

A first modern contribution to *Caloplaca* biodiversity in South Korea: two new species and some new country records

Yogesh JOSHI, Xin Yu WANG, Yoshikazu YAMAMOTO,
Young Jin KOH and Jae-Seoun HUR

Abstract: Eleven species are recognized of which *C. bogilana* and *C. subflavorubescens* are described here as new to science while nine species (*C. cinnabarina*, *C. decipiens*, *C. ferruginea*, *C. inconspicua*, *C. pellodella*, *C. scopularis*, *C. stantoni*, *C. squamosa* and *C. subsoluta*) are reported for the first time for South Korea. Both new species are peculiar due to their secondary chemistry; anthraquinones along with atranorin, gyrophoric acid and lecanoric acid in *C. bogilana*, and gyrophoric acid together with anthraquinones in *C. subflavorubescens*.

Key words: biodiversity, coastal regions, East Asia, gyrophoric acid, lecanoric acid, lichen-forming fungi, *Teloschistaceae*

Introduction

Caloplaca Th. Fr., a cosmopolitan genus occurring mostly in xeric and mesic habitats, includes perhaps more than 1000 species (Kärnefelt 1989; Søchting & Lutzoni 2003; Arup 2006). It comprises a group of lichens with various growth forms (crustose, squamulose, lobate, subfruticose and even endosubstratic), with hyaline polarilocular spores (occasionally plurilocular) and usually with anthraquinone pigments (occasionally also with depsides, depsidones, xanthenes and dibenzofurans) (Santesson 1970; Søchting & Frödén 2002; Elix 2008).

The genus has not been well worked out in South Korea and the literature pertaining to this genus is either scanty or scattered in various floristic accounts (Hue 1913; Zahlbruckner 1930; Sato 1943; Kim 1981; Moon 1999). Hur *et al.* (2005) reported the occurrence of 14 species of *Caloplaca* from South Korea, tentatively including five species of *Blastenia* (*B. atramentaria* (Hue)

Zahlbr., *B. granuligera* (Hue) Zahlbr., *B. hexaspora* (Hue) Zahlbr., *B. injucunda* (Hue) Zahlbr. and *B. multicolor* (Hue) Zahlbr.); these *Blastenia* species have not been studied by any taxonomists until now. Also, no recent contribution to this genus for any region of South Korea exists. Our paper presents descriptions of two new species, along with collection data for nine taxa new to South Korea. Our contribution increases the number of known South Korean *Caloplaca* species to twenty-five. Compared with *Caloplaca* biodiversity known in European territories of similar latitude and area, for example Greece (Abbott 2009), the number of known South Korean *Caloplaca* species is a small fraction of a total *Caloplaca* biodiversity in South Korea. Extensive exploration and further investigations on this genus in the near future will definitely increase its tally.

Materials and Methods

The present study is based on lichen specimens lodged at the herbarium of Lichen & Allied Bioresource Center, Korean Lichen Research Institute (KoLRI), Suncheon National University, Korea, as well as fresh collections from Jeju and Bogil-Do (Do means Island). Morphological characters of the thallus and reproductive structures, colour, size and shape were examined using standard microscopical techniques under a NIKON

Y. Joshi, X. Y. Wang, Y. J. Koh and J. Hur: Korean Lichen Research Institute, Suncheon National University, Suncheon 540-742, Republic of Korea. Email: jshur1@suncheon.ac.kr

Y. Yamamoto: Department of Bioproduction Science, Akita Prefectural University, Akita 010-0195, Japan.

C-PS 1068908 dissecting microscope. Hand-cut sections prepared for studying the anatomy of thalli and fruiting bodies were examined under an OLYMPUS BX 50 compound microscope. All measurements were made on material mounted in water and lactophenol cotton blue (LCB) was used as a stain. For characters such as size of thallus, ascumata and thickness of the hymenium, hypothecium, exciple, ascospores and conidia dimensions, ten measurements were obtained per specimen. Only free ascospores lying outside the asci were measured. The dimensions are generally presented as (smallest value recorded–) mean of smallest recorded – mean of largest recorded (–largest value recorded). K, and C reactions were carried out on hand sections of thalli and apothecia under the microscope. Chemical analyses were made by TLC (White & James 1985; Elix *et al.* 1987) using solvent system C (toluene : acetic acid; 85:15) and HPLC chromatography (Yoshimura *et al.* 1994) using YMC-Pack ODS-A column and eluent solvent of MeOH : H₂O : H₃PO₄ (80:20:1). Terminology for apothecial tissues generally follows Wetmore (1994), while that for thallus follows Nash & Gries (2002).

New Species

Caloplaca bogilana Y. Joshi & Hur sp. nov.

Similis *C. leptozona* sed differt in substantiis secundariis dissimilibus, sporis grandioribus et distributione maritima.

Typus: South Korea, Jeonnam Prov., Wando Co., Bogil Island, 34°09' 14.7" N, 126°37' 33.2" E, alt. 5 m, on rock, 31 December 2004, *Jae-Seoun Hur* 041679 (KoLRI—holotypus; KNH—isotypus).

(Fig. 1A)

Thallus saxicolous, crustose, determinate, usually growing in distinct irregular patches, areolate to cracked areolate, coalescing with other thalli to cover large areas, 2–9 cm diam., (110–)125–135(–150) µm thick, areoles plane to ± subconvex, 0.3–1 mm diam., grey to greyish white, dull, chalky. *Cortex* 22–25 µm high, paraplectenchymatous, made up of thin-walled cells, necral layer absent. *Algal layer* of even and continuous algal cells. *Medulla* macroscopically white, very thin, of compactly arranged hyaline hyphae. *Vegetative diaspores* absent. *Prothallus* present, black, often surrounding the thallus or where the thallus meets another thallus.

Apothecia biatorine to lecanorine, few to numerous, scattered to ± aggregated (1–3),

adnate to sessile, round to ± angular owing to pressure, 0.3–0.6(–1.0) mm diam. *Disc* orange-brown to brownish red to rust-red, plane to convex, epruinose. *Proper margin* smooth, entire, thin, 20–40 µm, flush, persistent to evanescent, black. *Thalline margin* smooth, entire, thin to ± thick, 75–130 (–210) µm, flush, persistent to evanescent, concolorous with the thallus. *Epithymenium* brown, with granular epipsamma, (7.5–) 12.5–15.5(–16.3) µm high. *Hymenium* hyaline, (58.4–)62.5–87.5(–90) µm high. *Hypothecium* hyaline, (50–)75–100(–175) µm high, of isodiametric cells, without oil-droplets; *proper margin* annular, paraplectenchymatous, outer region ± aeruginose pigmented; *thalline margin* with algae. *Paraphyses* thin, simple to furcate at the top, with 1–2(–3) swollen cells at the top. *Asci* 57.5–62.5 × 10–12.5 µm, 8-spored, *ascospores* polarilocular, ellipsoid, (10–)12.5–15(–17) × 5.2–7.5 µm, isthmus (2.8–)3.3–5.8 (–6.2) µm.

Pycnidia present, few to numerous, often 1 per areole, ostiole black. *Conidia* ellipsoid, 2.5–3.7 × 1.7–2 µm.

Chemistry. Spot tests: thallus and medulla K+ yellow, C–, Pd–, UV–. Apothecial discs K+ red, C–, Pd–. Ostiolar tissue and aeruginose region of proper exciple are K–. Secondary metabolites: atranorin, gyrophoric and lecanoric acids are the major compounds, while parietin is in traces.

Etymology. The specific epithet derives its name from the type locality (Bogil Island).

Ecology and distribution. The new taxon is so far known only from the coastal regions of Bogil Island (Fig. 1B) where it grows abundantly on large siliceous boulders (rocks) both on sub-vertical and horizontal faces exposed to the sun along with *Caloplaca cinnabarina* (Ach.) Zahlbr., *C. stantonii* W. A. Elder ex Arup, *Buellia* spp., *Lecanora* spp., *Heterodermia diademata* (Taylor) D.D. Awasthi, *Physcia* spp., *Endocarpon petrolepidium* Ach., *Phylliscum* spp., *Aspicilia* spp., *Karoovia saxeti* (Stizenb.) Hale, *Xanthoparmelia* spp., *Ramalina* spp., *Verrucaria* spp.

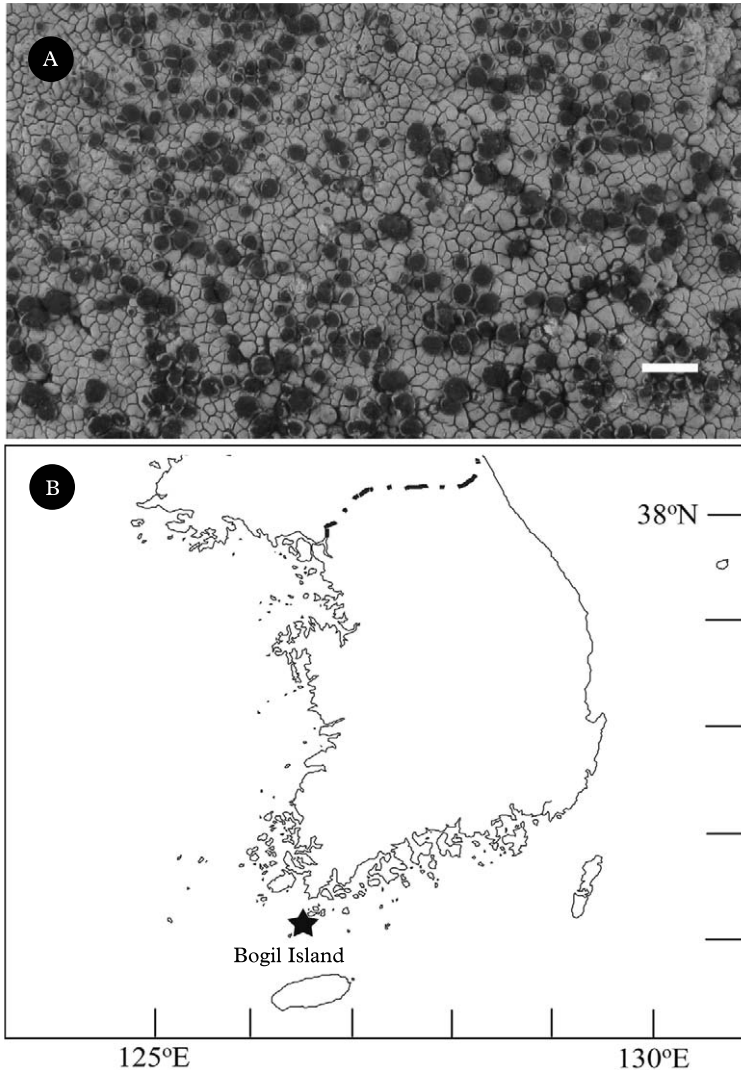


FIG. 1. *Caloplaca bogilana*. A, habitus (holotype in KoLRI); B, distribution in South Korea. Scale: A = 2 mm.

Remarks. *Caloplaca bogilana* is characterized by a cracked areolate to areolate, matt, greyish, K+ yellow thallus surrounded by a black prothallus, a rust-red apothecial disc, a black proper margin, a grey thalline margin and maritime distribution. The new taxon is affiliated to the *Caloplaca sideritis* group (Wetmore 1996) as anthraquinone pigments are present only in the apothecial discs and are absent from the thallus. The new taxon may be confused with *Caloplaca agrata* (Vain.) Zahlbr., *C. leptozona* (Nyl.) Zahlbr.,

C. subleptozona Y. Joshi & Upreti, *C. poliotera* (Nyl.) J. Steiner and *C. subpoliotera* Y. Joshi & Upreti. *Caloplaca agrata* differs in having granules in the thallus cortex and apothecia without thalline margins; *C. leptozona* differs in having smaller spores (10–11 × 4–5.5 μm), paraphyses without swollen tips, different chemistry (lacking gyrophoric and lecanoric acid) and an inland distribution; *C. subleptozona* differs in having cream to yellowish white thallus, biatorine apothecia with yellow pruinose discs and a temperate

distribution; *C. subpoliotera* differs in having rimose-areolate thallus, numerous soredia, biatorine apothecia, smaller spores 6–8 (–11) × (2–)3–5 µm and an inland distribution, while *C. poliotera* differs in having a rimose-areolate thallus, smaller spores (9–12 × 4–6 µm) and an inland distribution.

Additional specimens examined. South Korea: Jeonnam Prov.: Wando Co., Bogil Island, Bogil-myeon, Tong-ri, near Tong-ri beach, 34°09'640" N, 126°35'115" E, alt. 15 m, on rock, 2010, Y. Joshi et al. 100162 (KoLRI); Jung-ri, near Jung-ri beach, 34°09'714" N, 126°35'527" E, alt. 13 m, on rock, 2010, Y. Joshi et al. 100226 (KoLRI); Yesong-ri, near Yesong-ri beach, 34°08'293" N, 126°33'566" E, on rock, 2010, Y. Joshi et al. 100236 (KoLRI).

Caloplaca subflavorubescens Y. Joshi & Hur sp. nov.

Similis *C. flavorubescens* et *C. gordejjevi* sed differt in thallo squamoso vel subfolioso, margine crenato, substantiis secundariis dissimilibus.

Typus: South Korea, Kangwon Prov., Mt. Seokbyung, 37°34'31.0" N, 128°52'02.7" E, alt. 860 m, on bark, 24 May 2008, *Jae-Seoun Hur* 080212 (KoLRI—holotypus; KNH—isotypus).

(Fig. 2A)

Thallus corticolous, subsquamulose to squamulose to subfoliose to ± crustose, covering a large area, up to 7 cm diam., (172–)190–250(–265) µm thick, yellowish green, greenish yellow, greenish grey to grey; upper surface with small lobules, 0.2–0.3(–0.7) × 0.1–0.2(–0.7) mm diam., uplifted at the margins, crowded to ± overlapping. *Cortex* (10–)12.5–15.5(–17) µm high, paraplectenchymatous, made up of thin walled cells, necral layer absent. *Algal layer* of even and continuous algal cells. *Medulla* macroscopically white, of compactly arranged hyaline hyphae, prosoplectenchymatous. *Vegetative diaspores* absent. *Prothallus* rarely present, black.

Apothecia zeorine, numerous, scattered to ± aggregated (1–4), sessile to ± constricted at the base, round to ± angular, 0.3–1(–2.2) mm diam., disc orange-red to orange-brown, plane to subconvex, glossy, *proper margin* smooth, entire, persistent, thin, 30–100(–180) µm, flush, concolorous or

paler than disc, *thalline margin* present, persistent to ± evanescent in later stages, crenate to ± smooth, flush, (80–)100–170(–200) µm, concolorous to disc. *Epihymenium* golden brown, (10.2–)12.5–15(–25.3) µm high; *hymenium* hyaline, (57.7–)65–100(–110) µm high; *hypothecium* hyaline, of indistinct cells, with numerous oil-droplets, (103.8–)120–175(–180) µm high; *proper margin* cupular, prosoplectenchymatous, of compactly interwoven hyphae with narrow lumina; *thalline margin* with algae that covers the proper margin entirely. *Paraphyses* septate, with 1–3 swollen cells at the tip. *Asci* 8-spored, *ascospores* polarilocular, ellipsoid to broadly ellipsoid, (12–)15–17.5(–19) × (5.5–)6–7(–7.5) µm, isthmus 7.5–10 µm.

Pycnidia rare, ostiole orange-red. *Conidia* bacilliform, 2.5–3.7 × 0.7–1.2 µm.

Chemistry. Spot tests: thallus K+ red (in yellowish regions), + yellow (in greyish regions), C–, Pd–, UV–. Apothecial disc and epihymenium K+ red, C+ red, Pd–. Medulla K–, C–, Pd–. Secondary metabolites: parietin, 7-chloroemodin, emodin, fragilin, atranorin, gyrophoric acid and triterpenes between Rf 6–7.

Two chemotypes are reported here for the new species: the most common chemotype (1) comprises 7-chloroemodin, emodin, fragilin, parietin and atranorin; while the rare one (2) contains gyrophoric acid as an additional substance.

Etymology. The specific epithet derives its name from *C. flavorubescens* (Huds.) J. R. Laundon, with which it is most confused in the field.

Ecology and distribution. Currently *C. subflavorubescens* is known from four localities in Kangwon Province. The species is found growing over bark between elevations of 860–1305 m in temperate regions of Mt. Seokbyung, Mt. Galiwang, Mt. Odae and Mt. Gaebang (Fig. 2B).

Remarks. The new taxon can be recognized by its subsquamulose to subfoliose greenish yellow to greenish grey thallus, with very small uplifted lobules, orange-red apothecia,

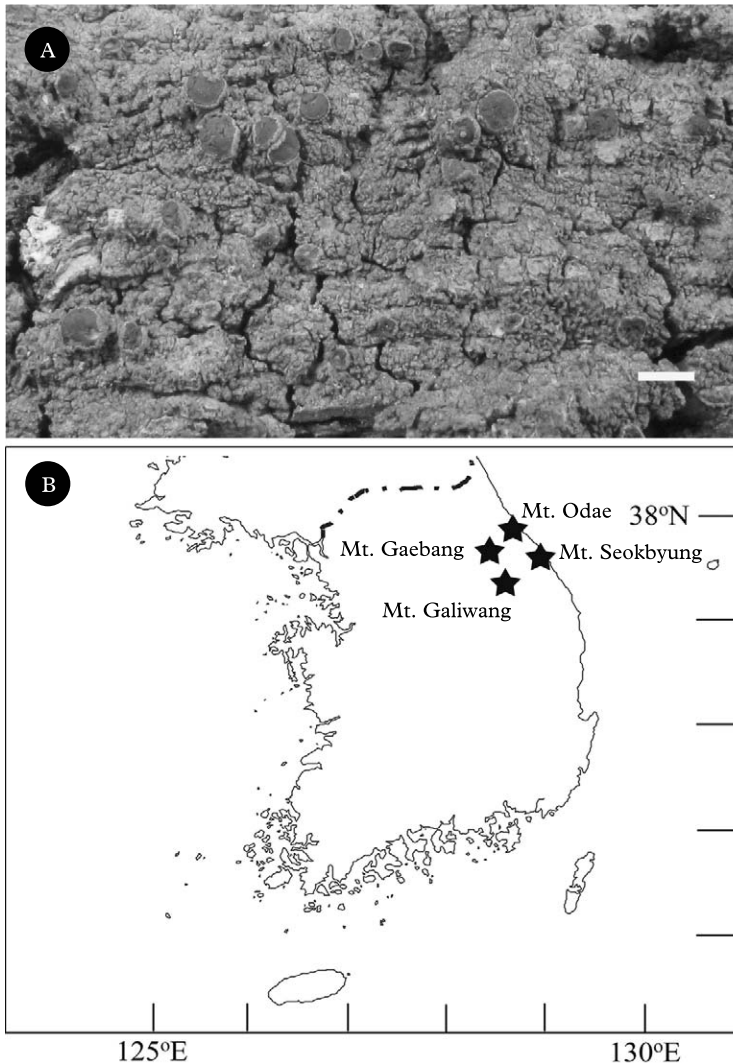


FIG. 2. *Caloplaca flavorubescens*. A, habitus (holotype in KoLRI); B, distribution in South Korea. Scale: A = 2 mm.

crenate thalline margin, bacilliform conidia and corticolous habitat. *Caloplaca flavorubescens* (Huds.) J. R. Laundon and *C. gordejjevi* (Tomin) Oxner ex Khodosovtsev with deep reddish apothecia are difficult to separate from the new taxon, but differ in having no lobules on the thallus surface. Also *C. flavorubescens* and *C. gordejjevi* never have 7-chloroemodin or bacilliform conidia. *Caloplaca himalayana* Y. Joshi & Upreti, another related species known from temperate regions of the Himalaya, is often confused

with this new taxon in thallus colour and \pm similar chemistry (7-chloroemodin) but differs in having a crustose thallus, biatorine ferruginous red apothecia with smooth margins, and in lacking pycnidia and some secondary metabolites (parietin and atranorin). *Caloplaca juniperi* Poelt & Hinterl., another related species having a yellowish thallus and ferruginous coloured apothecial discs, differs from the new taxon in being substratum in specific (only on *Juniperus* bark) and in its distribution in the Himalaya.

Additional specimens examined. South Korea: Kangwon Prov.: Mt. Odae, 37°46'06.7" N, 128°36'10.7" E, alt. 1305 m, on bark, 2008, *Jae-Seoun Hur* 080515 (KoLRI); Mt. Galiwang, 37°27'31.0" N, 128°32'17.9" E, alt. 1098 m, on bark, 2008, *Jae-Seoun Hur* 080082 (KoLRI); Mt. Seokbyung, 37°34'57.3" N, 128°52'27.1" E, alt. 870 m, on bark, 2008, *Jae-Seoun Hur* 080227 (KoLRI).

New Records

C. cinnabarina (Ach.) Zahlbr.

In Engler & Prantl., *Nat. Pflanzenfam.*, Teil. I (Leipzig) 1: 228 (1908).—*Lecanora cinnabarina* Ach., *Lich. univ.*: 402 (1810).

For a description see Wetmore & Kärnefelt (1999).

Specimens examined. South Korea: Gyeongnam Prov.: Namhae-gun, Mt. Geum, 34°46'08.3" N, 127°59'24" E, alt. 171 m, on rock, 2004, *Jae-Seoun Hur* 040022 (KoLRI). Jeonbuk Prov.: Naeso temple, 35°37'02.7" N, 126°35'01.7" E, alt. 260 m, on rock, 2004, *Jae-Seoun Hur* 040167 (KoLRI). Jeonnam Prov.: Geogeu Island, 34°25'20.8" N, 127°08'43.1" E, alt. 10 m, on rock, 2005, *Jae-Seoun Hur* 050208/1 (KoLRI); Wando Co., Bogil-myeon, Bogil Island, Tong-ri, near Tongri beach, 34°09'64" N, 126°35'11.5" E, alt. 15 m, on rock, 2010, Y. *Joshi*, H. S. *Jeon* & M. H. *Jeong* 100166, 100194 (KoLRI); Jeongdong-ri seaside, 34°10'90" N, 126°31'83.6" E, alt. 11 m, on rock, 2010, Y. *Joshi*, H. S. *Jeon* & M. H. *Jeong* 100256, 100257 (KoLRI); Goheung-gun, Jeomam-myeon, Mt. Palyeong, 34°38'23.9" N, 127°25'19.5" E, alt. 85 m, on rock, 2010, Y. *Joshi*, H. S. *Jeon* & G. S. *Han* 100270 (KoLRI).

C. decipiens (Arnold) Blomb. & Forssell

Points Förteckning 4: 69 (1880).—*Physcia decipiens* Arnold, *Flora, Jena* 50: 562 (1867).

For a description see Wetmore & Kärnefelt (1998).

Specimens examined. South Korea: Gyeongbuk Prov.: Bonghwa Co., Mt. Cheongyang, 36°47'21.5" N, 128°54'49" E, alt. 490 m, on rock, 2004, *Jae-Seoun Hur* 040090 (KoLRI); 36°47'06.6" N, 128°55'33.7" E, alt. 825 m, on rock, 2004, *Jae-Seoun Hur* 040116 (KoLRI). Jeonbuk Prov.: Mt. Naejang, 35°29'44.7" N, 126°53'41.3" E, alt. 535 m, on rock, 2005, *Jae-Seoun Hur* 050004 (KoLRI); Gochang Co., Mt. Seonwoon, 35°28'30.4" N, 126°33'42.8" E, alt. 283 m, on rock, 2004, *Jae-Seoun Hur* 040076 (KoLRI); Mt. Juwang, 36°23'58.9" N, 129°09'53.1" E, alt. 310 m, on rock, 2005, *Jae-Seoun Hur* 050622 (KoLRI); Mt. Cheonda, 36°09'14.5" N, 127°36'59.6" E, alt. 214 m, on rock, 2006, *Jae-Seoun Hur* 061160 (KoLRI); 36°09'26.6" N, 127°36'36" E, alt. 356 m, on rock, 2006, *Jae-Seoun Hur* 061176 (KoLRI). Jeonnam Prov.: Goheung Co., Yeongnam-myeon, Ucheon-ri, Yongam village, Yongbawi seaside, 34°35'76.5" N, 127°30'37.5" E, alt. 10 m, on rock, 2010, Y. *Joshi*, H. S. *Jeon* & G. S. *Han* 100317, 100322, 100327 (KoLRI).

C. ferruginea (Huds.) Th. Fr.

Nova Acta R. Soc. Scient. upsal., Ser. 3, 3: 223 (1861) [1860].—*Lichen ferrugineus* Huds., *Fl. Angl.* 2: 444 (1762).

For a description see Magnusson (1944).

Specimen examined. South Korea: Jeju Prov.: Jeju Island, alt. 565 m, 33°25'67.8" N, 126°32'93.8" E, on bark, 2009, *Jae-Seoun Hur* 090049 (KoLRI).

C. inconspicua Arup

Bryologist 98: 102 (1995).

For a description see Arup (1995).

Specimens examined. South Korea: Chungnam Prov.: Anmyon Island, 36°30'13.7" N, 126°20'06.6" E, alt. 5 m, on cliff rock, 2006, *Jae-Seoun Hur* 061238 (KoLRI). Jeju Prov.: Jeju Island, 33°34'00.1" N, 126°45'44.4" E, on dead wood, 2009, *Jae-Seoun Hur* 090033 (KoLRI).

C. pellodella (Nyl.) Hasse

Contrib. U. S. Nation. Herbarium 17: 115 (1913).—*Lecanora pelodella* Nyl., *Lich. South California*, edit. 2: 10 (1898).

For a description see Wetmore (1996).

Specimens examined. South Korea: Jeju Prov.: Jeju Island, 33°22'20.5" N, 126°52'42.4" E, alt. 1 m, on rock, 2006, *Jae-Seoun Hur* 061009 (KoLRI); 33°34'00.1" N, 126°45'44.4" E, on rock, 2009, *Jae-Seoun Hur* 090019 (KoLRI).

C. scopularis (Nyl.) Lettau

Hedwigia 52: 242 (1912).—*Lecanora scopularis* Nyl., *Flora, Jena* 56: 195 (1883).

For a description see Arup (1994).

Specimens examined. South Korea: Jeonnam Prov.: Wando Co., Bogil Island, Jung-ri, near Jung-ri beach, 34°09'714" N, 126°35'527" E, alt. 13 m, on rock,

2010, Y. Joshi & party 100204, 100221, 100223 (KoLRI).

C. squamosa (B. de Lesd.) Zahlbr.

Cat. Lich. Univers. **10**: 629 (1940).—*Placodium squamosum* B. de Lesd., *Annal. Cryptog. Exot.* **6**: 123 (1933).

For a description see Wetmore (2003).

Specimen examined. **South Korea:** Jeju Prov.: Jeju Island, 33°34'00.1" N, 126°45'44.4" E, on rock, 2009, *Jae-Seoun Hur* 090020 (KoLRI).

C. stantonii W. A. Weber ex Arup

Bryologist. **95**: 454 (1992).

For a description see Arup (1992).

Specimen examined. **South Korea:** Jeju Prov.: Jeju Island, 33°30'26.2" N, 126°54'30.6" E, on rock, 2004, *Jae-Seoun Hur* 040900, 040903 (KoLRI); 33°27'42.3" N, 126°55'22.5" E, on rock, 2004, *Jae-Seoun Hur* 040909 (KoLRI); 33°33'26" N, 126°43'56.9" E, on rock, 2004, *Jae-Seoun Hur* 040881 (KoLRI). *Gyeongbuk Prov.:* Ulleung Co., Ulleung Island, 37°31'53.8" N, 130°51'55.9" E, alt. 11 m, on rock, 2005, *Jae-Seoun Hur* 050318 (KoLRI). *Jeonnam Prov.:* Wando Co., Bogil Island, 34°08'08.9" N, 126°30'23.5" E, alt. 5 m, on rock, 2004, *Jae-Seoun Hur* 041647, 041650 (KoLRI); Yeosu city, Geomun Island, 34°00'39.4" N, 127°19'81.6" E, alt. 14 m, on rock, 2007, *Jae-Seoun Hur* 070080 (KoLRI).

C. subsoluta (Nyl.) Zahlbr.

Cat. Lich. Univers. **7**: 185 (1931).—*Lecanora murorum** *subsoluta* Nyl., *Flora* **56**: 197 (1873).

For a description see Wetmore (2003).

Specimens examined. **South Korea:** Jeju Prov.: Jeju Island, 33°22'20.5" N, 126°52'42.4" E, alt. 1 m, on rock, 2006, *Jae-Seoun Hur* 061009 (KoLRI); 33°34'00.1" N, 126°45'44.4" E, on rock, 2009, *Jae-Seoun Hur* 090019, 090022 (KoLRI).

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