

Two New Species and a New Record of the Genus *Sinularia* (Octocorallia: Alcyonacea) from the Penghu Archipelago, Taiwan

Leendert Pieter van Ofwegen^{1,*} and Yehuda Benayahu²

¹Netherlands Center for Biodiversity Naturalis, PO Box 9517, Leiden 2300 RA, the Netherlands

²Department of Zoology, George S. Wise Faculty of Life Sciences, Tel Aviv University, Ramat Aviv 69978, Israel
E-mail: yehudaB@tauex.tau.ac.il

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Leendert Pieter van Ofwegen and Yehuda Benayahu (2012) Two new species and a new record of the genus *Sinularia* (Octocorallia: Alcyonacea) from the Penghu Archipelago, Taiwan. *Zoological Studies* 51(3): 383-398. Two new species of the genus *Sinularia* (family Alcyoniidae), featuring *leptocladus*-type clubs, are described and depicted from the Penghu Archipelago, Taiwan: *S. penghuensis* sp. nov. and *S. wanannensis* sp. nov. *Sinularia slieringsi* Ofwegen & Vennam, 1994, a new zoogeographical record for Taiwan which features clubs of the same type, is described and discussed. <http://zoolstud.sinica.edu.tw/Journals/51.3/383.pdf>

Key words: Octocorallia, *Sinularia*, New species, Coral reefs, Taiwan.

Recent papers by Benayahu and Ofwegen (2011) and Benayahu and McFadden (2011) dealt with 4 new species of octocorals from the Penghu Archipelago in the Taiwan Strait, resulting from the 1st octocoral surveys ever conducted there (July 2006 and July 2009). Those studies yielded 4 new species, *Lobophytum hsiehi* Benayahu & Ofwegen, 2011; *Sinularia dai* Benayahu & Ofwegen, 2011; *S. soongi* Benayahu & Ofwegen, 2011; and *Aldersladum jengi* Benayahu & McFadden, 2011 that were described and depicted.

The surveys mentioned above revealed diverse octocoral assemblages in Penghu reefs, with the genus *Sinularia* May, 1898 being the most diverse (Benayahu et al. in prep.). *Sinularia* is known to be a highly speciose genus among Indo-Pacific coral reefs octocorals (Ofwegen 2002), with a substantial number of new species continually being described from various regions (Palau: Ofwegen 2008; Vietnam: Dautova et al. 2010; and Singapore: Benayahu and Ofwegen 2011). Among the ~165 known morphospecies of *Sinularia*,

the most diverse group of species features *leptocladus*-type clubs (Verseveldt 1980, Benayahu and Ofwegen 2011). McFadden et al. (2009) constructed a molecular phylogeny for *Sinularia*, among which the largest number of species were assigned to the clade with *leptocladus*-type clubs. The current paper further deals with the octocorals from Penghu, which belong to that *Sinularia* clade and thus denote both the diversity of the region and of this clade.

MATERIALS AND METHODS

Material was collected by scuba diving by Y.B. on a field trip conducted in July 2009 (for details see Benayahu and Ofwegen 2011). Samples were preserved in 70% alcohol, and subsamples were removed and preserved in absolute alcohol and dimethyl sulfoxide for molecular studies. Results of the molecular studies are reported elsewhere (Benayahu et al. in prep.). In order to identify the

*To whom correspondence and reprint requests should be addressed. Tel: 3171-568-7653. Fax: 3171-568-7666.
E-mail: leen.vanofwegen@ncbnaturalis.nl

material, sclerites from different parts of the colony (polyp, polyparium surface and interior, and base surface and interior) were obtained by dissolving tissues in 10% sodium hypochlorite, followed by rinsing in fresh water. They were then prepared for scanning electron microscopy (SEM) as follows: sclerites were carefully rinsed with double-distilled water, dried at room temperature, coated with gold, and examined with a Jeol 6480LV electron microscope operated at 10 kV. Identification of species was facilitated by comparisons with permanent sclerite preparations of type material kept in the Zoological Museum, Department of Zoology, Tel Aviv Univ., Israel (ZMTAU) and the Netherlands Center for Biodiversity, Naturalis, Leiden, the Netherlands (RMNH). Identified specimens were deposited at ZMTAU and RMNH as indicated below.

SYSTEMATICS

Sinularia penghuensis sp. nov.

(Figs. 1-5)

Material examined: ZMTAU Co 34706, holotype, Penghu, Houdaidzai (23°21.683'N, 119°32.366'E), 6-7 m, 30 July 2009; paratypes: ZMTAU Co 34630, 4 colonies, RMNH Coel 40123, 2 colonies Penghu, Sansui (23°30.573'N, 119°36.569'E), 7-11 m, 27 July 2009; ZMTAU Co 34643, 1 colony, Penghu, Aimen (23°32.685'N,

119°38.158'E), 7-11 m, 27 July 2009; ZMTAU Co 34659, Penghu, Tonggee (23°15.273'N, 119°39.891'E), 6-8 m, 28 July 2009; ZMTAU Co 34739, Penghu, Ton Pan (23°30.674'N, 119°30.822'E), 5-7 m, 31 July 2009; ZMTAU Co 34681, Penghu, Mudo (23°48.079'N, 119°35.474'E), 7-9 m, 29 July 2009.

Holotype an encrusting colony with a maximum cross-section of 4.5 × 9 cm and height of up to 5 cm (Fig. 1A). Polyparium consisting of short undivided closely set lobes and longer ones that branch off and bear lobules. Lobes and lobules knob- to finger-shaped. Lobules up to 1 cm long and 0.5 mm wide. Colony with a hard texture. Polyps with collaret and 8 points. Point sclerites with poorly developed club-heads, up to 0.20 mm long (Fig. 2A). Collaret consisting of slightly bent spindles, up to 0.25 mm long (Fig. 2B).

Surface layer of lobules with *leptocladus*-type clubs, smallest 0.10 mm long, but some longer, reaching 0.15 mm (Fig. 2C). Also possessing longer clubs with a warty head and tubercles along handles, up to 0.30 mm long (Fig. 2D), and extreme ones, up to 0.40 mm long (Fig. 2E). Spindles of surface of layer of lobes up to 0.53 mm long (Fig. 3A), with simple tubercles.

Surface layer of base of colony containing *leptocladus*-type clubs, similar to those of lobules, but wider, up to 0.20 mm long (Fig. 3B). Also wide clubs with a warty head and tubercles on handle, up to 0.35 mm long (Fig. 3C). Spindles of surface

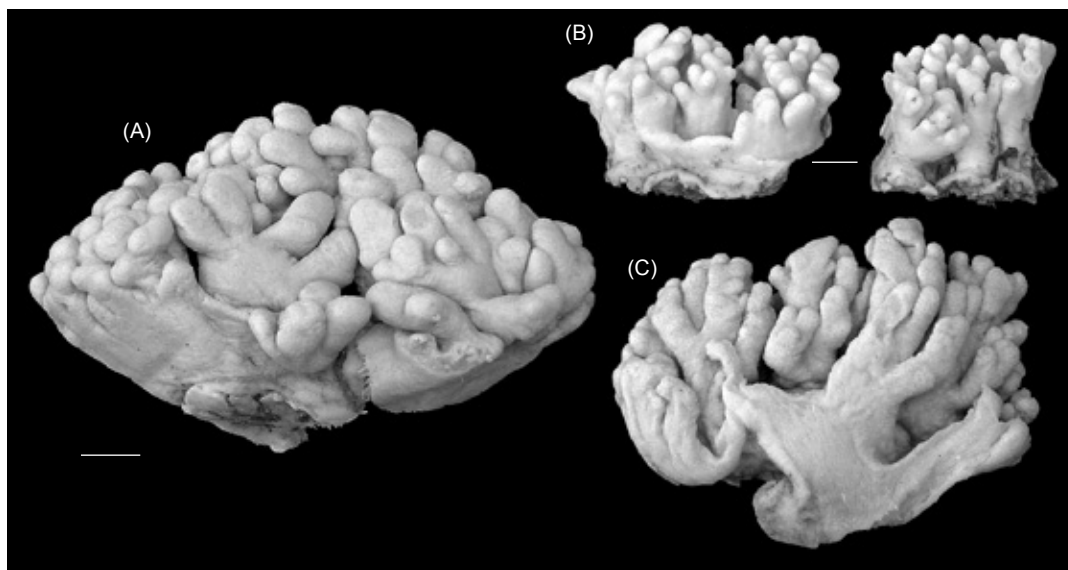


Fig. 1. *S. penghuensis* sp. nov. (A) Holotype (ZMTAU Co. 34706); (B) paratype (ZMTAU Co 34630); (C) paratype (ZMTAU Co 34643). Scale bar = 10 mm.

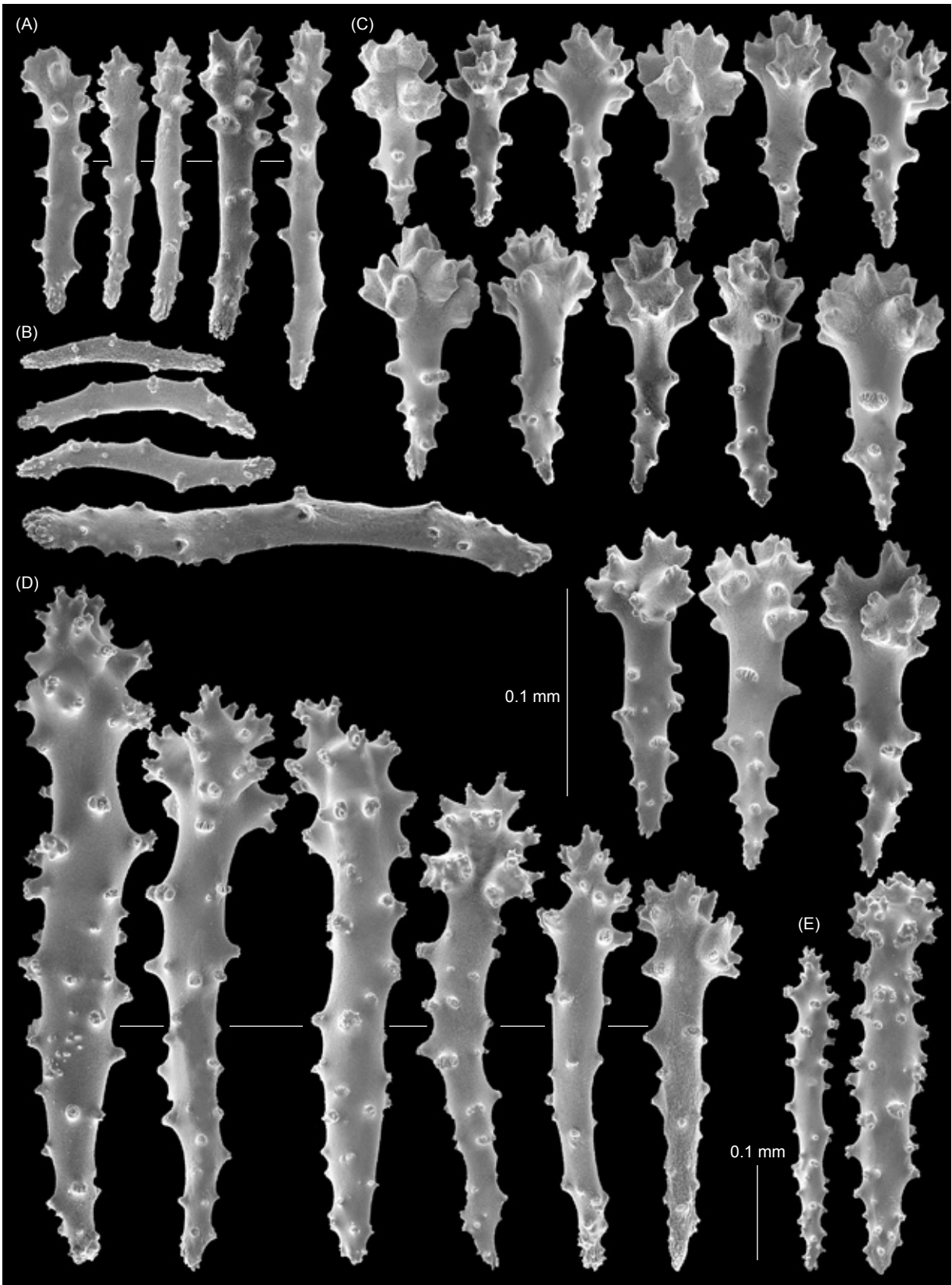


Fig. 2. *S. penghuensis* sp. nov. holotype (ZMTAU Co 34706). (A) Point clubs; (B) collaret spindles; (C-E) clubs of surface layer of lobules. Scale bars = 0.1 mm, that in C also applies to A, B, D; that in E only applies to E.

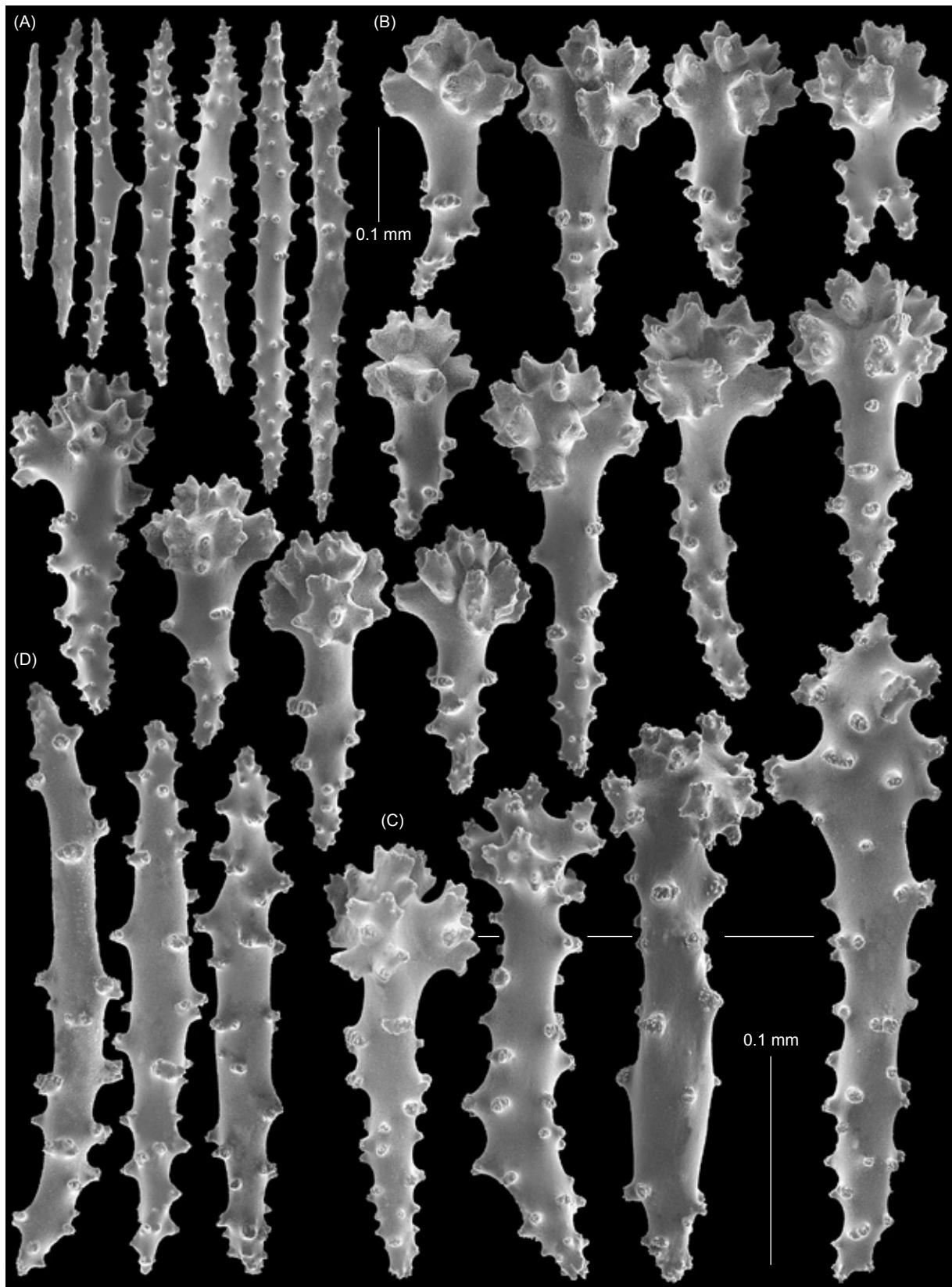


Fig. 3. *S. penghuensis* sp. nov. holotype (ZMTAU Co 34706). (A) Spindles of surface layer of lobules; (B-D) sclerites of surface layer of base; (B, C) clubs; (D) spindles. Scale bars = 0.1 mm, that in A only applies to A; that in C also applies to B and D.

layer of base up to 0.30 mm long (Fig. 3D).

Interior of lobules with spindles up to 3 mm long, several with short side branches (Fig. 4A). Most spindles with simple tubercles (Fig. 4B). Interior of base with similarly sized spindles (Fig. 4C), with larger warty tubercles (Fig. 4D).

Color: Preserved holotype white.

Living features: Colonies with retracted polyps gray (Fig. 5A, B) and expanded polyps brownish (Fig. 5B).

Etymology: The species is named after the Penghu Archipelago, where the holotype and paratypes were collected.

Variability: Paratypes ZMTAU Co 34630 (Fig. 1B) and 34681 feature distinctly smaller lobes and lobules, up to 0.5 cm long and only a few millimeters wide, and ZMTAU Co 34643 has somewhat longer lobules, up to 2 cm long (Fig. 1C). All colonies have similar sclerites.

Remarks: *Sinularia penghuensis* sp. nov.

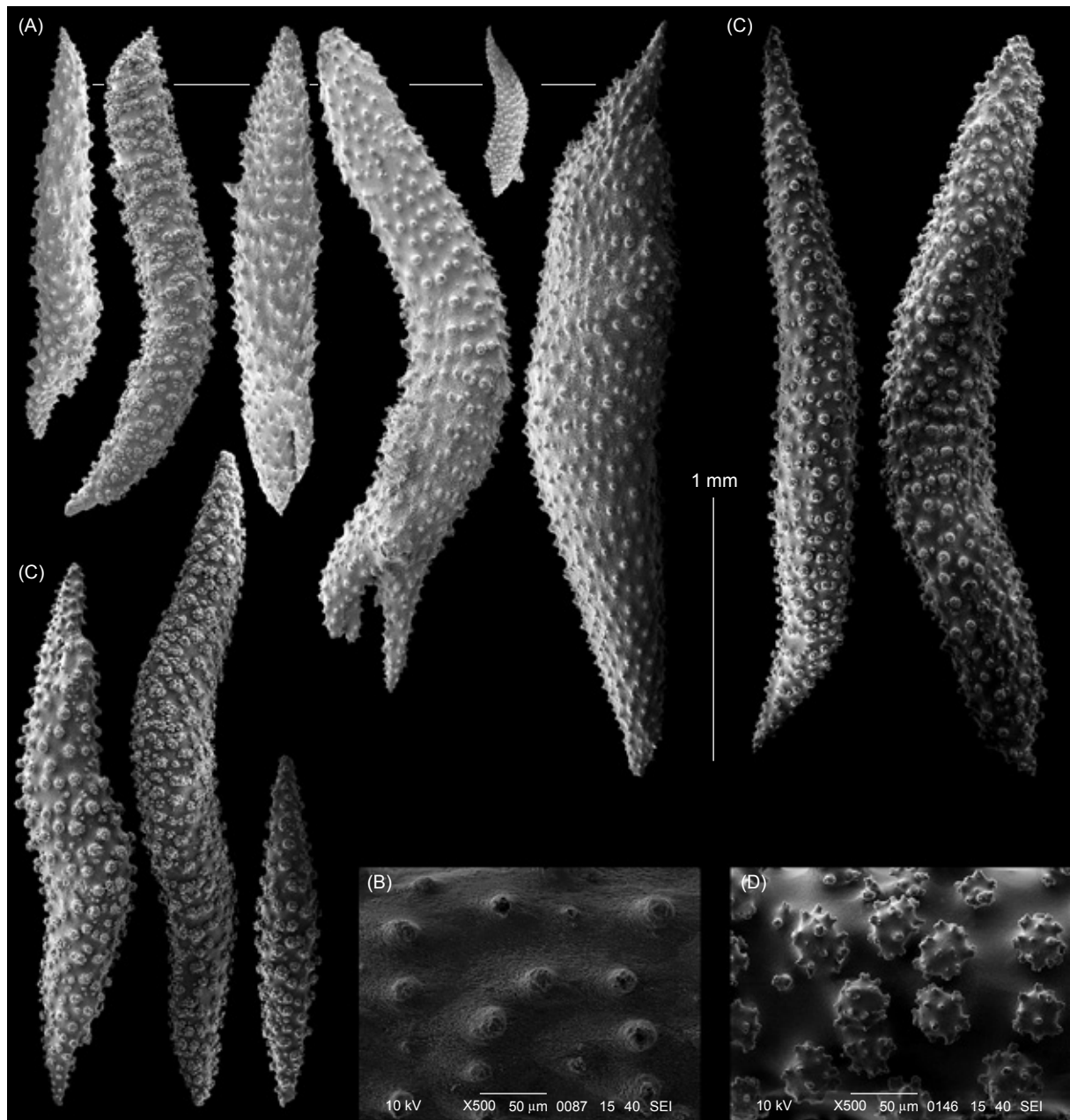


Fig. 4. *S. penghuensis* sp. nov. holotype (ZMTAU Co 34706). (A, C) Spindles of interior; (A) lobules; (C) base; (B, D) tubercles on spindles; (B) interior lobules; (D) interior base. Scale in A, 1 mm, which also applies to C.

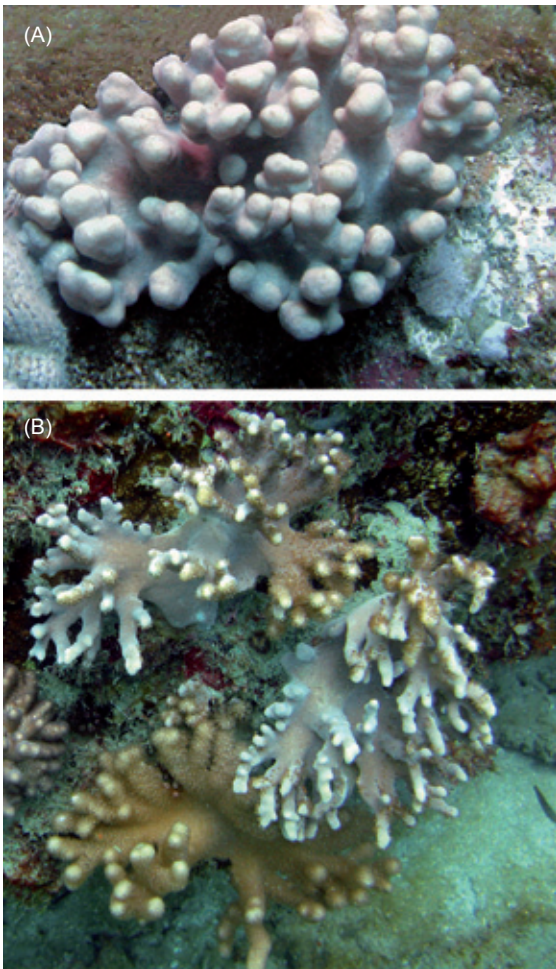


Fig. 5. Underwater photographs of *S. penghuensis* sp. nov.

belongs to *Sinularia* clade 5c of McFadden et al. (2009) based on polyps with a collaret and point sclerites, and a surface layer with *leptoclados*-type clubs. The holotype, ZMTAU Co 34706, and paratypes ZMTAU Co 34630, 34643, and 34739 had identical COI and *msh1* sequences (McFadden pers. comm.); paratype ZMTAU Co 34659 slightly differed from the above (McFadden pers. comm.; Benayahu et al. in prep.). All had unique sequences compared to other species in clade 5c. ZMTAU Co 34681 had different sequences for both COI and *msh1* and was genetically closest to *S. bisulca* Ofwegen, 2008. As this concerns only 1 paratype and the sclerites only slightly differed from the holotype (Figs. 2-4), we temporarily included this specimen in *S. penghuensis* sp. nov. Morphologically, *S. penghuensis* sp. nov. is most similar to *S. bisulca* Ofwegen, 2008, where the former differs in having longer, less-branched lobes, and interior spindles mostly with simple tubercles. Genetically, the species is most similar to *S. daii* Benayahu & Ofwegen, 2011, also described from Taiwan. *Sinularia penghuensis* sp. nov. has much longer sclerites on all parts of the colony.

***Sinularia wanannensis* sp. nov.**

(Figs. 6-11)

Material examined: ZMTAU Co 34695, holotype, Penghu, Wanann (23°20.913'N, 119°30.753'E), 8-10 m, 30 July 2009; paratypes:

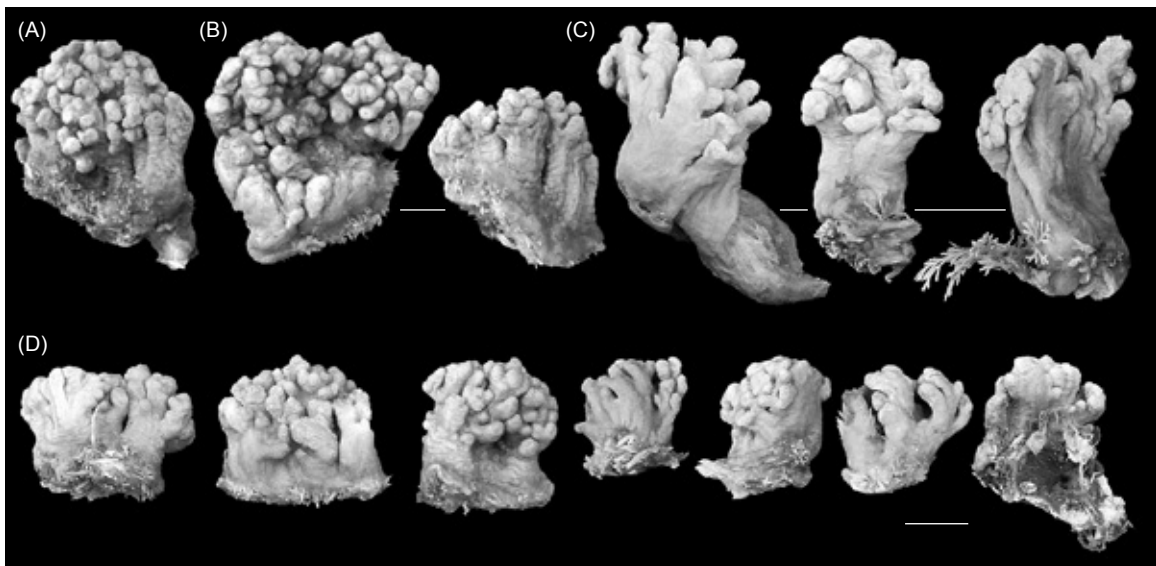


Fig. 6. *S. wanannensis* sp. nov. (A) Holotype (ZMTAU Co 34695); (B) paratype (ZMTAU Co 35311); (C) paratype (ZMTAU Co 34704); (D) paratype (ZMTAU Co 34700). Scale bar = 10 mm.

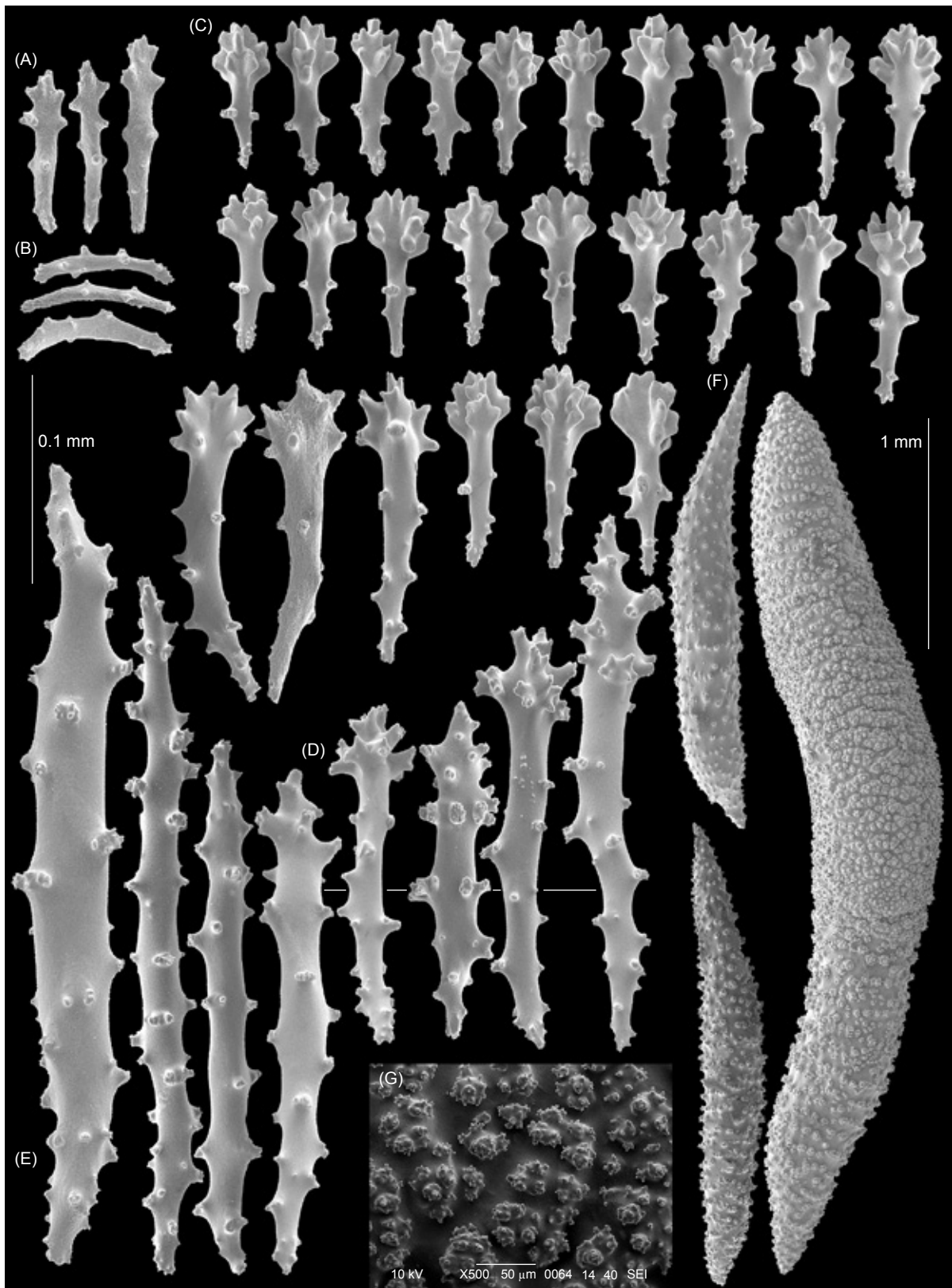


Fig. 7. *S. wanannensis* sp. nov. holotype (ZMTAU Co 34695). (A) Point clubs; (B) collaret spindles; (C-E) sclerites of surface layer of lobules; (C, D) clubs; (E) spindles; (F) spindles of interior lobule; (G) tubercles on spindle. Scale in A, 0.1 mm, which also applies to B-E; that in F, 1 mm, only applies to F.

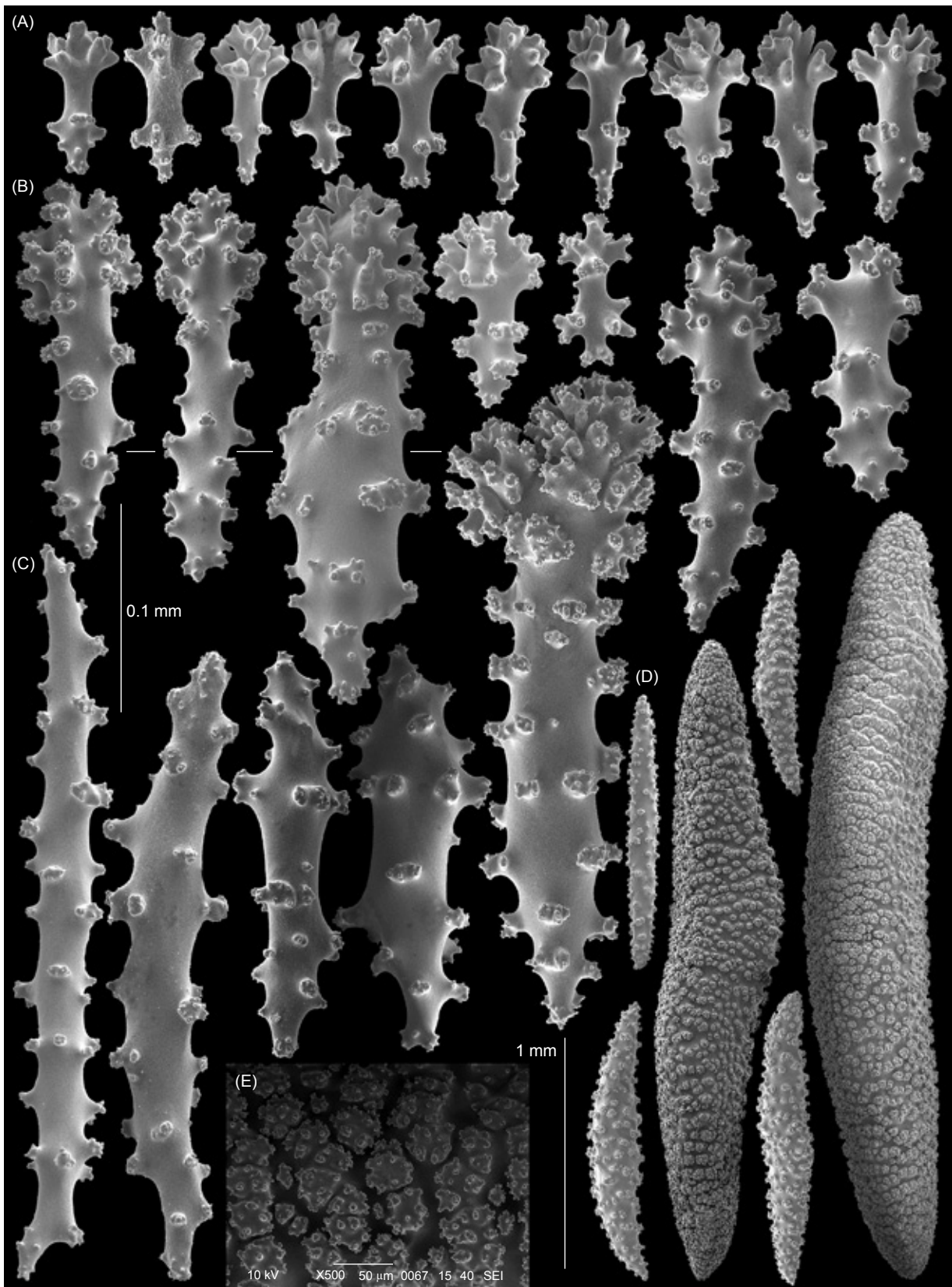


Fig. 8. *S. wanannensis* sp. nov. holotype (ZMTAU Co 34695). (A-C) Sclerites of surface layer of base; (A, B) clubs; (C) spindles; (D) spindles of interior base; (E) tubercles on spindles. Scale in B, 0.1 mm, which also applies to A-C; that in D, 1 mm, only applies to D.

ZMTAU Co 35311, 2 colonies; RMNH Coel 40124, 2 colonies; ZMTAU Co 34700, 7 colonies; ZMTAU Co 34704, 3 colonies, same data as for holotype.

Holotype a stalked colony, with a maximum cross-section of polyparium of 2.5 × 2 cm and height of 3 cm (Fig. 6A). Polyparium consisting of lobes bearing small lobules. Lobules knob-shaped, a few millimeters long and wide. Colony with a hard texture.

Polyps with collaret and 8 points. Point sclerites with poorly developed club-heads, up to 0.10 mm long (Fig. 7A). Collaret consisting of slightly bent spindles, up to 0.15 mm long (Fig. 7B).

Surface layer of lobules with *leptoclados*-type clubs, most 0.07 mm long, but others longer, up to 0.15 mm long (Fig. 7C). Also possessing longer clubs with a warty head and tubercles along handles, up to 0.25 mm long (Fig. 7D). In addition, with spindles up to 0.40 mm long, with simple tubercles (Fig. 7E).

Surface layer of base of colony containing *leptoclados*-type clubs, similar to those of lobules, but wider, up to 0.10 mm long (Fig. 8A). Also with wide clubs with a warty head and rather-complex tubercles along handles, up to 0.30 mm long (Fig. 8B). Spindles of surface layer of base up to 0.35 mm long (Fig. 8C).

Interior of lobules with spindles up to 4 mm long (Fig. 7F), with simple or complex tubercles (Fig. 7G). Interior of base with similarly sized spindles (Fig. 8D), with slightly more-complex, densely placed tubercles (Fig. 8E).

Color: Preserved holotype light beige-white.

Living features: Mostly stalked, small, greenish colonies (Fig. 9A, B), growing on reefs commonly as aggregations (Fig. 9B).

Etymology: The species is named after Wanann, Penghu Archipelago, where the holotype and paratypes were collected.

Variability: One of the paratypes of ZMTAU Co 35311 appeared to be encrusting (Fig. 6B). Sclerites of one of the paratype colonies of ZMTAU Co 34704 (Fig. 6C) are presented in figures 10 and 11. In general, the sclerites resemble those of the holotype (Figs. 7, 8). However, that paratype features larger polyp sclerites (Fig. 10A, B) compared to the holotype (Fig. 7A, B), some tentacle sclerites (Fig. 10C) not found in the holotype, and branched spindles in the interior lobes (Fig. 10G) and base (Fig. 11E). The 7 paratype colonies of ZMTAU Co 34700 are presented in figure 6D; they are smaller than the holotype (Fig. 6A) and paratype ZMTAU Co 35311 (Fig. 6B), but generally have a similar shape. The paratype colony of ZMTAU 34704 has a longer stalk (Fig. 6C).

Remarks: *Sinularia wanannensis* sp. nov. belongs to *Sinularia* clade 5c of McFadden et al. (2009) based on polyps with a collaret and point sclerites, and a surface layer with *leptoclados*-type clubs. ZMTAU Co 34695 and 34700 feature identical sequences for both *msh1* and *COI* (McFadden pers. comm.; Benayahu et al. in prep.). ZMTAU Co 34704 has the same sequences as the above with regards to *COI*, but it differs from those two at *msh1*, where it is identical to *S. verseveldti* Ofwegen, 1996. Morphologically, colonies of *S. wanannensis* sp. nov. most resemble *S. pumila* Dautova et al., 2010, but that species features much-wider *leptoclados*-type clubs, longer surface spindles (up to 0.6 mm), and smaller, more slender interior spindles (up to 3 mm). *Sinularia verseveldti*, with an identical *msh1* sequence as

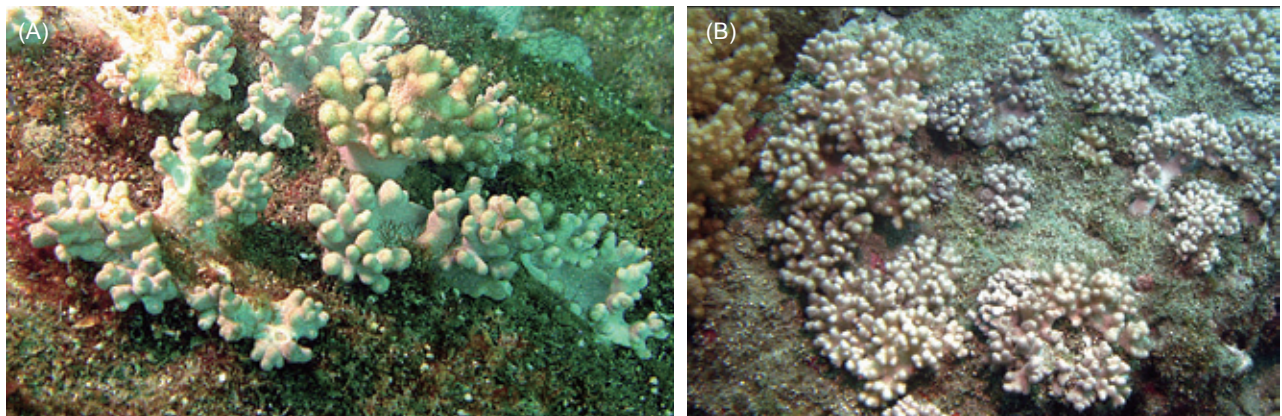


Fig. 9. Underwater photographs of *S. wanannensis* sp. nov.

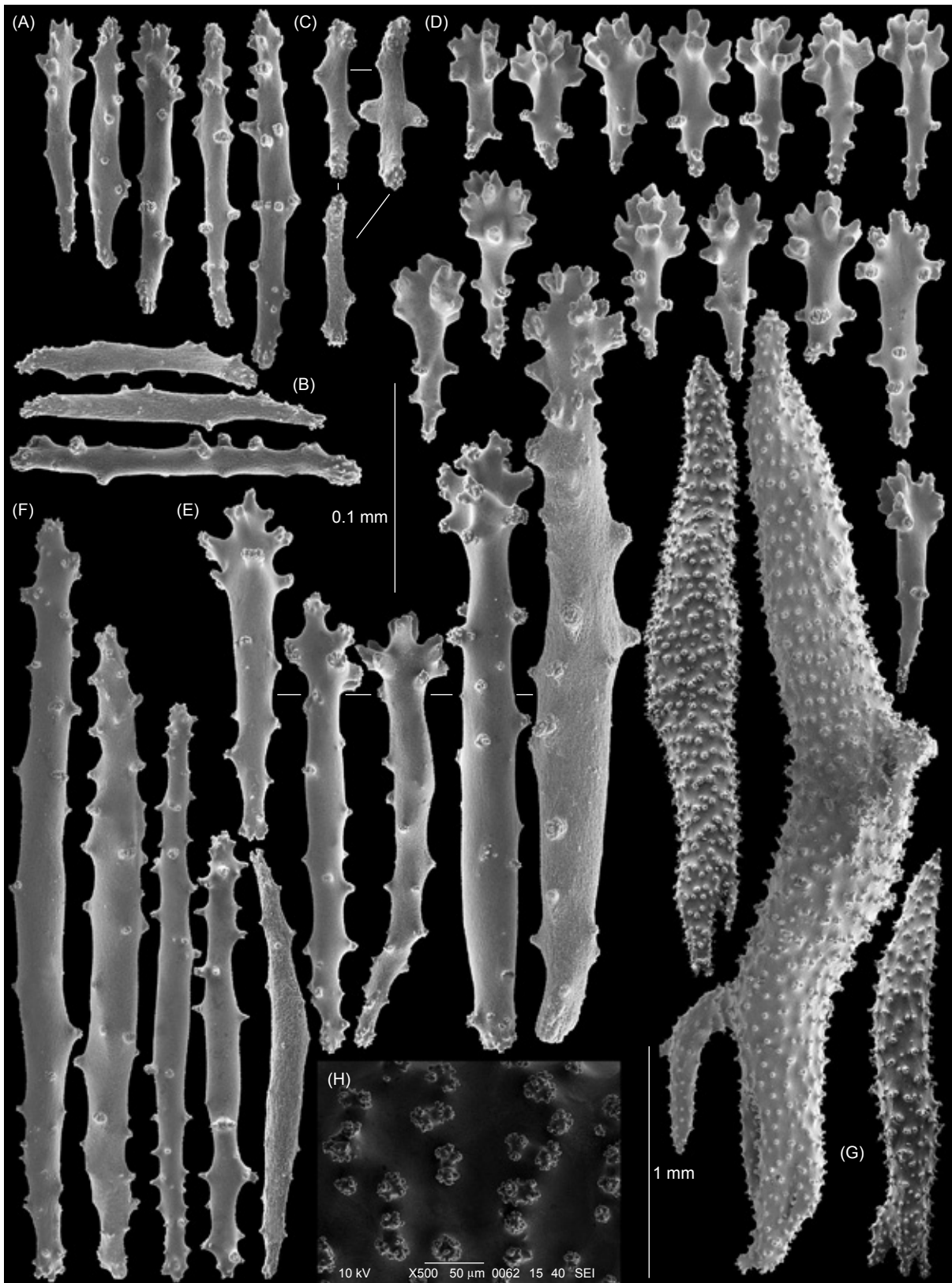


Fig. 10. *S. wanannensis* sp. nov. paratype (ZMTAU Co 34704). (A) Point clubs; (B) collaret spindles; (C) tentacle sclerites; (D-F) sclerites of surface layer of lobules; (D, E) clubs; (F) spindles; (G) spindles of interior lobule; (H) tubercles on spindle. Scale bar in E, 0.1 mm, which also applies to A-D, and F; that in G, 1 mm, only applies to G.

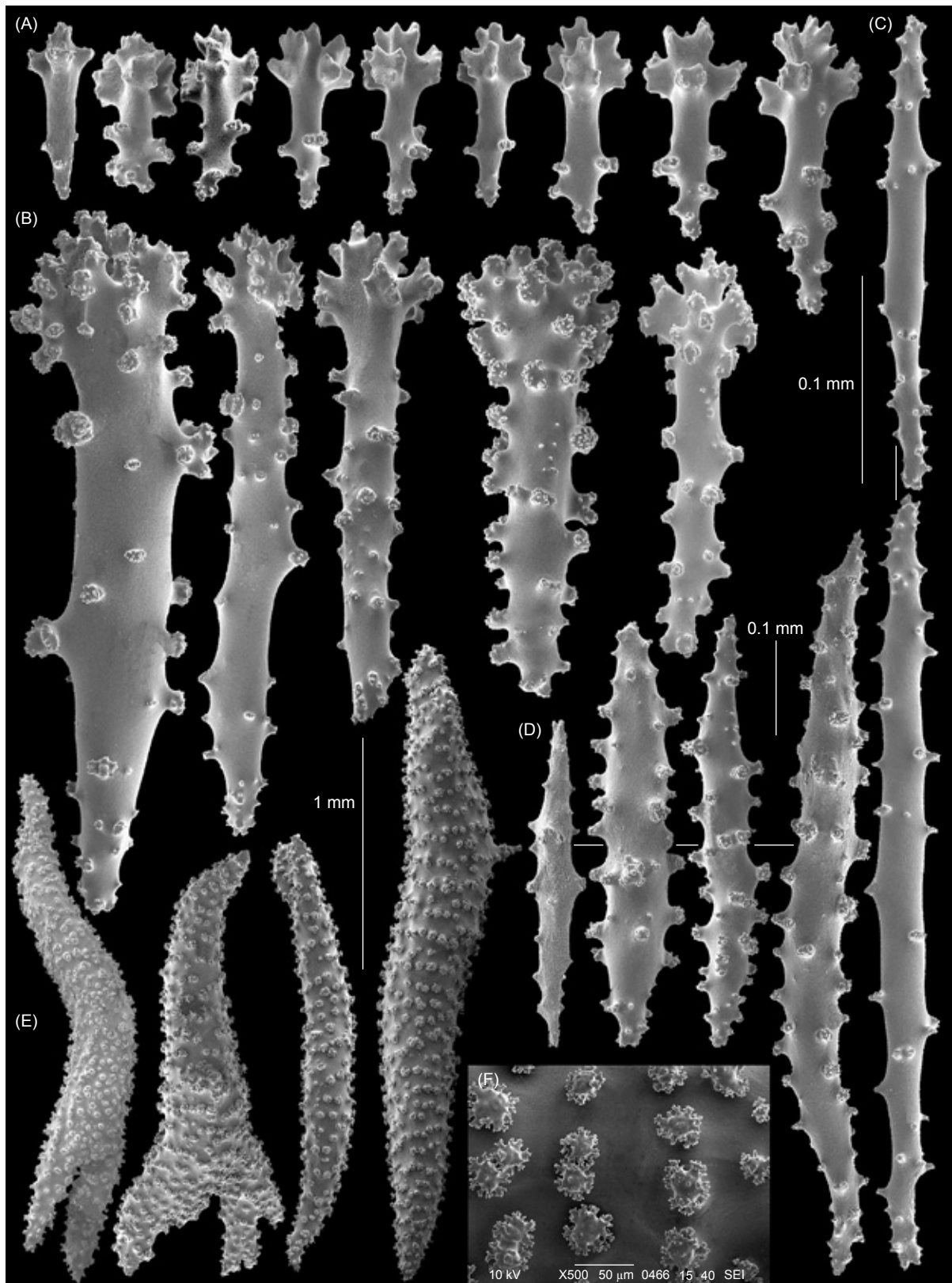


Fig. 11. *S. wanannensis* sp. nov. paratype (ZMTAU Co 34704). (A-D) Sclerites of surface layer of base; (A, B) clubs; (C, D) spindles; (E) spindles of interior base; (F) tubercles on spindle. Scales 0.1 mm, that in A applies to A-C; that in D only applies to D; that in E, 1 mm, only applies to E.

S. wanannensis sp. nov., differs in having finger-like lobules and *leptoclados*-type clubs with a 90° angle between the head and handle of the clubs (see Manuputty and Ofwegen 2007, figs. 2b, 4; erroneously identified as *S. leptoclados*). Based on the above argument, it is evident that *S. wanannensis* sp. nov. differs from all previously described *Sinularia* species.

***Sinularia slieringsi* Ofwegen & Vennam, 1994**
(Figs. 12-16)

Material examined: ZMTAU Co 34654, 1 specimen broken into 2 pieces, Penghu, Tonggee (23°15.723'N, 119°39.891'E), 6-8 m, 28 July 2009.

Encrusting colony broken into 2 pieces, with a maximum cross-section of 5.5 × 16 cm and height of up to 2 cm (Fig. 12). Polyparium consisting of knobs, unbranched finger-lobes, and a few ridges.

Polyps with collaret and 8 points. Point sclerites with poorly developed club-heads up to 0.20 mm long (Fig. 13A). Collaret consisting of slightly bent spindles up to 0.35 mm long (Fig. 13B).

Surface layer of lobes and crests containing clubs with a central wart, 0.10-0.25 mm long; longer clubs with less-distinct central wart (Fig. 13C). Also with spindles up to 0.40 mm long, with simple tubercles (Fig. 13D, E).

Surface layer of base of colony containing clubs, similar to those at top of colony, up to 0.30 mm long, but wider (Fig. 14A). Spindles of surface layer of base reaching 0.40 mm and mostly wider than those at top of colony (Fig. 14B).

Interior of lobules with spindles up to 4 mm long, several with short side branches (Fig. 15A). These spindles with simple or complex tubercles (Fig. 15B, C). Interior of base with shorter spindles up to 2 mm long (Fig. 15D), with more-complex tubercles (Fig. 15E).

Color: Preserved specimen is light beige-white.

Living features: Encrusting gray colony (ZMTAU Co 34654) (Fig. 16).

Remarks: *Sinularia slieringsi* belongs to clade 5b of McFadden et al. (2009) based on polyps with a collaret and point sclerites, surface layer with distinct central wart clubs, and tentacles with a few rods. We identified the species as *S. slieringsi*, but with some doubts. The present specimen differs from previously identified material in having much-larger polyp sclerites; clubs 0.20 mm long vs. 0.10 mm; and spindles 0.40 mm long vs. 0.20 mm (Fig. 13C, D vs. Ofwegen and Vennam 1994, respectively). Prior to the present survey, *S. slieringsi* was only known from Ambon, Indonesia.

DISCUSSION

The current study has yielded 2 new species, *S. penghuensis* sp. nov. and *S. wanannensis* sp. nov. and a new zoogeographical record for Taiwanese reefs, *S. slieringsi*, all of the genus *Sinularia* (Benayahu and Perkol-Finkel 2004, Benayahu et al. 2004, Benayahu and Ofwegen 2011). Specifically, it provides further contributions to our knowledge of octocorals from Penghu

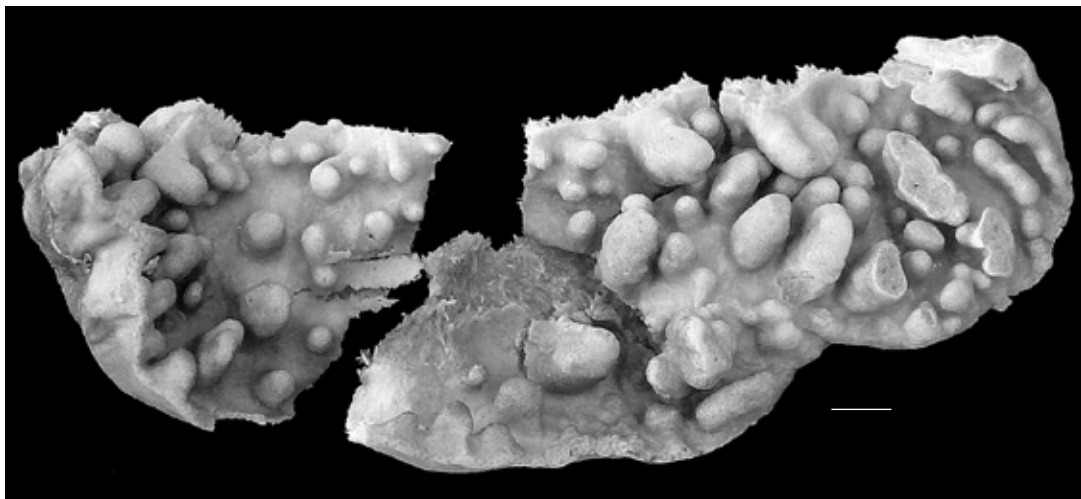


Fig. 12. *S. slieringsi* Ofwegen & Vennam, 1994 (ZMTAU Co 346540). Scale bar = 10 mm.

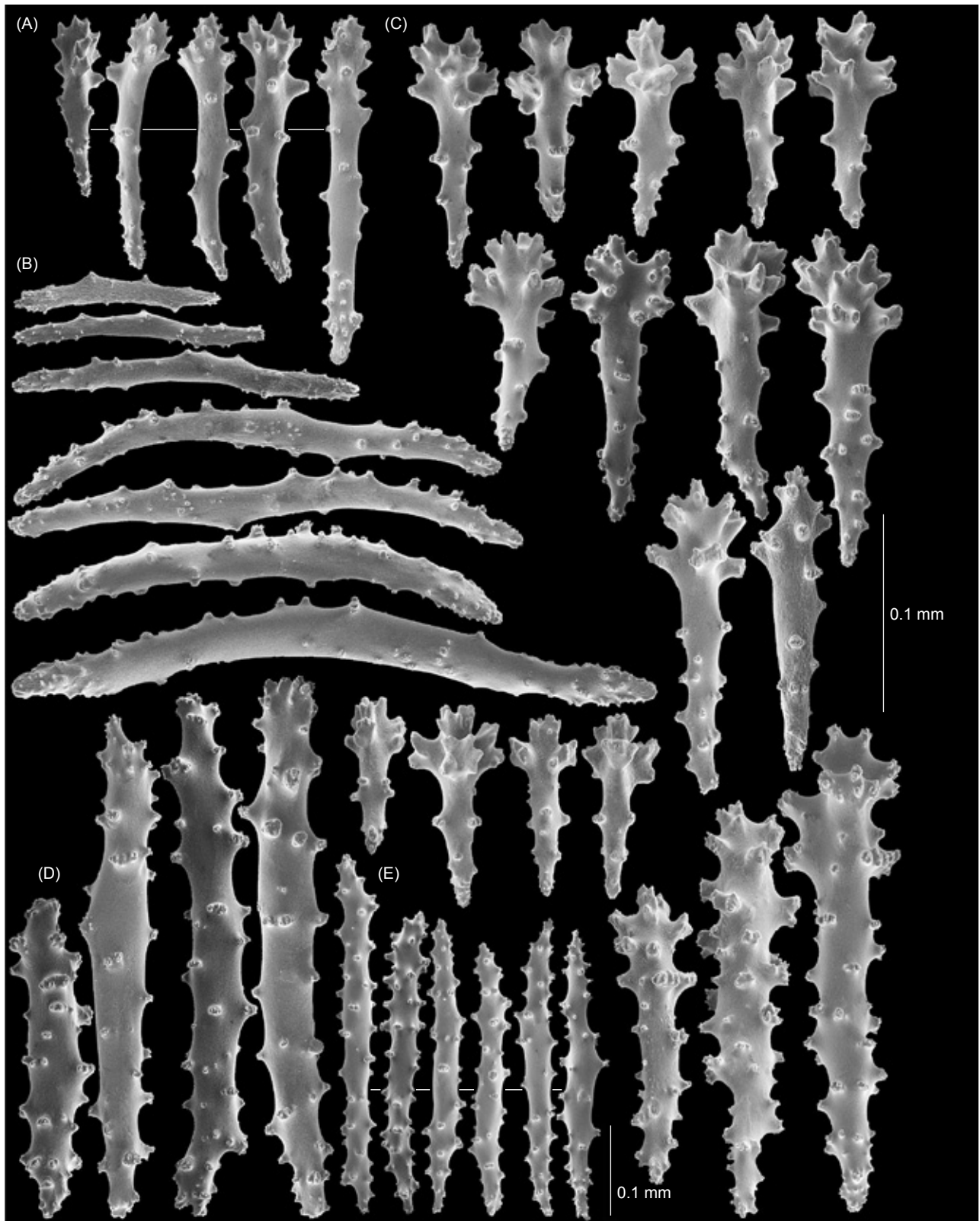


Fig. 13. *S. slieringsi* (ZMTAU Co 34654). (A) Point clubs; (B) collaret spindles; (C-E) sclerites of surface layer of lobes; (C) clubs; (D, E) spindles. Scale bars = 0.1 mm, that in C also applies to A, B, and D; that in E only applies to E.

reefs, from which recently another 4 new species were described (Benayahu and McFadden 2011, Benayahu and Ofwegen 2011), thus bringing to 6 the total number of new species from the Penghu

Archipelago. The current findings demonstrate the diversity of the speciose genus, *Sinularia*, and particularly of the *leptocladus*-clade within that genus (McFadden et al. 2009). In the future, a

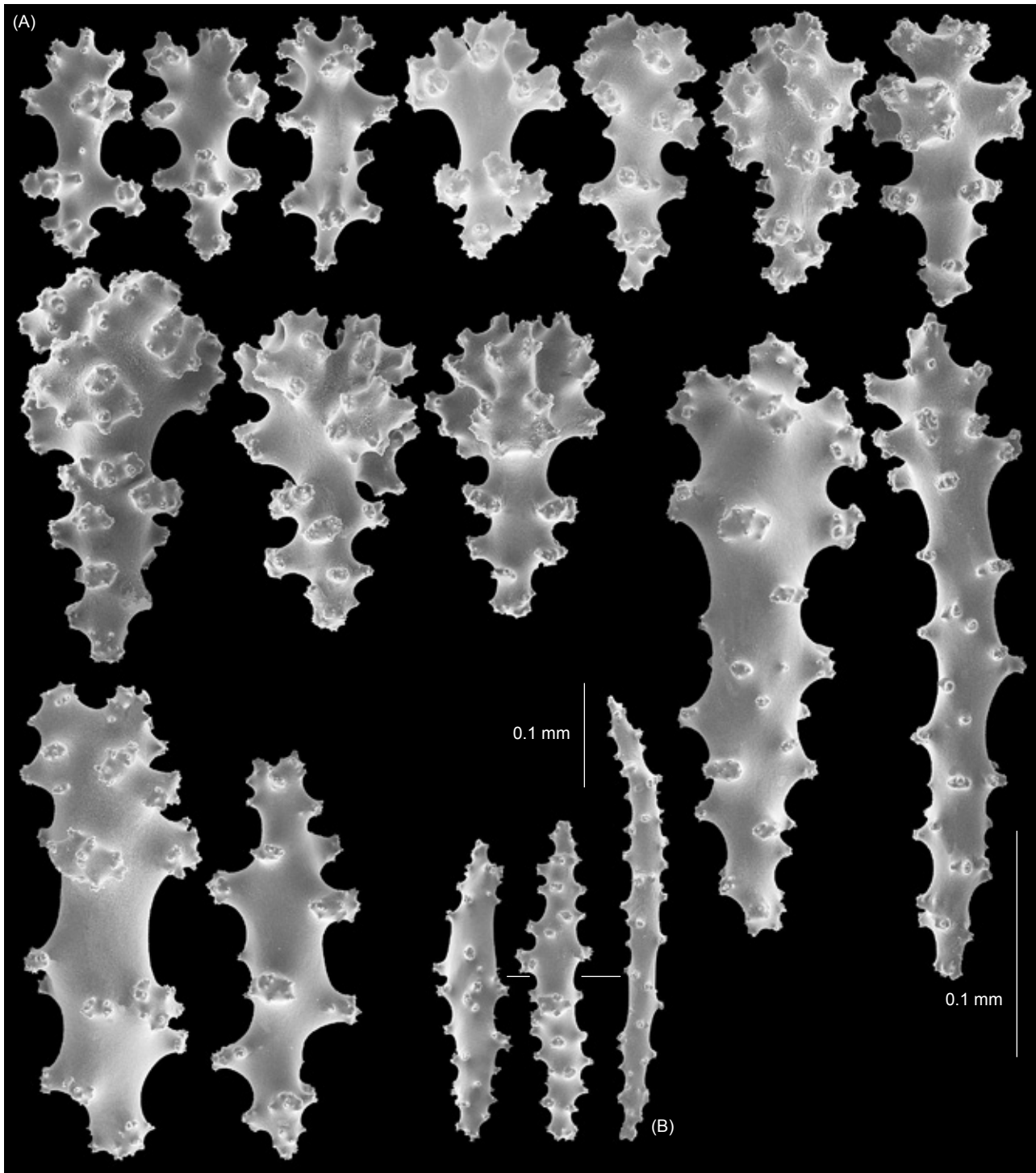


Fig. 14. *S. slieringsi* (ZMTAU Co 34654). (A, B) Sclerites of surface layer of base; (A) clubs; (B) spindles. Scale bars = 0.1 mm, that in A only applies to A; that in B only applies to B.

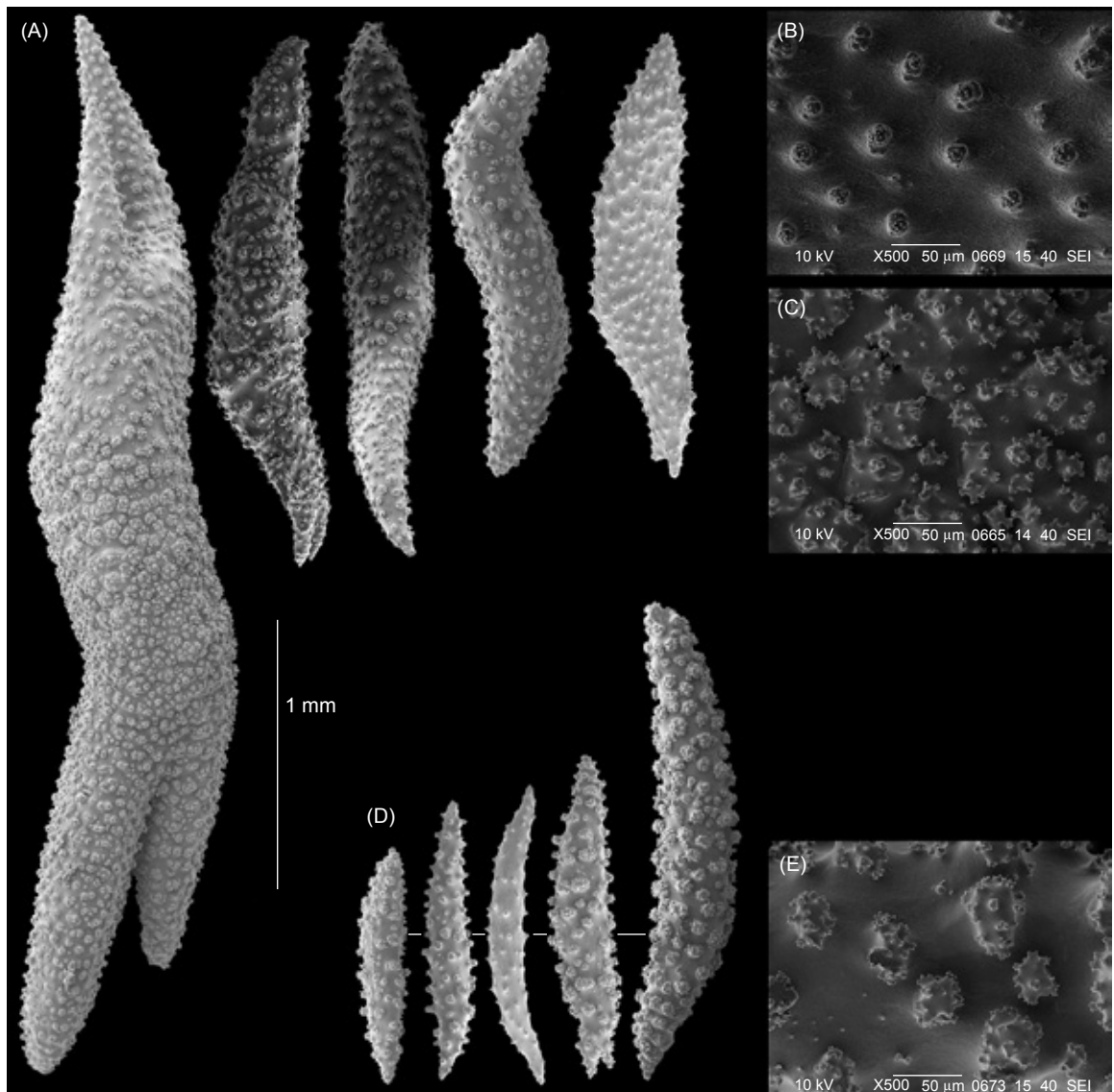


Fig. 15. *S. slieringsi* (ZMTAU Co 34654). (A, D) Spindles of interior; (A) lobules; (D) base; (B, C, E) tubercles on spindles; (B, C) interior lobules; (E) interior base. Scale in A, 1 mm, also applies to D.



Fig. 16. Underwater photograph of *S. slieringsi* Ofwegen & Vennam, 1994 (ZMTAU Co 34654).

combined approach of both classical taxonomy and molecular phylogeny will be necessary to resolve species boundaries of look-alikes within this clade. Undoubtedly, our findings are an indication of the need to further explore the octocoral fauna of this region in order to reveal their distributions and relationships to other East China Sea reefs.

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