

Notes on the Lichen Genus *Hypotrachyna* (Parmeliaceae) from South Korea

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Abstract *Hypotrachyna* (Vainio) Hale is a somewhat rare lichen genus found on the Korean Peninsula. Since it was first recorded more than two decades ago, no detailed taxonomic or revisionary study of the genus has been conducted. Thus, the present study was conducted to carry out a detailed taxonomic and revisionary study of *Hypotrachyna* in South Korea. This study was based on specimens deposited in the Korean Lichen Research Institute (KoLRI). Detailed taxonomic studies and a literature review confirmed the presence of seven species of *Hypotrachyna* from South Korea, including one new record, *Hypotrachyna nodakensis* (Asahina) Hale. Descriptions of each species with their morphological, anatomical and chemical characters together with a key to all known *Hypotrachyna* species are presented.

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

The genus *Hypotrachyna* (Vainio) Hale was segregated from the collective genus *Parmelia* Ach. s. lat. by Hale [1]. According to Hale [2], the segregated *Hypotrachyna* was a unique group in the Parmeliaceae due to the presence of a characteristic branching pattern of the rhizines. Recent phylogenetic studies of foliose Parmeliaceae conducted by Blanco *et al.* [3] and Crespo *et al.* [4] have revealed seven and eight well-supported clades, respectively. In both studies, *Hypotrachyna* clade is distinguished as one of the main clade. Several genera (*Cetrariastrum*, *Everniastrum*, *Hypotrachyna*, and *Parmelinopsis*) are included in the *Hypotrachyna* clade [4], with *Hypotrachyna* being the largest and containing more than 190 species [5, 6].

The genus *Hypotrachyna* is primarily found at higher elevations (between 1,300 and 2,500 m) in tropical America and tropical Asia [7]. Recently, a molecular study carried out by Divakar *et al.* [8] resulted in segregation of a new genus *Remototrachyna* from the genus *Hypotrachyna*. This new genus is composed of 15 species that were previously

in the *Hypotrachyna* genus.

To date, no detailed studies of *Hypotrachyna* in South Korea have been conducted. However, a total of eight species, *Hypotrachyna exsecta* (Taylor) Hale, *Hypotrachyna ikomae* (Asahina) Hale, *Hypotrachyna incognita* (Kurok.) Hale [currently known as *Remototrachyna incognita* (Kurok.) Divakar & A. Crespo comb. nov.], *Hypotrachyna koyaensis* (Asahina) Hale [currently known as *Remototrachyna koyaensis* (Asahina) Divakar & A. Crespo comb. nov.], *Hypotrachyna osseoalba* (Vain.) Y. S. Park & Hale, *Hypotrachyna physcioides* (Nyl.) Hale, *Hypotrachyna pseudosinuosa* (Asahina) Hale and *Hypotrachyna revoluta* (Flörke) Hale, have been recorded in South Korea [9]. In the present study, a species novel to Korea, *Hypotrachyna nodakensis* (Asahina) Hale, is reported. Monographic studies of the genus have been carried out by Hale [2], Krog and Swinscow [10], Elix [7, 11], and Divakar and Upreti [12]. Thus, the main objective of this study was to prepare a detailed taxonomic description of the South Korean *Hypotrachyna* species.

MATERIALS AND METHODS

This study was based on specimens deposited in the Korean Lichen Research Institute (KoLRI). The lichen samples were identified using stereo and light microscopes, while a dissecting microscope (Nikon SMZ645; Nikon, Tokyo, Japan) was used to identify morphological characteristics of the thallus, reproductive structures, color, size and shapes. Additionally, a compound microscope (Zeiss Scope. A1; Zeiss, Jena, Germany) was used to investigate the anatomy of thalli and fruiting bodies. Spot test reactions were conducted to investigate the thalli under a compound microscope, and thin layer chromatography (TLC) was

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performed in solvent systems A (toluene:dioxin:acetic acid = 180:45:5) and C (toluene:acetic acid = 85:15) [13]. All examined locations 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.

RESULTS AND DISCUSSION

Key to the all known species of *Hypotrachyna* in South Korea

1. Thallus isidiate or lobulate 2
 - 1a. Thallus lacking isidia, sorediate or pustulate sorediate 4
2. Isidia absent, lobules present, medulla C-, barbatic acid present *H. physcioides*
 - 2a. Isidiate thallus 3
3. Medulla C-, KC-, gyrophoric acid absent *H. ikomae*
 - 3a. Medulla C± rose, KC+ rose or red, gyrophoric acid present ***H. nodakensis***
4. Soralia capitate, pustules absent, protocetraric acid present *H. pseudosinuosa*
 - 4a. Soredia pustulate 5
5. Upper cortex UV+ yellow, lichexanthone present *H. osseoalba*
 - 5a. Upper cortex UV-, lichexanthone absent 6
6. Medulla C+ rose, KC+ rose or red, gyrophoric acid present *H. revoluta*
 - 6a. Medulla C+ yellow or C-, KC+ orange, barbatic acid present *H. exsecta*

Species description.

Hypotrachyna nodakensis (Asahina) Hale, *Phytologia* 28: 341 (1974).

Parmelia nodakensis Asahina 1959.

Thallus foliose, loosely adnate to the substrate, 5~8 cm across. Lobes subirregular, 1~5 mm wide; margins entire, eciliate apices subrotund. Upper surface pale yellowish grey, emaculate, smooth, without phyllidia and sorediate, isidiate. Isidia simple to coralloid branched, somewhat brown tipped. Medulla white. Lower surface black with brown margin, sparsely rhizinate. Rhizines dichotomously branched, black. Apothecia and pycnidia not seen (Fig. 1).

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

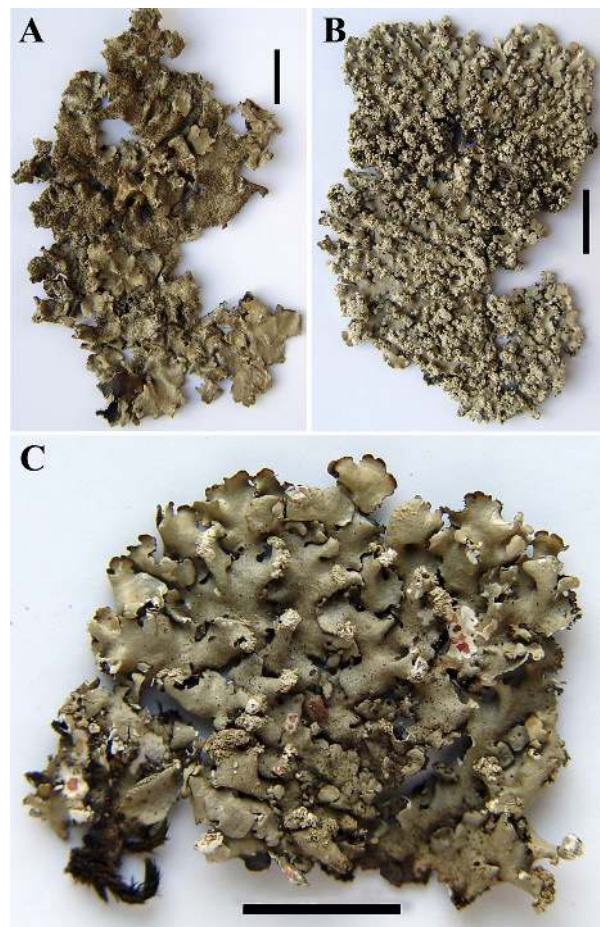


Fig. 1. *Hypotrachyna* species. A, *H. nodakensis* (J. S. Hur, X. Y. Wang, J. A. Ryu, J. Y. Hur, 90041); B, *H. osseoalba* (J. S. Hur, 70056); C, *H. revoluta* (J. S. Hur, X. Y. Wang, J. A. Ryu, J. Y. Hur, 90338) (scale bars: A~C = 1 cm).

Remarks: *H. nodakensis* is new to South Korea and a somewhat rare species. It is characterized by the presence of simple to coralloid branched isidia and protolichesterinic and gyrophoric acids in the medulla. According to Chen *et al.* [14], *H. nodakensis* closely resembles *H. infirma* and *H. ikomae* due to the presence of isidia and fatty acids in the medulla. However, it differs from *H. infirma* by not having caperatic and norcaperatic acids in the medulla. *H. ikomae* has the same fatty acids in the medulla as *H. nodakensis*, but lacks gyrophoric acid.

Specimens examined: Jeju Island, on bark (Cherry tree), 33°27'6.94" N, 126°33'07.9" E, alt. 278 m, 19 Apr 2009, 090041; Mt. Gaya, on bark, 35°47'54.8" N, 128°05'56.2" E, alt. 642 (675) m, 15 Apr 2004, 040193 (Fig. 3).

Geographical distribution: This species has been reported from China [15] and Japan [16].

Hypotrachyna osseoalba (Vain.) Y. S. Park & Hale, *Taxon* 38: 88 (1989).

Parmelia osseoalba Vain., *Ann. Bot. Soc. Zool. Bot. Fenn. Vanamo* 1: 39 (1921).

Thallus foliose, adnate to loosely adnate, 3~8 cm across. Lobes crowded, sublinear, 1~3 mm wide; margins entire, eciliate, apices incised. Upper surface pale yellowish grey, emaculate, shiny, smooth, without isidia or phyllidia, sorediate. Soredia in coarse, laminal pustules or coralloid clusters. Medulla white. Lower surface black, densely rhizinate. Rhizines dichotomously branched, black. Apothecia and pycnidia not seen (Fig. 1).

Chemistry: Cortex K⁻, UV⁺ (yellow), C⁻, KC⁻, P⁻; medulla K⁺ (reddish), C⁻, KC⁺ (red), P⁺ (orange). TLC: chloroatranrin, lichexanthone, lividic acid, physodic acid (Fig. 2).

Remarks: This species is characterized by pustulate soredia and cortical lichexanthone (yellow under UV light). According to Elix [11], *Hypotrachyna novella* is very closely related to *H. osseoalba*, but is very rare and lacks vegetative propagules.

Specimens examined: Mt. Baekseokbong, Gangwon-do, on rock, 37°28'7.39" N, 128°39'7.60" E, alt. 494 m, 16 May

2009, 090469; Mt. Bannon, Buk-myeon, Gangwon-do, on rock, 37°26'6.19" N, 128°45'49.0" E, alt. 1,064 m, 28 May 2010, 100848; 37°26'6.37" N, 128°45'49.4" E, alt. 1,067 m, 28 May 2010, 100838; Mt. Cheongwan, Jeollanam-do, on bark (*Pinus* sp.), 34°32'33.1" N, 126°55'46.7" E, alt. 300 m, 7 Oct 2005, 050547; Mt. Joryeong, Chungcheongbuk-do, on bark (*Pinus* sp.), 36°49'00.2" N, 128°03'10.4" E, alt. 909 (965) m, 27 Oct 2006, 061102, 061102-1; on rock, 36°49'00.9" N, 128°02'53.7" E, alt. 784 (840) m, 27 Oct 2006, 061049; Mt. Kongduck, on rock, 36°45'00.3" N, 128°15'53.0" E, alt. 643 m, 20 Jun 2007, 070080; Mt. Mangeun, Gyeongsangnam-do, on rock, 34°51'18.5" N, 127°51'49.6" E, alt. 618 m, 28 Apr 2011, 110204; 34°51'25.3" N, 127°51'44.3" E, alt. 630 m, 28 Apr 2011, 110198; Saryang Island, Gyeongsangnam-do, on rock, 34°50'44.8" N, 128°12'13.9" E, alt. 266 m, 17 Mar 2007, 070056; Mt. Talma, Jeollanam-do, on rock, 34°22'32.0" N, 126°35'03.9" E, alt. 435 m, 26 Jul 2005, 050367; Mt. Weolchul, on bark (*Pinus* sp.), 34°45'22.3" N, 126°40'34.5" E, alt. 400 m, 5 Apr 2003, 030120; Mt. Yang, Gyeongsangnam-do, on bark, 36°09'24.1" N, 127°36'22.2" E, alt. 580 (680) m, 3 Nov 2006, 061204 (Fig. 3).

Ecology and distribution: This species is commonly distributed in South Korea. According to Elix [11], this species occurs in cosmopolitan subtropical and temperate areas.

Hypotrachyna revoluta (Flörke) Hale, Smithsonian. Contrib. Bot. 25: 60 (1975).

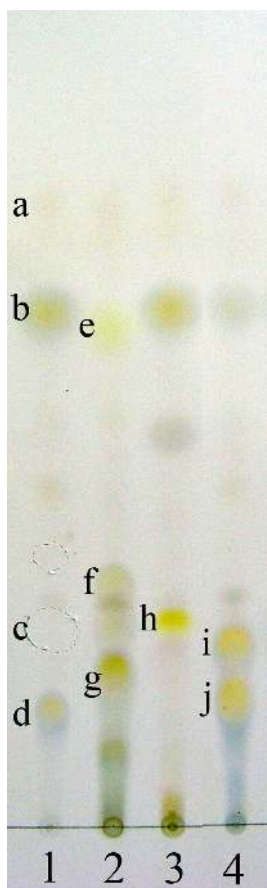


Fig. 2. Thin layer chromatography profile of *Hypotrachyna* species in solvent system A. 1, *H. nodakensis* with chloroatranrin (a), atranorin (b), protolichesterinic acid (c), gyrophoric acid (d); 2, *H. osseoalba* with lichexanthone (e), lividic acid (f), physodic acid (g); 3, Control [*Lethariella cladonioides* (Nyl.) Krog] with norstictic acid (h); 4, *H. revoluta* with unknown 1 (i) and gyrophoric acid (j).

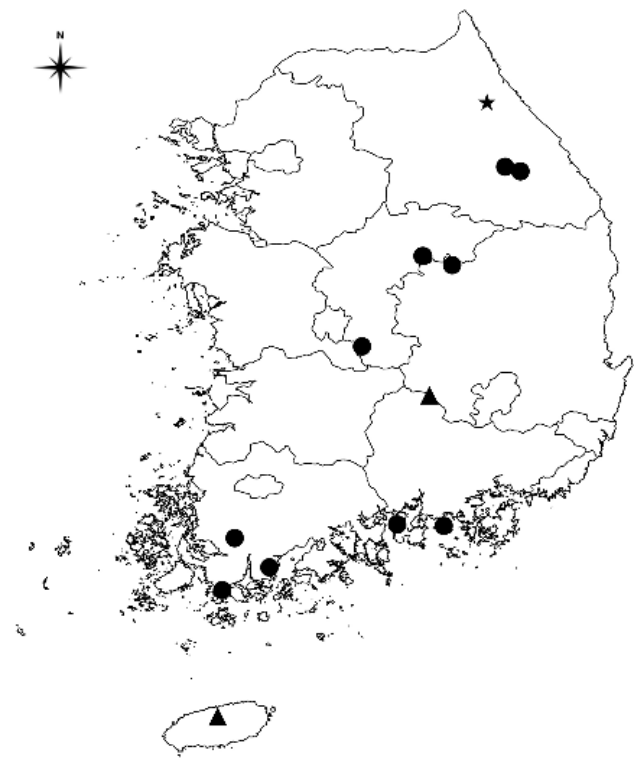


Fig. 3. Distribution of *Hypotrachyna* species in South Korea: *H. nodakensis* (▲), *H. osseoalba* (●), and *H. revoluta* (★).

Parmelia revoluta Flörke, in Sprengel, Syst. Veg., Ed. 16 4: 248 (1827).

Imbricaria revoluta Fw. In 28. Jahresber. Schlesisch. Gesellsch. Vaterl. Kultur 129 (1850).

Imbricaria sinuosa f. *concentrica* Arnold, Flora, Jena 53: 212 (1870).

Parmelia forsteri Leight., in Lindsay, Bull. U. S. Natl. Mus. 9: 91 (1869).

Parmelia laevigata var. *forsteri* (Leight.) Leight., Trans. Bot. Soc. Edinb. 9: 91 (1869).

Parmelia quercina var. *erratica* (Linds.) Hillmann, Rabenh. Krypt. Fl., Ed. 2 (Leipzig) 9: 192 (1936).

Parmelia revoluta var. *concentrica* (Arnold) Cromb., Monogr. Lich. Br. 1: 238 (1894).

Parmelia revoluta var. *erratica* (Linds.) Zahlbr., Cat. Lich. Univers. 6: 195 (1929) [1930].

Parmelia revoluta var. *minor* Harm., in Kieffer, Bull. Soc. Hist. Nat. Metz: 53 (1895).

Parmelia sinuosa var. *erratica* Linds., Trans. R. Soc. Edinb. 22: 216 (1859) [1861].

Parmelia sinuosa var. *excentrica* Mudd, Man. Br. Lich.: 96 (1861).

Thallus loosely adnate to the substratum, thin, fragile, 4 cm across. Lobes sublinear to subirregular, short, ascending at the tips, 1~3 mm wide. Upper surface mineral grey, smooth, emaculate, becoming pustulate towards the lobe tips, pustules becoming sorediate. Medulla white. Lower surface black, with brown marginal zone, sparsely rhizinate. Rhizines short, dichotomously branched. Apothecia and pycnidia not seen (Fig. 1).

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

Remarks: This species is characterized by pustulate soredia, revolute lobes and the presence of gyrophoric acid in the medulla. According to Divakr and Upreti [12], this species is closely related to *H. rockii* by the nature of its soredia and C+ rose medulla, but the latter has a white maculate upper surface and evernic and lecanoric acids in the medulla.

Specimens examined: Micheongol Valley, Gangwon-do, on bark, 37°56'10.6" N, 128°31'8.77" E, alt. 420 m, 14 May 2009, 090338 (Fig. 3).

Geographical distribution: In South Korea, *H. revoluta* was first reported by Kashiwadani *et al.* [17]. This species has also been reported in China [15], Japan [18], and most European countries.

Species excluded from this study.

According to earlier publications by different authors, the *Hypotrachyna* taxa listed below have been reported from South Korea. Some of these taxa have not been found in South Korea or have been synonymized by other taxa. However, taxonomic details are provided for the following species, *Hypotrachyna exsecta* (Taylor) Hale, *Hypotrachyna ikomae* (Asahina) Hale, *Hypotrachyna physcioides* (Nyl.)

Hale and *Hypotrachyna pseudosinuosa* (Asahina) Hale, based on previous literature.

Hypotrachyna exsecta (Taylor) Hale, Phytologia 28: 341 (1974).

Parmelia exsecta Taylor, Lond. J. Bot. 6: 166 (1847).

This species is characterized by pustules that become erumpent, eroded and granular-sorediate with age and by the presence of atranorin, chloroatranorin and barbatic acid in the medulla. This species is closely related to *Hypotrachyna laevigata*, but the latter has wider lobes and faint maculae without pustules [11].

According to Park [19], *H. exsecta* was first reported on cherry trees in South Korea. In addition to South Korea, this species has been reported in Australia [11], India [12], Japan [18], North Korea [20], Malaysia [21], and Papua New Guinea [22].

Hypotrachyna ikomae (Asahina) Hale, Phytologia 28: 341 (1974).

Parmelia ikomae Asahina, J. Jpn. Bot. 28: 134 (1953).

This species is characterized by broad, sublinear lobes with subrotund apices, cylindrical to irregularly thickened isidia and the presence of protolichesterinic, lichesterinic, nephrosterinic and isonephrosterinic acids in the medulla [14].

H. ikomae was first reported in South Korea by Park [19]. This species has also been reported from China [14], Japan [23], and Malaysia [24].

Hypotrachyna physcioides (Nyl.) Hale, Smithson. Contrib. Bot. 25: 54 (1975).

Parmelia physcioides Nyl., Syn. Meth. Lich. 1: 385 (1860).

This species is characterized by a lack of vegetative propagules (rarely sparse lobules may be present) and the presence of a barbatic acid complex in the medulla. It is widely distributed and shows many morphological and chemical variations [14].

H. physcioides from South Korea was reported by Park [25]. This species has also been reported in many countries at tropical region.

Hypotrachyna pseudosinuosa (Asahina) Hale, Smithson. Contrib. Bot. 25: 58 (1975).

Parmelia pseudosinosa Asahina, J. Jpn. Bot. 26: 329 (1951).

According to Chen *et al.* [14], *H. pseudosinuosa* is characterized by the presence of capitate, subterminal soralia, and protocetraric acid in the medulla.

This species is widespread in panatropical regions including Brazil [26], China [14, 15], Costa Rica [27], Japan [18], Malaysia [21], Papua New Guinea [28], Taiwan [29], and Venezuela [30].

The following two *Hypotrachyna* species have been

synonymized with the genus *Remototrachyna*.

Hypotrachyna incognita (Kurok.) Hale=*Remototrachyna incognita* (Kurok.) Divakar & A. Crespo comb. nov.

Hypotrachyna koyaensis (Asahina) Hale=*Remototrachyna koyaensis* (Asahina) Divakar & A. Crespo comb. nov.

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