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The genus *Stichopus* (Echinodermata: Holothuroidea) from the Johore Marine Park (Malaysia) with the description of two new species

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Abstract

The study of the holothurian genus *Stichopus* from the Johore Marine Park (Malaysia) revealed at least six different species, two being new to science: *Stichopus ocellatus* n. sp. and *Stichopus rubermaculosus* n. sp. Each species is fully described and illustrated. For the known species a list of records and the geographic distribution are given. A seventh species, *Stichopus monotuberculatus*, not yet recorded from the Johore Marine Park, but likely to be found there, is included in an identification key based on ossicle characters, colour patterns and behaviour.

Key words: *Stichopus*, Holothuroidea, new species, identification key, South China Sea, Malaysia

Résumé

L'étude des holothuries du genre *Stichopus* provenant du 'Johore Marine Park' permet de distinguer au moins six espèces différentes, dont deux sont nouvelles pour la science: *Stichopus ocellatus* n. sp. et *Stichopus rubermaculosus* n. sp.. Chaque espèce est décrite et illustrée. Pour les espèces connues la liste des citations et la distribution géographique sont données. Une septième espèce, *Stichopus monotuberculatus*, non encore mentionnée du 'Johore Marine Park' mais potentiellement présente est inclue dans une clé d'identification basée sur les spicules, la coloration de la peau et le comportement.

Mots-clefs: *Stichopus*, Holothuroidea, nouvelle espèce, clef d'identification, Mer de Chine du Sud, Malaisie

Introduction

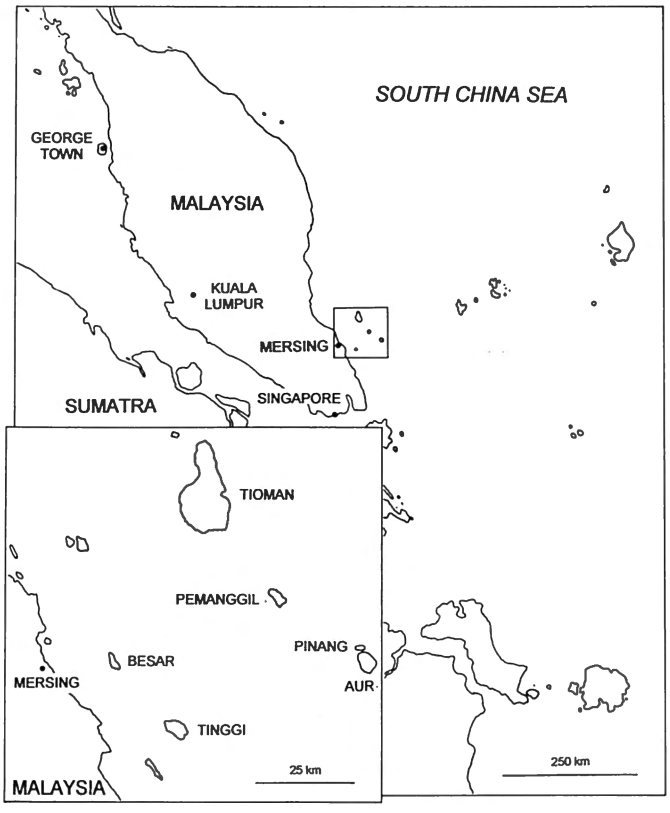
The holothurian fauna of Malaysia has been dealt with in two recent publications: BAINE & FORBES (1998) record three unidentified *Stichopus* species as *Stichopus* sp. 1, sp. 2, and sp. 3, but these are not included by FORBES *et al.* (1999). ZULFIGAR & TAN SHAU HWAI (1999), RIZAL BOSS *et al.* (1999) and ZULFIGAR *et al.* (2001b) give lists of species present in the Johore Marine Park (South China Sea, Malaysia). Once again, some stichopodids are reported as *Stichopus* sp. 1, sp. 2, sp. 3. Two other works (ZULFIGAR *et al.*, 1999, 2001a) deal with the taxonomy of *Stichopus herrmanni* and *Stichopus variegatus.* These studies fail to reveal any obvious differences in their internal anatomy (Polian vesicle, stone canal, madreporic plate) but show clear differences in some of their ossicles. The present paper will try to clarify the taxonomic status of the stichopodids from the Johore Marine Park.

Material and methods

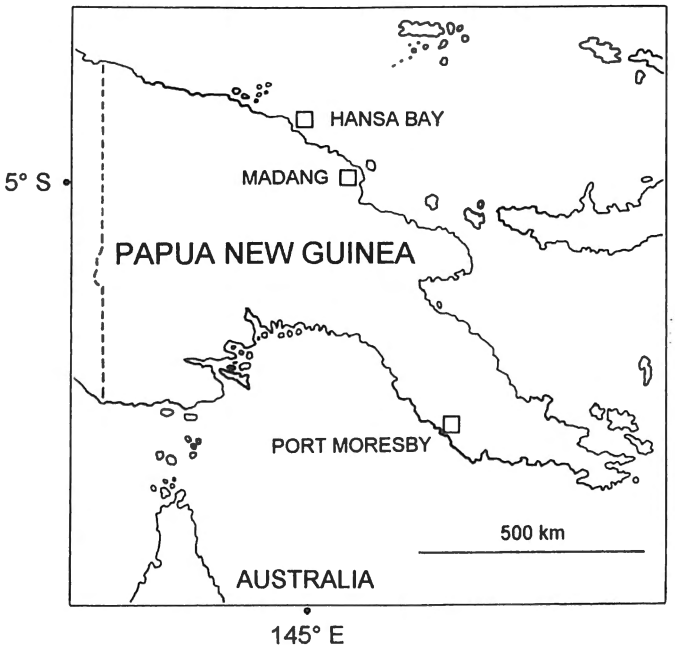
Several expeditions to the Johore Marine Park, organised by the Universiti Sains Malaysia (10-15 March, 14-23 April and 11-17 September 1998, 13-21 March, 14-28 April and 21-24 November 1999, 03-11 August 2000), allowed to photograph and to collect holothurians and more particularly stichopodids during day and night dives. The islands visited were Pulau Besar, Pulau Pemanggil, and Pulau Aur (map 1). Comparative material was also collected along the north coast of Papua New Guinea (Hansa Bay, Madang) by one of us (C.M.)(map 2). Most of the material was collected in shallow waters (1-20 m depth). Each specimen was relaxed for a few hours in 3.5% $MgCl_2$ then transferred to 10% buffered formalin for a few months and preserved in buffered 75% alcohol. Ossicles were prepared for light microscopy.

For each known stichopodid species a list of records, as complete as possible mainly for recent papers (1980-2001), is given. For older references we refer to synthetic works. Papers dealing with physiology and biochemistry were not taken into account unless they give a new locality for the distribution of a species.

The present study is based on material from the Institut royal des Sciences naturelles de Belgique, Bruxelles (IRSNB), Naturalis, Leiden (RMNH) and the Universiti Sains Malaysia, George Town, Pulau Pinang Malaysia (USMPPM).



Map 1. Collecting sites in the Johore Marine Park: Pulau Besar, Pulau Pemanggil and Pulau Aur.



Map 2. Collecting sites in Papua New Guinea: Hansa Bay and Madang.

Taxonomical account

O. Aspidochirotida GRUBE, 1840
F. Stichopodidae HAECKEL, 1896
G. *Stichopus* BRANDT, 1835

Stichopus chloronotus BRANDT, 1835
Figs 1A-P, 2A-E; pl. 1A

SYNONYMY

Stichopus (Perideris) chloronotos BRANDT, 1835: 50.
Stichopus chloronotus; PANNING, 1944: 30, fig 3a-e (records before 1940); DAWIDOFF, 1952: 118; LOI & SACH, 1963: 238, pl. 1, fig. A, pl. VI, fig. 1; LOI, 1967: 230; CLARK & ROWE, 1971: 178, pl. 27, fig. 18; HUMPHREYS & LÜTZEN, 1972: 4; TOWNSLEY & TOWNSLEY, 1972: 176; ANON, 1979: 18, text fig.; LEVIN, 1979: 22; SLOAN *et al.*, 1979: 123; LAWRENCE, 1980: 202; MARY BAI, 1980: 16, text fig. 10I; GROSENBAUGH, 1981: 51; TAN TIU, 1981: 65, pl.7; fig. 1-3; KROPP, 1982: 447; PRICE, 1982: 11; MUKHOPADHYAY & SAMANTA, 1983: 312; CLARK, A.M., 1984: 99; REYES-LEONARDO, 1984: 151, pl. 9, fig. 1a-d; JAMES, 1985: 404; PRICE & REID, 1985: 6, fig. 3; REYES-LEONARDO *et al.*, 1985: 267; BROUNS & HEIJS, 1986: 175; FÉRAL & CHERBONNIER, 1986: 94, text fig.; MARSH, 1986: 73; CANNON & SILVER, 1986: 27, figs 4h, 7h; GEORGE & GEORGE, 1987: 246; CHERBONNIER, 1988: 146, fig. 60A-O (synonymy and records before 1980); MUKHOPADHYAY, 1988: 9; CHAMBERS, 1989: 89; CONAND, 1989: 30, fig. 3; LEVIN & DAO, 1989: 52; JAMES, 1989: 13; JANGOUX *et al.*, 1989: 163; KALASHNIKOV, 1989: 68, fig. 5; ZOUTENDIJK, 1989: 2; MC ELROY, 1990: 3; GILLILAND, 1993: pl.6, figs 7-10; MARSH *et al.*, 1993: 64; SOMMERVILLE, 1993: 4; ALLEN & STEENE, 1994: 245; FIEGE *et al.*, 1994: 87; HOLLAND, 1994: 2; JAMES, 1994: 27; JAMES & JAMES, 1994:12, pl. VI; JAMES & MANIKFIAN, 1994: 103, pl. 1C; KERR, 1994: 163; MARSH, 1994a: 11; UTHICKE, 1994: 569; COLIN & ARNESON, 1995: 262, fig. 1237; ROWE & GATES, 1995: 323; SANT, 1995: 27; BRITAYEV & ZAMISHLIAK, 1996: 180; GOSLINER *et al.*, 1996: 281, fig. 1035; LIAO, 1997: 151, fig. 87a-f (synonymy and records before 1995); ROWE & RICHMOND, 1997: 306, fig. p. 307; TSUDA, 1997: 16; UTHICKE, 1997: 438; KLINGER & JOHNSON, 1998: 468; ABDULA, 1998: 34; BAINE & FORBES, 1998: 4; CONAND, 1998: 1186, text fig.; CONAND *et al.*, 1998: 15; JAMES, 1998: 13 (records for India); MOORE, 1998: 32; REICHENBACH *et al.*, 1998: 14; LIAO, 1998: 80; FORBES *et al.*, 1999: 9; UTHICKE & KAREZ, 1999; 71; UTHICKE *et al.*, 1999: 123; ZULFIGAR & TAN SHAU HWAI, 1999: 77; BUSSARAWIT & THONGTHAN, 1999: 35; RIZAL BOSS *et al.*, 1999: 39; SAMYN, 2000: 15; SCHOPPE, 2000a: 11; SAMYN & VANDEN BERGHE, 2000: 30, pl. 2D; TAN SHAU HWAI & ZULFIGAR, 2001: 389; HOAREAU & CONAND, 2001: 4; UTHICKE, 2001: 125; ZULFIGAR *et al.*, 2001b: 364.
Stichopus chloromatus SUTAMAN, 1993: 23, fig. 9.
Green Fish, ADAMS, 1992: 13; ANON, 1996: 13.

MATERIAL EXAMINED

IRSNB IG 28680/48, Pulau Aur (Malaysia), 15.ix.98, 11 m depth, night dive (one specimen). Ten of specimens observed and photographed in Papua New Guinea and Malaysia.

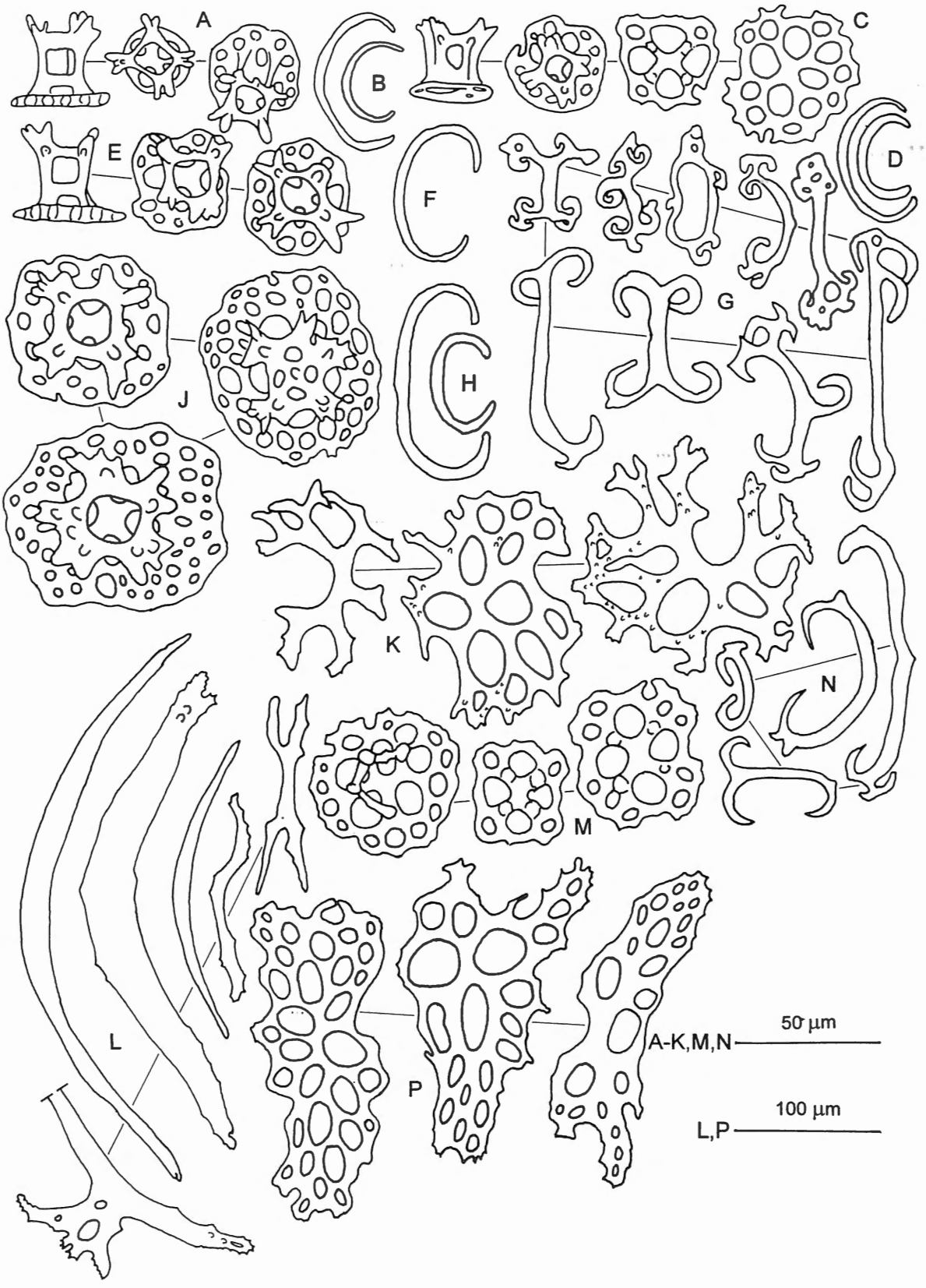


Fig. 1. *Stichopus chloronotus* BRANDT, 1835. L = 250 mm . A: Tables of the dorsal body wall; B: C-shaped rods of the dorsal body wall; C: tables of the ventral body wall; D: C-shaped rods of the ventral body wall; E: tables of the base of the dorsal papillae; F: C-shaped rod of the base of the dorsal papillae; G: rosettes and modified C-shaped rods from the top of the dorsal papillae; H: C-shaped rods of the top of the dorsal papillae; J: tables of the top of the dorsal papillae; K: small perforated plates from the top of the dorsal papillae; L: rods of the top of the dorsal papillae; M: tables of the tube feet; N: modified C-shaped rods of the tube feet; P: large perforated plates of the tube feet.

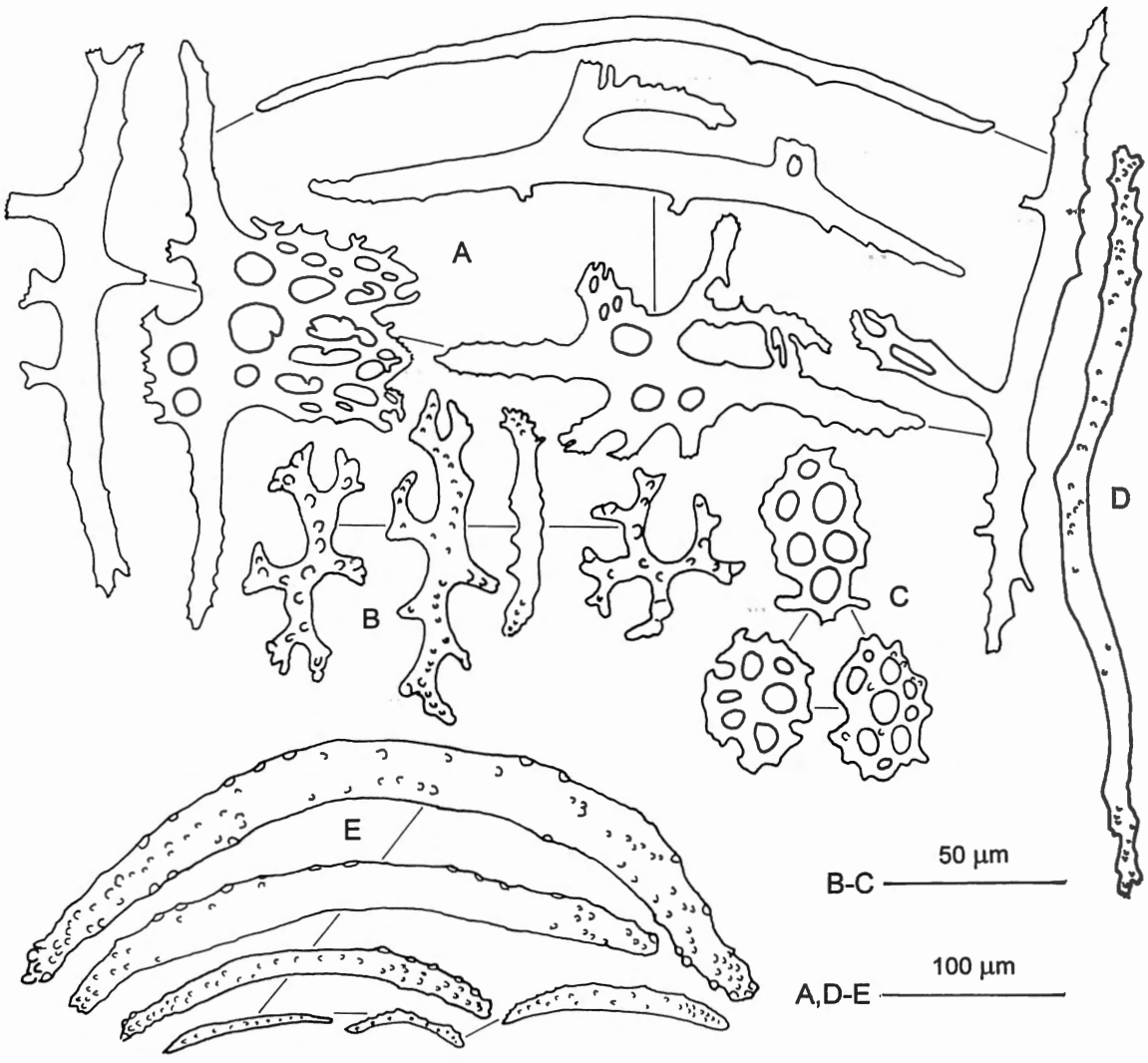


Fig. 2. *Stichopus chloronotus* BRANDT, 1835. L = 250 mm. A: rods of the tube feet; B: knobbed rods of the base of the tentacles; C: reduced tables of the base of the tentacles; D: rods of the base of the tentacles; E: rods of the top of the tentacles.

TYPE LOCALITY

Lugunor Islands, Guam.

DESCRIPTION

- External anatomy: Specimen 250X50 mm. Colour of living animal deep green to almost black with the tip of the dorsal papillae ochre-yellow (pl. 1A); colour in alcohol deep brown dorsally, somewhat lighter ventrally, tip of the dorsal papillae yellow-cream. Ventral sole flattened with tube feet only in the ambulacral areas; central row twice as wide as the lateral ones; interambulacral areas very narrow. Body quadrangular in cross-section each dorso-lateral edge being provided with a double row of long, rigid dorsal papillae. Ventro-lateral edges each with a single row of papillae. Mouth ventral with 20 tentacles surrounded by a collar of large papillae. Anus terminal.
- Internal anatomy: Body wall thin (5-8 mm) if compared to other stichopodids. Calcareous ring very similar to the one of *S. rubermaculosus* (cf fig. 10A) with a well marked V-shaped notch at the rear of the radial plates. Ampullae of the tentacles are 1/6 to 1/9 of body length. A single Polian vesicle, 1/6 of body length. A single stone canal, embedded in the dorsal mesentery, contorted, going upwards to the calcareous ring where it ends in an ovoid madreporic plate.
- Ossicles: Body wall with tables and C-shaped rods dorsally and ventrally. Tables larger ventrally (30-45 µm across, fig. 1C) than dorsally (25-30 µm across, fig. 1A); disc smooth, perforated by 4 large central holes and 4-10 small peripheral holes; 4 pillars united by one cross beam, crown of spines at the top of the pillars more or less as a Maltese cross with 4 groups of 2-4 spines. C-shaped rods small (fig. 1B, D), maximum 45 µm long. At the base of the dorsal papillae, tables (fig. 1E) and C-shaped rods (fig. 1F) similar to those of the dorsal body wall. At the top of the dorsal papillae large tables (fig. 1J), 55-80 µm across with numerous small peripheral holes in the disc, C-shaped rods (fig. 1H) up to 70 µm long, irregular rosettes (fig. 1G) mainly derived from C-shaped rods, small perforated plates (fig. 1K) some being spiny and rods (fig. 1L), sometimes provided with a central perforated

process. In the tube feet tables, most with reduced pillars (fig. 1M), a few irregular C-shaped rods, 40-100 µm long (fig. 1N), large perforated plates (fig. 1P) and rods (fig. 2A) 270-420 µm long with a very large central, perforated process. End plate of the tube feet more or less 900-1000 µm across, made of 10-13 perforated plates. At the base of the tentacles tables reduced to an irregular disc (fig. 2C), small knobbed rods (fig 2B) and a few very long spiny rods (fig. 2D). At the top of the tentacles spiny curved rods (fig. 2E), 65-470 µm long.

DISTRIBUTION

S. chloronotus is widely distributed in the Indo-Pacific area from the East Coast of Africa (Red Sea excluded) to Hawaii and Cook Islands, and from Japan to the Tasman Sea.

REMARKS

S. chloronotus is one of the easiest species of *Stichopus* to identify in the field because of its very characteristic and constant green-black or blue-black colour. Sometimes the apex of the dorsal papillae are tipped with orange or ochre yellow. The very rigid rows of elongate papillae aligned along the edges of the body are also very characteristic. Ossicles show few variations within the distribution area. Locally, some special ossicles, namely massive rods in the tentacles, are present, as described also by CHERBONNIER (1988) for the tentacles of specimens from Madagascar. The modified C-shaped rods described in the present work and by MASSIN (1996b) at the top of the dorsal papillae had already been mentioned by THÉEL (1886), SLUITER (1887), LUDWIG (1887) and MITSUKURI (1912) but without specifying the location of these ossicles.

Stichopus herrmanni SEMPER, 1868
Fig . 3A-R, pl. 1B-C

SYNONYMY

Stichopus variegatus Herrmanni SEMPER, 1868: 73, pl. 17, pl.30, fig. 2.
Stichopus variegatus var. *hermanni*; PANNING, 1944: 33; GEORGE & GEORGE, 1987: 246.
Stichopus hermanni; ROWE & RICHMOND, 1997: 306, fig. p 307; LAMBETH, 2000: 18; SAMYN, 2000: 13, fig. 1; SCHOPPE, 2000a: 11; SCHOPPE, 2000b: 122, text figs; ZULFIGAR *et al.*, 2001b: 364.
Stichopus herrmanni; MASSIN, 1999: 63, fig. 52a-m (synonymy and records before 1998); FORBES *et al.*, 1999: 13, text fig.; ZULFIGAR & TAN SHAU HWAI, 1999: 77; ZULFIGAR *et al.*, 1999: 169; SAMYN & VANDEN BERGHE, 2000: 31, pl. 2E; ZULFIGAR *et al.*, 2001: 387.
Stichopus variegatus; ANON, 1979: 17, text fig.; FÉRAL & CHERBONNIER, 1986: 98, text fig. p 99; CANNON & SILVER, 1987: 28, text fig.; CONAND, 1989: 31, fig. 3; JAMES, 1989: 130; ALLEN & STEEN, 1994: 246; JAMES, 1994: 27, pl. 1A; COLIN & ARNESON, 1995: 263, fig. 1241; GOSLINER *et al.*, 1996: 281, fig. 1038; LAMBETH, 2000: 18; JAMES, 2001: 6.
Actinopyga echinites; JAMES & JAMES, 1994: pl. III.

MATERIAL EXAMINED

IRSNB IG 28680/29, Pulau Pemanggil (Malaysia), 14.ix.98, 20 m depth, day dive (one specimen); IRSNB IG 28680/34, Pulau Pemanggil (Malaysia), 14.ix.98, 22 m depth, day dive (one specimen); USMPPM/3, Pulau Pemanggil (Malaysia), 22.xi.99, 19 m depth, day dive (one specimen); USMPPM/8, Pulau Besar (Malaysia), 11.iii.98, 3m depth, day dive (one specimen); USMPPM/45, Pulau Pemanggil (Malaysia), 15.v.98, 18 m depth, day dive (one specimen).

TYPE LOCALITY

Philippines (Bohol).

DESCRIPTION

- External anatomy: Largest specimen 385X95 mm, smallest specimen 130X30 mm. Living specimens with dorsal body wall grey-green, brown-green, sometimes yellowish with numerous very small orange-brown to deep brown dorsal papillae (cf. plate 1B-C). Transversal brown folds present dorsally (their number increases with increasing body size). Colour in alcohol light brown to pale yellow dorsally and white to light brown ventrally. A few large, conical papillae posteriorly located on the smallest specimen. For the large specimens, large papillae more abundant, principally located at the ventro-lateral edges. Mouth ventral with 20 tentacles surrounded by a collar of papillae; anus terminal. Tube feet only along the ambulacral areas, on 5-7 rows in the central one and on 3-4 rows in the lateral ones. Interambulacral areas very narrow giving the impression that the tube feet are present all over the ventral surface.
- Internal anatomy: Body wall very thick (11-18 mm). Calcareous ring very similar to the one of *S. rubermaculosus* (cf fig. 10A). Ampullae of the tentacles 1/5 to 1/7 of body length. A single Polian vesicle, very contracted, nearly spherical, 1/11 of body length. A single stone canal, embedded in the dorsal mesentery, contorted, going upward to the calcareous ring where it ends in a very long, cylindrical madreporic plate similar to the one of *S. ocellatus* (cf fig. 6B).
- Ossicles: Dorsal body wall with tables, C-shaped rods and rosettes. Tables are 25-35 µm across (fig. 3A), rosettes 25-55 µm long (fig. 3B) and C-shaped rods 35-100 µm long (fig. 3C). According to the specimen the rosettes are rare (L=260 mm) or very abundant (L=130 mm). Ossicles of ventral body wall (fig. 3D-F) very similar to those of dorsal body wall. Sometimes among the C-shaped rods a S-shaped rod. At the base of the dorsal papillae same ossicles as in the dorsal body wall but tables larger (40-55 µm across)(fig. 3G, H). At the top of the dorsal papillae tables (fig. 3J), C-shaped rods and rosettes still present together with small perforated plates (fig. 3K) and rods (fig. 3L, M). According to the specimen these rods are nearly without central process (fig. 3L) or with a well developed one (fig. 3M). In the tube feet reduced tables (fig. 3N), 30-45 µm across, large perforated plates (fig. 3P) and rods, 200-360 µm long (fig. 3Q, R) with a perforated central process. The end plate, 480-600 µm across, is made of several perforated plates. In the tentacles spiny rods, slightly curved, sometimes forked and or perforated at the extremities. In small specimens they are 60-850 µm long with very

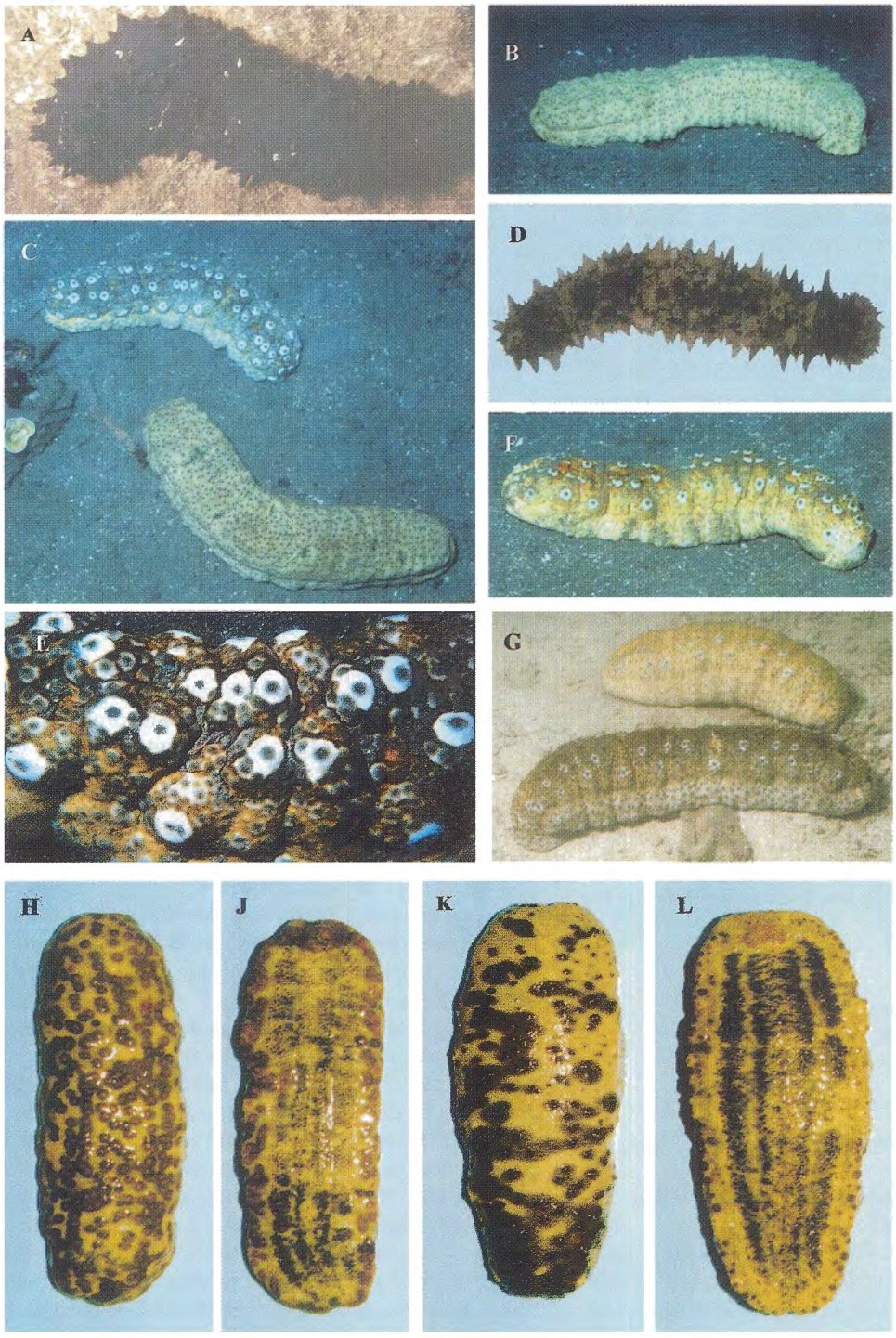


Plate 1. A: *Stichopus chloronotus* BRANDT, 1835. Pulau Pemanggil. (Malaysia) (photo ZULFIGAR); B: *Stichopus herrmanni* SEMPER, 1868, Hansa Bay (Papua New Guinea), 22 m depth (photo MASSIN)(L= ± 310 mm); C: *Stichopus herrmanni* SEMPER, 1868 (lower specimen, L= ± 320 mm) and *Stichopus ocellatus* n. sp. (upper specimen, L= ± 230 mm), Hansa Bay (Papua New Guinea), 21 m depth (photo MASSIN); D: *Stichopus horrens* SELENKA, 1867, Hansa Bay (Papua New Guinea), reef flat at low tide (photo MASSIN); E: *Stichopus ocellatus* n. sp., close up of the dorsal side, Hansa Bay (Papua New Guinea), 21 m depth (photo MASSIN); F: *Stichopus ocellatus* n. sp., Hansa Bay (Papua New Guinea), 21 m depth (photo MASSIN)(L= ± 280 mm); G: *Stichopus ocellatus* n. sp., Pulau Besar (Malaysia), 3 m depth (photo MASSIN)(upper specimen L= ± 200 mm, lower specimen L= ± 300 mm); H: *Stichopus rubermaculosus* n. sp., dorsal view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=245 mm); J: *Stichopus rubermaculosus* n. sp., ventral view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=245 mm); K: *Stichopus rubermaculosus* n. sp., dorsal view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=275 mm); L: *Stichopus rubermaculosus* n. sp., ventral view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=275 mm).

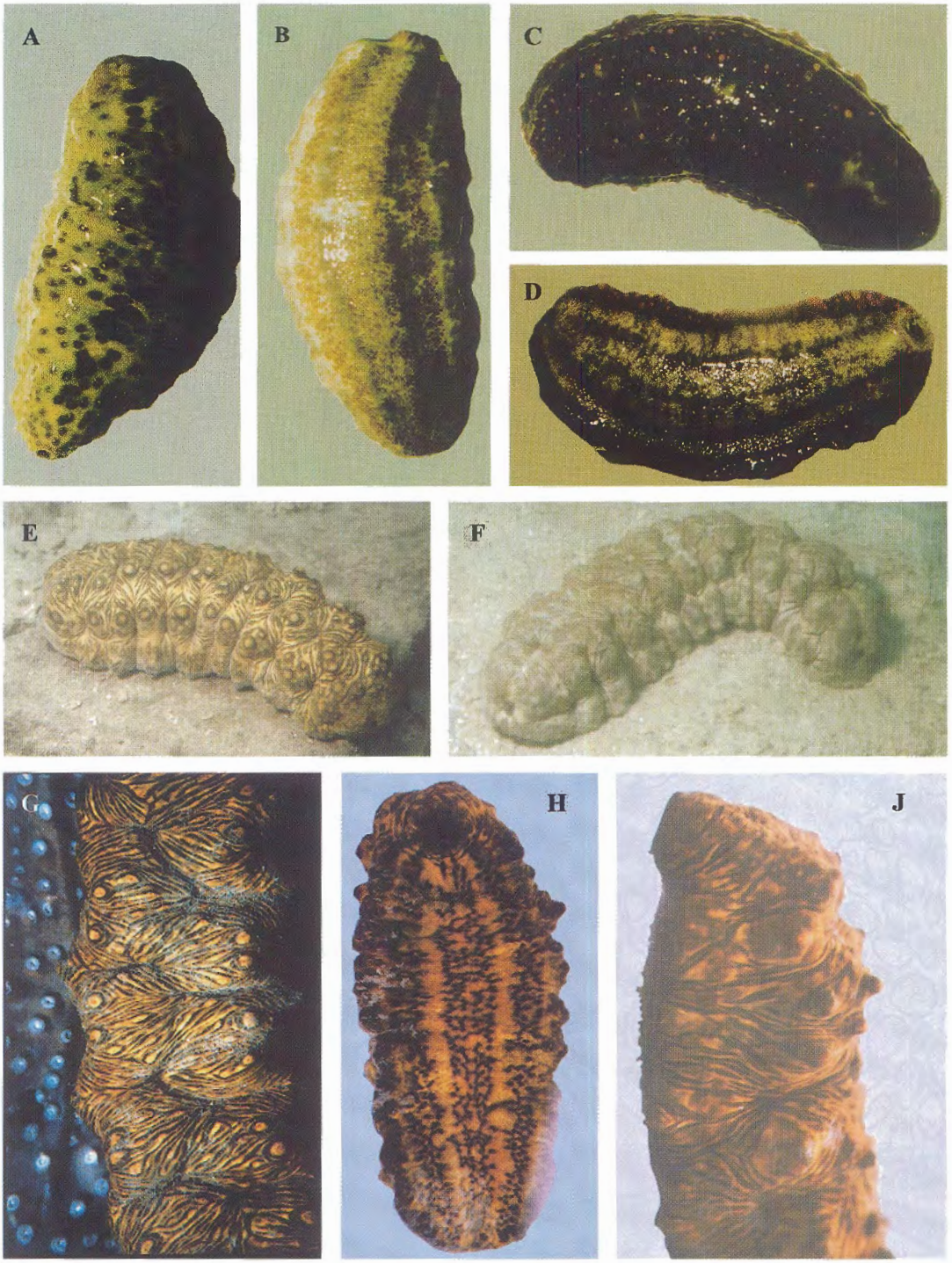


Plate 2. A: *Stichopus rubermaculosus* n. sp., dorsal view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=260 mm); B: *Stichopus rubermaculosus* n. sp., ventral view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=260 mm); C: *Stichopus rubermaculosus* n. sp., dorsal view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=285 mm); D: *Stichopus rubermaculosus* n. sp., ventral view, Pulau Besar (Malaysia), 3m depth (photo ZULFIGAR) (L=285 mm); E: *Stichopus vastus* SLUITER, 1887, Madang (Papua New Guinea) 2 m depth (photo MASSIN)(L= ± 250 mm); F: *Stichopus vastus* SLUITER, 1887, Pulau Besar (Malaysia), 3 m depth (photo MASSIN)(L= ± 340 mm); G: *Stichopus vastus* SLUITER, 1887, Hansa Bay (Papua New Guinea), 10 m depth (photo MASSIN)(L=270 mm); H: *Stichopus vastus* SLUITER, 1887, Hansa Bay (Papua New Guinea), 10 m depth (photo MASSIN)(L=200 mm); J: *Stichopus vastus* SLUITER, 1887 Hansa Bay (Papua New Guinea), 10 m depth (photo MASSIN)(L=200 mm).

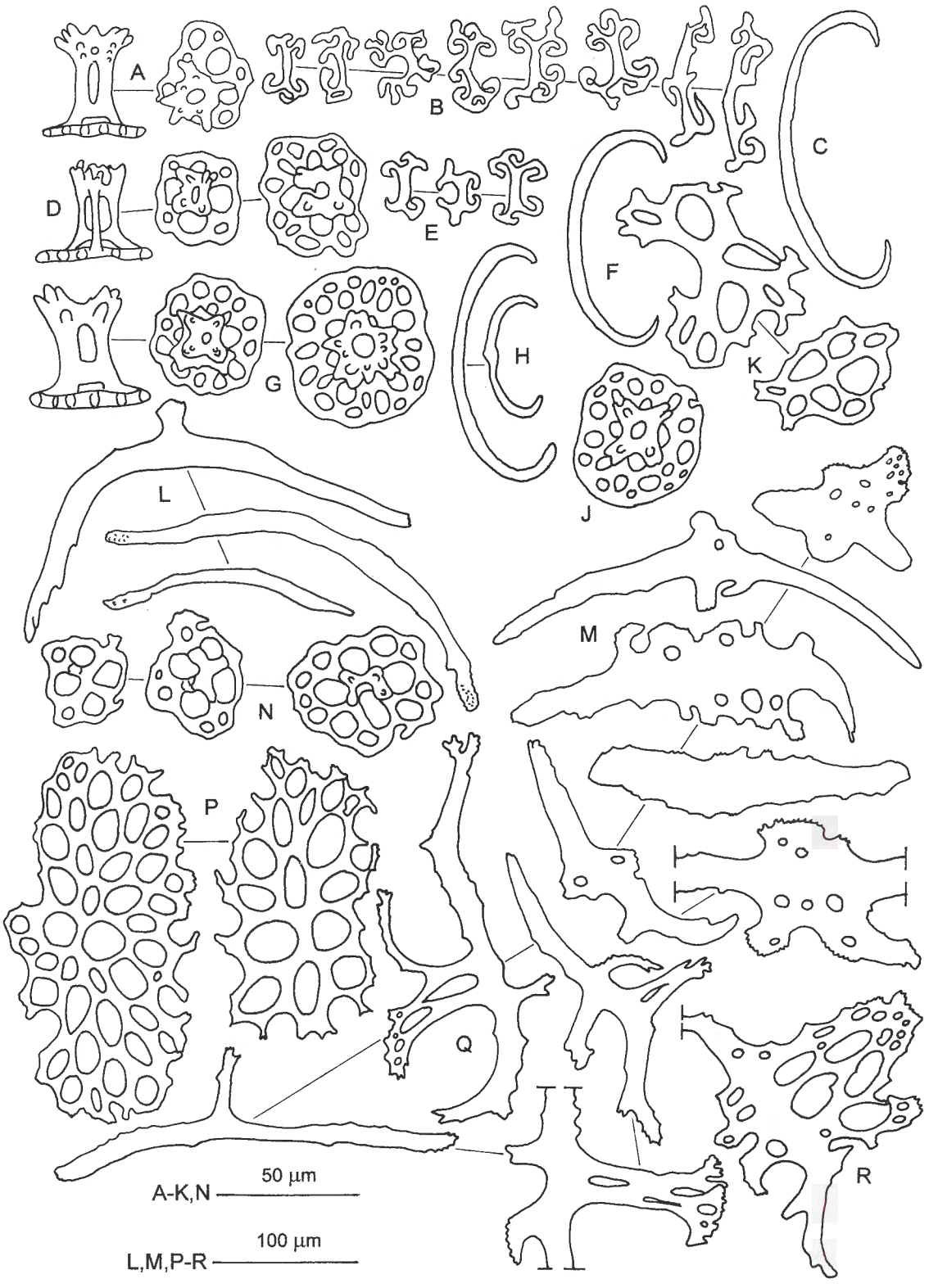


Fig. 3. *Stichopus herrmanni* SEMPER, 1868. A: tables of the dorsal body wall (L=260 mm); B: rosettes of the dorsal body wall (L=130 mm); C: C-shaped rod of dorsal body wall (L=130 mm); D: tables of the ventral body wall (L=260mm); E: rosettes of ventral body wall (L=260 mm); F: C-shaped rod of ventral body wall (L=260 mm); G: tables of the base of the dorsal papillae (L=260 mm); H: C-shaped rods of the base of the dorsal papillae (L= 260 mm); J: tables of the top of the dorsal papillae (L= 260 mm); K: small perforated plates of the top of the dorsal papillae (L= 260 mm); L: rods of the top of the dorsal papillae (L= 260 mm); M: rods of the top of the dorsal papillae (L= 130 mm); N: tables of the tube feet (L= 260 mm); P: large perforated plates of the tube feet (L= 260 mm); Q: rods of the tube feet (L= 260 mm); R: rods of the tube feet (L= 130 mm).

spiny extremities and in large specimens 70-740 µm long with non-perforated and undivided extremities.

REMARKS

As explained in previous papers (MASSIN, 1996a, 1999) following the action of ROWE (in ROWE & GATES, 1995: 324), the name *Stichopus variegatus* cannot be systematically replaced by *S. herrmanni*. Therefore, the records of *S. variegatus* here cited (cf. supra) are limited to papers with good illustrations where no doubt is left between *S. herrmanni* and *S. monotuberculatus*.
The number of rosettes is highly variable. CHERBONNIER (1988) reported them to be abundant whereas MASSIN (1996b) found them to be few. This seems unrelated to the size of the specimens because the specimen with few rosettes observed by MASSIN (1996a) is 135 mm long whereas the specimen with numerous rosettes of the present work is 130 mm long. The shape and prominence of the central perforated process of the rods of the tube feet and dorsal papillae is also highly variable (see figs 3L, M and 3Q, R). Therefore abundance of rosettes, and shape of the rods from the tube feet and dorsal papillae cannot be used as characters to distinguish *Stichopus herrmanni* from other species. The rods of the tentacles present also variations: they can be branched (rare) or not. This character, used by ZULFIGAR *et al.* (1999) to separate *S. herrmanni* from "*Stichopus variegatus*" (= *Stichopus rubermaculosus*), should be discarded.

Stichopus horrens SELENKA, 1867
Figs 4A-H, 5A-G, pl. 1D

SYNONYMY

Stichopus horrens SELENKA, 1867: 316, pl. 18, figs 27-29; PANNING, 1944: 35; DAWIDOFF, 1952: 118; LOI & SACH, 1963: 238, pl. 1, fig. B, c, pl. VI, fig. 2; LOI, 1967: 230; LEVIN, 1979: 22; KROPP, 1982: 448; PRICE & REID, 1985: 6; CANNON & SILVER, 1987: 27, figs 2d, 7g, text fig.; MARSH, 1986: 73; FÉRAL & CHERBONNIER, 1986: 96, text fig. pp 96-97; CHERBONNIER, 1988: 147, fig. 61A-P (synonymy and records before 1981); MALUF, 1988: 98; CHAO & CHANG, 1989: 115, figs 8, 29C; CONAND, 1989: 30; KALASHNIKOV, 1989: 68; LEVIN & DAO, 1989: 57; MARSH *et al.*, 1993: 64; ALLEN & STEEN, 1994: 245; KERR, 1994: 163; MARSH, 1994a: 11; MARSH, 1994b: 57; LIAO & CLARK, 1995: 461, fig. 280; ROWE & GATES, 1995: 324 (synonymy); GOSLINER *et al.*, 1996: 281, fig. 1033; LIAO, 1997: 153, fig. 89 (synonymy and records before 1995); ROWE & RICHMOND, 1997: 306, fig. p. 307; BAINE & FORBES, 1998: 4; CONAND, 1998: 1187, text fig; LIAO, 1998: 80; HICKMANN, 1998: 57, text fig.; FORBES *et al.*, 1999: 10, text fig.; FORBES & ILIAS, 1999: 44; BAINE & CHOO, 1999: 49; ZULFIGAR & TAN SHAU HWAI, 1999: 77; SCHOPPE, 2000a: 11; ZULFIGAR *et al.*, 2001b: 364.
Stichopus sp. cf. *S. horrens*; SLOAN *et al.* 1979: 123.

MATERIAL EXAMINED

IRSNB IG 28680/49, Pulau Aur (Malaysia), 15.ix.1998, 10 m depth, night dive (1 specimen).

TYPE LOCALITY

Society Islands.

DESCRIPTION

- External anatomy: Specimen examined 250X50 mm. Colour of living specimen grey-brown with irregular grey-white spots, dorsal papillae white-grey with transversal brown stripes (pl. 1D). Colour in alcohol white grey dorsally and ventrally, with here and there brown patches dorsally. Very long (18-23 mm) dorsal papillae, especially anteriorly and posteriorly. Prominent row of papillae along the ventro-lateral edges. Mouth ventral with 20 tentacles surrounded by a collar of papillae; anus terminal. Ventral sole flat with tube feet only in the ambulacral areas: on 3-4 rows in the lateral ones and 5-7 rows in the central one. Tube feet very long, up to 11 mm. Interambulacral areas are well visible. One small eulimid present on the ventral sole.
- Internal anatomy: Calcareous ring identical to that illustrated by Cherbonnier (1988, fig. 61M). Ampullae of the tentacles are long (more or less 1/5 of body length). Polian vesicle single, short, ovoid. One very long stone canal, contorted, embedded in the dorsal mesentery and ending in a rounded madreporic plate located close to the calcareous ring. Longitudinal muscles narrow, flat with a swelling along each edge.
- Ossicles: In the dorsal body wall numerous tables 25-32 µm across (fig. 4B), numerous rosettes 17-30 µm long and a few C-shaped rods 45-60 µm long (fig. 4C). In the ventral body wall tables, very numerous, 30-55 µm across and a few C-shaped rods 55-85 µm long (fig. 4E). In the tube feet tables 40-120 µm across (fig. 4F), large perforated plates (fig. 4H) and rods 390-500 µm long, some with a huge central perforated process (fig. 4G). Perforations of the processes numerous and small. End plate (900-1000 µm across) made of 13-18 plates. Ossicles located at the base of the dorsal papillae very similar to those of dorsal body wall: numerous tables 32-35 µm across (fig. 5A), small rosettes 17-25 µm long (fig. 5B) and C-shaped rods 40-110 µm long (fig. 5C). At the top of the dorsal papillae, huge tack like tables (fig. 5D), 130-155 µm across, C-shaped rods 45-80 µm long (fig. 5E), a few huge abnormal C-shaped rods (fig. 5F) and rods with large central perforated process (fig. 5G). Perforations of the processes are few and large. In the tentacles spiny rods from nearly straight to U-shaped, 60-700 µm long, some with a forked extremity.

DISTRIBUTION

West Pacific from Malaysia to Society Islands, and from Southern Japan and Hawaii to New Caledonia

REMARKS

With its greyish background colour and its very large conical, dorsal papillae, *Stichopus horrens* seems easy to identify in the field. However, *S. quadrifasciatus* MASSIN, 1999 looks like very much to *S. horrens* at the first glance. Both species are immediately separated by the presence/absence of tack like tables in the dorsal papillae (MASSIN, 1999). Among the *Stichopus* species present in the Johore Marine Park, *S. horrens* is the only one with tack like tables.

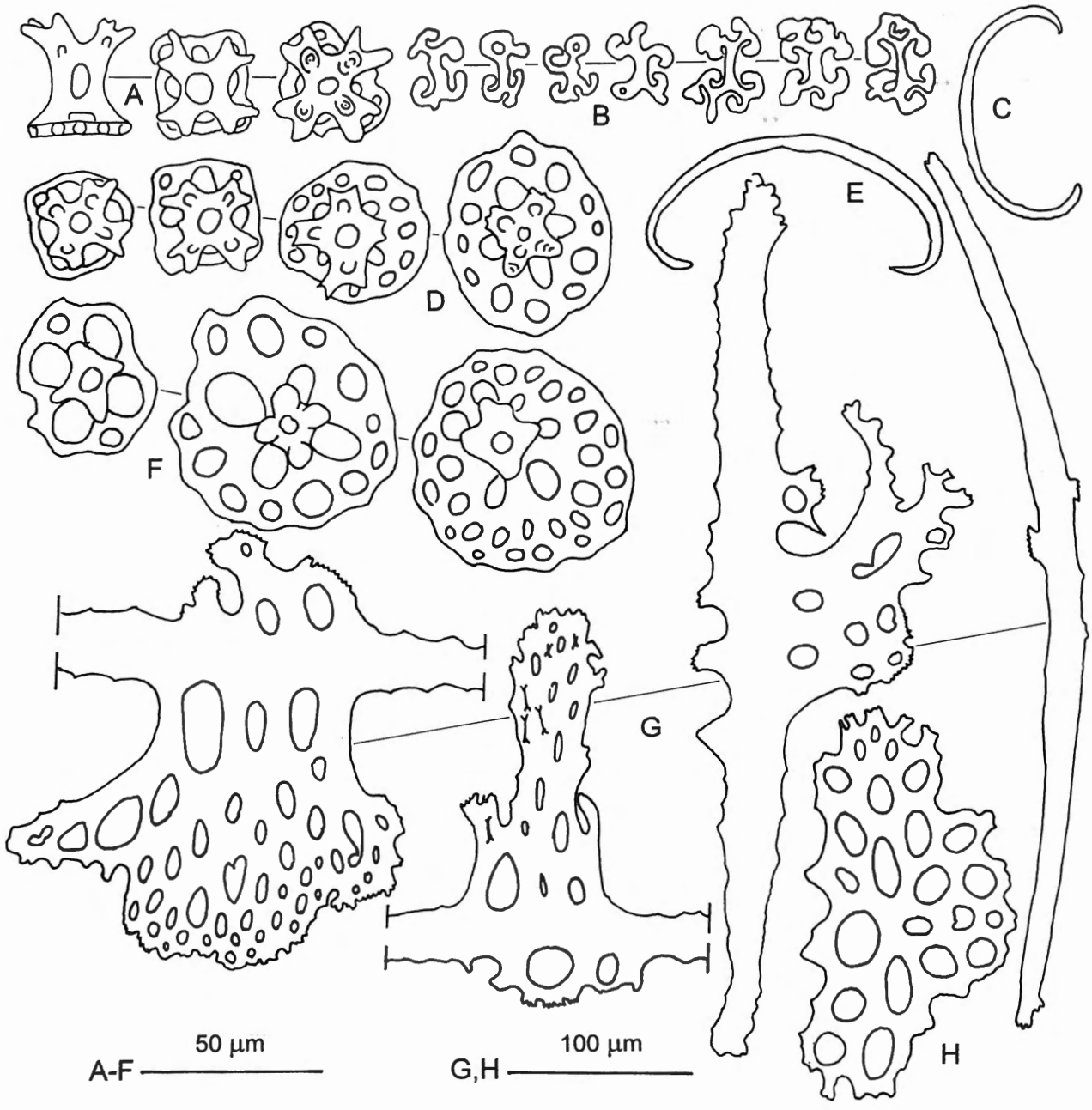


Fig. 4. *Stichopus horrens* SELENKA, 1867. (L=250 mm). A: tables of the dorsal body wall; B: rosettes of the dorsal body wall; C: C-shaped rod of the dorsal body wall; D: tables of ventral body wall; E: C-shaped rod of ventral body wall; F: tables of the tube feet; G: rods of the tube feet; H: large perforated plates of the tube feet.

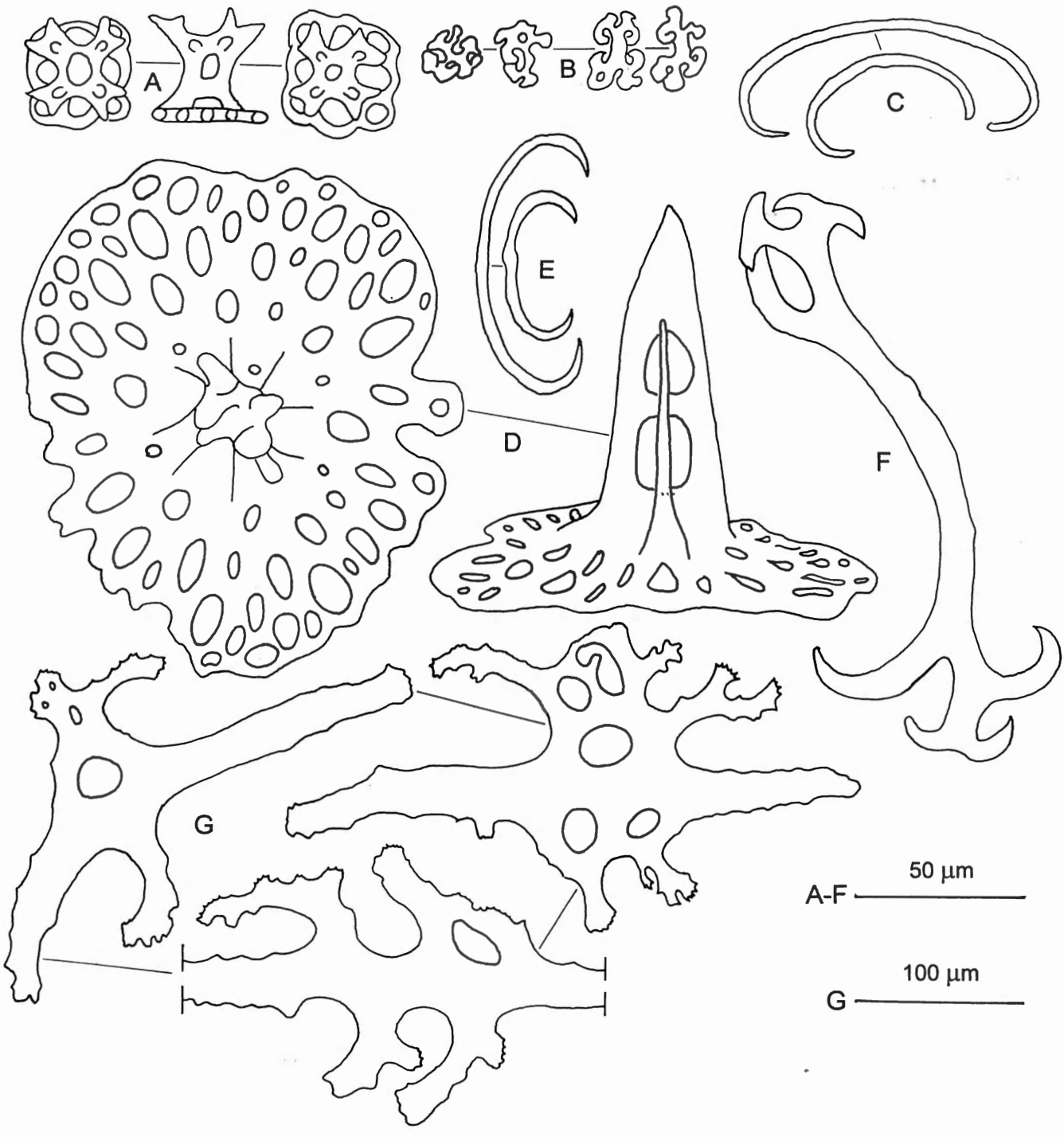


Fig. 5. *Stichopus horrens* SELENKA, 1867. (L= 250 mm). A: Tables of the base of the dorsal papillae; B: rosettes of the base of the dorsal papillae; C: C-shaped rods of the base of the dorsal papillae; D: tables of the top of the dorsal papillae; E: C-shaped rods of the top of the dorsal papillae; F: abnormal C-shaped rods of the top of the dorsal papillae; G: rods of the top of the dorsal papillae.

Stichopus monotuberculatus (QUOY & GAIMARD, 1833)

SYNONYMY

Holothuria monotuberculata QUOY & GAIMARD, 1833: 131, pl. 432, fig. 1.
Stichopus monotuberculatus; CHERBONNIER, 1952: 23, pl. 3, fig. 4, text fig. 8a-t; TORTONESE, 1977: 275; PRICE, 1982: 11; MARSH *et al.*, 1993: 64; MARSH, 1994b: 57; ROWE & GATES, 1995: 325; ? MASSIN, 1996b: 163, figs 9, 10, pl. 1C, D; ROWE & RICHMOND, 1997: 306; SAMYN, 2000: 15.
Stichopus cf. *monotuberculatus*; SAMYN & VANDEN BERGHE, 2000: 31, pl. 2F-H.
? *Stichopus variegatus*; CODOCEO, 1974: 53; CASTILLA & ROZBACZYLO, 1987: 211.
? *Stichopus chloronotus*; DI SALVO *et al.*, 1988: 460.

MATERIAL EXAMINED

None

TYPE LOCALITY

Port Louis (Mauritius)

DESCRIPTION

See CHERBONNIER, 1952

DISTRIBUTION

See MASSIN, 1996b + ? Marshall Islands + ? Easter Island

REMARKS

Stichopus monotuberculatus has not yet been observed in Malaysia. It is cited here because it presents many affinities with *S. rubermaculosus* n. sp. Characters distinguishing both species will be discussed in the section devoted to *S. rubermaculosus* n. sp.
The *Stichopus* from Easter Island (CODOCEO, 1974; CASTILLA & ROZBACZYLO, 1987; DI SALVO *et al.*, 1988; MASSIN, 1996b) identified as S. monotuberculatus by MASSIN (1996b) are cited here with a question mark because they could represent a new species. They will not be included in the discussion comparing *S. monotuberculatus* with *S. rubermaculosus* n. sp.

Stichopus ocellatus n. sp.
Figs 6A-W, 7A-J, 8A-D, pl. 1C, E-G

SYNONYMY

Stichopus variegatus; FORBES *et al.*, 1999: 12, text fig.
Stichopus sp1; RIZAL BOSS *et al.*, 1999: 38; ZULFIGAR *et al.*, 2001b: 364.

MATERIAL EXAMINED

IRSNB IG 28455/85, 23.x.96, Hansa Bay (Papua New Guinea), 18 m depth, on muddy black sand, day dive (holotype); IRSNB IG 28680/1, 12.ix.98, Pulau Besar (Malaysia), 2 m depth on white sand, day dive (paratype); IRSNB IG 26700/222, 10.xi.83, Hansa Bay (Papua New Guinea), 20 m depth on muddy black sand, day dive (one specimen); USMPPM/1, 11.iii.98, Pulau Besar (Malaysia), 4 m depth on sandy bottom, day dive (one specimen); USMPPM/15, 21.xi.99, Pulau Besar (Malaysia), 6 m depth on sandy bottom with sea grass, day dive (one specimen). A ten of specimens observed and photographed in Papua New Guinea and Malaysia.

TYPE LOCALITY

Hansa Bay (Madang Province, Papua New Guinea)

DESCRIPTION

- External anatomy: All the specimens observed were large. The ones collected measure from 290X90 to 330X75 mm. Colour of living specimens yellow-orange mottled with green-grey (pl. 1F) dorsally. Dominating colour can be the orange-yellow or the green-grey (pl. 1G). Large dorsal papillae white at the base and green-grey at the apex (pl. 1E). Small papillae green-grey with only a paler narrow ring at the base (pl. 1E). Ventrally yellow with green-brown tube feet. Colour in alcohol white-beige ventrally, light brown dorsally with the large, white papillae still visible. Ventral sole flat with tube feet only in the ambulacral areas: on 4-6 rows in the lateral ones and 10-12 in the central one. Tube feet are large (up to 10 mm long) with a prominent sucker (up to 1.5 mm across). Interambulacral areas narrow but well visible. Dorsal surface rounded with four rows of large, white papillae in a zigzag pattern (pl. 1C, F, G). The row of papillae at the edge between bivium and trivium sometimes reduced. Mouth ventral with 20 tentacles surrounded by a collar of papillae; anus terminal.
- Internal anatomy: Body wall thick (4-18 mm). Calcareous ring with large radial plates and narrow interradial plates (fig. 6A). Radial plates with a deep posterior notch. Tentacles ampullae very long (1/4 to 1/3 of body length). One Polian vesicle, ovoid, 1/10 of body length. One very long, contorted dorsal stone canal embedded in the dorsal mesentery and ending in a club shaped madreporic plate (fig. 6B). Gonads in two bundles, well develqped, each made of seven tubes, undivided on the first 30 mm, then bearing small lateral tufts.
- Ossicles: In the dorsal body wall, tables (fig. 6E, G), 28-38 µm across, rosettes (fig. 6F, H), 20-40 µm long and C-shaped rods (fig. 6C, D), 155-175 µm long. Rosettes are much more abundant in the paratype (L=290 mm) than in the holotype (L=330 mm). A few S-shaped rods have been observed in the paratype but not in the holotype. Ossicles of ventral body wall (fig. 6J, K, L) very similar to those of dorsal body wall but with smaller C-shaped rods (40-75 µm long). At the base of the dorsal papillae tables (fig. 6N, P), rosettes (fig. 6Q, R) and C-shaped rods (fig. 6M). All of them are larger in the paratype than in the in the holotype: C-shaped rods *i.e.* are 60-110 µm long and 50-75 µm long, respectively. At the top of the dorsal papillae C-shaped rods (fig. 6S, V), tables, 25-50 µm across (fig. 6T, U), rosettes (fig. 6W), small rods and perforated plates (fig. 7A, B), and curved rods with variable central perforated process (fig. 7C, D). In the tube feet large

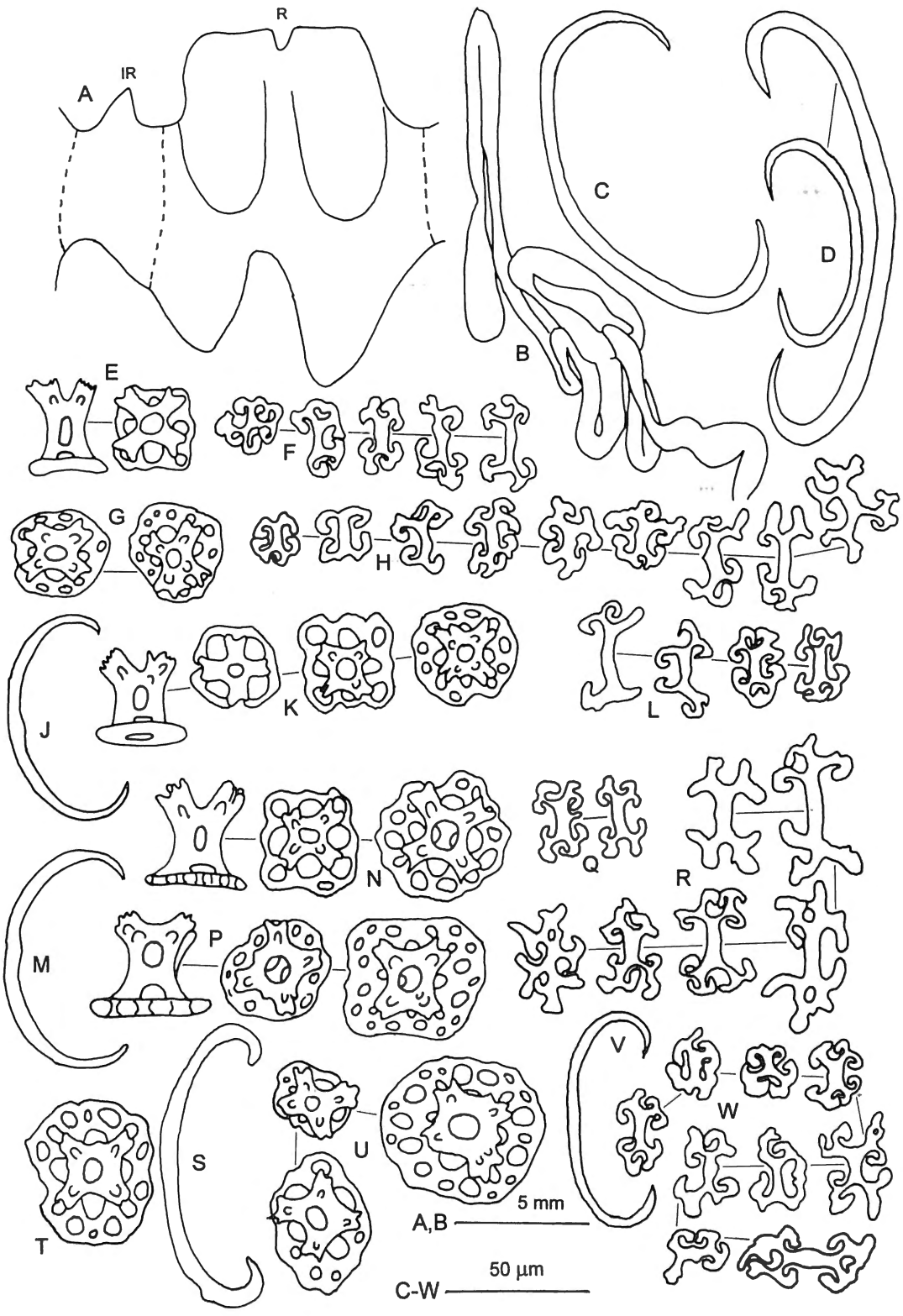


Fig. 6. *Stichopus ocellatus* n. sp. A: calcareous ring (r: radial plate; ir: interradial plate)(paratype); B: stone canal and madreporic plate (paratype); C: C-shaped rod of dorsal body wall (holotype); D: C-shaped rod of dorsal body wall (paratype); E: tables of dorsal body wall (holotype); F: rosettes of dorsal body wall (holotype); G: tables of dorsal body wall (paratype); H: rosettes of dorsal body wall (paratype); J: C-shaped rod of ventral body wall (holotype); K: tables of ventral body wall (holotype); L: rosettes of ventral body wall (holotype) ; M: C-shaped rod of the base of the dorsal papillae (holotype); N: tables of the base of the dorsal papillae (holotype); P: tables of the base of the dorsal papillae (paratype); Q: rosettes of the base of the dorsal papillae (holotype); S: C-shaped rod of the top of the dorsal papillae (holotype); T: tables of the top of the dorsal papillae (holotype); U: tables of the top of the dorsal papillae (paratype); V: C-shaped rod of the top of the dorsal papillae (paratype); W: rosettes of the top of the dorsal papillae (paratype).

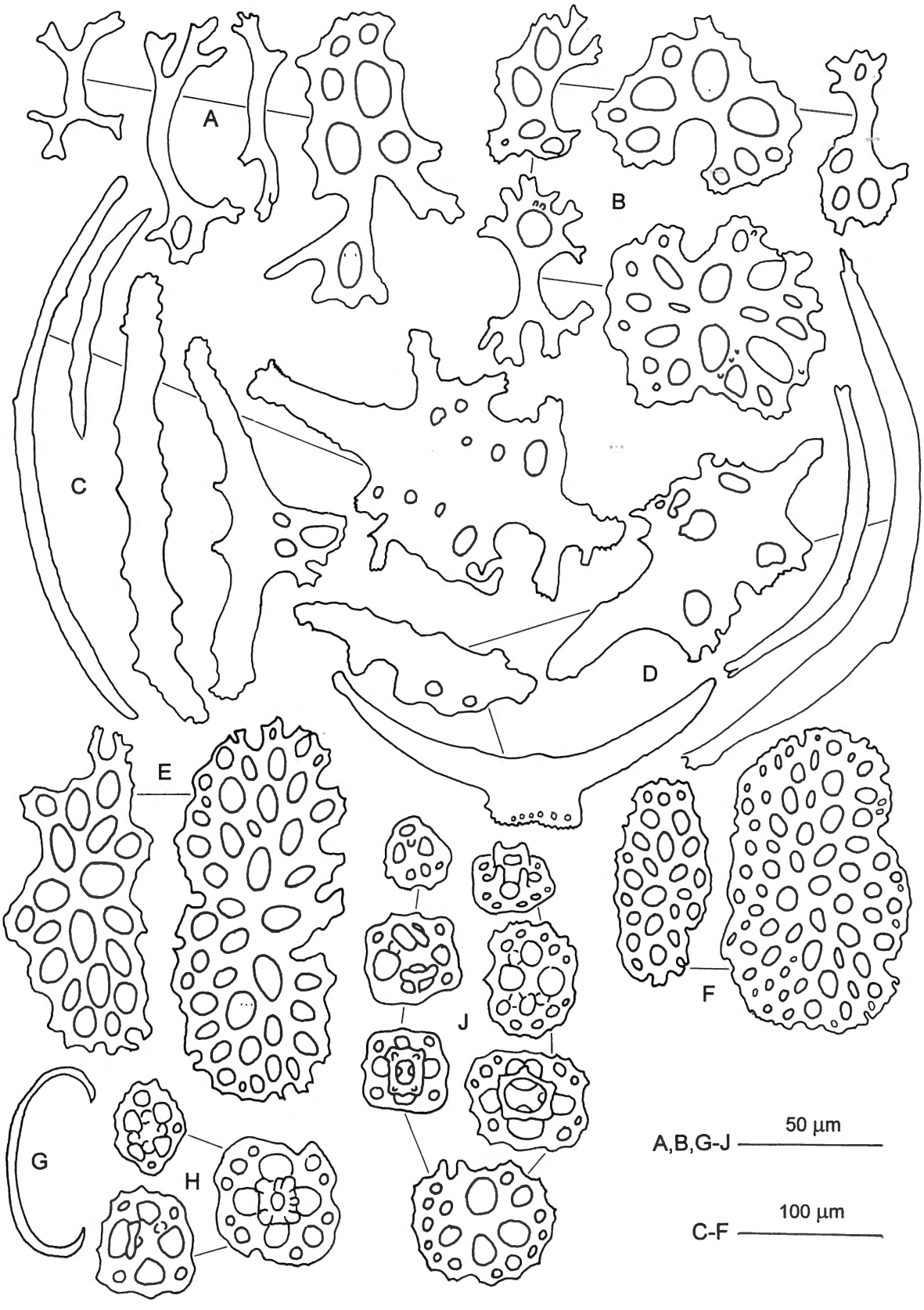


Fig. 7. *Stichopus ocellatus* n. sp. A: small rods and plates of the top of the dorsal papillae (holotype); B: plates of the top of the dorsal papillae (partype); C: large rods of the top of the dorsal papillae (holotype); D: large rods of the top of the dorsal papillae (paratype); E: large plates of the top of the tube feet (holotype); F: large plates of the top of the tube feet (paratype); G: C-shaped rod of the tube feet (holotype); H: tables of the tube feet (holotype); J: tables of the tube feet (paratype).

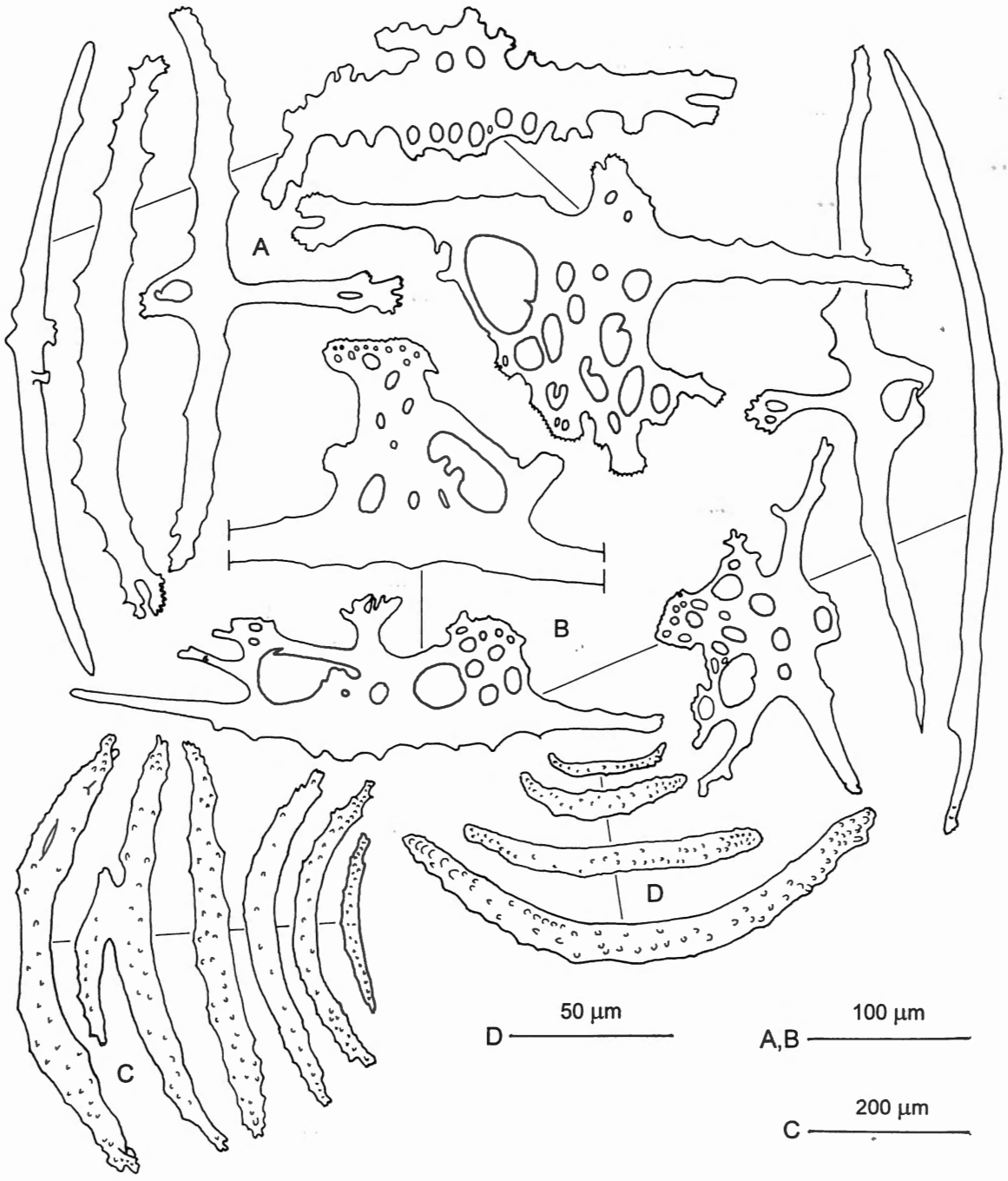


Fig. 8. *Stichopus ocellatus* n. sp. A: rods of the tube feet (holotype); B: rods of the tube feet (paratype); C-D: rods of the tentacles (holotype).

perforated plates (fig. 7E, F), 140-265 µm long, C-shaped rods (fig. 7G), 55-65 µm long, reduced tables (fig. 7H, J), 25-50 µm across and rods (Fig. 8A, B), smooth or spiny, 230-500 µm long, most of them with a large central perforated process. In the tentacles curved spiny rods, 40-600 µm long (fig. 8C, D).

DISTRIBUTION

Malaysia (Peninsula), Papua New Guinea (Hansa Bay)

ETYMOLOGY

ocellatus means with eye-like spots. It refers to the numerous white dorsal papillae looking like eye-like spots.

REMARKS

S. ocellatus n. sp. is very often associated with *S. herrmanni* as well in Malaysia as in Papua New Guinea (pl. 1C). Both species are very easy to distinguish in the field and no intermediary colour pattern have been observed up to now. Re-

garding their ossicles they are very similar to each other. They differ mainly by the size of the C-shaped rods located in the ventral body wall: they are much larger in *S. herrmanni* than in *S. ocellatus*. They differ also by the size of the perforated plates located at the top of the dorsal papillae: 45-60 µm long for *S. herrmanni* versus 60-100 µm long for *S. ocelllatus*. Ossicles of *S. ocellatus* present also many affinities with those of *S. vastus*, the main difference being the size of the dorsal C-shaped rods.

Stichopus rubermaculosus n. sp
Figs 9A-M, 10A-F, 11A-K, pls 1H-L, 2A-D

SYNONYMY

Stichopus variegatus; ZULFIGAR *et al.*, 1999: 163, figs 5, 6, Pls 2-4.

MATERIAL EXAMINED

IRSNB IG 28680/3, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype);IRSNB IG 28680/4, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/5, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (holotype); IRSNB IG 28680/6, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/7, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/8, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/9, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/11, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/12, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/13, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/14, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); IRSNB IG 28680/17, Pulau Besar (Malaysia), 11.ix.98, 2 m depth, night dive (paratype); USMPPM/1 Pulau Besar (Malaysia), 11.viii.00, 2 m depth, night dive (one specimen); USMPPM/2 Pulau Besar (Malaysia), 11.viii.00, 2 m depth, night dive (one specimen); USMPPM/3 Pulau Besar (Malaysia), 11.viii.00, 2 m depth, night dive (one specimen); USMPPM/5 Pulau Besar (Malaysia), 11.viii.00, 2 m depth, night dive (one specimen); USMPPM/6 Pulau Besar (Malaysia), 11.viii.00, 2 m depth, night dive (one specimen); USMPPM/7 Pulau Besar (Malaysia), 11.viii.00, 1 m depth, night dive (one specimen); USMPPM/8 Pulau Besar (Malaysia), 11.viii.00, 1 m depth, night dive (one specimen); USMPPM/9 Pulau Besar (Malaysia), 11.viii.00, 1 m depth, night dive (one specimen); USMPPM/10 Pulau Besar (Malaysia), 11.viii.00, 1 m depth, night dive (one specimen). Tens of specimens observed and photographed in March and May 1998.
A few specimens have been observed during a night dive (15.IX.98) around Pulau Aur.

TYPE LOCALITY

Pulau Besar (Johore Marine Park, Malaysia)

DESCRIPTION

- External anatomy: The observed specimens range from 115X30 mm up to 340X65 mm. Colour of living specimens highly variable. The background colour of the body wall is from light yellow to deep green. Yellowish specimens have or a variable amount of brown-black patches with nearly always the top of some dorsal and lateral papillae red (pl. 1K), or papillae fully red with this colour spreading in between the dorsal papillae (pl. 1H). Greenish specimens have deep green to black dorsal patches (pl. 2A) sometimes covering nearly the whole body wall (pl. 2C). Red is then restricted to the top of the dorsal and lateral papillae. Ventrally same colour as dorsally (pls 1J, L, 2B, D) with tube feet from yellow to deep brown. Whatever the background colour, the tops of the papillae from the collar around the tentacles are nearly always red (a few exceptions for the specimens with a yellow background colour)(pls 1J, L, 2B, D). In alcohol the yellowish specimens appear grey yellow dorsally with pale brown papillae, and whitish ventrally. Greenish specimens appear brownish dorsally and ventrally with the top of the papillae white. Dorsal papillae numerous, highly variable in size but never prominent, without alignment. At the ventro-lateral edges a prominent, continue row of large papillae. Tube feet only in the ambulacral areas. Interambulacral areas generally narrow. The number of tube feet increases with increasing body size. In the lateral and central ambulacral areas they are on 3-4 and 6-7 rows, respectively, for a 115 mm long specimen and on 4-6 and 8-10 rows, respectively, for a 330 mm long specimen. Tube feet are long (5-12 mm) on relaxed specimens. The mouth is ventral with 18-20 tentacles surrounded by a prominent collar of papillae (2 specimens with 2-3 reduced tentacles). Anus terminal.
- Internal anatomy: Body wall from 3 to 15 mm thick according to the state of contraction. For a single specimen it can vary from 5 to 15 mm thick. Calcareous ring with radial plates twice the width of the interradial ones (fig. 10A). V-shaped notch at the rear of the radial plates very deep (fig. 10A). The single stone canal meanders upwards, embedded in the dorsal mesentery, and ends in a triangular madreporic plate located close to the calcareous ring. Most of the specimens with a single club-shaped Polian vesicle 1/12 to 1/7 of body length. Two specimens with 2 short Polian vesicles 1/21 to 1/11 of body length. Tentacle ampullae 1/8 to 1/4 of body length. Gonads not observed.
- Ossicles: Dorsal body wall with tables, rosettes and C-shaped rods. Tables 20-60 µm across (fig. 9A), with a smooth disc rim; tables generally abundant to very abundant (rare only in a single specimen), similar to those found in the other stichopodids here described. Rosettes generally rare but can be also very abundant, 20-45 µm long, highly variable in shape (fig. 9B) or derived only from X-shaped or C-shaped rods (fig. 11A). C-shaped rods always very abundant, 55-80 µm long (fig. 9C). In small and large specimens S-shaped rods are present or absent; if present, always rare. In the ventral body wall tables 25-50 µm across (fig. 9D), generally very abundant but can also be rare, and C-shaped rods, 20-80 µm long (fig. 9E), the small ones (20-30 µm long) being the most abundant. In the tube feet tables (fig. 9F), 20-60 µm across, often with reduced crown of spines and pillars, large

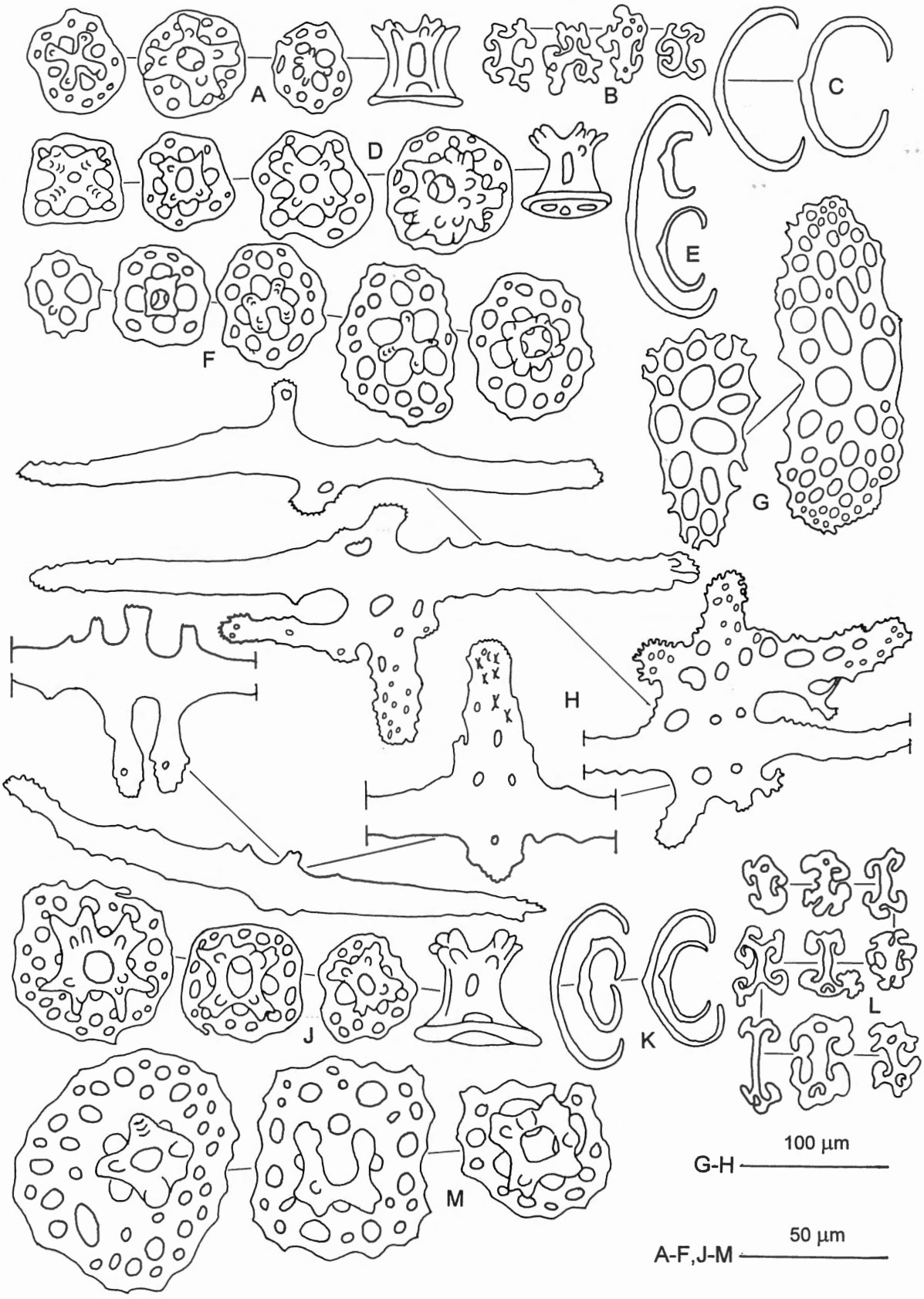


Fig. 9. *Stichopus rubermaculosus* n. sp. Holotype (L=340 mm). A: tables of the dorsal body wall; B: rosettes of the dorsal body wall; C: C-shaped rods of the dorsal body wall; D: tables of the ventral body wall; E: C-shaped rods of the dorsal body wall; F: tables of the tube feet; G: large perforated plates of the tube feet; H: rods of the tube feet; J: tables of the base of the dorsal papillae; K: C-shaped rods of the base of the dorsal papillae; L: rosettes of the base of the dorsal papillae; M: tables of the top of the dorsal papillae.

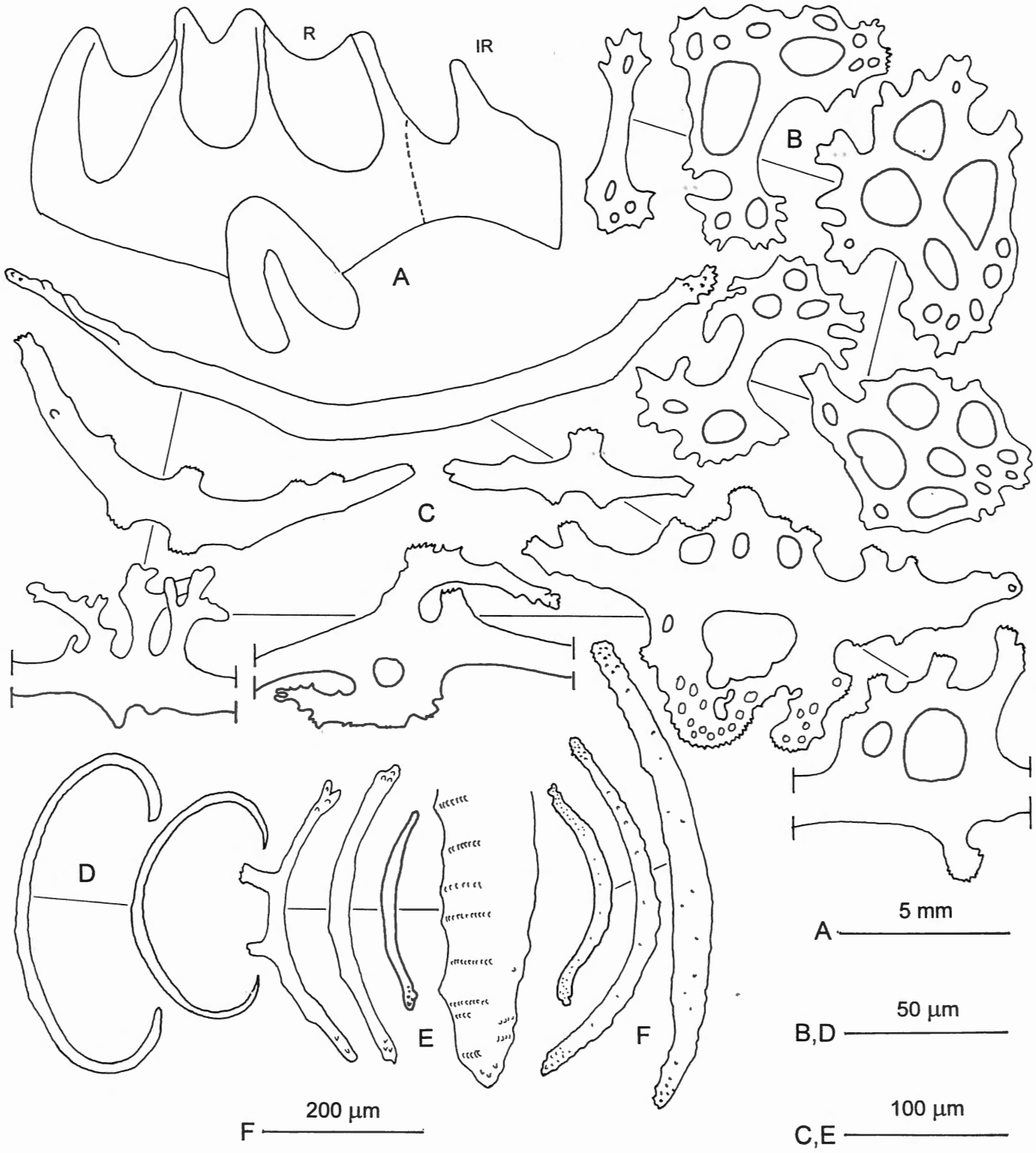


Fig. 10. *Stichopus rubermaculosus* n. sp. Holotype (L=340 mm). A: Calcareous ring (r: radial plate; ir: interradial plate); B: small perforated plates of the top of the dorsal papillae; C: rods of the top of the dorsal papillae; D: C-shaped rods of the top of the dorsal papillae; E, F: rods of the tentacles.

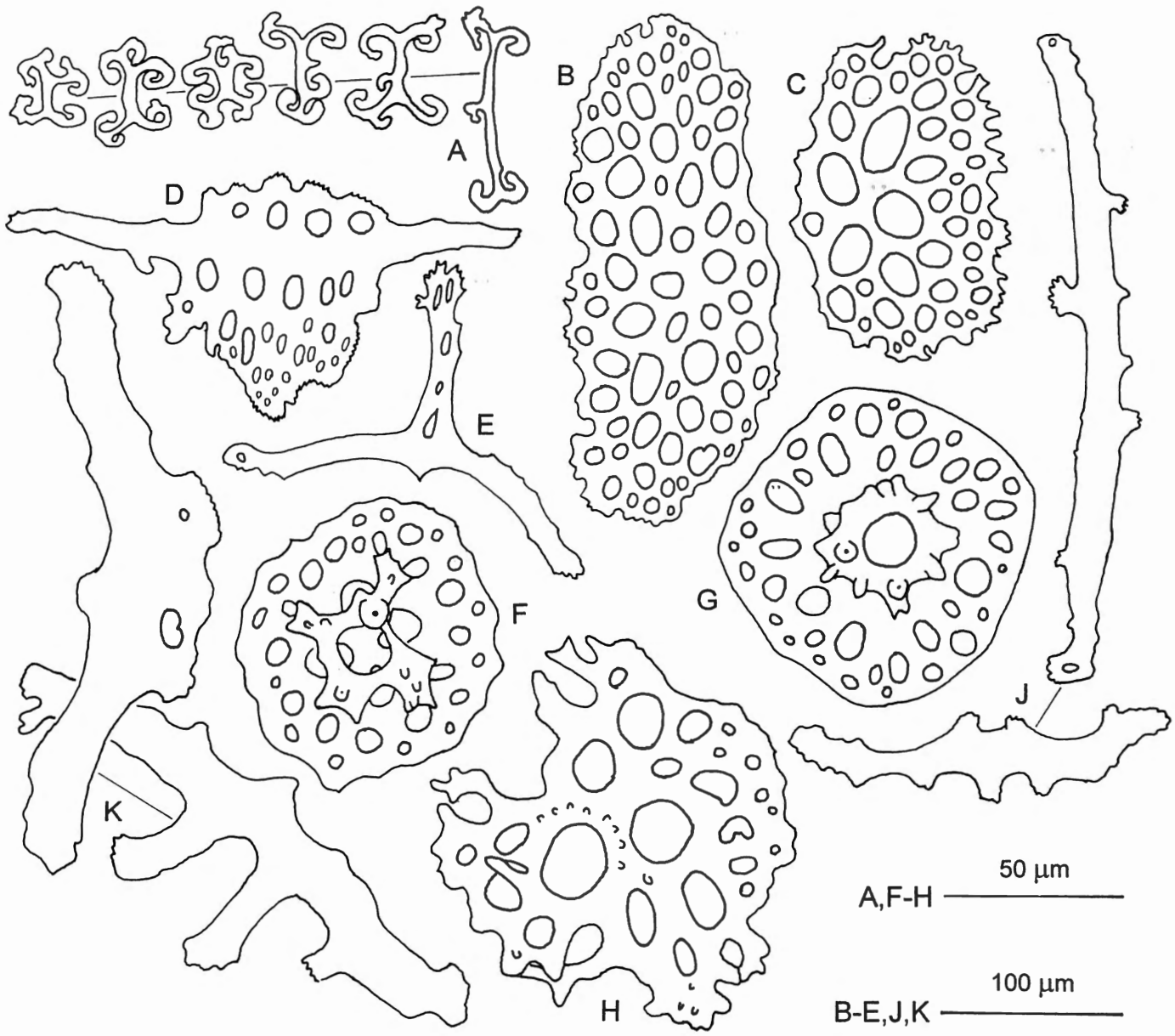


Fig. 11. *Stichopus rubermaculosus* n. sp. Paratypes. A: rosettes of the dorsal body wall (paratype 3, L=270 mm); B: perforated plate of the tube feet (paratype 7, L=250 mm); C: perforated plate of the tube feet (paratype11, L=280 mm); D: rod of the tube feet (paratype 8, L=180 mm); E: rod of the tube feet (paratype 12, L=240 mm); F: table of the top of the dorsal papillae (paratype 11, L= 280 mm); G: table of the top of the dorsal papillae (paratype 14, L=115 mm); H: perforated plate of the top of the dorsal papillae (paratype 13, L=240 mm); J: rods of the top of the dorsal papillae (paratype 3, L=270 mm); K: rods of the top of the dorsal papillae (paratype 4, L=330 mm).

perforated plates (fig. 9G), 155-280 µm long, generally with central holes much larger than peripheral ones; plates with regular holes are also present (fig. 11B, C); rods, 200-475 µm long without central perforated process (fig. 9H) or with a very important one (fig. 9H); all the intermediary shapes of lateral process present, from very massive (fig. 11D) to very slender (fig. 11E); end plates, 700-850 µm across, made of a ten of perforated plates.

At the base of the dorsal papillae tables (fig. 9J) slightly larger (25-70 µm across) than in the dorsal body wall, C-shaped rods (fig. 9K), 30-80 µm long, rare or abundant, and rosettes (fig. 9L), 20-35 µm long, rarely abundant, sometimes absent. At the top of the dorsal papillae large tables (fig. 9M), 35-110 µm across, often with a reduced crown of spines (fig. 9M), sometimes with a well developed one (fig. 11F, G) and with a smooth disc rim, C-shaped rods (fig. 10D), 70-100 µm long, small perforated plates with spiny edge (fig. 10B), 65-95 µm long, exceptionally up to 115 µm long (fig. 11H), and rods (fig . 10C), 150-485 µm long with or without a central perforated process; in some specimens no process at all (fig. 11J) or low, massive, non-perforated process (fig. 11K). The ratio between disc diameter of the

tables from dorsal body wall and top of the papillae varies from 1.0 to 2.1 for specimens of the same size (230-290 mm long).
In the tentacles spiny curved rods (fig. 10E, F), 35-800 µm long, some small ones with short lateral processes; on large rods, spines are sometimes aligned forming transversal folds (fig. 10E).

ETYMOLOGY

rubermaculosus means spotted with red. It refers to the red colour at the top of the papillae.

ECOLOGY

During the day *Stichopus rubermaculosus* is hidden under corals and not visible. It comes out only at night, foraging on sandy bottom with coral rubbles.

REMARKS

ZULFIGAR *et al.* (1999: figs 5-6, pls 2-4) illustrated a new *Stichopus* species which is, in the present paper, named *S. rubermaculosus*. Unfortunately, instead of giving it a new name or naming it *Stichopus sp*, ZULFIGAR *et al.* (1999) used the name *Stichopus variegatus* which is no longer valid. They compared *Stichopus herrmanni* with "*Stichopus variegatus*" (= *S. rubermaculosus*). No differences were found in size and number of Polian vesicles, stone canals and madreporic plates between both species. However, ZULFIGAR *et al* (1999) observed some differences in the perforated plates located in the dorsal papillae. In their table 3 they also mentioned the presence of rosettes in dorsal and ventral body wall of *S. herrmanni* and only in dorsal body wall of "*S. variegatus*" (= *S. rubermaculosus*).
S. rubermaculosus has a highly variable colour pattern. The only nearly constant feature observed in the present study is the uniform red colour at the top of the papillae (dorsal, lateral, and/or collar) and the brown-black dorsal patches. *S. monotuberculatus* has papillae with coloured rings (CHERBONNIER, 1952: pl. 3, fig.4). Moreover, *S. monotuberculatus* has prominent dorsal papillae whereas it is not the case for *S. rubermaculosus* (comparing living non contracted specimens).
The ossicles of *S. rubermaculosus* are very close to those of *S. monotuberculatus*. The ratio between the diameter of the tables from the dorsal body wall and the top of the papillae is highly variable for *S. rubermaculosus* and cannot be used to separate both species. The rim of the table disc is usually spiny for *S. monotuberculatus* (see CHERBONNIER, 1952) but smooth for *S. rubermaculosus*, comparing specimens of the same size. Moreover, *S. rubermaculosus* has perforated plates located at the top of the dorsal papillae whereas these ossicles have not yet been described for *S. monotuberculatus* (see CHERBONNIER, 1952).
The abundance, rarity or even the absence of some ossicles (tables, C-shaped rods, S-shaped rods) cannot be taken into account to separate *S. rubermaculosus* from other species because of the high intraspecific variability of these characters. Only the absence of rosettes in the ventral body wall is constant and allows us to separate *S. rubermaculosus* from the group *S. vastus*, *S. herrmanni* and *S. ocellatus*.

Stichopus vastus SLUITER, 1887
Figs 12A-R, 13A-D, pl. 2E-J

SYNONYMY

Stichopus vastus SLUITER, 1887: 198, pl. 2, figs 46-48; MASSIN, 1999: 71, figs 57a-l, 58a-m, 59a-g, 60a-d, 61, 112d, e (synonymy and records before 1998); JAMES, 1998: 13, fig. 1; FORBES *et al.*, 1999: 14, text fig; ZULFIGAR *et al.*, 2001b: 364.

MATERIAL EXAMINED

IRSNB IG 28680/2, 11.ix.98, Pulau Besar (Malaysia), 2 m depth, night dive (one specimen); IRSNB IG 28680/10, 11.ix.98, Pulau Besar (Malaysia), 2 m depth, night dive (one specimen); IRSNB IG 28680/30, 14.ix.98, Pulau Pemanggil (Malaysia), 8 m depth, day dive (one specimen); RMNH Ech 6089, 30.viii.94, Sulawesi, Panikiang (Indonesia), reef flat at low tide (one specimen); IRSNB IG 28251/54, Sulawesi, Panikiang W (Indonesia), 11m depth (one specimen); USMPPM/6, 11.iii.98, Pulau Besar (Malaysia), 3 m depth, day dive (one specimen); USMPPM/32, 18.iv.98, Pulau Pemanggil (Malaysia), 9 m depth, day dive (one specimen); USMPPM/2, 22.xi.99, Pulau Pemanggil (Malaysia), 17 m depth, day dive (one specimen); a ten of specimens observed and photographed in Papua New Guinea and Malaysia.

TYPE LOCALITY

Java (Indonesia)

DISTRIBUTION

See MASSIN, 1999 + India (Andaman Islands), Maldives, Malaysia (Peninsula, Sabah).

DESCRIPTION

– External anatomy: Specimens observed from 160X50 up to 350X80 mm. Colour of living specimens grey-green dorsally with brown stripes whose abundance and intensity are highly variable (pl. 2E, F). Some specimens from Papua New Guinea with a gold yellow background colour and numerous green brown stripes (pl. 2E) or reddish background colour with deep brown stripes (pl. 2J). Ventrally red-orange with deep red to black tube feet (pl. 2H). Colour in alcohol grey-brown dorsally with stripes faded but still visible and yellow-white ventrally. Dorsally the stripes originate from hollows located in between the large dorsal papillae and run around these papillae (pl. 2G). Laterally the stripes are running vertically, more or less parallel to each other (pl. 2J). Two rows of very large but low dorsal papillae. The papillae at the edge between the bivium and the trivium are few but large, forming a discontinuous row. Ventral sole flat with the tube feet restricted to the ambulacral areas. In the small specimen (L=160 mm long) tube feet on 3-4 rows in the lateral ambulacral areas and 6-8 in the central one; for large specimens (>300 mm long), 3-5 and 10-12 rows of tube feet, respectively. Tube feet are 9-12 mm long on relaxed specimens. Interambulacral areas large and well visible on small specimens (pl. 2H) but very narrow on large specimens.

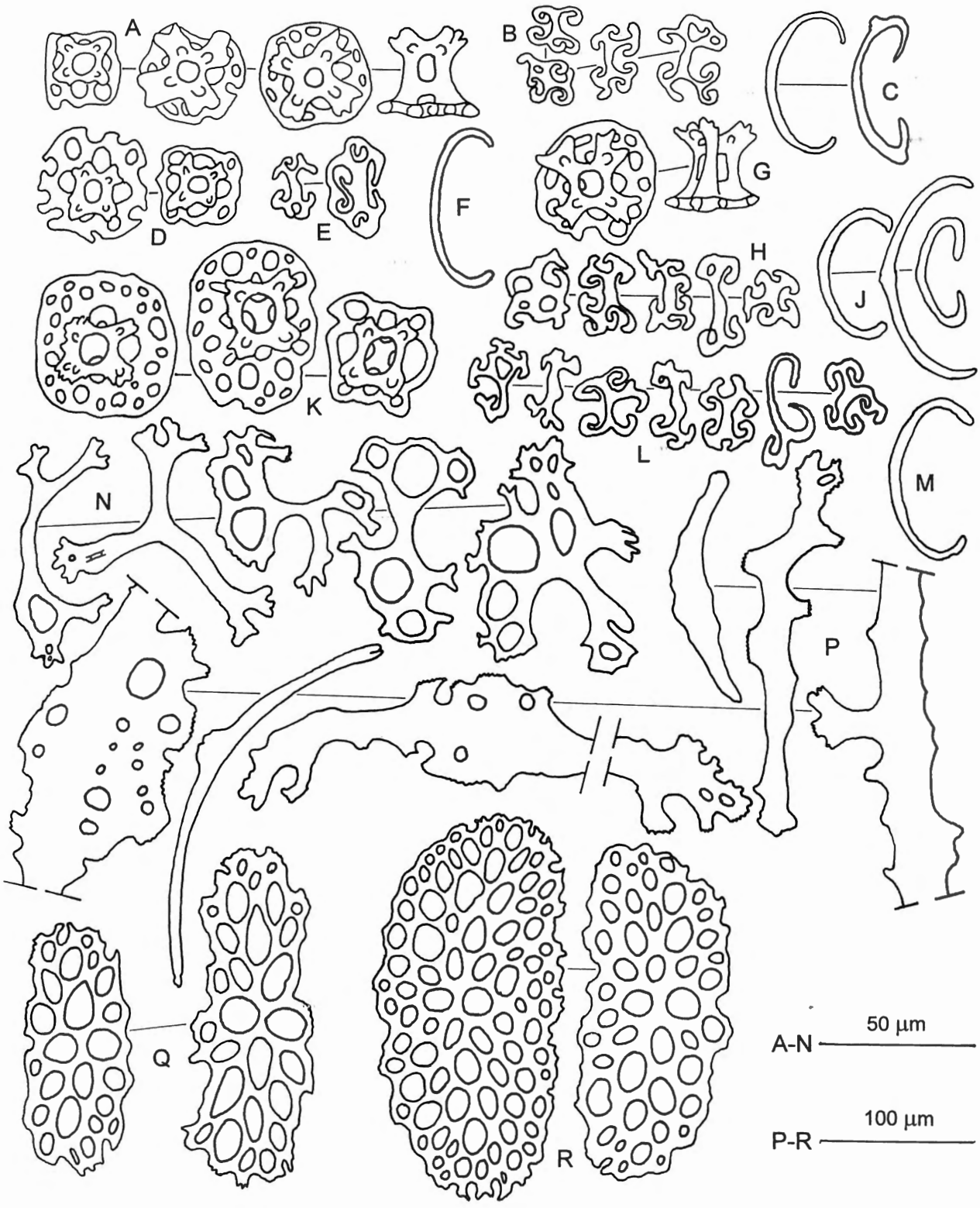


Fig. 12. *Stichopus vastus* SLUITER, 1887. A: tables of dorsal body wall (L=360 mm); B: rosettes of dorsal body wall (L=360 mm): C: C-shaped rods of dorsal body wall (L=360 mm); D: tables of ventral body wall (L=360 mm); E: rosettes of ventral body wall (L=360 mm); F: C-shaped rod of ventral body wall (L=360 mm); G: tables of the base of the dorsal papillae (L=360 mm); H: rosettes of the base of the dorsal papillae (L=360 mm); J: C-shaped rods of the base of the dorsal papillae (L=360 mm); K: tables of the top of the dorsal papillae (L=360 mm); L: rosettes of the top of the dorsal papillae (L=360 mm); M: C-shaped rods of the top of the dorsal papillae (L=360 mm); N: small perforated plates of the top of the dorsal papillae (L=360 mm); P: rod of the top of the dorsal papillae (L=360 mm); Q: large perforated plates of the top of the tube feet (L=360 mm); R: large perforated plates of the top of the tube feet (L=160 mm);

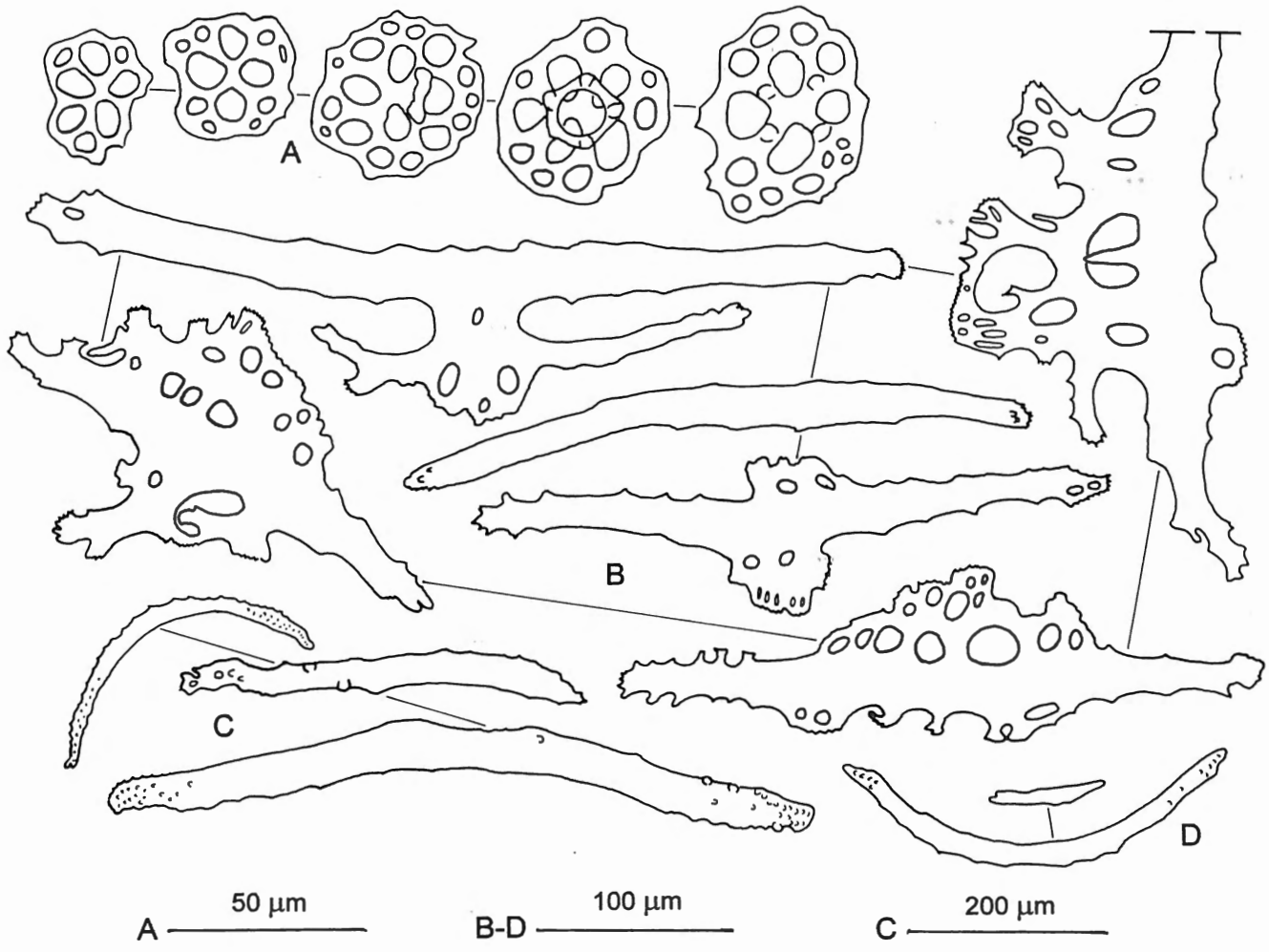


Fig. 13. *Stichopus vastus* SLUITER, 1887. (L=360 mm). A: tables of the tube feet; B: rods of the tube feet; C, D: rods of the tentacles.

Mouth ventral with 18-20 tentacles surrounded by a prominent collar of papillae. Anus terminal.

– Internal anatomy: Body wall 5-10 mm thick. Calcareous ring similar to the figure 57a of MASSIN (1999). The notch at the rear of the radial plates is always very deep but can be very narrow (U-shaped) or more open (V-shaped). Tentacle ampullae very long ± 1/5 of body length whatever the length of the specimens. One Polian vesicles 1/8 to 1/6 of body length. One long contorted stone canal embedded in the dorsal mesentery and ending in a round madreporic plate (see fig. 57b of MASSIN, 1999).

– Ossicles: In the dorsal body wall tables (fig. 12A), 23-38 µm across, rosettes (fig. 12B) 14-30 µm long in large specimens, slightly larger (15-38 µm long) in small specimens and C-shaped rods (fig. 12C) 45-50 µm long in large specimens and 40-95 µm long in small specimens. Tables with disc round to quadrangular, smooth, perforated by 4 large central holes and 4-10 small peripheral holes; 4 pillars united by one cross beam and ending in a crown of spines looking like a Maltese cross when seen from above; crown of spines nearly as wide as the disc. A few S-shaped ossicles present in small specimens but not in large ones. In the ventral body wall same types of ossicles as dorsally (fig. 12D-F) and with similar size. C-shaped rods also larger (40-70 µm long) in small specimens than in large ones (40-50 µm long). At the base of the dorsal papillae tables (fig. 12G), 30-40 µm across, rosettes (fig. 12H), 19-33 µm long and C-shaped rods (fig . 12J), 35-70 µm long. At the top of the dorsal papillae large tables (fig. 12K), 35-55 µm across with quadrangular to ovoid disc, smooth, perforated by 4 large central holes and 4-25 small peripheral holes; 4 pillars united by one cross beam and ending in a small crown of spines 1/2 to 1/3 of disc diameter. Together with the large tables, rosettes (fig. 12L), C-shaped rods (fig. 12M), small perforated plates (fig. 12N), 60-80 µm long, and spiny rods (fig. 12P), 159-280 µm long in large specimens and up to 360 µm long in small specimens. These rods have a low central perforated process in large specimens and a taller one in small specimens. In the tube feet large perforated plates, 160-220 µm long (fig. 12Q) in large specimens and 220-250 µm long (fig. 12R) in small specimens. Tube feet have also tables (fig. 13A), 30-55 µm across, with reduced pillars or no pillars at all and rods, 250-450 µm long, some with very large central perforated process (fig. 13B). End plate of the tube feet 460-500 µm across for

large specimens and 550-800 for small specimens. It is made of several plates. In the tentacles curved rods with spiny extremities (fig. 13C, D), 60-695 µm long.

REMARKS

The ossicles of the *Stichopus vastus* from Malaysia are very similar to those of the specimens from Indonesia (MASSIN, 1999). The perforated plates of the tube feet for example evolve in the same way with increasing body size (compare fig. 59c, d of MASSIN (1999) and fig. 11Q, R of the present work).The size variation of the dorsal C-shaped rods with increasing body length is very characteristic and implies that size differences of some ossicles cannot be taken into account to separate species without comparing specimens of the same length. The identification key takes into account the size variation of the dorsal C-shaped rods.
The reticulate black-brown "tiger" pattern covering the dorsal body wall is variable in density and intensity but remains always very characteristic and allows to identify easily *S. vastus* in the field. It is one of the largest *Stichopus* species reaching nearly 400 mm long in the field. It lives always in shallow water (1-11 m) at Andaman Islands (JAMES, 1998), in Indonesia (MASSIN, 1999), in Malaysia (FORBES *et al.*, 1999; present work) and in Papua New Guinea (MASSIN pers. observations).

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Identification key

1.	■ Tack like tables present in the dorsal papillae	*Stichopus horrens*
	■ Tack like tables absent in the dorsal papillae	2
2.	■ Rosettes absent from body wall (sometimes modified C-shaped ossicles present), colour of body wall uniform blue-green	*Stichopus chloronotus*
	■ Rosettes present in body wall, colour of body wall not uniform blue-green	3
3.	■ Rosettes present only dorsally, colour pattern highly variable, mainly active at night	4
	■ Rosettes present dorsally and ventrally, colour pattern fairly constant, mainly active during day time	5
4.	■ Dorsal papillae never prominent, apex of most papillae uniform red sometimes the whole papillae red, colour pattern of body wall with nearly always more or less developed dark patches, rim of the table disc smooth	*Stichopus rubermaculosus*
	■ Dorsal papillae prominent, with ring of colours, rim of the table disc spiny	*Stichopus monotuberculatus*
5.	■ C-shaped ossicles of dorsal body wall maximum 100 µm long, stripy colour pattern (still visible on preserved specimens)	*Stichopus vastus*
	■ C-shaped ossicles of dorsal body wall up to 180 µm long, no stripy colour pattern	6
6.	■ C-shaped ossicles of ventral body wall up to 150 µm long, dorsal colour pattern uniform green-yellow to brown with numerous, small black brown papillae	*Stichopus herrmanni*
	■ C-shaped ossicles of ventral body wall maximum 80 µm long, dorsal colour pattern yellow-orange and green with 4-5 rows of large dorsal papillae, white at the base and green-grey at the apex	*Stichopus ocellatus*

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