

Lichen Mycota in South Korea: The Genus *Usnea*

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Abstract *Usnea* Adans. is a somewhat rare lichen in South Korea, and, in nearly two decades, no detailed taxonomic or revisionary study has been conducted. This study was based on the specimens deposited in the lichen herbarium at the Korean Lichen Research Institute, and the samples were identified using information obtained from recent literature. In this study, a total of eight species of *Usnea*, including one new record, *Usnea hakonensis* Asahina, are documented. Detailed descriptions of each species with their morphological, anatomical, and chemical characteristics are provided. A key to all known *Usnea* species in South Korea is also presented.

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

The lichen genus *Usnea* Adans. belongs to the family Parmeliaceae [1] (Lecanorales, Ascomycota), with ca. 300 species, and shows a world-wide distribution [2, 3]. Due to a fruticose habit and a beard like appearance, it is easily recognized, but difficult to identify up to species level due to the presence of varying characteristics [4, 5]. According to Ohmura [6], four taxonomically important problems have persisted in the genus *Usnea*, including distinction of similar forms of soralia between different species; evaluation of annular cracks as a taxonomic character; lack of detailed tissue-level studies and specificity and variation in lichen substances. The main characteristics of the genus include fruticose thallus, branches with a cartilaginous central axis, and the presence of usnic acid in the cortex [3, 4, 6].

The first world-wide monograph of the genus *Usnea* was published by Motyka [7], who proposed six subgenera, including *Usnea* Dill. ex Adans., *Protousnea* Motyka, *Lethariella* Motyka, *Chlorea* Nyl., *Neuropogon* Nees & Flot. and *Eumitria* Stirt. based on axis structure, thallus, and disc color and distribution pattern. Later in 2001, Ohmura

[6] proposed another subgenus *Dolichousnea* (Y. Ohmura) Articus from the subgenus *Usnea*. The subgenus *Eumitria* (Stirt.) Zahlbr. and sections *Usnea* Dill. ex Adans. and *Ceratinae* (Motyka) Y. Ohmura were segregated from the subgenus *Usnea* based on the molecular analysis reported by Ohmura [8]. Later, the subgenus *Neuropogon* was placed as a section within the subgenus *Usnea* [9]. Another molecular study reported by Articus [5] confirmed *Dolichousnea*, *Eumitria*, and *Neuropogon* as independent genera, since they have shown a monophyletic origin. According to the molecular analysis of nuclear internal transcribed spacer rDNA sequences, Wirtz *et al.* [10] reported that *Neuropogon* is polyphyletic with a core group nested within *Usnea* subgen. *Usnea* is a sister-group to section *Usnea*. Therefore, they proposed synonymizing *Neuropogon* with *Usnea*. Although the revisionary work on the genus *Usnea* was conducted in South East Asia, by Aptroot *et al.* [11]; Clerc [12], Ohmura *et al.* [13], and Ohmura [3], study of the South Korean species has been sparse. To date, seven species of *Usnea* have been reported from South Korea [14, 15]. These species include *Usnea diffracta* Vain., *Usnea longissima* Ach., *Usnea nipparensis* Asahina, *Usnea pangiana* Stirt., *Usnea rubrotincta* Stirt., *Usnea subfloridana* Stirt., and *Usnea trichodeoides* Vain. In the current study, one species, *Usnea hakonensis* Asahina, is reported as new to South Korea. In this report, detailed descriptions of all available species and an artificial key for all known species of South Korea are provided.

MATERIALS AND METHODS

This study was based on specimens deposited in the Korean Lichen Research Institute (KoLRI). The lichen samples were identified using dissecting and light microscopes. The dissecting microscope (SMZ645; Nikon, Tokyo, Japan) was

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used for identification of morphological characteristics of the thallus, reproductive structures, color, size, and shape. A compound microscope (ZEISS Scope, A1; Zeiss, Oberkochen, Germany) was used in investigation of the anatomy of thalli and fruiting bodies. Spot test reactions were performed on the thallus under the dissecting microscope, and thin layer chromatography (TLC) was performed in solvent system B (hexane : methyl *tert*-butyl ether : formic acid = 140 : 72 : 18) [16]. Localities of all examined 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 Centre at the KoLRI, Sunchon National University, South Korea. The newly reported species are indicated in bold in the identification key.

RESULTS AND DISCUSSION

Key to all known species of *Usnea* in South Korea

1. Red pigment present in the thallus *U. rubrotincta*
 - 1a. Red pigment absent in the thallus 2
2. Cortex fragile on main branches, decorticate or areolately corticated, annular pseudocyphellae present, numerous perpendicular fibrils on elongated branches 3
 - 2a. Cortex stable, consistent on the branches, elongated branches not as above 4
3. Salazinic or fumarprotocetraric acids present, branches flattened, with longitudinal furrows on the surface *U. trichodeoides*
 - 3a. Diffratic, barbatic, or evernic acids present; branches terete, without longitudinal furrows on the surface *U. longissima*
4. Thallus esorediate, pendent, branches uninflated *U. diffracta*
 - 4a. Thallus sorediate 5
5. Thallus with a jet black base, thamnolic or squamatic acids present *U. subfloridana*
 - 5a. Thallus with concolor to dark brown base 6
6. Soralia developed from the scars of detached fibrils, salazinic acid present *U. pangiana*
 - 6a. Soralia developed from the top of eroded papillae 7
7. Soralia smaller than branch diameter, US1 and US2 present, caperatic acid absent *U. hakonensis*
 - 7a. Soralia larger than branch diameter, US1 and US2 absent, caperatic acid present *U. nipparensis*

Species description.

Usnea diffracta Vain., Bot. Mag., Tokyo 35: 45 (1921).

Dolichousnea diffracta (Vain.) Articus, Taxon 53:

932 (2004).

Usnea diffracta f. *huei* Asahina, Lich. Jpn. 3: 69 (1956).

Usnea diffracta f. *depauperata* Asahina, Lich. Jpn. 3: 69 (1956).

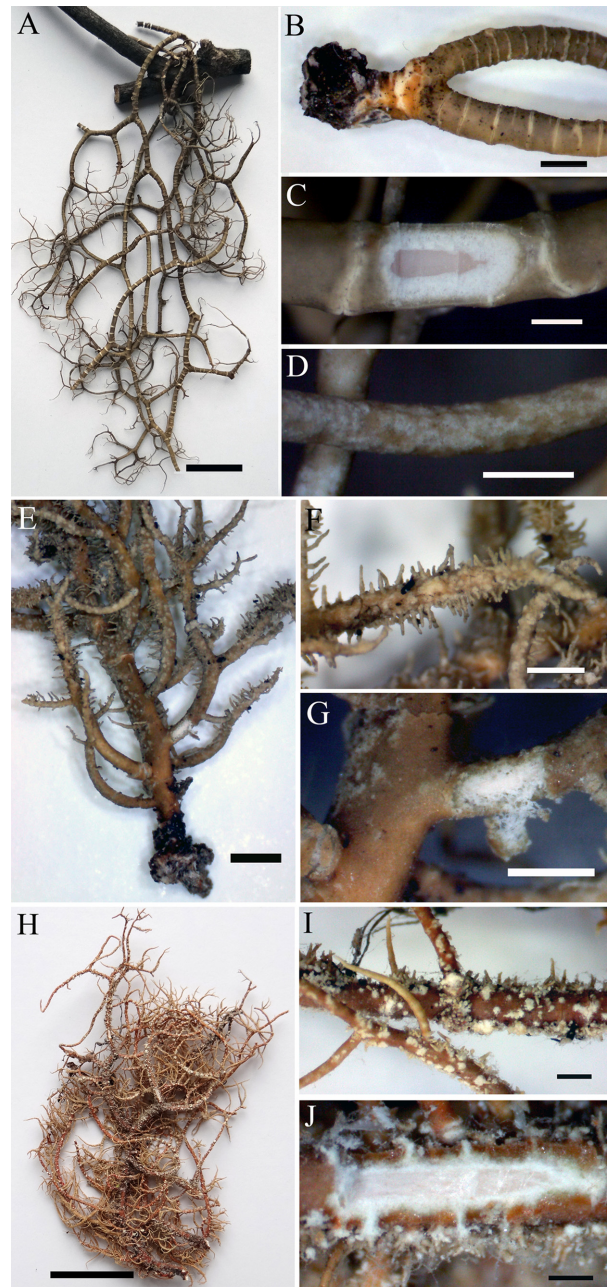


Fig. 1. *Usnea* species. *U. diffracta* (J. S. Hur, 040526): A, Thallus; B, Base of the thallus and annular pseudocyphellae at the segments; C, Uninflated branch with dense medulla; D, Punctiform maculae. *U. hakonensis* (J. S. Hur, 041199): E, Thallus; F, Lateral branches with fibrils; G, Inflated branch with medulla. *U. rubrotincta* (J. S. Hur, 050347): H, Thallus; I, Lateral branches with soralia; J, Uninflated branch with medulla (scale bars: A, E, H = 1 cm, B = 1 mm, C, D, F, G, I = 0.5 mm, J = 0.3 mm).

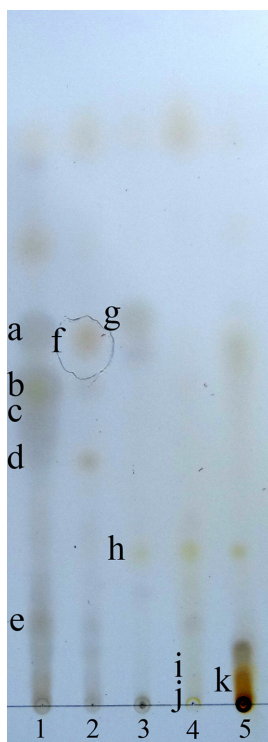


Fig. 2. Thin layer chromatography profile of *Usnea* species in solvent system B. 1, *U. diffracta* with chemical race 2, including usnic acid (a), barbatic acid (b), diffractaic acid (c), baemycesic acid (d), and squamatic acid (e); 2, *U. diffracta* with chemical race 1, including bourgeanic acid (f); 3, control [*Lethariella cladonioides* (Nyl.) Krog] with atranorin (g), norstictic acid (h); 4, *U. hakonensis* with US2 (i) and US1 (j); 5, *U. rubrotincta* with salazinic acid (k).

Thallus fruticose, pendent, up to 15 cm long, grayish green to yellowish green, pale to dark brown base; branching isotomic-dichotomous, branches corticated, glossy, with annular-pseudocyphellae between segments, terete, uninflated, 0.5~1.8 mm in diameter, gradually tapering; papillae, isidia, soralia absent; cortex thick, 10~40% of the radius, merrillii-type plectenchymatous, cortex white, pigment absent; axis solid, 20~30% of the diameter; apothecia not seen (Fig. 1).

Chemistry: Cortex K⁻, C⁻, KC⁻, P⁻; medulla K⁻, C⁻, KC⁻, P⁻; TLC: Race 1: usnic, barbatic, bourgeanic, diffractaic, baemycesic, and squamatic acids. Race 2: usnic, barbatic, diffractaic, baemycesic, and squamatic acids (Fig. 2).

Remarks: *U. diffracta* is characterized by the pendent nature of the thallus with the presence of isotomic dichotomous branching, uninflated branches, annular pseudocyphellae between segments, merrillii-type plectenchymatous cortex, and absence of soralia and papillae.

Ecology and distribution: This species is the most common *Usnea* species in South Korea. It was commonly found on coniferous and broad-leaved trees and rocks (Fig. 3). According to Ohmura [6], this species rarely grows on rock surfaces in Japan but is common in other countries of

East Asia. This species has also been recorded from North Korea [17], China [18], Japan, Taiwan [6], and South Africa [19].

Selected specimens examined: Mt. Odeda, on bark (*Abies* sp.), 37°47'18.2" N, 128°33'02.4" E, alt. 1,355 m, 7 May 2004, J. S. Hur, 040454; 37°47'03.7" N, 128°36'13.9" E, alt. 1,365 m, 8 May 2004, J. S. Hur, 040526.

Usnea hakonensis Asahina, Lich. Jpn., 3: 77 (1956).

Usnea hakonensis f. *inactiva* Asahina, Lich. Jpn. 3: 77 (1956).

Thallus fruticose, pendent, up to 2 cm long, grayish green to yellowish green, dark brown base; branching anisotomic-dichotomous, branches corticated, glossy, lacking pseudocyphellae and maculae, terete, uninflated, 0.25~0.6 mm in diameter, gradually tapering; papillae absent, soralia common, formed mainly on lateral branches, developed from the top of eroded papillae, somewhat rounded, smaller than branch diameter; isidiomorphs present, grow up to fibrils; cortex white, thin, 12~25% of the radius, pigment absent; Axis solid, 30~35% of the diameter; apothecia not seen (Fig. 1).

Chemistry: Cortex K⁺ (yellow), C⁻, KC⁻, P⁻; medulla K⁺ (yellow orange), C⁻, KC⁻, P⁺ (orange); TLC: usnic acid (trace), norstictic acid, US1, US2 (trace) (Fig. 2).

Remarks: The characteristic features of *U. hakonensis* are an erect thallus with anisotomic dichotomous branching, inflated branches with few papillae, rounded soralia at the

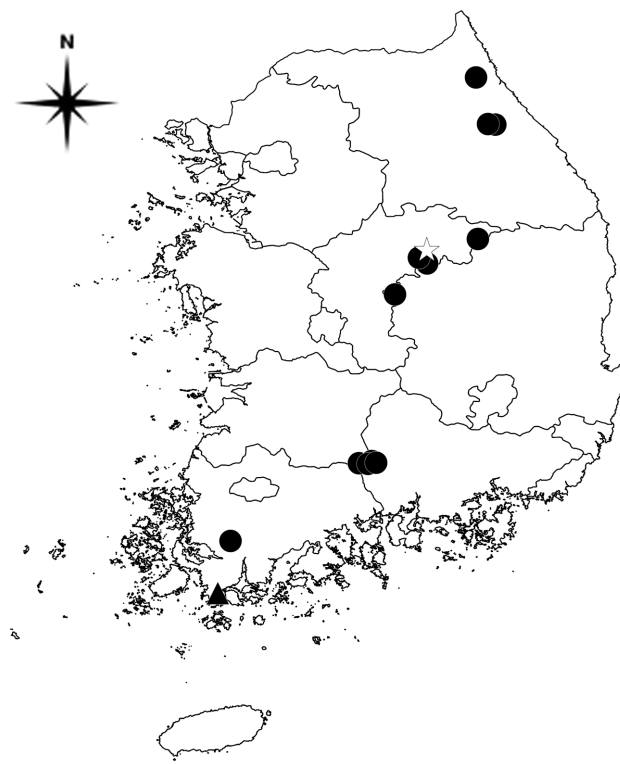


Fig. 3. Distribution of *Usnea* species in South Korea: *U. diffracta* (●), *U. hakonensis* (☆), and *U. rubrotincta* (▲).

top, often with many isidiomorphs, and the presence of US1 and US2 as major chemicals. Although two chemical races have been recognized by Ohmura [6], only Race 1 has been found in Taiwan and South Korean species.

Ecology and distribution: *U. hakonensis* species is new to South Korea and was recorded from a rock surface at Mt. Sorak (Fig. 3). This species has also been recorded from China [18], Japan, and Taiwan [6].

Selected specimen examined: Mt. Sorak, on rock, 36°52'12.7" N, 128°06'19.9" E, alt. 835 m, 19 Sep 2004, J. S. Hur, 041199.

Usnea rubrotincta Stirt., Scott. Nat. 6: 103 (1881).

Usnea ceratinella Vain., Bot. Mag. Tokyo 35: 45 (1921).

Usnea pseudorubescens Asahina, J. Jpn. Bot. 40: 130, (1965).

Usnea rubescens Stirt., Scott. Nat., N. S. 7: 76 (1883).

Usnea spilota Stirt., Scott. Nat. 6: 294 (1882).

Thallus fruticose, sub-pendent, up to 4 cm long, red to reddish brown when fresh, pale to dark brown at the base; branching anisotomic-dichotomous; branches terete, uninflated, less than 1.5 mm in diam., gradually tapering, papillate, lacking pseudocyphellae and maculae; abundant fibrils and lateral branches, lateral branches cylindrical at the base; soralia common, formed mainly on thicker branches, developed from scars of detached fibrils or lateral branches, discrete, round, smaller than branch diam., sessile, lacking granular soredia; cortex thick, 13~18% of the radius, the ceratina-type plectenchymatous cortex, red pigmented; axis solid, 46~47% of the radius; apothecia not seen (Fig. 1).

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

Remarks: *U. rubrotincta* is the only species reported so far with red pigmented cortex in South Korea [15]. The species is characterized by an erect to sub-pendent thallus with anisotomic dichotomous branching and the presence of a red pigment in the cortex, formation of sinuose soralia on lateral branches and fibrils, the ceratina-type plectenchymatous cortex, salazinic or stictic acids as the major substance, and the absence of granular soredia.

Ecology and distribution: *U. rubrotincta* was recorded from a granite rock surface at Mt. Dalma (Fig. 3). According to Asahina [20] and Ohmura [6], this species is widely distributed in temperate regions of Asia, Europe, Africa, and South America.

Selected specimen examined: Mt. Dalma, on rock, 34°22'45.4" N, 126°35'13.6" E, alt. 480 m, 26 Jul 2005, J. S. Hur, 050347.

Species excluded in this study. According to the literature, lichen species *Usnea longissima* Ach., *Usnea nipparensis* Asahina, *Usnea pangiana* Strtn., *Usnea subfloridana* Stirt., and *Usnea trichodeoides* Stirt. have previously been

reported from South Korea. However, the specimens of those species are untraceable, therefore, the descriptions are based on the previous literature.

Usnea longissima Ach., Lich. Univ.: 626 (1810).

Dolichousnea longissima (Ach.) Articus, Taxon 53: 932 (2004).

According to Ohmura [6], this species is characterized by the presence of a "fish-bone" like appearance, pendent thallus, terete and decorticate main branches, annular-pseudocyphellae between segments, especially near the base of the thallus, the merrillii-type plectenchymatous cortex, and barbatic, diffractaic, or evernic acids as the major substances.

In South Korea, this species was reported by Tou [21] and Kim [22]. In North Korea, this species was reported by Jeon *et al.* [17]. According to Ohmura [6] and Motyka [7], this is one of the common species in genus *Usnea* and has been reported from boreal regions of Asia, Europe, Russia, and North America.

Usnea nipparensis Asahina, Lich. Jpn. 3: 91 (1956).

Usnea nipparensis f. *reagens* Asahina, J. Jpn. Bot. 47: 257 (1972).

This species is characterized by the presence of an erect to sub-pendent thallus with anisotomic dichotomous branching, rounded soralia, ceratina-type plectenchymatous cortex, and caperatic acid as a major substance and the absence of granular soredia. *U. nipparensis* resembles *U. hakonensis* in having rounded soralia, which are distinctly stipitate. However, it is distinguished from the latter species by the presence of caperatic acid and the absence of US1 and US2 [6].

This species was first reported in South Korea by Kim [22]. Other than South Korea, this species was reported from Japan, Taiwan, India, Nepal [6], and China [18].

Usnea pangiana Strtn. Scott. Nat., 7: 77 (1883).

Usnea cineraria Motyka, Lich. Gen. Usnea Stud. Monogr. Pars Syst. 3: 618 (1938).

Usnea croceorubescens Vain., Bot. Mag., Tokyo 35: 46 (1921).

Usnea hondoensis Asahina, Lich. Jpn. 3: 87 (1956).

The main characteristic features of this species are an erect to sub-pendent thallus with anisotomic-dichotomous branching, annular cracks, especially near the base, punctiform soralia, which are discrete from one another, absence of granular soredia, the merrillii-type plectenchymatous cortex, and the presence of salazinic acid and/or barbatic acids as major substances [6].

In South Korea, this species was reported by Kim [22]. Other than South Korea, this species has been reported from Japan, India, Nepal, Thailand [6], and China [18].

Usnea subfloridana Stirt., Scott. Nat. 6: 294 (1882).

Lichen comosus Ach., K. Vetensk-Acad. Nya Handl.:

209 (1795).

Usnea comosa (Ach.) Röhl., *Deutschl. Fl., Abth. 2* (Frankfurt) 3: 144 (1813).

According to Ohmura [6], *U. subfloridana* is characterized by the presence of an erect to sub-pendent thallus, a jet black base, uninflated branches with cylindrical papillae on the surface, soralia having a convex top, the Florida-type plectenchymatous cortex, and thamnolic acid in the medulla.

In South Korea, this species was first reported by Kim [22]. Apart from South Korea, this species has been reported from temperate regions of Europe, Asia, and North America [6].

Usnea trichodeoides Vain., *Ann. Acad. Sci. Fenn., Ser. A* 6: 8 (1915).

Dolichousnea trichodeoides (Vain. ex Motyka) Articus, *Taxon* 53: 932 (2004).

This species is a pendent thallus, which is characterized by the presence of elongated branches (flat and areolately corticated when well developed), annular pseudocyphellae between segments, especially near the base of the thallus, the merrillii-type plectenchymatous cortex and depsidones such as salazinic or fumarprotocetraric acids as the major substance [6].

The first report of this species in South Korea was made by Kim [22]. Apart from South Korea, this species has been widely reported from boreal to temperate regions of Asia, Australia, Europe, and South Africa [6].

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