

The Lichen Genus *Parmotrema* in South Korea

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Abstract *Parmotrema* A. Massal. is a common lichen genus scattered throughout the Korean Peninsula; however, no detailed taxonomic or revisionary study of this genus has been conducted for nearly two decades. Therefore, this study revised the taxonomy of this genus based on specimens deposited in the lichen herbarium at the Korean Lichen Research Institute and samples were identified using recent literature. In this revisionary study, a total of eighteen species of *Parmotrema* including eight new records [*Parmotrema cetratum* (Ach.) Hale, *Parmotrema cristiferum* (Taylor) Hale, *Parmotrema grayanum* (Hue) Hale, *Parmotrema defectum* (Hale) Hale, *Parmotrema dilatatum* (Vain.) Hale, *Parmotrema margaritatum* (Hue) Hale, *Parmotrema pseudocrinitum* (Abbayes) Hale, and *Parmotrema subsumptum* (Nyl.) Hale] are documented. Detailed descriptions of each species with their morphological, anatomical and chemical characteristics are also given and a key to the known *Parmotrema* species of the Korean Peninsula is presented.

Keywords Key, New record, Parmeliaceae, *Parmotrema*, South Korea

Parmotrema A. Massal. (previously known as *Parmelia* s. lat.) is one of the largest genera of parmelioid core in the family Parmeliaceae [1]. According to Bayesian analysis of nuclear internal transcribed spacer (ITS), large-subunit rDNA and mitochondrial small subunit (SSU) rDNA sequences carried out by Blanco *et al.* [1], the parmotremoid genera *Rimelia*, *Canomaculina*, and *Concamerella* are synonymized with *Parmotrema*. These findings were further confirmed by morphological analysis of the same groups by Louwhoff and Crisp [2]. Molecular phylogenetic analyses carried out by Divakar *et al.* [3] revealed that *P. reticulatum* and *P. clavuliferum* formed a monophyletic clade based on nuclear ITS rDNA and mitochondrial SSU rDNA sequences. Thus, *P. reticulatum* and *P. clavuliferum* were combined under the older name, *P. reticulatum*.

The genus *Parmotrema* is usually characterized by large foliose thalli with broad lobes, commonly with a

broad erhizinate marginal zone on the lower surface, pored epicortex, thick-walled hyaline ellipsoid ascospores, sublageniform or filiform conidia and with or without marginal cilia. The greatest distribution of the genus is in tropical regions, where more than 220 species are known [4]. Currently, this genus is composed of c. 350 species worldwide [1, 5, 6]. To date, only 12 species have been reported from South Korea: *Parmotrema arnoldii* (Du Rietz) Hale 1974, *Parmotrema austrosinense* (Zahlbr.) Hale 1974, *Parmotrema clavuliferum* (Räsänen) Streimann 1986 [previously known as *Rimelia clavulifera* (Räsänen) Kurok. 1991], *Parmotrema crinitum* (Ach.) M. Choisy 1974, *Parmotrema eciliatum* (Nyl.) Hale 1974, *Parmotrema mellissii* (C. W. Dodge) Hale 1974, *Parmotrema perlatum* (Huds.) M. Choisy 1952 (previously known as *Parmotrema chinense* sensu auct.), *Parmotrema praesorediosum* (Nyl.) Hale 1974, *Parmotrema reticulatum* (Taylor) M. Choisy 1952 [previously known as *Rimelia reticulata* (Taylor) Hale & A. Fletcher, 1990], *Parmotrema subtinctorium* (Zahlbr.) Hale 1974 [previously known as *Canomaculina subtinctoria* (Zahlbr.) Elix 1997], *Parmotrema tinctorum* (Despr. ex Nyl.) Hale 1974 and *Parmotrema ultralucens* (Krog) Hale 1974 [7].

The current study resulted eight species, *Parmotrema cetratum* (Ach.) Hale 1974, *Parmotrema grayanum* (Hue) Hale 1974, *Parmotrema defectum* (Hale) Hale 1974, *Parmotrema dilatatum* (Vain.) Hale 1974, *Parmotrema margaritatum* (Hue) Hale 1974, *Parmotrema pseudocrinitum* (Abbayes) Hale 1974, and *Parmotrema subsumptum* (Nyl.) Hale 1977 as new records from South Korea. Further, *Parmotrema cristiferum* (Taylor) Hale 1974, which was identified incorrectly as *Parmotrema ultralucens* (Krog) Hale 1974 [8], also is added as a new record. Thus, a total of 18 species of

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Parmotrema are reported from South Korea. The first world monograph of *Parmotrema* was published under the name *Parmelia* subgenus *Amphigymnia* by Hale in 1965 [9]. Later, monographic studies of the genus *Parmotrema* were carried out by Krog and Swinscow [10], Elix [11, 12], and Divakar and Upreti [13].

MATERIALS AND METHODS

The study was based on specimens deposited in Korean Lichen Research Institute (KoLRI). The lichen samples were identified using stereo and light microscopes. Specifically, a dissecting microscope (SMZ645; Nikon, Tokyo, Japan) was used to identify morphological characteristics of the thallus and the reproductive structures, while a compound microscope (Zeiss Scope. A1; Carl Zeiss, Jena, Germany) was used to study the anatomy of thalli and fruiting bodies. Spot test reactions were carried out on thalli under the compound microscope. Thin layer chromatography (TLC) was performed in solvent system A (toluene:dioxin:acetic acid = 180:45:5) [14]. All examined localities of specimens were mapped using the open source GIS software Quantum GIS 1.7.0 (QGIS). Voucher specimens have been deposited in the herbarium of the Lichen and Allied Bio-resource Center at the KoLRI, Suncheon National University, South Korea. In the identification key, the newly reported species are indicated in bold.

Key to the South Korean species of *Parmotrema*

- | | | | |
|--|---------------------------------|--|-------------------------------|
| 1. Thallus lacking isidia and soredia | 2 | 8a. Lobe margins eciliate | 14 |
| 1a. Thallus isidiate or sorediate | 3 | 9. Medulla K+ red, salazinic acid present | 10 |
| 2. Thallus eciliate, stictic acid present | <i>P. eciliatum</i> | 9a. Medulla K+ (yellow/orange) or K- | 12 |
| 2a. Thallus ciliate, salazinic acid present | <i>P. cetratum</i> | 10. Upper surface faintly maculate, lobes dimorphic, secondary lobes arising from margins in the center of the thallus | <i>P. margaritatum</i> |
| 3. Thallus isidiate | 4 | 10a. Upper surface highly maculate, dimorphic lobes absent | 11 |
| 3a. Thallus sorediate | 8 | 11. Maculae forming an intricate reticulate network and fissuring into fine cracks | <i>P. reticulatum</i> |
| 4. Lobe margins ciliate | 5 | 11a. Maculae not forming reticulate cracks, effigurate | <i>P. subsumptum</i> |
| 4a. Lobe margins eciliate, isidia cylindrical, medulla C+ red, lecanoric acid present | <i>P. tinctorum</i> | 12. Medulla P+ orange or red | 13 |
| 5. Isidia ciliate | 6 | 12a. Medulla P-, saxicolous | <i>P. grayanum</i> |
| 5a. Isidia eciliate or very rarely ciliate | 7 | 13. Stictic acid present | <i>P. perlatum</i> |
| 6. Isidia coralloid branched and sorediate, medulla K-, C-, alectoronic acid present | <i>P. mellissii</i> | 13a. Alectoronic acid present | <i>P. arnoldii</i> |
| 6a. Isidia cylindrical, simple and not sorediate, medulla K+ yellow, P+ orange red, stictic acid present | <i>P. crinitum</i> | 14. Medulla K+ red, salazinic acid present | <i>P. cristiferum</i> |
| 7. Medulla C+ rose red, gyrophoric acid present | <i>P. pseudocrinitum</i> | 14a. Medulla K- | 15 |
| 7a. Medulla C-, salazinic acid present | <i>P. subtinctorium</i> | 15. Medulla P+ red, protocetraric acid present | <i>P. dilatatum</i> |
| 8. Lobe margins ciliate | 9 | 15a. Madulla P- | 16 |
| | | 16. Medulla C+ red, KC+ red, lecanoric acid present | 17 |
| | | 16a. Medulla C-, KC- | <i>P. praesorediosum</i> |
| | | 17. Thallus rugose, lobes 6~12 mm wide, margins crenate, linear soralia < 1 cm long | <i>P. defectum</i> |
| | | 17a. Thallus more or less smooth, lobes 6~20 mm wide, margins ascending imbricate, linear soralia > 1 cm long | <i>P. austrosinense</i> |

Species descriptions.

Parmotrema austrosinense (Zahlbr.) Hale, *Phytologia* 28: 335 (1974).

Parmelia austrosinensis Zahlbr., in Handel-Mazzetti, *Symb. Sinic.* 3: 180 (1930).

Thallus foliose, 6~10 cm broad, loosely attached to the substratum. Lobes rotund, 5~15 mm wide; margins ascending imbricate, sinuous, entire, eciliate. Upper surface slightly maculate, ash grey to grey green, shine, smooth and older parts reticulately cracked, without isidia, sorediate. Soralia marginal, submarginal, linear, very wavy and continuous for a few centimeters in length. Soredia farinose to granular. Medulla white. Lower surface finely reticulately wrinkled, black with a broad 4~6 mm wide yellowish brown, light tan to white mottled, shiny erhizinate marginal zone. Rhizines, sparse, simple, unevenly distributed, short, up to 1 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1A~1E).

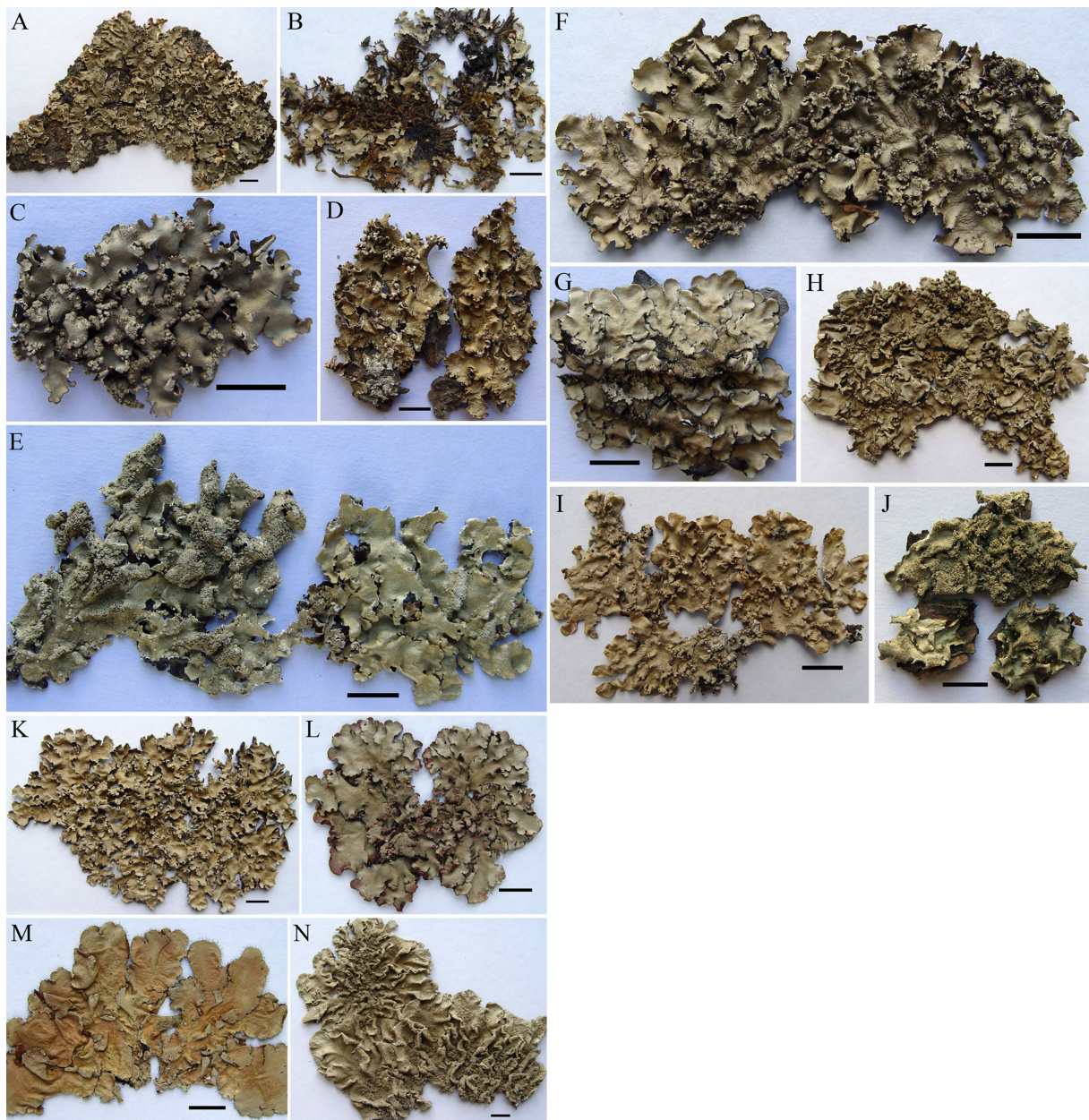


Fig. 1. A~E, *Parmotrema* species. A, *P. austrosinense* (J. S. Hur, 86774); B, *P. cetratum* (J. S. Hur, 40060); C, *P. cristiferum* (J. S. Hur, 30473); D, *P. defectum* (J. S. Hur, 41654); E, *P. dilatatum* (J. S. Hur, 60349). F~J, *Parmotrema* species. F, *P. grayanum* (J. S. Hur, 40534); G, *P. margaritatum* (J. S. Hur, 70794); H, *P. perlatum* (J. S. Hur, 70649); I, *P. praesorediosum* (J. S. Hur, 70007); J, *P. pseudocrinitum* (J. S. Hur, 80797). K~N, *Parmotrema* species. K, *P. reticulatum* (J. S. Hur, 41659); L, *P. subsumptum* (J. S. Hur, 30431); M, *P. subtinctorium* (J. S. Hur, 30029); N, *P. tinctorum* (J. S. Hur, 70183) (scale bars: A~N = 1 cm).

Chemistry: Cortex K+ (yellow), C-, KC-, P-; medulla K-C+ (red), KC+ (red), P-. TLC: atranorin, chloroatranorin, lecanoric acid, unknown 1 and unknown 2 (Fig. 2).

Remarks: *P. austrosinense* has a thallus rather soft to the touch with eciliate, marginal soralia, and C+ red medulla. According to Divakar and Upreti [13], this species resembles *P. sancti-angelii* and *P. hababianum* in its sorediate condition. However, *P. sancti-angelii* is different from *P. austrosinense* in that it has a coriaceous, ciliate, granular sorediate thallus with gyrophoric acid in the medulla. *P.*

hababianum, which has a soft thallus, differs from *P. austrosinense* in having cilia along the margins and C-medulla. *P. cooperi* also resembles *P. austrosinense*, but it has ciliate lobe margins [12].

Ecology and distribution: In South Korea, this species is found on the bark of *Pinus* sp. and Cherry trees in Mt. Halla, Mt. Illim, Mt. Ungseokbong, Baal Beach, Gwangpo Village and the Wondangbong area. This is a pantropical species that has been identified in tropical regions of Africa [9]. It has also been recorded from Asia, America

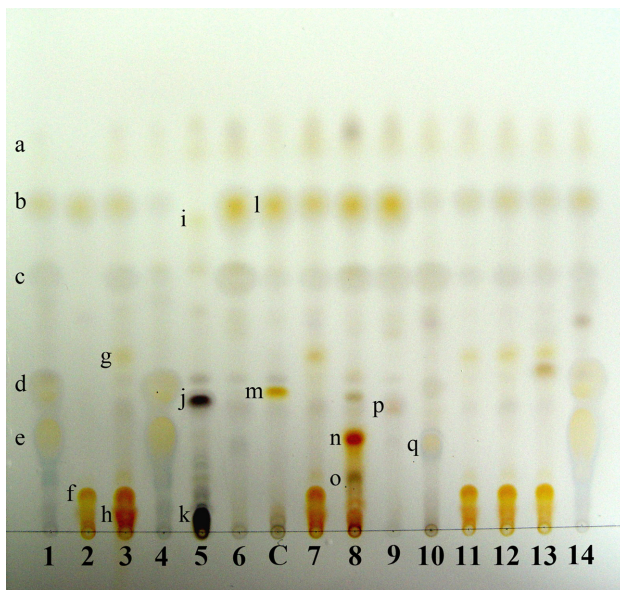


Fig. 2. Thin layer chromatography profile of *Parmotrema* species in solvent system A. 1, *P. austrosinense* with chloroatranorin (a), atranorin (b), unknown 1 (c), unknown 2 (d), lecanoric acid (e); 2, *P. cetratum* with salazinic acid (f); 3, *P. cristiferum* with unknown 3 (g), consalazinic acid (h); 4, *P. defectum*; 5, *P. dilatatum* with usnic acid (i), unknown 4 (j), protocetraric acid (k); 6, *P. grayanum*; C, control [*Lethariella cladonioides* (Nyl.) Krog] with atranorin (l), norstictic acid (m); 7, *P. margaritatum*; 8, *P. perlatum* with stictic acid (n), menegazziaic acid (o); 9, *P. praesorediosum* with unknown 5 (p); 10, *P. pseudocrinitum* with gyrophoric acid (q); 11, *P. reticulatum*; 12, *P. subsumptum*; 13, *P. subtinctorium*; 14, *P. tinctorum*.

and Central American regions.

Selected specimens examined: Mt. Halla, Jeju-si, on bark (Cherry), 33°22'17.7" N, 126°34'15.2" E, alt. 1,300 m, 9 Aug 2008, J. S. Hur, 086774; Baedal Beach, Taeindong, Gwangyang-si, Jeollanam-do, on bark (*Pinus* sp.), 34°57'3.90" N, 127°45' 6.55" E, alt. 7 m, 16 Jan 2010, J. S. Hur, M. H. Jeong, GW1030; Gwangpo Village, Gadeok-ri, Hadong-gun, Gyeongsangnam-do, on bark (*Pinus* sp.), 34°58'2.91" N, 127°48'9.14" E, alt. 37 m, 25 Jan 2010, J. S. Hur, M. H. Jeong, GW1053; Wondangbong, Jeju Island, on bark (*Pinus* sp.), 33°31'7.49" N, 126°35'35.2" E, alt. 45 m, 19 Apr 2009, J. S. Hur, X. Y. Wang, J. A. Ryu, J. Y. Hur, 090004; Mt. Ungseokbong, Sancheong-eup, Sancheong-gun, Gyeongsangnam-do, on bark (Cherry tree), 35°23'25.7" N, 127°52'6.68" E, alt. 173 m, 11 Oct 2010, X. Y. Wang, J. A. Ryu, 101342; Mt. Illim, Ungchi-myeon, Boseong-gun, Jeollanam-do, on bark (*Pinus* sp.), 34°41'17.7" N, 127°00'57.3" E, alt. 220 m, 1 Sep 2005, J. S. Hur, 050374 (Fig. 3).

Parmotrema cetratum (Ach.) Hale, *Phytologia* 28: 335 (1974).

Parmelia cetrata Ach., *Syn. Lich.*: 198 (1814).

Rimelia cetrata (Ach.) Hale & A. Fletcher, *Bryologist* 93: 26 (1990).

Thallus foliose, loosely adnate to the substratum, 5–12 cm across. Lobes apically round, sub irregular, often lacinate, up to 8 mm wide; margins crenate, dentate, lateral margins in the central part of the thallus lacinales, subdichotomously divided and tapering, ciliate. Cilia sparse to dense, simple to sparingly branched, 0.5–2 mm long, black. Upper surface pale grey to mineral grey, without soredia, isidia or dactyls densely maculate. Maculae forming an intricate reticulate network and fissuring into fine cracks. Soredia, when present, developing either laminally or marginally. Medulla white. Lower surface black, glossy, with a narrow, 1–2 mm wide, erhizinate marginal zone. Rhizines dense, simple to squarrosely branched, black. Apothecia not observed. Conidiomata pycnidial, immersed, laminal, black. Conidia filiform, 9–12 × 1 μm (Fig. 1A–1E).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K+ (yellow to red), C–, KC+ (red), P+ (orange). TLC: atranorin, chloroatranorin, salazinic acid, consalazinic acid (Fig. 2).

Remarks: *P. cetratum* is characterized by a smooth cortex, reticulate maculate upper surface, and esorediate thallus with salazinic acid in the medulla. This species is similar to *P. reticulatum* in chemistry, but the latter species differs in having a sorediate thallus.

Ecology and distribution: In South Korea this species has only been recorded on a rock from a single location on Mt. Sonum. According to Elix [12], this is a very rare species that has been recorded from Asian, African and Central American regions.

Specimens examined: Mt. Sonun, Gochang-gun, on rock, 35°29'41.2" N, 126°34'14.1" E, alt. 295 m, 20 Apr 2004, 040060 (Fig. 3).

Parmotrema cristiferum (Taylor) Hale, *Phytologia* 28: 335 (1974).

Parmelia cristifera Taylor, *Lond. J. Bot.* 6: 165 (1847).

Parmelia perforata var. *ulophylla* Meyen & Flot., *Nova Acta Acad. Caes. Leop. Carol. Nat. Curiosorum*, Suppl. 119: 218 (1843).

Thallus foliose, loosely attached to the substratum, coriaceous, 4–6 cm broad, lobes rotund, 5–10 mm wide; margins entire, crenate, eciliate. Upper surface pale grey, dull, emaculate, without isidia, sorediate. Soralia marginal to submarginal, sinuous and revolute. Medulla white. Lower surface black, smooth with broad, pale brown to tan, erhizinate marginal zone. Rhizines, sparse, simple, short, up to 1 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1A–1E).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K+ (red), C–, KC–, P+ (orange-red). TLC: atranorin, chloroatranorin, salazinic acid and unknown (Fig. 2).

Remarks: This is the first record of this species in South Korea. *P. cristiferum* is characterized by the loosely adnate, coriaceous thallus, eciliate lobes, marginal soralia and salazinic acid in the medulla. According to Divakar and Upreti [13], this species is closely related to *P. stuppeum* in

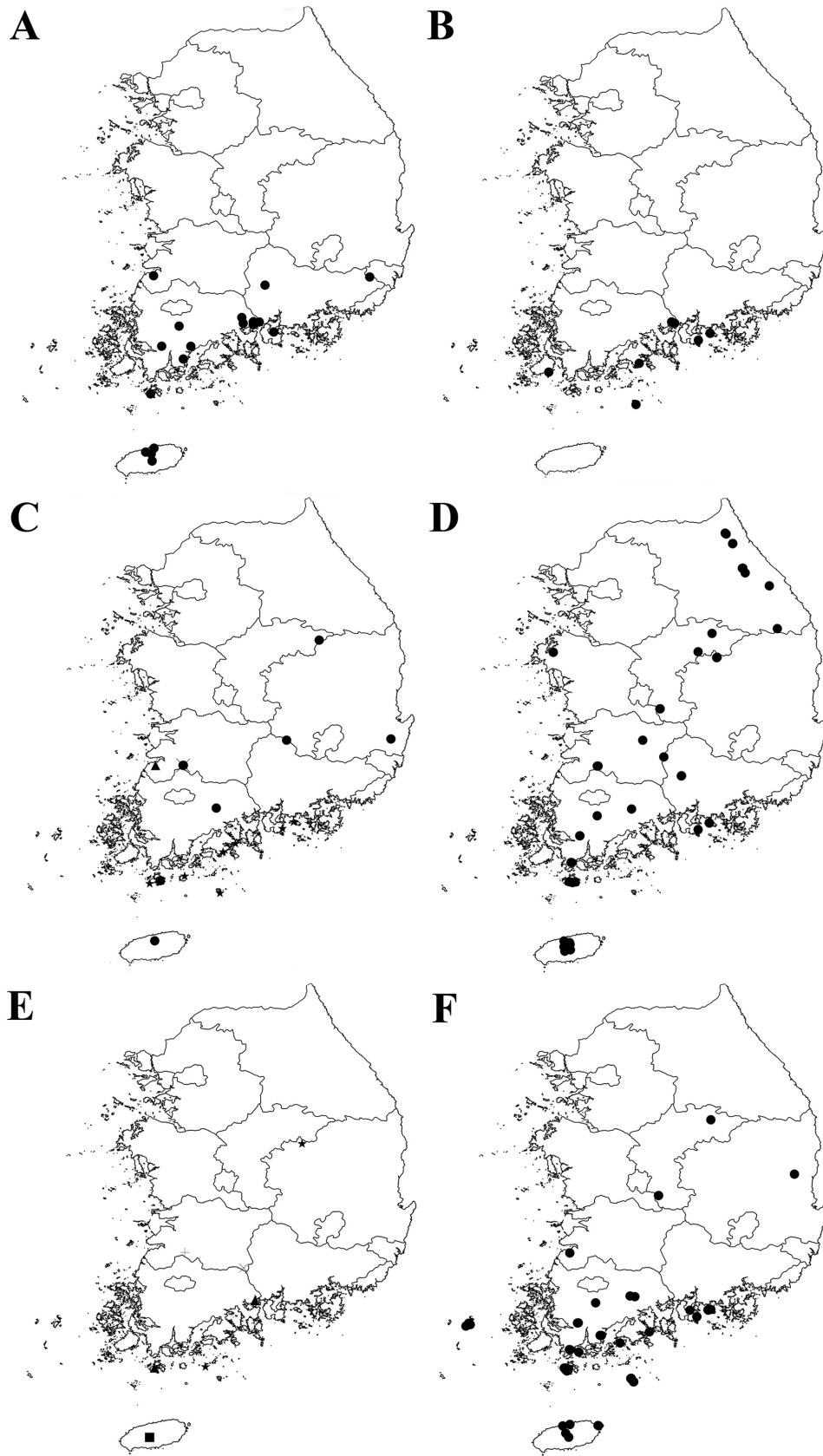


Fig. 3. Distribution of *Parmotrema* species in South Korea. A, *P. austrosinense*; B, *P. praesorediosum*; C, *P. cetratum* (▲), *P. grayanum* (★), *P. subsumptum* (●), *P. subtinctorium* (×); D, *P. reticulatum*; E, *P. cristiferum* (+), *P. defectum* (▲), *P. dilatatum* (×), *P. margaritatum* (★), *P. pseudocrinitum* (■); F, *P. tinctorum*.

having marginal soralia and the presence of salazinic acid, but it differs in that it has ciliate margins.

During the current study, the specimens referred to under *Parmotrema ultralucens* (Krog) Hale [8] were identified as *Parmotrema cristiferum*.

Ecology and distribution: In South Korea this species has only been recorded on a rock from a single location on Mt. Naejang. However, this organism is a cosmopolitan species that is widely distributed in tropical and subtropical areas [10, 12].

Specimens examined: Mt. Naejang, on rock, 35°29'38" N, 126°54'28" E, alt. 590 m, 29 Jun 2003, J. S. Hur, 030473 (Fig. 3).

Parmotrema defectum (Hale) Hale, Phytologia 28: 335 (1974).

Parmelia defecta Hale, Contrib. U. S. Nat. Herb. 36: 244 (1965).

Thallus foliose, closely attached to the substratum, coriaceous, 5–8 cm broad, Lobes round to irregular, 5–10 mm wide; margins crenate, eciliate. Upper surface pale grey, smooth, somewhat shiny, rugose, cracked in the center, sorediate. Soralia marginal, linear, but not continuous for about 1 cm, sorediate margins revolute. Medulla white. Lower surface minutely wrinkled, black with smooth, pale brown to tan, erhizinate marginal zone. Rhizines, sparse, simple, short, up to 1 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1A–1E).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K–, C+ (rose to red), KC+ (red), P–. TLC: atranorin, chloroatranorin and lecanoric acid (Fig. 2).

Remarks: This is the first report of *P. defectum* from South Korea. This species is characterized by a rugose, emaculate, thallus with eciliate margins and lecanoric acid in the medulla. According to Divakar and Upreti [13], *P. defectum* is a saxicolous species, but this species was found on the bark of *Pinus* sp.

Ecology and distribution: In South Korea, this species was recorded on a rock and bark from two locations, Bokil-do and from a large bridge in Geumho. Outside of South Korea, this species has been recorded in African and South Asian regions.

Specimens examined: Bokil-do, on bark, 34°09'31.7" N, 126°33'27.7" E, alt. 5 m, 31 Dec 2004, J. S. Hur, 041654; Geumho, Geumho-dong, Gwangyang-si, Jeollanam-do, on rock, 34°56'6.12" N, 127°43'5.71" E, alt. 14 m, 16 Jan 2010, J. S. Hur, M. H. Jeong, GW1012 (Fig. 3).

Parmotrema dilatatum (Vain.) Hale, Phytologia 28: 335 (1974).

Parmelia dilatata Vain., Acta Soc. Fauna Flora Fenn. 7: 32 (1890).

Thallus foliose, loosely attached to the substratum, coriaceous, 4–6 cm broad. Lobes rotund, 5–10 mm wide; margins entire, crenate, eciliate. Upper surface pale grey, shiny, emaculate, without isidia, sorediate. Soralia marginal,

globular or confluent, soredia granular. Medulla white. Lower surface black, smooth with broad, pale brown to tan, erhizinate marginal zone. Rhizines, sparse, simple, short, up to 1 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1A–1E).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K–, C–, KC+ (red), P+ (red). TLC: atranorin, chloroatranorin, usnic acid, protocetraric acid and unknown 4 (Fig. 2).

Remarks: *P. dilatatum* is characterized by coriaceous, eciliate lobes, marginal soralia and protocetraric acid in the medulla. Externally, this species externally resembles *P. cristiferum*, but it differs due to the presence of protocetraric acid in the medulla [13].

Ecology and distribution: In South Korea, this species has only been recorded on a rock from a single locality of Mt. Chiri. Apart from South Korea, this species has been reported from Asian and Central American regions.

Specimens examined: Mt. Chiri, on bark, 35°18'48.9" N, 127°35'13.5" E, alt. 1,120 m, 18 Jun 2006, J. S. Hur, 060349 (Fig. 3).

Parmotrema grayanum (Hue) Hale, Phytologia 28: 336 (1974).

Parmelia grayana Hue, Nouv. Arch. Mus. Hist. Nat., Paris, 4 Sér. 1: 184 (1899).

Thallus foliose, loosely attached to the substratum, 3–6 cm wide. Lobes rotund, crowded, rather narrow, 3–6 mm wide, margins ascending, crenate, ciliate; cilia simple to branched, black, thick, 0.5–2 mm long. Upper surface ashy-grey, smooth, epruinose, emaculate, sorediate near the margins, developed on apices of dents, linear to subglobose, soredia granular, often with a grey-brown tinge. Medulla white. Lower surface faintly wrinkled, black with a broad, brown, erhizinate marginal zone. Rhizines at the center, sparse, black, simple, 1–2 mm long. Apothecia not seen. Pycnidia present at the periphery of lobes, black, immersed. Conidia rod shaped, 6–8 µm long (Fig. 1F–1J).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; Medulla K–, C–, KC–, P–. TLC: atranorin and chloroatranorin (Fig. 2).

Remarks: *P. grayanum* closely resembles *P. praesorediosum* in that it has sorediate margins and negative chemical reactions, but *P. grayanum* can be differentiated by the presence of cilia along the margins.

Ecology and distribution: In South Korea this species has only been recorded from rock surfaces in Bogil Island, Cheongsan Island, Saryang Island, Geomun Island, Mt. Sobaek, the Yongbawi seaside and Daeki Valley. This species has also been reported in East Asian, African and Central American regions.

Selected specimens examined: Bogil Island, Shinan Co., Jeonam Prov., on rock, 34°07'8.62" N, 126°30'7.28" E, alt. 19 m, 23 Jun 2011, X. Y. Wang, J. A. Ryu, 110683; Cheongsan Island, Wando Co., Jeonam Prov., on rock, 34°12'21.8" N, 126°54'35.7" E, alt. 5 m, 23 Jun 2011, X. Y. Wang, J. A. Ryu, 110751; Yongbawi Seaside, Yongam Village, Ucheon-ri,

Goheung-gun, Jeollanam-do, on rock, 34°35'7.65" N, 127°30'3.75" E, alt. 10 m, 19 Feb 2010, Y. Joshi, H. S. Jeon, G. S. Han, 100355; Daeki Valley, Nanhae-gun, Gyeongshangnam-do, on rock, 34°45'38.3" N, 128°02'53.6" E alt., 280 m, 11 Nov 2007, J. S. Hur, 070977; Geomun Island, Samsan-myeon, Jeollanam-do, on rock, 34°00'28.9" N, 127°19'14.8" E alt. 80 m, 24 Mar 2007, J. S. Hur, 070172; Mt. Sobaek, on rock, 36°57'13.1" N, 128°28'38.2" E alt. 1,386 m, 2 Oct 2003, J. S. Hur, 030783; Saryang Island, Saryang-myeon, Sangnam-do, on rock, 34°50'13.9" N, 128°10'44.0" E, alt. 118 m, 17 Mar 2007, J. S. Hur, 070035; Fire Goheung, on rock, 34°29'17.3" N, 127°21'27.4" E, alt. 5 m, 6 Aug 2004, J. S. Hur, 040534 (Fig. 3).

Parmotrema margaritatum (Hue) Hale, *Phytologia* 28: 337 (1974).

Parmelia margaritata Hue, *Nouv. Arch. Mus. Paris. Ser. 4* 1:193 (1899).

Thallus foliose, loosely attached to the substratum, medium sized, 3~6 cm across, rather coriaceous to crisp. Lobes rotund, irregular, 5~8 mm wide, with several ascending, simple to dichotomously branched cilia. Cilia simple, 0.5 to 1 mm long, moderately dense. Upper surface pale grey to grey, smooth, dull, maculate, without isidia, sorediate. Soralia terminal on the lacinales, rounded or confluent and sinuous, sorediate lobes revolute. Medulla white. Lower surface black, with shiny, brown erhizinate marginal zone. Rhizines simple to slightly branched, dense in the central part. Apothecia and pycnidia not seen (Fig. 1F~1J).

Chemistry: Cortex K⁺ (yellow), C⁻, KC⁻, P⁻; medulla K⁺ (red), C⁻, KC⁻, P⁺ (orange red). TLC: atranorin, chloroatranorin, salazinic acid (Fig. 2).

Remarks: *P. margaritatum* shows a close resemblance to *P. stuppeum* in the presence of marginal cilia, soralia and similar chemical substances, but the presence of secondary lobules and a faint maculate upper surface differentiate it from the latter. *P. leucosemohetum* also very closely resembles *P. margaritatum*, but has a highly maculate upper surface and lacks secondary lobules [13].

Ecology and distribution: In South Korea, this species has been recorded from Mt. Kongduck, Mt. Naejang, and the Asan Hwasun area. Outside of South Korea, this species has been reported from India [13], the United States [9], and Venezuela [15].

Specimens examined: Mt. Kongduck, on bark (*Pinus* sp.), 36°44'58.6" N, 128°15'52.1" E, alt. 628 m, 20 Jun 2007, J. S. Hur, 070794; Mt. Naejang, on rock, 29 Jun 2003, J. S. Hur, 030473; Hwasun, Asan, on rock, 34°10'14.0" N, 127°08'45.0" E, alt. 500 m, 8 Oct 2005, J. S. Hur, 050570 (Fig. 3).

Parmotrema perlatum (Huds.) M. Choisy, *Bull. Mem. Soc. Linn. Lyon* 21: 174 (1952).

Lichen perlatum Huds., *Fl. Angl.* 1: 448 (1762).

Imbricaria ciliata (DC.) Arnold, *Flora, Jena* 67: 158

(1884).

Imbricaria perlata (Huds.) Körb., *Lichenogr. Germ.* (Breslau): 8 (1846).

Lobaria perlata (Huds.) Hoffm., *Deutschl. Fl., Zweiter Theil* (Erlangen): 148 (1796).

Parmelia coniocarpa Laurer, *Linnaea* 2: 39 (1827).

Parmelia perlata (Huds.) Ach., *Method. Lich.*: 216 (1803).

Parmelia perlata var. *ciliata* (DC.) Duby, *Bot. Gall., Ed. 2* (Paris) 2: 601 (1830).

Parmelia trichotera Hue, *J. Bot., Paris* 12: 245 (1898).

Parmotrema perlatum var. *ciliata* (DC.) M. Choisy, *Bull. Mens. Soc. Linn. Lyon* 21: 175 (1952).

Parmotrema trichotera (Hue) M. Choisy, *Bull. Mens. Soc. Linn. Lyon* 21: 175 (1952).

Platysma perlatum (Huds.) Frege, *Deutsch. Bot. Taschenb.* 2: 167 (1812).

Parmotrema chinense auct., non (Osbeck) Hale & Ahti, *Taxon* 35: 133 (1986).

Thallus foliose, membranaceous to coriaceous, loosely attached to the substratum, 5~8 cm broad. Lobes rotund, irregular, 5~8 mm wide; margins entire to crenate, but lacking sublinear lacinae, eciliate. Cilia simple to branched, rather long (0.5~2 mm), moderately dense to dense. Upper surface pale grey to mineral grey, dull, without isidia, sorediate. Soralia marginal to submarginal, causing lobe margins to become revolute and suberect, ultimately appearing labriform, soredia granular. Medulla white. Lower surface black, shiny with a broad 3~6 mm wide, brown to tan erhizinate marginal zone. Rhizines moderately dense, simple, up to 2 mm long. Apothecia and Pycnidia not seen (Fig. 1F~1J).

Chemistry: Cortex K⁺ (yellow), C⁻, KC⁻, P⁻; medulla K⁺ (yellow), C⁻, KC⁻, P⁺ (orange-red). TLC: atranorin, chloroatranorin, stictic acid, constictic acid, menegazziaic acid (trace) and norstictic acid (trace) (Fig. 2).

Remarks: *P. perlatum* is characterized by a loosely attached thallus, marginal to sub marginal soralia with strongly revolute and suberect margins, and the presence of stictic acid in the medulla. The organism resembles *Parmotrema reticulatum* in the nature of soralia, but the latter species has a maculate, reticulately cracked upper surface and salazinic acid in the medulla. *P. perlatum* is similar to *P. crinitum* due to the presence of a brown to tan erhizinate marginal zone and stictic acid complex in the medulla, but the latter species has an isidiate upper surface [13]. According to Park [16], the species description was given under the species name *P. chinense* (Osbeck) Hale & Ahti.

According to Louwhoff's descriptions [17], *P. perlatum* is sensitive to air pollution and prefers well-lit, neutral to somewhat acid-barked, broad-leaved trees and siliceous rocks and coastal rocks where illumination is moderate to good. However, the recent revisionary work conducted by Jabłońska *et al.* [18] stated that *P. perlatum* is close to

extinct from Poland.

Ecology and distribution: In South Korea this species has been recorded from Mt. Ungseok, Mt. Chiri, Mt. Hambeak, Mt. Taebaek, and the Sanchong area. *P. perlatum* is a cosmopolitan lichen and widespread in both the southern and northern hemisphere and tropical areas [9, 17]. This species has been identified in many European countries [18], as well as other Asian countries including Australia [12], India [13], Japan [19], and Taiwan [4].

Selected specimens examined: Mt. Ungseok, Sancheong-eup, Sancheong-gun, Gyeongsangnam-do, on bark (*Quercus* sp.), 35°22'53.3" N, 127°51'17.6" E, alt. 783 m, 16 Oct 2007, 070883; Mt. Chiri, on bark, 35°22'07.3" N, 127°34'52.7" E, alt. 480 m, J. S. Hur, 18 Jun 2006, 060376; Mt. Hambeak, on bark (*Quercus* sp.), 37°11'47.4" N, 128°54'53.6" E, alt. 1355 m, J. S. Hur, 19 Jun 2007, 070649; Jiri (Piagol, Market Place), on bark (*Quercus* sp.), 35°17'45.1" N, 127°33'38.5" E, alt. 1,202 m, 27 Sep 2006, J. S. Hur, 060774; Mt. Taebaek, on bark (*Quercus* sp.), 37°12'35.3" N, 128°55'11.9" E, alt. 1,399 m, J. S. Hur, 25 May 2008, 080279; Sanchong, Gyeongnam Province, Woong-Seok-Bong, on bark (*Quercus* sp.), 35°22'55.0" N, 127°51'20.7" E, alt. 795 m, 16 Oct 2007, J. S. Hur, 070885 (Fig. 3).

Parmotrema praesorediosum (Nyl.) Hale, *Phytologia* 28: 338 (1974).

Parmelia praesorediosa Nyl., *Sert. Lich. Trop. Labuan Singapore*: 18 (1891).

Thallus foliose, adnate to the substratum, 3–10 cm across. Lobes round, 4–10 mm wide; margins entire or crenate, eciliate, sorediate. Upper surface pale grey to grey, smooth, dull, emaculate, weakly rugose, lacking isidia, sorediate. Soralia marginal, linear to crescent shaped, granular. Medulla white. Lower surface black, minutely rugose, with shiny, mottled, ivory or brown, erhizinate marginal zone. Rhizines sparse, simple, short. Apothecia and pycnidia not seen (Fig. 1F–1J).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K–, C–, KC–, P– TLC: atranorin, chloroatranorin, fatty acids (protopraesorediosic acid, praesorediosic acid) [13] and unknown 5 (Fig. 2).

Remarks: *P. praesorediosum* is characterized by an adnate coriaceous thallus, eciliate lobes with ascending sorediate margins and fatty acid in the medulla. Externally, *P. grayanum* is similar to *P. praesorediosum*, but the former has ciliate margins [12]. According to Divakar and Upreti [13], the chemical composition of *P. praesorediosum* is similar to that of *P. mesotropum*, but the latter differs in having esorediate thalli.

Ecology and distribution: This species is very common on exposed rock surfaces [13] and has been reported from Geomun Island, Saryang Island, Jeob Island, Balpo, Changchon Village, Gopo Village and Mt. Nogudwit in South Korea. Apart from this country, this species has been reported from East Asia, South Asia and Central America.

Selected specimens examined: Geomun Island, Samsan-myeon, Jeollanam-do, on bark (*Camellia japonica*), 34°00'34.2" N, 127°19'12.4" E, alt. 61 m, 24 Mar 2007, J. S. Hur, 070151; Saryang Island, Saryang-myeon, Sangnam-do, on bark, 34°50'06.4" N, 128°10'53.7" E, alt. 26 m, 17 Mar 2007, J. S. Hur, 070007; Balpo, Goheung-gun, Jeollanam-do, on rock, 34°29'17.3" N, 127°21'27.4" E, alt. 5 m, 6 Aug 2004, J. S. Hur, 040536; Changchon Village, Jinsang-myeon, Gwangyang-si, Jeollanam-do, on rock, 34°58'5.92" N, 127°44'0.71" E, alt. 43 m, 16 Jan 2010, J. S. Hur, M. H. Jeong, GW1039; Gopo Village, Geumseong-myeon, Hadong-gun, Gyeongsangnam-do, on bark (*Pinus* sp.), 34°57'7.45" N, 127°46'7.36" E, alt. 4 m, 25 Jan 2010, J. S. Hur, M. H. Jeong, GW1051; Jeob Island, Jeonam Prov., Jindo-Co., on rock, 34°23'6.80" N, 126°18'25.1" E, alt. 1 m, 3 Jun 2011, X. Y. Wang, J. A. Ryu, 110498; Mt. Nogudwit, Namhae-gun, Gyeongsangnam-do, on rock, 34°45'20.3" N, 128°02'39.4" E, alt. 210 m, 11 Nov 2007, 070942 (Fig. 3).

Parmotrema pseudocrinitum (Abbayes) Hale, *Phytologia* 28: 338 (1974).

Parmelia pseudocrinita des Abb., *Bull. Inst. Fr. Afr. Noire* 20: 19 (1958).

Thallus foliose, loosely attached to the substratum, coriaceous, 4–8 cm broad, lobes imbricate, 5–10 mm wide; margins crenate, ciliate. Cilia evenly distributed, coarse, 0.5–1 mm long. Upper surface pale grey, smooth, somewhat shiny, emaculate, esorediate, with isidia. Isidia laminal, sparse to dense, simple, cylindrical or coralloid. Medulla white. Lower surface black with smooth, pale brown to tan, erhizinate marginal zone. Rhizines, sparse, simple, short, up to 2 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1F–1J).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K–, C+ (rose to red), KC+ (red), P–. TLC: atranorin, chloroatranorin and gyrophoric acid (Fig. 2).

Remarks: *P. pseudocrinitum* is characterized by emaculate, isidiate upper surface, ciliate margin and the presence of gyrophoric acid in the medulla. *P. crinitum* also has similar ciliate and isidiate conditions, but differs from *P. pseudocrinitum* in having a stictic acid complex in the medulla.

Ecology and distribution: In South Korea, this species has been reported on bark in the Mt. Halla area. Outside South Korea, this species has been reported from East Africa [10], India [13], and Thailand [20].

Specimens examined: Mt. Halla, Jeju-si, on bark, 33°21'18.8" N, 126°30'00.4" E, alt. 1,492 m, 10 Aug 2008, J. S. Hur, 080787, 080797 (Fig. 3).

Parmotrema reticulatum (Taylor) M. Choisy, *Bull. Mens. Soc. Linn. Lyon* 21: 148 (1952).

Parmelia reticulata Taylor, in Mackay, *Fl. Hibern.* 2: 148 (1836).

Canomaculina leucosemotheta (Hue) Elix, *Mycotaxon* 65: 477 (1997).

Parmelia ciliata (DC.) Nyl., Flora, Jena 61: 247 (1878).

Parmelia ciliata (Nyl.) Gyeln., Feddes Repert. 30: 225 (1932).

Parmelia concors Kremp., Verh. Zool. Bot. Ges. Wien 30: 337 (1880).

Parmelia laevigata var. *reticulata* (Taylor) Linds., Trans. Linn. Soc. Lond., Bot. 25: 514 (1866).

Parmelia leucosemtheta Hue, Nouv. Arch. Mus. Hist. Nat., Paris, 4 Sér. 1: 192 (1899).

Parmelia macquariensis C.W. Dodge, Nova Hedwigia 19: 450 (1970).

Parmelia perforata var. *ciliata* Nyl., Anns Sci. Nat., Bot., Sér. 4 15: 373 (1861).

Parmelia pseudovirens Gyeln., Reprim Nov. Spec. Regni Veg. 29: 288 (1931).

Parmelia urceolata var. *sorediifera* Müll. Arg., Flora, Jena 63: 266 (1880).

Parmelia urceolata var. *subcetrata* Müll. Arg., Flora, Jena 66: 46 (1883).

Parmelia virens var. *sorediata* Müll. Arg., Flora, Jena 69: 256 (1886).

Parmotrema leucosemthetum (Hue) Hale, Phytologia 28: 337 (1974).

Parmotrema pseudovirens (Gyeln.) Elix, Mycotaxon 47: 127 (1993).

Rimelia reticulata (Taylor) Hale & A. Fletcher, Bryologist 93: 28 (1990).

Parmelia clavulifera Räsänen, Ann. Zool. Bot. Fenn., Vanamo 20: 4 (1944).

Parmotrema clavuliferum (Räsänen) Streimann, Bibliotheca Lich. 22: 93 (1986).

Rimelia clavulifera (Räsänen) Kurok., J. Jpn. Bot. 66: 158 (1991).

Thallus foliose, adnate to loosely adnate to the substratum, 5~15 cm across. Lobes apically round to sub rotund, imbricate 4~12 mm wide; central part of the thallus lacinales, lacunae up to 2 mm wide, ciliate. Cilia sparse to dense, simple to sparingly branched, 0.5~2 mm long, black. Upper surface pale grey to mineral grey, sorediate, isidia or dactyls absent, densely maculate. Maculae forming an intricate reticulate network and fissuring into fine cracks. Sometimes flaking off in older parts. Soredia marginal to submarginal. Linear to capitate, linear soralia on lateral margins and capitate soralia developing on apices of lacinae, which becomes involute, soredia granular. Medulla white. Lower surface black, glossy, with narrow, 1~2 mm wide, erhizinate marginal zone or rhizinate up to margins. Rhizines dense, simple to squarrosely branched, black. Apothecia and pycnidia not observed (Fig. 1K~1N).

Chemistry: Cortex K+ (yellow), C-, KC-, P-; medulla K+ (yellow to red), C-, KC-, P+ (orange-red). TLC: atranorin, chloroatranorin, salazinic acid, consalazinic acid (Fig. 2).

Remarks: *P. reticulatum* is characterized by marginal to submarginal soralia and the presence of salazinic acid in

the medulla. This species is similar to *P. cetratum* in chemistry, but the latter species differs in that it has an esorediate upper surface.

Ecology and distribution: In South Korea this species has been recorded from Mt. Halla, Mt. Talmasan, Mt. Hugseok, Mt. Naejang, Mt. Kongduck, Mt. Jumbong, Mt. Odae, and the Bokildo area. According to Elix [12] and Kurokawa and Lai [4], this species is widely distributed in tropical and temperate regions.

Selected specimens examined: Mt. Halla, Jeju-si, on bark, 33°22'17.7" N, 126°34'15.2" E, alt. 1,300 m, 9 Aug 2008, J. S. Hur, 080747, 080748, 080757, 080758, 080766, 080770, 080771; Mt. Talmasan, Songji-ri, Haenum-gun, Jeollanam-do, on rock, 34°22'45.1" N, 126°35'07.5" E, alt. 389 m, 26 Jul 2005, J. S. Hur, 050335; Mt. Hugseok, Gahak-ri, Haenam-gun, Jeollanam-do, on bark, 34°41'21.1"N, 126°40'47.5"E, alt. 230 m, 23 Sep 2005, J. S. Hur, 050499; Mt. Naejang, on rock, 35°29'41.0" N, 126°52'53.3" E, alt. 650 m, 8 Aug 2003, J. S. Hur, 030616; Mt. Kongduck, on rock, 36°45'12.4" N, 128°16'07.6" E, alt. 628 m, 20 Jun 2007, J. S. Hur, 070811; Jeju-do, on bark, 33°26'04.4" N, 126°34'01.7" E, 29 Aug 2004, J. S. Hur, 040872; Mt. Jumbong, on bark, 38°03'56.4" N, 128°26'51.7" E, alt. 600 m, 9 Oct 2004, J. S. Hur, 041324; Mt. Odae, on bark, 37°46'59.1" N, 128°33'59.1" E, alt. 890 m, 7 May 2004, J. S. Hur, 040418; Bokildo, on bark, 34°09'31.7" N, 126°33'27.7" E, alt. 5 m, 31 Dec 2004, J. S. Hur, 041659 (Fig. 3).

Parmotrema subsumptum (Nyl.) Hale, Mycotaxon 5: 434 (1977).

Parmelia subsumpta Nyl., Flora, Jena 52: 117 (1869).

Canomaculina subsumpta (Nyl.) Elix, Mycotaxon 65: 477 (1997).

Rimeliella subsumpta (Nyl.) Kurok., Ann. Tsukuba Bot. Gard. 10: 9 (1991).

Thallus foliose, loosely attached to the substratum, 6~12 cm broad. Lobes rotund, 7~15 mm wide; margins crenate, ciliate. Cilia dense, simple, black, markedly tapered, 0.5~1 mm long. Upper surface mineral grey to grey, white maculate, maculae effigurate, often cracked in older parts, without isidia, sorediate. Soralia linear, marginal in the central part, sorediate lobes involute. Medulla white, sometimes pale reddish with age due to salazinic acid in the medulla. Lower surface pale brown, rhizines dense. Rhizines black, short, dimorphic, marginal rhizines simple, central rhizines squarrosely branched. Apothecia and pycnidia not seen (Fig. 1K~1N).

Chemistry: Cortex K+ (yellow), C-, KC-, P-; medulla K+ (yellow to red), C-, KC-, P+ (orange). TLC: atranorin, chloroatranorin and salazinic acid (Fig. 2).

Remarks: *P. subsumptum* is characterized by sorediate upper surface and presence of salazinic acid in the medulla. In chemistry, this species is similar to *P. subtinctorium*, but the latter has isidia on the thallus.

Ecology and distribution: According to Divakar and Upreti [13], this species is only known to be corticolous,

but it has been reported as corticolous and saxicolous in areas of Jeju-do, Bogil Island, Mt. Sunwoon, Mt. Naejang, Mt. Sorodo, Mt. Wolchul, and the Haein Temple area in South Korea. Outside of South Korea, this species has been reported in East and South Asia and Central America.

Selected specimens examined: Jeju-do, on bark, 33°27'15.4" N, 126°33'41.1" E, alt. 370 m, 29 Aug 2004, J. S. Hur, 040865, 040868; Bogil Island, on rock, 34°09'14.7" N, 126°37'33.2" E, alt. 5 m, 31 Dec 2004, J. S. Hur, 041668, 041669, 041670; Mt. Sunwoon, on bark, 35°29'46.9" N, 126°53'40.7" E, alt. 140 m, 11 May 2003, J. S. Hur, 030233; Mt. Naejang, on rock, 36°57'13.1" N, 128°28'38.2" E, alt., 29 Jun 2003, J. S. Hur, 030431, 030431-2; Mt. Sorodo, on bark, 35°48'11.2" N, 129°18'47.3" E, alt. 15 m, 23 Mar 2003, J. S. Hur, 030071; Mt. Wolchul, on rock, 34°59'55.9" N, 127°16'42.10" E, alt. 816 m, 8 Jun 2003, J. S. Hur, 030324; Haein Temple, Mt. Gaya, 35°47'20.7" N, 128°05'51.5" E, 22 Apr 2003, J. S. Hur, 030151 (Fig. 3).

Parmotrema subtinctorium (Zahlbr.) Hale, *Phytologia* 28: 339 (1974).

Parmelia subtinctoria Zahlbr., in Handel-Mazzetti, *Symb. Sinic.* 3: 193 (1930).

Canomaculina subtinctoria (Zahlbr.) Elix, *Mycotaxon* 65: 477 (1997).

Parmelia virens f. *isidiosa* Müll. Arg., *Annln K. K. Naturh. Hofmus. Wien* 7: 303 (1892).

Rimelia subtinctoria (Zahlbr.) Kurok., *Ann. Tsukuba Bot. Gard.* 10: 10 (1991).

Thallus foliose, loosely attached to the substratum, 4–10 cm broad. Lobes rotund, 5–15 mm wide; margins crenate, dentate, ciliate. Cilia dense, simple to branched, markedly tapered, 0.5–2 mm long. Upper surface mineral grey to grey, turning buff in the herbarium with age, white maculate, maculae effigurate, often cracked in older parts, without soredia, isidiate. Isidia laminal, filiform, simple to branched, sometimes ciliate, dark brown tipped. Medulla white, sometimes reddish with age due to salazinic acid in the medulla. Lower surface dark to pale brown, with shiny, pale brown, narrow marginal zone. Rhizines simple, brown to black, uniformly distributed, up to 2 mm long. Apothecia and pycnidia not seen (Fig. 1K–1N).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K+ (yellow to red), C–, KC–, P+ (orange). TLC: atranorin, chloroatranorin and salazinic acid (Fig. 2).

Remarks: *P. subtinctorium* is characterized by an isidiate upper surface and the presence of salazinic acid in the medulla. In chemistry, this species is similar to *P. subsumptum*, but the latter has a marginal soralia.

Ecology and distribution: This species has a saxicolous and corticolous habitat and has been recorded from areas of Mt. Jiri, Mt. Sunun, Mt. Sunwoon and Mt. Baekwoon. This species has also been reported in Asia, Africa and Central America.

Specimens examined: Mt. Jiri, Baemsagol, 35°29'44.3" N, 126°53'27.6" E, on bark, alt. 530 m, 22 Mar 2003, J. S. Hur,

030029; Mt. Sunun, 35°29'46.9" N, 126°53'40.7" E, 11 May 2003, J. S. Hur, 030260; Mt. Baekwoon, on rock, 1 Jun 2003, J. S. Hur, 030275; Mt. Sunwoon, 35°29'46.9" N, 126°53'40.7" E, alt. 45 m, 11 May 2003, J. S. Hur, 030259 (Fig. 3).

Parmotrema tinctorum (Despr. ex Nyl.) Hale, *Phytologia* 28: 339 (1974).

Parmelia tinctorum Despr. ex Nyl., *Flora, Jena* 55: 547 (1872).

Lichen chinensis Osbeck, *Dagbok öfwer en Ostindisk Resa Aren* 1750, 1751, 1752: 221 (1757).

Parmotrema chinense (Osbeck) Hale & Ahti, *Taxon* 35: 133 (1986).

Thallus foliose, loosely attached to the substratum, membranaceous to coriaceous, up to 18 cm across. Lobes rotund to irregular, 5–15 mm wide; margins entire to crenate, eciliate. Upper surface pale grey to grey green, shiny, becoming dull towards the thallus center, somewhat longitudinally folded in the marginal region, emaculate, without soredia, isidiate. Isidia sparse to dense, laminal and eventually marginal, granular to filiform, simple to coralloid branched, thin, brown tipped or concolorous. Medulla white. Lower surface black, minutely wrinkled, smooth, shiny, with a broad, erhizinate, pale brown to dark tan marginal zone. Rhizines sparse, simple, short. Apothecia and pycnidia not seen (Fig. 1K–1N).

Chemistry: Cortex K+ (yellow), C–, KC–, P–; medulla K–, C+ (red), KC+ (red), P– TLC: atranorin, chloroatranorin, lecanoric acid (Fig. 2).

Remarks: *P. tinctorum* is characterized by a large, loosely adnate thallus with broad, eciliate, laminal isidiate lobes and lecanoric acid in the medulla. This species is very similar to *P. pseudotinctorum*, but the latter has inflated isidia. The species that grow under high humidity and moist conditions are larger in size, with large lobes and cylindrical, coralloid isidia, whereas species that grow under dry and stressed conditions are smaller in size with narrow lobes and granular, simple isidia [13].

During the current study, the specimens previously recorded as *Parmotrema saccatilobum* (Taylor) Hale [21] were identified as *Parmotrema tinctorum*.

Ecology and distribution: In South Korea, this species has been recorded from Mt. Sonun, Mt. Jogae, Mt. Halla, Mt. Cheontae, Mt. Jakseong, Mt. Nogudwit, and the Daeki Valley area. This is a cosmopolitan species [12] widely distributed throughout tropical, subtropical and temperate regions [13].

Selected specimens examined: Mt. Sonun, Gochang-gun, on bark, 35°29'40.4" N, 126°35'01.5" E, alt. 37 m, 20 Feb 2004, J. S. Hur, 040056-1; Mt. Jogae, on bark, 34°59'27.9" N, 127°20'01.8" E, alt. 210 m, 31 Jan 2004, J. S. Hur, 040008; Mt. Halla, Jeju Island, on rock, 33°30'17.8" N, 126°54'47.5" E, alt. 5 m, 17 Oct 2006, J. S. Hur, 061016; Mt. Cheontae, Deokhak-ri, Congju-si, Chungcheongnam-do, on rock, 36°09'24.4" N, 127°36'28.0" E, alt. 484 m, 3 Nov 2006, J. S. Hur,

061183; Mt. Jakseong, Seongnue-ri, Jechen-si, Chunchongbuk-do, on rock, 37°01'44.5" N, 128°12'35.6" E, alt. 560 m, 28 Oct 2006, J. S. Hur, 0561115; Daeki Valley, Nanhae-gun, Gyengshangnam-do, on rock, 34°45'38.6" N, 128°02'54.0" E, alt. 262 m, 11 Nov 2007, J. S. Hur, 070972; Mt. Nogudwit, Namhae-gun, Gyeongsangnam-do, on bark, 34°45'38.6" N, 128°02'54.4" E, alt. 289 m, 11 Nov 2007, 070992 (Fig. 3).

Species excluded from this study.

According to the literature, lichen species *Parmotrema arnoldii* (Du Rietz) Hale, *Parmotrema crinitum* (Ach.) M. Choisy, *Parmotrema mellissii* (C. W. Dodge) Hale and *Parmotrema eciliatum* (Nyl.) Hale have been reported from South Korea. However, the specimens of these species could not be traced; therefore, the description is based on previous literature.

Parmotrema arnoldii (Du Rietz) Hale, *Phytologia* 28: 335 (1974).

Parmelia arnoldii Du Rietz, *Nytt Mag. Natur.* 62: 80 (1924).

Imbricaria nilgherrensis Arnold, *Verh. Zool. Bot. Ges. Wien* 25: 472 (1875).

Parmelia nilgherrensis Nyl., *Flora, Jena* 57: 318 (1874).

Parmelia subarnoldii Abbayes, *Mém. Inst. Sci. Madagascar, Sér. B* 10: 113 (1961).

Parmotrema subarnoldii (Abbayes) Hale, *Phytologia* 28: 339 (1974).

P. arnoldii is characterized by the presence of a slightly maculate upper surface, coarsely sorediate margins of the lobes, revolute sorediate tips with irregular eruptions, and atranorin, alectoronic acid, and α -collatolic acid in the medulla [16, 18, 22]. This species is very closely related to *P. mellissii*, which is a panatropical species with both soredia and isidial initials. However, only soredia are present in *P. arnoldii* [16].

P. arnoldii is a temperate species [23] that has been recorded from several countries in Europe.

Parmotrema crinitum (Ach.) M. Choisy [as '*crinita*'], *Bull. Mens. Soc. Linn. Lyon* 21: 175 (1952).

Parmelia crinita Ach., *Syn. Meth. Lich.* (Lund): 196 (1814).

Imbricaria crinita (Ach.) Arnold, *Flora* 67: 159 (1884).

Imbricaria proboscidea (Taylor) Jatta, *Nuov. Giorn. Botan. Ital.* 22: 50 (1890).

Parmelia proboscidea Taylor, in Mackay, *Fl. Hibern.* 2: 143 (1836).

P. crinitum is characterized by the presence of coralloid branched, epically ciliate isidia or often eciliate isidia and stictic acid complex in the medulla. *P. mellissii* also shows a coralloid isidiate condition, but differs from *P. crinitum* in having alectoronic and α -collatolic acid [13]. According to Elix [12], *P. crinitum* resembles *P. ochrocrinitum* both

morphologically and chemically, but the latter shows pigments in the medulla. The specimen of the taxon is untraceable; therefore, the description is based on Kim [24], Divakar and Upreti [13] and Elix [12].

P. crinitum is a cosmopolitan species that is widespread in temperate, tropical regions and even subboreal forests, where high humidity is available [4, 12, 17]. Many European countries have reported the presence of *P. crinitum* [18]. Some Asian countries such as Japan [19], China [25], and Taiwan [26] have also reported the presence of *P. crinitum*.

Parmotrema mellissii (C. W. Dodge) Hale, *Phytologia* 28: 337 (1974).

Parmelia mellissii C. W. Dodge, *Ann. Mo. Bot. Gard.* 46: 134 (1959).

P. mellissii is characterized by a long abundant marginal cilia, marginal sorediate isidia and the presence of alectoronic acid in the medulla. According to Divakar and Upreti [13], this species shows great variation in the isidia. Coralloid isidia are sometimes difficult to differentiate from isidia, soredia or dactyls. Further, the specimens found from the E. Himalayan region are fertile, whereas the specimens from other regions are sterile. The specimen of the taxon could not be found; therefore, the description is based on Moon [27], Divakar and Upreti [13], and Elix [12].

Outside of South Korea, this species has also been reported in Asia, Africa and Central America.

Parmotrema eciliatum (Nyl.) Hale, *Phytologia* 28: 336 (1974).

Parmelia crinita var. *eciliata* Nyl. *Flora* 52: 291 (1869).

Parmelia eciliata (Nyl.) Nyl., in Fedde, *Repert.* 30: 225 (1932).

Parmelia platycarpa Stirt., *Scott. Nat.* 4: 252 (1878).

Remarks: *P. eciliatum* is characterized by a loosely attached thallus, dichotomous rhizines and the presence of lobules and a stictic acid complex in the medulla. *P. eciliatum* resembles *P. crinitum* in its medullary chemical nature, but the latter species has isidia on the upper surface [12]. The specimen of the taxon could not be found; therefore, the description is based on Park [16] and Elix [12].

P. eciliatum has been reported from Asia, Africa and Central America.

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REFERENCES

1. Blanco O, Crespol A, Divakar PK, Elix JA, Lumbsch HT. Molecular phylogeny of Parmotremoid lichens (Ascomycota, Parmeliaceae). *Mycologia* 2005;97:150-9.
2. Louwhoff SH, Crisp MD. Phylogenetic analysis of *Parmotrema* (Parmeliaceae: lichenized Ascomycotina). *Bryologist* 2000; 103:541-54.
3. Divakar PK, Blanco O, Hawksworth DL, Crespo A. Molecular phylogenetic studies on the *Parmotrema reticulatum* (syn. *Rimelia reticulata*) complex, including the confirmation of *P. pseudoreticulatum* as a distinct species. *Lichenologist* 2005; 37:55-65.
4. Kurokawa S, Lai MJ. Parmelioid lichen genera and species in Taiwan. *Mycotaxon* 2001;77:225-84.
5. Kirk PM, Cannon PF, Minter DW, Stalpers JA. Dictionary of fungi. 10th ed. Wallingford: CABI Publishers; 2008.
6. Crespo A, Kauff F, Divakar PK, del Prado R, Pérez-Ortega S, de Paz GA, Ferencova Z, Blanco O, Roca-Valiente B, Núñez-Zapata J, *et al.* Phylogenetic generic classification of parmelioid lichens (Parmeliaceae, Ascomycota) based on molecular, morphological and chemical evidence. *Taxon* 2010;59:1735-53.
7. Hur JS, Koh YJ, Harada H. A checklist of Korean lichens. *Lichenology* 2005;4:65-95.
8. Hur JS, Harada H, Oh SO, Lim KM, Kang ES, Lee SM, Kahng HY, Kim HW, Jung JS, Koh YJ. Distribution of lichen flora on South Korea. *J Microbiol* 2004;42:163-7.
9. Hale ME. A monograph of *Parmelia* subgenus *Amphigygnia*. *Contrib U S Natl Herb* 1965;36:193-358.
10. Krog H, Swinscow TD. *Parmelia* subgenus *Amphigygnia* (lichens) in East Africa. *Bull Br Mus (Nat Hist) Bot* 1981; 9:143-231.
11. Elix JA. Progress in the generic delimitation of *Parmelia* sensu lato, lichens (Ascomycotina: Parmeliaceae) and a synoptic key to Parmeliaceae. *Bryologist* 1993;96:359-83.
12. Elix JA. Flora of Australia. Vol. 55. Lichens: Lecanorales. 2. Parmeliaceae. Canberra: Australian Biological Resources Study; 1994.
13. Divakar PK, Upreti DK. Parmelinoid lichens in India (a revisionary study). Dehradun: Bishen Singh Mahendra Pal Singh, India; 2005. p. 295-380.
14. Orange A, James PW, White FJ. Microchemical methods for the identification of lichens. 2nd ed. London: British Lichen Society; 2010.
15. López-Figueiras M. Censo de macrolíquenes venezolanos de los estados Falcón, Lara, Mérida, Táchira y Trujillo. Merida: Faculty of Pharmacy, Los Andes University; 1986.
16. Park YS. The macrolichen flora of South Korea. *Bryologist* 1990;93:105-60.
17. Louwhoff SH. *Parmotrema* A. Massal. (1860). In: Smith CW, Aptroot A, Coppins BJ, Fletcher A, Gilbert OL, James PW, Wolseley PA, editors. The lichens of Great Britain and Ireland. London: Natural History Museum Publications; 2009. p. 661-3.
18. Jabłońska A, Oset M, Kukwa M. The lichen family Parmeliaceae in Poland. I. The genus *Parmotrema*. *Acta Mycol* 2009;44:211-22.
19. Yoshimura I. Lichen flora of Japan in colour. Osaka: Hoikusha; 1974 (in Japanese).
20. Wolseley PA, Aguirre-Hudson B, McCarthy PM. Catalogue of the lichens of Thailand. *Bull Nat Hist Mus Lond (Bot)* 2002; 32:13-59.
21. Joshi Y, Wang XY, Lee YM, Byun BK, Koh YJ, Hur JS. Notes on some new records of macro- and micro-lichens from Korea. *Mycobiology* 2009;37:197-202.
22. Sipman H. Mason Hale's key to *Parmotrema*, revised edition: key to wide-lobed parmelioid species occurring in Tropical America (genera *Canomaculina*, *Parmotrema*, *Rimelia*, *Rimeliella*) [Internet]. Berlin: Botanischer Garten und Botanisches Museum; 2005 [cited 2012 Sep 22]. Available from: <http://www.bgbm.org/sipman/keys/Neoparmo.htm>.
23. Jabłońska A, Oset M, Kukwa M. The lichen family Parmeliaceae in Poland. I. The genus *Parmotrema*. *Acta Mycol* 2009;44:211-22.
24. Kim S. Floral studies on the lichens in Korea. *Bull Kongju Teachers Coll* 1981;17:279-305.
25. Wei JC. An enumeration of lichens in China. Beijing International Academic Publishers; 1991.
26. Wang-Yang JR, Lai MJ. Additions and corrections to the lichen flora of Taiwan. *Taiwania* 1976;21:226-8.
27. Moon KH. Lichens of Mt. Sorak in Korea. *J Hattori Bot Lab* 1999;(86):187-220.