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Hypogymnia in the Himalayas of India and Nepal

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Abstract: Morphological and chemical studies of *Hypogymnia* from the Himalayas revealed one new species, three species new to the region, and a previously unrecognized synonym. *Hypogymnia crystallina*, distinguished by its rimmed holes in the lobe axils, a pruinose disc, POL+ epihymenium, and distinctive chemistry (zeorin, hypoprotocetraric acid, usnic acid and atranorin) is described as new. *Hypogymnia pseudohypotrypa* (Asah.) A. Singh is synonymized with *H. thomsoniana* and a second location is reported for the recently described *H. sikkimensis*. *Hypogymnia bitteri*, *H. mundata*, and *H. subarticulata* are reported as new to India. A total of 17 species of the genus *Hypogymnia* are accepted for the Himalayan region of India and Nepal, with one additional species from southern India. A key is given to the species known from this region.

Key words: China, *Hypogymnia crystallina, H. mundata, H. pseudohypotrypa, H. sikkimensis, H. thomsoniana, Lecanorales*, lichenized fungi, *Parmeliaceae*, Sikkim

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Introduction

Awasthi (1984, 1988) published the first comprehensive treatments of *Hypogymnia* in India, but the genus has since received only sporadic attention in India and Nepal. Elix & Jenkins (1989) provided chemical and morphological data for several species from the region. Singh (1999) reported six species from the eastern Himalayan region, including three from Sikkim, two from Nagaland, one from Manipur, and one from Darjeeling. Sinha (1999) listed four species from Sikkim. Sinha & Elix (2003) described *H. sikkimensis* from one site in Sikkim. Upreti & Divakar (2008) reported *H. hengduanensis* as new to India, the first of the Chinese species with rimmed holes (McCune *et al.* 2002) to be reported south or east of China. McCune (2012) corrected the concepts of *H. delavayi* and *H. alpina*, based on examination of the types, such that *H. delavayi* is no longer accepted for India or Nepal.

Recent compendia of Indian lichens have included 13 species of *Hypogymnia* (Awasthi 2000), and then 14 species (Awasthi 2007). In the latest checklist for India, Singh & Sinha (2010) reported 15 species, while Aptroot & Feijen (2002) reported seven species from Bhutan, and Baniya *et al.* (2010) reported three species from Nepal.

Our understanding of *Hypogymnia* in northern India and Nepal suffers from patchy collections. Although we still lack sufficient information to present a thorough treatment, we take this opportunity to resolve a few taxonomic problems in the genus, report species new to the region, and provide a key to species known from the area.

Methods

We applied standard microscopy and chemical spot test methods. Many specimens were subjected to thin-layer chromatography (TLC), using the standard methods of Culberson (1972) and reference tables of Chicita Culberson (1996, unpublished). Fragments of specimens were extracted in acetone at room temperature, spotted on aluminum-backed silica gel plates (Merck 5554/7 Silica gel 60 F_{254}), run in solvent systems A and C of Culberson (1972), lightly brushed with 10% H_2SO_4, and charred in an oven at 100°C. No attempt was made to distinguish chloroatranorin from atranorin.

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Key to Species of *Hypogymnia* in India and Nepal

Species not yet known from northern India and Nepal, but known from adjoining regions in Asia, are indicated by square brackets [. . .].

1 Lobes solid; soredia absent . . . . . **H. mundata**
Lobes hollow; soredia absent or present 2

2(1) Thallus isidiate, the isidia sometimes degrading into soredia. . . . . **Group 1**
Thallus lacking isidia, sorediate or not 3

3(2) Thallus yellowish green (containing usnic acid, always lacking atranorin); lobes broad, mostly >2 mm wide . . . . . **Group 2**
Thallus colour various (with or without usnic acid, always with atranorin), lobes broad or narrow, but if lobes >2 mm broad then not yellowish 4

4(3) Thallus sorediate . . . . . **Group 3**
Thallus lacking soredia, isidia, and laminal lobules, though sometimes with lateral bud-like branches that resemble lobules . . . . . **Group 4**

Group 1—Isidiate

1 Holes (perforations) in lower surface with a raised rim; isidia cylindrical, clavate, or pear-shaped; diffractaic acid present, physodic acid lacking (KC−) . . . . . **H. hengduanensis**
Holes in lower surface with an even rim, not or only slightly raised 2

2(1) Thallus containing usnic acid in addition to atranorin, physodic acid lacking (medulla KC−). . . . . **H. sikkimensis**
Thallus lacking usnic acid, containing atranorin and physodic acid (medulla (KC+ orange or red); isidia roundish to bursting (pustular) or cylindrical, often compound or branched; physodic acid present; lobes nearly contiguous to separate; isidia laminal and marginal; branching typically frondose with dense, narrow, perpendicular side lobes. Corticolous; reported from Sri Lanka, southern India, Papua New Guinea, Java, North Borneo, Phillipines, but not known from the Himalayan region . . . . . [**H. pectinatula and H. zeylanica**]

Group 2—Thallus large and yellowish, containing usnic acid

1 Soredia absent . . . . . **H. flavida**
Soredia present, often on the edges of detaching corticate flakes (schizidia) . . . . . **H. hypotrypa**

Group 3 — Sorediate

1 Soredia lining burst lobe tips 2
Soredia laminal or terminal, but not lining burst lobe tips. 4

2(1) Lower surface entire, lacking roundish holes; lobes usually without perpendicular adventitious side branches; solarized thalli blackish or greyish rather than brownish-melanized. Apparently rare in India . . . . . **H. physodes**
Lower surface and lobe tips with roundish holes; lobes sometimes with perpendicular adventitious side branches; solarized thalli with brownish to dark brown upper surface. 3

3(2) Medulla P+ orange; lobes typically short and broad (internodes *c.* 2–5(9) mm long; lobes (0·7)1·5–3(4) mm broad) . . . . . **H. subarticulata**
Medulla P−; lobes generally elongate and slender, rarely >2 mm broad . . **H. vittata**

4(1) Soredia initially developing along edges of flakes of cortex on the upper surface, becoming schizidiate, the upper cortex plus algal layer detaching as flakes, often with sorediose edges; 3-hydroxyphysodic acid present (medulla K+ reddish brown) . . . . . **H. pseudobitteriana**
Soredia otherwise, not derived from cortical flakes, derived from erupting isidia-like warts or the cortex dissolving into a mass of powdery or granular soredia; 3-hydroxyphysodic acid present or not (medulla K+ reddish brown or K−) 5

5(4) Lobes becoming separated, suberect or erect; branching mainly isotomic dichotomous; upper surface pale mineral grey or pale greenish grey, lobe tips sometimes slightly browned before soredia emerge . . . . . **H. tubulosa**
Lobes contiguous, appressed; branching anisotomic in part; upper surface pale greenish grey to more often pale to dark brown 6

6(5) Soralia partly or wholly terminal, often on small upturned side lobes, sometimes on the main lobes; lobe tips often sparsely perforate . . . . . **H. bitteri**
Soralia mainly laminal, sometimes on the tips of main lobes, but not terminal on small side lobes, coarsely granular to powdery; lobe tips imperforate except where eaten by herbivores or otherwise damaged . . . . . **H. austerodes**

Group 4—Isidia and soredia absent

1 Disc usually pruinose; lobe tips and axils with rimmed holes; thallus with hypoprotocetraric acid, zeorin, usnic acid, and atranorin . . . . . **H. crystallina**
Disc epruinose; lobe tips and axils with holes that do not have a differentiated raised rim 2

2(1) Upper cortex readily solarized to dark brown or blackish, only very shaded individuals pale greenish grey; substratum commonly soil, rock, alpine sod, wood, and bark; medulla P+ orange-red (physodalic acid) or P− . . . . . **H. alpina**
Upper cortex usually pale greenish grey, rarely solarized to dark brown or blackish under extreme exposure; substratum usually bark or wood; medulla always P− (physodalic acid lacking) 3

3(2) Upper surface becoming distinctly verrucose; adventitious buds abundant; lobes strongly pinched-and-swollen (i.e. with alternating constrictions and swellings) . . . . . **H. wattiana**
Upper surface smooth to slightly rugose. 4

4(3) Lower surface and axils with sparse, large holes; lobes commonly >2 mm broad, though slender lobes may be present; perpendicular adventitious branches sparse or lacking . . . . . **H. thomsoniana**
Lower surface and axils with frequent holes that are small or large; lobes mostly slender (<2 mm broad); perpendicular adventitious branches frequent. 5

5(4) Holes in lower surface frequently offset from the midline of the lobe, sometimes lateral, and sometimes forming a staggered series near the lobe tips; soredia absent; apothecia and pycnidia frequent . . . . . **H. irregularis**
Holes in lower surface $\pm$ centred on the midline of the lobe, usually just a single hole centred on the lobe tip or axil with few or no holes in the internodes; soredia usually present with careful searching; apothecia and pycnidia typically absent. . . . . **H. vittata**

The Species

In the following synopses, more detail is given for species whose concepts are being revised here. Type specimens are listed only for Asian species.

Hypogymnia alpina D. D. Awasthi

Kavaka **12**(2)**:** 1. (1984); type: India, Uttar Pradesh, Uttarkashi District, Gomukh area, 6th moraine, 3750 m, on twigs of scandent shrubs, *Awasthi & Singh* 8567B (LWG!).

Synopsis. Thallus loosely appressed, with separate, rarely contiguous lobes; brown to dark brown, uniformly blackening or blackish mottled, holes in lobe tips occasional to frequent, appressed to suberect, cavity white above and dark below or tan to grey above and below; isidia and soredia absent.

Chemistry. Atranorin and physodic acids, usually (75% of 40) with physodalic and protocetraric acids, with accessory 3-hydroxyphysodic acid (55%); medulla K− or K+ slow reddish brown, KC+ orange-red, usually P+ orange, sometimes P−.

Substratum. Commonly on soil and rock, also on bark and wood; subalpine and alpine.

Distribution. Northern India, Nepal, Sichuan, Tibet, and Yunnan. The species apparently occurs along the whole length of the Himalayas, from the western Himalayas through Nepal to the eastern Himalayas, and extending into the Hengduan Mountains of Sichuan and Yunnan.

Discussion. Previously confused with *H. delavayi*, but *H. alpina* is morphologically unrelated to that species (McCune 2012).

Selected specimens examined. See McCune (2012).

Hypogymnia austerodes (Nyl.) Räsänen

Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo **18**(1)**:** 13 (1943).—*Parmelia austerodes* Nyl., *Flora* **64**(33)**:** 537 (1881).

Synopsis. Thallus forming rosettes, with appressed, contiguous lobes, readily solarizing to brown, with laminal granular to isidiose soredia; lobes imperforate.

Chemistry. Atranorin, physodic acid, and accessory 3-hydroxyphyodic acid; medulla K+ slow red-brown or K−, KC+ orange-red, P−.

Substratum. On bark, wood, tundra sod, or mosses or detritus over rock.

Distribution. Widespread in the Northern Hemisphere, tundra to boreal and montane; rare in SW China and Himalayas. The report from Sikkim, India (*Divakar* 3849, Upreti & Divakar 2008) is redetermined here as *H. bitteri*.

Discussion. The propagules of *H. austerodes* are quite variable, most often corticate granules that gradually degrade into soralia. Sometimes expanded laminal lobules or finger-like isidia are formed. All tend to have the cortex disintegrating eventually, but some specimens may have persistently corticate lobules. In *H. austerodes*, broken or abraded marginal lobules or isidia simulate *H. bitteri*, but there are no true terminal soralia in *H. austerodes*, except where laminal buds develop terminal soredia. A problematic form has laminal and marginal isidia and lobules that develop sorediate tips. Specimens of this form that have sparse holes in the lobe tips are *H. bitteri*, while imperforate forms may be best assigned to *H. austerodes*. See Hansen & McCune (2010) for further comparisons of *H. austerodes* and *H. bitteri*.

Selected specimens examined. **India**: *Uttaranchal*: 16 km SE of Gangotri, Tabovan, 30°54′N 79°6′W, on rocks, *Tibell* 22033 (UPS).

Hypogymnia bitteri (Lynge) Ahti

Ann. Bot. Fenn. **1:** 20 (1964).—*Parmelia bitteri* Lynge, *Stud. Lich. Flora Norway*, p. 138 (1921).

Synopsis. Thallus forming rosettes; *lobes* contiguous, appressed solarizing to brown, with terminal and laminal soralia; similar to *H. austerodes* but with soralia on short, narrow upturned lateral lobes and often with small holes in the lobe tips.

Chemistry. Medulla K+ slow red-brown or K−, KC+ orange-red, P−; typically containing atranorin, physodic acid, and accessory 3-hydroxyphysodic, 2′-*O*-methylphysodic, and

TABLE 1. Hypogymnia *species in India and Nepal and their occurrences from west to east along the Himalayas to the Hengduan Mountains of China; "+" indicates presence; "++" indicates common occurrence and the area of peak frequency within its range. Records from Bhutan are partly based on Aptroot & Feijen (2002), the specimens not seen by us. Species other than* H. delavayi *that occur in the Hengduan Mountains of China, but not in India or Nepal are not shown*

Hypogymnia species	S India	NW India	Nepal	NE India	Bhutan	SW China
alpina	−	++	++	++	+	+
austerodes	−	+	−	−	−	+
bitteri	−	−	−	+	−	+
crystallina	−	−	−	+	−	−
delavayi	−	−	−	−	−	++
flavida	−	−	+	−	−	+
hengduanensis	−	−	−	+	−	++
hypotrypa	−	+	+	+	+	++
irregularis	−	−	+	−	−	++
mundata	−	−	−	+	−	−
physodes	−	+	−	−	−	+
pseudobitteriana	+	+	+	+	+	+
sikkimensis	−	−	−	+	−	−
subarticulata	−	−	+	+	−	++
thomsoniana	−	−	−	+	−	+
tubulosa	−	+	−	−	−	−
vittata	−	+	+	+	+	+
wattiana	−	−	−	+	−	−
zeylanica	+	−	−	−	−	−

vittatolic acids. Upreti & Divakar (2008) reported vittatolic acid as a submajor compound in a specimen from India (as *H. austerodes*), but did not report 3-hydroxyphysodic acid.

Substratum. On alpine sod or soil, bark, and wood; the sole known specimen from India (*Divakar* 3849) was on soil.

Distribution. Widespread but rare in the high mountains of southern Asia, more common northward in Asia, Europe and North America.

Discussion. The best diagnostic character for *H. bitteri* is the presence of short, narrow, upturned lateral lobes tipped with small soralia. These occur with or without larger terminal soralia or laminal soralia. In contrast, *H. austerodes* typically has only laminal soralia. Occasionally, however, *H. austerodes* has terminal soralia, but usually these are restricted to the larger lobe tips and they are accompanied by extensive laminal soredia.

Selected specimens examined. **India:** *North Sikkim*: Kalep, before Thanngu, 2004, 3900 m, *Divakar & Upreti* 04-003849 (LWG, duplicate in MAF).

Hypogymnia crystallina McCune, Divakar & Upreti sp. nov.

MycoBank No: MB 564553

Thallus with congested apothecia and short lobes with rimmed holes in axils and lobe tips and frequent budding; discs often whitish pruinose; epithecium with superficial POL+ crystals.

Type: India, Arunachal Pradesh, West Kameng District, 7 km before Sela, on *Cedrus deodora* twigs, 12 November 2008, *D. K. Upreti* 08-009390A, with *U. Dubey, R. Khare* & *G. Mishra* (LWG—holotype). [Although coordinates are not given on the packet label, the approximate location is 27·505°N, 92·109°E. As Sela Pass is at 4200 m, this location must be at a somewhat lower elevation.]

(Fig. 1)

Thallus appressed to suberect, to 3 cm broad; texture cartilaginous; branching variable, budding present (Fig. 1A); upper surface brown to brownish grey, epruinose, dark mottles present, black border sometimes present, smooth to weakly rugose; *lobes* centrally contiguous to separate, 0·6–1·8(–2) mm wide; lobe profile even to ± pinched and swollen; lobe width / height ratio 0·7–2·0; lobe tips and axils often perforate, the holes with a differentiated, raised rim (Fig. 1H). *Medulla*

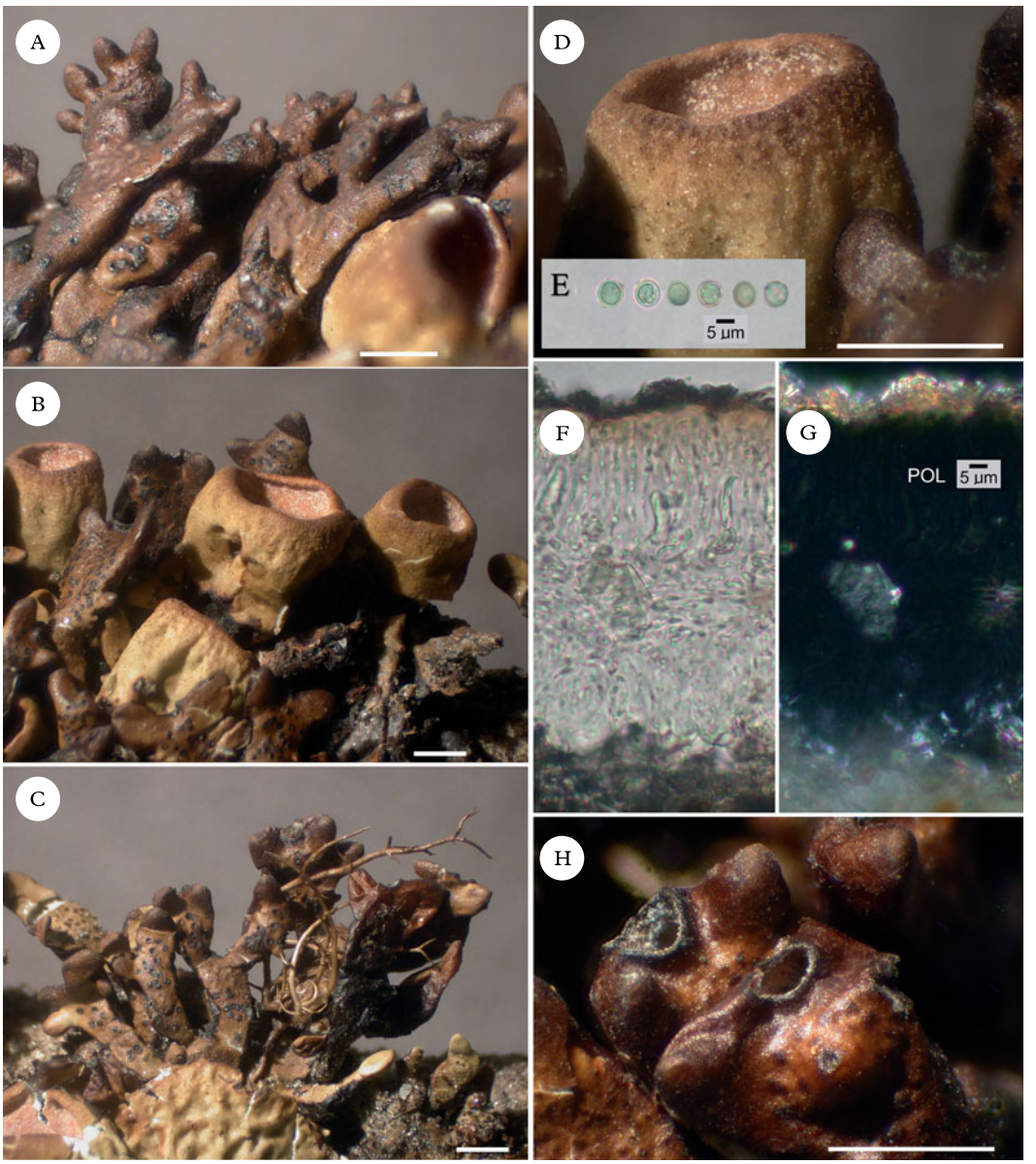

FIG. 1. *Hypogymnia crystallina*, holotype. A, lobes showing adventitious bud-like side lobes; B, apothecia crowded among emergent lobes; C, relatively elongate marginal lobes (and a sprig of *Bryoria*); D, apothecium showing pruinose disc; E, ascospores; F, apothecial section in water; G, same as F but in polarized light; H, rimmed holes in lobe tips and axils. Scales = 1 mm except as labelled. In colour online.

hollow, ceiling and floor of cavity dark; soredia, isidia, and lobules lacking.

Apothecia abundant, substipitate, to 5(–8) mm diam.; receptacle urn or funnel shaped, stipe hollow; *disc* brown to reddish brown, whitish pruinose (Fig. 1D); *epithecium* often with thin superficial granular layer that is POL+, 2–5 μm thick (Fig. 1F, G); *hymenium* 37 μm thick, including the epithecium, POL– except for epithecium; *subhymenium* of horizontal hyphae, 12–14 μm thick, hypothecium 25–35 μm thick, hyaline, POL–; *ascospores* 8 per ascus, subglobose, 7·3–8·5 × 5·5–7·8 μm (Fig. 1E).

Pycnidia common but spermatia not seen.

Chemistry. Spot tests: cortex K+ yellow, KC+ stronger yellow, P+ pale yellow; medulla K–, C–, KC–, P–. TLC: atranorin, usnic acid, hypoprotocetraric acid, and zeorin.

Etymology. The epithet '*crystallina*' refers to the epihymenium having a superficial layer of small crystals.

Substratum. On *Cedrus deodora*.

Distribution. So far known only from two sites near Sela Pass in India.

Discussion. Although only two small specimens of this species are currently known, it is readily distinguished both morphologically and chemically from all other *Hypogymnia* species. Morphologically, *H. crystallina* most closely resembles *H. bulbosa* and *H. congesta* from south-west China in having rimmed holes and short, congested lobes, densely arrayed apothecia (Fig. 1B), and similar-sized spores. In contrast to other species with rimmed holes, *H. macrospora* has much larger spores, while *H. pseudocyphellata* has open branching and apothecia are still unknown. The disc of *H. crystallina*, however, differs from that of all other species in this group in being whitish pruinose (Fig. 1D). Under polarized light in a compound microscope, *H. crystallina* displays a thin, superficial, birefringent (POL+) layer of crystals in the epihymenium (Fig. 1G), a rare character state among *Hypogymnia* species. The composition of these crystals is unknown.

Although the spores of *H. crystallina* are somewhat larger than many *Hypogymnia* species, they are much smaller than those of *H. macrospora*, and proportionately broader than spores of *H. bulbosa* and *H. congesta*.

Zeorin is previously unknown as a major substance in *Hypogymnia*, and is presently unique to *H. crystallina*. Hypoprotocetraric acid occurs as a major substance in only one other *Hypogymnia* species, *H. rugosa* (G. Merrill) L. Pike, from western North America. Usnic acid occurs as a major substance in only three other *Hypogymnia* species, the two large-lobed species *H. flavida* and *H. hypotrypa*, and the smaller, isidiate species, *H. sikkimensis*. Neither zeorin nor hypoprotocetraric acid occurs in the other species of *Hypogymnia* with rimmed holes: *H. bulbosa* (physodic ± physodalic acid), *H. congesta* (physodic and virensic acid), *H. diffractaica* (diffractaic acid), *H. hengduanensis* (diffractaic acid), *H. laxa* (physodic and physodalic acids), *H. macrospora* (norbarbatic acid), or *H. pseudocyphellata* (see below).

In the initial description, the secondary chemistry of *H. pseudocyphellata* was not fully resolved, but described as containing atranorin, barbatic acid, and five unknowns (McCune *et al*. 2002). Since then, J. A. Elix has determined by TLC and HPLC that this species contains atranorin (minor), chloroatranorin (minor), usnic acid (minor), barbatic acid (minor), elatinic acid (minor), baeomycesic acid (trace), squamatic acid (major), 1′-methyl hypothamnolate (major), and hypothamnolic acid (submajor). We independently detected all of these substances by TLC except for usnic acid.

Additional specimen examined. **India:** *Arunachal Pradesh*: West Kameng District, near Sela Pass, on *Cedrus deodora*, 2008, *D. K. Upreti* 08-009390B, with *U. Dubey, R. Khare* & *G. Mishra* (OSC).

Hypogymnia flavida McCune & Obermayer

Mycotaxon **79:** 24 (2001); type: China, Yunnan Province, Luquan Co., 3700 m, *McCune* 25622 (OSC, CANB, GZU, M, NY, UPS).

H. hypotrypa (Nyl.) Rass. *sensu* Asahina and *sensu* Awasthi (2007); non *H. hypotrypa* s. str.

Synopsis. Lobes large, neatly dichotomous, with yellowish tinge and no soredia or isidia.

Chemistry. Usnic, physodalic, and protocetraric acids (all constant); medulla K−, KC−, P+ orange-red.

Substratum. On bark and wood, rarely on rock.

Distribution. Mountains of southern and eastern Asia, including India, Nepal, China (many provinces) and Taiwan, but as yet unknown from Russia and Japan.

Discussion. Apparently a rare species in the Himalayas; see notes under *H. hypotrypa*. *Hypogymnia flavida* is apparently less common and more narrowly distributed than its sorediate counterpart, *H. hypotrypa*. This follows the general pattern of more broadly distributed sorediate species in *Hypogymnia* (Miądlikowska *et al.* 2011). The species is expected to occur in the eastern Himalayas of India.

Selected specimens examined. **Nepal:** Mewa Khola, path near Topke Thola, *Norkett* 9318 (BM).

Hypogymnia hengduanensis J. C. Wei

Acta Mycol. Sin. **3:** 214 (1984); type: China, Sichuan Province, Kangding region, Yulinkong, Gomba La, on *Betula* trunk, 3700 m, *Smith* 14078 (holotype UPS!, isotype HMAS-L!).

Synopsis. True isidia present, cylindrical to globose; lobes erect to more often trailing, with rimmed holes in the lower surface.

Chemistry. Atranorin and diffractaic acid (both constant); medulla K−, KC−, P−.

Substratum. On bark and wood.

Distribution. Occasional in SW China with rare disjuncts in Taiwan and Japan (McCune 2009) and India (Upreti & Divakar 2008); so far known in India from a single specimen.

Discussion. This species belongs to the group of *Hypogymnia* species with a raised, differentiated rim forming around holes in the lower surface (McCune *et al.* 2002). It is the only isidiate member of that group. Only one other member of this group, *H. crystallina*, is so far known from India or Nepal.

Specimens examined. **India:** *North Sikkim*: near Yumthang, 3800 m, *Divakar & Upreti* 04-004167 (LWG, duplicate in MAF).—**China:** numerous specimens.

Hypogymnia hypotrypa (Nyl.) Rass.

Novosti sistematiki nizshikh rasteniui 1967: 297. (Notul. System. e Sect. Cryptog. Inst. Bot. nomine V. L. Komarovii Acad. Sci. URSS) (1967); type: India, Sikkim, Lachen, 3600 m, *J. D. Hooker* 2016 (BM!), lectotype by Awasthi (1984).

H. hypotrypella (Asah.) Rass., *Bot. Mater. Otd. Spor. Rast.* **13:** 23 (1960).

Synopsis. Thallus large and appressed, with broad lobes, neatly dichotomous branching, and yellowish tinge (usnic acid), with sparse to abundant soredia that form along the edges of flakes in the upper cortex.

Chemistry. Usnic, physodalic, and protocetraric acids (all constant); medulla K−, KC−, P+ orange-red.

Substratum. On bark and wood, rarely on rock.

Distribution. Mountains of southern and eastern Asia, including India, Nepal, China (many provinces), Taiwan, Russia, Korea, and Japan.

Discussion. The historical application of *H. hypotrypa* to esorediate material is incorrect (McCune & Obermayer 2001). Fertile, esorediate material should be referred to *H. flavida*, while *H. hypotrypa* is sorediate.

Selected specimens examined. **India:** *Arunachal Pradesh*: 7 km before Sela Pass, 3835 m *Upreti, Dubey, Kahre & Mishra* 08-009356/A (LWG). *Sikkim*: Lachen, alpine region, *J. D. Hooker* 2016 (BM, lectotype). *North Sikkim*: near Yumthang, 3800 m, *Upreti, Chatterjee & Divakar* 04-004209 (LWG).

Hypogymnia irregularis McCune

Mycotaxon **115:** 485 (2011); type: China, Yunnan Province, 3700 m, *McCune* 25576 (holotype: KUN, isotypes: H, HMAS-I, OSC, UPS, US).

Synopsis. Lobes free, short or long, often arcuate-tipped; long, slender, adventitious lobes often abundant; lobes 0·5–4·0 mm broad and internodes often 1–2 cm long; lobes somewhat pinched and swollen or smooth in profile; ceiling of cavity greyish brown to black; floor brownish black; similar

to *H. vittata* but soredia lacking and holes on lower surface irregularly arranged or staggered.

Chemistry. Containing atranorin and physodic acid, usually with 3-hydroxyphysodic and vittatolic acids; cortex K+ yellow; medulla K− or K+ slow red-brown, KC+ orange-red, P−.

Substratum. On bark or wood, rarely on rock.

Distribution. Mainly in south-west China; also in Taiwan, Tibet, and Nepal.

Discussion. This recently described species appears to be the sexual counterpart of the sorediate *H. vittata* (McCune 2011). *Hypogymnia irregularis* has a much smaller range than *H. vittata* and is apparently a relatively rare species in the Himalayas of India and Nepal. It is, however, one of the most common *Hypogymnia* species in the Hengduan Mountains of south-west China between 3000 and 4400 m in elevation, in *Abies–Rhododendron* forests, above the zone of hardwood dominance (McCune 2011).

Selected specimens examined. See McCune (2011).

Hypogymnia mundata (Nyl.) Oxner ex Rass.

Bot. Mater. Gerb. Bot. Inst. Komarova Akad. Nauk SSSR **11:** 11 (1956).—*Parmelia mundata* (Nyl.) Cromb., *J. Linn. Soc., Bot.* **17:** 395 (1879); type: Tasmania, ad cortices, Verreaux (H-NYL 1814!). A specimen at BM marked as 'Type. Herb. Stirt' is labelled '*Parmelia mundata* Nyl. N. S. Wales, Mountains: Miss F. M. Campbell.' But this is not the type cited by Nylander.

Parmelia physodes subsp. *mundata* Nyl., *Syn. Meth. Lich.* **1**(2)**:** 401 (1860).

Parmelia campbellii C. Knight, *Proc. Roy. Soc.* Queensland 1: 114 (1884).

Synopsis. Lobes solid, appressed to suberect and becoming separate; isidia and soredia absent.

Chemistry. Containing atranorin, physodic, 3-hydroxyphysodic, and 2′-*O*-methylphysodic acids, with accessory physodalic and protocetraric acids; cortex K+ yellow; medulla K+ slow red-brown, KC+ orange-red, P+ orange-red, or P−. Most Australasian specimens of *H. mundata* lack physodalic and protocetraric acids.

Substratum. On bark or wood, less often on rock.

Distribution. Australasia and Asia.

Discussion. The combination *Hypogymnia mundata* has been used for decades, but appeared to be threatened by the discovery that *Parmelia campbellii* was used earlier at the species level. Professor T. Ahti (pers. comm., 2011), however, pointed out Crombie's (1879) overlooked combination *Parmelia mundata*. This places the name *mundata* at the species level, so that the correct name is still *H. mundata*, rather than *H. campbellii*.

Although *H. mundata* has been widely reported in Asia and Australasia, the reports outside of Australasia should be referred to *H. pulverata* [=*Hypogymnia mundata* f. *sorediosa* (Bitter) Rass.]. Because the Indian specimen is the only one we have seen of *H. mundata* s. str. outside of Australia and New Zealand, and since the specimen is small and rather battered, its identity should be considered tentative at this time. On the other hand, the specimen clearly has solid lobes (unknown in all other Indian *Hypogymnia* species), is fertile, lacks soredia, and matches *H. mundata* in chemistry.

Specimen examined. **India:** *Arunachal Pradesh*: West Kameng District, Tawang, on twigs, 20 v 2008, *Rout* s.n. (LWG).

Hypogymnia physodes (L.) Nyl.

Lich. Envir. Paris **39** (1896).—*Lichen physodes* L., *Spec. Plant*. p. 1144 (1753).

Synopsis. Lobes appressed to imbricate; lip shaped soralia present beneath the tips of imbricate lobes, lobes imperforate except for incipient soralia.

Chemistry. Containing atranorin and physodic, 3-hydroxyphysodic, physodalic, and protocetraric acids; cortex K+ yellow; medulla K+ slow red-brown, KC+ orange-red, P+ orange-red.

Substratum. On bark or wood, less often on rock or alpine sod.

Distribution. Circumpolar in the Northern Hemisphere, in Arctic to temperate regions.

Discussion. Although abundant in northern Asia and elsewhere in the Northern Hemisphere, this species becomes infrequent to rare in the Himalayan and Hengduan Mountain regions.

Selected specimens examined. **India:** NW Himalaya, Pangi, *Stoliczka* 454 (BM); Himalayas, Sach Village, 9000 ft (2743 m), *Watt* s.n. (BM).

Hypogymnia pseudobitteriana (D. D. Awasthi) D. D. Awasthi

Geophytology **1:** 101 (1971).—*Parmelia pseudobitteriana* Awasthi, *Curr. Sci.* **26:** 123 (1957); type: India, Tamil Nadu, Kodaikanal, 2100 m, *A. Höeg* 2515 (hb. Awasthii).

Synopsis. Thallus small to medium sized with a soft texture and laminal soredia, often with adventitious budding or pinnate branching; lobe cavity with white ceiling and dark floor.

Chemistry. Containing atranorin and physodic and 3-hydroxyphysodic acids; cortex K+ yellow, medulla K+ slow reddish brown, KC+ orange-red, P−.

Substratum. On bark or wood.

Distribution. Widespread in eastern and southern Asia, including China, India, Papua New Guinea, Philippines, Taiwan and Thailand; only in temperate mountain climates, absent from tropical and subtropical climates. Also reported from Australia (Elix & Streimann 1999).

Discussion. This species is the most common sorediate *Hypogymnia* in the higher mountains of SE Asia, outside of the Himalayan and Hengduan regions. Although rather variable in form, it is readily distinguished from other sorediate species in the region. It is, however, similar in morphology and chemistry to *H. pseudophysodes* of Far East Russia, Japan, and China. In both species the soredia tend to intergrade with schizidia. *Hypogymnia pseudobitteriana* has a white ceiling and dark floor of the lobe cavity, whereas *H. pseudophysodes* has a dark ceiling and floor. Furthermore, *H. pseudobitteriana* tends to produce lateral budding and adventitious lobes, often developing a somewhat pinnate pattern, while branching in *H. pseudophysodes* is more isotomic dichotomous to irregular.

Selected specimens examined. **Bhutan:** Thimphu District, Thimphu Valley below Tango Gonpa, temperate oak forest with *Rhododendron*, on dead wood, *Søchting* 8404 (C, THIM).—**India**: many locations in southern India, plus: *North Sikkim*: near Yumthang, on *Rhododendron*, *Divakar & Upreti* 04-004168 (LWG, duplicate in MAF).—**Nepal:** Langtang Himal, valley of Langtang Khola, *Weber* 87518 (COLO).

Hypogymnia sikkimensis G. P. Sinha & Elix

Mycotaxon **87:** 81 (2003); type: India, Sikkim, East Sikkim, surroundings of Mei-menchu Lake, 3200–3500 m, on moss-covered tree, *G. P. Sinha* 1477A, 18 September 1998 (holotype BSHC; isotype CANB; types not seen – not available for study).

Synopsis. Thallus yellowish green to grey, isidiate, with adventitious budding; large holes in the lower surface (similar to *H. flavida* and *H. hypotrypa*).

Chemistry. One of two *Hypogymnia* species worldwide that contain both atranorin and usnic acids, in this case with atranorin (minor) and usnic and isousnic acids (major), but not containing other major lichen substances. Sinha & Elix (2003) also reported traces of placodiolic and pseudoplacodiolic acid by HPLC, but these were not observed by us with TLC of one specimen. Placodiolic acid is known as a major substance in *Hypogymnia* from a single specimen of *H. imshaugii* from western North America (McCune *et al.* 2011).

Substratum. On bark, including *Rhododendron.*

Distribution. So far known only from two locations in the eastern Himalayas, the type locality in East Sikkim, India, plus one locality in North Sikkim.

Discussion. According to Sinha & Elix (2003), "*H. sikkimensis* can be separated from *H. zeylanica* by the linear-elongate lobes (sublinear to sublinear-elongate in *H.*

zeylanica), the scattered, globose then short-cylindrical isidia which may become ultimately procumbent, flattened and lobulate (in contrast to the fragile, cylindrical isidia of *H. zeylanica* which may become coralloid-branched and/or ultimately granular and subsorediate)...". The morphology of the lobes and holes, as well as the presence of usnic acid, indicate an affinity to *H. hypotrypa* and *H. flavida*.

Specimen examined. **India:** *North Sikkim*: above Lachen, on *Cedrus deodora*, 12 viii 2004, *Divakar & Upreti* 04-004097 (LWG, duplicate in MAF).

Hypogymnia subarticulata (J. D. Zhao, *et al.*) J. C. Wei & Y. M. Jiang

Lichens of Xizang, p. 37 (1986).—*Parmelia vittata* var. *subarticulata* J. D. Zhao *et al.*, *Acta Phytotax. Sin.* **16:** 96 (1978); type: China, Yunnan Province, Lijiang, 3000 m, *Zhao & Chen* 4414, (HMAS-L!).

Synopsis. Lobes short, broad, brownish to dark brown, with apical labriform soralia; large holes present below the tips of esorediate lobes; medulla P+ orange-red.

Chemistry. Containing atranorin, physodalic, and protocetraric acids, rarely with 2′-*O*-methylphysodic acid.

Substratum. On bark and wood of both conifers and hardwoods, rarely on rock.

Distribution. In India known only from a single, unspecified locality in Sikkim.

Discussion. Originally described from Tibet (Xizang), this species has proven to be relatively widespread. It is most common in the mountains of south-west China, but also occurs in Taiwan (McCune 2009) and now the eastern Himalayas of India.

Selected specimens examined. **India:** *Sikkim*: alpine region, 12 000 ft (3657 m) *Hooker* 2012 (BM); numerous specimens from SW China.

Hypogymnia thomsoniana (Müll. Arg.) D. D. Awasthi

Kavaka **12**(2)**:** 94 (1984).—*Parmelia thomsoniana* Müll. Arg., *Flora* **74:** 379 (1891); type: India, Sikkim, no precise locality, *T. Thomson* 277, holotype (G) photograph in Awasthi (1984); isotypes (H-NYL!, BM!).

Parmelia pseudohypotrypa Asahina ex Nuno, *J. Jap. Bot.* **39:** 99 (1964).

Hypogymnia pseudohypotrypa (Asahina) A. Singh *Lichenol. Ind. Subcontinent* 1966–1977. *Eco. Bot. Inform. Serv. Nat. Bot. Res. Inst. Lucknow* **2** (1980). [Superfluous combination later made by Wei, *Enum. Lich. China* p. 117 (1991).]

Synopsis. Lobes broad, short to elongate, with frequent large holes below; lobe cavity with dark ceiling and floor; perpendicular bud-like side lobes infrequent or absent; thallus to 10 cm or more broad; spores 9–$10 \times 7{\cdot}0$–$7{\cdot}5$ µm; thallus similar to *H. flavida* except containing atranorin instead of usnic acid and lacking physodalic acid.

Chemistry. Of 11 specimens with TLC data, atranorin and physodic acid were found to be constant, with accessory 3-hydroxyphysodic acid, vittatolic acid (each of these in about half of the specimens) and infrequently with 2′-*O*-methylphysodic acid; medulla K− or K+ slow red-brown, KC+ orange-red, P−. A prominent unknown was found in one specimen (China: Sichuan Province, *Xuan Yu* 4264, KUN), Culberson Rf classes A7, C7+, long-wave UV+ peach.

Substratum. On bark and wood.

Distribution. Sikkim, India, and south-west China.

Discussion. Hypogymnia thomsoniana has the general appearance of *H. flavida*, but differs in chemistry and colour. The pale greenish grey colour of *H. thomsoniana* differs from the pale yellowish green of *H. flavida*. *Hypogymnia flavida* always contains physodalic acid, with accessory physodic acid, while *H. thomsoniana* never contains physodalic acid, but physodic acid is constant.

Hypogymnia pseudohypotrypa is synonymized here with *H. thomsoniana*, the earlier name, but previously reported from only the type locality (Awasthi 2007). Like *H. flavida* (*H. hypotrypa sensu* Asahina), the growth form of *H. thomsoniana* varies from having short, broad lobes and a compact growth form (*H. pseudohypotrypa*) to relative lax and elongate lobes and an open growth form (e.g. the type of *H. thomsoniana*).

We found no substantial difference in the chemistry of short-lobed and elongate-lobed forms. Elix annotated the type of *H. pseudohypotrypa* in TNS as containing physodic (major), 3-hydroxyphysodic (trace), 2′-*O*-methylphysodic (minor), and vittatolic (trace) acids, along with atranorin and a trace of chloroatranorin by HPLC. We found an apparent isotype in H-NYL (Sikkim: *Thomson* 277) to contain physodic and vittatolic acids and atranorin by TLC.

Selected specimens examined. **India:** *Sikkim*: Jangri – Gamotang, Botanical Expedition to Eastern India, 26 v 1960, *Hara et al.* s. n. [TNS; holotype of *H. pseudohypotrypa*; Asahina annotation says PD-; Elix (1990) annotation: physodic acid (major), atranorin, 2′-O-methylphysodic acid (minor) and traces of chloratranorin, 3-hydroxyphysodic acid, vittatolic acid, by HPLC and TLC; second specimen has same results].—**Nepal:** *East Nepal*: Mewakhola Valley, on branches of *Rhododendron*, 1953, *Awasthi* 2302 (UPS); Topgegola near Saduporthari, on ground and twigs of shrubs, 1953, *Awasthi* 2339 (UPS); Ganja La, N flank, N-facing rock ledges, on mossy ground, 1986, *Miehe* 5171 [GZU; Elix HPLC: atranorin, chloroatranorin, physodic acid (major), 3-hydroxyphysodic acid, 2′-*O*-methylphysodic acid; det. as *H. delavayi* by Elix]. *Khumbu*: Langmoche, *Ogawa* 38 (TNS, sub *H. pseudohypotrypa*).

Hypogymnia tubulosa (Schaer.) Hav.

Bergens Mus. Aarbog, Hefte 1, Naturvidensk. Raekke 1917–18 (2)**:** 31 (1918).—*Parmelia ceratophylla* var. *tubulosa* Schaer. *Lich. Helvet. Spicil.* **10:** 459 (1840).

Synopsis. Suberect to erect lobes with powdery soredia coating the tips, lobes entire to sparsely perforate, with cavity white or dark; medulla K+ slow reddish brown, KC+ orange red, P–.

Chemistry. Containing atranorin and physodic, 3-hydroxyphysodic, and 2′-*O*-methylphysodic acids; cortex K+ yellow; medulla K+ slow red-brown, KC+ orange-red, P–.

Substratum. On bark and wood, rarely on rock.

Distribution. Europe, North America, Africa and Asia.

Discussion. Although *H. tubulosa* is a broadly distributed species in the Northern Hemisphere, it appears to be rare in the Himalayas. The only specimen from India, Nepal, or Bhutan that we were able to confirm was reported by Bitter (1901, p. 213) from India. This specimen (*Scoliczka* 454) was partly the basis of reports in Awasthi (1984, 2007), and Singh & Sinha (2010). We confirmed that the chemistry of this specimen is typical of *H. tubulosa*. The morphology of this specimen is also nearly typical, having large terminal capitate, powdery soralia. It is unusual only in the presence of black mottles on the thallus.

A specimen reported as *H. tubulosa* from Himachal Pradesh, India, by Awasthi (1984) contains, as they reported, protocetraric and physodalic acids, substances unknown in *H. tubulosa*. This specimen has the chemistry and morphology of *H. physodes*, except that the lobe tips are sparsely perforate and the lobe cavities have dark ceilings. We have seen no other such specimens.

Specimen examined. **India:** NW Himalaya, Pangi. [Himachal Pradesh, Chamba, Pangi Valley], *Scoliczka* 454. *Lichenes Himalayenses* 454 (W, originally in hb. Lojkanum).

Hypogymnia vittata (Ach.) Parrique

Act. Soc. Linn. Bordeaux **53:** 66 (1898); listed as (Ach.) Gasilien in Awasthi (1984) and some other authors. Note that Parrique and Gasilien are the same person but 'Parrique' is currently accepted.—*Parmelia physodes* var. *vittata* Ach., *Meth. Lich.* 250 (1803).

Synopsis. Open branching with occasional to abundant adventitious lobes; lobe cavity with a dark ceiling and floor, lower surface and lobe tips conspicuously perforate with large holes, soralia sparse to abundant, labriform beneath the lobe tips.

Chemistry. Containing atranorin and physodic acid and usually with 3-hydroxyphysodic and vittatolic acids, the latter two detected by TLC in about 85% of specimens; medulla K– or more often K+ slow reddish brown, KC+ orange-red, P–.

Substratum. Bark or wood, less often on rock or alpine sod.

Distribution. Cool temperate regions of the Northern Hemisphere.

Discussion. See McCune (2011) for a detailed comparison of *H. vittata*, *H. irregularis*, and *H. stricta* (Hillmann) K. Yoshida.

Selected specimens examined. **Bhutan:** Thimphu Distr., below Cheri Gonpa, by end of road from Thimphu, *Søchting* 8343 (C, THIM).—**India:** *North Sikkim*: Shinghba *Rhododendron* Sanctuary, near Yumthang, *Divakar & Upreti* 04-004097 (LWG, duplicate in MAF); W. Himalayas, Himachal Pradesh, Kullu district, Greater Himalayan National Park, Dhela, 3737 m, *Srivastava* 04-003346 (LWG).—**Nepal:** Between Coprang and Shin Gompa, *Sharma et al.* L7.2 (E); East Nepal, Mewakhola valley, *Awasthi* 2302 (LWG-AWAS). See also McCune (2011).

Hypogymnia wattiana (Müll. Arg.) D. D. Awasthi

Kavaka **12**(2)**:** 95 (1984).—*Parmelia wattiana* Müll. Arg., *Flora* **74:** 379 (1891); type: India, Manipur, G. Watt, s. n. (BM! plus fragment in UPS). Photograph of holotype in Awasthi (1984).

Synopsis. Lobes pinched and swollen with lots of budding; upper surface verrucose; lower surface with holes; lobe cavities with cark ceilings and floors.

Chemistry. Containing atranorin, physodic, 2′-*O*-methylphysodic, and 3-hydroxyphysodic (major) acids; also an unknown substance in solvent C. Awasthi (1984), however, reported physodic, hypoprotocetraric, and protocetraric acid (?); medulla K+ slow reddish brown, KC+ orange-red, P–.

Substratum. Unknown.

Distribution. India; apparently known only from the type locality, the details of which are unknown.

Discussion. This poorly known species is currently known only from the paltry type specimen in BM, plus a fragment of the type, a single forked lobe, in UPS. Only one well-developed apothecium is present on the type specimen. This has immature spores according to Awasthi (1984) and we did not re-examine it. *Hypogymnia wattiana* was listed as a species of temperate climates by Singh (1999).

The verrucose upper surface, frequent budding, secondary substances, and more temperate habitats of *H. wattiana* are similar to *H. delavayi*. The latter species, however, has a mostly pale greyish brown to white ceiling of the lobe cavity, while lobes of the type of *H. wattiana* have dark ceilings. Likely habitats in Manipur should be searched for additional material. Fresh material is needed to better understand the variability in this species and to clarify the relationship between *H. wattiana* and *H. delavayi*.

Specimens examined. Only the type specimen seen.

Excluded or doubtful species from India and Nepal

Hypogymnia delavayi (Hue) Rass.

Bot. Mater. Gerb. Bot. Inst. V. A. Komarova **11:** 5 (1956).—*Parmelia delavayi* Hue, *Bull. Soc. Bot. France* **34:** 21 (1887).

H. yunnanensis Y. M. Jiang & J. C. Wei, *Acta Mycol. Sin.* **9:** 293 (1990).

Hypogymnia alpina, the common saxicolous and terricolous species present in Tibet, Nepal, India, and SW China was previously confused with *H. delavayi* (e.g. Awasthi 1984; Elix & Jenkins 1989) but the two differ in both chemistry and morphology (McCune 2012).

Hypogymnia enteromorpha (Ach.) Nyl.

Acta Soc. Scient. Fenn. **26:** 7 (1900). Lectotypified by Pike & Hale (1982).—*Parmelia enteromorpha* Ach., *Method. Lich.* 252 (1803).

For description and photographs see McCune & Geiser (2009). This species has been reported from Asia by various authors, including from India (Singh 1999). This species is, however, a North American endemic. Phylogenetic reconstructions show that *H. enteromorpha* belongs to a group of strictly North American species (Miądlikowska *et al.* 2011). Of the Asian species, *H. enteromorpha* most closely resembles *H. thomsoniana*.

Hypogymnia fragillima (Hillmann) Rass.

Bot. Materialy (Notul. System. e Sect. Cryptog. Inst. Bot. nomine V. L. Komarovii Acad. Sci. URSS) **11:** 8 (1956).—*Parmelia fragillima* Hillmann, *Fedde Repert.* **45:** 172 (1938).

This species has been reported from India by Awasthi & Singh (1978), Awasthi (1984, 2007) and Singh & Sinha (2010). Awasthi (2007) reported it from the "upper temperate region (alt. 3480–3780 m) of Uttaranchal, Gomukh area," of India. We have not, however, seen any material of this distinctive species from southern Asia. A specimen from Uttaranchal (*Awasthi* 8505, LWG) determined as *H. fragillima* by Awasthi is a P– chemotype of *H. alpina* and contains physodic, 3-hydroxyphysodic and vittatolic acids. To our knowledge, *H. fragillima* is restricted to Pacific coastal areas of northern Asia.

Hypogymnia zeylanica (R. Sant.) D. D. Awasthi & Kr. P. Singh

Geophytology **1:** 100. 1971 (1972).—*Parmelia zeylanica* R. Sant., *Bot. Not.* **1942:** 325 (1941). Type: S!

This species is possibly a synonym of *H. pectinatula* (Zahlbr.) Elix. The type specimen of *H. pectinatula* (W!) has granular soredia which are isidiose in part, originating along the edges of wavy cracks (like skull sutures) in the upper cortex. The presence of soredia and sorediose isidia on the type of *H. pectinatula* has apparently not been mentioned previously in the literature. Because *H. zeylanica* is morphologically and chemically very similar to *H. pectinatula*, differentiation of *H. zeylanica* from *H. pectinatula* needs more careful study. Both species contain atranorin, physodic and 3-hydroxyphysodic acids, and accessory 2′-*O*-methylphysodic acid. Furthermore, the status of esorediate, non-isidiate specimens from Indonesia, Java, Borneo and the Phillipines requires further study. They could represent a separate, unnamed species or simply an esorediate form of *H. pectinatula*.

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