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 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 subsupsumtum (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 Parmelioideae 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 Concaramella 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 austrospinense (Zahlbr.) Hale 1974, Parmotrema clavuliferum (Räsanen) Streimann 1986 [previously known as Rimelia clavulifera (Räsanen) Kurok. 1991], Parmotrema cristiferum (Ach.) M. Choisy 1974, Parmotrema ciliatum (Nyl.) Hale 1974, Parmotrema mellissii (C. W. Dodge) Hale 1974, Parmotrema perlatum (Huds.) M. Choisy 1952 [previously known as Parmotrema chinense sensu auct.], Parmotrema praecondiosum (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 subsupsumtum (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...
**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, Sunchon 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
   1a. Thallus isidiate or sorediate .................................. 3

2. Thallus eciliate, stictic acid present —— P. eciliatum
   2a. Thallus ciliate, salazinic acid present —— P. cetramatum

3. Thallus isidiate .......................................................... 4
   3a. Thallus sorediate ................................................... 8

4. Lobe margins ciliate ................................................... 5
   4a. Lobe margins eciliate, isidia cylindrical, medulla C+ red, lecanoric acid present —— P. tinctorum

5. Isidia ciliate ................................................................ 6
   5a. Isidia eciliate or very rarely ciliate ........................... 7

6. Isidia coralloid branched and sorediate, medulla K-, C-, electoronic acid present —— P. mellissii
   6a. Isidia cylindrical, simple and not sorediate, medulla K+ yellow, P+ orange red, stictic acid present —— P. crinitum

7. Medulla C+ rose red, gyrophoric acid present ...................... P. pseudocrinitum
   7a. Medulla C-, salazinic acid present —— P. subtinctorium

8. Lobe margins ciliate ..................................................... 9

9. Medulla K+ red, salazinic acid present ———— 10
   9a. Medulla K+ (yellow/orange) or K— ———— 12

10. Upper surface faintly maculate, lobes dimorphic, secondary lobes arising from margins in the center of the thallus —— P. margaritatum
   10a. Upper surface highly maculate, dimorphic lobes absent ———— 11

11. Maculae forming an intricate reticulate network and fissuring into fine cracks —— P. reticulatum
   11a. Maculeae not forming reticulate cracks, effigurate ———— P. subsumptum

12. Medulla P+ orange or red .............................................. 13
   12a. Medulla P−, saxicolous —— P. grayanum

13. Stictic acid present —— P. perlatum
   13a. Alectoronic acid present —— P. arnoldii

14. Medulla K+ red, salazinic acid present —— P. cristiferum
   14a. Medulla K− ———— 15

15. Medulla P+ red, protocetraric acid present ———— P. dilatatum
   15a. Madulla P− ———— 16

16. Medulla C+ red, KC+ red, lecanoric acid present —— 17
   16a. Medulla C−, KC− —— P. praeosoredium

17. Thallus rugose, lobes 6-12 mm wide, margins crenate, linear soralia < 1 cm long —— P. defextum
   17a. Thallus more or less smooth, lobes 6-20 mm wide, margins ascending imbricate, linear soralia > 1 cm long ———— P. austrosinense

**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 reticulate wrinkled, black with a broad 4-6 mm wide yellowish brown, light tan to white mottled, shiny erlizinate 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).
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**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. austrosinensis* 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. austrosinensis* 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. austrosinensis* in having cilia along the margins and C− medulla. *P. cooperi* also resembles *P. austrosinensis*, 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, Baeal 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.

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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. praecordiosum* (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).
Thallus foliose, loosely adnate to the substratum, 5–12 cm across. Lobes apically round, sub irregular, often laciniate, up to 8 mm wide; margins crenate, dentate, lateral margins in the central part of the thallus lacinules, 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 sparingly 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. Sonum, 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 Upeti [13], this species is closely related to *P. stippeum* in...
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Fig. 3. Distribution of *Parmotrema* species in South Korea. A, *P. austrosinense*; B, *P. praesorediosum*; C, *P. cetratum* (▲), *P. grayanum* (★), *P. subsumptum* (●), *P. subtintctorium* (×); 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 crispiferum.

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, eiliate. Upper surface pale grey, smooth, somewhat shiny, rugose, cracked in the center, sorediate. Sorala 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, erhzinate 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−, KC+, KC+ (red), P+ (red). TLC: atranorin, chloroatranorin, usnic acid, protocetraric acid and unknown 4 (Fig. 2).

Remarks: This is the first report of P. defectum from South Korea. This species is characterized by a rugose, emaculate, thallus with eiliate 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 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, erhzinate 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−, KC−, KC+, P−. TLC: atranorin and chloroatranorin (Fig. 2).

Remarks: P. grayanum closely resembles P. prasorediosum 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, J. Yoshi, H. S. Jeon, G. S. Han, 100355; Daeki Valley, Nanhæe-gun, Gyengshangnam-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, Samsanmyeon, 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. Sobeak, 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-myeon, Jeollanam-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 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, 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. leucosmotheatum* 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, 070974; 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. Mens. Soc. Linn. Lyon 21: 174 (1952).

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

**Imbricaria ciliata** (DC.) Arnold, Flora, Jena 67: 158 (1884).

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

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

**Parmelia coniocopora** Lourier, Linnaea 2: 39 (1827).

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

**Parmelia perlatata** 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 (0.3~2 mm), moderately dense to dense. Upper surface pale grey to 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+ (red), 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, Gyeongsang 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, eilicate, 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, erhzinate marginal zone. Rhizines sparse, simple, short. Apothecia and pycnidia not seen (Fig. 1F–I).

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

**Remarks:** *P. praesorediosum* is characterized by an adnate coriaceous thallus, eilicate lobes with ascending sorediate margins and fatty acid in the medulla. Externaly, *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 esoredate thalli.

**Ecology and distribution:** This species is very common on exposed rock surfaces [13] and has been reported from Geumun 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:** Geumun Island, Samsan-myeon, Jeolnam-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, Sangdam-no, 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, Jeolnam-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′5.9″ N, 127°44′0.7″ 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′3.76″ 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* (Abbeyes) 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, 0.5–3 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, erhzinate marginal zone. Rhizines, sparse, simple, short, up to 2 mm long. Apothecia and pycnidia not seen in the specimens examined (Fig. 1F–I).

**Chemistry:** Cortex K+ (yellow), C–, KC–, P–; medulla K–, C+, 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, 1 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 leucosmotheta* (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 leucomensotheta Hue, Nouv. Arch. Mus. Hist. Nat., Paris, 4 Sér. 1: 192 (1899).
Parmelia macrouriensis C.W. Dodge, Nova Hedwigia 19: 450 (1970).
Parmelia perforata var. ciliata Nyl., Annls Sci. Nat., Bot., Sér. 4 15: 373 (1861).
Parmelia pseudovirens Gyeln., Reptrium 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 leucosomenothetum (Hue) Hale, Phytologia 28: 337 (1974).
Parmotrema pseudovirens (Gyeln.) Elix, Mycotaxon 47: 127 (1993).
Rimelia reticulata (Taylor) Hale & A. Fletcher, Bryologist 93: 28 (1990).
Parmotrema subsumptum (Nyl.) Hale, Mycotaxon 5: 434 (1977).
Parmelia ciliata (Nyl.) Gyeln., Flora, Jena 52: 117 (1869).
Canomaculina subsumpta (Nyl.) Kurok., Annls Sci. Nat., Paris, 4 Sér. 1: 192 (1899).
Rimelia subsumpta (Nyl.) Kurok., Ann. Tsukuba Bot. Gard. 10: 9 (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 lacunae, 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 grey, sorediate, isidia or isidiose phialides not seen (Fig. 1K–1N).

**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-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).
but it has been reported as corticolar 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, M ycotaxon 65: 477 (1997).

*Parmelia virens f. isidiosa* Müll. Arg., Annln K. K. Naturh. W en 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. 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. This species is very similar to *Parmotrema saccatilobum* recorded as corticolar and saxicolous 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 sacctilobum* (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. Jakeong, 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, 35°29′46.9″ 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, Congiu-si, Chungcheongnam-do, on rock, 36°09′24.4″ N, 127°36′28.0″ E, alt. 484 m, 3 Nov 2006, J. S. Hur,
Parmotrema arnoldii, as previously reported, could not be traced; therefore, the description is based on the specimens from South Korea. However, the specimens of these species were not previously reported from the E. Himalayan region. The specimen of the taxon could not be found; therefore, the description is based on Park [16], Divakar and Upreti [13], and Elix [12].

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 'crinitæ'], 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 isidial 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 Stirr., 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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