

Taxonomic Study of *Bryoria asiatica*-group (Lichenized Ascomycota, Parmeliaceae) in Yunnan, Southern China

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Abstract The *Bryoria asiatica*-group (= *Alectoria asiatica*-group) in Yunnan, southern China is taxonomically revised, and two species are recognized: *B. asiatica* (Du Rietz) Brodo & D. Hawksw. and *B. himalayana* (Motyka) Brodo & D. Hawksw. Distinction between these two species are discussed, and a description, figures etc. are provided for each species. The only previous record of *B. lactinea* (Nyl.) Brodo & D. Hawksw. from Yunnan is proved to be based on *B. himalayana*, thus *B. lactinea* is excluded from the Yunnan flora. *B. asiatica* and *B. himalayana* are also recognized in Sichuan, to the north of Yunnan.

Key words: lichens, lichenized Ascomycota, *Bryoria*, taxonomy, distribution, Yunnan, Sichuan, China.

A classic lichen genus *Alectoria* Ach. in Luyken sensu Zahlbruckner (1926, 1930) has the fruticose thallus composed of a prominent cortex and medulla of arachnoid hyphae with Trebouxioid phycobionts, lecanorine lateral apothecia, and colorless simple ascospores. It has been separated into *Alectoria* s. str., *Bryoria* Brodo & D. Hawksw., and *Sulcaria* (Motyka) Bystrek based on morphological and chemical characters (Brodo and Hawksworth, 1977). Among these, the genus *Bryoria* is the most species-rich, and distinguished by ascospores characters (8 per ascus, simple, under 16 μ m long, colorless at maturity), various vegetative structures (cortex, medullary hyphae etc.), and chemical components (Brodo and Hawksworth, 1977). This genus is widely distributed in the northern hemisphere (Brodo and Hawksworth, 1977) with ca. 45 species in the world (Hawksworth *et al.*, 1995), and seems to have a distribution center in the Himalayan region where many species are known, including 14 species from India and Nepal on the south (Awasthi and Awasthi, 1985), and 13 species on the east, namely, Yunnan in China (out of 18 species from the whole China; Wang and

Chen, 1994; Wu and Wang, 1992). However, there still remain many taxonomic problems unsolved for this group of lichens in this region. Thus, we started a joint project of a taxonomic study on alectoroid lichens including *Bryoria* in Yunnan and its vicinity. First, we taxonomically investigated the so-called "*Alectoria asiatica*-group" (Nuno, 1971), which now should be called "*Bryoria asiatica*-group". In this paper, we report the result of this investigation.

Materials and Methods

Descriptions of external morphology are based on air-dried materials observed under a dissecting stereomicroscope. Sections were made with a razor blade under the stereomicroscope, mounted in GAW (glycerol: ethanol: water = 1:1:1), and anatomical descriptions were made. Chemical analyses were made by the color tests and thin layer chromatography (TLC). The TLC method follows Culberson (1972) by use of the solvent A (toluene: dioxane: acetic acid = 180:45:5) and DC Platten Kieselgel 60 F254 (Merck). The specimens used in this study are deposited in the Lichen Herbarium, Cryptogamic

Herbarium, Kunming Institute of Botany, Academia Sinica (KUN-L), and some of them were duplicated to the Natural History Museum and Institute, Chiba (CBM). The type materials from the following herbaria were also used: BM, UPS.

Taxonomy

Species of *Bryoria asiatica*-group (or *Alectoria asiatica*-group) have the thallus pendent, generally brownish, with lateral spi-

nules, and lack soralia (Nuno, 1971; present study). In Yunnan and its vicinity, three species of this group have been previously reported (Wang and Chen, 1994; Wu & Wang, 1992): *B. asiatica* (Du Rietz) Brodo & D. Hawksw., *B. himalayana* (Motyka) Brodo & D. Hawksw. and *B. lactinea* (Nyl.) Brodo & D. Hawksw. At this time, however, only two species, *B. asiatica* and *B. himalayana* are recognized, and the only previous record of *B. lactinea* was proved to be based on *B. himal-*

Table 1. A comparison of morphology, chemistry, habitat, and distribution of *Bryoria asiatica* and *B. himalayana*.

	<i>B. asiatica</i>	<i>B. himalayana</i>
Morphology		
Thallus	up to 15(-20) cm l. soft	15-25(-30) cm l. rigid
Branching	isotomic dichotomous	anisotomic dichotomous but \pm isotomic dichotomous towards apices
Angles between dichotomies	acute, usually 30-60°	mainly acute, usually 45-60°
Main branches diameter	0.1-0.3 mm	0.5-1 mm at base 0.3-0.7 mm in middle
color	very dark brown or blackish towards base dark brown towards apices	black at base pale brown in middle dark brown to reddish brown towards apices
dull or shiny	shiny	dull
Lateral spinules	sparse 0.5-2 mm l. mainly acute, 30-80°	numerous 1-5 mm l. perpendicular to obtuse, 80-90°
Pseudocyphellae	absent	sparse fissural, plane to slightly raised 0.2-0.3 mm wide pale brown or whitish
Cortex in lateral spinules or thin branches	20-35 μ m thick even in thickness	20-50 μ m thick uneven in thickness
Medullary hyphae	2-4 μ m diam. uneven in diam.	4-5 μ m diam. even in diam.
Apothecia	rare	common
Ascospores	ca. 8 \times 4 μ m	9-10 \times 4-5 μ m
Chemistry		
Color tests on medulla	P-, K-, C-, KC-	P+ orange-red, K-, C-, KC-
Lichen substances	not detected	fumarprotocetraric and lobaric acids
Habitat	on branches	on trunks, branches, bushes, rocks
Distribution		
elev. in Yunnan and Sichuan range	3750-4300 m China (Yunnan, Sichuan), Japan	1700-4300 m China (Yunna, Sichuan), Nepal, Bhutan, India

ayana as noted below.

The main characters of *Bryoria asiatica* and *B. himalayana* are summarized in Table 1. Diagnostic characters distinguishing them are the toughness (rigid or soft) of the thallus, branching type, color, glossiness (shiny or dull; Figs. 3B, C, 4D, E) and diameter of main branches (Figs. 3B, C, 4D, E), density of lateral spinules (Figs. 3C, 4E), the presence or absence of pseudocyphellae (Fig. 4C), diameter of medullary hyphae (Fig. 2), and the chemical constituents. They also tend to differ in thickness of cortex (even in *B. asiatica*, Fig. 2 A; uneven in *B. himalayana*, Fig. 2B), frequency of apothecia, habitat selection and distribution.

1. *Bryoria asiatica* (Du Rietz) Brodo
& D. Hawksw
(Figs. 1A, 2A, 3, 5A)

Bryoria asiatica (Du Rietz) Brodo & D. Hawksw., Opera Bot. 42: 155 (1977). = *Alectoria asiatica* Du Rietz, Ark. Bot. 20A (11): 18 (1926). Type: China, Sichuan prov. (as

Sze-chu'an), reg. bor.-occid., mellan Tsagoga-gamba och Tamba, alt. 4000 m. s.m., på *Juni-perus*, *Picea* eller *Rhododendron*, H. Smith 5018, 2 Oct. 1922 (UPS holotype!).

External Morphology. Thallus pendent, usually up to 15(–20) cm long, soft, anisotomic-dichotomously branched, becoming isotomic-dichotomously branched towards apices, with angles between dichotomies mainly acute (usually 45°–60°); main branches cylindrical, even in diameter, 0.1–0.3 mm diam., very dark brown or blackish towards base, dark brown towards apices, shiny, smooth; lateral spinules sparse, acute (30°–80°), 0.5–2 mm long, tapering, soft, concolorous with main branches, shiny, smooth; soralia and pseudocyphellae lacking. Apothecia rare, lateral, immersed when young, sessile when mature, sometimes slightly geniculate or with branches somewhat angled to disc side; thalline margin thin, c 0.1 mm thick, almost entire, concolorous with and frequently paler than branches; disc 0.5–1 mm diam., slightly concave when young, becoming almost flat,

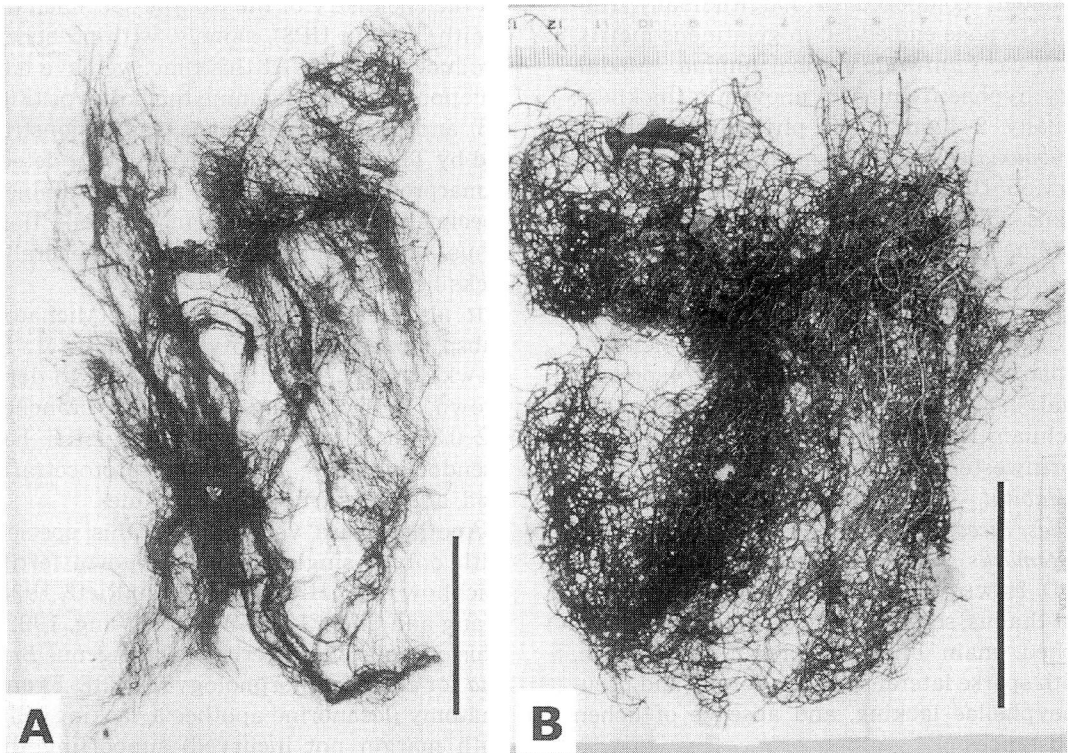


Fig. 1. Type specimens of *Bryoria*. A, *B. asiatica* (holotype); B, *B. himalayana* (isotype in BM). Scales: 5 cm.

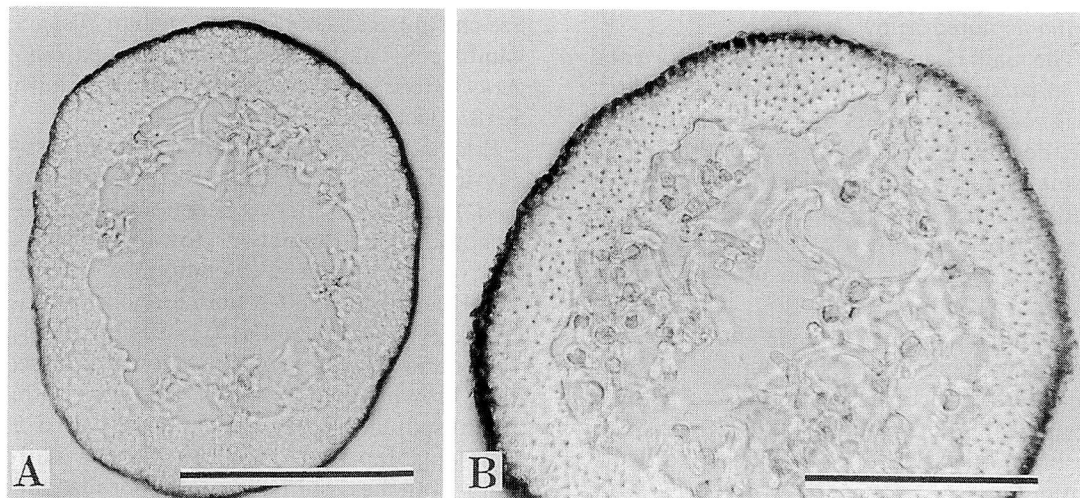


Fig. 2. Cross section of branches. A, *Bryoria asiatica* (Wang Li-song 81-2149); B, *B. himalayana* (Wang Li-song 92-842). (A, B, GAW preparations). Scales: 100 μm .

epruinose, medium to dark brown, somewhat shiny.

Anatomy. Cortex even in thickness in cross-section, 20–35 μm thick for lateral spinules or thin branches with 100–200 μm diam., brownish in outermost, colorless in remainder, composed of longitudinally running hyphae embedded in gelatinous matrix, with ca. 1 μm -wide hyphal lumina. Medullary hyphae frequently uneven in thickness, usually 2–4 μm diam.; phycobiont cells of *Trebouxia* scattered in medulla, usually solitary, 5–10.5 μm diam. Ascospores 8 per ascus, subglobose to ellipsoidal, ca. 8 \times 4 μm , hyaline, simple, with ca. 0.5 μm thick wall.

Chemistry. Medulla P–, K–, C–, KC–; no lichen substance detected.

Distribution. China (Yunnan, Sichuan), Japan (Nuno, 1971; Yoshimura, 1974; present study); 3750–4300 m elev. in Yunnan and Sichuan; rare in Yunnan, restricted to the northwesternmost.

Habitat. On branches of *Rhododendron*, *Abies*, *Picea*, *Larix* and bushes.

Remarks. *Bryoria asiatica* (Du Rietz) Brodo & D. Hawksw. is characterized by the pendent thallus, soft, isotomic dichotomously branched, main branches brown to blackish, with sparse lateral spinules, soralia and pseudocyphellae lacking, and absence of lichen substances.

Nuno (1971) reported the chemistry of the type specimen of *Bryoria asiatica* from Si-

chuan, China (as *Alectoria asiatica* Du Rietz, 1926) deposited in UPS (with no direct citation of the status, collector etc. of the type specimen she examined) as containing fumarprotocetraric acid. However, Awasthi and Awasthi (1985) presented another result on the chemistry of the isotype specimen (H. Smith 5018 in UPS), namely, with no lichen product detected. At this time, we have had an opportunity to examine the holotype (Fig. 1B), and no lichen substance was demonstrated by TLC. In addition, we could not detect fumarprotocetraric acid for all the examined specimens of this species in our collection. Thus, we conclude that *B. asiatica* generally lacks lichen substances.

It also resembles *B. trichodes* (Michaux) subsp. *americana* (Motyka) Brodo & D. Hawksw. in the thallus soft, brown to dark brown, 5–15 cm long, and main branches 0.2–0.3 mm diam. However, the latter has pseudocyphellae and fumarprotocetraric acid, and lacks true lateral spinules.

Apothecia are very rare in this species, with only a single specimen known fertile (Eichhow no. 1, HKAS 17392; Du Rietz, 1926; Wang and Chen, 1994; Wu and Wang, 1992). This organ is characteristic of the genus *Bryoria* for external morphology (Fig. 3E, F) and anatomy (lecanorine apothecia, lacking cilia, with margin not incurved) supporting the placement of the present species in this genus.

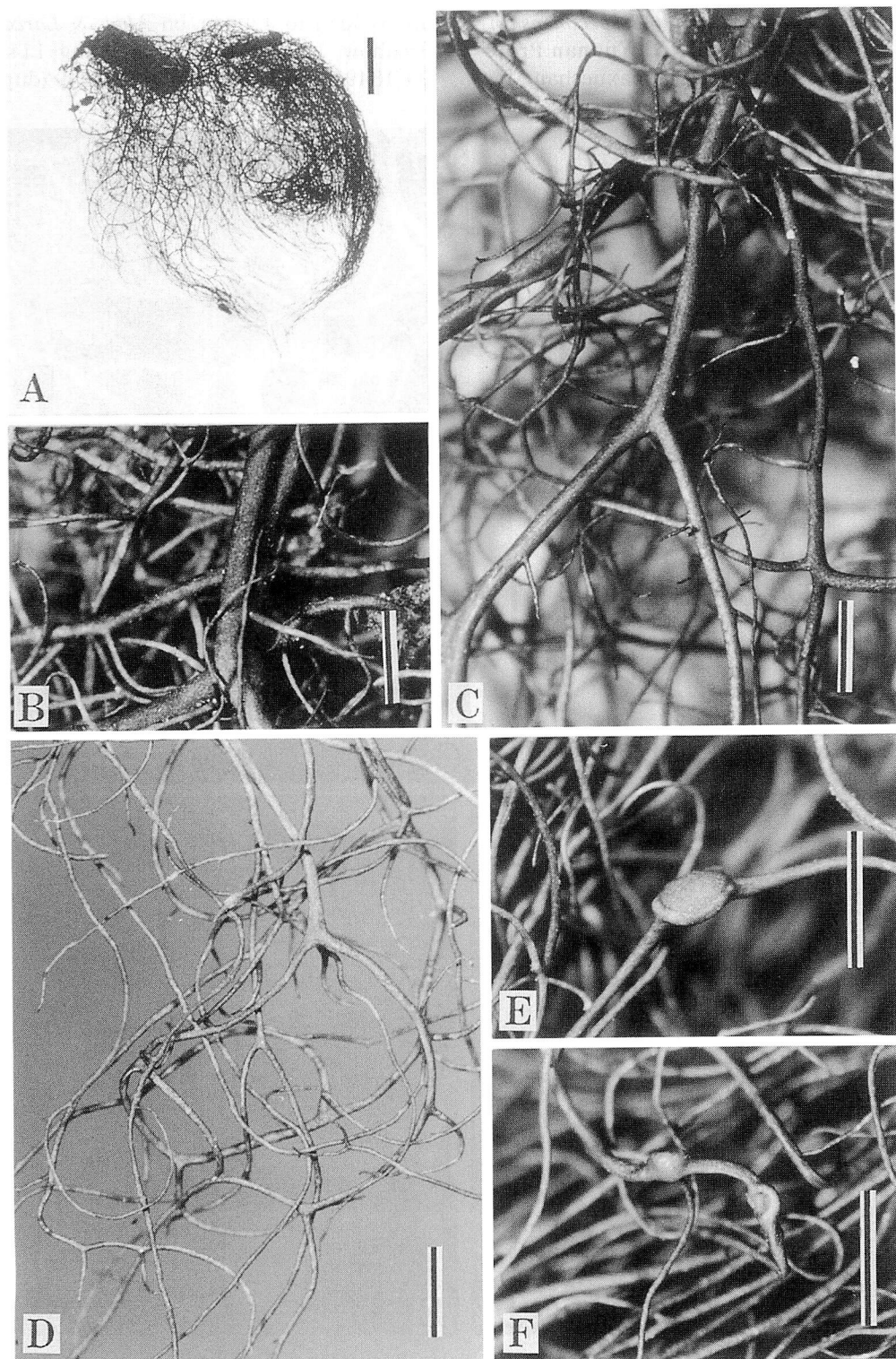


Fig. 3. Morphology of *Bryoria asiatica*. A, habit; B, main branch towards base, with smooth and shiny surface; C, main branches in middle; D, main branches towards apices; E, mature apothecium; F, young apothecia. (A–D, Wang 81–2149; E, F, Eichhow 1). Scales: A, 1 cm; B–F, 1 mm.

Specimens examined (all the specimens in KUN-L unless stated): CHINA. Yunnan Prov. (3 specimens). Deqen Co., Baimaxueshan Mt.,

alt. 3750 m to 4200 m, on *Abies* & *Larix*, M. Eichhow 1 (KUN-L 17392), Wang Li-song 99-18491 and Li Xin-jiang 81-2149 (dup. in

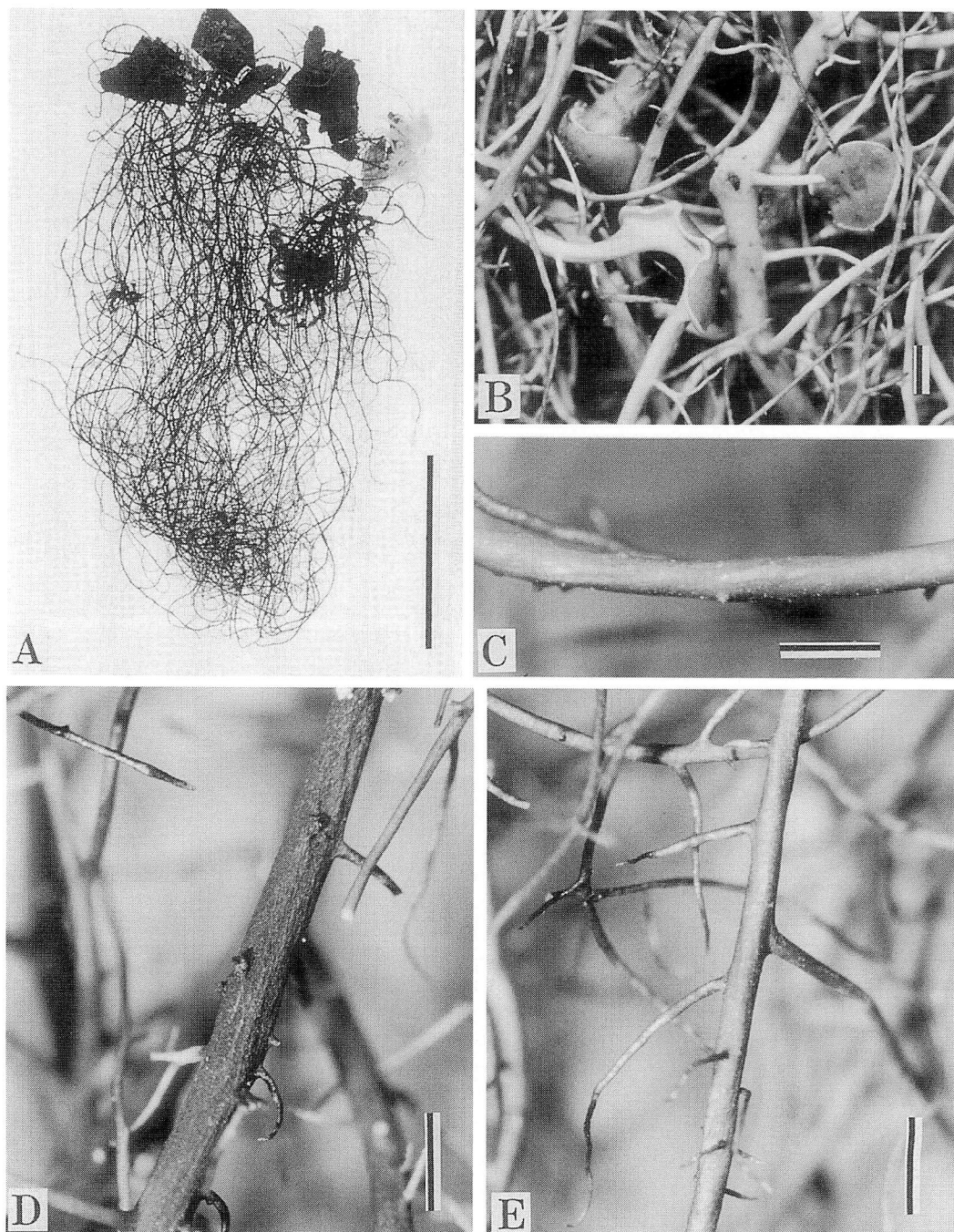


Fig. 4. Morphology of *Bryoria himalayana*. A, habit; B, apothecia; C, fissural pseudocyphellae; D, main branch at base, dull and with fine furrows or wrinkles; E, main branch in middle, with numerous spinules. (A, Wang 92842; B, Wang 17402; C-E, Wang 92-130654. A-E, air-dried materials). Scales: A, 5 cm; B-E, 1 mm.

CBM). **Sichuan Prov.** (4 specimens). Jiulong Co., Jichoushan Mt., alt. 4300 m, on bush, Wang Li-song 96-16529 (b). Muli Co., Donglang to Sanqu, alt. 4200 m, on *Abies*, Wang Li-song 83-2301 & 83-2284. Daocheng Co., Wang Li-song 2406.

2. *Bryoria himalayana* (Motyka) Brodo & D. Hawksw
(Figs. 1B, 2B, 4, 5B)

Bryoria himalayana (Motyka) Brodo & D. Hawksw., Opera Bot. 42: 155 (1977). = *Alectoria himalayana* Motyka, Fragm. Florist. Geobot. 6: 450 (1960). Type: Himalaya, Sikkim, T. Thomson 299 (BM isotype!).

External Morphology. Thallus pendent, usually 15-25(-30) cm long, rigid, anisotomic-dichotomously branched, \pm becoming isotomic-dichotomously branched towards apices, with angles between dichotomies mainly acute (usually 45° - 60°); main branches cylindrical, but sometimes more or less flattened especially in basal parts, usually 0.5-1 mm diam. at base, usually 0.3-0.7 mm diam. in middle, black in basal parts, usually pale or very pale brown (rarely dark) in middle, becoming dark brown to reddish brown towards apices, dull, usually smooth,

but sometimes with indistinct longitudinal furrows or ridges (or fine wrinkles); lateral spinules numerous over whole thallus, perpendicular to obtuse (80° - 90°), variable in length, usually 1-5 mm long, usually 0.1-0.2 mm diam. at base, tapering, rigid, concolorous with main branches, usually dull or slightly shiny (compared to main branches), smooth; soralia lacking; pseudocyphellae sparse, usually on lateral spinules, indistinct, fissural, plane to slightly raised, usually 0.2-0.3 mm wide, variable in length, concolorous or frequently paler general surface of branches. Apothecia common, lateral, immersed when young, sessile and geniculate when mature; thalline margin thin, c. 0.1-0.2 mm thick when young, becoming obscured when mature, entire, becoming slightly undulating, concolorous with and frequently paler than branches; disc 3-5 mm diam., slightly concave when young, becoming flat and then convex, epruinose, cervin brown, dull.

Anatomy. Cortex slightly uneven (disrupted at pseudocyphellae) in thickness in cross-section, usually 20-50 μ m thick for basal part of lateral spinules with 100-200 μ m diam., brownish in outermost, colorless in

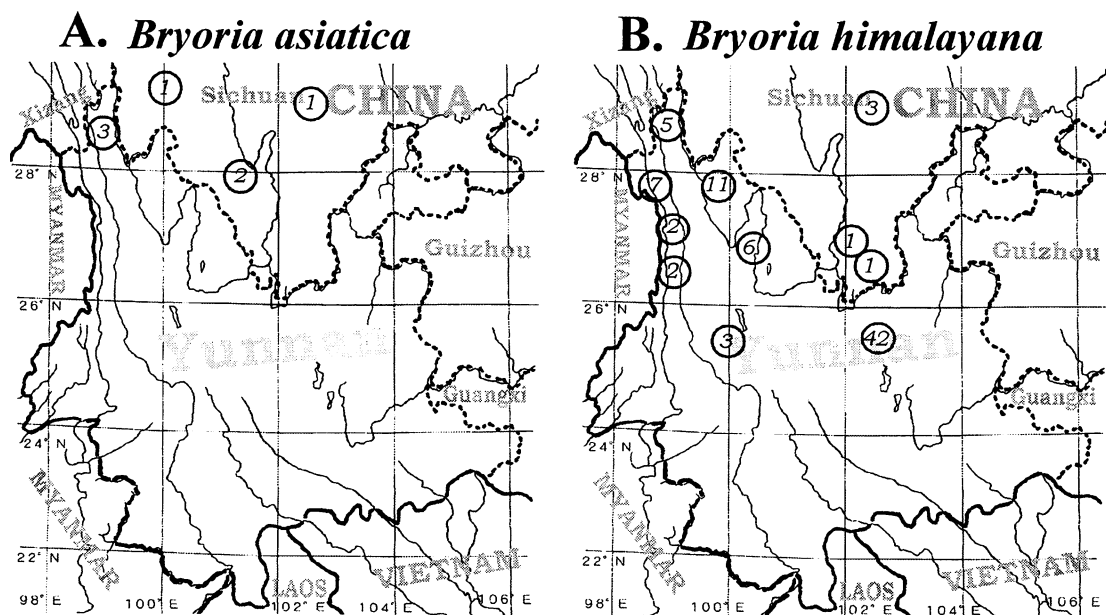


Fig. 5. Distribution of *Bryoria asiatica* and *B. himalayana*. A, *Bryoria asiatica*; B, *B. himalayana*. Numeral in each circle represents number of the specimens examined from that area.

remainder, composed of longitudinally running hyphae embedded in gelatinous matrix, with ca. $2\ \mu\text{m}$ -wide hyphal lumina. Medullary hyphae even in thickness, usually $4\text{--}5\ \mu\text{m}$ diam., frequently lost in main branches; phycobiont cells of *Trebouxia* scattered in medulla, usually solitary, $7\text{--}12\ \mu\text{m}$ diam. Ascospores 8 per ascus, subglobose to ellipsoidal, $9\text{--}10 \times 4\text{--}5\ \mu\text{m}$, hyaline, simple, with ca. $1\ \mu\text{m}$ -thick wall.

Chemistry. Medulla P+ orange, K-, C-, KC-; fumarprotocetraric acid, lobaric acid.

Distribution. China (Yunnan, Sichuan), Nepal, Bhutan, India (Awasthi and Awasthi, 1985; Bystrek, 1969; present study); 1700–4300 m elev. in Yunnan and Sichuan; rather common in northern Yunnan.

Habitat. Usually on trunks of hardwoods (*Rhododendron fastigiatum* etc.) and conifers (*Abies georgei* etc.), and on bushes, sometimes associated with *B. bicolor*; also on rocks under bushes of *Rhododendron*, associated with *B. nitidula*.

Remarks. *Bryoria himalayana* (Motyka) Brodo & D. Hawksw. is characterized by the pendent thallus, rigid, anisotomic dichotomously branched, main branches black at base, pale in middle, dark brown to reddish brown towards apices, with numerous lateral spinules, pseudocyphellae sparse, soralia lacking, medullary hyphae relatively thick ($4\text{--}5\ \mu\text{m}$ in diam.), and the presence of fumarprotocetraric and lobaric acids (P+ orange-red).

Bryoria lactinea (Nyl.) Brodo & D. Hawksw., another species of the *Bryoria asiatica*-group described from Japan (Nuno, 1971; Nylander, 1890) resembles *B. himalayana* in containing fumarprotocetraric and lobaric acids (Hawksworth, 1972; Nuno, 1971). However, *B. lactinea* is distinguishable by the thallus totally pale versus black at the base and dark brown towards apices in *B. himalayana*. Although *B. lactinea* has been once reported from Nepal in the Himalaya by Awasthi and Awasthi (1985), this species was not found in Yunnan and Sichuan during our thorough field surveys. In addition, the previous report of *B. lactinea* from Yunnan (Wang and Chen, 1994; Wu and Wang, 1992) was proved to be based on *B. himalayana* as the result of re-examination of the voucher specimen (Wang Li-song 82–934, from Lijian) at this time.

Thus, *B. lactinea* should be excluded from the Yunnan flora.

Some specimens of *Bryoria himalayana* growing on rocks resemble *B. asiatica* in having the thallus totally dark brown. In *B. asiatica*, however, lateral spinules are rare, and pseudocyphellae are absent.

Bryoria himalayana is similar to *B. confusa* (D. D. Awasthi) Brodo & D. Hawksw., *B. bicolor* (Ehrh.) Brodo & D. Hawksw. and *B. nitidula* (Th. Fr.) Brodo & D. Hawksw. in having numerous spinules. However, the latter three species have the thallus caespitose to subpendent, and not exceeding 10 cm in length. In addition, *B. confusa* contains no lichen substance, *B. bicolor* has main branches black in the basal part and olivaceous gray to cervine brown towards the apices, and *B. nitidula* is black to dark brown for the whole thallus.

Specimens examined (all the specimens in KUN-L unless stated): CHINA. Yunnan Prov. (78 specimens). Lushuei Co., Pian-ma, Tingming-hu Lake, alt. 3700 m, on rock, Wang 2314; on *Tsuga dumosa*, Wang 2292. Luquan Co., Jiao-zi-shan Mt., alt. 3750 m, on trunks of *Abies georgei* and *Rhododendron*, Wang Li-song 92–834, 92–842 (dup. in CBM) and 92–844; alt. 3600 m, on bushes, Wang Li-song 92–843, 92–13064, 92–13078 and 92–13134; alt. 3900 m, on rock, Wang Li-song 92–846, 92–847, 92–849, 92–13132, 92–13158 (dup. in CBM), 93–13378 (dup. in CBM) and 96–17051; alt. 3700 m, on *Abies*, Wang Li-song 92–839, 92–845, 92–848, 92–13122, 92–13126, 92–13127, 96–17037, 96–16746, 99–18483 and 99–18485; alt. 3700–3800 m, on *Rhododendron*, Wang Li-song 92–838, 92–840, 92–12893, 92–13128, 96–16753, 96–17050, 97–17400, 97–17401, 97–17402 and 97–17403; alt. 3600 m, on *Sorbus*, 92–837, 92–841, 92–13123, 92–13124 and 92–13125; alt. 3700 m, on bamboo, 92–835; alt. 3500 m, on stump, 92–836; alt. 4000 m, Wang Li-song 92–13159 (dup. in CBM). Zhongdian Co., Tian-chi Lake, alt. 3750 m to 3800 m, on trunks of *Rhododendron* and *Abies*, Wang Li-song 93–13654, 93–13659, 93–13663, 93–13668, 93–13671, 93–13699 and 94–14913 (dup. in CBM); Napahai Lake, alt. 3250 m, under *Picea* and *Rhododendron*, Wang Li-song 98–18160; on *Bambusa*, 98–18154 and 98–18193; Tianbao-shan Mt., on branches of *Larix*, alt. 3700 m,

Wang Li-song 81-2259 (a). Deqin Co., Baimaxueshan Mt., alt. 4200 m, under *Larix*, Wang Li-song 92-13263 and 93-13497; Yongzhi to Tongda Yakou, alt. 3700 m, on *Picea*, Wang Li-song 99-18677, 99-18678 and 99-18697. Lijiang Co., Heibaishuei, on *Picea*, alt. 3000 m, Wang Li-song 94-14662; Yulongshan Mt., alt. 2500 m, Wu Su-gong 2 and Zang Mu 1815; Yuhu Lake, on *Abies*, alt. 3400 m, Wang Li-song 82-934; Jiuhe village, Laojuenshan Mt., alt. 4000 m, on *Abies*, Wang Li-song 99-18742 and 18744. Dali Co., Xiaolinfeng, on *Picea*, Wang Han-chen 4824 and 1049 (b); Xiaolingfenshan Mt., on *Picea*, Wang Han-chen 4509. Fugong Co., Lumadeng village, alt. 3750 m, Wang Li-song s.n. (KUN-L: 14129); alt. 1700 m, Wang Li-song 82-458. Gongshan Co., Binzhongluo to Tongda Yakou, alt. 2500 m, on *Pinus*, Wang Li-song 99-18644; alt. 3600 m to 3800 m, on *Picea*, Wang Li-song 99-18527, 99-18530, 99-18531, 99-18672 and 99-18673; on *Abies*, 99-18497. **Sichuan Prov.** (5 specimens). Jiulong Co., Tangguxiang Village, alt. 3000 m, on *Larix*, Wang Li-song 96-16591 and 96-16596; Jichoushan Mt., alt. 4300 m, on bush, Wang Li-song 96-16529. Hueili Co., Longzhoushan Mt., alt. 3500 m, on *Rhododendron*, Wang Li-song 97-18032. Miyi Co., Beipushan Mt., on *Rhododendron*, alt. 3200 m, Wang Li-song 83-803.

Acknowledgments

We are indebted to the keepers and curators of the following herbaria for the loan of specimens: BM, UPS. Wang thanks W. L. Culberson, Duke University for sending papers for this study, and Bruce McCune, Oregon State University for sending specimens for this study. Deep thanks are extended to T. L. Esslinger, North Dakota State University for correcting the English text. Financial support for this work was partly made by the Goho Life Sciences International Fund.

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(Accepted 16 January 2001)

中国雲南省産ハリガネキノリ属 地衣類の一群 (*Bryoria asiatica*-group) の分類学的研究

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ハリガネキノリ属地衣類のうち、地衣体が多少とも

褐色で粉芽を欠き棘枝を生ずる、いわゆる *Bryoria asiatica*-group について、今回、中国雲南省および周辺地域（四川省の一部）を対象に分類学的検討を行った。その結果、従来雲南省から知られる 3 種のうち、*B. asiatica* (Du Rietz) Brodo & D. Hawksw. と *B. himalayana* (Motyka) Brodo & D. Hawksw. の 2 種

を認め、*B. lactinea* (Nyl.) Brodo & D. Hawksw. の報告を否定した。これら 2 種について、それぞれ記載と図を示し、ノートを付した。*B. asiatica* については、正基準標本を含め一般にフマルプロトセトラール酸を欠くことが明らかになった。また、四川省からも *B. asiatica* と *B. himalayana* の 2 種を確認した。