

New Additions to Lichen Mycota of the Republic of Korea

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Abstract The current study describes seven species that are new to the lichen mycota of South Korea. A taxonomic description of *Arthonia excipienda*, *A. radiata*, *Arthothelium ruanum*, *Enterographa leucolyta*, *Fissurina elaiocarpa*, *Rinodina oleae*, and *Thelotrema porinaceum* was given and supported by distribution, ecology, and illustrations. Each species was compared with a species showing close resemblance.

Keywords Crustose, Lichen, New records, Taxonomy

Recent taxonomic investigations of lichenized fungi from the Republic of Korea [1-9] added several species to the first checklist of lichens reported by Hur *et al.* [10]. In order to update the Korean lichen glossary, a constant approach of collection, identification, and publication of new and interesting records from South Korea is in progress. The current study is part of an ongoing effort to record new lichens in Korea, and seven reports of crustose (crust like appearance) taxa recently collected from the country are described here. The recorded species belong to the genera *Arthonia*, *Arthothelium*, *Enterographa*, *Fissurina*, *Rinodina*, and *Thelotrema*. The cosmopolitan genus *Arthonia* Ach. was placed in the family Arthoniaceae, and comprises c. 500 species. The genus has different life forms: lichenized ascomycetes, non-lichenized ascomycetes, parasites, and parasymbionts. The closely related *Arthothelium* A. Massal., with uncertain affinities to Arthoniaceae, comprises c. 80 species, and differs from *Arthonia* in having muriform ascospores [11, 12]. The Roccellaceae member, *Enterographa*

Fée, was revised by Sparrius and recorded for c. 30 species worldwide, mostly confined to tropical and oceanic areas [13]. The key characteristics of the genus include: \pm homoiomerous thallus, punctiform or rounded to elongate lirelliform, closed or open apothecia with a pink to red-brown or brown disc, *Opegrapha*-type ascus, and fusiform to acicular-fusiform ascospores. *Fissurina* Fée and *Thelotrema* Ach., which are known for c. 100 species, were placed in the Graphidaceae, a widespread family found in the tropics [14]. *Fissurina* is characterized by mostly slit-like lirellae (fissurine), which distinguish it from other lirellate members of Graphidaceae. In addition, the ascospores of the genus are thick-walled and halonate [15, 16]. *Thelotrema*, on the other hand, contains species with mostly lepadinoid apothecia with more or less free excipulum lined internally by periphysoids [14]. The genus *Rinodina* (Ach.) Gray represents c. 200 species found throughout the world and has close affinity with *Buellia*, from which it differs in having a thalline exciple, unpigmented hypothecium, a *Lecanora*-type ascus, and ascospores with \pm unequal thickened wall. Critical investigation is needed in order to determine the distinction between the two [11]. The genera *Arthonia*, *Arthothelium*, and *Enterographa* are newly recorded in Korea, while *Fissurina* and *Rinodina* were already known for *F. insidiosa* C. Knight & Mitt., and *R. membranifera* (Hue) Zahlbr., respectively. The genus *Thelotrema* has recently been described for *T. diplostrema* Nyl., *T. lepademersum* Nagarkar, Sethy & Patw., *T. lepadinum* (Ach.) Ach., *T. similans* Nyl., and *T. subtile* Tuck. [3].

The species of *Arthonia excipienda*, *A. radiata*, *Arthothelium ruanum*, *Enterographa leucolyta*, *Fissurina elaiocarpa*, *Rinodina oleae*, and *Thelotrema porinaceum* have been recorded from the north-east and southern regions of South Korea and are described here as new records for the country.

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MATERIALS AND METHODS

The specimens examined were preserved in the herbarium of the Korean Lichen Research Institute (KoLRI). The species were studied using standard lichen identification techniques. The nomenclatural placement of the samples was ensured after observation of the taxonomical characteristics under SMZ 168 (Motic, Hong Kong, China) dissecting and OLYMPUS BX50 (Nikon, Tokyo, Japan) compound microscopes, for morphological and anatomical details, respectively. The color reaction spot tests were checked after application of the reagents directly on the thallus. The presence or absence of lichen compound was confirmed by thin layer chromatography (TLC) using solvent system A (toluene : dioxane : acetic acid = 180 : 45 : 5) [17]. Different literature sources were consulted for identification of the species [11-21].

RESULTS AND DISCUSSION

Taxonomic description of the species.

Arthonia excipienda (Nyl.) Nyl. (Fig. 1A and 1B)
Lich. Scand. (Uppsala): 261 (1861).

Description: Thallus is corticolous, non-lichenized, but with a few chlorococcoid cells sometimes present in aggregates, immersed often unapparent to scarcely apparent. Apothecia 1~1.5 × 0.1~0.5 mm, scattered often curved or flexuose, occasionally a few branched with a slightly raised margin. Disc is epruinose, exposed, and has a pale brown appearance in old apothecia. Epithecium is pale brown, 5~10 µm. Hymenium is hyaline, clear, gelatinous, 50~80 µm high, I+ blue, with a well-developed, lateral, dark brown (K+ pale green) exciple-like zone 25~40 µm wide. Paraphyses are indistinct. Hypothecium is distinct, hyaline, 15~20 µm high. Ascus is broadly clavate, 8-spored, 40~60 × 10~14 µm, outer coat I+ blue. Ascospores are hyaline, ovoid, slipper shaped, 1-septate, 20~25 × 8~10 µm, I-.

Chemistry: Thallus K-, PD-, C-; no lichen compound detected upon TLC.

Distribution and ecology: The taxon was recorded earlier from Atlantic and Western European countries [11, 18]. It is the first report of the species from Asia. In South Korea, the species was collected from smooth tree trunk at an altitude c. 700 m, where it was found growing along with graphidaceous lichens.

Remarks: *Arthonia excipienda* is distinguished from other species of the genus in having well developed exciple like margins like those of *Graphis* or *Opegrapha*. It shows superficial resemblance to *Arthonia punctiformis* Ach. and *A. radiata*, however, both species have multiseptate ascospores. *Arthonia didyma* Körb. has 2-celled ascospores, but is a distinctly lichenized species, and ascospores become brown and warty upon maturity [11]. The species fulfills all of the diagnostic characteristics recorded for *Arthonia excipienda* so far.

Specimen examined: Donneako Trail, Mt. Halla, Jeju-si, Jeju-do, 646 m, on trunk, 20 June 2012, Hur *et al.*, 121250

(KoLRI).

Arthonia radiata (Pers.) Ach. (Fig. 1C and 1D)

K. Vetensk-Acad. Nya Handl. 29: 131 (1808).

Description: Thallus is corticolous, lichenized, immersed, usually delimited by a brown line, and often mosaic-forming, white, pale grey, sometimes with a brown or olive tinge. Apothecia are aggregated, variably shaped, rounded to substellate, 1~2.5 mm diam. Disc is flat or slightly convex, black, and epruinose. Epithecium is brown or olive-brown, 10~12 µm high, K+ pale green. Hymenium is hyaline, clear, gelatinous, 30~40 µm high, I+ blue. Paraphyses are indistinct to 2 µm wide, with apical brown pigmentation. Hypothecium is pale olive-brown, 10~25 µm high, K+ pale green. Asci are broadly clavate, 8-spored, 30~32 × 14~15 µm, outer coat I+ bluish. Ascospores are hyaline to grey-brown at maturity, oblong-ovoid to oblong, transversely 3~5-septate, 14~15 × 4~5 µm, I-.

Chemistry: Thallus K-, PD-, C-; no lichen compound detected upon TLC.

Distribution and ecology: The species is widespread throughout Europe, North America, Asia, Africa, and New Zealand [11]. It was collected from the southern coastal area of South Korea from smooth tree trunk at an altitude below 10 m.

Remarks: The specimen examined showed good agreement with *Arthonia radiata*, a cosmopolitan species, in all of its morpho-anatomical and chemical characteristics; however, ascospores are multiseptate in appearance (4~6-locular) and can be easily confused with *Arthonia punctiformis*, which has similar taxonomical characteristics but differs in that it is non-lichenized [11]. The Korean material is contradictory to *Arthonia radiata* in having more than 3-septate ascospores, however, slight variation in ascospore septation is acceptable as it is a taxonomically less significant characteristics [19]. Therefore, the material was placed provisionally in *A. radiata*.

Specimen examined: Jickpo coast, Geumoh-do, Dumo-ri, Nam-myeon, Yeosu-si, Jeollanam-do, alt. c. 6 m, on trunk, 26 Apr 2012, Jayalal, Park and Ryu, 120404 (KoLRI).

Arthothelium ruanum (A. Massal.) Körb. (Fig. 1E and 1F)

Parerga Lichenol. (Breslau): 263 (1861).

Description: Thallus is corticolous, lichenized, with *Trentepohlia* as a photobiont, immersed, effuse or delimited by a brown line, brownish-grey, apparently 50~70 µm thick. Apothecia 1~2 mm diam., irregular or bluntly stellate, sometimes punctiform in appearance. Disc is flat to convex, reddish brown to blackish brown, and epruinose. Epithecium is dark red-brown, K+ green, 10~15 µm. Hymenium is hyaline, clear, 40~50 µm high, I+ blue. Paraphyses are distinct, 1~1.5 µm wide, and apically brown pigmented. Hypothecium 10~30 µm high, dark red-brown, K+ dark green. Asci are broadly clavate, 8-spored, 40~50 × 15~20 µm, apically K/I+ blue. Ascospores are hyaline, ovoid-

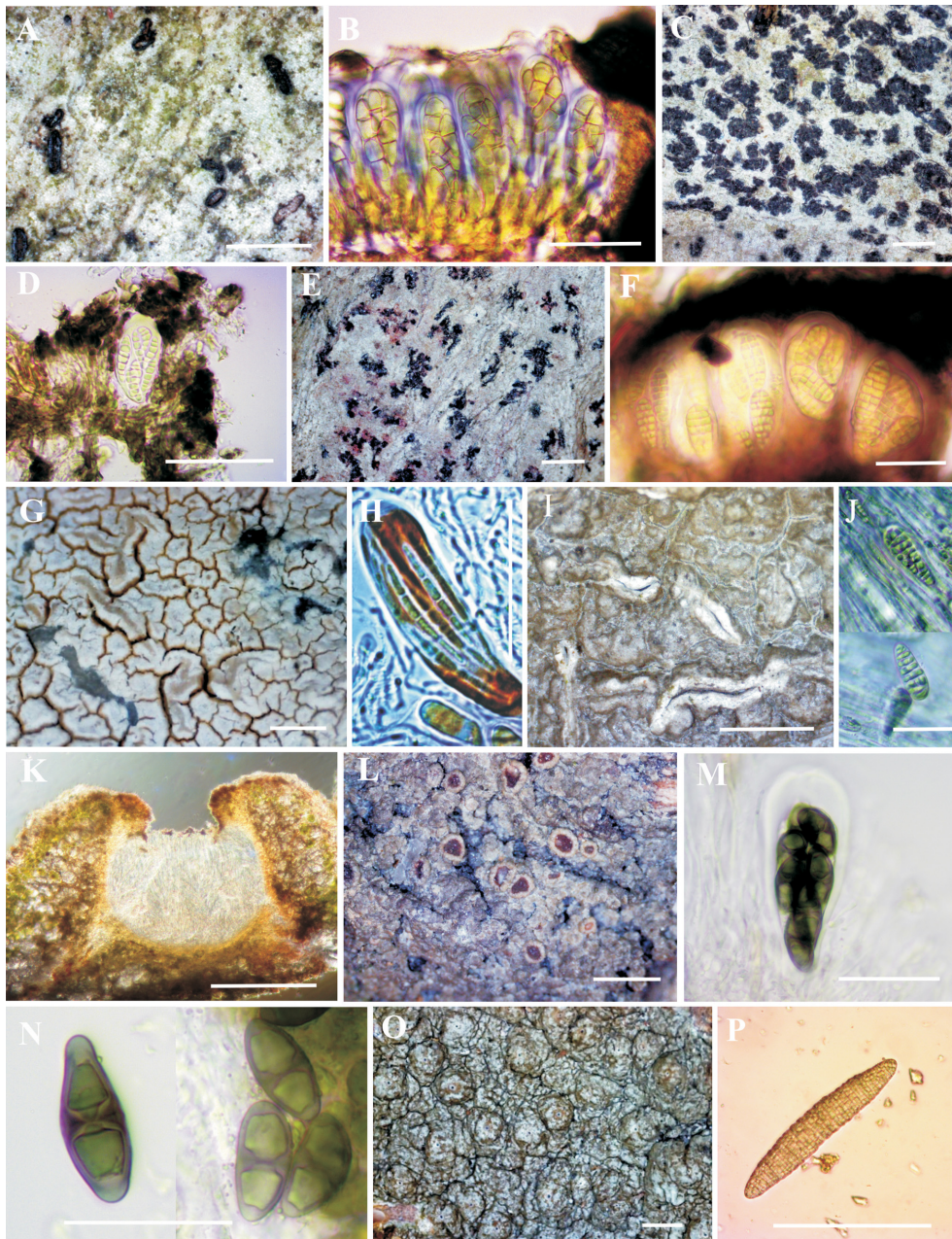


Fig. 1. New records of lichens from South Korea. A, Habitus of *Arthonia excipienda*; B, Vertical section of ascomata showing asci and ascospores of *A. excipienda*; C, Habitus of *Arthonia radiata*; D, Ascus and ascospores of *A. radiata*; E, Habitus of *Arthothelium ruanum*; F, Vertical section of ascomata showing asci and ascospores of *A. ruanum*; G, Habitus of *Enterographa leucolyta*; H, Ascus and ascospores of *E. leucolyta*; I, Habitus of *Fissurina elaiocarpa*; J, Ascospores of *F. elaiocarpa*; K, Vertical section of ascomata of *F. elaiocarpa*; L, Habitus of *Rinodina oleae*; M, Ascus and ascospores of *R. oleae*; N, *Physcia* type ascospores of *R. oleae*; O, Habitus of *Thelotrema porinaceum*; P, Ascospore of *T. porinaceum* (scale bars: A = 1.5 mm, B = 50 μ m, C, E, G, I, L, O = 1 mm, D, H, M = 30 μ m, F, J, N = 20 μ m, K, P = 150 μ m).

oblong, muriform, 6~8 \times 2~5 septate, 17~18 \times 6~8 μ m, I-.
Chemistry: Thallus K-, PD-, C-; no lichen compound detected upon TLC.

Distribution and ecology: *Arthothelium ruanum* has a distribution in Europe, North America, and Asia [11]. The species was collected from the north-east part of South Korea at an altitude of 900~1,000 m, where it was found

growing on the trunk of *Euonymus oxyphyllus*.

Remarks: This species is close to *Arthothelium norvegicum* Coppins & Tønsberg and *A. spectabile* A. Massal. in that it has a lichenized thallus containing *Trentepohlia* as a photobiont, and ascospores with no undivided enlarged upper cell, however, both of the latter species have larger ascospores of c. 25~35 μ m [11]. Although the material

collected from Korea was rather poor in quality and small in amount, based on almost all of its characteristics, it was well fit with those of *A. ruanum*.

Specimen examined: Danggol Manggyeong-sa, Mt. Taebaek, Mungoksodo-dong, Taebaek-si, Gangwon-do, alt. c. 910 m, on trunk, 13 Oct 2005, Lökös, 050709 (KoLRI).

***Enterographa leucolyta* (Nyl.) Redinger (Fig. 1G and 1H)**
Feddes Repert. 43: 58 (1938).

Description: Thallus is saxicolous, epilithic, homoiomerous, water absorbing, continuous, deeply fissured or cracked, whitish, greyish white or pinkish white, up to 200 µm thick; photobiont *Trentepohlia*; medulla distinctly white; prothallus whitish. Apothecia, numerous, immersed, lirellate, scattered to fused, simple or infrequently branched, 1~2.5 × 0.5~0.8 mm. Disc is exposed, brownish to pale brown, epruinose, almost as wide as apothecia. Thalline margin is distinct, 0.2~0.3 µm thick. Proper exciple is hyaline to yellowish, 20~30 µm thick. Epithemium is distinct, brownish, 5~8 µm high, I-. Hymenium is hyaline, clear, 120~130 µm high, I- or I+ reddish. Hypothecium is hyaline, 20~25 µm high, I- or I+ reddish. Paraphyses are branched and anastomose, particularly in apices, up to 1~2 µm thick. Asci are clavate, 8-spored, 60~65 × 10~15 µm, I- or I+ reddish. Ascospores are hyaline, fusiform, straight to slightly curved inside the ascus, with acute ends, transversely 3~4-septate, 25~28 × 2~3 µm, I-, halonate, halo 1~2 µm thick, observed primarily in immature ascospores.

Chemistry: Thallus K-, PD-, C+ red; gyrophoric acid detected upon TLC.

Distribution and ecology: This taxon is pantropical in distribution and grows on surfaces of coastal, volcanic rock [13]. In South Korea, it was collected from shaded, vertical face of volcanic rock at an altitude of c. 10 m.

Remarks: *Enterographa leucolyta* is similar to *E. pallidella* (Nyl.) Redinger in having a C+ pink or red (gyrophoric acid) thallus having *Trentepohlia* as a photobiont and lack of vegetative propagules, however, the latter species has a smooth, continuous surface without cracks or areoles, slightly larger ascospores (>30 µm) with more transverse septation (6~15), and a mostly corticolous habitat [13]. The material examined shows no geographical variation and it shares all of the important taxonomic characteristics so far recorded for *Enterographa leucolyta*.

Specimen examined: Geumoh-do, Yusong-ri, Nam-myeon, Yeosu-si, Jeollanam do, alt. 11 m, on rock, 27 Apr 2012, U. Jayalal, J. S. Park and J. A. Ryu, 120556 (KoLRI).

***Fissurina elaiocarpa* (A. W. Archer) A. W. Archer (Fig. 1I~1K)**

Telopea 11(1): 71 (2005).

Description: Thallus is corticolous, epidermal, and continuous; surface is uneven to verrucose-bullate, yellowish green to olive-brown, 200~300 µm thick. Cortex distinct, 20~35 µm. Algal layer is continuous, photobiont *Trentepohlia*, 50~100 µm. Medulla is white, crystalline, 110~190 µm.

Apothecia are lirellate, dispersed. Lirellae are straight to curved, unbranched to sparsely branched, erumpent to prominent, with a lateral thalline margin, 1~3 × 0.2~0.3 mm. Disc is partially exposed, grey-pruinose. Labia are conspicuous, thick, and white. Thalline margin is paler than the thallus, 0.1~0.3 mm wide. Proper exciple entire, hyaline to apically orange-brown, 50~100 µm wide; laterally covered by a corticate algiferous thallus, including clusters of crystals. Epithemium is greyish, granulate, 10~15 µm high. Hymenium is hyaline, clear, 100~160 µm high. Paraphyses are unbranched, glabrous, 1~2 µm thick. Hypothecium is hyaline, 20~35 µm high. Asci are fusiform, 8-spored, 100~130 × 20~25 µm. Ascospores are hyaline, ellipsoid, muriform with 5~8 × 2~3 septa, 25~30 × 9~10 µm with comparatively thin septa and angular-rounded lumina, I+ slightly blue, halonate, halo up to 6 µm.

Chemistry: Thallus K-, PD-, C-; no compound detected upon TLC.

Distribution and ecology: This species has previously been recorded from Australia, Réunion, and Ecuador [15]. In South Korea, the species was collected from semi-exposed forest of Mt. Halla, where it was found growing on tree bark in association with other *Graphis* species at an altitude of c. 700 m.

Remarks: This species is similar to *Fissurina incrustans* Fée in that it has labiate and gaping lirellae, and muriform ascospores, but differs in having a verrucose thallus, and slightly amyloid to non-amyloid and larger ascospores [15, 20]. The specimens examined were in good agreement with all of the diagnostic characteristics of *Fissurina elaiocarpa*, but have indistinct amyloidity in ascospores. *Fissurina* aff. *elaiocarpa* (A. W. Archer) A. W. Archer [21] is comparable with our sample in having non-amyloid ascospores, however, the lack of formal description of the latter species resulted in placement of Korean material in *F. elaiocarpa*.

Specimen examined: Seongpanak Trail, Mt. Halla, Jeju-si, Jeju-do, alt. 702 m, on bark, 6 Jul 2012, Hur *et al.*, 121527 (KoLRI); Gwanumsa Trail, on bark, 6 Jul 2012, Hur *et al.*, 120971 (KoLRI).

***Rinodina oleae* Bagl. (Fig. 1L~1N)**

Mem. R. Accad. Sci. Torino, Sér. 2 17: 403 (1857).

Description: Thallus is corticolous, epidermal, ± continuous, dark grey to olive-green, 150~200 µm thick. Cortex is well developed, 15~20 µm. Algal layer is continuous, photobiont *Trebouxia*, 70~80 µm. Medulla is distinctly white, up to 90 µm. Prothallus is indistinct to white. Apothecia are numerous, often aggregate, round, sessile, rarely immersed, 0.5~0.6 mm diam. Thalline margin c. 0.06 mm wide, concolorous with thallus, entire, persistent or occasionally occluded. Disc is dark brown-black, flat, becoming convex. Proper exciple is hyaline to brownish, up to 30 µm thick. Hymenium is hyaline, clear, 100~120 µm high, I+ blue. Hypothecium 50~70 µm high. Paraphyses are simple, branched near apices, 1~2 µm thick. Asci are

clavate, 8-spored, 70~80 × 20~22 μm, I+ blue. Ascospores are grey-brown, 2 celled, *Physcia*- and *Dirinaria*-type [11], 14~17 × 9~11 μm, I-.

Chemistry: Thallus K-, PD-, C-; no lichen compound detected upon TLC.

Distribution and ecology: This species is known from the temperate regions of both Northern and Southern Hemisphere [11]. In South Korea, it was found growing on tree bark.

Remarks: *Rinodina oleae* shows similarity to *R. biloculata* (Nyl.) Sheard in lacking thallus compounds but differs in having *Orcularia*-type ascospores [11]. Although *Rinodina oleae* is commonly found growing on rock and man-made substratum, it has also been reported from nutrient rich woody substrata. However, the investigated material, which reported only on tree barks, showed good agreement with the taxonomy of *Rinodina olea*.

Specimen examined: Humanitarian faculty, Sunchon National University, Suncheon-si, Jeonnam do, on bark, 4 Oct 2011, Kondratyuk, 110988 (KoLRI); at the top of Nogodan ridge, Mt. Jiri, Gurae Co., alt. c. 1,450 m, Wang, Ryu and Kondratyuk, 111019 (KoLRI).

***Thelotrema porinaceum* Müll. Arg. (Fig. 10 and 1P)**

Nuovo Giorn. Bot. Ital. 23: 130 (1891).

Description: Thallus is corticolous, epiperidermal, green to olive-green, dull, verrucose, 200~300 μm thick. Cortex is continuous, 20~30 μm. Algal layer is continuous, interspersed with crystals, 100~120 μm. Medulla is white, crystalline, indistinct, mostly endoperidermal. Prothallus is whitish. Ascomata is apothecoid, porinoid with round margins, semi-emergent, 0.5~1 mm, solitary, and dispersed. Pore rounded, 0.04~0.06 mm in diam., lined by a whitish thalline rim. Disc not seen from above, flesh colored. Thalline margin up to 250 μm thick. Proper exciple is hyaline to brownish, cupular, fused to free below, 50~70 μm thick, surrounded by a periderm layer. Epihymenium is indistinct, greyish, and crystalline. Hymenium is hyaline, clear, 300~400 μm high. Paraphyses are lax, simple, unbranched, 1~2 μm thick. Lateral paraphyses are inconspicuously present apically, 20~60 μm. Subhymenium is hyaline, up to 60 μm high. Asci are narrowly clavate, 1-spored, I-. Ascospores are hyaline, muriform, multicelled, oblong to fusiform, with acute ends, 140~180 × 20~30 μm, non-halonate, I+ faintly blue in mature ascospores.

Chemistry: K+ yellow turning red, PD-, C-, KC-; norstictic acid detected upon TLC.

Distribution and ecology: This species has distribution in Australia, Sri Lanka, and Japan [15].

South Korea, it was found growing along with other thelotremoid and graphidioid taxa at the altitudinal range of 900~1000 m.

Remarks: This species can be confused with other *Thelotrema* species containing norstictic acid, such as *Thelotrema eungellaense* Mangold, Elix & Lumbsch, *T. weberi* Hale, and *T. subweberi* Sipman. The latter two

species have apothecoid ascomata and distinctly amyloid ascospores, while ascospores of *T. eungellaense* are slightly smaller [14, 15]. The Korean material examined was rather small in amount but showed good agreement with all of its taxonomic characteristics similar to those of *Thelotrema porinaceum*.

Specimen examined: Seongpanak Trail, Mt. Halla, Jeju-si, Jeju-do, alt. c. 950 m, on tree, 6 Jul 2012, Hur *et al.*, 121447 (KoLRI).

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