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Ten new species of genus *Sarcotragus* (Demospongiae: Dictyoceratida: Irciniidae) from Korea

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Ten new species of genus *Sarcotragus* (Demospongiae: Dictyoceratida: Irciniidae) are described from Geomundo Island and Jejudo Island, Korea. All new species of the *Sarcotragus* are distinguished from the other reported species of *Sarcotragus* by the skeletal structure, especially fasciculate primary fibres. The characters of genus *Sarcotragus* have cylindrical primary fascicles filled with wads of filaments or flattened fascicles. All of the primary fibres are not cored with foreign debris. Secondary fibres have slightly fasciculate branch or plastic-like web. They are all not cored with foreign debris. All skeletal fibres are very irregular. The surface is covered with loose or tight filamentous membrane.

Keywords: Dictyoceratida, Irciniidae, Korea, new species, *Sarcotragus*

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Introduction

The genus *Sarcotragus* in family Irciniidae erected by Schmidt (1862) are not well known throughout the world. Diagnosis of the genus *Sarcotragus* is that the fibre skeleton is comprises primary and secondary fibres and very fine filaments. The skeleton has fasciculate primary fibres which are clear of foreign debris, or with only intermittent inclusions. Secondary fibres are not cored with any detritus. The surface is conulose and unarmoured (Bergquist, 1980; Cook and Bergquist, 2002).

To date, ten species are reported worldwide (Pallas, 1766; Lamarck, 1814; Schmidt, 1862; 1868; Poléjaeff, 1884; Lendenfeld, 1888; Burton, 1928; Sim and Lee, 2000). Among them, two species were described from Korean waters (Sim and Lee, 2000). In this study ten new species are described and illustrations are provided.

Materials and Methods

Specimens were collected from depth 15-25 m using SCUBA during the 2000-2015 from Jejudo Island and Geomundo Island, Korea. Collected specimens preserved in 95% ethyl alcohol and were identified on their morphological characters. The external feature of sponges was observed with a stereo microscope (Stemi DV 4, Carl Zeiss, Göttingen, Germany). The skeletal fibres were studied under a light microscope (Primo Star, Carl Zeiss, Göttingen, Germany). The type specimens were deposited in the National Institute of Biological Resources (NIBR), Incheon, Korea.

Systematic Account

Phylum Porifera Grant, 1836
Class Demospongiae Sollas, 1885
Order Dictyoceratida Minchin, 1900
Family Irciniidae Gray, 1867
Genus *Sarcotragus* Schmidt, 1862

Key to the species of Korean *Sarcotragus*
(The key is illustrated by Figs. 1-12)

1. Primary fibres are cylindrical fascicles ····· 2
− Primary fibres are not cylindrical fascicles ····· ····· *S. geomunensis* n. sp.
2. Colour in life beige turns to dark brown ····· 3
− Colour is not changed ····· 4
3. Ladder-like choanosome skeletal fibres ·····

..... *S. scalaris* n. sp.
− Prismatic branched choanosome skeletal fibres .....
..... *S. sucinum* n. sp.
4. Cylindrical primary fibres are loose fascicles 5
− Cylindrical primary fibres are dense fascicles 6
5. Surface conules with porous membrane are clearly distinct ..... *S. dentilus* n. sp.
− Surface conules with thick membrane are not distinct
..... *S. purpureus* n. sp.
6. Subdermal skeletal structure have very complex fibres
..... 7
− Subdermal skeletal structure have simple fibres 8
7. Secondary fibres are fasciculated branch .....
..... *S. seogwiensis* n. sp.
− Secondary fibres have large perforated pattern .....
..... *S. mamillus* n. sp.
8. Subdermal branched secondary fibres are very rare ···
..... *S. mureungensis* n. sp.
− Subdermal branched secondary fibres are numerous ···
..... 9
9. Primary fibres are large meshed cylindrical fascicles
..... *S. chagwiensis* n. sp.
− Primary fibres are braided longitudinal fascicles .....
..... *S. schmidti* n. sp.

1. *Sarcotragus seogwiensis* n. sp. (Fig. 1)

Type specimen. Holotype (NIBRIV0000325789), Korea: Seogwi-dong, Seogwipo-si, Jeju-do, 12 Nov 2001, Lee KJ, by SCUBA, depth 15 m, deposited in the NIBR.
Description. Massive, hemispherical sponge, size up to 13×9×3.5 cm, conulous surface covered with thick filamentous membrane. Conules, low without emergent terminal fibres, but fine fasciculate fibres distributed under surface. Oscules very rare, 3 mm in diameter, colour in life dark gray. Texture firm and compressible. Choanosome lacunose. Subdermal skeletal fibres well developed (Fig. 1B).

Skeleton: Fasciculate primary fibres, cylindrical net, appeared with wads of filaments. Primary fibres fascicles network, 200-300 μm in diameter under membrane, and 600-1000 μm in diameter at choanosome. Branch type of secondary fibres, light fasciculates, 50-200 μm in diameter. Secondary web, variety of wide in diameter. Filaments, 5 μm in diameter, and terminal knobs, 10-12 μm in diameter.
Etymology. This species is named after the type locality Seogwidong, Jeju-do, Korea.
Remark. This new species is similar to *Sarcotragus dentilus* n. sp. in sponge shape, but differs in surface membrane. Filamentous membrane of this new species is not perforated, and numerous thin branched fibres are distributed under membrane.

2. *Sarcotragus geomunensis* n. sp. (Fig. 2)

Type specimen. Holotype (NIBRIV0000325790), Korea: Geomundo Island, Samsan-myeon, Yeosu-si, Jeollanam-do, 27 Feb 2002, Lee KJ, by SCUBA, depth 20 m, deposited in the NIBR.
Description. Irregular mass, size up to 8×5×3 cm. Conulous surface covered with thin filamentous membrane and perforated round opening. Conules mostly blunt except on side of sponge. Under filamentous membrane, thick primary fibres connected with branches of other primary fibres, or large webs of secondary fibres. Oscules open at the end of protruding surface, 1-3 mm in diameter. Colour, beige in life. Texture, elastic and compressible. Filaments easily separated from fibres. Primary fibres in choanosome, flattened, forming plate, and easily broken. Wide secondary plate like web located between adjacent primary fibres. Thin branched fibres like web, spread under filamentous membrane.

Skeleton: Primary fibres, 400-750 μm in diameter. Secondary fibres, simple fasciculate branch, 80-180 μm, 200-300 μm in diameter and web pattern, 200-300 μm in diameter. Filaments, 5 μm in diameter, terminal knobs, 10-12 μm in diameter.
Etymology. This species is named after the type locality Geomundo Island.
Remark. This new species is a unique in that its choanosome primary fibres are flattened shape and easily broken. Secondary fibres have mostly web pattern.

3. *Sarcotragus schmidti* n. sp. (Fig. 3)

Type specimen. Holotype (NIBRIV0000325791), Korea: Marado Island, Daejung-eup, Seogwipo-si, Jeju-do. 4 Nov 2000, Lee KJ, by SCUBA, depth 21 m, deposited in the NIBR.
Description. Round mass, size up to 10.5×6×3.5 cm. Conules, difficult to distinct except at the side of sponge because many other animals attached on sponge surface. Thick filamentous membrane with fine branched fibres. Colour pale gray in life. Texture soft and compressible.

Skeleton: Primary fibres, strongly braided longitudinal fascicles, and fine meshed net like bark of tree. Primary fibres's diameter, diverse, 300-700 μm, thin primary fibres confused with secondary fibres. Cylindrical primary fascicles filled with wads of filaments. Secondary fibres with porous branch, 50-150 μm in diameter, secondary web, 800 μm in diameter. Filaments, 5-7 μm in diameter, terminal knobs, 15 μm in diameter. Filaments difficult to separate from fibres.
Etymology. This species name *schmidti* is named after Schmidt who erected this genus *Sarcotragus*.
Remark. This new species is characterized by strongly braided longitudinal primary fascicles with fine meshed net.

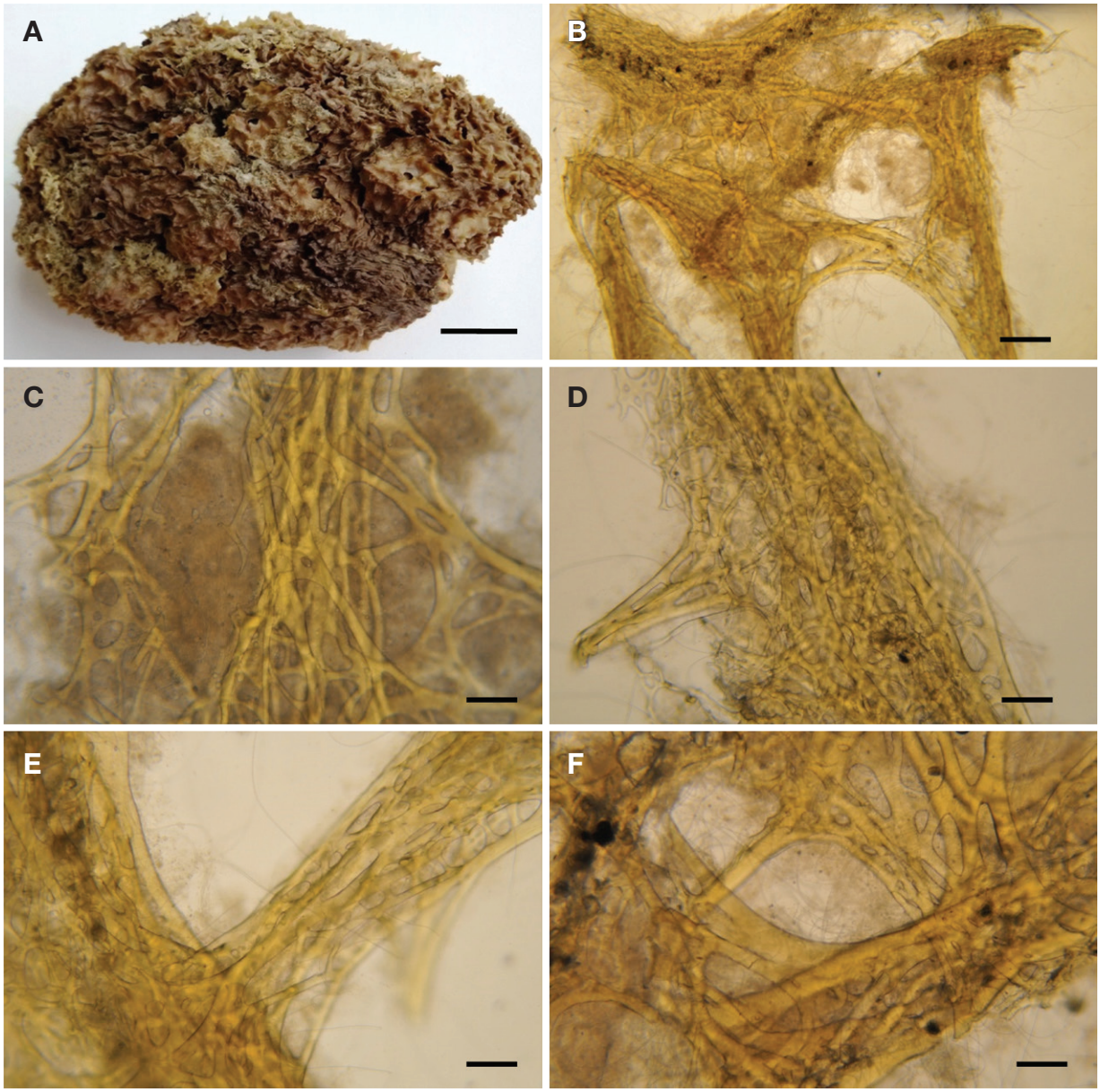

Fig. 1. *Sarcotragus seogwiensis* n. sp. A, entire animal; B, subdermal skeletal structure; C, fine skeletal structure under membrane; D, primary fibres fascicles; E, fasciculate branched secondary fibres; F, web of secondary fibres. Scale bars: A = 2 cm, B = 200 μm, C-F = 100 μm.

4. *Sarcotragus chagwiensis* n. sp. (Fig. 4)

Type specimen. Holotype (NIBRIV0000325792), Korea: Chagwido, Gosan-ri, Hankyung-myeon, Jeju-si, Jeju-do, 6 Nov 2000, Lee KJ, by SCUBA, Depth 20 m, deposited in the NIBR.

Description. Thick irregular mass, size up to 12 × 10 × 3.5 cm. Surface very low conules covered with loose filamentous membrane, and mixed with rare spicules. Subdermal branched skeletal fibres, very complex. Oscules, 1.5-4 mm in diameter, open on sponge surface. Colour dark beige in life. Texture soft and compressible.

Skeleton: Primary fibres porous cylindrical fascicles, 700-1000 μm in diameter, filled with wads of filaments. Secondary fibres, branch with loose fascicles 180-300 μm in diameter. Secondary web like thin plate broaden between adjacent primary fibres. Filaments, 4 μm in diameter, terminal knobs, 10 μm in diameter. Fibres difficult to separate from wads of filaments.

Etymology. This species is named after the type locality Chagwido, Jejudo Island.

Remark. This new species is similar to *Sarcotragus gapaensis* Sim and Lee, 2000 in skeletal structure, but differs in sponge shape and surface conules. Subdermal

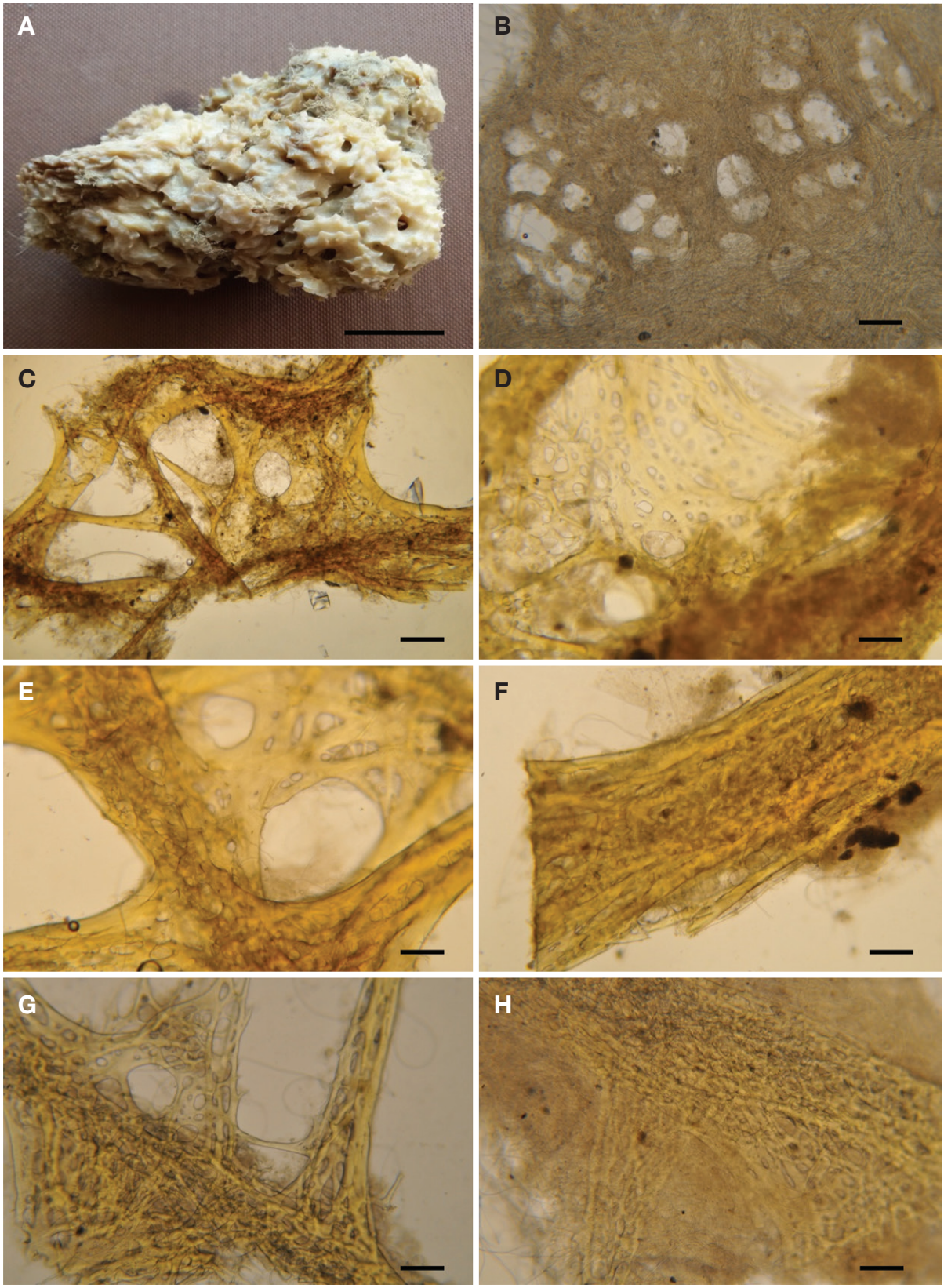

Fig. 2. *Sarcotragus geomunensis* n. sp. A, entire animal; B, filamentous membrane; C, subdermal skeletal structure; D, secondary fibres web; E, primary and secondary fibres web; F, choanosome primary fibres. G-H, skeletal structure at the base of sponge. Scale bars: A = 2 cm, B = 100 μm, C = 200 μm, D-H = 100 μm.

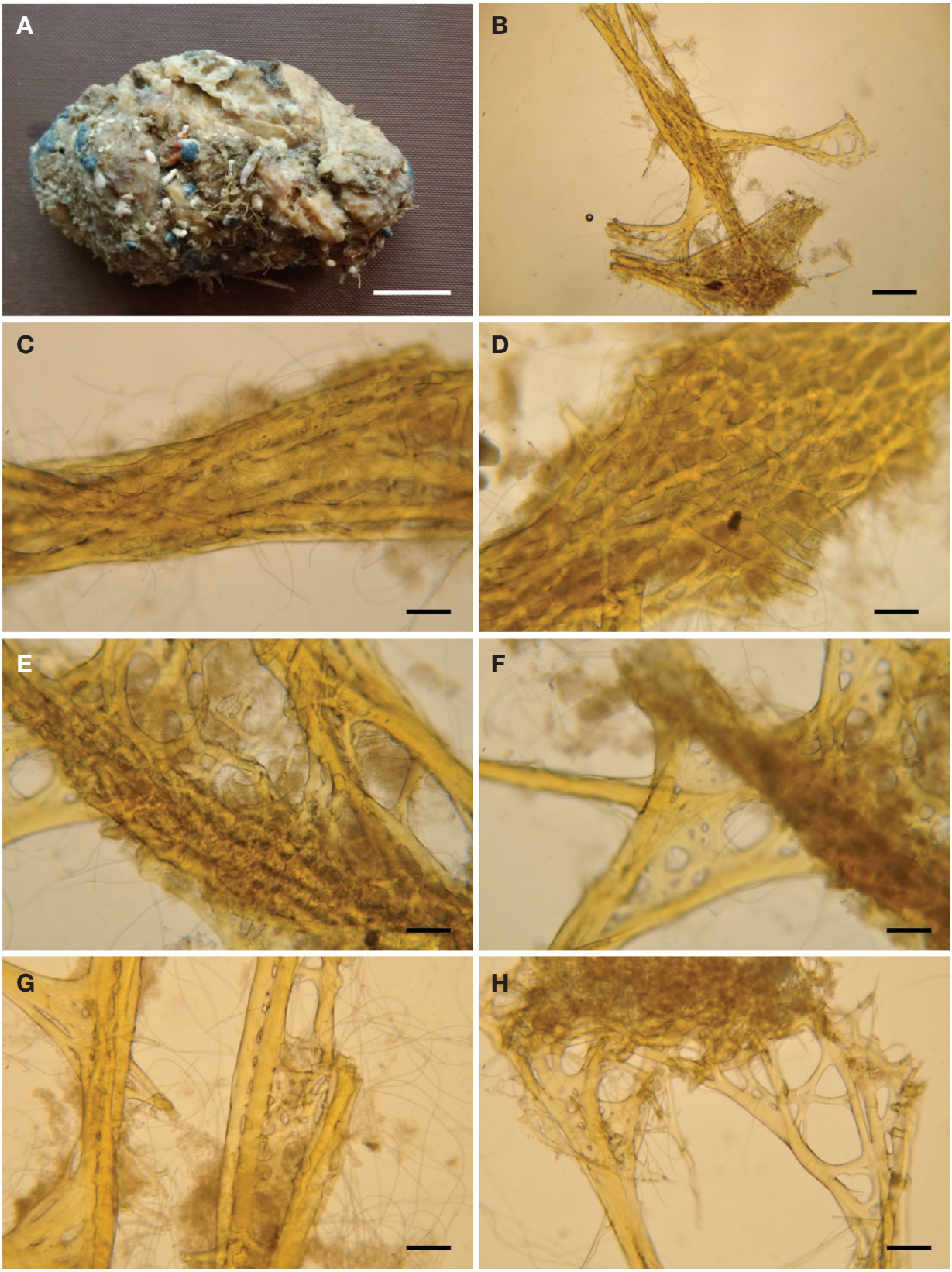

Fig. 3. *Sarcotragus schmidti* n. sp. A, entire animal; B, surface skeletal structure; C, primary fibres; D, broad primary fibres fascicles; E, primary and secondary fibres; F, branched secondary fibres; G, narrow primary fibres with simple fascicles; H, branched secondary fibres. Scale bars: A = 2 cm, B = 200 μm, C-H = 100 μm.

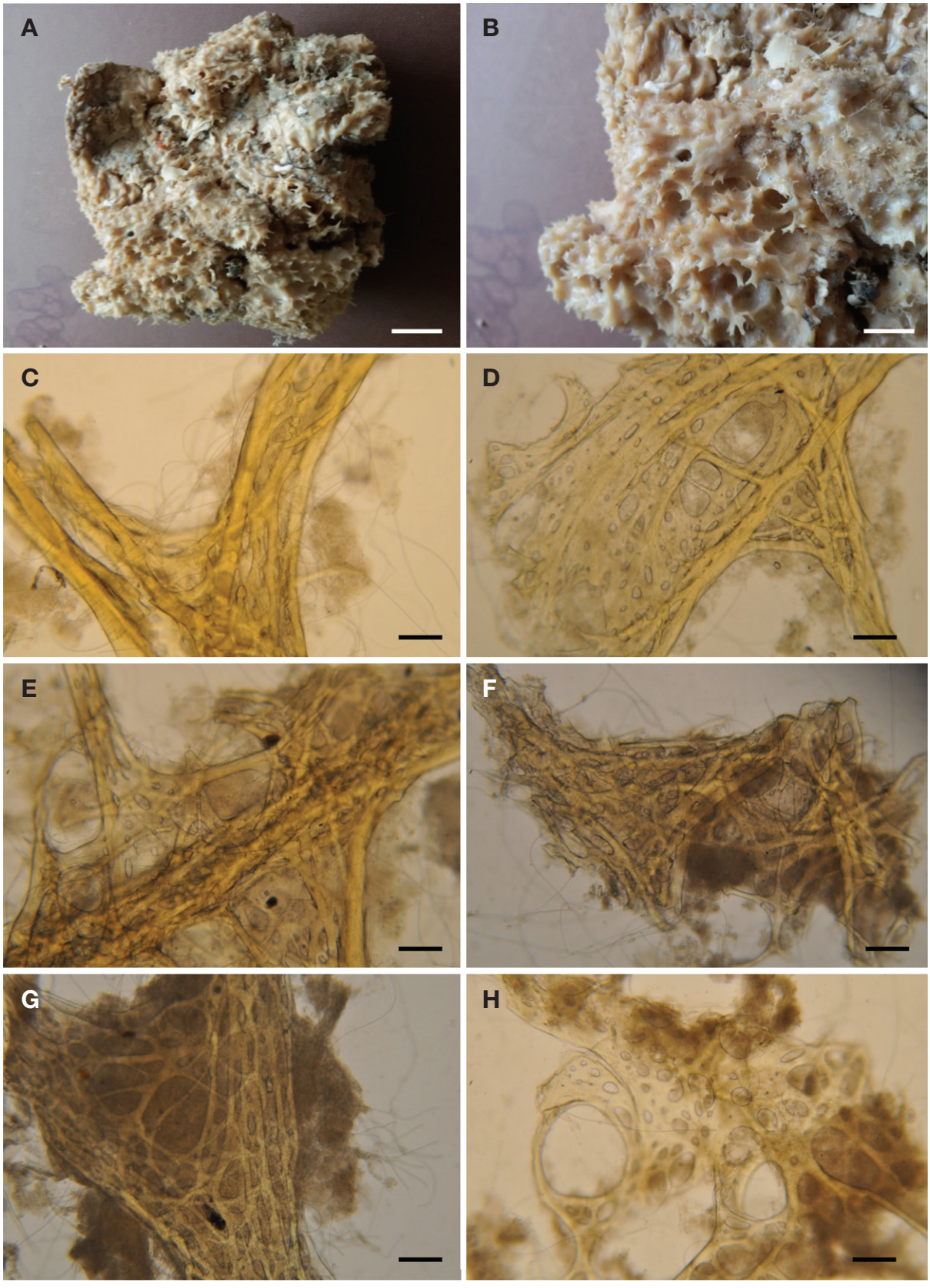

Fig. 4. *Sarcotragus chagwiensis* n. sp. A, entire animal; B, closed surface; C, primary and secondary fibres; D, secondary web; E, skeletal structure; F, surface thin secondary fibres; G, primary fibres; H, secondary web. Scale bars: A = 2 cm, B = 7 cm, C-H = 100 µm.

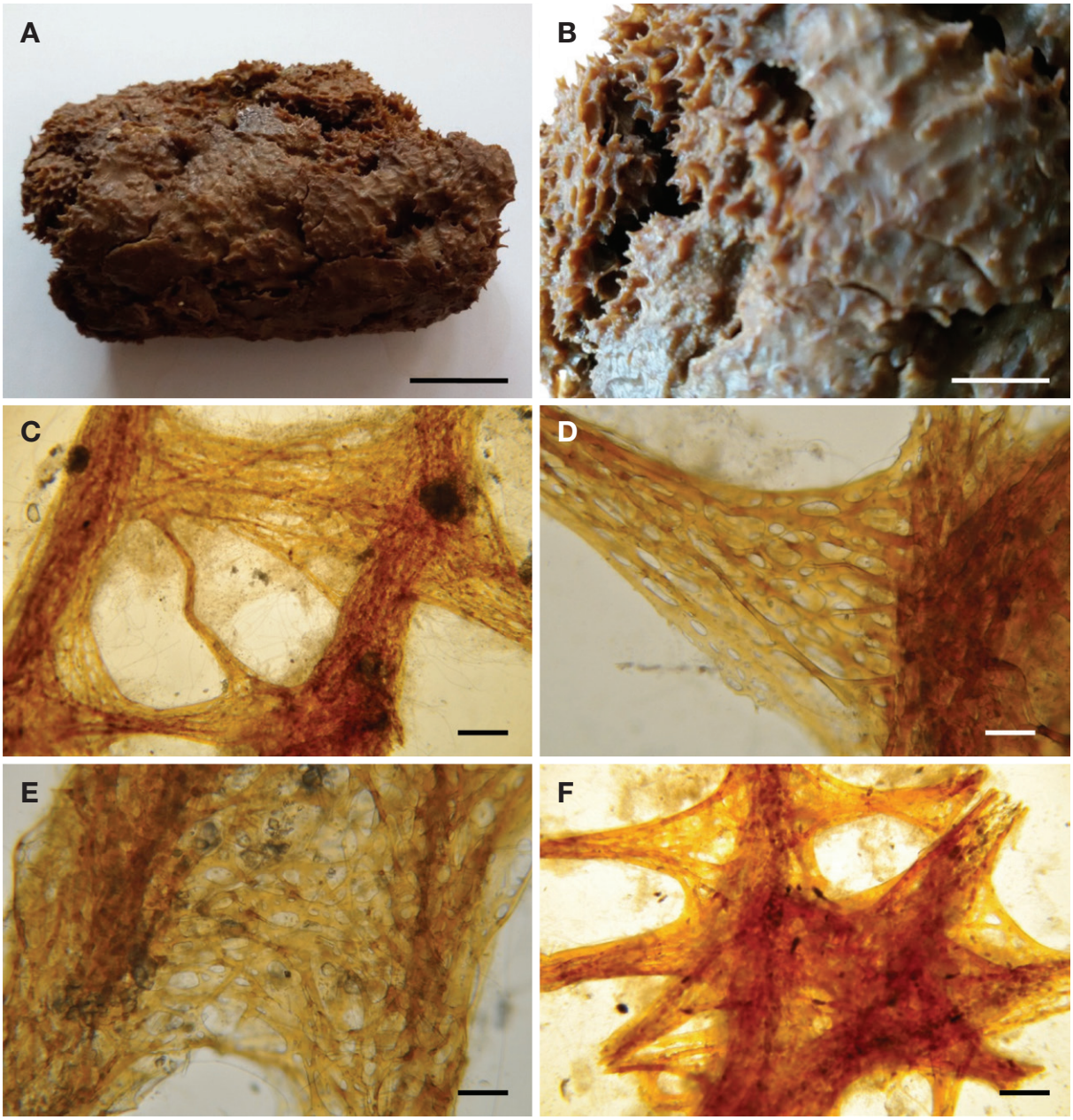

Fig. 5. *Sarcotragus sucinum* n. sp. A, entire animal; B, closed surface; C, surface skeletal structure; D, branched secondary fibres with mesh net; E, secondary web between primary fibres; F, choanosome prismatic skeletal structure. Scale bars: A = 2 cm, B = 10 cm, C, F = 200 µm, D, E = 100 µm.

branched skeletal fibres of this new species are very complex and primary fibres fascicles filled with wads of filaments (Fig. 4G). Surface conules of *S. gapaensis* are very sharp and easily distinct, but conules of this new species are very low and difficult to distinct.

5. *Sarcotragus sucinum* n. sp. (Figs. 5, 6)

Type specimen. Holotype (NIBRIV0000325793), Korea: Jikgudo, Chuja-myeon, Jeju-si, Jeju-do, 5 Nov 2009, Kim HS, by SCUBA, Depth 15 m, deposited in the NIBR.

Description. Thick irregular mass, size up to 10 × 8 × 3 cm. Surface smooth. Conules difficult to distinct except sharp conules on side of sponge. Thick skeletal fibres, irregularly branched out, covered with dense filamentous membrane. Oscules rare, 1 mm in diameter, open on sponge surface. Colour pale gray in life, turn to dark

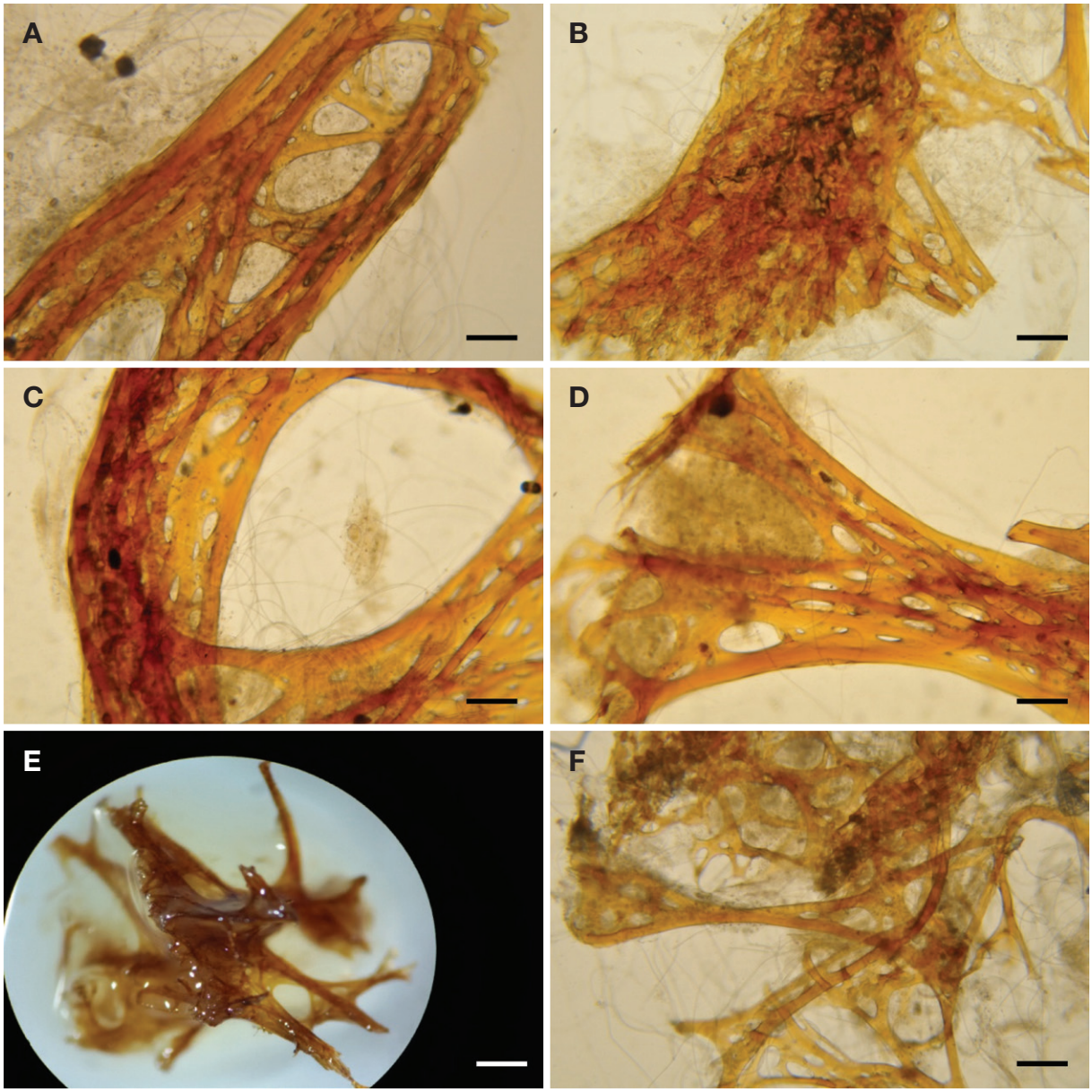

Fig. 6. *Sarcotragus sucinum* n. sp. A, thick secondary fibres; B, primary fascicles with mesh net; C, choanosome skeletal structure; D, choanosome secondary fibres; E, surface thick skeletal structure; F, thin secondary fibres. Scale bars: A-D, F = 100 μm, E = 1 cm.

brown upon collection. Texture very soft and compressible. Sponge shape easily changed because soft texture. Choanosome slightly lacunous.

Skeleton: Surface skeletal fibres, thicker than choanosome's. Choanosomal skeletal fibres arranged in three dimensions (Fig. 5F). All fibres amber colour. Primary fibres, 300-700 μm in diameter, very loose fascicles. Secondary fibres, 50-200 μm in diameter, branched with regular mesh net. Filaments, 5 μm in diameter, terminal knobs, 10-15 μm in diameter.

Etymology. This species name *sucinum* is named after amber colour of skeletal fibres.

Remark. This new species is similar to *Sarcotragus scalaris* n. sp. in colour changing, but differs in skeletal structure. Skeletal fibres of *S. scalaris* n. sp. is arranged like ladder shape in choanosome, but skeletal fibres of this new species have prismatic arrangement with secondary branch in choanosome.

6. *Sarcotragus dentilus* n. sp. (Fig. 7)

Type specimen. Holotype (NIBRIV0000325794), Korea:

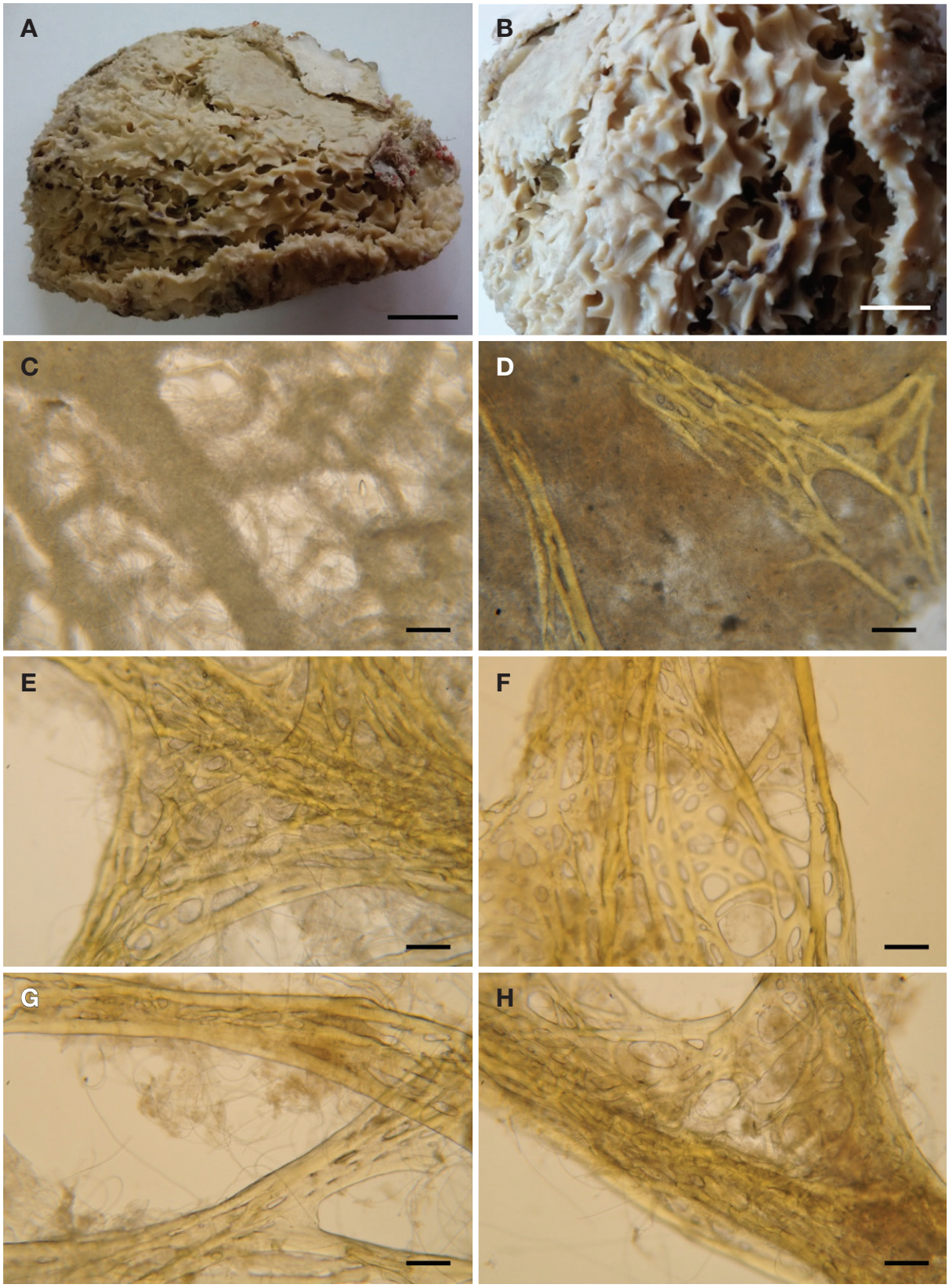

Fig. 7. *Sarcotragus dentilus* n. sp. A, entire animal; B, closed surface; C, surface filamentous membrane with pore; D, subsurface thin primary and secondary fibres; E, fasciculate secondary fibres; F, primary fibres fascicle; G, thin primary fibres; H, primary and branched secondary fibres. Scale bars: A = 2 cm, B = 20 cm, C-H = 100 μm.

Munseom, Seogwipo-si, Jeju-do, 10 Feb 2002, Lee KJ, by SCUBA, Depth 25 m, deposited in the NIBR.
Description. Hemispherical mass, size up to 12 × 9 × 4 cm. Surface, sharp conules covered with thin perforated filamentous membrane. Fine fasciculate fibres appeared under membrane. Several oscules open on sponge surface, 1-5 mm in diameter. Colour pale gray and beige in life. Texture firm and compressible.

Skeleton: Primary fibres loose fascicles, 400-1000 μm in diameter, with numerous perforations. Fasciculate or porous secondary fibres branched out. Bridge form of secondary fibres, 50-200 μm in diameter. Filaments, 3-5 μm in diameter, terminal knobs, 10-12 μm in diameter. Fibres difficult to separate from filaments.
Etymology. This species name *dentilus* is named after teeth-like surface conules.
Remark. This new species is characterized by perforating membrane with numerous opening. Loose fasciculate primary fibres have numerous perforation.

7. *Sarcotragus purpureus* n. sp. (Fig. 8)

Type specimen. Holotype (NIBRIV0000325795), Korea: Gapado Island, Daejeong-eup, Seogwipo-si, Jeju-do, 5 Jul 2015, Kim BI, by SCUBA, Depth 15-18 m, deposited in the NIBR.
Description. Irregular mass, size up to 14 × 9 × 7 cm. Surface covered with filamentous membrane and row conules. Many other animals appeared on surface. Filamentous membrane mixed with fine fibres. Osculesnot distinct. Colour pale purple in life. Texture soft and compressible.

Skeleton: Skeletal fibres very loosely arranged, all fibres with large and small perforation. Primary fibres, 400-900-1900 μm in diameter, cylindrical fascicles with large mesh net (Fig. 8F). Wads of filaments on primary fibre fascicles easily come out from fibres because large mesh net. Primary fibres at the base of sponge are very thick and dense fascicles (Fig. 8G). Secondary fibres, 250-400 μm in diameter under surface membrane, and 600-1000 μm in diameter at the base. Filaments, 5 μm in diameter, terminal knobs, 10-13 μm in diameter.
Etymology. This species name *purpureus* is named after purple colour of sponge.
Remark. This new species is characterized by cylinder shape of primary fibres fascicles with large mesh net. Cylindrical fascicles are filled with wads of filaments, but easily come out from the fibres.

8. *Sarcotragus mureungensis* n. sp. (Fig. 9)

Type specimen. Holotype (NIBRIV0000325796), Korea: Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 19 Aug 2015, Moon SE, by SCUBA, Depth 20 m, deposited in the NIBR.
Description. Massive, size up to 13 × 11 × 4.5 cm. Surface covered with filamentous membrane and sharp conules. Filaments wrapped fibres loosely, and filamentous membrane mixed with spicules. Between primary fibres appeared rare branched fibres under membrane. Oscules scattered over sponge surface. Colour in life, gray on outside of sponge and white inside. Texture soft and compressible. Choanosome lacunose.

Skeleton: Primary fibres, 500-1600 μm in diameter, loose and cylindrical fascicles, which filled with wads of filaments. Bridge form of secondary fibres, 100-300 μm in diameter. Under surface membrane, thin branched secondary fibres appeared rarely, and thick subdermal skeletal fibres not appeared. Filaments, 3-6 μm in diameter, terminal knobs, 8-13 μm in diameter.
Etymology. This species is named after the type locality Mureungachi, Jeju-do.
Remark. This new species is distinguished by its rare subdermal branched secondary fibres.

9. *Sarcotragus scalaris* n. sp. (Figs. 10, 11)

Type specimen. Holotype (NIBRIV0000554218), Korea: Jikgudo, Chuja-myeon, Jeju-si, Jeju-do, 5 Nov 2009, Kim HS, by SCUBA, Depth 15 m, deposited in the NIBR.
Description. Thick round mass, size up to 12 × 7 × 4 cm. Surface covered with porous thin filamentous membrane. Conules easily distinct, but not sharp. Numerous oscules, 3-7 mm in diameter, open on sponge surface. Colour beige in life, changed to dark brown after collection. Texture very soft and compressible. Choanosome not lacunose. Surface fibres thinner than ladder-like choanosomal fibres.

Skleton: Primary fibres, 300-700 μm in diameter, dense cylindrical fascicles. Secondary fibres, various size of fibres in web type, 700-1000 μm in diameter, and 200-400 μm in diameter, in branch type. Filaments, 5-7 μm in diameter, terminal knobs, 10-12 μm in diameter.
Etymology. This species is named after the shape of ladder-like choanosome skeletal structure.
Remark. This species is very similar to *Sarcotragus sucinum* n. sp. in colour change upon collection, but it is big different in skeletal structure. Surface fibres of *S. sucinum* n. sp. are thicker than this new species. *S. sucinum* n. sp. have prismatic skeletal fibres in choanosome, but this new species has ladder-like skeletal fibres at the choanosome. The surface has porous filamentous membrane.

10. *Sarcotragus mamillus* n. sp. (Fig. 12)

Type specimen. Holotype (NIBRIV0000554219), Korea: Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 15

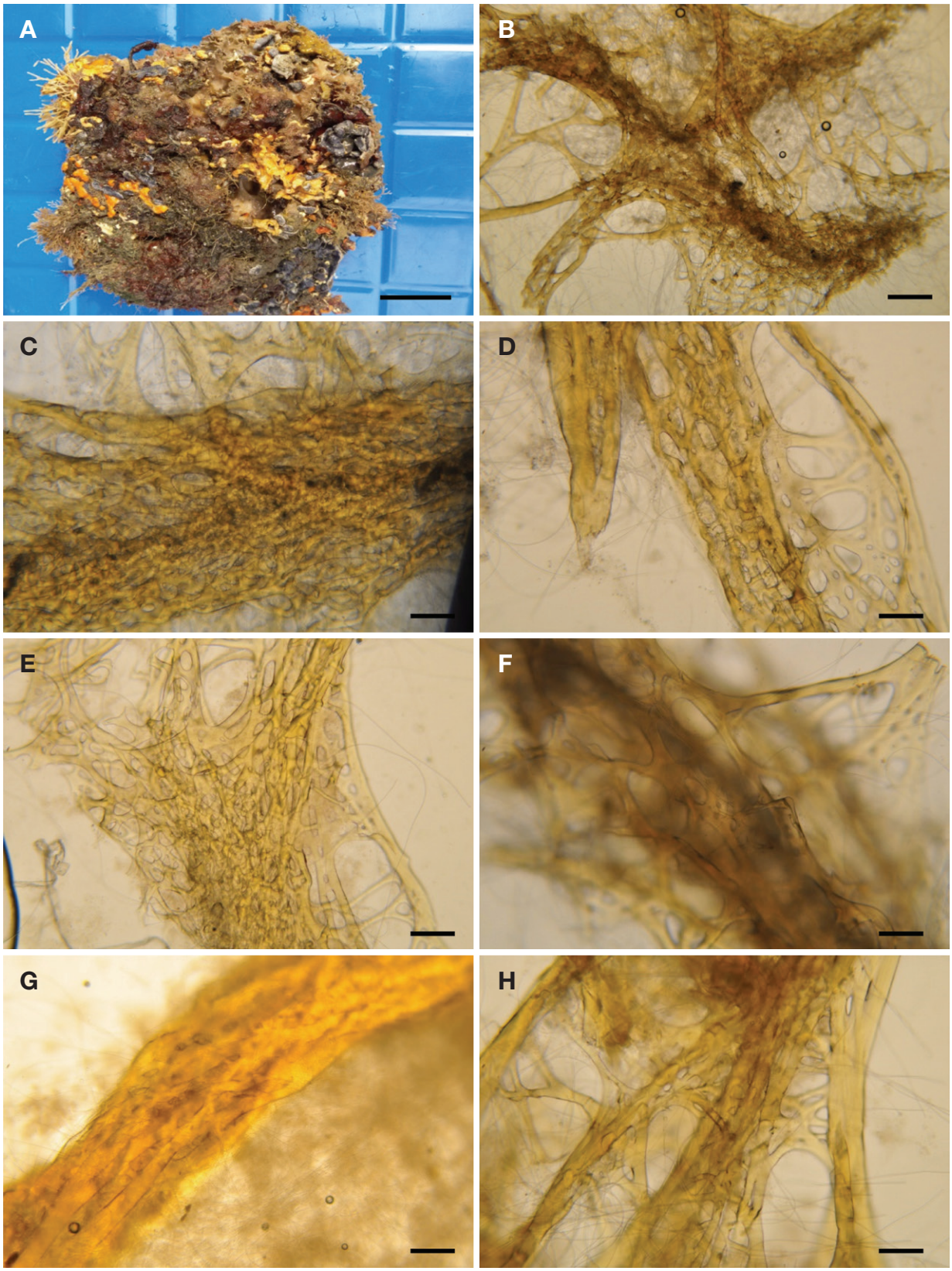

Fig. 8. *Sarcotragus purpureus* n. sp. A, entire animal; B, surface skeletal structure; C, primary fibres fascicle; D, end of primary fibres fascicle; E, thin primary and secondary fibres; F, cylindrical primary fibres; G, thick primary fascicles at the base of sponge; H, choanosome skeletal structure. Scale bars: A = 4 cm, B = 200 µm, C-H = 100 µm.

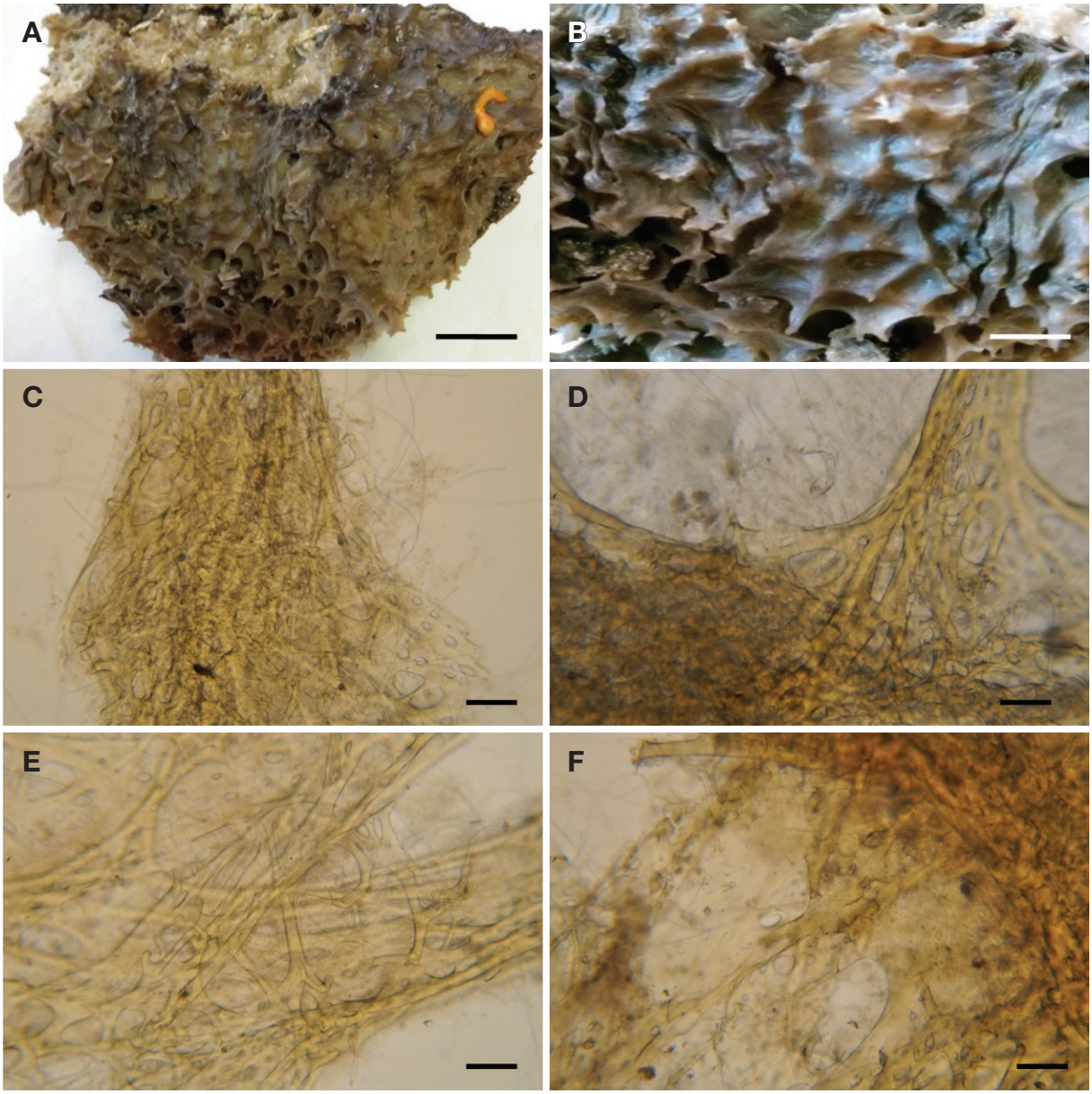

Fig. 9. *Sarcotragus mureungensis* n. sp. A, entire animal; B, closed surface; C, primary fibres fascicle; D, branched secondary fibres; E, secondary fibres; F, secondary web. Scale bars: A = 2 cm, B = 15 cm, C = 200 μm, D-F = 100 μm.

Aug 2015, Moon SE, by SCUBA, Depth 20 m, deposited in the NIBR.

Description. Irregular mass, size up to 12 × 8 × 4 cm. Surface, slightly protruding like mamillate form, low conules with filamentous membrane. Oscules, 4-6 mm in diameter, open at protruding surface. Colour in life gray. Texture very soft and compressible. Choanosome lacunose, subdermal skeletal fibres well develope.

Skeleton: Subdermal skeletal structure very thick, primary fibres, 400-800 μm in diameter, wide secondary web, 600-1400 μm in diameter, bridged secondary fibres, 100-400 μm in diameter. Skeletal structure of basal part, very thick, it's big different from one near surface. All primary and secondary fibres have numerous irregular perforations. Filaments, 3-5 μm in diameter, terminal knobs, 10 μm in diameter.

Etymology. This species is named after surface mamillate form.

Remark. This new species is similar to *Sarcotragus geomunensis* n. sp. in collagenous secondary web, but differs in choanosomal primary fibres. Surface membrane of this new species has no perforation.

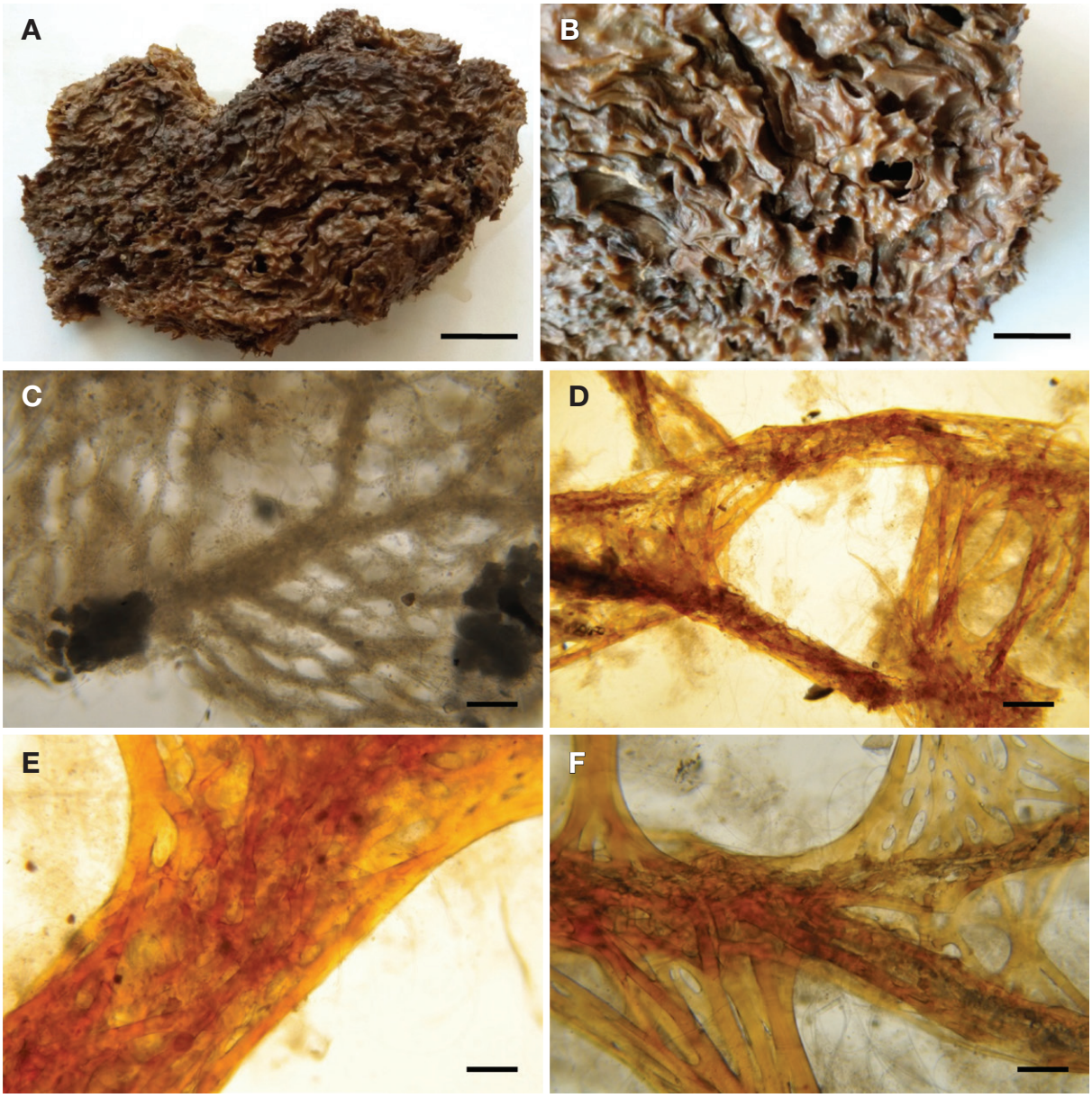

Fig. 10. *Sarcotragus scalaris* n. sp. A, entire animal; B, closed surface; C, filamentous membrane with pore; D, choanosomal skeletal structure; E, thick primary fibres; F, branched secondary fibres. Scale bars: A = 2 cm, B = 20 cm, C, E, F = 100 μm, D = 200 μm.

Discussion

Ten species of *Sarcotragus* have been described worldwide (Pallas, 1766; Schmidt, 1862; 1868; Poléjaeff, 1884; Lendenfeld, 1888; Burton, 1928; Sim and Lee, 2000). Two of these occur from the Korean waters. The genus *Sarcotragus* has caused confusion with genus *Ircinia*. In this study we try to find the consistent characters of genus *Sarcotragus*. This study is focused on surface and subdermal skeletal structure because it is easy to detect consistent characteristic in detail which easily distinguishes the species. Choanosome skeletal fibres are thicker than ectosomal fibres in mostly all the specimen.

Ten our new species are not cored with foreign debris in primary fibres. Primary fibres fascicles are very tightly cylindrical or slightly flattened. Most of the cylindrical fascicles are filled with wads of filaments. Secondary fibres have two kinds of skeletal structure, branch type and plastic-like web, which are always not cored. Connective bridged pattern of secondary fibres are slightly fasciculate.

Burton (1928) stated that the surface of *Sarcotragus aligera* is covered with tough cuticle, but our all specimens are covered with loose or tight filamentous mem-

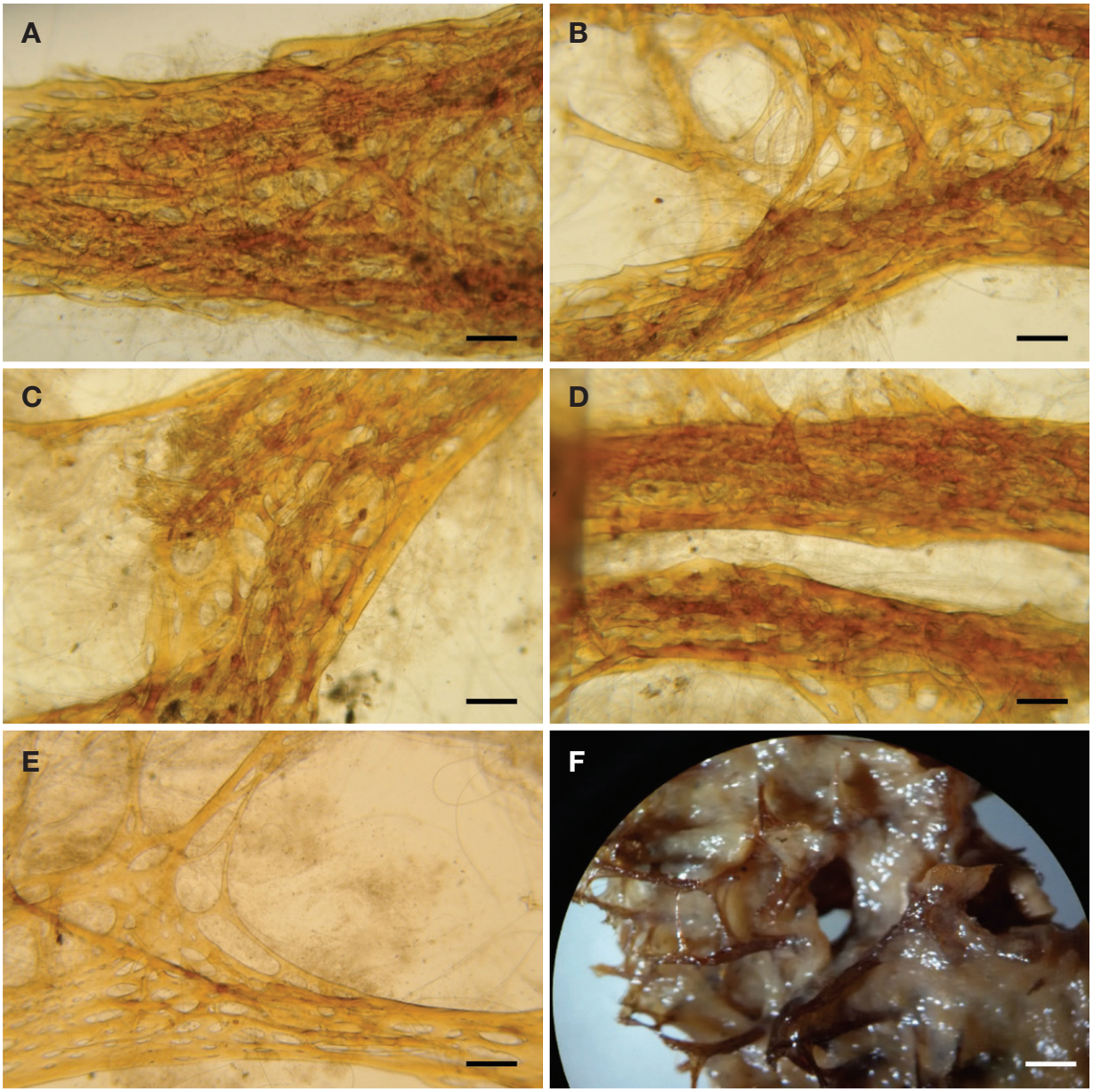

Fig. 11. *Sarcotragus scalaris* n. sp. A, primary fibres; B, secondary web between primary fibres; C, secondary fibres branch; D, small primary fibres; E, secondary fibres web; F, large skeletal structure at the base of sponge. Scale bars: A-E = 100 μm, F = 1 cm.

brane.

Lendenfeld (1889) described that the primary fibres in *Sarcotragus foetidus* Schmidt, 1862 have longitudinal trellis-like fascicules, and the primary fascicles in *Sarcotragus fasciculatus* (Pallas, 1766) are cylindrical or slightly flattened. He also reported that the connective secondary fibres have extension ending like trumpet shape attached to the primary fascicles. As a result, the characters of genus *Sarcotragus* have cylindrical primary fascicles filled with wads of filaments or flattened fascicles. All of the primary fibres are not cored with foreign debris. Secondary fibres have slightly fasciculate branch or plastic-like web. They are all not cored with foreign debris. All skeletal fibres are very irregular. The surface is covered with loose or tight filamentous membrane.

In regard to the genus *Bergquistia*, Sim and Lee (2002) reported that the skeletal structure of *B. coreanus* are very regular and simple. The primary fibres as genus *Thorecta* are not cylindrical fascicules. Bridged secondary fibres are also simple and thin. *B. coreanus* is no secondary fibres web. Two or three filaments are coiled

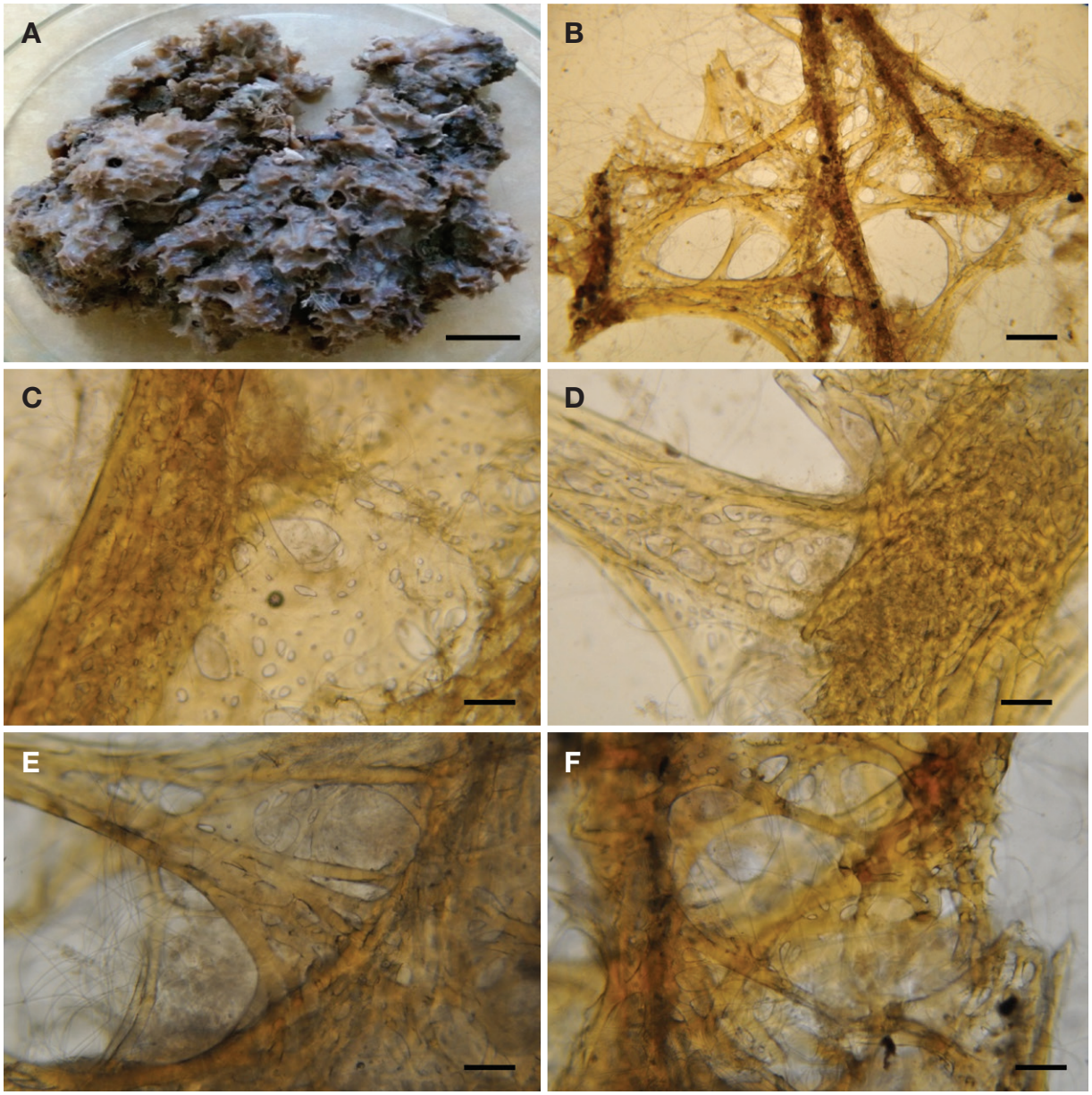

Fig. 12. *Sarcotragus mamillus* n. sp. A, entire animal; B, subdermal skeletal structure; C, secondary web; D, branched secondary fibres; E, F, skeletal structure at the base of sponge. Scale bars: A = 2 cm, B = 200 μm, C-F = 100 μm.

with each other forming a thicker filament which shows peculiar figure. Surface conules are very distinct and regularly arranged. Genus *Bergquistia* is big different from other three genera, *Psammocinia*, *Sarcotragus* and *Ircinia*, in family Irciniidae.

Acknowledgements

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