Taxonomic Study of the Lichen Genus *Lobaria* in South Korea

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*Lobaria* (Schreb.) Hoffm. is a common foliose lichen genus found on the Korean Peninsula, yet until now, no revision study has been done on this genus. After careful examination of specimens deposited in the Korean Lichen Research Institute (KoLRI), nine distinct species of *Lobaria* were confirmed. Morphological characteristics such as the presence or absence of isidia, or whether or not the surface was ridged or smooth, and chemical characteristics such as the result of the medulla reaction were of significant importance in the differentiation of species. Here, we provided detailed descriptions together with a key to all the known Korean species.

**KEYWORDS** : Anatomy, Chemistry, Lobariaceae, Morphology

Introduction

*Lobaria* (Schreb.) Hoffm. is a common large foliose lichen genus widely distributed in tropical and temperate regions, especially in the Southern hemisphere [1]. It belongs to the family *Lobariaceae* which includes two other genera, *Pseudocyphellaria* Vain, and *Sticta* (Schreb.) Ach. The genus was first proposed as *Lobaria* by Hoffmann in 1796 [2] but the establishment of this genus remained uncertain until Wainio [3] also described it. Wainio divided the *Lobaria* into two sections based on the different morphologies of the mature spore: *Lobaria* and *Ricasolia*. This taxonomic system has remained widely accepted.

Several reports had been published on *Lobaria* in Korea before [4-9] but no expert study on Korean *Lobaria* was conducted until ‘The macrolichen flora of South Korea’ was published by Park [10]. However, only seven species were included in her paper. Since then, there has been no further taxonomic research on South Korean *Lobaria*. Many other *Lobaria* species were also reported later [11], and specimens that we collected were not been able to be identified using her paper. Furthermore, some of the species she reported no longer exist in South Korea. Thus, in order to clarify the status of *Lobaria* in South Korea, it was necessary to carry out a revision study on this genus.

Materials and Methods

Two hundred and nine South Korean *Lobaria* specimens were examined and deposited in the Korean Lichen Research Institute (KoLRI), Sunchon National University. Specimens were examined using standard microscopic techniques using a NIKON SMZ645 dissecting microscope (Tochigi, Japan). Spores were observed under a NIKON Eclipse E 200 microscope. Thin layer chromatography (TLC) was performed using solvent system C (toluene : acetic acid = 85 : 15) as described by Culberson [12], and White and James [13].

Results and Discussion

**Key for all the known species of *Lobaria* in South Korea**

Includes the species found in our study (bold) in addition to previously reported species.

1. Isidia or lobules present .................................................. 2
2. Medulla KC− rose or red .................................................... 3
3. Isidia more or less spathulate, medulla K− ................................. *L. spathulata*
4. Medulla KC− ................................................................. 4
5. Medulla KC+ yellow to red .................................................. 6
6. Isidia or lobules absent ...................................................... 1

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Lobaria adscripturiens

Description of the species.

Lobaria adscripturiens (Nyl.) Hue, (1900).

Diagnostic characteristics: Thallus is medium to large, 6–8 cm in diameter, color is greenish gray to olive brown, dark brown at the margin; lobes are rounded and ascending, margin crenulate, slightly wave-shaped, 1–2 cm wide; upper surface is smooth, without soredia, isidia or lobules; lower surface is light brown to yellow-brown, covered with sparse dark-brown tomentum, brown rhizines are present near the center of the lower surface. Photobiont is green algae.

Habitat and distribution: The species is found growing on bark around 1,000–1,500 m elevation. Reported to exist in Indonesia [14] and common in South Korea (Fig. 2B).

Remarks: Morphologically and chemically, L. discolor is similar to L. quercizans due to absence of isidia and lobules, plain surface and cortex, K+ yellow, medulla K–, KC+ red containing gyrophoric acid.

Representative specimens examined: Gangwon Prov., Inje-gun, Mt. Sorak, N 38°06’45.4"E 128°26’44.9", alt 1,485 m, on bark, Hur 041613; Gangwon Prov., Mt. Odae, N 37°47’17.6", E 128°33’10.6", alt. 1,280 m, Hur 040444; Gyeongnam Prov., Hadong-gun, Hwagae-myeon, Mt. Jiri, N 35°19’679", E 127°39’522", alt. 1,346 m, Hur 091317.

Lobaria isidiophora

Diagnostic characteristics: Thallus is medium to large, 10–15 cm broad, color is blue-green when wet, becomes brown or dark brown after dried; lobes are irregularly or delicately branched, truncated at the tips; upper surface has clear reticular ridge, soredia are absent, isidia and lobules are present; flat or cylindrical isidia either single or clustered together along the ridge (Fig. 1B), lobules are irregular and covered with pruinose; lower surface is grayish-brown, covered with dark brown tomentum, growing between naked and gray swellings, brown rhizines are present. Blue-green algae are the photobiont.

Remarks: This species closely resembles L. quercizans but lacks grrophoric acid, and it has a rougher thallus. It could also be confused with L. japonica, but while it contains gyrophoric acid, L. japonica does not.

Species examined: Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°18’24.7", E 127°34’53.9", alt 1,550 m, on bark, Hur 040293; Gangwon Prov., Pyeongchang-gun, Mt. Odae, N 37°46’04.5", E 128°35’58.1", alt 1,400 m, on bark, Hur 040499; Gangwon Prov., Yangyang-gun, Seo-myeon, Galjeongokbong, N 37°52’88.0", E 128°26’84.9", alt 1,101 m, on rock, Hr 090628.
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30 × 10–12 µm.

**Chemistry:** Thallus K−; medulla K+ red, P+ orange, KC−; containing gyrophoric, constictic, norstictic, stictic and thelephoric acids.

**Habitat and distribution:** Grows on tree bark or on moss growing over rocks at an elevation of 700–1,700 m. It has been reported throughout Eastern Asia but is rare in South Korea (Fig. 2C).

**Remarks:** The species is similar to *L. retigera* with flat or cylindrical isidia along the ridged portions, but it has the K+ red medulla reaction which contains norstictic and stictic acids.

**Representative specimens examined:** Jeju Prov., Mt. Halla, N 33°21’40.8”, E 126°32’52.4”, alt 1,700 m, on bark, Hur 040826; Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°20’31.5”, E 127°41’08.9”, alt 734 m, on bark, Hur 040938; Gangwon Prov., Taebaek city, Mt. Taebaek, N 37°05’31.6”, E 128°56’46.9”, alt 1,445 m, on bark, Hur 070582.

**Lobaria japonica** (Zahlbr.) Asahina, (1933).

**Diagnostic characteristics:** Thallus is medium to large, 6–15 cm wide, color is dull yellow-brown or olive brown; lobes are irregularly or delicately branched, elongate, rather narrow, 4–12 mm broad, truncated at the top; upper surface is plan and smooth without reticular ridges, sometimes with minor wrinkles; soredia, isidia and lobules are absent on the upper surface; lower surface is lightly brown to brown covered with dark brown tomentum, mainly in the center part; rhizines are black. Green algae are the photobiont.

Apothecia are common, diffuse on the upper surface, cup-shaped, tan to reddish-brown, adnate and constricted...

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**Fig. 1.** Characteristics of the *Lobaria* species. A, Cylindrical isidia of *L. meridionalis* Hur030877; B, Dense isidia of *L. isidiosa* 040938; C, Columnar and coralloid isidia of *L. retigera* 041592; D, Flat or lobule-like isidia of *L. spathulata* 040443; E, Ascus of *L. quercizans* Hur 080501; F, Linear spore of *L. quercizans* Hur 080501; G, Fusiform spores of *L. discolor* Hur 091120 (scale bar: A~D = 1 mm, E~G = 25 µm).
et al. at the base, up to 5 mm in diameter; spores are 4-cell, linear or acicular at maturity, 50~60 × 5 µm.

Chemistry: Thallus K−; medulla KC−; no lichen substances detected by TLC.

Habitat and distribution: On the bark of trees; it has been reported in Japan and Sakhalin [14]. In South Korea, it is rare (Fig. 2D).

Remarks: Morphologically, L. Japonica is similar to L. quercizans as they share having a clear ridge on the upper surface. But chemically they are distinct. L. quercizans contains gyrophoric acid, whereas L. japonica has no such compounds.

Specimen examined: Gangwon Prov., Jeongseon-gun, Mt. Gariwang, N 37°27’31.0”, E 128°32’17.9”, alt 1,098 m, on bark, Hur 080098.

Lobaria linita (Ach.) Rabenh., (1845).

Diagnostic characteristics: Thallus is 5~15 cm broad, color is greenish to yellowish brown; lobes are irregular and wide, truncate at the tip, 0.5~2.5 cm wide; upper surface is more or less ridged, without soredia, isidia or lobules; lower surface is light yellow-brown, ridged, covered
Remarks: This species might be mistaken for \( L. \) tenuiorin and no isidia, whereas \( L. \) retigera lacks tenuiorin due to the ridge on the upper surface but \( L. \) retigera lacks tenuiorin and has isidia or lobules.

Representative specimens examined: Gangwon Prov., Inje-gun, Mt. Jumnon, N 38°02'52.1", E 128°25'51.2", alt. 1,300 m, on rock, Hur 041389; Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°18'16.5", E 127°34'14.0", alt. 1,450 m, on bark, Hur 060296; Jeju Prov., Mt. Halla, N 33°21'59.2", E 126°30'10.4", alt. 1,560 m, on bark, Hur 090167.

**Lobaria meridionalis** Vain., (1913).

**Diagnostic characteristics:** Thallus is medium to large, 5–8 cm broad, color is grayish green; lobes are deeply and irregularly laciniate, marginal part is obtuse, 0.4–0.9 cm wide; upper surface slightly ridged without soredia, isidia and lobules present, isidia are cylindrical on the ridge and marginal parts (Fig. 1A); lobules are irregular or spoon-shaped, growing on the margin of thallus, pruinose on the tip; lower surface is yellow-brown to brown, covered with tomentum which are yellow brown, rhizines are sparse and blackish. Green algae are the photobiont.

Apothecia growing on the ridge and margin, 2–4 mm in diameter, constricted at the base, discs are reddish brown to brown; spores are 3-septate, fusiform, 20–30 × 7–8 μm.

**Chemistry:** Thallus K−; medulla K+ yellow or red, P+ yellow, KC−; contains norstictic, stictic, constictic and cryptostictic acids.

**Habitat and distribution:** On the bark of deciduous trees at altitudes of 600–1,600 m. Reported throughout Eastern Asia and North America [14]. In South Korea it is not common (Fig. 2G).

**Remarks:** Morphologically \( L. \) quercizans is similar to \( L. \) japonica but is distinguished by containing gyrophoric acid. It also might be confused with \( L. \) discolor but it has acicular spores while \( L. \) discolor has fusiform spores.

**Representative specimens examined:** Gangwon Prov., Pyeongchang-gun, Mt. Odae, N 37°46'00.5", E 128°36'14.7", alt. 1,252 m, on bark, Hur 080501; Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°19'21.5", E 127°38'28.9", alt. 1,450 m, on bark, Hur 060296; Jeonbuk Prov., Mt. Deukyu, N 35°46'10.5", E 127°41'01.0", alt. 1,376 m, Hur 060567.

**Lobaria retigera** (Bory) Trevis., Lichenotheca Veneta: no. 75 (1869).

**Diagnostic characteristics:** Thallus is medium to large, 5–12 cm in diameter, color is brown to dark bluish brown; lobes are irregular, 5–10 mm wide; upper surface is ridged, isidia and lobules present, soredia absent; isidia are on the ridge or margin of the lobes, lobulate or cylindrical (Fig. 1C); lower surface is lightly yellow-brown, covered with tomentum and rare brown rhizines. Blue-green algae are the photobiont.

Apothecia are mostly on the ridge, constricted at the base, discs are brown, 2–4 mm in diameter, and spores are 3-septate, fusiform, 30–40 × 5–7 μm.

**Chemistry:** Thallus K−; medulla K−, P−, KC−; containing triterpenoids and theleporphic acid.

**Habitat and distribution:** Growing on mosses over rocks or on the base of trees at altitudes of 600–1,500 m. It has been reported in Japan, Australia, South Africa and Alaska [14]. It is common in South Korea (Fig. 2H).
Remarks: Morphologically, *L. retigera* is similar to *L. spathulata* as both have a ridged surface and coralloid isidia, but chemically they are quite different. Medullar color reaction of *L. retigera* is KC−, whereas *L. spathulata* is KC+ red.

Representative specimens examined: Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°17′34.5″, E 127°32′45.6″, alt. 1,400 m, on bark, Hur 060229; Gyeongnam Prov., Taebaek city, Mt. Taebaek, N 37°06′10.4″, E 128°57′16.1″, alt. 1,070 m, Hur 041018; Jeju Prov., Mt. Halla, N 33°23′18.1″, E 126°29′45.1″, alt. 1,300 m, Hur 040729.

*Lobaria spathulata* (Inumaru) Yoshim., J Hattori Bot Lab 34: 278 (1971).

Diagnostic characteristics: Thallus is medium to large, 4–12 cm broad, color is dull yellow-brown to brown; lobes are irregularly or delicately branched, elongate, rather narrow, 3–6 mm broad, truncated at the tip; upper surface has a clear reticular ridge, soredia are absent, isidia and lobules are present; isidia are lobule-like or cylindrical and on the ridge and margin (Fig. 1D); lobules are irregular and pruinose on the tip; lower surface is yellow-brown to dark-brown, tomentum are present together with brown rhizines. Green algae are the photobiont.

Apothecia are rare, mostly on ridges and 1–2 cm wide, discs are reddish brown; spores are 3-septate, fusiform, 25–30 × 5–7 µm.

Chemistry: Thallus K−, medulla P−, K−, KC+ rose; containing gyrophoric and thelophoric acids.

Habitat and distribution: Grows on the bark of trees at altitudes of 700–1,600 m; Reported in Japan and Formosa [14] but in South Korea it is uncommon and generally found in the Northeastern part of the country (Fig. 21).

Remarks: *L. spathulata* closely resembles *L. meridionalis*, which has well developed irregular lobules and contains cyanobacteria as phycobionts. However, *L. spathulata* has flat or lobule-like isidia and contains gyrophoric and thelophoric acids whereas *L. meridionalis* has cylindrical isidia and contains norstictic acids.

Representative specimens examined: Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°20′31.5″, E 127°41′08.9″, alt. 715 m, on bark, Hur 040934; Gangwon Prov., Tongbaram Valley, Mt. Eungbok, N 37°51′692″, E 128°31′522″, alt. 706 m, Hur 090720; Gyeongnam Prov., Sancheong-gun, Mt. Jiri, N 35°19′42.4″, E 127°35′21.8″, alt. 850 m, Hur 060369.

Six species were previously recorded on the Korean peninsula [10, 11] but not found in our study. They are listed here:

*Lobaria kurokawae* Yoshim., J Hattori Bot Lab 34: 297 (1971).

This species was recorded by Huneck et al. [8] in North Korea. Its diagnostic characteristics are: ridged surface, the absence of isidia and lobes, fusiform spores and blue-green algae as the photobiont. Its color reaction closely resembles *L. japonica*, which has medium K−, KC−, P− and thallus K− reactions, but it can be uniquely distinguished as it contains thelophoric acid.

*Lobaria isidiophora* Yoshim., J Hattori Bot Lab 34: 276 (1971).

This species was recorded by Asahina [4] in Korea. It is characterized by cylindrical and antler-like isidia, fusiform spores; medulla K+ yellow, KC+ red and P+ yellow reaction. Yoshimura considered this species to be a gyrophoric acid containing strain of *L. meridionalis* [15] and *L. orientalis* [14].

*Lobaria orientalis* (Asahina) Yoshim., (1969).

This species was recorded by Kim [5] in Korea. Its diagnostic characteristics are: the lack of isidia, the presence of antler-like lobes, fusiform spores, and the presence of gyrophoric, norstictic and stictic acids. This species was distinguished from *L. pulmonaria* by the absence of isidia and soredia by Yoshimura [15].

*Lobaria pseudopulmonaria* Gyeln., (1933).

This species was recorded by Huneck et al. [8] in North Korea. Its obvious diagnostic characteristics are: a ridged surface, absence of soredia and isidia, presence of triterpenoids and stictic acid (medullar P+ yellow or orange-red).

*Lobaria pulmonaria* (L.) Hoffm., Deutschl Flora, Zweiter Theil (Erlangen): 146 (1796).

This species was recorded by Kim [5] in Korea. This species could be easily distinguished from the Korean species by the presence of soredia. Green algae are the photobiont.

*Lobaria scrobiculata* (Scop.) P. Gaertn., in Lamarck & de Candolle, Fl. franç., ed. 3 (Paris) 2: 402 (1805).

This species was recorded by Park [6] in Korea. Its obvious diagnostic characteristics include possession of soredia and containing cyanobacteria as the photobiont.

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