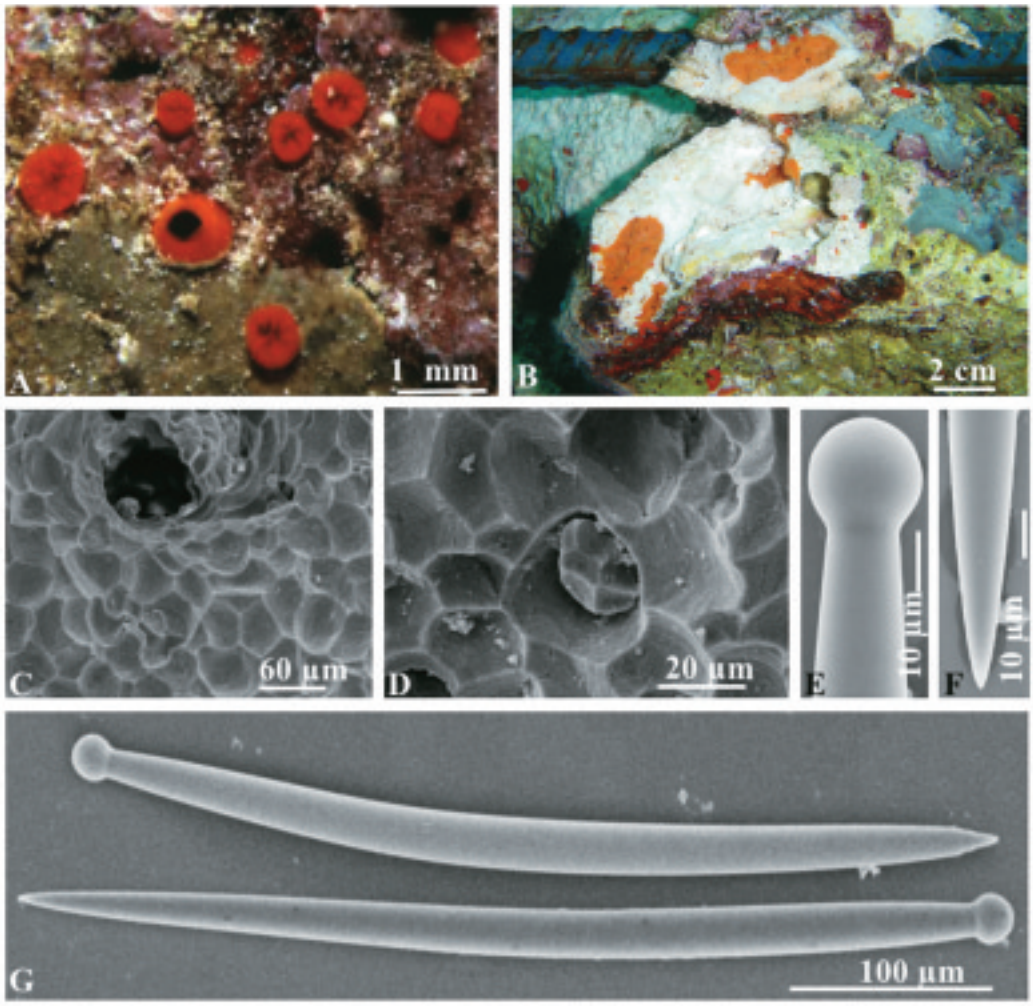

Fig. 9. *Cliona utricularis* sp. nov. (A) Field image showing the reddish-orange inhalant and exhalant papillae of the aquiferous system; (B) field image showing the bagpipe excavations and the papillar channel filled by yellowish-orange sponge tissue; (C) erosion scars on the chamber wall; (D) magnification showing a partially detached calcareous chip on the chamber wall; (E, F) details of the head and the tip of the tylostyles; (G) curved tylostyles.

200-480 (391.6 ± 54.5) x 5-16.2 (11.3 ± 2.5), BU 115: 385-480 (432.8 ± 23.9) x 10-17.5 (13.7 ± 2.4) µm. With globular, rarely trilobate or subterminal, heads (Fig. 6E, G) BU 13: 10-18.7 (15.6 ± 2.1), BU 31: 10-17.5 (14.6 ± 1.9), BU 115: 4-7.5 (6.1 ± 0.9) µm. Shaft thicker in central part and slimmer under head ending in acerate tip (Fig. 9F). Often tylostyles with rounded or mucronate extremities (Fig. 9G). Very slim tylostyles also common but probably represent young spicules.

Etymology: The specific name (Latin *utriculus* = bagpipes) refers to the bagpipe-like erosion of this species.

Remarks: In the Bunaken area, boring sponges in the alpha stage with orangish-red papillae are very common; they are *C. favus*, *Cth. hancocki*, and *C. utricularis*. In the field, after the substratum is broken, *C. utricularis* is easily distinguishable from *C. favus* which shows an unmistakable erosion pattern, while in the field, it may be confused with *Cth. hancocki* which shares a similar color and boring pattern (Shönberg 2000).

The presence of only tilostyles as spicules, the color, and boring pattern are the distinguishing characters that justify erection of this new excavating species.

DISCUSSION

In a recent revision of the family Clionaidae, Rützler (2002) defines the genus *Cliothosa* as being characterized by amphiasters as microscleres, while the microscleres of *Cliona* are "raphides or spirasters, including amphiastrose modifications of spirasters or entirely smooth forms (sinuous microrhabds)". Moreover Rosell and Uriz (1997) considered the presence of 2 size categories of tylostyles in the definition of the genus *Cliothosa*. On these bases, Rosell and Uriz (1997) considered the genus *Cliothosa* to be composed of 3 species: *hancocki* Topsent 1888, *quadrata* (Hancock 1849), formerly *Cliona* and transferred to *Cliothosa* by Rützler and Stone (1986), and *aurivilli* (Lindgren 1897), described by Lindgren as *Spirastrella*, and later moved to *Cliona* by de Laubenfels (1936).

Because of these definitions of the genera *Cliona* Grant and *Cliothosa* Topsent and the presence in Indonesian material of 3 species (*C. dichotoma*, *C. liangae*, and *C. mucronata*) characterized by branched amphiastrose microscleres, we faced the problem of their attribution to the 2 Clionaid genera *Cliona* or *Cliothosa*.

In *Cth. hancocki*, widely recorded in Indonesian material, amphiasters have straight axes with groups of unbranched rays at their extremities (Fig. 8M-O). The rays show verticils of hooks at the distal ends resembling the amphiasters, characteristic of the genera *Alectona* and *Thoosa*. In *C. dichotoma* (Fig. 8A-C), *C. mucronata* (Fig. 8D-F), and *C. liangae* (Fig. 8G-I), ramose amphiasters are present, but they always end with simple or bifurcated extremities.

The SEM analysis of the type material of *C. aurivilli* showed that in this species, the microscleres are spiralate, and the rays often end with verticils of hooks as in *Cth. hancocki* (Fig. 8J, K).

The value of the character "2 kinds of tylostyles" for *Cliothosa* appears ambiguous, and in fact, 2 kinds of megascleres are more evident in *C. mucronata*, showing spiralate microscleres, than in *C. aurivilli* (Fig. 3J-L) or *Cth. hancocki* (Fig. 3M-O). On the other hand, a bi- or multimodal frequency distribution of the spicule size could indicate discontinuous spicule production resulting in the formation of cohorts of the same spicular kind (Jones 1987). We therefore suggest that this character is not useful in the definition of the genera *Cliona* and *Cliothosa*.

In this light, we prefer to maintain the genus *Cliothosa* only for *Cth. hancocki* which completely lacks spirasters and is characterized by branched amphiasters with a straight axis and by 2 groups of unbranched rays ending with verticils of hooks. This idea is reinforced by the contemporaneous presence in *Cth. hancocki* of another kind of microsclere, nodulose amphiasters, (Fig. 8O). Based on the photographs of Hancock's slides published in Rützler and Stone (1986), the amphiasters of *Cth. quadrata* appear similar to those of *Cth. hancocki*, but SEM analysis will be necessary for a definitive decision.

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REFERENCES

Amir I. 1992. A comparison of sponge fauna of exposed and sheltered reef flats in eastern Indonesia. Mar. Res. Indonesia **28:** 1-12.

Bromley RG, A D'Alessandro. 1984. The ichnogenus *Entobia* from the Miocene, Pliocene and Pleistocene of southern Italy. Riv. Ital. Paleontol. S. **90:** 227-296.

Calcinai B, C Cerrano, M Sarà, G Bavestrello. 2000. Boring

sponges (Porifera, Demospongiae) from the Indian Ocean. Ital. J. Zool. **67:** 203-219.

de Laubenfels MW. 1936. A discussion of the sponge fauna of the Dry Tortugas in particular and the West Indies in general, with material for a revision of the families and order of the Porifera. Pap. Tortugas Lab. **30:** 1-225.

Gomez R. 1980. The isolation and structure elucidation of the steroid and glycosphingolipid fractions in the sponge *Xestospongia halichondroides*. Diss. Abstr. Int. B. Sci. Eng. **40:** 5234

Hooper JNA, JA Kennedy, RWM Van Soest. 2000. Annotated checklist of sponges (Porifera) of the South China Sea Region. Raffles Bull. Zool. **Supplement 8:** 125-207.

Jones WC. 1987. Seasonal variations in the skeleton and spicule dimensions of *Haliclona elegans* (Bowerbank) *sensu* Topsent (1887) from two sites in north Wales. *In* WC Jones ed. European contribution to the taxonomy of sponges. Middleton, Ireland: Litho Press, pp. 109-129.

Kott P. 1995. A new colonial *Styela* (Ascidiacea: Styelidae) from an isolated marine habitat, Kakaban Island, East Kalimantan, Indonesia. Raffles Bull. Zool. **43:** 469-474.

Lindgren NG. 1898. Beitrag zur Kenntniss der Spongienfauna des Malayischen Archipels und der chinesischen Meere. Zoologische Jahrbucher. Abteilung Syst. Geogr. Biol. Thiere. **11:** 283-378.

Lévi C, P Lévi. 1989. Spongiaires (MUSORSTOM 1 and 2) [Philippines]. *In* J Forest, ed.: Résult. Camp. MUSORSTOM, 4. Mém Mus. Natn. Hist. Nat. Paris (A) **143:** 25-103.

Lourie SA, JE Randall. 2003. A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific. Zool. Stud. **42:** 284-291.

Ng PK, T Tomascik. 1994. *Orcovita saltatrix*, a new genus and species of anchialine varunine crab (Crustacea: Decapoda: Brachyura: Grapsidae) from Kakaban Island, Indonesia. Raffles Bull. Zool. **42:** 937-948.

Pang RK. 1973. The systematic of some Jamaican excavating sponges (Porifera). Postilla **161:** 1-75.

Ridley SO, A Dendy. 1886. Preliminary report on the Monaxonida collected by H.M.S. "Challenger". Ann. Mag. Nat. Hist. **18:** 325-351, 470-493.

Ridley SO, A Dendy. 1887. Report on the Monaxonida collected by H. M. S. "Challenger" during the years 1873-1876. Report on the scientific results of the Voyage of H. M. S. "Challenger", 1873-1876. Zoology **20:** 1-275.

Roberts CM, CJ McClean, JEN Veron, JP Hawkins, RG Allen, DE McAllister, et al. 2002. Marine biodiversity hotspots and conservation priorities for tropical reefs. Science **295:** 1280-1284.

Rosell D, MJ Uriz. 1997. Phylogenetic relationships within the excavating Hadromerida (Porifera), with a systematic revision. Cladistics **13:** 349-366.

Rützler K. 1974. The burrowing sponges of Bermuda. Smithson. Contr. Zool. **165:** 1-32.

Rützler K. 2002. Family Clionaidae D'Orbigny, 1851. *In* JNA Hooper, RWM Van Soest, eds. Sistema Porifera: a guide to the classification of sponges. New York: Kluger Academic/Plenum Publisher, pp. 173-185.

Rützler K, SM Stone. 1986. Discovery and significance of Albany Hancock's microscope preparations of excavating sponges (Porifera: Hadromerida: Clionidae). Proc. Biol. Soc. Wash. **99:** 659-675.

Schönberg CHL. 2000. Bioeroding sponges common to the Central Australian Great Barrier Reef: description of three new species, two new records, and additions to two previously described species. Senckenbergiana Marit. **30:** 161-221

Schönberg CHL. 2002. Sponges of the "*Cliona viridis* complex" - a key for species identification. Proc. 9th Int. Coral Reef Symp. MK Moosa, S Soemodihardjo, A Soegiarto, K Romimohtarto, A Nontji, Soekarno, Suharsono, eds. Bali 2000.Indonesian Institute of Sciences and State Ministry for Environment Publ. Bali, **1:** 295-299.

Schulze FE. 1887. Report on the Hexactinellida collected by HMS "Challenger", during the years 1873-1876. Report on the scientific result of the voyage of HMS "Challenger", 1873-1876. Zoology **21:** 1-514.

Sheppard C, SM Wells. 1988. Coral reefs of the world. Vol. 2: Indian Ocean, Red Sea and Gulf. Nairobi, Kenya: UNEP, and Cambridge, UK: IUCN, 389 pp.

Sollas WJ. 1878. On two new and remarkable species of *Cliona*. Ann. Mag. Nat. Hist. **5:** 54-66.

Sollas WJ. 1888. Report on the Tetractinellida collected by HMS "Challenger", during the years 1873-1876. Report on the scientific result of the voyage of HMS "Challenger", 1873-1876. Zoology **25:** 1-458.

Tomascik T, AJ Mah, A Nontji, MK Moosa. 1997. The ecology of Indonesian seas. Singapore, Periplus Ed. **1**, Vol. **2** 1388 pp.

Van Soest RWM. 1989. The Indonesian sponge fauna: a status report. Neth. J. Sea Res. **23:** 223-230.

Wilson HV. 1925. Silicious and horny sponges collected by the U. S. Fisheries Steamer "Albatross" during the Philippine Expedition, 1907-10. *In* Contribution to the biology of the Philippine Archipelago and adjacent regions. Bull. US Nat. Mus. **100**(2, pt. 4)**:** 273-532.

Vacelet J, P Vasseur, C Lévi. 1976. Spongiaires de la pente externe des récifs corallines de Tulèar (Sud-Ouest de Madagascar). Mém. Mus. Nat. Hist. Nat. **49:** 1-116.