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Nine new species of genus *Ircinia* (Demospongiae: Dictyoceratida: Irciniidae) from Korea

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Nine new species of genus *Ircinia* (Demospongiae: Dictyoceratida: Irciniidae) from Jejudo Island, Korea are described. All of the new species are distinguished from the others reported species of *Ircinia* by the skeletal structure, especially massive fasciculate primary fibres. The characters of genus *Ircinia* have primary fibres cored with foreign debris and no cored secondary fibres. Primary fibres are not easy to distinguish from secondary fibres if they are not cored. Secondary web has perforated plate or meshed net. All new species have loosely arranged skeletal fibres network.

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

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Introduction

The genus *Ircinia*, in family Irciniidae, erected by Nardo, 1833 comprises of over 70 species known from worldwide (Schmidt, 1862; 1864; Duchassaing and Michelotti, 1864; Polejaeff, 1884; Lendenfeld, 1888; 1889; de Laubenfels, 1948; Wiedenmayer, 1977; Bergquist, 1980; Pulitzer-Finali, 1982; Cook and Bergquist, 1999; Van Soest *et al*., 2016). Twenty two species in this genus are in the Australian, 13 in the Mediterranean, 7 each on the American coast of the North Atlantic and in the Indian Ocean, 7 in the New Zealand. Cook and Bergquist (2002) defined diagnosis of the skeleton of the *Ircinia* species that the primary fibres are cored with foreign debris, and form massive fascicles. Secondary fibres are simple and uncored. The consistency of these sponges is soft to firm, though they are extremely tough, and are difficult to cut or tear. Fourteen Irciniid sponges (*Psammocinia*, *Sarcotragus*, and *Bergquistia*) except genus *Ircinia* have previously been described from Korean waters (Sim, 1998; Sim and Lee, 1998; 2000; 2001; 2002a; 2002b; Lee and Sim, 2004). Several authors reviewed this genus (Polejaeff, 1884; Lendenfeld, 1889; de Laubenfels, 1948; Bergquist, 1980; Cook and Bergquist, 1999). In the present study, we discovered nine new species of genus *Ircinia* from Korean waters. These new species are described and provided illustrations.

Materials and Methods

Sponges were collected from depth 15-25 m using SCUBA during the 2014-2016 from Jejudo 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 DV4, 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 Accounts

Phylum Porifera Grant, 1836
Class Demospongiae Sollas, 1885
Order Dictyoceratida Minchin, 1900
Family Irciniidae Gray, 1867
Genus *Ircinia* Nardo, 1833

Key to the species of Korean *Ircinia*

(The key is illustrated by Figs. 1-12)

1. Primary fibres are cored with foreign debris ····· 2
− Primary fibres are slightly cored or uncored with foreign debris ····· 8
2. Surface have thin filamentous membrane ····· 3
− Surface have thick filamentous membrane ····· 7
3. Primary fibres at conules are cored with small and large sands ····· 4
− Primary fibres at the base of sponge are cored with small and large sands ····· *I. jejuensis*
4. Primary fibres are cored with pebble-like large sands ····· *I. lapillus*
− Primary fibres are cored with small sands ····· 5
5. All fibres have numerous perforation ····· *I. gapaensis*
− All fibres have rare perforation ····· 6
6. Root-like branched secondary fibres ····· *I. grobulosa*
− Fasciculate branched secondary fibres ····· *I. bakusi*
7. Thin incrusting sponge, choanosomal skeletal fibres are loosely arranged network ····· *I. incrustans*
− Round mass sponge, choanosomal skeletal fibres are thick and dense bundles ····· *I. munsumensis*
8. Flabbily large round mass sponge, primary fibres are slightly cored ····· *I. mureungensis*
− Thick encrusting sponge, primary fibres are uncored ····· *I. bergquistia*

1. *Ircinia incrustans* n. sp. (Fig. 1)

Type specimen. Holotype (NIBRIV0000554220), Korea: Munseom, Seogwipo-si, Jeju-do, 15 Aug 2015, Kim BI, by SCUBA, Depth 25 m, deposited in the NIBR.

Description. Thin encrusting, size up to 14 × 5 cm wide 0.5 cm thick, attached on shell of oyster. Surface smooth, and covered with thick collagenous filamentous membrane. Conules, rare and low, but easily discerned at side of sponge. Several oscules, 2-8 mm in diameter, opened through sponge. Colour pale grey in life turns to dirty gray in alcohol. Texture firm.

Skeleton: Primary fibres, 150-450 μm in diameter, some thin primary fibres at membrane cored with sands and broken spicules. Choanosome primary fibres not cored mostly and uncored primary fibres not easy to distinguish from secondary fibres. Branched secondary fibres, 250-500 μm in diameter. Filaments, 6-7 μm in diameter, terminal knobs, 13-15 μm in diameter.

Etymology. This species is named after the encrusting habit.

Remark. This new species is characterized by its encrusting form. Thick collagenous filamentous membrane of surface is easily covered out.

2. *Ircinia grobulosa* n. sp. (Fig. 2)

Type specimen. Holotype (NIBRIV0000554221), Korea: Munseom, Seogwipo-si, Jeju-do, 15 Aug 2015, Kim BI, by SCUBA, Depth 25 m, deposited in the NIBR.

Description. Round mass, attached to shell of mollusc, size up to 8 × 5 × 3.3 cm. Surface, week honeycomb pattern with row conules. Several oscules, 2-4 mm in diameter, opened at side of sponge. Colour yellowish gray in life. Texture soft and compressible.

Skeleton: Primary fibres, 450-750 μm in diameter, cored with large sands and broken spicules. Two kinds of secondary fibres, secondary web with large irregular mesh net, 400-500 μm in diameter, and some branch pattern with root-like diverging secondary fibres, 500 μm in diameter. Filaments have two categories in size, 2 and 8 μm in diameter, terminal knobs, 10-15 μm in diameter.

Etymology. This species is named after the ball shape of sponge.

Remark. This new species is characterized by thick encrusting, and two categories of filament in diameter, and secondary fibres always joined to primary fascicles by a number of diverging roots (Fig. 2C).

3. *Ircinia gapaensis* n. sp. (Figs. 3, 4)

Type specimen. Holotype (NIBRIV0000554222), Korea: Gapado, Daejeong-eup, Seogwipo-si, Jeju-do, 29 Sep 2014, Kim HS, by SCUBA, Depth 15-18 m, deposited in the NIBR.

Description. A massive, round, size up to 9 × 8 × 4 cm. Surface, low mammilate form with conules. Oscules, 2-4 mm in diameter, opened at end of mammilate. Colour in life grayish beige. Texture very soft and compressible.

Skeleton: Primary fibres near surface, 300-400 μm in diameter, cored with sparse small sands. Two kinds of secondary fibres at conules, 200-500 μm in diameter, bridged branch type and V shape of secondary web. Secondary web have irregularly arranged mesh net. Primary fibres in choanosome, 300-500 μm in diameter, cored with sands and secondary fibres, 250-400 μm in diameter. Primary and secondary fibres have numerous perforation, loose network and amber colour. Filaments, 3-5 μm in diameter, terminal knobs, 15 μm in diameter.

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

Remark. This new species is similar to *Ircinia bakusi* n. sp. in shape, but differs in skeletal structure. Primary and secondary fibres of this new species have numerous and large perforation and cored with sands sparsely.

4. *Ircinia lapillus* n. sp. (Fig. 5)

Type specimen. Holotype (NIBRIV0000554223), Korea:

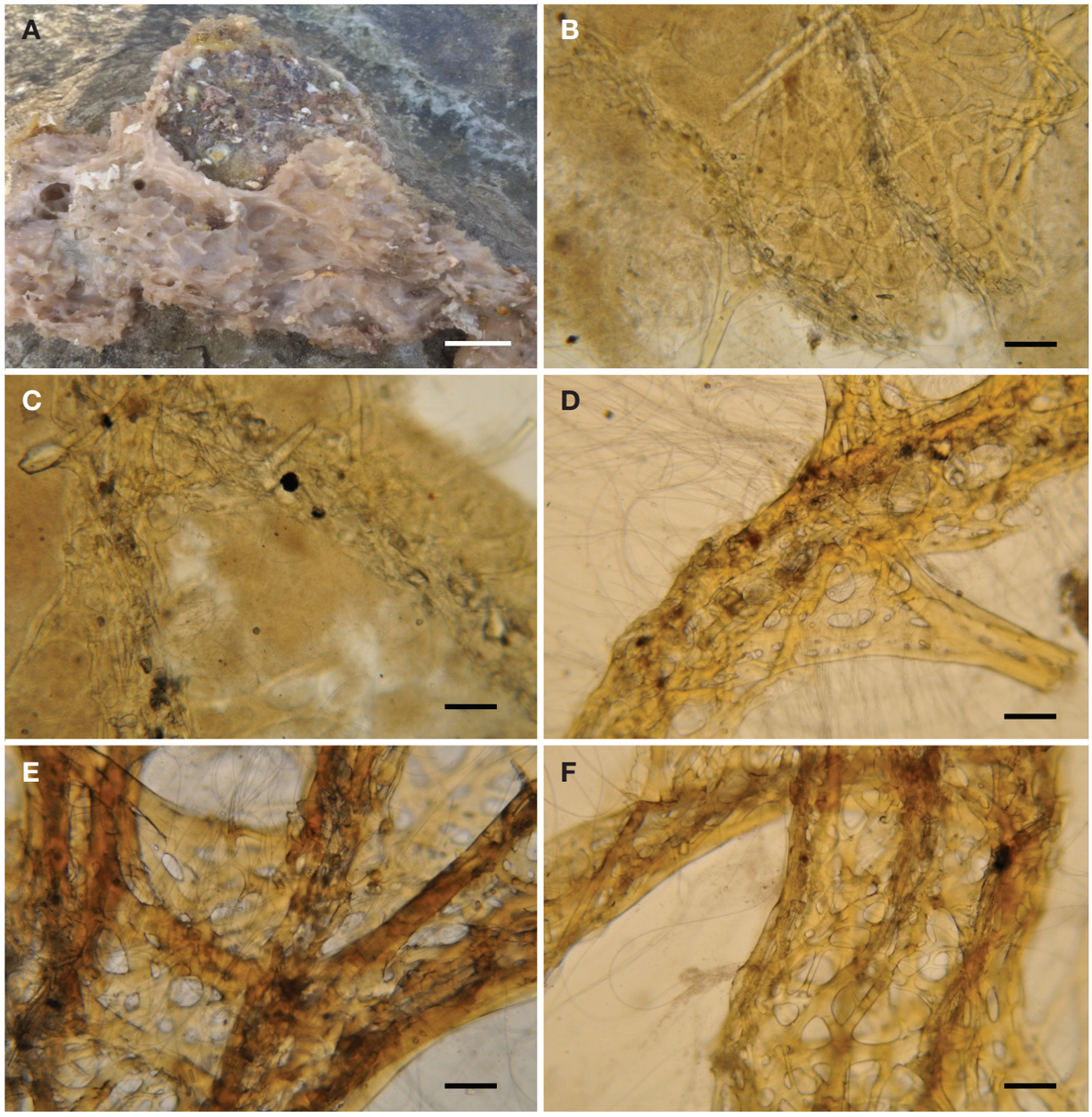

Fig. 1. *Ircinia incrustans* n. sp. A, entire animal; B, surface skeletal structure; C, closed surface skeletal structure; D, cored primary and secondary fibres; E, F, uncored primary and secondary fibres. Scale bars: A = 2 cm, B = 200 μm, C-F = 100 μm.

Munseom, Seogwipo-si, Jeju-do, 15 Aug 2015, Kim BI, by SCUBA, Depth 25 m, deposited in the NIBR.

Description. Thick irregular mass, size up to 8 × 8 × 3.5 cm. Surface, covered with filamentous membrane. Conules round, but sharply branched at side of sponge. Oscules, 3 mm in diameter, opened on top of sponge. Colour in life yellowish brown. Texture soft and compressible.

Skeleton: Primary fibres, 200-400 μm in diameter, cored with very large sands, and have loose fascicles. In two types of secondary fibres, secondary web, 800-1100 μm in diameter, have large perforation, and branch type, 250-400 μm in diameter. Filaments, 5-8 μm in diameter, terminal knobs, 15 μm in diameter.

Etymology. This species is named after the pebble-like large sand cored in primary fibres of this sponge.

Remark. This new species is similar to *Ircinia munsumensis* n. sp. in sponge shape, but differs in skeletal structure.

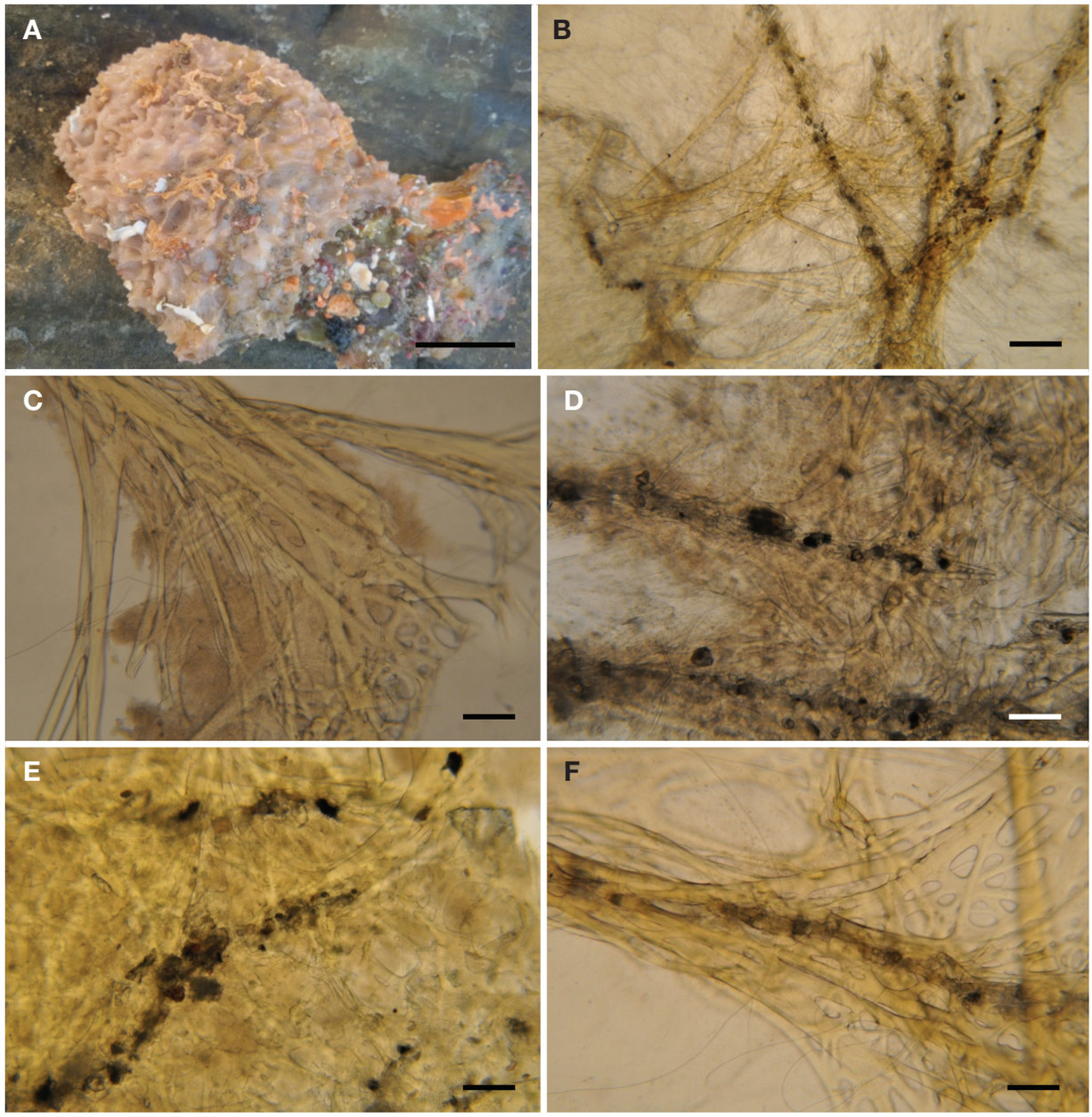

Fig. 2. *Ircinia grobulosa* n. sp. A, entire animal; B, skeletal structure near surface; C, branched secondary fibres; D, cored primary fibres and secondary web; E, F, choanosome skeletal structure. Scale bars: A = 2 cm, B = 200 μm, C-F = 100 μm.

Primary fibres of this new speces are cored with larger sands than *I. munsumensis*'s.

5. *Ircinia bakusi* n. sp. (Fig. 6)

Type specimen. Holotype (NIBRIV0000554224), Korea: Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 17 Aug 2015, Moon SE, by SCUBA, Depth 15 m, deposited in the NIBR.

Description. Round mass, size up to 13 × 9 × 6 cm. Surface, numerous mammilate form with low conules, but sharp conules at side of sponge. Oscules, 2-4 mm in diameter, open on top of mammilate. Colour in life pinkish brown. Texture soft and compressible. Choanosome lacunose.

Skeleton: Primary fibres, 100-150 μm, 250-270 μm in diameter, cored with small sands. In secondary fibres, secondary web, 400-1000 μm in diameter, perforated

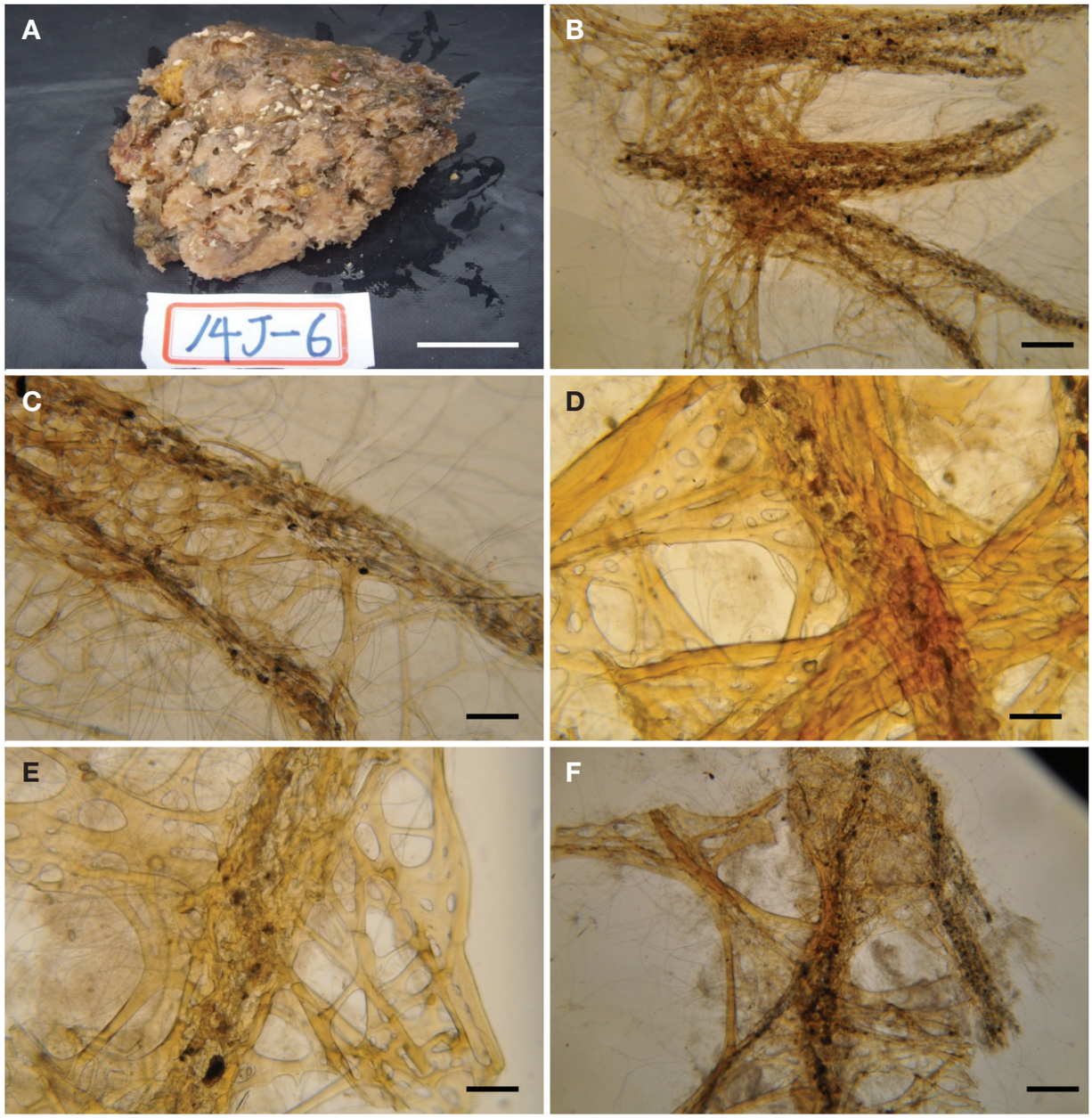

Fig. 3. *Ircinia gapaensis* n. sp. A, entire animal; B, C, skeletal structure in conules; D-F, subdermal skeletal structure. Scale bars: A = 2 cm, B, F = 200 μm, C-E = 100 μm.

with large space, and root-like branch type, 100-300 μm in diameter. Choanosome skeletal structure, more simple than surface's. Filaments, 3-5 μm in diameter, terminal knobs, 10-15 μm in diameter.

Etymology. This species name *bakusi* is named after late Dr. Gerald J. Bakus, who was a professor in the Department of Biological Sciences, University of Southern California, a marine ecologist and a sponge taxonomist.

Remark. This new species is closed to *Ircinia gapaensis* n. sp. in sponge shape, but differs in skeletal structure. This new species have well developed choanosome skeletal structure.

6. *Ircinia munsumensis* n. sp. (Figs. 7, 8)

Type specimen. Holotype (NIBRIV0000554225), Korea:

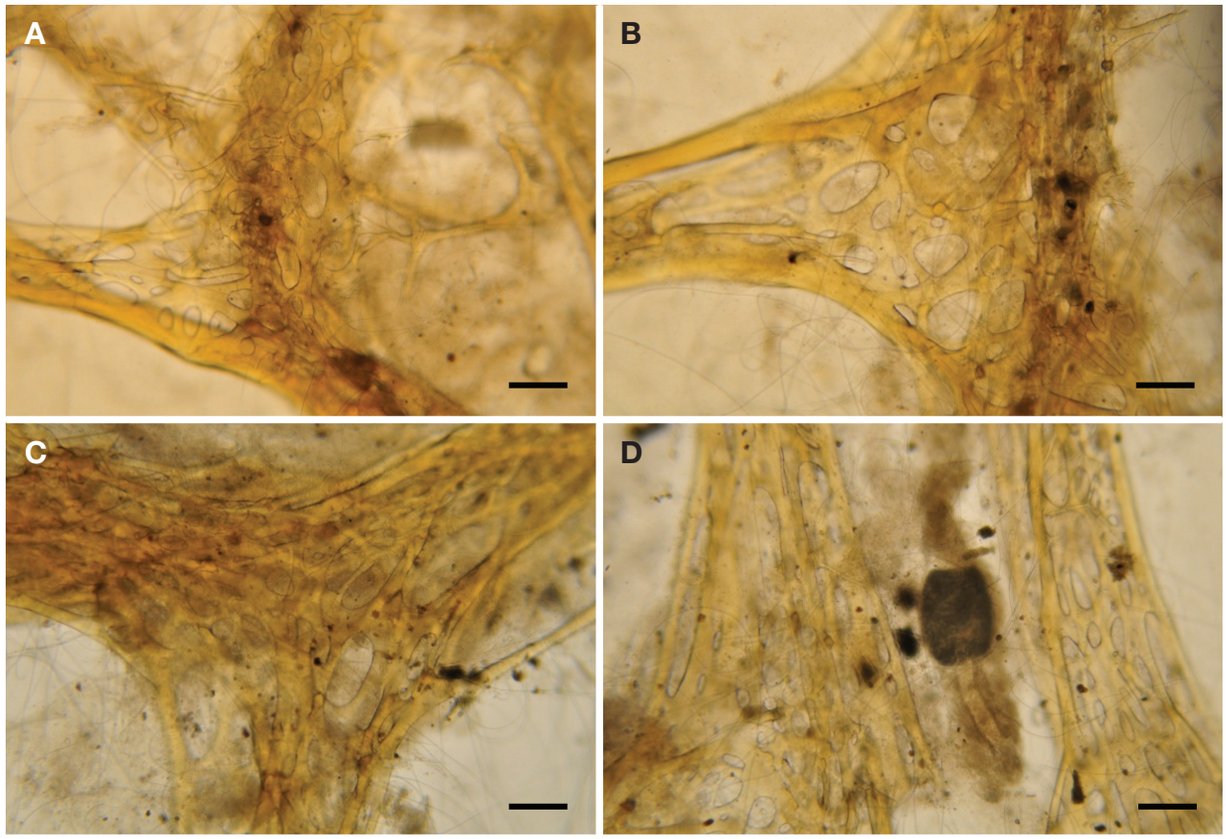

Fig. 4. *Ircinia gapaensis* n. sp. A, B, choanosome skeletal structure; C, D, perforated fibres at the choanosome. Scale bars: A-D = 100 μm.

Munseom, Seogwipo-si, Jeju-do, 15 Aug 2015, Kim BI, by SCUBA, Depth 25 m, deposited in the NIBR.

Description. Thick mass, size up to 7 × 7 × 5 cm. Surface with low round conules covered with thick collagenous membrane. Membrane not easy to separate from sponge body. Large holes located on top of sponge. Several oscules, 1-5 mm in diameter, opened on sponge surface. Colour in life pinkish brown. Texture elastic and compressible. Choanosome are very lacunose.

Skeleton: Primary fibres, 200-400 μm in diameter, cored with sands and broken spicules near surface, but uncored in some part of sponge. Choanosomal primary fibres cored with foreign debris irregularly. Two kinds of secondary fibres appeared near surface, irregularly arranged secondary fibres, 700-1000 μm in diameter, and very simply fasciculate branched secondary fibres, 150-400 μm in diameter. Choanosomal secondary fibres very thick. Filaments, two categories in size, 4 and 8 μm in diameter, terminal knobs, 10-15 μm in diameter.

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

Remark. This new species is similar to *Ircinia lapillus* n. sp. in shape, but differs in skeletal structure. Primary fibres in conules of this new species cored with sands and broken spicules, and choanosomal primary fibres are irregularly cored with foreign debris rarely. Secondary fibres are very thick at the choanosome. Filaments of surface membrane are loosely arranged. Trumpet-like branch type of secondary fibres show big different from root-like shape of other genera. Choanosome are very lacunose.

7. *Ircinia jejuensis* n. sp. (Figs. 9, 10)

Type specimen. Holotype (NIBRIV0000554226), Korea: Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 17 Aug 2015, Moon SE, by SCUBA, Depth 20 m, deposited in the NIBR.

Description. Large round mass, size up to 22 × 16 × 7 cm. Surface with low branched conules covered with filamentous membrane. Oscules, 1-5 mm in diameter, opened at sponge surface. Colour in life dark gray. Texture soft and compressible. Choanosome lacunose.

Skeleton: Primary fibres, 150-300 μm, 650-700 μm in diameter. Primary fibres near surface conules cored with spicules slightly. Primary fibres at base of sponge cored

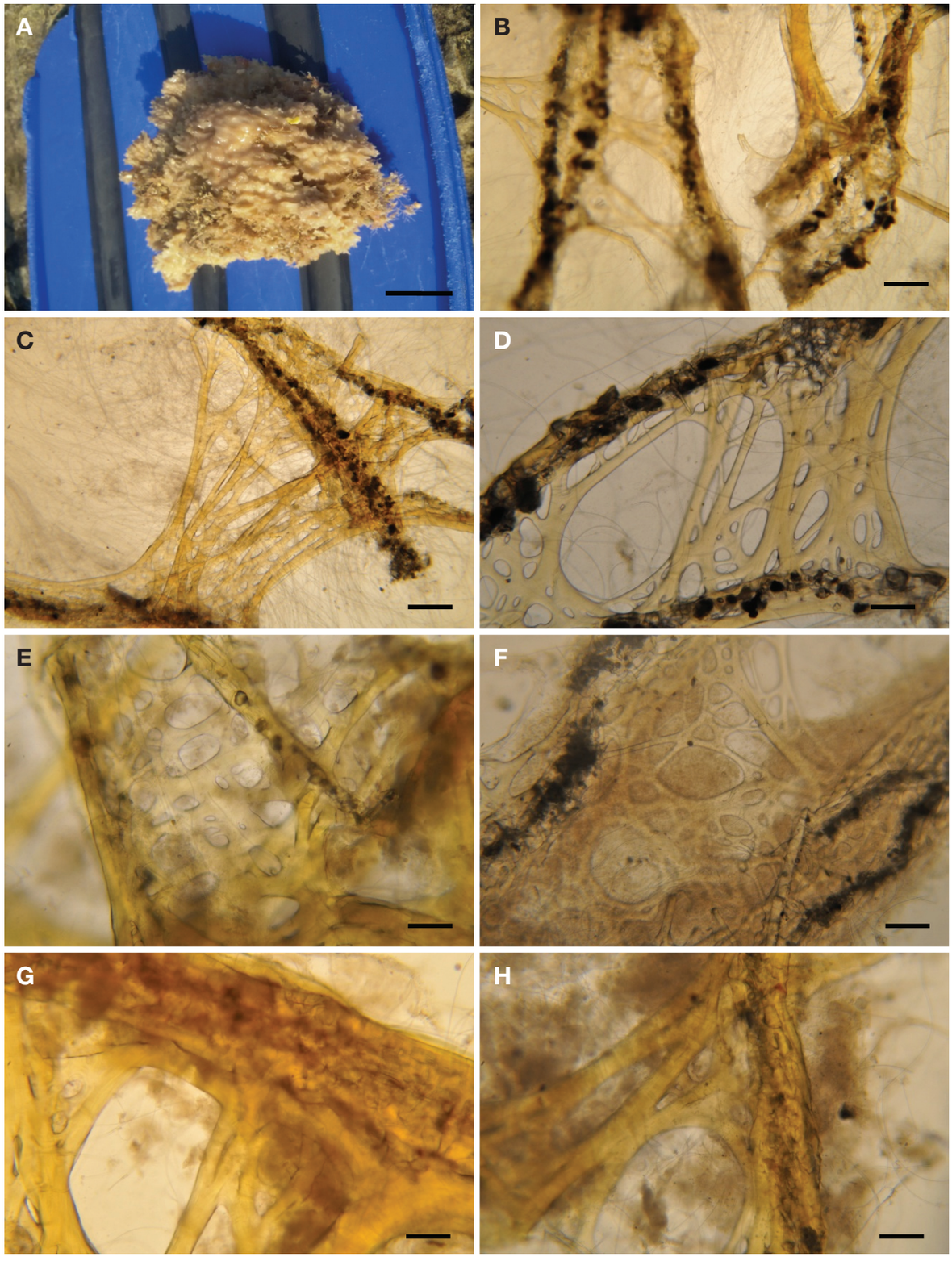

Fig. 5. *Ircinia lapillus* n. sp. A, entire animal; B, C, skeletal structure in conules; D, cored primary and secondary web; E, choanosome skeletal structure; F, skeletal structure near surface; G, choanosome thick skeletal structure; H, choanosome skeletal structure. Scale bars: A = 2 cm, B, C = 200 μm, D-H = 100 μm.

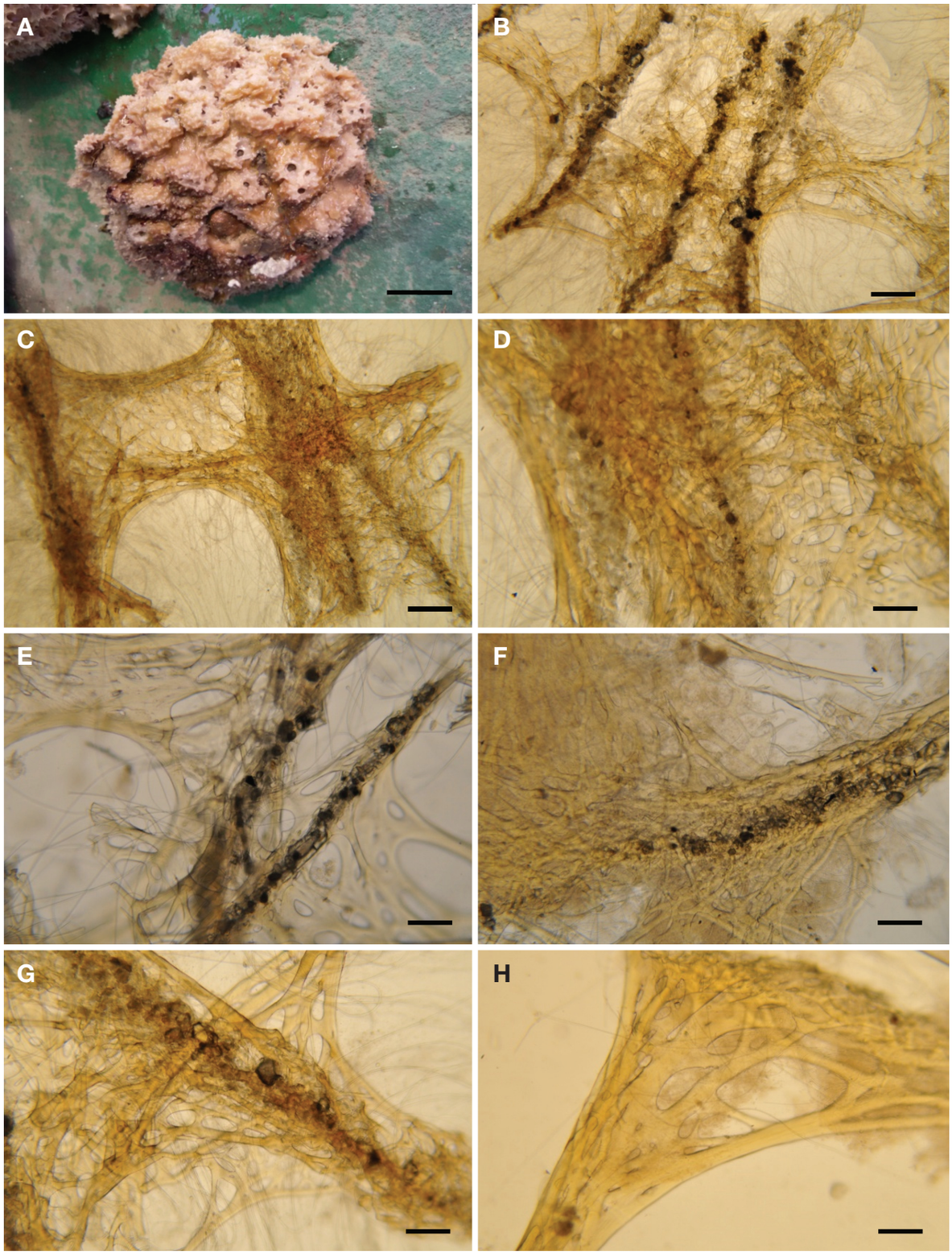

Fig. 6. *Ircinia bakusi* n. sp. A, entire animal; B, skeletal structure in conules; C, subdermal skeletal structure; D, closed skeletal structure; E, cored primary fibres near surface; F, choanosome skeletal structure; G, primary and secondary fibres; H, branched secondary fibres. Scale bars: A = 3 cm, B, C = 200 μm, D-H = 100 μm.

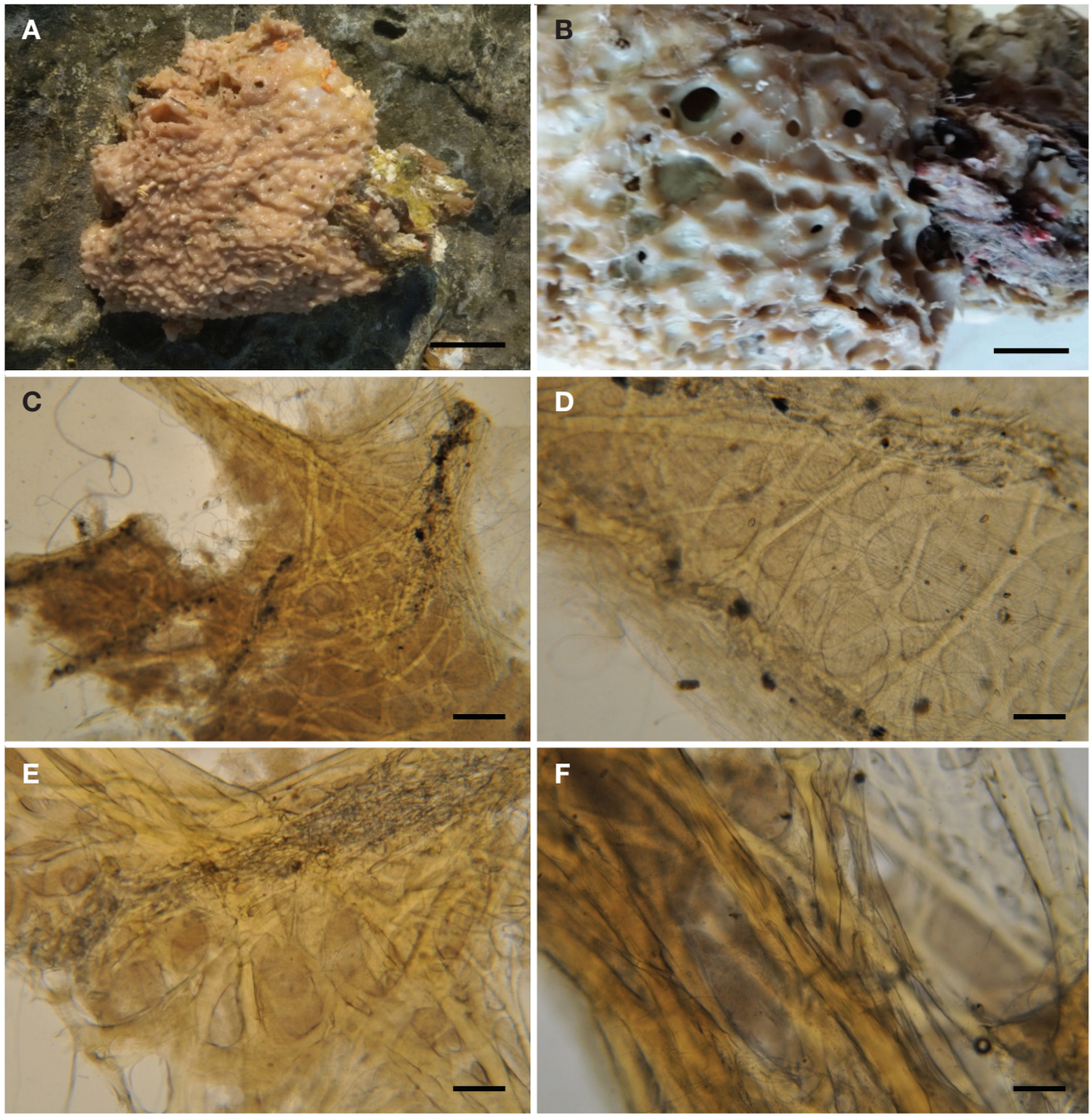

Fig. 7. *Ircinia munsumensis* n. sp. A, entire animal; B, closed surface; C, skeletal structure near surface; D, secondary web between cored primary fibres; E, choanosome skeletal structure; F, choanosome thick secondary fibres. Scale bars: A = 2 cm, B = 10 cm, C = 200 μm, D-F = 100 μm.

with large sands, 150-300 μm in diameter, and small sands, below 50 μm in diameter (Fig. 7I, J). In secondary fibres, net-like secondary web in conules, 650 μm in diameter, loosely arranged, and simple bridged secondary fibres, 250-350 μm in diameter, have root-like extension. Filaments, 3-5 μm in diameter, terminal knobs, 10 μm in diameter.

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

Remark. This new species is distinguished from other *Ircinia* species by primary fibres at base of sponge cored with large and small sands.

8. *Ircinia mureungensis* n. sp. (Fig. 11)

Type specimen. Holotype (NIBRIV0000554227), Korea:

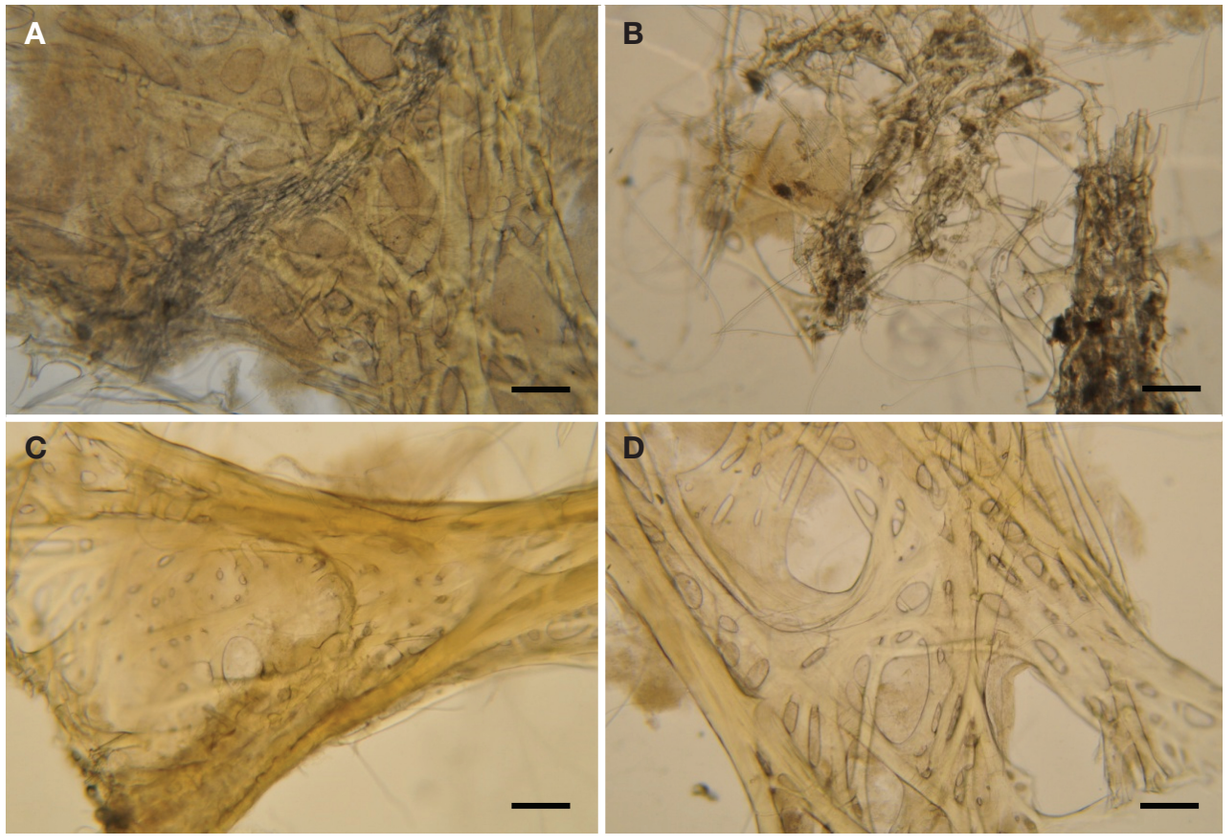

Fig. 8. *Ircinia munsumensis* n. sp. A, choanosome skeletal structure; B, surface membrane with cored primary fibres; C, branched secondary fibres; D, secondary web. Scale bars: A-D = 100 μm.

Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 17 Aug 2015, Moon SE, by SCUBA, Depth 20 m, deposited in the NIBR.

Description. Large irregular mass, size up to 21 × 20 × 8 cm. Surface have very low branched conules, and covered with thin filamentous membrane which mixed with spicules. Oscules, 3-8 mm in diameter, spread all over sponge surface. Colour in life dirty gray. Texture very soft and compressible. Sponge unstable with flexible nature. Choanosome lacunose.

Skeleton: Primary fibres, 150-300 μm in diameter, usually slightly cored. Primary fibres at end of conules, 800 μm in diameter. In secondary fibres, secondary mesh net, 500-1500 μm in diameter, loosely arranged, and simple bridge types rare, 250-350 μm in diameter. Filaments, 5 μm in diameter, terminal knobs, 12-15 μm in diameter.

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

Remark. This new species is easily changed in shape because their texture is very flabby. Primary fibres are slightly cored with foreign material.

9. *Ircinia bergquistia* n. sp. (Fig. 12)

Type specimen. Holotype (NIBRIV0000554228), Korea: Mureungachi, Daejeong-eup, Seogwipo-si, Jeju-do, 26 June 2016, Moon SE, by SCUBA, Depth 15-20 m, deposited in the NIBR.

Description. Sponge irregular thick, encrusting, size up to 8 × 9 × 4 cm. Surface conules covered with filamentous membrane mixed pigments and spicules. Oscules, 4-5 mm in diameter, opened on sponge surface rarely. Colour in life, blackish gray on upper surface, pale brown near base of sponge. Texture soft and compressible.

Skeleton: Fasciculated primary fibres near surface, 700-1100 μm in diameter, very loose and not cored. Branched secondary fibres fasciculate, 300-400 μm in diameter. Filaments, 3-6 μm in diameter, terminal knobs, 10-15 μm in diameter.

Etymology. This species name *bergquistia* is named after late Dr. Particia R. Bergquist, who was a professor School of Biological Sciences, University of Auckland, New Zealand, and reported many Dictyoceratid sponges.

Remark. Primary and secondary fibres of this sponge

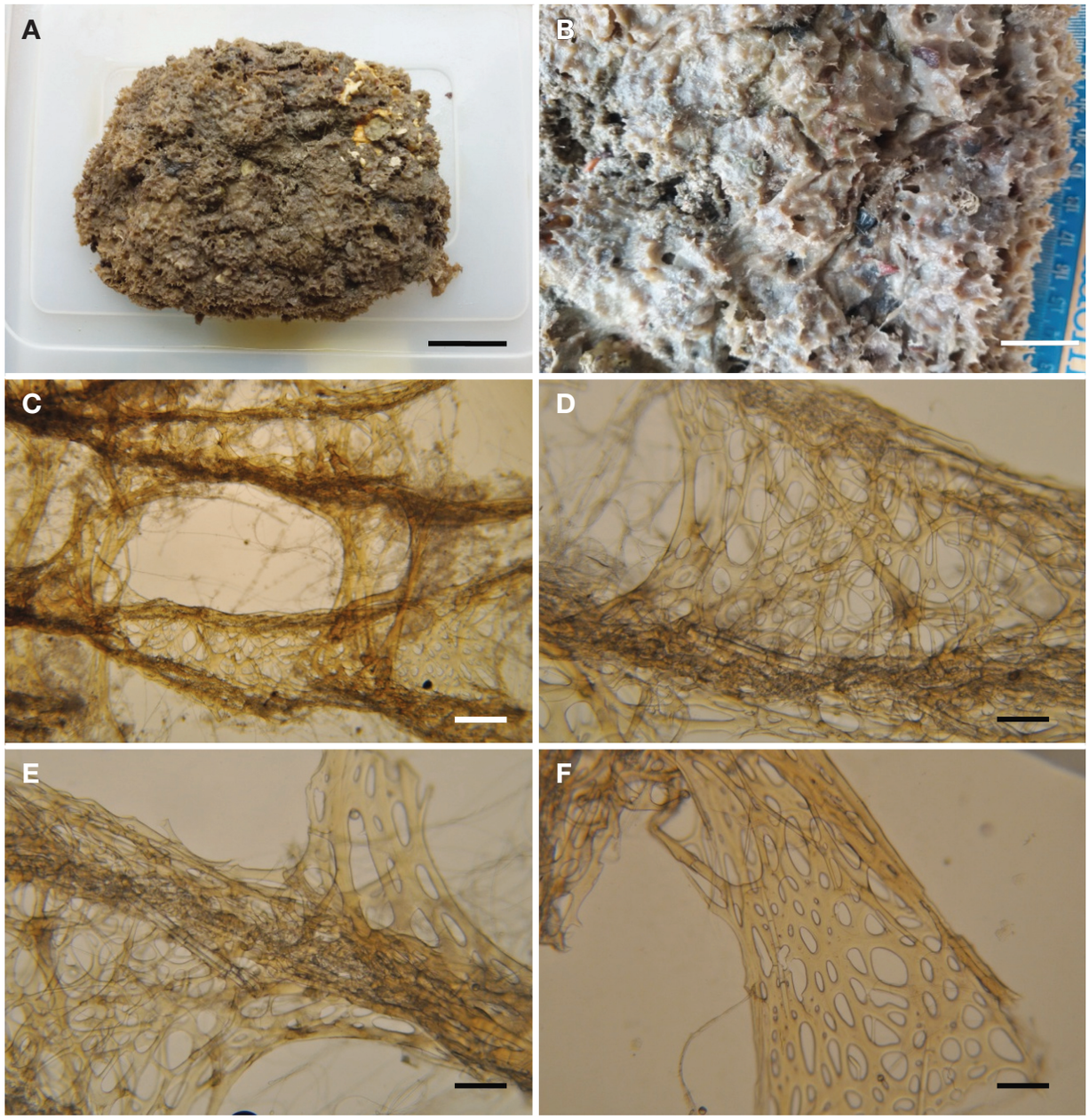

Fig. 9. *Ircinia jejuensis* n. sp. A, entire animal; B, closed surface; C, skeletal structure in conule; D, secondary web between primary fibres cored with spicules; E, uncored primary fibres and secondary fibres; F, perforated secondary fibres. Scale bars: A = 4 cm, B = 12 cm, C = 200 μm, D-F = 100 μm.

are free from foreign debris.

Discussion

Many species of *Ircinia* have been reviewed by several authors (Polejaeff, 1884; Lendenfeld, 1889; de Laubenfels, 1948; Bergquist, 1980; Cook and Bergquist, 1999).

Some of the *Ircinia* species has caused confusion with other genera of family Irciniidae, *Psammocinia* and *Sarcotragus*. Cook and Bergquist (2002) state that it is not easy to ascertain the structural organization of these sponges, because of the irregularly disposed fibre skeleton, or to detect consistent differences in detail which

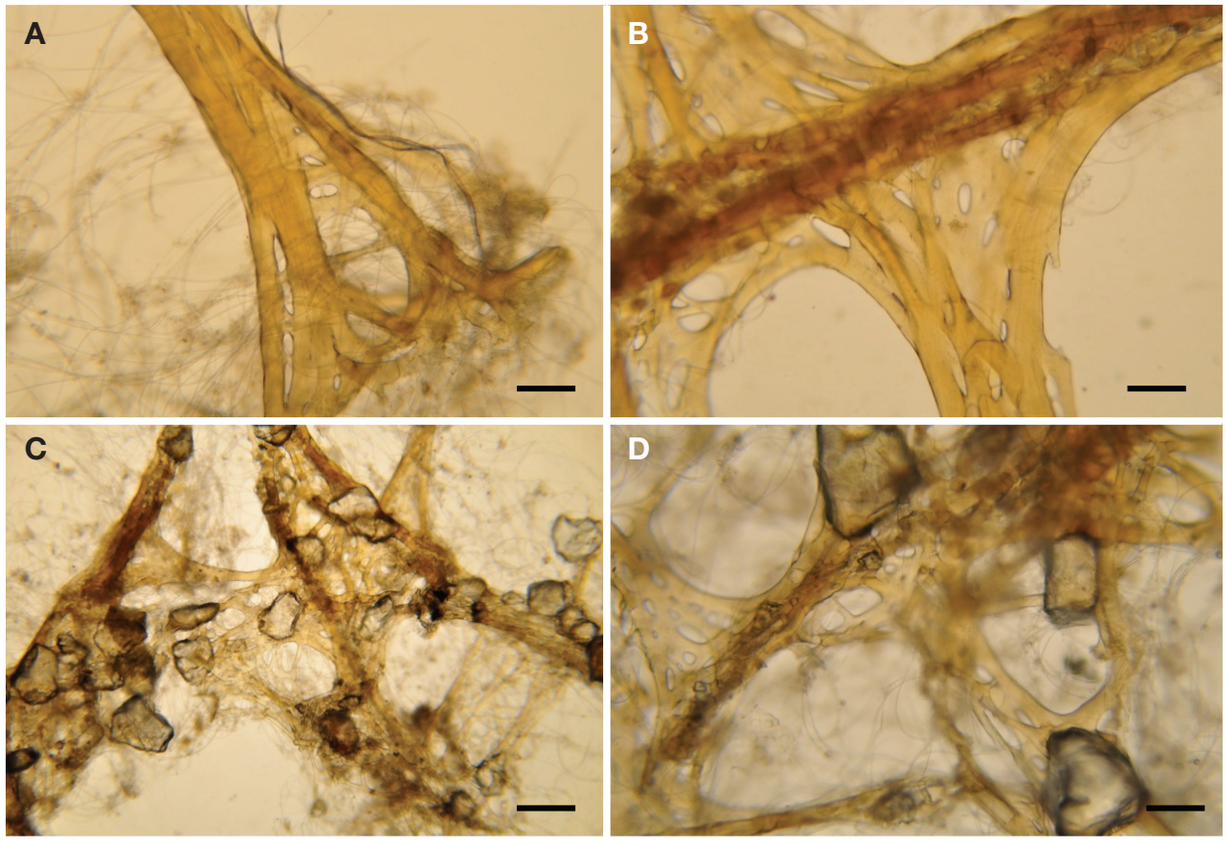

Fig. 10. *Ircinia jejuensis* n. sp. A, basal part of secondary fibre branch; B, skeletal structure of sponge basement; C, D, primary fibres cored with large and small sands at the base of sponge. Scale bars: A-D = 100 μm.

easily distinguish the species and possibly subgeneric and generic groups.

Sandes and Pinheiro (2014) reported two species. There specimens have sands cored in secondary fibres like *Psammocinia*. In the most our new species, primary fibres are cored with foreign debris and secondary fibres are uncored, as Cook and Bergquist's (2002) diagnosis, but one species has very loose skeleton network entirely free from foreign bodies as Lendenfeld's (1889) diagnosis of *Ircinia*. Cook and Bergquist (1999) described new species, *Ircinia turrita*'s primary fibres as follow: Primary fibres form braided or rope-like fascicles with numerous fine branching and are axially to fully cored with foreign inclusions, however, there are sections of primary fibre that are completely clear of debris. In this case, primary fibres are frequently fused slender fibres which lie close together. It looks like situated foreign debris in the joining points of the fibres fascicles. In regards to the thickness of filament, Soest (1978) reported very thick filament, 15-29 μm in diameter, but our species have mostly thin filament, 3-8 μm in diameter. Density of filaments is difficult to define.

As a result, our *Ircinia* specimens show loose fibres network. Primary fibres are cored with foreign debris, and form massive fascicles. Secondary fibres are uncored and it is not easy to distinguish from no cored primary fibres. Our specimens have no sulphurous smell.

In this study, we try to find consistent characteristics from the numerous *Ircinia* specimens. The nine new species described in this paper, are cored with sands in primary fibres, especially at the conules, except one species, *Ircinia bergquistia* n. sp.. In some species, choanosome primary fibres are not cored with foreign debris. This study is focused on surface and subdermal skeletal structure, because their fibres are distributed horizontally and easy to find distinct structure pattern in each species. Choanosome skeletal structure shows very variable according to vertical distribution, and so difficult to comparing with each other. In our all new species, secondary fibres are all free from foreign debris. Mostly all the specimen, choanosome skeletal fibres are thicker than ectosomal fibres. Most of our species show loose skeletal network.

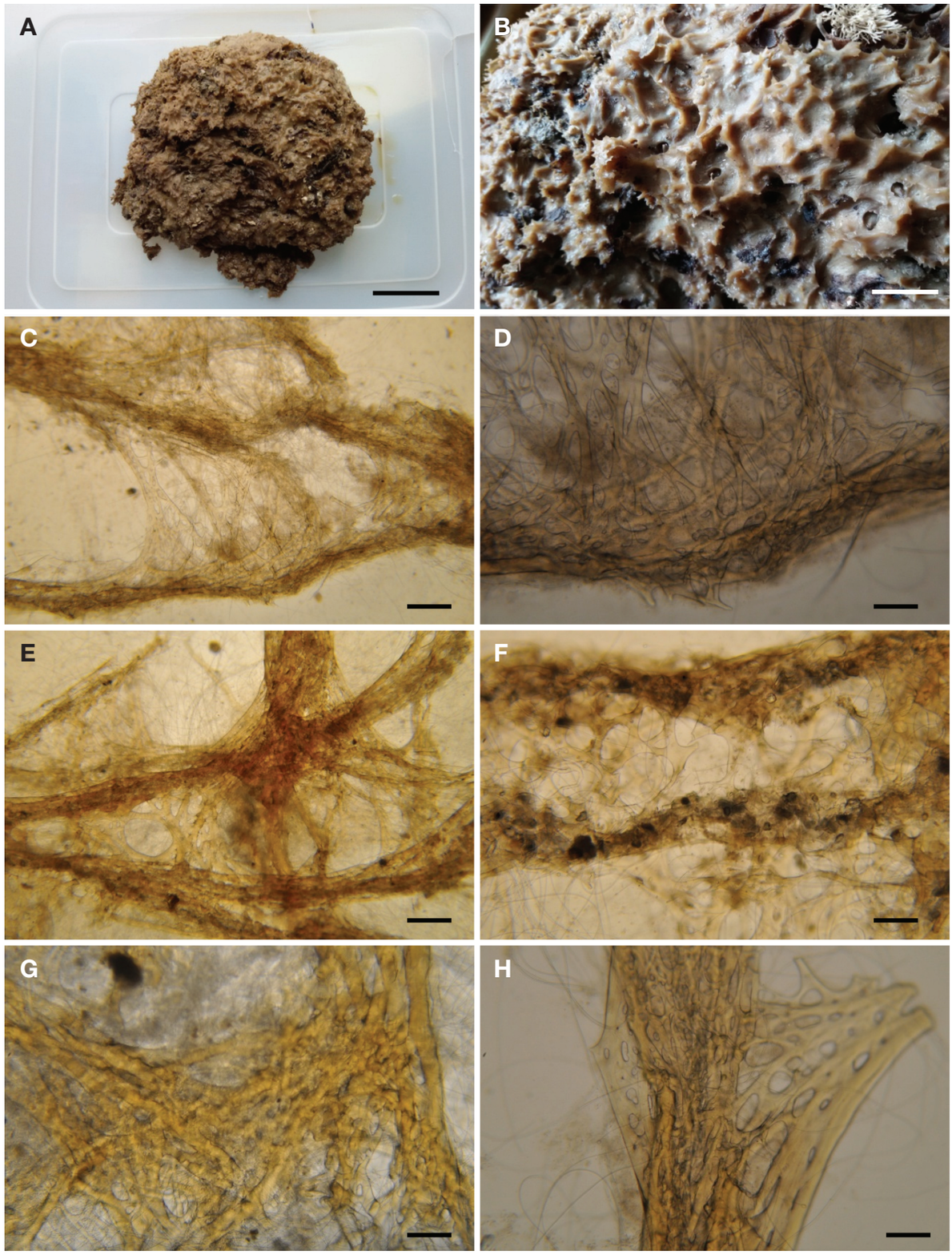

Fig. 11. *Ircinia mureungensis* n. sp. A, entire animal; B, closed surface; C, skeletal structure near surface; D, closed primary fibres and secondary web; E, subdermal skeletal structure; F, secondary fibres between cored primary fibres; G, choanosome skeletal structure; H, branched secondary fibres. Scale bars: A = 6 cm, B = 10 cm, C = 200 μm, D-H = 100 μm.

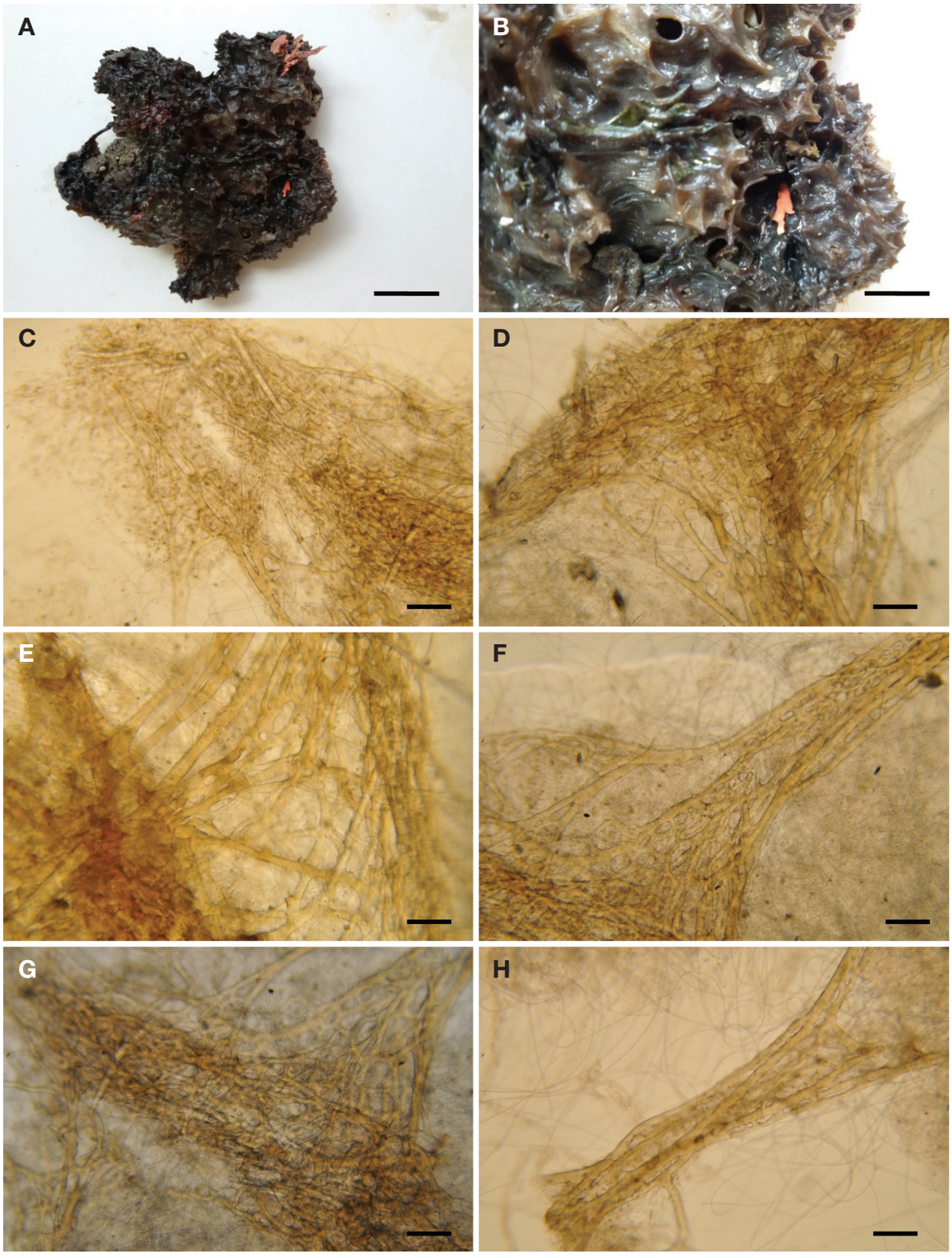

Fig. 12. *Ircinia bergquistia* n. sp. A, entire animal; B, closed surface; C, surface conules and membrane with spicules; D, E, skeletal structure near surface; F, branched secondary fibres; G, primary and secondary fibres; H, branched secondary fibres. Scale bars: A = 2 cm, B = 10 cm, C-H = 100 μm.

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