

## A Synopsis of the Lichen Genus *Usnea* (Parmeliaceae, Ascomycota) in Taiwan

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**Abstract.** A key to the 40 taxa in the genus *Usnea* in Taiwan is presented. *Usnea articulata* is new to Taiwan. *Usnea mutabilis* is excluded from the lichen flora of Taiwan. Photographs of diagnostic features are also provided for the species that have not been adequately illustrated previously based on the Asian materials. Orthographical errors were corrected in *U. shimadae* and *U. pseudogatae*.

**Key words:** flora, lichenized Ascomycota, morphology, secondary substances, taxonomy, TLC.

### Introduction

The genus *Usnea* (Parmeliaceae, Ascomycota) consists of ca. 300 species, and is widely distributed from polar zones to tropical area (Kirk *et al.*, 2008). Diagnostic features of the genus include a fruticose thallus with a cortex, medulla, and a cartilaginous central axis, and the presence of usnic acid in the cortex. Monophyly of the genus has been confirmed by molecular phylogenetic methods using the taxa having these synapomorphic features (Ohmura, 2002; Ohmura & Kanda, 2004; Articus, 2004; Wirtz *et al.*, 2006), although Articus (2004) elevated several infrageneric groups to generic level (i.e., *Dolichousnea*, *Eumitria*, *Neuropogon*, and *Usnea*).

The *Usnea* flora of Taiwan was primarily summarized by Ohmura (2001) who revised the former studies in this area made by Zahlbruckner (1933), Motyka (1936–1938), and Asahina (1956, 1963, 1965a, 1965b, 1967a, 1967b, 1967c, 1967d, 1968a, 1968b, 1969a, 1969b, 1969c, 1969d, 1970, 1972a, 1972b). After that, several taxa were added to the *Usnea* flora in Taiwan (Aptroot *et al.*, 2002; Clerc, 2004; Ohmura *et al.*, 2010).

This paper provides a practical key to 40

accepted taxa (39 species and one variety) of the genus *Usnea* in Taiwan, along with the diagnostic features with images which have not been adequately illustrated previously.

### Materials and Methods

This study is primarily based on Ohmura (2001) and Ohmura *et al.* (2010) and the herbarium specimens deposited in the National Museum of Nature and Science, Tokyo (TNS) and the National Museum of Natural Science, Taichung (TNM), as well as specimens collected mainly by the author between 2008 and 2010. All specimens examined are deposited in TNS otherwise indicated.

Morphological observations were made using a dissecting microscope or a bright field microscope. The diameter of branch was measured using a well-developed thicker branch. The ratios of thickness of the cortex, medulla, and axis for the branch were measured following the method of Clerc (1984). The minimum-average-maximum values of them are shown in the description. Cross sections of thallus were cut by hand with a razor blade, and observed after mounting in GAW (glycerin : ethanol : water, 1 : 1 : 1).

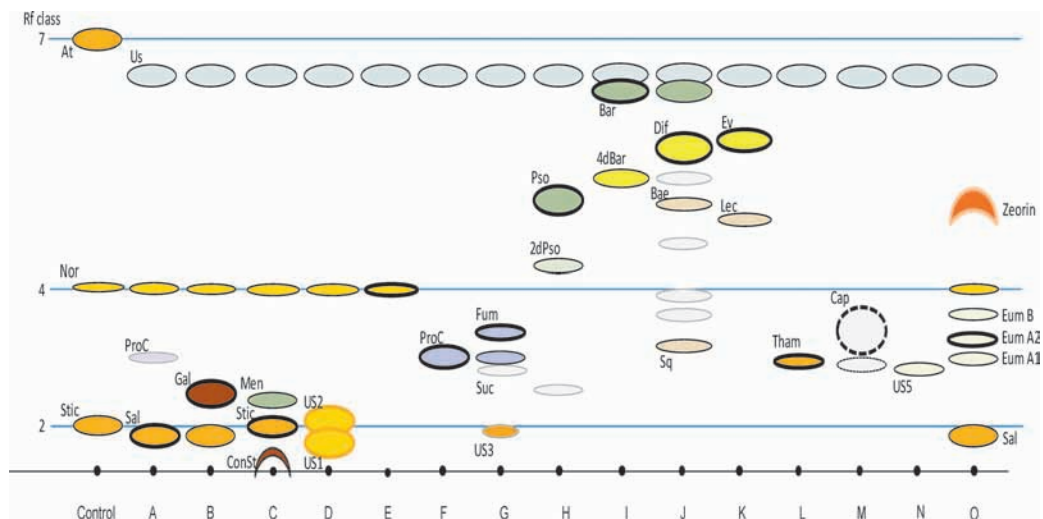


Fig. 1. TLC spots of major lichen substance detected from Taiwanese *Usnea* (solvent B). Control of Rf classes 2 (stictic acid), 4 (norstictic acid) and 7 (atranorin) is shown in the leftmost column. The spot of usnic acid is shown in all columns as a standard except in a control column. Spot of diagnostic substance is encircled with a bold line. Fatty acid is encircled with a dashed line (fatty acid is visible only in wet condition of TLC plate). Spot color after heating (110°C, 10 min) with 10% H<sub>2</sub>SO<sub>4</sub> is shown. 2dPso=2'-O-demethylpsoromic acid, 4dBar=4-O-demethylbarbatic acid, At=atranorin, Bae=baeomycesic acid, Bar=barbatic acid, Cap=caperatic acid, ConSt=constictic acid, Dif=diffRACTAIC acid, Eum=eumitrin, Ev=evernic acid, Fum=fumarprotocetraric acid, Gal=galbinic acid, Lec=lecanoric acid, Men=menegazziaic acid, Nor=norstictic acid, ProC=protocetraric acid, Pso=psoromic acid, Sal=salazinic acid, Sq=squamatic acid, Stic=stictic acid, Tham=thamnolic acid, Us=usnic acid, Zeo=zeorin, and unidentified substances (US1, US2, US3, and US5; see in Ohmura, 2001).

Lichen substances were examined using thin layer chromatography (TLC) (Culberson & Johnson, 1982). Solvent B system (hexane : methyl tert-butyl ether : formic acid, 140 : 72 : 18) was used for all TLC analyses. A summary of lichen substances detected from Taiwanese *Usnea* taxa is shown in Fig. 1.

Morphological and chemical characteristics for distinguishing taxa are followed by Ohmura (2001).

## Results and Discussion

### Lichen substances in Taiwanese *Usnea*

Diagnostic substances and several accessory substances detected in Taiwanese *Usnea* by TLC are summarized by schematic illustration in Fig. 1.

Usnic acid is a constant substance in the cortex of *Usnea* spp. although it varies in amount depending on the place of thallus. Atranorin is sometimes detected as an accessory substance in various species such as *U. baileyi*, *U. fuscorubens*, *U. rubicunda*, *U. rubrotincta*, and *U. trichodeoides*, and considered to be no taxonomic value for distinguishing species in the genus. Salazinic acid is one of common substances in Taiwanese *Usnea* taxa, and often follows norstictic (minor), protocetraric (faint trace) and constictic acids (faint trace) (Fig. 1A). It is found in e.g. *U. baileyi*, *U. cornuta* subsp. *cornuta*, *U. dasaea*, *U. dendritica*, *U. fuscorubens*, *U. glabrata*, *U. glabrescens*, *U. himalayana*, *U. masudana*, *U. nidifica*, *U. orientalis*, *U. pangiana*, *U. pseudogatae*, *U. rubrotincta* (Race 1), *U. shimadae*, *U. trichodeoides*, and *U. wasmuthii*.

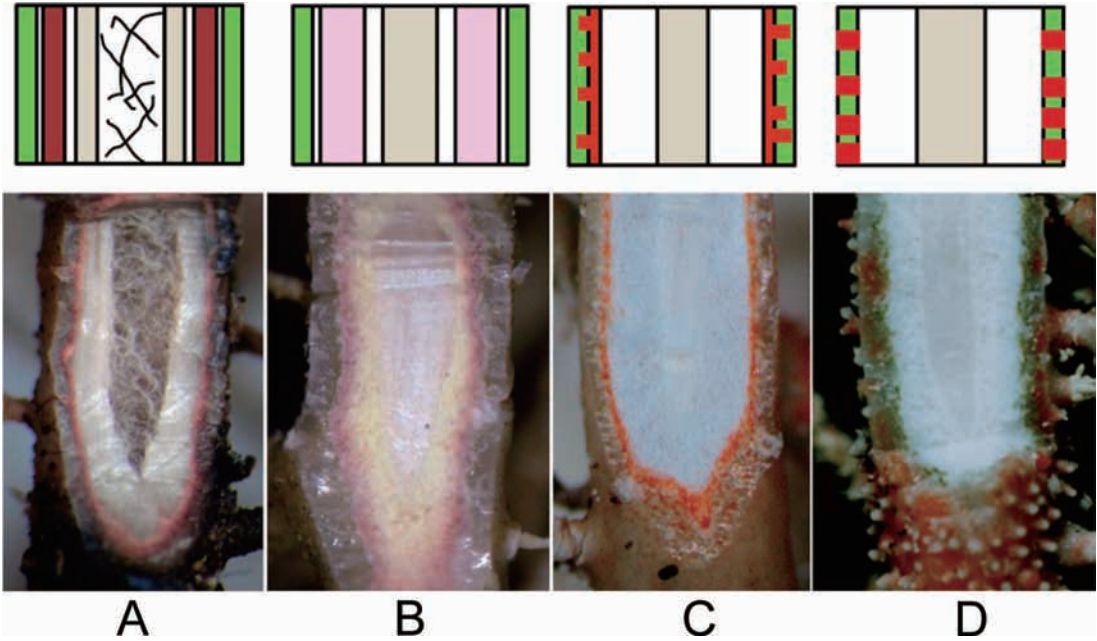


Fig. 2. Red pigmentation patterns in Taiwanese *Usnea*. A. Wine red pigment present in the cortex-side of medulla (*U. baileyi*). B. Strawberry pink pigment present in the cortex-side of medulla (*U. ceratina*). C. Red pigment in both subcortical thin layer and parts of cortex (*U. bicolorata*). D. Red pigment in cortex (*U. rubicunda* and *U. rubrotincta*). A. Fistulose axis. B-D. Solid axis.

Galbinic acid (Fig. 1B) is found in *U. dasaea* (Race 2) and *U. shimadae*, and its TLC spot might become smear if its concentration is high. Stictic acid usually follows constictic, menegazziaic, and norstictic acids (Fig. 1C). It is found in e.g. *U. aciculifera*, *U. bismolliuscula*, *U. pectinata*, *U. pygmoidea*, *U. rubicunda*, and *U. rubrotincta* (Race 2). Unidentified substances of US1 and US2 (Ohmura 2001) are diagnostic substances for *U. hakonensis*. The TLC spots repel water on the plate and exhibiting a lemon yellow color after heating (Fig. 1D). Norstictic acid (Fig. 1E), without salazinic acid, stictic acid, US1 and US2, is detected in e.g. *U. angulata*, *U. fulvoreagens*, *U. praetervisa*, and *U. sinensis*. Protocetraric acid (Fig. 1F) without other distinct substances is detected from *U. cornuta* subsp. *brasiliensis* and *U. hesperina*. Fumarprotocetraric acid (Fig. 1G) is found in *U. articulata* and *U. trichodeoides* (Race 2). Although Ohmura (2001) reported the presence of succinprotocetraric acid accompany

with fumarprotocetraric acid in *U. trichodeoides* (Race 2), the occurrence or concentration of the substance seems to be variable. Protocetraric acid accompany with fumarprotocetraric acid was detected in Taiwanese materials of *U. trichodeoides*. Both succinprotocetraric and protocetraric acids might be present in *U. trichodeoides* (Race 2) when they would be checked by High Performance Liquid Chromatography (HPLC). Psoromic (major) and 2'-O-demethylpsoromic acids (minor) (Fig. 1H) are detected as accessory substances from *U. rubicunda* in Taiwan. Barbatic acid (major) usually follows 4-O-demethylbarbatic acid (minor) (Fig. 1I). Barbatic acid without diffractaic acid is detected from *U. dendritica*, *U. longissima* (Race 1), *U. pangiana* (Race 2), and *U. wasmuthii* (Race 2). Diffractaic acid (major) usually follows small amount of barbatic, 4-O-demethylbarbatic, baeomycesic, and squamatic acids (Fig. 1J). It is found in *U. ceratina*, *U. diffracta*, *U. fulvoreagens* (Race 2),

and *U. longissima* (Race 2). Evernic acid (major) follows lecanoric acid (minor) (Fig. 1K), and it is only found in *U. longissima* (Race 3). Thamnic acid (Fig. 1L) is a diagnostic substance for *U. florida* and *U. subfloridana*. Caperatic acid (Fig. 1M) is known as a constant substance in *U. angulata*, *U. nipparensis*, and *U. sinensis*. Unidentified substance of US5 (Ohmura, 2001) (Fig. 1N) is a medurally red pigment of *U. ceratina*. Zeorin (Fig. 1O) is found as a constant substance in *U. baileyi* and *U. fulvorenans*. Eumitrins (A<sub>1</sub>, A<sub>2</sub> and B) are detected in *U. baileyi* which species usually follows salazinic and norstictic acids, although eumitrins A<sub>1</sub> and B are variable in amount (Fig. 1O).

#### Key to the *Usnea* taxa in Taiwan

- 1a. Red pigment present in thallus (including scattered small red spots on cortex) (Fig. 2) .....2
- 1b. Red pigment absent in thallus .....6
- 2a. Red pigment present in medulla or subcortical layer (Fig. 2A-C).....3
- 2b. Red pigment present in cortex (Fig. 2D) .....5
- 3a. Axis fistulose (Fig. 2A) .....*U. baileyi* (Stirt.) Zahlbr. (Fig. 6)
- 3b. Axis solid.....4
- 4a. Red pigment strawberry pink, present in the cortex side of medulla to  $\pm$  whole medulla (Fig. 2B), secreted outside of the hyphal cell wall; soralia convex at the top; diffractaic acid present .....*U. ceratina* Ach. (Fig. 8)
- 4b. Red pigment present in both subcortical thin layer and parts of cortex (Fig. 2C), secreted in the hyphal cell wall; soralia concave at the top; protocetraric acid present .....*U. bicolorata* Motyka
- 5a. Terminal and subterminal branches not elongated; fibrils sparse and sorediate fibrils very rare on braches; soralia present mainly on thick branches .....*U. rubicunda* Stirt.

- 5b. Terminal and subterminal branches elongated; sorediate fibrils abundant on branches; soralia present on both fibrils and thick branches .....*U. rubrotincta* Stirt.
- 6a. Cortex fragile on main branches, denticulate or areolately corticate; thallus "fish-bone" like appearance with numerous perpendicular fibrils on elongated branches .....7
- 6b. Cortex stable, consistent on the branches; thallus not as above .....9
- 7a. Thallus with black to dark brown base; annular-pseudocyphellae absent; stictic acid present; saxicolous or corticolous .....*U. pectinata* Taylor (Fig. 24)
- 7b. Thallus with concolous or pale base; annular-pseudocyphellae present especially near the base of thallus; stictic acid absent; corticolous.....8
- 8a. Salazinic or fumarprotocetraric acids present; branches flattened in well developed thallus with longitudinal-furrows on the surface .....*U. trichodeoides* Motyka
- 8b. Diffractaic, barbatic or evernic acids present; branches terete, without longitudinal-furrows on the surface .....*U. longissima* Ach.
- 9a. Branches ridged .....10
- 9b. Branches terete .....11
- 10a. Cortex of elongated branches broken into alate plates, distinctly ridged; caperatic acid present, stictic acid absent .....*U. angulata* Ach. (Fig. 4)
- 10b. Cortex of elongated branches never broken into alate plates, slightly ridged; caperatic acid absent, stictic acid present .....*U. himantodes* Stirt. (Fig. 18)
- 11a. Thallus esorediate .....12
- 11b. Thallus sorediate .....22
- 12a. Thallus pendent; apothecia usually absent or rare .....13
- 12b. Thallus erect to subpendent; apothecia usually present .....15
- 13a. Thallus isotomic-dichotomously branched;

- branches uninflated; medulla dense; axis thick .....**U. diffracta** Vain. (Fig. 12)
- 13b. Thallus anisotomic-dichotomously branched; branches inflated; medulla loose; axis thin .....14
- 14a. Pseudocyphellae present on branch surface; salazinic acid present ..... **U. himalayana** C.Bab. (Fig. 17)
- 14b. Pseudocyphellae absent; fumarprotocetraric acid present .....**U. articulata** (L.) Hoffm. (Fig. 5)
- 15a. Apothecia with few or no fibrils along the thalloid exciple .....16
- 15b. Apothecia with many fibrils along the thalloid exciple .....17
- 16a. Branches uninflated; base of thallus distinctly annularly cracked; barbatic acid present .....**U. dendritica** Stirt. (Fig. 11)
- 16b. Branches inflated; base of thallus continuous or irregularly cracked; barbatic acid absent .....**U. pseudogatae** Asahina (Fig. 26)
- 17a. Fibrils crisp .....**U. masudana** Asahina (Fig. 19)
- 17b. Fibrils straight .....18
- 18a. Thallus with jet black base; thamnolic acid present ...**U. florida** (L.) F. H. Wigg. (Fig. 13)
- 18b. Thallus with concolor base; thamnolic acid absent .....19
- 19a. Fibrils on apothecia broadened at the base .....**U. shimadae** Asahina (Fig. 28)
- 19b. Fibrils on apothecia cylindrical at the base .....20
- 20a. Branches uninflated, matt on the surface; caperatic acid present .....**U. sinensis** Motyka (Fig. 29)
- 20b. Branches inflated, glossy on the surface; caperatic acid absent .....21
- 21a. Apothecia cup-shaped at least when juvenile .....**U. fuscorubens** Motyka (Fig. 14)
- 21b. Apothecia flat through the juvenile to mature stages .....**U. orientalis** Motyka (Fig. 22)
- 22a. Thallus with jet black base .....23
- 22b. Thallus with concolor to dark brown base .....28
- 23a. Branches inflated, slightly glossy on the surface .....**U. fragilescens** Hav. ex Lynge
- 23b. Branches uninflated, matt on the surface .....24
- 24a. Soralia convex .....25
- 24b. Soralia concave .....26
- 25a. Thamnolic or squamatic acids present .....**U. subfloridana** Stirt.
- 25b. Norstictic acid present .....**U. praetervisa** (Asahina) P. Clerc (Fig. 25)
- 26a. Soralia deeply excavating nearly into central axis; isidiomorphs absent; zeorin present ...**U. fulvoreagens** (Räsänen) Räsänen
- 26b. Soralia slightly excavating and never reaching to central axis; isidiomorphs present at least in juvenile stages of soralia; zeorin absent.....27
- 27a. Soralia discrete, rounded; norstictic acid present .....**U. glabrescens** (Vain.) Vain.
- 27b. Soralia confluent, elliptic; norstictic acid absent .....**U. wasmuthii** Räsänen
- 28a. Maculae present on the surface of branches, punctiform to irregular-shaped .....**U. hesperina** Motyka (Fig. 16)
- 28b. Maculae absent on the surface of branches .....29
- 29a. Perforations present on thicker branches .....**U. bismolliuscula** Zahlbr. (Fig. 7)
- 29b. Perforations absent on thicker branches .....30
- 30a. Soralia concave, cortical margin reflexed .....**U. glabrata** (Ach.) Vain. (Fig. 15)
- 30b. Soralia convex to flat .....31
- 31a. Soralia developed from scars of detached fibrils .....32
- 31b. Soralia developed from cortex, cracks or top of eroded papillae .....34
- 32a. Soralia partially confluenting each other

- to form irregular mass of asexual propagules ..... **U. dasaea** Stirt. (Fig. 10)
- 32b. Soralia punctiform, discrete from each other ..... 33
- 33a. Base of thallus distinctly annular cracked; salazinic acid present  
..... **U. pangiana** Stirt. (Fig. 23)
- 33b. Base of thallus continuous or irregularly cracked; stictic acid present  
..... **U. aciculifera** Vain. (Fig. 3)
- 34a. Soralia developed from cortex or cracks; thallus usually pendent  
..... **U. nidifica** Taylor (Fig. 20)
- 34b. Soralia developed from the top of eroded papillae; thallus usually erect or subpendent ..... 35
- 35a. White annular rings distinct at the segments of branches; barbatic acid present ..... **U. pycnoclada** Vain.
- 35b. White annular rings absent at the segments of branches; barbatic acid absent ..... 36
- 36a. Soralia irregularly elongated, with granular soredia  
... **U. pygmoidea** (Asahina) Y. Ohmura (Fig. 27)
- 36b. Soralia rounded, without granular soredia ..... 37
- 37a. Cortex *merrillii*-type plectenchmatous ..... 38
- 37b. Cortex *ceratina*-type plectenchmatous ..... 39
- 38a. Salazinic acid present  
..... **U. cornuta** Körb. subsp. **cornuta** (Fig. 9)
- 38a. Protocetraric acid present as major substance, salazinic acid absent  
..... **U. cornuta** subsp. **brasiliensis** (Zahlbr.) P. Clerc
- 39a. Soralia smaller than branch diameter; US1 and US2 present, caperatic acid absent  
..... **U. hakonensis** Asahina
- 39b. Soralia grow up to larger than branch diameter; US1 and US2 absent, caperatic acid present  
..... **U. nipparensis** Asahina (Fig. 21)

**1. Usnea aciculifera** Vain., Bot. Mag. Tokyo 35: 45, 1921. [Fig. 3]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic, norstictic, menegazziac, stictic, constictic acids, and atranorin ( $\pm$ ).

The distinguishing features of *U. aciculifera* are (1) the erect to subpendent thallus with isotomic-dichotomous branching, (2) the continuous or irregularly cracked base of thallus, (3) the presence of punctiform soralia and isidiomorphs on the surface of branches, (4) the uninflated branches with a thick axis and compact medulla, (5) the absence of papillae, (6) the absence of soredia, (7) the *ceratina*-type plectenchmatous cortex, and (8) the presence of stictic acid as major substance.

*U. aciculifera* resembles *U. dasaea* and *U. pangiana* in having punctiform soralia which are developed from scars of detached fibrils. However, it is distinguished from *U. dasaea* by the uninflated branches, and from *U. pangiana* by the continuous or irregularly cracked base of the thallus and the presence of stictic acid.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 6.1.1964, S. Kurokawa 585; Nimandaira, Mt. Ali, 10–12.7.1964, S. Asahina, s.n.; en route from Su-Su-Lu to Fun-Chi-Fu, 1,700–2,000 m, 5.1.1964, S. Kurokawa 534; en route from Su-Su-Lu to Mt. Ali, 2,000–2,200 m, 7.1.1964, S. Kurokawa 654. Ilan Co.: Piyanan, 1,100–1,300 m, 15.1.1964, S. Kurokawa 762; ditto, 1,600–1,900 m, 16.1.1964, S. Kurokawa 841. Kaohsiung Co.: Mt. Nanfong, 800–1,300 m, 7.2.1965, S. Kurokawa 2843. Nantou Co.: Keitau, 1936, H. Masuda s.n. (herb. Y. Asahina 36009); Chitou, 1.30.1964, S. Kurokawa 1408a; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of deciduous broad-leaf tree, 2,385 m, 27.8.2008, Y. Ohmura 6131; Meifang Farm, Renai, on bark of dead tree, 2,015 m, 16.11.2007, Y.-M. Shen 342 (TNM, TNS); Chichidashan, Chichi, on *Prunus mume* of roadside, 21.12.1992, C.-K. Lin, s.n. (TNM, TNS). Taichung Co.: en route from Ssu-yuan

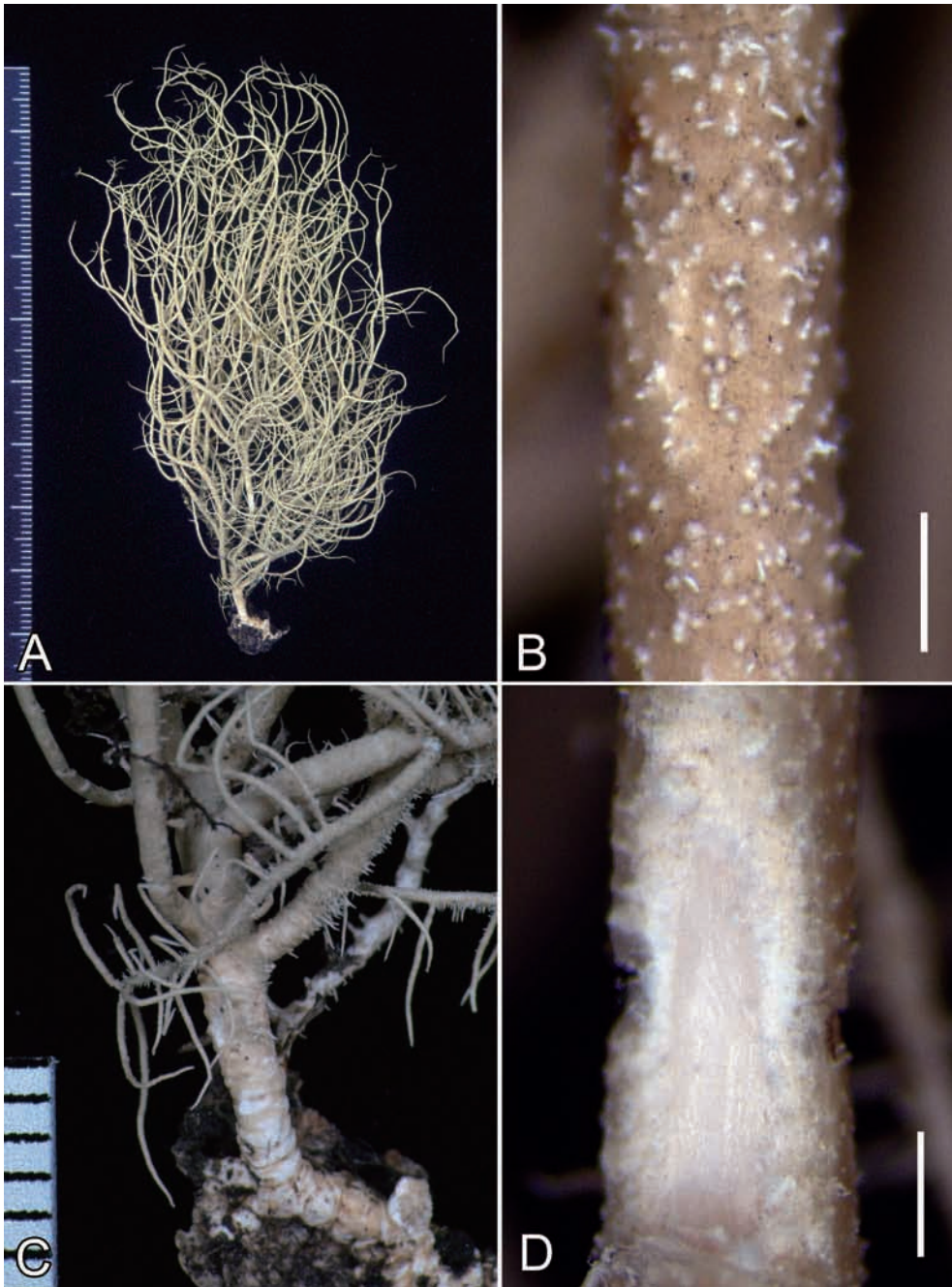


Fig. 3. *Usnea aciculifera* (Y. Ohmura 6131, TNS). A. Thallus. B. Soralia. C. Base of thallus. D. Uninflated branch with a thick axis and compact medulla. Scales: A, C=1 mm; B, D=0.5 mm.

to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 1,900–2,250 m, 9.11.1989, H. Kashiwadani 35770; Anmashan, Tungshih, 2,100 m, on

tree at breeding field of Chuanshinshan, 26.7. 1994, C.-K. Lin 3916 (TNM, TNS).

2. *Usnea angulata* Ach., Synops. Lich., 307, 1814. [Fig. 4]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic, and caperatic acids.

*U. angulata* is a distinctive species and it is readily distinguished from other species by (1) the pendent thallus with anisotomic-dichotomous branching, (2) the ridged to alate branches, (3) the punctiform soralia which are developed from scars of detached fibrils and lateral branches, (4) the absence of granular soredia, (5) the *ceratina*-type plectenchymatous cortex, and (6) the presence of norstictic and caperatic acids.

Specimen examined. TAIWAN. Ilan Co.: Piyanan, 1,100–1,300 m, 15.1.1964, S. Kurokawa 759.

3. *Usnea articulata* (L.) Hoffm., Deutschl. Fl., Zweiter Theil (Erlangen): 133, 1796.

[Fig. 5]

*Lichen articulatus* L., Sp. Pl. 2: 1156, 1753.

Lectotype [selected by P. W. James in Swinscow & Krog (1976)]: England, Burnley s.n., herb. Sherard (OXF, not seen). Chemistry: usnic, protocetraric, and fumarprotocetraric (trace) acids [demonstrated by P. W. James (Swinscow & Krog, 1976)].

For synonyms, see Swinscow & Krog (1976) and Stevens (1999).

Thallus fruticose, pendent or subpendent, up to 13 cm long, grayish-green when fresh, straw-yellow in herbarium specimens, dark brown at the base; branching anisotomic-dichotomous; branches glossy on the surface, lacking pseudocyphellae and maculae, terete, inflated, occasionally foveolate, segments constricted, gradually tapering, with sparse fibrils and later-

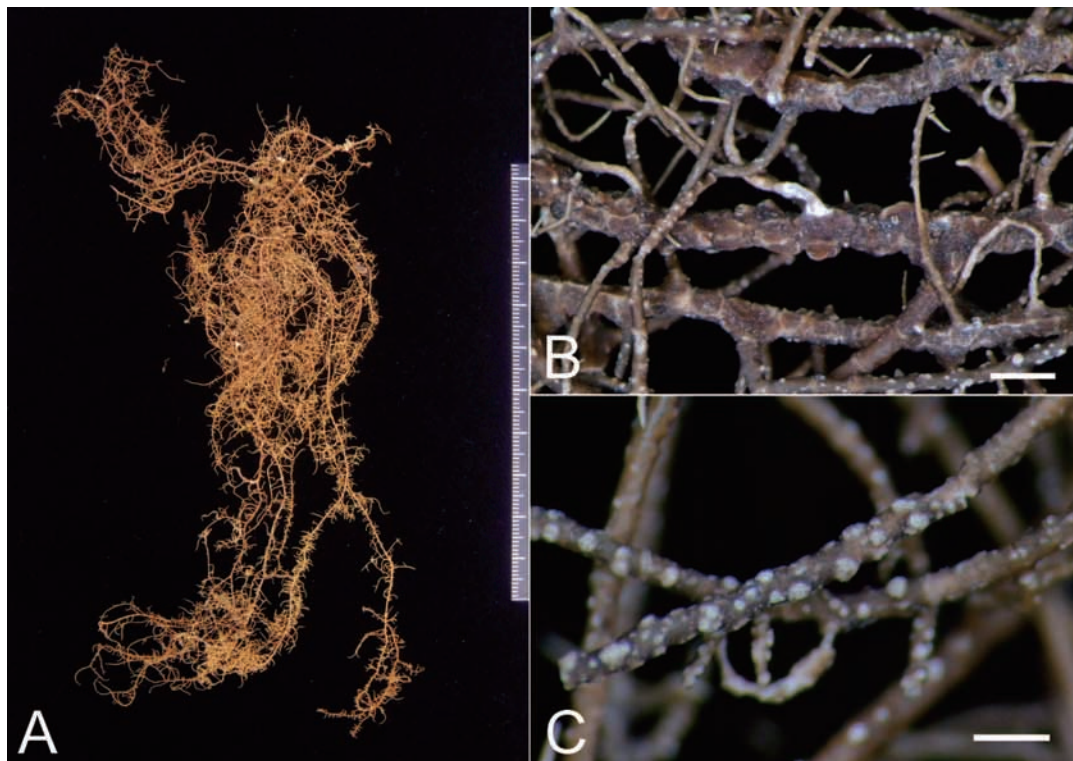


Fig. 4. *Usnea angulata* (S. Kurokawa 759, TNS). A. Thallus. B. Ridged to alate branches. C. Soralia. Scales: A = 1 mm; B, C = 0.5 mm.



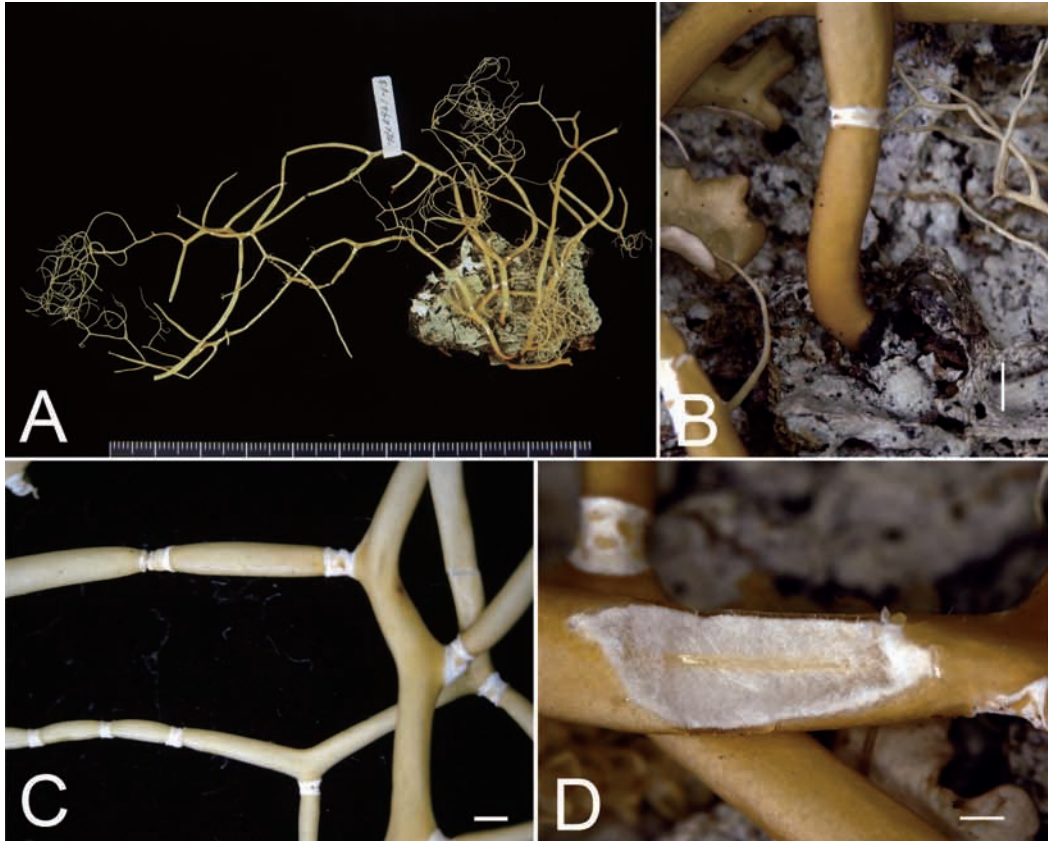


Fig. 5. *Usnea articulata* (Y. Ohmura 6097, TNS). A. Thallus. B. Base of thallus. C. Branches lacking pseudocyphellae and constricted at the segments. D. Inflated branch with thin axis and broad medulla. Scales: A-C=1 mm; D=0.5 mm.

al branches, 0.8–1.5 mm in diam.; lateral branches constricted at the base, often with exposed medulla of the crack to form white annular rings as well as those in branch segments; papillae absent; soralia absent. Cortex thin, 4.3–6.7–9.0% of the radius, *merrillii*-type plectenchymatous; hyphae pachdermatous, lacking red pigment, lumina almost the same as medullary hyphae. Medulla lax, wide, 29–34–39% of the radius, lacking red pigment. Axis soild, thin, 13–19–24% of the diameter, I–. Apothecia not seen.

**Chemistry.** Usnic, diffractaic, fumarprotocetraric, protocetraric acids, and US3 (trace).

The distinguishing features of *U. articulata* are (1) the pendent thallus with anisotomic-

dichotomous branching, (2) the inflated branches which is glossy and lacking pseudocyphellae on the surface, (3) the constricted branch segments, (4) the absence of soralia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of fumarprotocetraric acid as a major substance.

*Usnea articulata* is known as a variable species in morphology and chemistry. Although pseudocyphellae and isidia are commonly produced in many individuals from Europe and Africa (Swinscow & Krog, 1976), they are not seen in Australian individuals (Stevens, 1999). Five chemical strains have so far been reported for this species: (1) fumarprotocetraric acid, (2) salazinic acid, (3) psoromic acid, (4) stictic acid, (5) deposidone-deficient (Swinscow &

Krog, 1976). All Taiwanese specimens belong to the fumarprotocetraric acid race. The morphological and chemical features of Taiwanese specimens are well identical with the specimen of Almborn, Lich. Afric. 149 (TNS) and the description based on the Australian specimens reported by Stevens (1999).

*U. articulata* resembles *U. himalayana* and *U. nidifica*. However, it is distinguished from them by the absence of pseudocyphellae and soralia and the presence of fumarprotocetraric acid.

In Taiwan, *U. articulata* is found on bark of *Pinus* sp. at elevation 2,200 to 2,600 m. This species has been also recorded from Africa, Europe, Australia, New Zealand, India, and southeast Asia (Stevens, 1999).

Exsiccata examined. Canary Islands, Tenerife, Valle de Orotava, La Caldera near Aguamansa, on twigs of *Pinus canariensis*, c. 1,200 m, 25.11.1989, H. T. Lumbsch (7126) & E. Mietzsch (Almborn: Lich. Afric. 149).

Specimens examined. TAIWAN. Nantou Co.: Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6097. Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on trunk of *Pinus* sp., 2,249 m, 30.9.2010, Y. Ohmura 7363.

**4. *Usnea baileyi* (Stirt.) Zahlbr., in Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl. 83: 182, 1909. [Fig. 6]**

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic acids, eumittrin A<sub>2</sub>, zeorin, protocetraric ( $\pm$ ), salazinic ( $\pm$ ), barbatic ( $\pm$ ), 4-O-demethylbarbatic ( $\pm$ ) acids, eumittrin A<sub>1</sub> ( $\pm$ ), and eumittrin B ( $\pm$ ).

*U. baileyi* is a distinctive species and is readily distinguished from other species by (1) the erect to subpendent thallus with concolour or dark brown base, (2) the fistulose axis, (3) the punctiform soralia, (4) the presence of red pigment in the medulla near the cortex, (5) the *baileyi*-type plectenchymatous cortex, and (6)

the presence of zeorin and eumittrins.

Although two chemical races (Race 1, containing depsidones; Race 2, lacking depsidones) have been recognized in Ohmura (2001), only Race 1 has been found in Taiwan. Fatty acids such as bourgeanic, protolichesterinic, caperatic acids, which were detected from other areas of east Asian materials, have not yet been detected from Taiwanese specimens.

Representative specimens examined. TAIWAN. Changhua Co.: Lienhuachih (Rengechi), 30.12.1925, Y. Asahina 25123. Chiayi Co.: en route from Su-Su-Lu to Fun-Chi-Fu, 1,700–2,000 m, 5.1.1964, S. Kurokawa 536. Hsinchu Co.: at 18 K of Talulindao, Kuanwu, 1,480 m, on bark of *Gordonia axillaris*, 17.10.1994, C.-K. Lin 4140 (TNM, TNS). Ilan Co.: Piyanan Pass, 1,600–1,900 m, 16.1.1964, S. Kurokawa 833; Mingchih, on *Osmanthus fragrans*, 15.9.1992, C.-K. Lin s.n. (TNM, TNS); ditto, 1,065 m, on trunk of *Persea*, 24.8.1993, C.-K. Lin 3194 (TNM, TNS). Nantou Co.: Chitou, 30.1.1964, S. Kurokawa 1410a; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of *Cryptomeria japonica*, 2,340 m, 27.8.2008, Y. Ohmura 6033; ditto, on bark of broad-leaf tree, 2,216 m, 27.8.2008, Y. Ohmura 6154; Renlue, on twig of *Quercus* sp., 1,699 m, 30.8.2008, Y. Ohmura 6220; ditto, on bark of *Pinus* sp., 1,578 m, 30.8.2008, Y. Ohmura 6227. Taichung Co.: Mt. Alisan, 25.12.1925, Y. Asahina F281b. Taoyuan Co.: Hsuewu, Fuhsing, on rotten logs, c. 1,350 m, 14.10.1992, C.-K. Lin s.n. (TNM, TNS); Lalashan, 1,500 m, on branch, 14.9.1994, C.-K. Lin 4051 (TNM, TNS).

**5. *Usnea bicolorata* Motyka, Lich. Gen. *Usnea* Stud. Monogr., Pars Syst. 2: 336, 1937.**

For a description and illustrations, see Ohmura *et al.* (2010).

Chemistry. Usnic, barbatic, protocetraric, and salazinic ( $\pm$ ) acids.

The distinguishing features of *U. bicolorata*

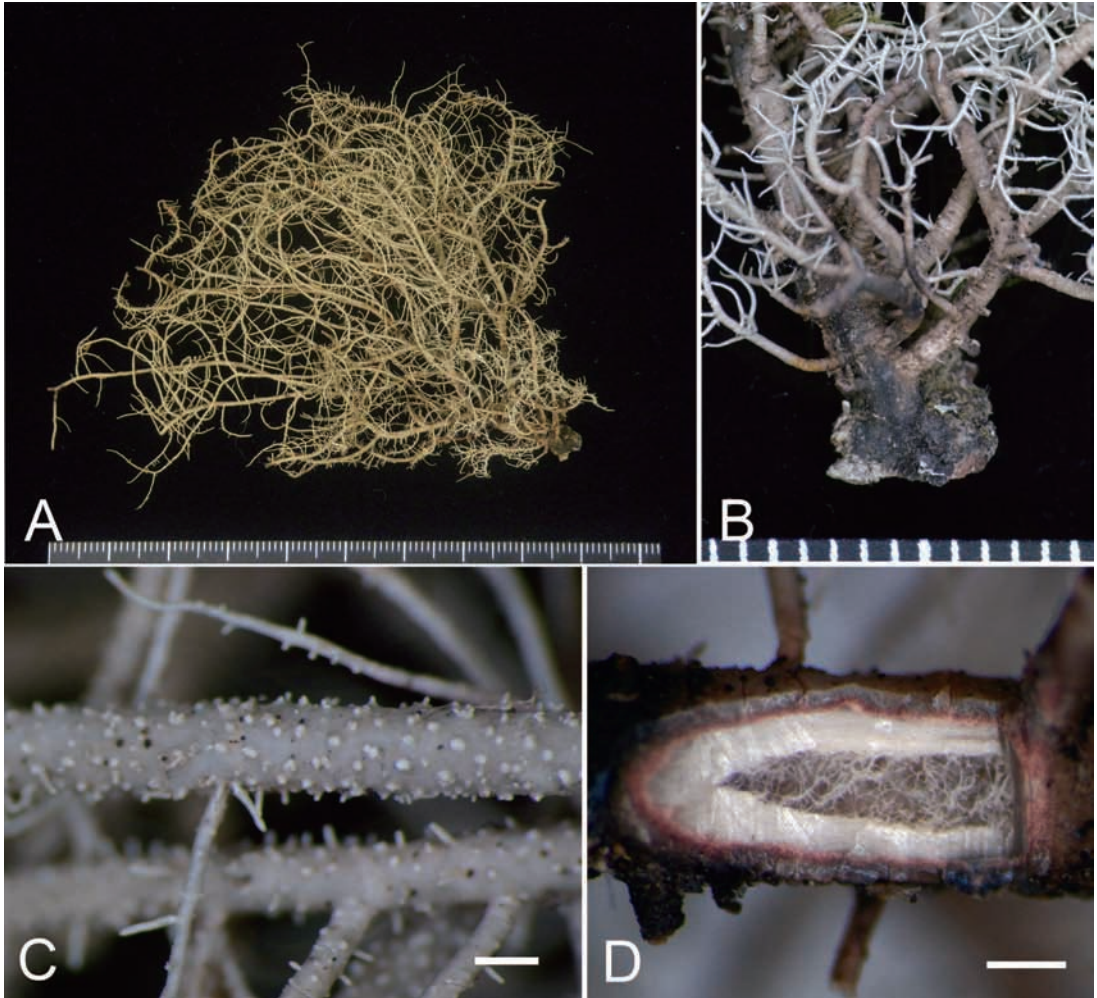


Fig. 6. *Usnea baileyi* (Y. Ohmura 6154, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Red pigment in the medulla and fistulose axis. Scales: A, B=1 mm; C, D=0.5 mm.

are (1) the erect thallus with anisotomic-dichotomous branching, (2) the jet black base, (3) the uninflated branches, (4) the concave soralia with granular soredia and few isidiomorphs, (5) the presence of red pigment secreting in the hyphal cell wall in the medulla near the cortex [“subcortical” in Swinscow & Krog (1979)], and (6) the presence of barbatic and protocetraric acids as major substances.

*U. bicolorata* resembles *U. fragilescens*, *U. fulvoreaegens*, *U. glabrescens*, and *U. wasmuthii* in having the jet black base of thallus and concave soralia with granular soredia. However,

it is readily distinguished from them by the presence of subcortical red pigment in the medulla. *U. bicolorata* may be confused with *U. rubicunda* and *U. rubroincta* in having partly red pigmented thallus. However, the red pigmentation of *U. rubicunda* and *U. rubroincta* occur in the cortex, while that of *U. bicolorata* occurs in subcortical part of medulla.

Specimens examined. TAIWAN. Nantou Co., Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6099, 6112 (TNS, TNM). Taichung Co.: Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1080.

6. *Usnea bismolliuscula* Zahlbr., Cat. Lich. Univ. 6: 542, 1923. [Fig. 7]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic, menegazziaic, stictic, and constictic acids.

The distinguishing features of *U. bismolliuscula* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches which are glossy, smooth and perforated on the surface, (3) the soralia

which are confluent each other to form irregular in shape and smaller than branch diam., (4) the absence of granular soredia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of stictic acid as major substance.

Although two chemical races (stictic acid race or thamnolic acid race) were recognized in Ohmura (2001), only stictic acid race has been found in Taiwan.

*U. bismolliuscula* resembles *U. dasaea*, *U.*

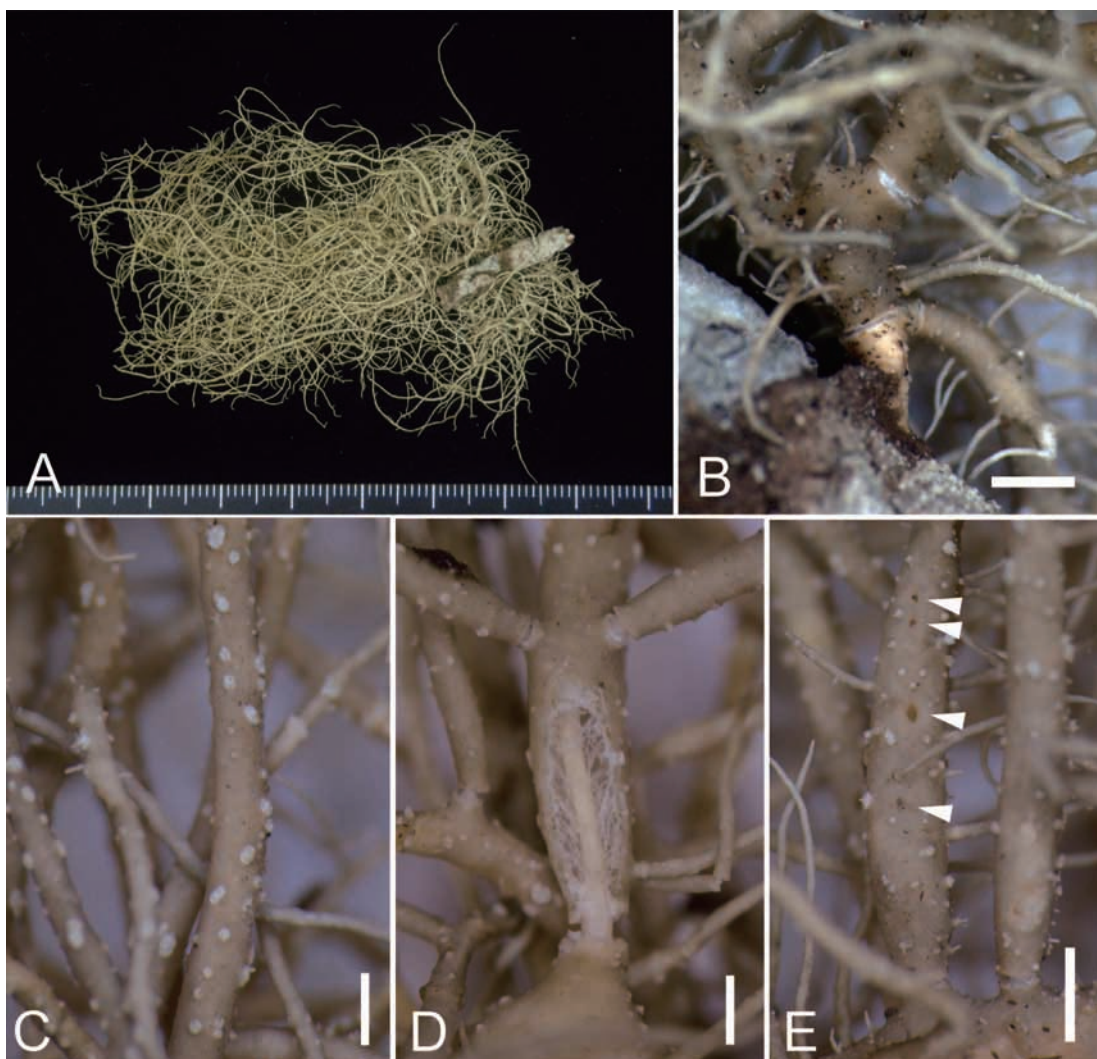


Fig. 7. *Usnea bismolliuscula* (Y. Ohmura 6222, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Inflated branch with lax medulla and a thin axis. E. Perforations on branch (arrows). Scales: A, B, E=1 mm; C, D=0.5 mm.

*nidifica* and *U. pygmoidea* in having inflated branches with soralia. However, it can be distinguished from the others by the presence of perforations on the branches.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali-san, 25.12.1925, Y. Asahina F-287; en route from Su-Su-Lu to Fun-Chi-Fu, 1,700–2,000 m, 5.1.1964, S. Kurokawa 533; en route from Su-Su-Lu to Mt. Ali, 2,000–2,200 m, 7.1.1964, S. Kurokawa 657, 666. Kaohsiung Co.: Mt. Nanfong, 800–1,300 m, 7.2.1965, S. Kurokawa 2842, 2846, 2859. Nantou Co.: Renlun, on twig of *Quercus* sp., 1,699 m, 30.8.2008, Y. Ohmura 6219; ditto, on bark of *Pinus* sp., 1,578 m, 30.8.2008, Y.

Ohmura 6222; Keitau, 23.12.1933, Y. Asahina 33287a; Chitou, 30.1.1964, S. Kurokawa 1402; Hweishunlinshang, on *Pinus taiwanensis*, 18.11.1990, C.-K. Lin s.n. (TNM, TNS). Taitung Co.: Antung Pass, 400–995 m, 27.1.1965, S. Kurokawa 2666. Yunlin Co.: Shipi, Kukeng, on tree, c. 1,500 m, 20.2.1991, C.-K. Lin s.n. (TNM, TNS).

7. *Usnea ceratina* Ach., Lich. Univ., 619, 1810. [Fig. 8]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, barbatic, diffractaic, baecomycesic and squamatic acids, and US5.

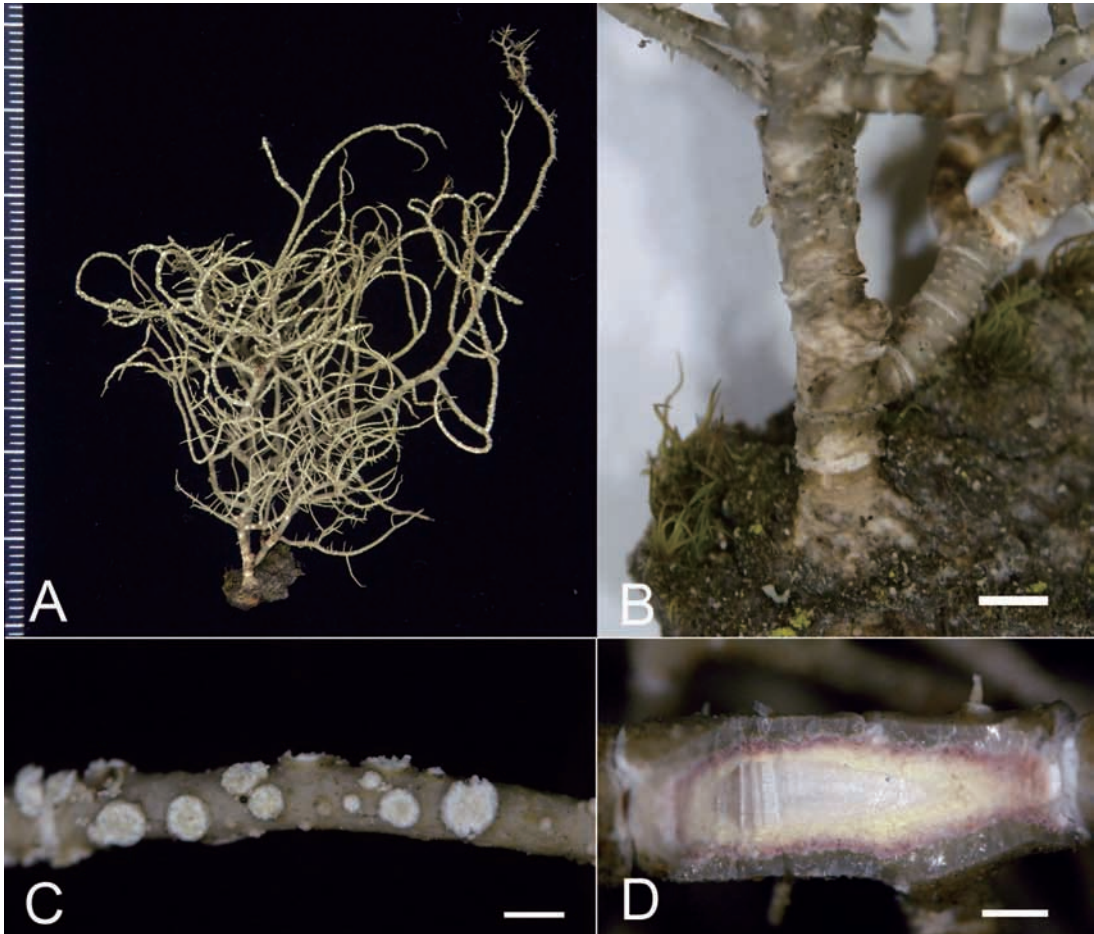


Fig. 8. *Usnea ceratina* (Y. Ohmura 6155, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Red pigment in the medulla. Scales: A, B=1 mm; C, D=0.5 mm.

The distinguishing features of *U. ceratina* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the rounded soralia which are stipitate and convex at the top often with isidiomorphs, (3) the strawberry pink pigmentation in the medulla near the cortex, and (4) the presence of diffractaic acid as a major substance.

Although two chemical races (Race 1, diffractaic acid as a major substance; and Race 2, barbatic acid as a major substance) were recognized in Ohmura (2001), only Race 1 has been found in Taiwan.

*U. ceratina* may be confused with some spe-

cies which have rounded soralia and shrubby thallus such as *U. cornuta* and *U. fragilescens*. However, it can be readily distinguished from others by the strawberry pink pigment in the medulla.

Representative specimens examined. TAIWAN. Nantou Co.: around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of broad-leaf tree, 2,216 m, 27.8.2008, Y. Ohmura 6155; Chito, 30.1.1964, S. Kurokawa 1407. Taichung Co.: Wulin Guest House, Heping Township, on bark of *Pinus* sp., 1,716 m, 29.9.2010, Y. Ohmura 7259, 7260; ditto, on bark of *Prunus* sp., Y. Ohmura 7264; between

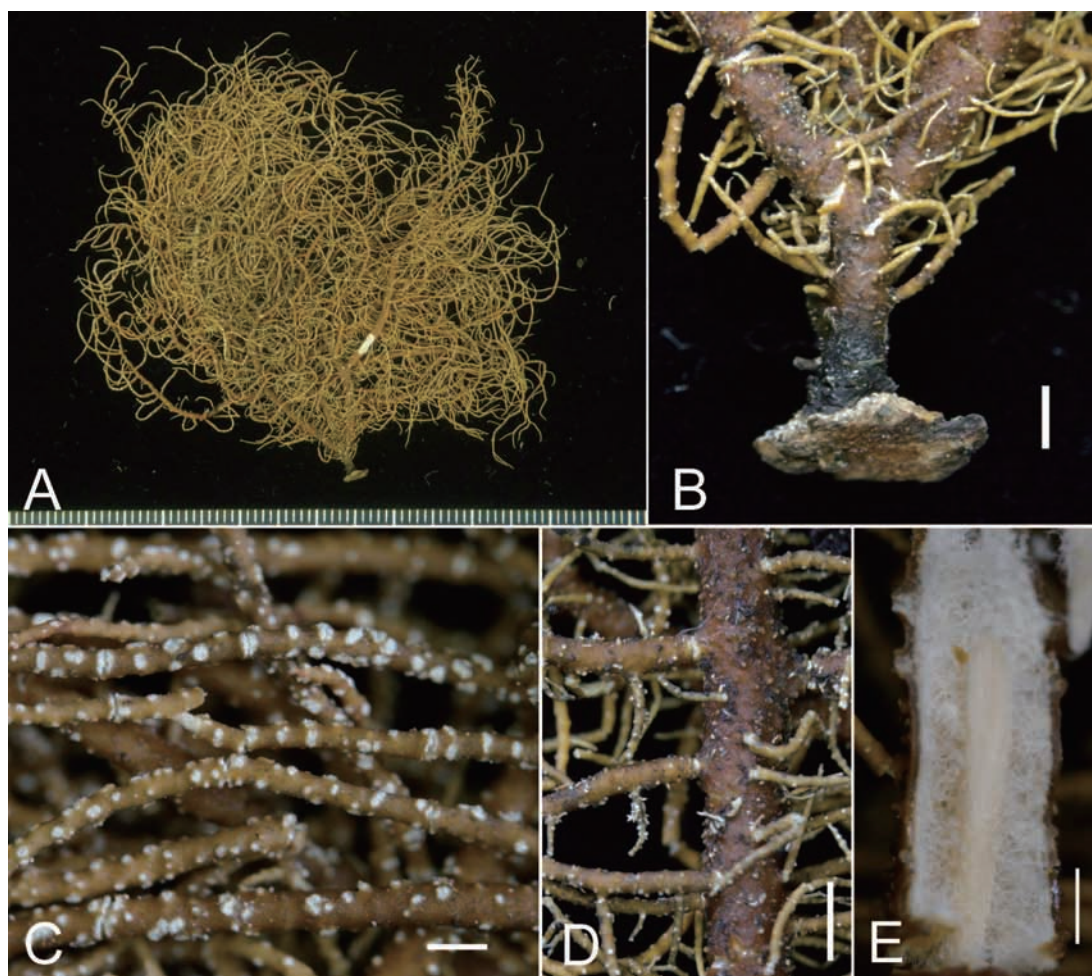


Fig. 9. *Usnea cornuta* subsp. *cornuta* (S. Kurokawa 583, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Constricted base of branches. E. Inflated branch. Scales: A, B, D=1 mm; C, E=0.5 mm.

0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Chamaecyparis obtusa*, 2,249 m, 30.9.2010, Y. Ohmura 7374; between 6.8 km point of mountain trail and Mt. Duojiatun-shan, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 2,439 m, 30.9.2010, Y. Ohmura 7416. Taitung Co.: Chokakurai, 1936, H. Masuda 36007.

**8. *Usnea cornuta* Körb. subsp. *cornuta*, Parerga Lichenol.: 2, 1859. [Fig. 9]**

*Usnea confusa* Asahina, Lich. Jpn. 3: 97, 1956. [Synonymized by Clerc (2004)].

For a description and synonyms, see in Ohmura (2001) and Clerc (2004).

Chemistry. Usnic, salazinic, protocetraric (trace), and constictic acids ( $\pm$ )

The distinguishing features of *U. cornuta* subsp. *cornuta* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the inflated branches which are constricted at the base, (3) the rounded soralia which are developed from at the top of eroded papillae, (4) the absence of granular soredia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of salazinic acid as the major substance.

*U. cornuta* subsp. *cornuta* resembles *U. cornuta* subsp. *brasiliensis*, *U. dasaea*, *U. glabrata*, *U. hakonensis* and *U. pygmoidea* in having inflated branches with soralia. However, *U. cornuta* subsp. *cornuta* is distinguished from *U. cornuta* subsp. *brasiliensis* by the presence of salazinic acid; from *U. dasaea* and *U. pygmoidea* by the rounded soralia and the absence of norstictic acid, from *U. glabrata* by the absence of granular soredia, and from *U. hakonensis* by the *merrillii*-type plectenchymatous cortex and the absence of US1 and US2.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 6.1.1964, S. Kurokawa 583. Nantou Co.: Chitou, 30.1.1964, S. Kurokawa 1409.

**9. *Usnea cornuta* subsp. *brasiliensis* (Zahlbr.)**

P. Clerc, Biblioth. Lichenol. 88: 81, 2004.

*Usnea bornmuelleri* var. *brasiliensis* Zahlbr., Cat. Lich. Univers. 6: 543, 1930.

For a description, see in Clerc (2004).

Chemistry. Usnic and protocetraric acids.

According to Clerc (2004), this subspecies is distinguished from subsp. *cornuta* by the presence of protocetraric acid as a major substance. Morphological differences are not clear between subsp. *cornuta* and subsp. *brasiliensis* for the Taiwanese materials.

Specimen examined. TAIWAN. Taichung Co.: Chokakulai, 1936, H. Masuda s.n. (herb. Y. Asahina 36004).

**10. *Usnea dasaea* Stirt., Scott. Natur. 6: 104, 1881. [Fig. 10]**

For a description and synonyms, see Ohmura (2001).

Chemistry. Race 1, usnic, norstictic, salazinic and protocetraric acids ( $\pm$ ), and atranorin ( $\pm$ ); Race 2, usnic, norstictic and galbinic acids.

The distinguishing features of *U. dasaea* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches often with many spinulose fibrils, (3) the irregular shaped soralia which are developed from scars of detached fibrils, (4) the absence of granular soredia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of salazinic and/or galbinic acids as the major substance.

Although three chemical races (Race 1, Race 2, and Race 3: usnic, psoromic, 2'-O-demethylpsoromic, norstictic, galbinic and salazinic acids) were recognized in Ohmura (2001), Race 3 has not been found in Taiwan.

*U. dasaea* resembles *U. cornuta* subsp. *cornuta*, *U. cornuta* subsp. *brasiliensis*, *U. fragilescens*, *U. glabrata* and *U. pygmoidea* in having the inflated branches with soralia. However, it can be distinguished from the others by the ontogeny of soralia which are developed from scars of detached fibrils.

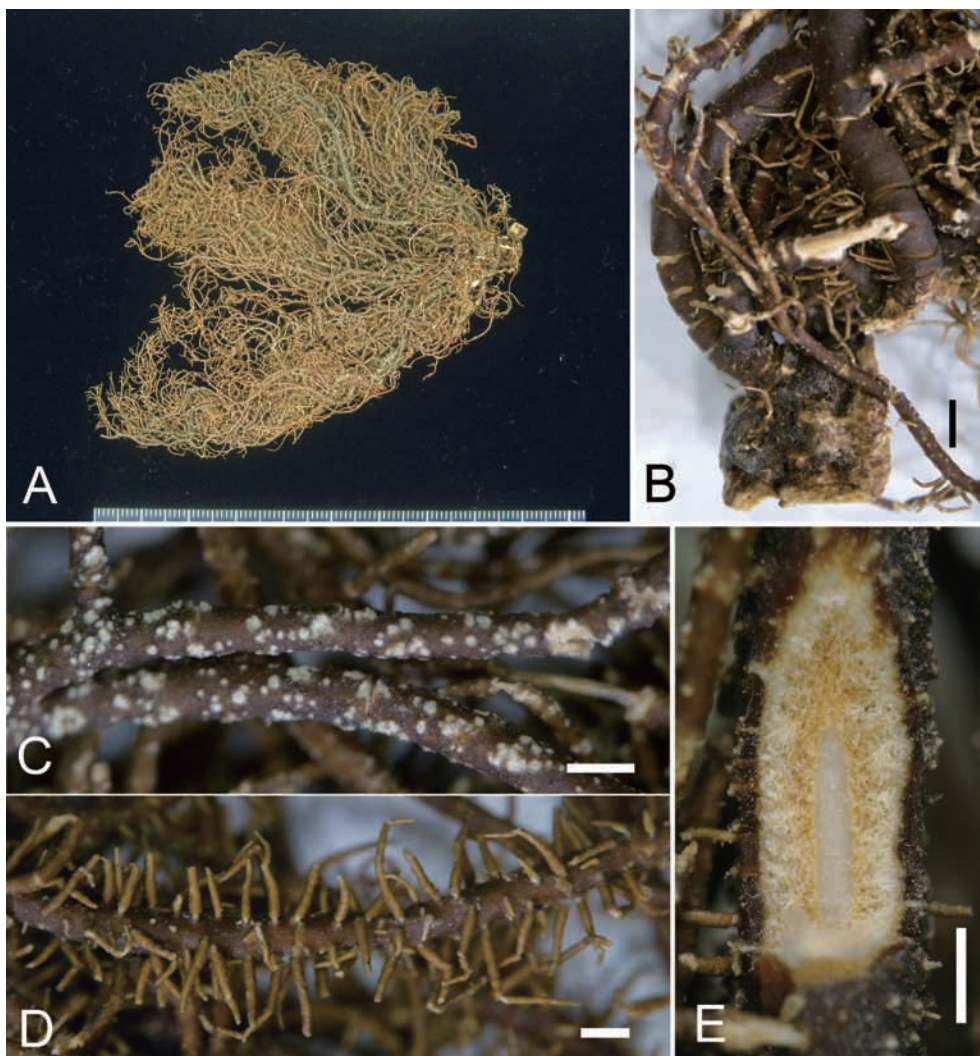


Fig. 10. *Usnea dasaea* (Y. Asahina F282b, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Spinulose fibrils on branch. E. Slightly inflated branch and moderate density of medulla. Scales: A, B=1 mm; C, D, E=0.5 mm.

Representative specimens examined. Race 1. TAIWAN. Nantou Co.: Paiyun-Tatachia, on rotten log, 3,000–3,400 m, 17.10.1992, S.-J. Chen s.n. (TNM, TNS); Yuanfeng, 2,756 m, on branch, 27.4.1993, S.-T. Chiu 1753b (TNM, TNS). Taichung Co.: Mt. Nan-Fu-Ta-San, 1,500–2,400 m, 19.1.1964, S. Kurokawa 968b.

Race 2. TAIWAN. Chiayi Co.: Mt. Arisan, 24.12.1925, Y. Asahina F-282b. Nantou Co.: Keitau, 30.10.1933, H. Masuda s.n. (herb. Y. Asahina 33103); Renluen, on bark of *Pinus* sp.,

1,578 m, 30.8.2008, Y. Ohmura 6228B.

11. *Usnea dendritica* Stirt., Scott. Natur. 6: 296, 1882. [Fig. 11]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic, barbatic, 4-O-demethylbarbatic, norstictic, protocetraric, and salazinic acids.

The distinguishing features of *U. dendritica* are (1) the erect to subpendent thallus with





Fig. 11. *Usnea dendritica* (Y. Asahina 33125, TNS). A. Thallus. B. Base of thallus. C. Apothecia with brown disc which are margined by white rim. D. Uninflated branch and moderate density of medulla. Scales: A, B, C=1 mm; D=0.5 mm.

anisotomic-dichotomous branching, (2) the annular cracks especially near the base, (3) the cylindrical papillae which produce few soralia at the top, (4) the absence of granular soredia, (5) the flat to sinuose apothecia with few or no fibrils along the margin, (6) the brown disc which are margined by white rim, (7) the *merrillii*-type plectenchymatous cortex, and (8) the presence of barbatic and salazinic acids

as major substances.

*U. dendritica* resembles other richly fertile species such as *U. florida*, *U. orientalis* and *U. pseudogatae*. However, it is distinguished from others by the flat to sinuose shaped apothecia which have few or no fibrils and possess a white rim on the disc, and by the presence of barbatic and salazinic acid as major substances. *U. dendritica* is considered to have a close rela-

tionship with *U. pangiana*, since the morphology and their chemistry are similar each other except for soralia morphology.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 30.12.1963, S. Kurokawa 46; Tefuyeh, Alishan, 1,400–1,900 m, on tree, 16.9.2004, C.-K. Lin 7962 (TNM, TNS). Nantou Co.: Keitau, 25.12.1933, Y. Asahina 33125. Taitung Co.: Mt. Lachialachiaerh, c. 1,800 m, 22.1.1965, S. Kurokawa 2508.

12. *Usnea diffracta* Vain., Bot. Mag. Tokyo 35: 45, 1921. [Fig. 12]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, diffractaic, barbatic, baecomycesic, squamatic, and atranorin ( $\pm$ ).

*U. diffracta* is a distinctive species and it is

readily distinguished from other *Usnea* species by (1) the pendent thallus with isotomic-dichotomous branching, lacking “fish-bone” like terminal and subterminal branches, (2) the uninflated branches, (3) the presence of annular-pseudocyphellae between segments, (4) the absence of soralia and papillae, (5) the occasional presence of punctiform maculae on the surface of lateral branches, and (6) the *merrillii*-type plectenchymatous cortex.

Although four chemical races (Race 1, diffractaic acid; Race 2, diffractaic and salazinic acids; Race 3, barbatic acid; Race 4, bourgeanic acid) were recognized in Ohmura (2001), only Race 1 has been found in Taiwan.

Representative specimens examined. TAIWAN. Chiayi Co.: Nimandaira, Mt. Arisan, 25.12.1925, Y. Asahina F-285. Ilan Co.: Mt. Taiping, 31.7.1936, S. Asahina s.n. Nantou

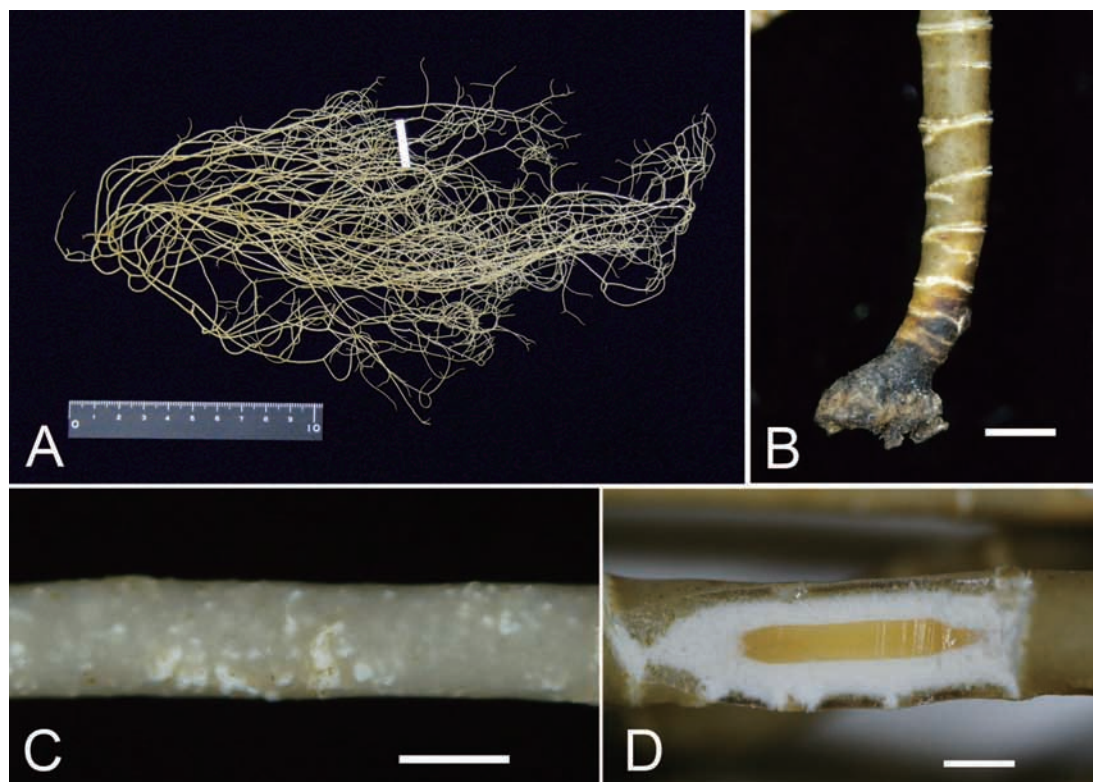


Fig. 12. *Usnea diffracta* (Y. Ohmura 6060, TNS). A. Thallus. B. Base of thallus and annular-pseudocyphellae at the segments. C. Punctiform maculae. D. Uninflated branch with dense medulla. Scales: A, B=1 mm; C, D=0.5 mm.

Co.: Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6060. Taitung Co.: Mt. Lachialachiaerh, c. 1,800 m, 22.1.1965, S. Kurokawa 70269.

**13. *Usnea florida* (L.) Weber ex F. H. Wigg.,**  
Pr. Fl. Holsat., 91, 1780. [Fig. 13]

For a description, see Ohmura (2001).

Chemistry: usnic and thamnolic acids.

The distinguishing features of *U. florida* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the jet black base, (3) the uninflated branches with cylindrical papillae on the surface, (4) the absence of soralia, (5) the common occurrence of apothecia, (6) the *florida*-type plectenchymatous cortex, and (7)

the presence of thamnolic acid.

*U. florida* may be confused with *U. dendritica*, *U. fuscorubens*, *U. masudana*, *U. orientalis*, *U. shimadae* and *U. sinensis*, since they form similar fertile thalli without soralium. However, it is distinguished from the others by the jet black base of the thallus and the production of thamnolic acid.

Specimen examined. TAIWAN. Taichung Co.: Mt. Dai-wu, on tree bark, c. 2,000 m, 9.1958, collector unknown 106.

**14. *Usnea fragilescens* Havaas ex Lynge, Vid.**  
Selsk. Skr. I. M.-N. Kl. 7: 230, 1921.

For a description, a synonym and illustrations, see Ohmura *et al.* (2000).

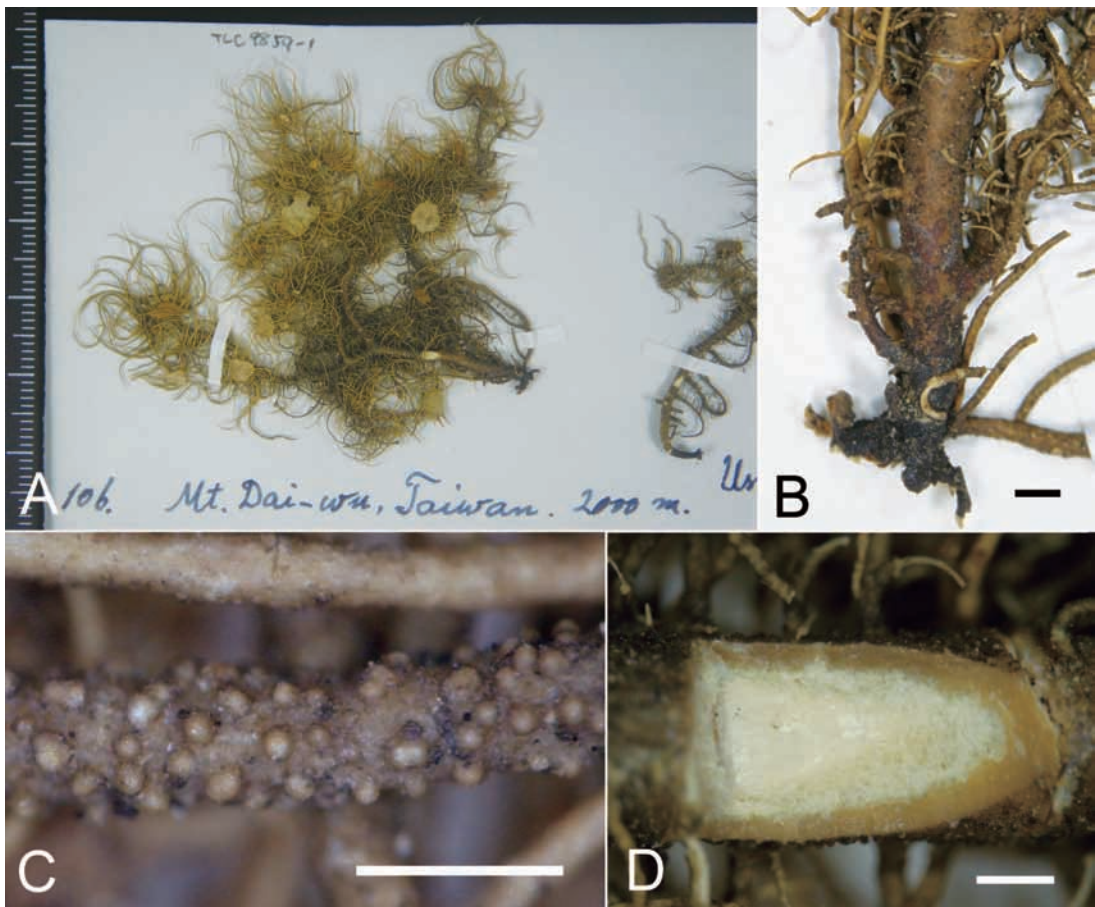


Fig. 13. *Usnea florida* (collector unknown 106, TNS). A. Thallus. B. Base of thallus. C. Cylindrical papillae. D. uninflated branch. Scales: A, B = 1 mm; C, D = 0.5 mm.

Chemistry. Usnic, barbatic, 4-O-demethylbarbatic, and protocetraric acids.

*U. fragilesceus* is characterized by the following morphology: (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the jet black base, (3) the inflated branches which are constricted at base, (4) the slightly excavated, rounded soralia with granular soredia, which become as large as the branch diam., and (5) the non-reflexed cortical margin around soralia.

Seven chemical races have been recognized for the species: Race 1, stictic acid; Race 2, salazinic acid; Race 3, psoromic acid; Race 4, squamatic acid; Race 5, barbatic, and Race 6, usnic acid only (Clerc, 1987; Halonen *et al.*, 1998; Ohmura *et al.*, 2000). Although Race 5 has been only reported from Japan, this race was also found in Taiwan.

The inflated branches and excavated soralia with granular soredia typical of *U. fragilesceus* resembles somewhat similar features in *U. glabrata*. However, *U. fragilesceus* can be distinguished from *U. glabrata* by its jet black base. In addition, the soralia of *U. fragilesceus* are slightly concave at the top with non-reflexed cortical margins, while the soralia of *U. glabrata* are deeply excavated with distinctly reflexed cortical margins. The jet black base and excavated soralia with granular soredia of *U. fragilesceus* also resemble similar features in *U. fulvoreagens*, *U. glabrescens* and *U. wasmuthii*. However, *U. fragilesceus* can be distinguished from these taxa on the basis of its inflated branches which are constricted at the base and slightly glossy branch surfaces.

Specimens examined. TAIWAN. Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 1,977 m, 30.9. 2010, Y. Ohmura 7273.

**15. *Usnea fulvoreagens*** (Räsänen) Räsänen, Lich. Fenn. Exs. 13, 1935.

For descriptions and illustrations, see Ohmura & Kashiwadani (2000) and Ohmura

(2001).

Chemistry: Race 1, usnic, norstictic acids, and zeorin; Race 2, usnic, norstictic and diffractaic acids, zeorin, and trace amounts of barbatic, 4-O-demethylbarbatic, baeomycesic, and squamatic acids, and atranorin ( $\pm$ ).

The distinguishing features of *U. fulvoreagens* are (1) the erect to subpendent thallus, (2) the jet black base, (3) the uninflated branches with cylindrical papillae on the surface, (4) the deeply excavating soralia which cortical margins are distinctly reflexed, (5) the presence of granular soredia and lacking isidiomorphs, (6) the *florida*-type plectenchymatous cortex, and (7) the presence of norstictic acid and zeorin.

*U. fulvoreagens* is distinguished from other related species by having deeply excavating soralia without isidiomorph, and by presence of norstictic acid and zeorin.

Representative specimens examined. Race 1. TAIWAN. Taichung Co.: en route from Ssu-yuan to To-chia-tun Shanm Mt. Nanhuta Shan, Hoping, on *Salix* sp., 1,900–2,250 m, 9.11.1989, H. Kashiwadani 35767.

Race 2. TAIWAN. Taichung Co.: Mt. Nan-Fu-Ta-San, 1,500–2,400 m, 19.1.1964, S. Kurokawa 963.

**16. *Usnea fuscrobens*** Motyka, Lich. Gen. Usnea Stud. Monogr. Pars Syst. 2: 546, 1938. [Fig. 14]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic and salazinic acids.

The distinguishing features of *U. fuscrobens* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches with cylindrical papillae, (3) the absence of soralia, (4) the cup-shaped apothecia, (5) the gray to pale brown disc which are not marginated by white rim, and (6) the presence of salazinic acid as the major substance.

*U. fuscrobens* strongly resembles *U. orientalis*, but it is distinguished by the cup-

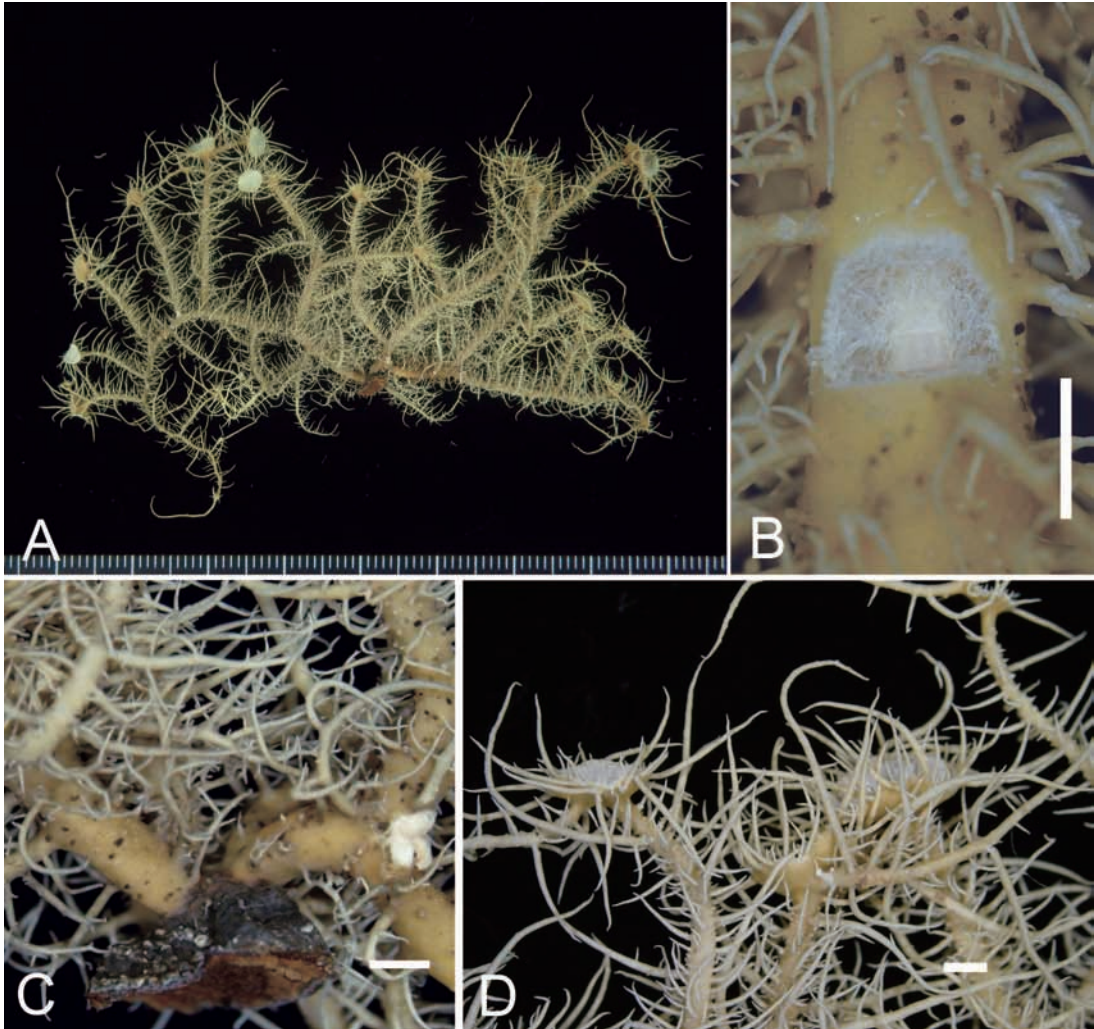


Fig. 14. *Usnea fuscrobens* (Y. Ohmura 6200, TNS). A. Thallus. B. Inflated branch with lax medulla. C. Base of thallus. D. Cup-shaped apothecia. Scales = 1 mm.

shaped apothecia.

Representative specimens examined. TAIWAN. Prov. Nantou: Keitai, 24.12.1933, Y. Asahina 33421; Mt. Chilai, Hehuan-shan Mts., Taroko National Park, on bark of *Alnus* sp., 3,034 m, 28.8.2008, Y. Ohmura 6200.

17. *Usnea glabrata* (Ach.) Vain., Ann. Acad. Sci. Fenn. ser. A, 6(7): 7, 1915. [Fig. 15]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic, salazinic, norstictic ( $\pm$ ), and protocetraric ( $\pm$ ) acids.

The distinguishing features of *U. glabrata* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the inflated branches which are constricted at the base, (3) the concolorous base with the thallus, (4) the concave soralia with granular soredia, (5) the reflexed cortical margin of soralia, (6) the *ceratina*-type plectenchymatous cortex, and (7) the presence of salazinic acid as a major substance.

*U. glabrata* resembles *U. cornuta* subsp. *cornuta* in having sorediate inflated branches and same chemistry. However, it is distinguished

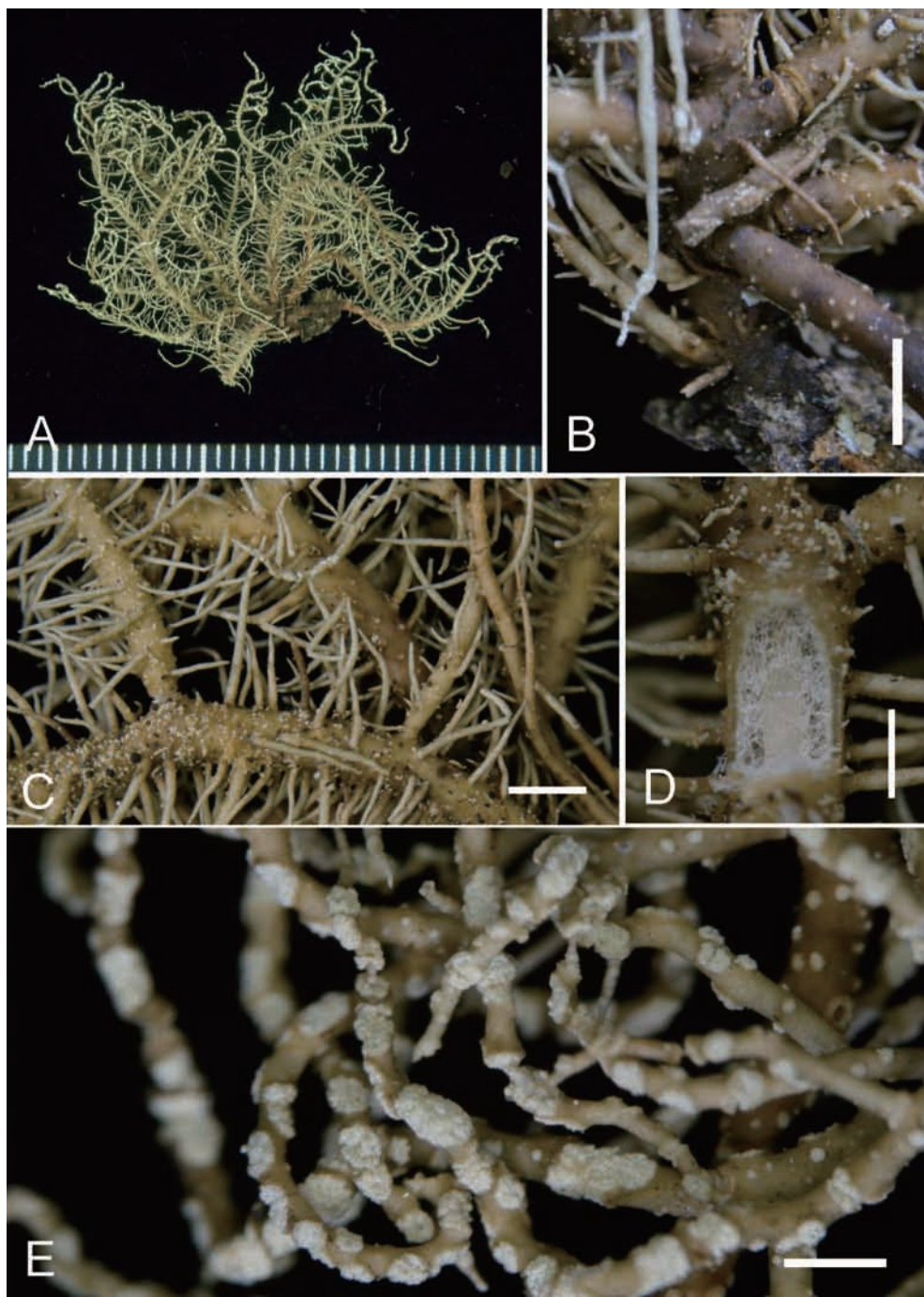


Fig. 15. *Usnea glabrata* (Y. Ohmura 6229, TNS). A. Thallus. B. Base of thallus. (Parts of this specimen are tarnished by perishing). C. Inflated branches which are constricted at the base. D. Inflated branch with lax medulla. E. Soralia. Scales: A, B, C=1 mm; D, E=0.5 mm.

from *U. cornuta* by the concave soralia with granular soredia and the *ceratina*-type plectenchymatous cortex. *U. glabrata* also resembles *U. fragilescens*, but it can be distinguished by the concolours base with thallus and chemistry from the latter species.

Representative specimens examined. TAIWAN. Nantou Co.: Renlun, on bark of *Pinus* sp., 1,578 m, 30.8.2008, Y. Ohmura 6229. Taichung Co.: Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1072.

**18. *Usnea glabrescens* (Nyl.) Vain., Med. Soc. Fa. Fl. Fenn. 48: 173, 1925.**

For descriptions and illustrations, see Ohmura & Kashiwadani (2000) and Ohmura (2001).

Chemistry: usnic, norstictic and salazinic acids.

The distinguishing features of *U. glabrescens* are (1) the erect to subpendent thallus with isotomic-dichotomous branching, (2) the jet black base, (3) the uninflated branches with papillae on the surface, (4) the rounded soralia, (5) the presence of granular soredia, (6) the *florida*-type plectenchymatous cortex, (7) the presence of norstictic acid and the absence of zeorin.

*U. glabrescens* resembles *U. fulvorangeans*, *U. fragilescens* and *U. wasmuthii* in having concave top soralia and jet black base of thallus. However, it is distinguished from *U. fulvorangeans* by the discrete soralia and the absence of zeorin; from *U. fragilescens* by the uninflated branches with matt surface; and from *U. wasmuthii* by the rounded soralia and the presence of norstictic acid.

Specimen examined. TAIWAN. Mt. Nan-Fu-Ta-San, on twigs of *Osmanthus birtsuensis*, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1088.

**19. *Usnea hakonensis* Asahina, Lich. Jpn. 3: 77, 1956.**

For a description, a synonym, and illustrations, see Ohmura *et al.* (2010).

Chemistry. Usnic and norstictic acids, US1 and US2.

The distinguishing features of *U. hakonensis* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the inflated branches which are glossy on the surface and with few papillae, (3) the rounded soralia which are convex at the top often with many isidiomorphs, and (4) the presence of US1 and US2 as major substances.

Although two chemical races (Race 1, containing norstictic acid; Race 2, lacking norstictic acid) have been recognized in Ohmura (2001), only Race 1 has been found in Taiwan.

*U. hakonensis* resembles *U. cornuta* subsp. *cornuta*, *U. cornuta* subsp. *brasiliensis*, *U. dasaea* and *U. pygmoidea* very much in having the inflated branches with rounded soralia. However, it is distinguished from them by the presence of US1 and US2.

Representative specimens examined. TAIWAN. Nantou Co.: Haitienhsih, Tantalindao of Hsini, on trunk of *Pinus* sp., 2,210 m, 25.9.1993, C.-K. Lin 3305 (TNM, TNS). Taichung Co.: Tashueshan Forest Park, Hopen, on decayed wood, c. 2,000 m, 28.10.2008, H. Kashiwadani 55008; ditto, on bark of *Prunus* sp., H. Kashiwadani 55009B1; Mt. Yuanzuei, on twigs of *Pinus* sp., c. 2,000 m, 4.10.2009, Y. Ohmura 7105.

**20. *Usnea hesperina* Motyka, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst. 2: 383, 1937. [Fig. 16]**

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic and protocetraric acids.

The distinguishing features of *U. hesperina* are (1) the pendent thallus with anisotomic-dichotomous branching, (2) the elongated branches, (2) the annular cracked base which is concolor with the thallus, (3) the uninflated branches with punctiform to irregular shaped maculae on the surface, (4) the punctiform to rounded soralia, (5) the solid axis, (6) the



Fig. 16. *Usnea hesperina* (S. Kurokawa 2500, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Punctiform maculae. E. Uninflated branch with thick axis and narrow medulla. Scales: A, B=1 mm; C, D, E=0.5 mm.

absence of granular soredia, (7) the *merrillii*-type plectenchymatous cortex, and (8) the presence of protocetraric acid as a major substance.

Although two chemical races (protocetraric acid race and salazinic acid race) have been recognized in Ohmura (2001), only protocetraric acid race has been found in Taiwan.

*U. hesperina* was treated as a synonym of *U. schadenbergiana* Göpp. & Stein by Clerc

(2004). However, the latter taxon contains stictic acid as a major substance and is distributed only in Asia. *U. schadenbergiana* may be related with *U. himantodes* which belongs to subgenus *Eumitria*. Although Ohmura (2001) treated *U. hesperina* under the subgenus *Usnea* section *Ceratinae*, it could possibly belong to subgenus *Eumitria* since some morphological features of this species are similar with *U. himantodes* and *U. pectinata* in having puncti-



form maculae on branches and elongation of terminal and subterminal branches. Further research should be made on the relationship between these taxa from morphological and phylogenetical points of view.

*U. hesperina* may be confused with *U. himantodes*, *U. pangiana* and *U. pectinata*. However, *U. hesperina* can be distinguished from *U. himantodes* and *U. pectinata* by the presence of protocetraric acid and the absence of stictic acid, and from *U. pangiana* by the presence of punctiform maculae on the surface of branches.

Specimens examined. TAIWAN. Taitung Co.: Mt. Lachialachiaerh, c. 1,800 m, 22.1.1965, S. Kurokawa 2500.

21. *Usnea himalayana* C.Bab., Hook. J. Bot. 4: 243, 1852. [Fig. 17]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, salazinic, norstictic ( $\pm$ ), and protocetraric ( $\pm$ ) acids.

The distinguishing features of *U. himalayana* are (1) the pendent thallus with anisotomic-dichotomous branching, (2) the inflated branches with pseudocypbellae on the glossy surface, (3) the absence of soralia, (4) the *merrillii*-type plectenchymatous cortex, and (5) the presence of salazinic acid as a major substance.

*U. himalayana* resembles *U. articulata* and *U. nidifica*. However, it is distinguished from the others by the presence of pseudocypbellae on the surface of branches.

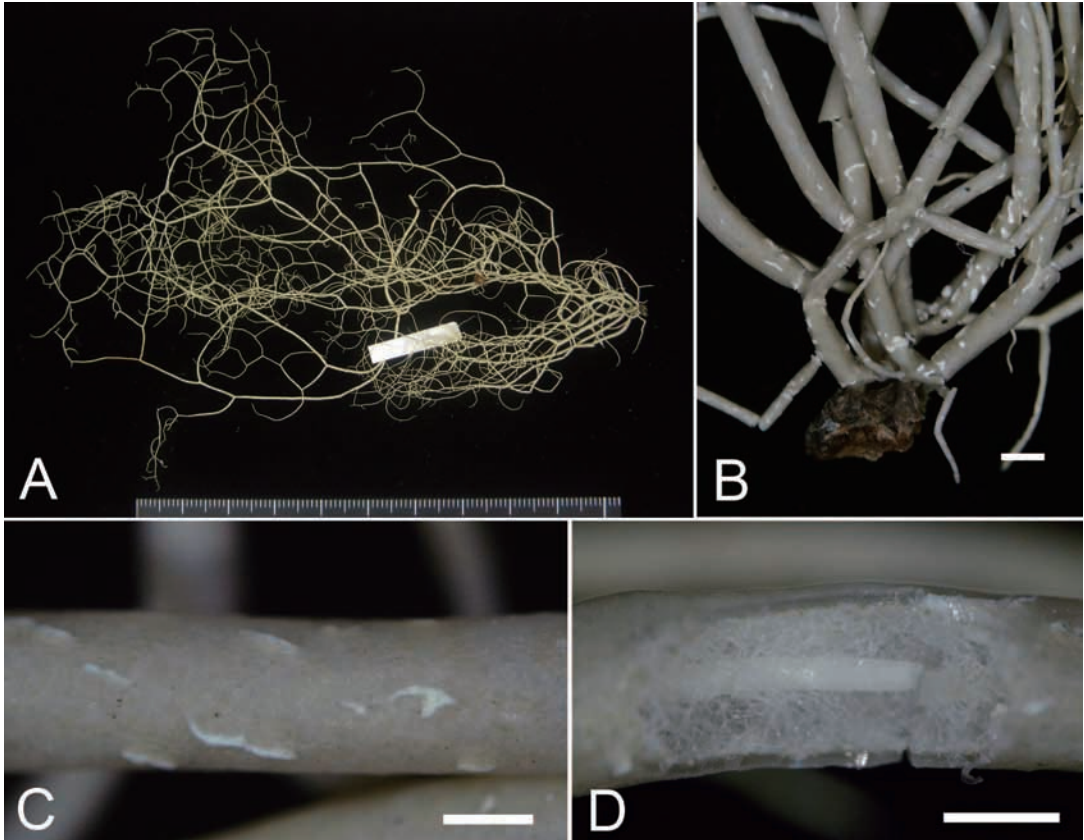


Fig. 17. *Usnea himalayana* (Y. Ohmura 6186, TNS). A. Thallus. B. Base of thallus. C. Pseudocypbellae. D. Inflated branch with thin axis and lax medulla. Scales: A, B=1 mm; C, D=0.5 mm.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 25.12.1925, Y. Asahina F-279. Nantou Co.: Mt. Chilai, Hehuan-shan Mts., Taroko National Park, on bark of *Rhododendron* sp., 3,034 m, 28.8.2008, Y. Ohmura 6186; Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura

6075. Taichung Co.: Mt. Nan-Fu-Ta-San, on twigs of *Osmanthus bioritsuensis*, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1054.

22. *Usnea himantodes* Stirt., Scott. Natur. 7: 75, 1883. [Fig. 18]

For a description and synonyms, see Oh-

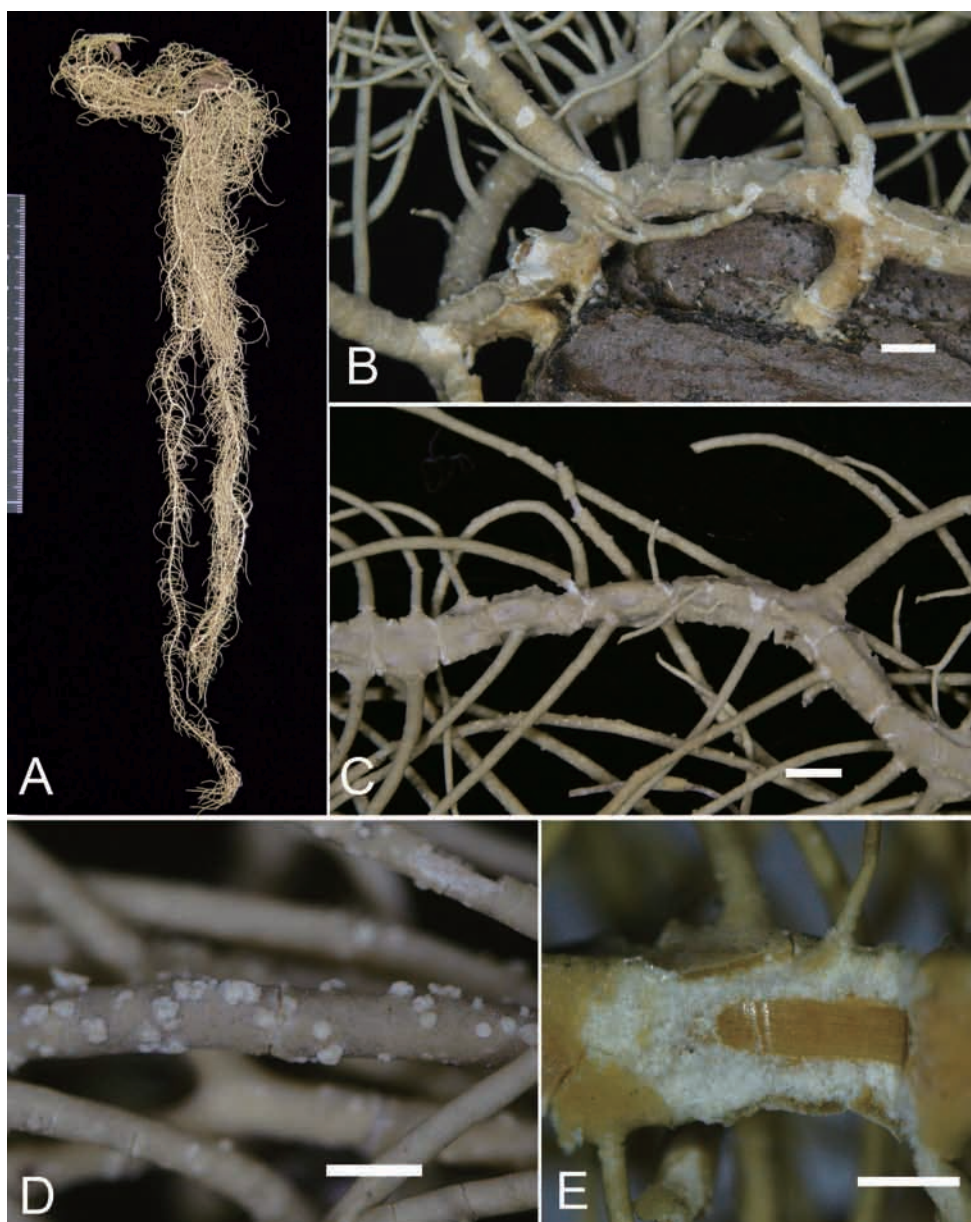


Fig. 18. *Usnea himantodes* (S. Kurokawa 1417, TNS). A. Thallus. B. Base of thallus. C. Ridged branch. D. Soralia. E. Uninflated branch. Scales: A–C=1 mm; D, E=0.5 mm.

mura (2001).

Chemistry. Usnic, norstictic, menegazziaic, stictic, and constictic acids.

The distinguishing features of *U. himantodes* are (1) the pendent thallus with subisotomic-dichotomous branching, (2) the ridged branches, (3) the small rounded soralia on lateral branches and the ridges of thicker branches, and (4) the presence of stictic acid as a major substance.

*U. himantodes* resembles *U. pectinata* in having a pendent thallus, and the presence of stictic acid as a major substance. However, it is distinguished from *U. pectinata* by the presence of ridged branches.

Specimens examined. TAIWAN. Nantou Co.: Chito, 30.1.1964, S. Kurokawa 1416, 1417; Keitau, 12.12.1933, Y. Asahina 3324.

**23. *Usnea longissima* Ach., Lich. Univ., 626, 1810.**

For a description, synonyms and illustrations, see Ohmura (2001).

Chemistry. Race 1, usnic, barbatic, 4-O-demethylbarbatic, and squamatic ( $\pm$ ) acids; Race 2, usnic, diffractaic, and barbatic acids; Race 3, usnic, evernic, and lecanoric acids.

The distinguishing features of *U. longissima* are (1) the "fish-bone" like appearance pendent thallus, (2) the terete and decorticate main branches, (3) the presence of annular-pseudocypbellae between segments especially near the base of thallus, (4) the *merrillii*-type plectenchymatous cortex, and (5) the presence of barbatic, diffractaic or evernic acids as the major substances.

*U. longissima* resembles *U. trichodeoides* very much. However, it is distinguished from the latter by the terete branches at elongated parts when mature and the presence of depsides such as barbatic, diffractaic and evernic acids.

Representative specimens examined. Race 1. TAIWAN. Taichung Co.: Mt. Nan-Fu-Ta-San, 1,500–2,400 m, 19.1.1964, S. Kurokawa 950; en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 1,900–2,250

m, 9.11.1989, H. Kashiwadani 35877.

Race 2. TAIWAN. Taichung Co.: Mt. Nan-Fu-Ta-San, on twigs of *Osmanthus birtsuensis*, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1056; en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 2,500 m, 10.11.1989, H. Kashiwadani 36003.

Race 3. TAIWAN. Taichung Co.: en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 2,700–2,950 m, 11.11.1989, H. Kashiwadani 36135.

**24. *Usnea masudana* Asahina, J. Jpn. Bot. 45: 132, 1970. [Fig. 19]**

For a description, see Ohmura (2001).

Chemistry. Usnic, norstictic and salazinic acids.

The distinguishing features of *U. masudana* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches with sparse verrucose to cylindrical papillae, (3) the absence of soralia, (4) the crisp fibrils on the branches and the margin of apothecia, (5) the brown colored disc without white rim, (6) the *merrillii*-type plectenchymatous cortex, and (7) the presence of salazinic acid as a major substance.

*U. masudana* resembles other richly fertile and esorediate species such as *U. dendritica*, *U. fuscorubens* and *U. orientalis*. However, it is distinguished from them by the crisp fibrils on the branches and the thalloid exciple of the apothecia, and by the brown colored disc with no white rim.

Specimens examined. TAIWAN. Taichung Co.: Chokakulai, 1936, H. Masuda 36001 (Holotype).

**25. *Usnea nidifica* Taylor, London J. Bot. 6: 191, 1847. [Fig. 20]**

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic, protocetraric and salazinic acids.

The distinguishing features of *U. nidifica* are (1) the pendent thallus with anisotomic-

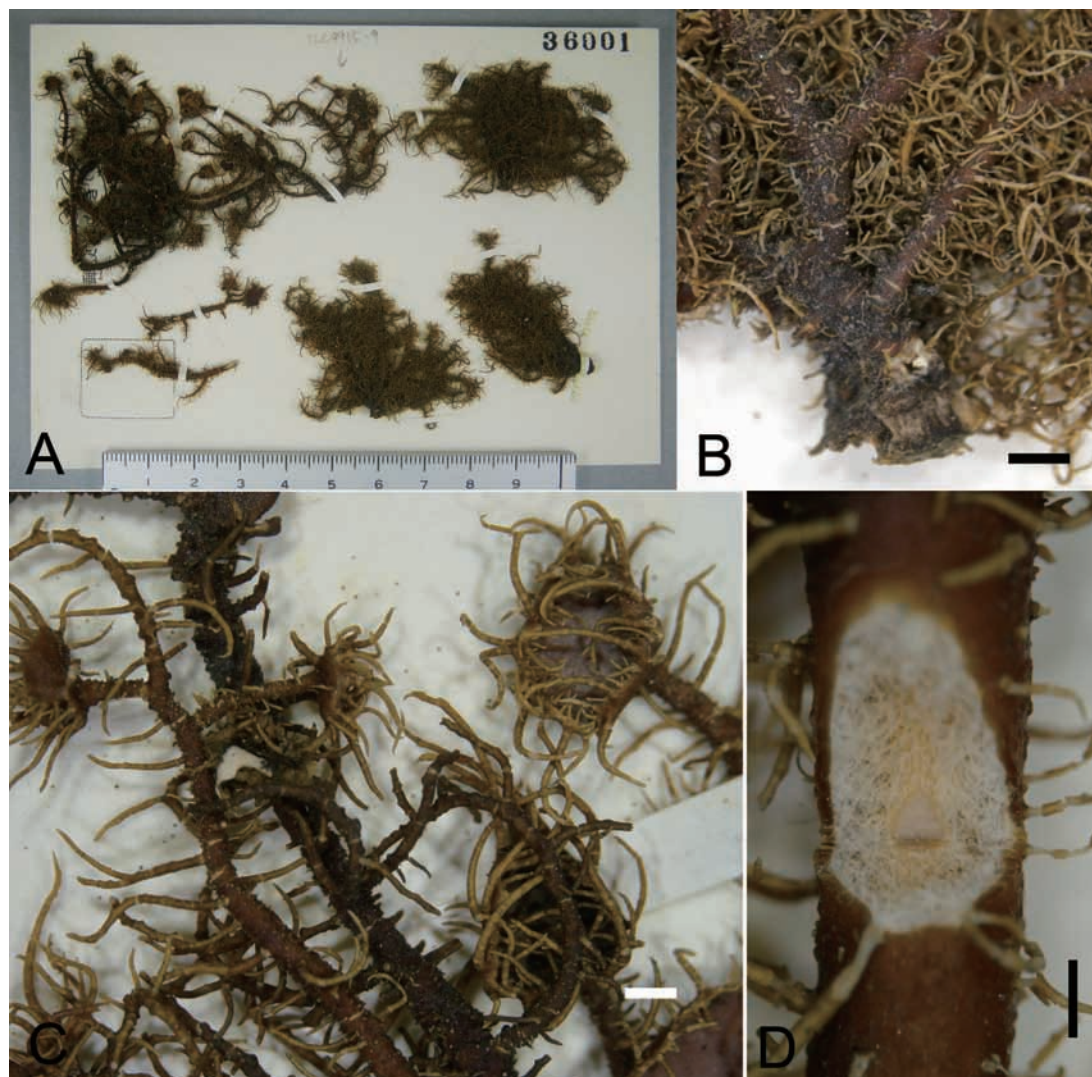


Fig. 19. *Usnea masudana* (Holotype, TNS). A. Thallus. B. Base of thallus and crisp fibrils on branches. C. Apothecia with crisp fibrils along the margin. D. Inflated branch. Scales: A-C=1 mm; D=0.5 mm.

dichotomous branching, (2) the inflated branches which are glossy and lacking papillae on the surface, (3) the irregular shaped soralia which are developed from cracks of cortex, (4) the absence of granular soredia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of norstictic and salazinic acids as major substances.

*U. nidifica* resembles *U. articulata*, *U. bismolliuscula* and *U. himalayana*. However, it is distinguished from *U. articulata* and *U.*

*himalayana* by the presence of soralia; from *U. bismolliuscula* by the absence of perforations on the thicker branches and the presence of salazinic acid.

Representative specimens examined. TAIWAN. Prov. Chiayi: Nimandaira, Mt. Ali, 25.12.1925, Y. Asahina F-297; Alishan, 2,200 m, on dead branch, 31.12.1993, C.-K. Lin 3494 (TNM, TNS). Kaohsiung Co.: Mt. Nanfong, 800–1,300 m, 7.2.1965, S. Kurokawa 2867. Taichung Co.: Mt. Nan-Fu-Ta-San, 2,400–

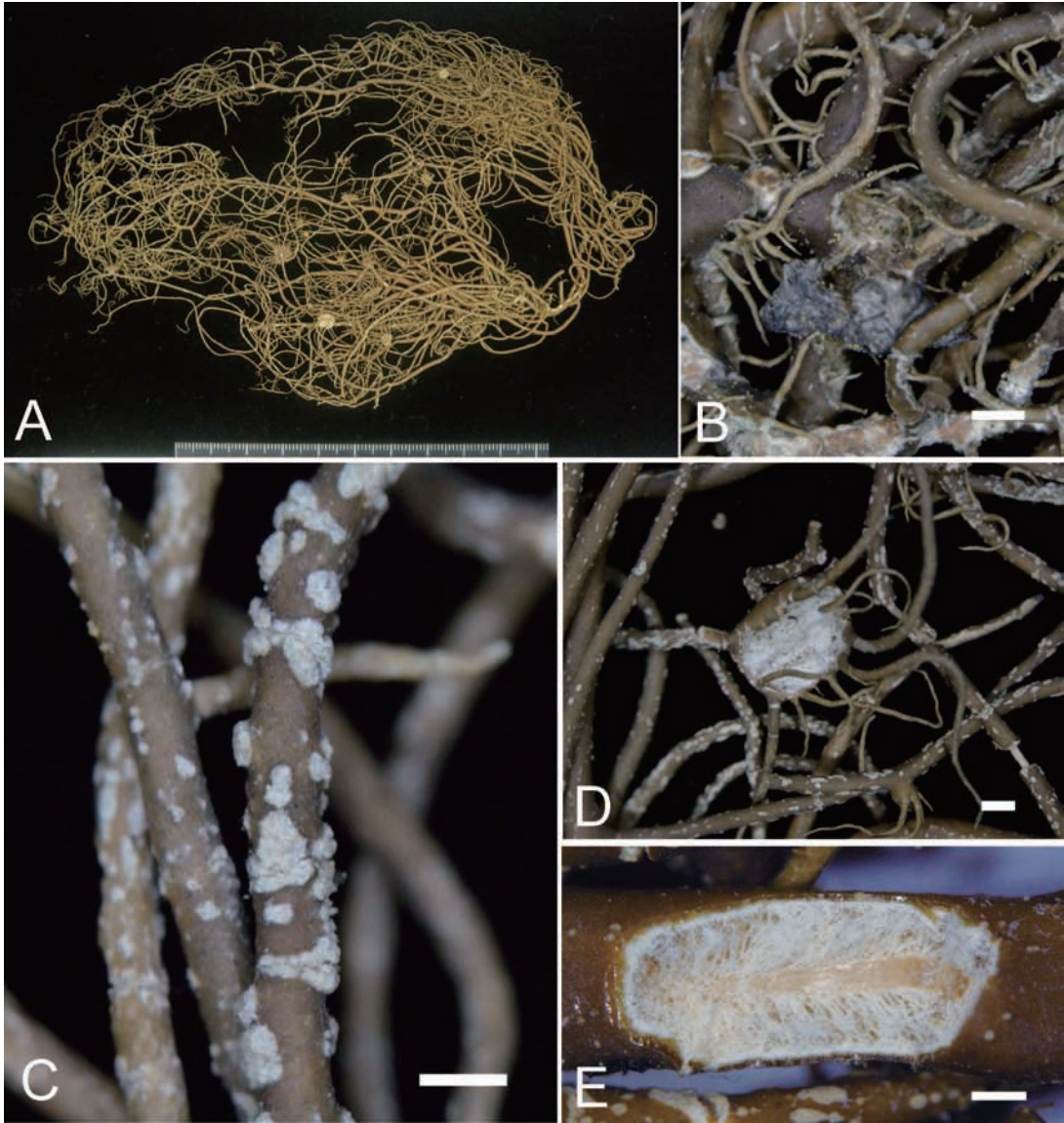


Fig. 20. *Usnea nidifica* (S. Kurokawa 2867, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Apothecia. E. Inflated branch with lax medulla and a thin axis. Scales: A, B, D=1 mm; C, E=0.5 mm.

2,600 m, 20.1.1964, S. Kurokawa 1091.

26. *Usnea nipparensis* Asahina, Lich. Jpn. 3: 91, 1956. [Fig. 21]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic and caperatic acids.

The distinguishing features of *U. nipparensis*

are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the rounded soralia which are distinctly stipitate and their cortical margins are not reflexed, (3) the absence of granular soredia, (4) the *ceratina*-type plectenchymatous cortex, and (5) the presence of caperatic acid as a major substance.

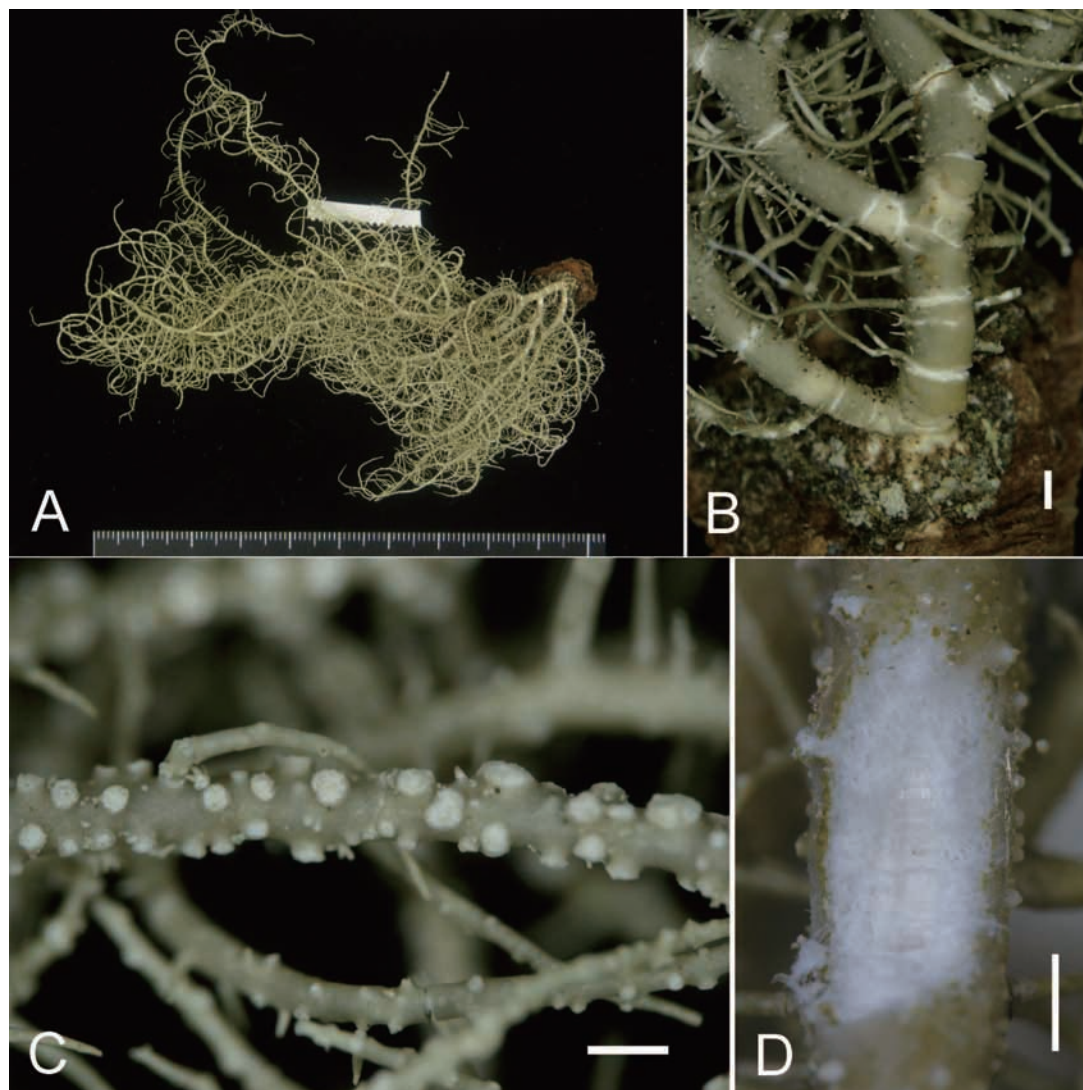


Fig. 21. *Usnea nipparensis* (Y. Ohmura 7365, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Uninflated branch. Scales: A, B=1 mm; C, D=0.5 mm.

Although two chemical races [Race 1, usnic and caperatic acids, and atranorin ( $\pm$ ); Race 2, usnic, caperatic, stictic, norstictic ( $\pm$ ), menegazziaic ( $\pm$ ) and constictic acids ( $\pm$ )] have been recognized in Ohmura (2001), only Race 1 has been found in Taiwan.

*U. nipparensis* may sometimes be confused with *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.

Representative specimens examined. TAIWAN. Ilan Co.: Piyanan Pass, 1,600–1,900 m, 16.1.1964, S. Kurokawa 832. Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhua, on trunk of *Pinus* sp., 2,249 m, 30.9.2010, Y. Ohmura 7365.

27. *Usnea orientalis* Motyka, Lich. Gen. Usnea Stud. Monogr. Pars Syst. 2: 547,

1937. [Fig. 22]

For a description and a synonym, see Ohmura (2001).

Chemistry. Usnic, salazinic, and protocetraric ( $\pm$ ) acids.

The distinguishing features of *U. orientalis* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the inflated branches with glossy surface, (3) the cylindrical papillae on thicker branches, (4) the absence of soralia, (5) the flat apothecia through the juvenile to mature stages, (6) the disc without white rim, (7) the *ceratina*-type plectenchymatous cortex, and (8) the presence

of salazinic acid as a major substance.

Although *U. orientalis* resembles *U. fuscorubens*, it is distinguished by the flat apothecia through the juvenile to mature stages.

Representative specimens examined. TAIWAN. Ilan Co.: Mt. Taiping, 8.1936, S. Asahina s.n. (herb. Y. Asahina 36600). Nantou Co.: Mt. Chilai, Hehuan-shan Mts., Taroko National Park, on bark of *Alnus* sp., 3,034 m, 28.8.2008, Y. Ohmura 6199; Hehuan-shan Service Station, Hehuan-shan Mts., Taroko National Park, on bark of *Sorbus commixta*, 3,014 m, 28.8.2008, Y. Ohmura 6211; Mt. Chilai, Hehuan-shan Mts., Taroko National Park, on

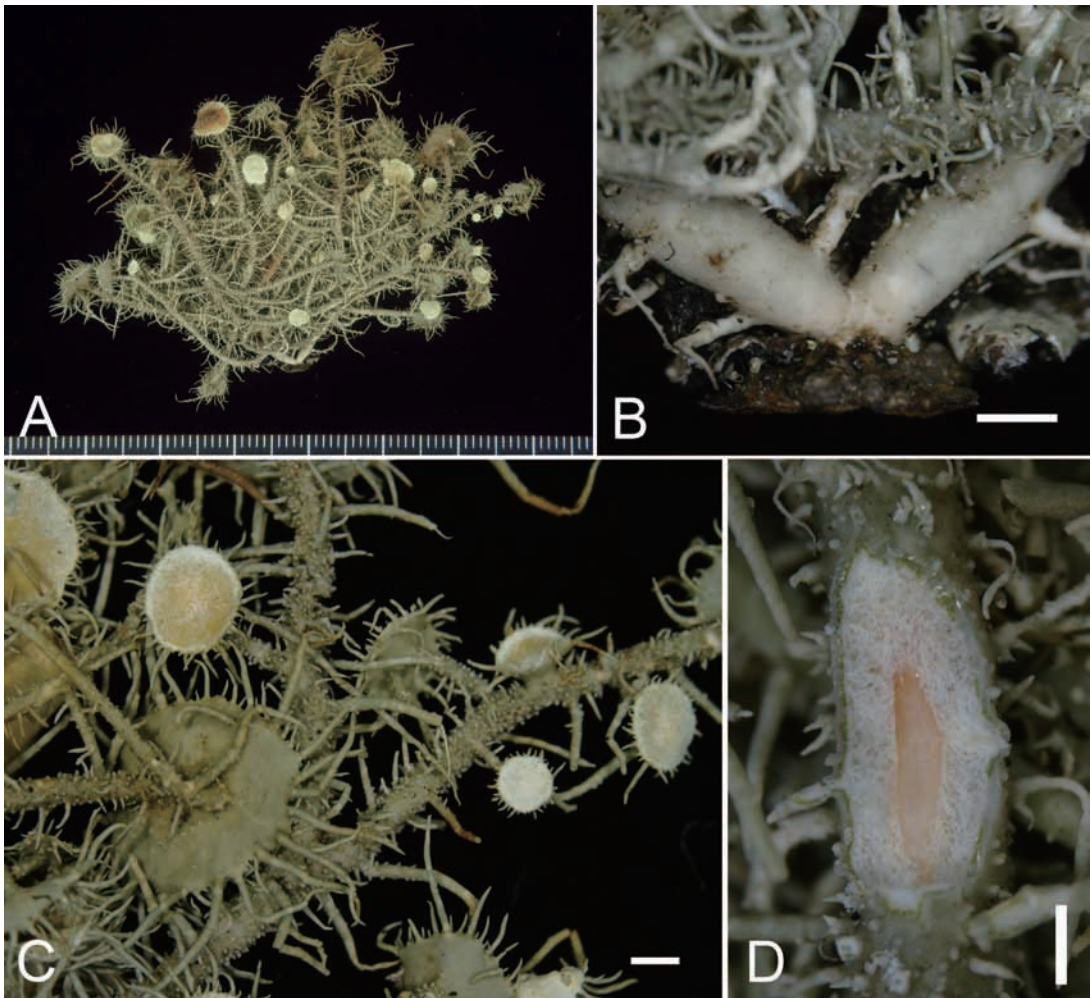


Fig. 22. *Usnea orientalis* (Y. Ohmura 7347, TNS). A. Thallus. B. Base of thallus. C. Apothecia. D. Inflated branch. Scales: A–C=1 mm; D=0.5 mm.

bark of *Alnus* sp., 3,034 m, 28.8.2008, Y. Ohmura 6197; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of deciduous broad-leaf tree, 2,385 m, 27.8.2008, Y. Ohmura 6130; Mt. Dasheue, on bark of *Metasequoia glyptostroboides*, 2,260 m, 2.9.2008, Y. Ohmura 6038. Taichung Co.: en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 1,900–2,250 m, 9.11.1989, H. Kashiwadani 35769; between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on twigs, 2,131 m, 30.9.2010, Y. Ohmura 7347.

**28. *Usnea pangiana*** Stirt., Scott. Natur. 7: 77, 1883. [Fig. 23]

For a description and synonyms, see Ohmura (2001).

Chemistry. Race 1, usnic, salazinic, norstictic ( $\pm$ ), protocetraric ( $\pm$ ), constictic ( $\pm$ ), and squamatic ( $\pm$ ) acids; Race 2, usnic, salazinic, barbatic and 4-O-demethylbarbatic, norstictic ( $\pm$ ) and protocetraric ( $\pm$ ) acids, and atranorin ( $\pm$ ).

The distinguishing features of *U. pangiana* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the annular cracks especially near the base, (3) the punctiform soralia which are discrete each other, (4) the absence of granular soredia, (5) the *merrillii*-type plectenchymatous cortex, and (6) the presence of salazinic acid and/or barbatic acids as major substances.

*U. pangiana* resembles *U. aciculifera* and *U. dasaea* in having punctiform soralia on lateral branches of shrubby thallus. However, it is distinguished from *U. aciculifera* by the annular cracked base of thallus and the presence of salazinic acid; and from *U. dasaea* by the uninflated thallus and the punctiform soralia which are discrete each other.

Representative specimens examined. Race 1. TAIWAN. Taichung Co.: Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1109, 1092. Taitung Co.; Mt. Tawu, 1–7.1.1922, Y. Matsuda s.n.

Race 2. TAIWAN. Chiayi Co.: Mt. Tsu-Tson-San, Mt. Ali, 2,300–2,900 m, 31.12.1963, S. Kurokawa 179; Tefuyeh, Alishan, 1,400–1,900 m, on tree, 14.1.2006, C.-K. Lin 8782 (TNM, TNS); Erwanping of Alishan, Alishan, 1,900 m, on tree, 11.3.2004, C.-K. Lin 7936 (TNM, TNS). Ilan Co.: Shenmihu, Nanao, 1,100 m, on rock, 27.1.1995, C.-K. Lin 4773 (TNM, TNS); Mingchih, 1,150 m, on tree, 17.4.2003, C.-K. Lin 7597 (TNM, TNS); Tsuifeng Lake of Mt. Taipin, Tatunh, on tree, 21.10.2004, C.-K. Lin 8042 (TNM, TNS). Kaohsiung Co.: Mt. Nanfong, 800–1,300 m, 7.2.1965. Nantou Co.: Mt. Shin-Kao-San, 3,100–3,300 m, 1.1.1964, S. Kurokawa 283; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of broad-leaf tree, 2,216 m, 27.8.2008, Y. Ohmura 6153; Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6115; Tatachia-Paiyun, 2,850 m, on dead tree, 2.7.1996, C.-K. Lin 5386 (TNM, TNS). Pingtung Co.: Wutoushan, Wutai, on tree, 9.2.1995, C.-K. Lin 4578 (TNM, TNS). Taichung Co.: Anmashan, Tungushih, 2,665 m, on tree, 1.6.2001, C.-K. Lin 7253 (TNM, TNS); en route from Sunghsueh Hostel to Chengkung No. 2, 3 Cabin, Mt. Chilai, Taroko National Park, on bark of *Pinus densiflora*, c. 2,800 m, 2.10.2009, Y. Ohmura 7087; between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on trunk of broad-leaf deciduous tree, 1,977 m, 30.9.2010, Y. Ohmura 7288. Taitung Co.: Mt. Lachialachiaerh, c. 1,800 m, 22.1.1965, S. Kurokawa 2502, 2504; Chokakurai, 1936, T. Masuda s.n. (herb. Y. Asahina 3600).

**29. *Usnea pectinata*** Taylor, in Hook, London J. Bot. 6: 191, 1847. [Fig. 24]

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic, menegazziaic, stictic and constictic acids.

The distinguishing features of *U. pectinata* are (1) the pendent thallus with elongated ter-



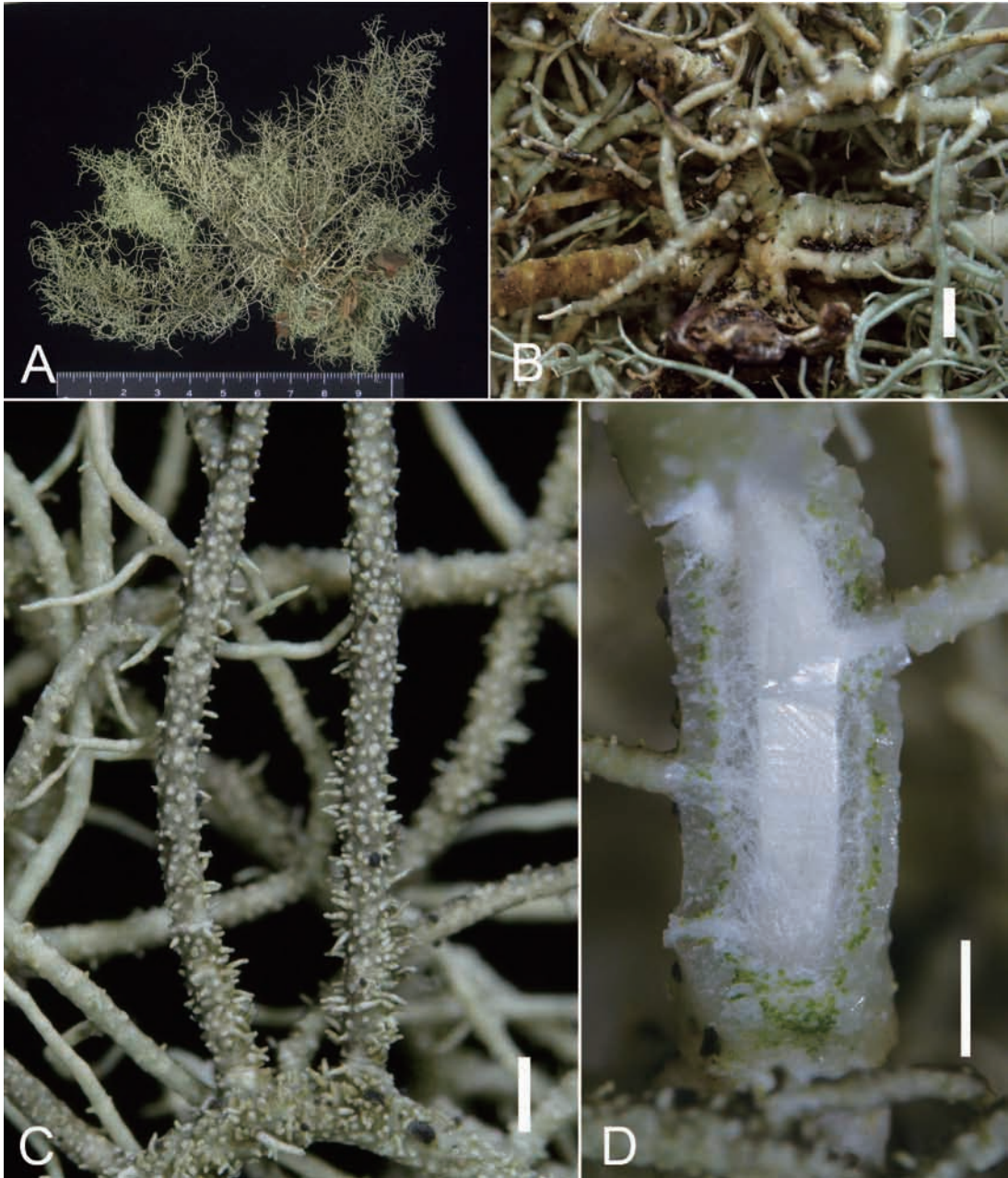


Fig. 23. *Usnea pangiana* (Y. Ohmura 7087, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Uninflated branch. Scales: A, B=1 mm; C, D=0.5 mm.

minal branches which are often decorticated on main branches, (2) the dark brown base of thallus, (3) the punctiform maculae on lateral branches, (4) the *merrillii*-type plectenchymatous cortex, and (5) the presence of stictic

acid as a major substance.

*U. pectinata* resembles *U. himantodes* in having a pendent thallus, and the presence of stictic acid as a major substance. This species can be distinguished from *U. himantodes* by the

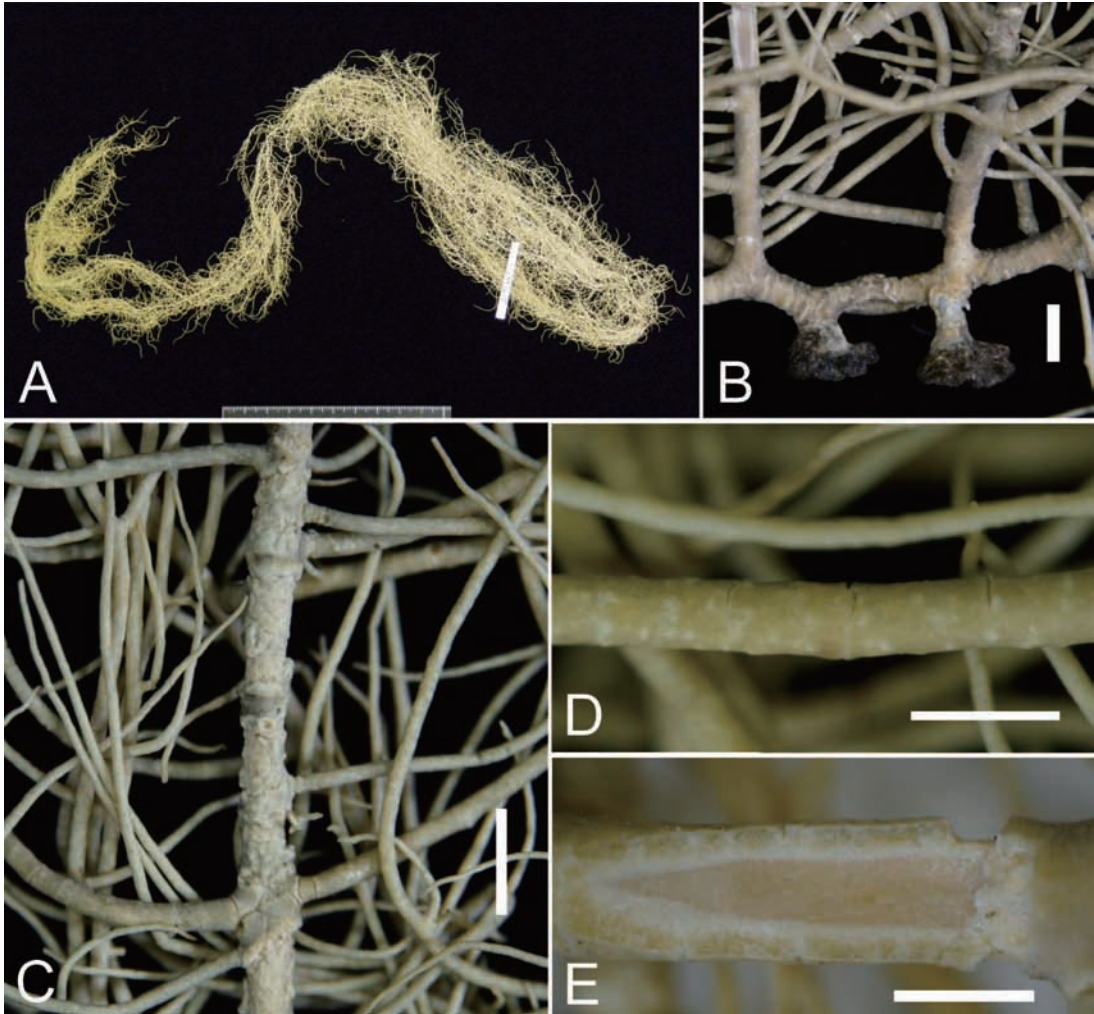


Fig. 24. *Usnea pectinata* (S. Kurokawa 673, TNS). A. Thallus. B. Base of thallus. C. Decorticated main branch. D. Punctiform maculae. E. Uninflated branch. Scales: A–C=1 mm; D, E=0.5 mm.

absence of ridged branches, but it is sometimes quite difficult to distinguish between *U. pectinata* and slender form of *U. himantodes*. Final taxonomic decision should be made when more materials will be studied.

Although *U. pectinata* has a solid axis and the general habit looks like *U. longissima*, this species is considered to belong to subgenus *Eumitria* for the following two reasons. *U. pectinata* itself does not have a fistulose axis, but the mature thallus of *U. himantodes* has a fistulose axis as reported by Asahina (1968b) and Ohmura (2001). In addition, a molecular

phylogenetic result based on ITS rDNA sequences strongly suggests that the close relationship between *U. pectinata* and *U. baileyi* (Ohmura 2002).

Exsiccata examined. TAIWAN. Chiayi Co.: en route from Su-Su-Lu to Mt. Ali, 2,000–2,200 m, 7.1.1964, S. Kurokawa 673 (S. Kurokawa & H. Kashiwadani; Lich. Rar. Cri. Exs., 547; as *U. misamisensis*).

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Arisan, 14.7.1935, M. Ogata s.n. (herb. Y. Asahina F-3574); en route from Su-Su-Lu to Mt. Ali, 2,000–2,200 m,

7.1.1964, S. Kurokawa 672. Kaohsing Co.: Shunsan, Mt. Nanfong, c. 1,200 m, 8.2.1965, S. Kurokawa 2934. Nantou Co.: Keitau, 24.12.1933, Y. Asahina F-3324a. Taitung Co.: Mt. Tawu, 11.8.1919, Y. Matsuda, s.n.

30. *Usnea praetervisa* (Asahina) P. Clerc, Biblioth. Lichenol. 88: 85, 2004. [Fig. 25]

For a description, see Clerc (2004).

Chemistry: usunic, norstictic, and salazinic ( $\pm$ ) acids.

The distinguishing features of *U. praetervisa* are (1) the erect to subpendent thallus, (2) the jet black base, (3) the uninflated branches with cylindrical papillae on the surface, (4) the irregular-shaped soralia having convex top often

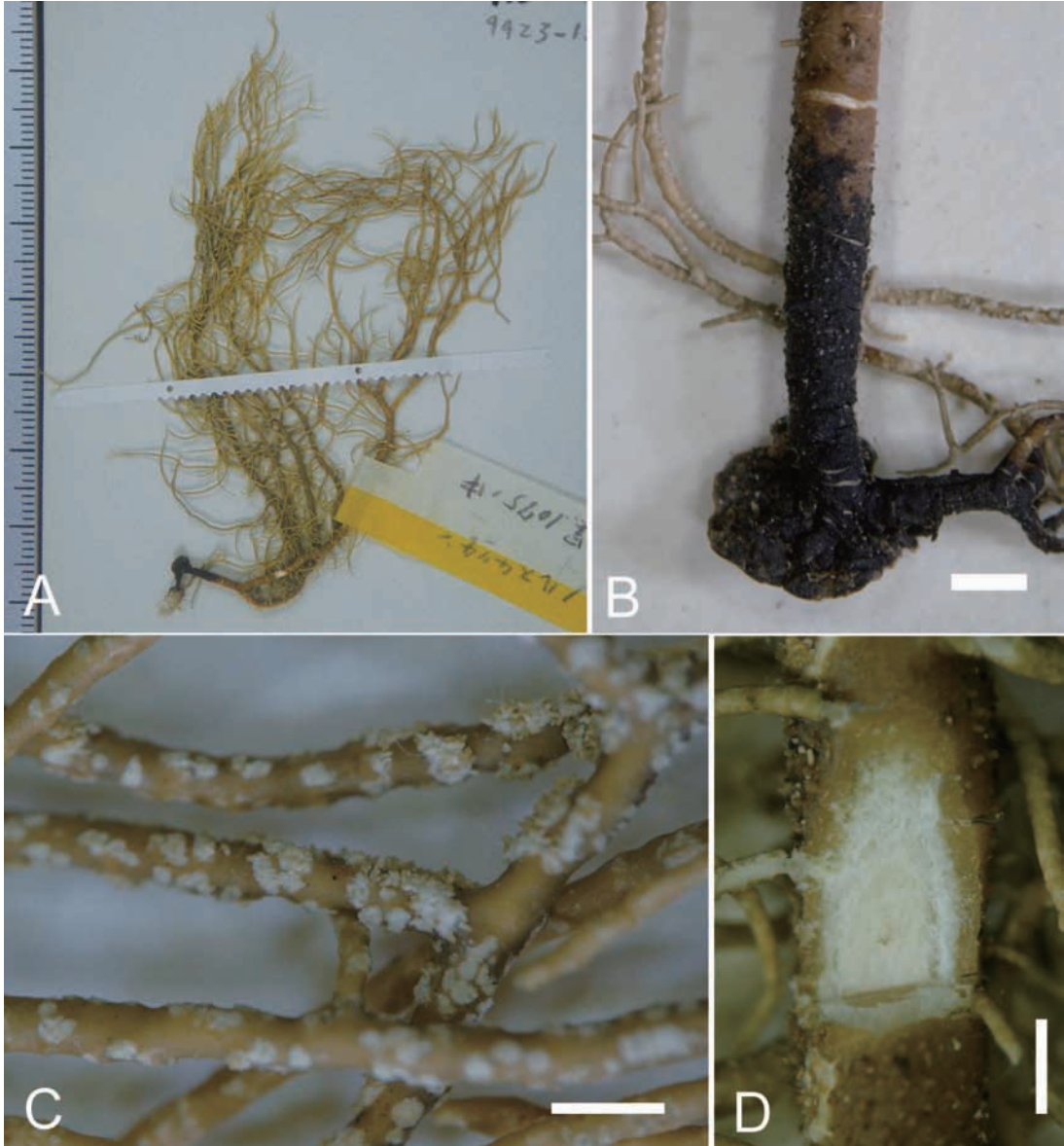


Fig. 25. *Usnea praetervisa* (S. Kurokawa 1075, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Uninflated branch. Scales: A, B=1 mm; C, D=0.5 mm.

with isidiomorphs, (5) the *florida*-type plectenchymatous cortex, and (6) the presence of norstictic acid.

According to Clerc (2004), *U. praetervisa* is different from *U. subfloridana* especially on the morphology and ontogeny of soralia. However, I have not been able to recognize these species clearly by the morphology for the Taiwanese and Japanese materials. As discussed in Ohmura (2001) and Clerc (2004), norstictic acid is biosynthetically distant from thamnolic and squamatic acids which are produced in *U. subfloridana*. Therefore, this paper follows the taxonomic concept of *U. praetervisa* made by Clerc (2004). Norstictic acid is the practically useful character for distinguishing *U. praetervisa* from *U. subfloridana*.

Specimens examined. TAIWAN. Nantou Co.: Mt. Chien-San, Mt. Shin-Kao-San, 3,100–3,300 m, 1.1.1964, S. Kurokawa 287. Taichung Co.: Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1075, 1111 pr. p. (mixed in *U. wasmuthii*).

**31. *Usnea pseudogatae*** Asahina, J. Jpn. Bot. 45: 131, 1970. [Fig. 26]

The original spelling of the epithet “*pseudogatai*” is corrected to “*pseudogatae*” according to ICBN 60C.1. (Vienna code) since the name was devoted to Mr. M. Ogata who is the collector of the type specimen.

Chemistry: usnic, norstictic, protocetraric, and salazinic acids.

For a description, see Ohmura (2001).

The distinguishing features of *U. pseudogatae* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches with cylindrical papillae, (3) the absence of soralia, (4) the flat to sinuose apothecia with few fibrils along the thalloid exciple, (5) the brown colored disc margined by white rim, (6) the *merrillii*-type plectenchymatous cortex, and (7) the presence of salazinic acid as a major substance.

Although *U. pseudogatae* resembles *U. dendritica*, it is distinguished by the wide medulla

and the absence of barbatic acid.

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 24.12.1925, Y. Asahina 2512; ditto, 14.7.1935, M. Ogata s.n. (herb. Y. Asahina 204); ditto, on bark of *Prunus campanulata*, 2,401 m, 24.3.2007, Y.-M. Shen 107 (TNM, TNS); Tatchiaanpu-Paiyunshanshuan, 3,000–3,200 m, 17.3.1991, C.-K. Lin s.n. (TNM, TNS). Hsinchu Co.: at 3 K of eastline of Talulindao, Kuanwu, 1950 m, on bark of *Alnus formosanum*, 18.10.1994, C.-K. Lin 4232 (TNM, TNS). Kaohsiung Co.: Changqing temple, Taoyuan, on bark of *Prunus campanulata*, 2,171 m, 5.11.2007, Y.-M. Shen 328, 329 (TNM, TNS); old-road of Zhongzhiguan, Taoyuan, on fallen branch, nearly Zhongzhiguan 0.5 K, 1,995 m, 5.11.2007, Y.-M. Shen 336 (TNM, TNS). Taichung Co.: Mt. Nanfuta-san, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1112. Taitung Co.: Mt. Wunitoparu, c. 1,900 m, 23.1.1965, S. Kurokawa 2621a.

**32. *Usnea pycnoclada*** Vain., Philipp. J. Sci. 4: 653, 1909.

For a description and illustrations, see Ohmura (2010).

Chemistry: usnic, barbatic, protocetraric, and 4-O-demethylbarbatic ( $\pm$ ) acids.

The distinguishing features of *U. pycnoclada* are (1) the erect thallus with anisotomic-dichotomous branching, (2) the jet black base of thallus, (3) the inflated branches which are constricted at the base often with exposed medulla of the crack to form white annular rings, (4) the convex soralia which are larger than branch diameter and distinctly stipitate, (5) the *ceratina*-type plectenchymatous cortex, and (6) the presence of barbatic and protocetraric acids as major substances.

Although *U. pycnoclada* resembles *U. glabrata* in having inflated branches and stipitate soralia which are larger than branch diameter, it is distinguished by the convex soralia and the jet black base.

Specimens examined. TAIWAN. Nantou

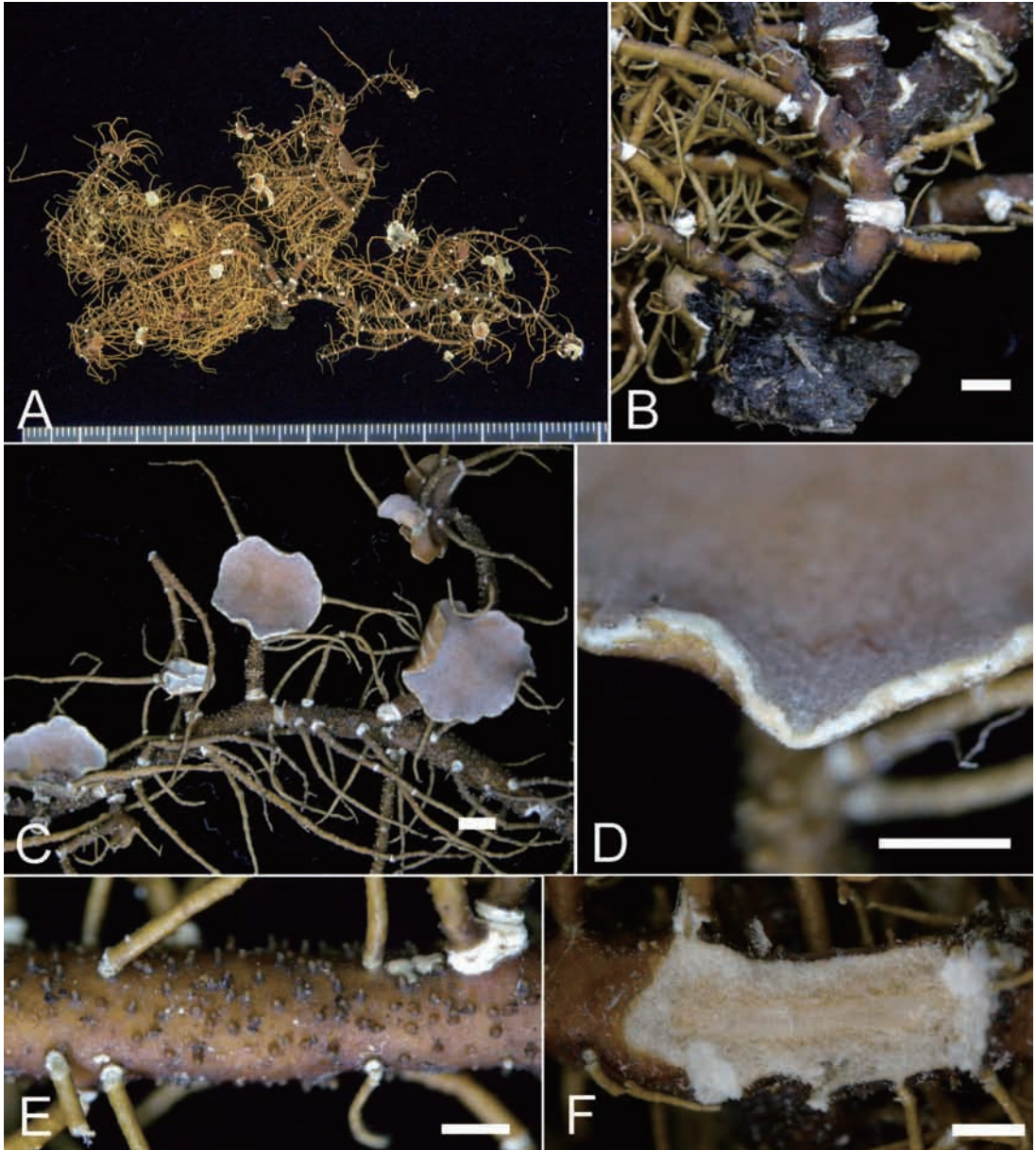


Fig. 26. *Usnea pseudogatae* (Y. Asahina 204, TNS). A. Thallus. B. Base of thallus. C. Apothecia. D. White rim along the apothecial margin. E. Cylindrical papillae. F. Inflated branch. Scales: A-C=1 mm; D-F=0.5 mm.

Co.: Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6054A, 6054B, 6079, and 6113 (TNS, TNM); en route from Sungshueh Hostel to Chengkung No. 2, 3 Cabin, Mt. Chilai, Taroko National Park, on twig of *Rhododendron* sp., c. 2,900 m, 29.9.2009, Y.

Ohmura 6959; Nantzusienchi, on trunk of *Pinus* sp., 2,250 m, 14.10.1993, S.-Z. Chen 113 (TNM, TNS).

33. *Usnea pygmoidea* (Asahina) Y. Ohmura, J. Hattori Bot. Lab. 90: 65, 2001. [Fig. 27]

For a description and synonyms, see in Ohmura (2001).

Chemistry. Race 1, usnic and salazinic acids; Race 2, usnic, norstictic, stictic, menegazziac and constictic acids ( $\pm$ ).

The distinguishing features of *U. pygmoidea* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the inflated branches which are glossy on the surface, (3) the stipitate and irregularly elongated soralia, (4) the presence of granular soredia together with isidiomorphs, (5) the *ceratina*-type plectenchymatous cortex, and (6) the presence of salazinic or stictic acids as major

substances.

*U. pygmoidea* resembles *U. cornuta* subsp. *cornuta*, *U. cornuta* subsp. *brasiliensis*, *U. dasaea*, *U. glabrata* and *U. hakonensis* in having inflated branches with soralia. However, *U. pygmoidea* is distinguished from them by the stipitate soralia which are elongated and irregular in shape, although juvenile stages of *U. pygmoidea* are very similar to *U. cornuta* subsp. *cornuta* in morphology and chemistry.

Representative specimens examined. Race 1. TAIWAN. Taichung Co.: between Yunleng Cabin and Shenmajhen Cabin, en route from Shiyuan Yakou to Mt. Nanhu, on twig of

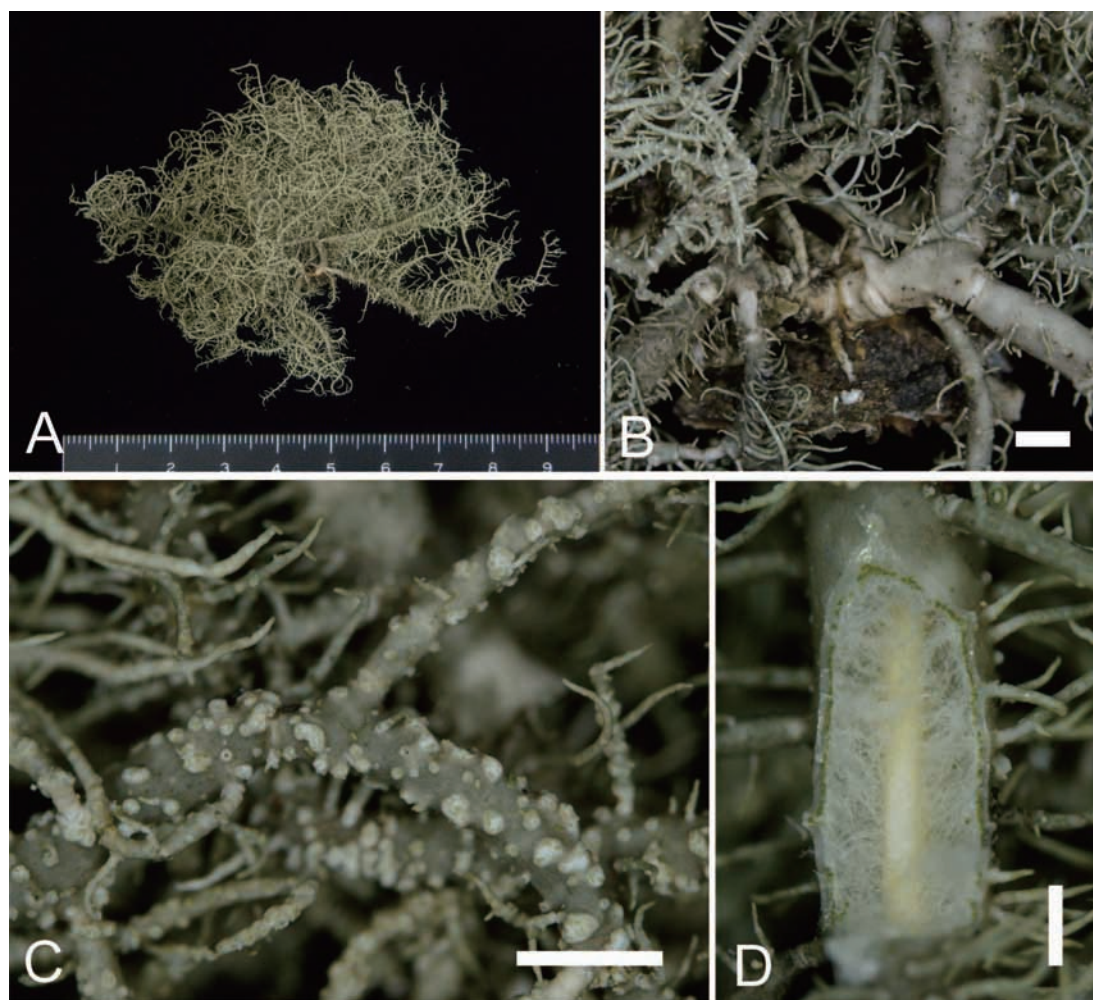


Fig. 27. *Usnea pygmoidea* (Y. Ohmura 7485, TNS). A. Thallus. B. Base of thallus. C. Soralia. D. Inflated branch. Scales: A, B=1 mm; C, D=0.5 mm.

broad-leaf deciduous tree, 3,068 m, 1.10.2010, Y. Ohmura 7485.

Race 2. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 6.1.1964, S. Kurokawa 586. Nantou Co.: Chitou, 30.1.1964, S. Kurokawa 1399. Taichung Co.: between Yunleng Cabin and Shenmajhen Cabin, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Tsuga* sp., 2,727 m, 1.10.2010, Y. Ohmura 7443; Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1106.

**34. *Usnea rubicunda* Stirt., Scott. Natur. 6: 102, 1881.**

For descriptions, illustrations, and synonyms, see in Ohmura (2001, 2008).

Chemistry. Race 1, usnic, norstictic, stictic, menegazziaic, constictic and squamatic ( $\pm$ ) acids, and atranorin ( $\pm$ ); Race 2, usnic, norstictic, stictic, menegazziaic, constictic, psoromic and 2'-O-demethylpsoromic ( $\pm$ ) acids.

The distinguishing features of *U. rubicunda* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the non-elongated terminal and subterminal branches, (3) the presence of red pigment in cortex, (4) the stipitate and rounded soralia on thick branches with many isidiomorphs, (5) the absence of soralia on fibrils, (6) the absence of granular soredia, (7) the *ceratina*-type plectenchymatous cortex, and (8) the presence of stictic acid as a major substance.

*U. rubicunda* resembles *U. rubrotincta* morphologically and chemically. However, it is distinguished from *U. rubrotincta* by (1) the absence of elongated terminal and subterminal branches, (2) the absence of soralia on fibrils, and (3) the rounded and stipitate soralia which are formed on thicker branches and developed from the top of eroded papillae.

Representative specimens examined. Race 1. TAIWAN. Chiayi Co.: Mt. Ali, 25.12.1925, Y. Asahina s.n.; ditto, 2,200 m, 30.12.1963, S. Kurokawa 63; Mt. Tsu-Tson-San, Mt. Ali, 2,300–2,900 m, 31.12.1963, S. Kurokawa 173. Hsinchu Co.: at 3 K of Eastline of Talulindao,

Kuanwu, 1,950 m, on cliff, 18.10.1994, C.-K. Lin 4216 (TNM, TNS). Ilan Co.: Piyanan Pass, 1,600–1,900 m, 16.1.1964, S. Kurokawa 831a. Nantou Co.: Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6055; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of *Cryptomeria japonica*, 2,340 m, 27.8.2008, Y. Ohmura 6031; Renlue, on bark of *Pinus* sp., 1,578 m, 30.8.2008, Y. Ohmura 6223; Juiyen, 2,200 m, on tree, 24.11.1994, C.-K. Lin 4306 (TNM, TNS). Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of broad-leaf deciduous tree, 1,977 m, 30.9.2010, Y. Ohmura 7332, 7387; Wulin Guest House, Heping Township, on bark of *Pinus* sp., 1,716 m, 29.9.2010, Y. Ohmura 7258, 7261; to Chihchia station, Hsuehshan, 2,000–2,600 m, on trunk of *Alnus formosana*, 1.9.1995, C.-K. Lin 4931 (TNM, TNS); along route to east peak of Mt. Xueshan, Heping, on bark of *Pinus taiwanensis*, 2,357 m, 15.7.2007, Y.-M. Shen 223 (TNM, TNS). Taitung Co.: Piyanan, 1,800–2,200 m, 18.8.1936, H. Koizumi s.n.

Race 2. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 30.12.1963, S. Kurokawa 63. Hualien Co.: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2,250 m, 11.10.2001, L. B. Sparrius 6115 (herb. Sparrius). Nantou Co.: Hweishunlinshang, on *Pinus taiwanensis*, 18.11.1990, C.-K. Lin s.n. (TNM, TNS). Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on twig of broad-leaf deciduous tree, 1,977 m, 30.9.2010, Y. Ohmura 7299; ditto, on bark of *Chamaecyparis obtusa*, 2,249 m, 30.9.2010, Y. Ohmura 7371; ditto, on bark of *Pinus* sp., 2,322 m, 30.9.2010, Y. Ohmura 7404.

**35. *Usnea rubrotincta* Stirt., Scott. Natur. 6: 103, 1881.**

For descriptions, illustrations, and synonyms, see in Ohmura (2001, 2008).

Chemistry. Race 1, usnic, norstictic, salazi-

nic, protocetraric ( $\pm$ ), and squamatic ( $\pm$ ) acids, and atranorin ( $\pm$ ); Race 2, usnic, norstictic, stictic, menegazziaic ( $\pm$ ) and constictic ( $\pm$ ) acids.

The distinguishing features of *U. rubrotincta* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the elongated terminal and subterminal branches, (3) the red pigment in the cortex, (4) the sinuose soralia formed on lateral branches and fibrils, (5) the absence of granular soredia, (6) the *ceratina*-type plectenchymatous cortex, and (7) the presence of salazinic or stictic acids as the major substance.

Although *U. rubrotincta* strongly resembles *U. rubicunda* morphologically and chemically, it is distinguished from *U. rubicunda* by the elongated terminal and subterminal branches and sinuose soralia formed on fibrils and lateral branches.

Representative specimens examined. Race 1. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 30.12.1963, S. Kurokawa 62; Mt. Tsu-Tson-San, Mt. Ali, 2,300–2,900 m, 31.11.1963, S. Kurokawa 171, 172; en route from Su-Su-Lu to Fun-Chi-Fu, 1,700–2,000 m, 5.1.1964, S. Kurokawa 539; en route from Su-Su-Lu to Mt. Ali, 2,000–2,200 m, 7.1.1964, S. Kurokawa 652. Ilan Co.: Piyanan Pass, 1,100–1,300 m, 15.1.1964, S. Kurokawa 757; ditto, 1,600–1,900 m, 16.1.1964, S. Kurokawa 831. Kaohsiung Co.: Mt. Nanfong, 800–1,300 m, 7.2.1965, S. Kurokawa 2871, 2872, 2873; Shunsan, Mt. Nanfong, c. 1,200 m, 8.2.1965, S. Kurokawa 2935. Nantou Co.: Keitau, 12.12.1933, Y. Asahina s.n.; Renlun, on bark of *Pinus* sp., 1,578 m, 30.8.2008, Y. Ohmura 6224, 6226; around Chui-Feng Parking along the Ren-He Road, Ren-ai Township, on bark of *Cryptomeria japonica*, 2,340 m, 27.8.2008, Y. Ohmura 6030; Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6052, 6122; Meifang Farm, Renai, on bark of *Prunus campanulata*, 1,978 m, 16.11.2007, Y.-M. Shen 350 (TNM, TNS); Chitou, 30.1.1964, S. Kurokawa 1414. Taichung Co.: between 0 km

and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 1,977 m, 30.9.2010, Y. Ohmura 7272, 7315; ditto, on bark of *Chamaecyparis obtusa*, 2,249 m, 30.9.2010, Y. Ohmura 7372; ditto, on trunk of broad-leaf deciduous tree, 2,268 m, 30.9.2010, Y. Ohmura 7386; between Mt. Duojiatun-shan and Yunleng Cabin, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 2,628 m, 4.10.2010, Y. Ohmura 7613. Pilushan, 2,600–2,900 m, on tree, 25.7.1990, C.-K. Lin s.n. (TNM, TNS). Taitung Co.: Chokakurai, 11.1937, M. Yasue s.n.; Mt. Wunitoparu, c. 1,900 m, 23.1.1965, S. Kurokawa 2601; Mt. Lachialachiaerh, c. 1,800 m, 22.1.1965, S. Kurokawa 2503; Xiangyang, Haiduan, on bark of *Chamaecyparis formosensis*, 2,214 m, 5.11.2007, Y.-M. Shen 326 (TNM, TNS). Yunlin Co.: Shipi, Kukeng, on tree, c. 1,500 m, 20.2.1991, C.-K. Lin s.n. (TNM, TNS).

Race 2. TAIWAN. Chiayi Co.: Mt. Tsu-Tson-San, Mt. Ali, 2,300–2,900 m, 31.12.1963, S. Kurokawa 172; Meifang Farm, Renai, on bark of *Prunus salicina*, 1,978 m, 16.11.2007, Y.-M. Shen 354 (TNM, TNS). Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on twig of broad-leaf deciduous tree, 1,977 m, 30.9.2010, Y. Ohmura 7300, 7319, 7336; ditto, on bark of *Pinus* sp., 2,322 m, 30.9.2010, Y. Ohmura 7403; Mt. Nan-Fu-Ta-San, 1,500–2,400 m, 19.1.1964, S. Kurokawa 956.

36. *Usnea shimadae* Asahina, J. Jpn. Bot. 45: 131, 1970. [Fig. 28]

The original spelling of the epithet “*shimadae*” is corrected to “*shimadae*” according to ICBN 60C.1. (Vienna code) since the name was devoted to Mr. Y. Shimada who is the collector of the type specimen.

For a description and synonyms, see Ohmura (2001).

Chemistry. Usnic, norstictic, galbinic and salazinic ( $\pm$ ) acids.



The distinguishing features of *U. shimadae* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the slightly inflated branches with cylindrical papillae, (3) the absence of soralia, (4) the apothecial margin with spinulose fibrils which are broadened at the base, (5) the *ceratina*-type plectenchymatous cortex, (6) the brown color apothecial disc  $\pm$  margined by white rim, and (7) the presence of galbinic acid as a major substance.

Although *U. shimadae* resembles other richly fertile and esorediate species, it is distinguished from others by the morphology of the fibrils along the thalloid exciple of apothecia and the chemistry.

Specimen examined. TAIWAN. Hsinchu Co.: Nihonmatsu, Taiko-gun, on trees, c. 1,000 m alt., 23.6.1928, Y. Shimada 53 (Holotype); at 1 km of westline of Talulindao, Kuanwu, 1,900 m, on bark of *Alunus formosanum*, 19.10.1994, C.-K. Lin 4166 (TNM, TNS);

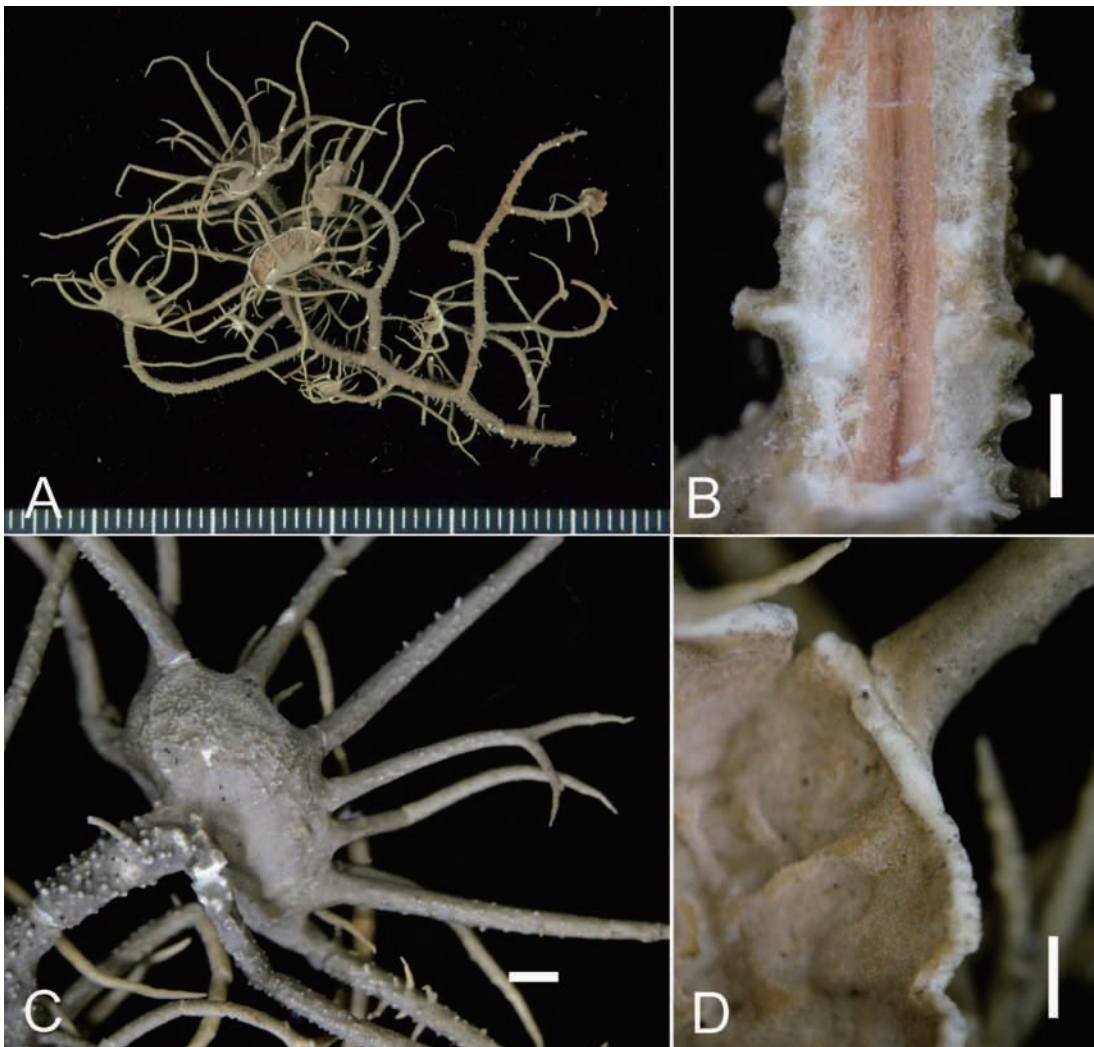


Fig. 28. *Usnea shimadae* (C.-K. Lin 4166, TNS). A. Thallus. B. Slightly inflated branch. C. Fibrils on apothecia which are broadened at the base. D. Apothecial disc margined by white rim. Scales: A, C=1 mm; B, D=0.5 mm.

Zhenxibao, Jianshih, on bark of *Albizia julibrissin*, 1,576 m, 11.9.2007, Y.-N. Shen 252 (TNM, TNS). Nantou Co.: Nantzusienshi, 2,200 m, on branch of *Alnus formosana*, 14.10.1993, S.-Z. Chen 120 (TNM, TNS).

37. *Usnea sinensis* Motyka, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst. 1: 248, 1936.

[Fig. 29]

For a description and synonyms, see Oh-

mura (2001).

Chemistry. Usnic, caperatic, norstictic ( $\pm$ ), and salazinic ( $\pm$ ) acids.

The distinguishing features of *U. sinensis* are (1) the erect to subpendent thallus with anisotomic-dichotomous branching, (2) the concolorous base with the thallus, (3) the uninflated branches which are matt on the surface, (4) the absence of soralia, (5) the large apothecia (up to 1.5 cm in diam.) lacking

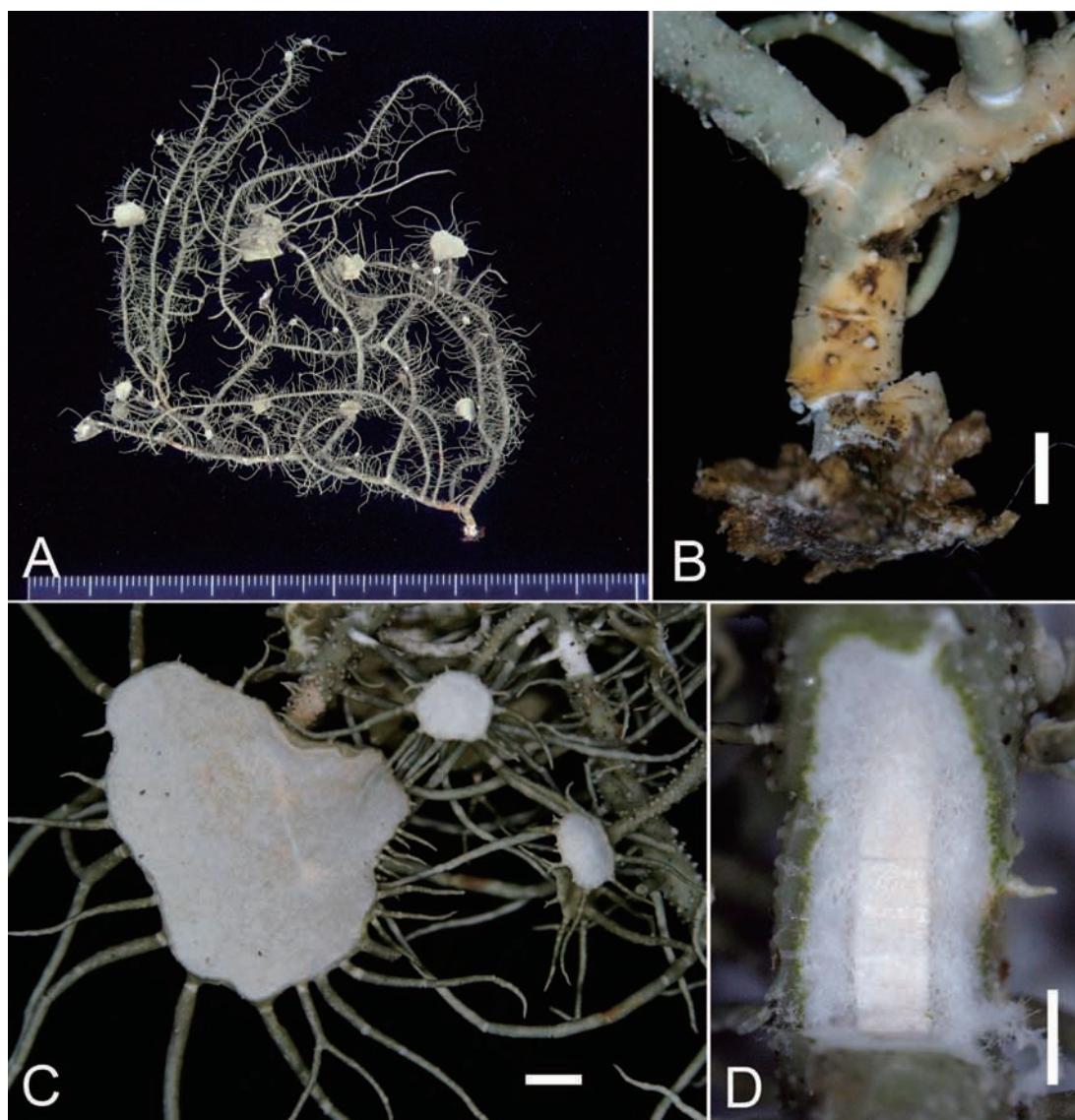


Fig. 29. *Usnea sinensis* (Y. Ohmura 7408, TNS). A. Thallus. B. Base of thallus. C. Apothecia lacking white rim. D. Uninflated branch. Scales: A-C=1 mm; D=0.5 mm.

white rim around the disc, (6) the *ceratina*-type plectenchymatous cortex, and (7) the presence of caperatic acid as a major substance.

Although *U. sinensis* resembles *U. florida*, it is distinguished by the base which is concolorous with the thallus, and by the presence of caperatic acid.

Exsiccata examined. TAIWAN. Ilan Co.: Mt. Nanfuta-San, on twigs, 1,500–2,400 m, 19.1.1964, S. Kurokawa 969a (S. Kurokawa: Lich. Rar. Cri. Exs. 146, as *U. alisani*).

Representative specimens examined. TAIWAN. Chiayi Co.: Mt. Ali, 2,200 m, 6.1.1964, S. Kurokawa 584; Mt. Tsu-Tson-San, Mt. Ali, 2,300–2,900 m, 31.12.1963, S. Kurokawa 175. Hsinchu Co.: westline of Talulindao, Kuanwu, 1,950 m, on bark of *Alnus formosanum*, 18.10.1994, C.-K. Lin 4174 (TNM, TNS). Ilan Co.: Piyanan Pass, 1,600–1,900 m, 16.1.1964, S. Kurokawa 834, 835. Nantou Co.: Lisan, 17.1.1964, S. Kurokawa 883; Nantzusienshi, 2,200 m, on branch of *Alnus formosana*, 14.10.1993. S.-Z. Chen 141 (TNM, TNS); Meifang Farm, Renai, on bark of *Alnus formosana*, 2,015 m, 16.11.2007, X.-H. Shi 357 (TNS, TNS). Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of broad-leaf deciduous tree, 1,977 m, 30.9.2010, Y. Ohmura 7313, 7314; ditto, on trunk of *Pinus* sp., 2,249 m, 30.9.2010, Y. Ohmura 7369; ditto, 2,322 m, 30.9.2010, Y. Ohmura 7408; ditto, on trunk of broad-leaf deciduous tree, 2,268 m, 30.9.2010, Y. Ohmura 7390.

**38. *Usnea subfloridana* Stirt., Scott. Natur. 6: 294, 1882.**

For a description, illustrations and synonyms, see Ohmura & Kashiwadani (2000) and Ohmura (2001).

Chemistry. Usnic and thamnolic acids.

The distinguishing features of *U. subfloridana* are (1) the erect to subpendent thallus, (2) the jet black base, (3) the uninflated branches with cylindrical papillae on the surface, (4) the soralia having convex top, (5) the

*florida*-type plectenchymatous cortex, and (6) the presence of thamnolic acid.

Only chemical race of thamnolic acid has been found so far in Taiwan although squamatic and both of thamnolic and squamatic acids races have been also found in Japan (Ohmura 2001).

*U. subfloridana* is distinguished from other related species by having convex top soralia and the presence of thamnolic acid.

Specimen examined. TAIWAN. Nantou Co.: Mt. Chien-San, Mt. Shin-Kao-San, 3,100–3,300 m, 1.1.1964, S. Kurokawa 279.

**39. *Usnea trichodeoides* Vain., Ann. Acad. Sci. Fenn., Ser. A, 6(7): 8, 1915.**

For a description, illustrations and synonyms, see Ohmura (2001).

Chemistry. Race 1, usnic, salazinic, protocetraric ( $\pm$ ) acids, and atranorin ( $\pm$ ); Race 2, usnic, fumarprotocetraric and protocetraric acids ( $\pm$ ), US3 ( $\pm$ ), and atranorin ( $\pm$ ).

The distinguishing features of *U. trichodeoides* are (1) the “fish-bone” like appearance pendent thallus, (2) the elongated branches which are flat and areolately corticate when well developed, (3) the presence of annular-pseudocyphellae between segments especially near the base of thallus, (4) the *merrillii*-type plectenchymatous cortex, and (5) the presence of depsidones such as salazinic or fumarprotocetraric acids as the major substance.

Although three chemical races (Race 1, salazinic acid; Race 2, fumarprotocetraric acid; Race 3, US4) have been recognized in Ohmura (2001), Race 3 has not been collected in Taiwan.

*U. trichodeoides* resembles *U. hesperina*, *U. longissima* and *U. pectinata*. However, it is distinguished from them by the flat branches when well developed. The slender form of *U. trichodeoides* can be distinguished from *U. longissima* and *U. pectinata* by the presence of salazinic and protocetraric acids, and from *U. hesperina* by the decorticate or areolately

cracked cortex on the elongated branches.

Exsiccata examined. TAIWAN. Nantou Co.: Mt. Hohuan-shan, Hsiulin-gun, on trunk of *Abies* sp., c. 3,100 m, 31.7.1985, H. Shibuchi (7965), K. Yoshida & M. Mineta [Y. Ohmura, Lich. Min. Cog. Exs. 400].

Representative specimens examined. Race 1. TAIWAN. Chia Co.: Tatchiaanpu-Paiyunshanshuan, 3,000–3,200 m, 17.5.1991, C.-K. Lin s.n. (TNM, TNS); Paiyunshanshuan-Tatchiaanpu, 3,528–3,400 m, 16.5.1991, C.-K. Lin s.n. (TNM, TNS); Paiyunshanshuan-West pick of Yushan, 3,528–3,650–3,528 m, 15.5.1991, C.-K. Lin s.n. (TNM, TNS). Nantou Co.: Mt. Chilai, Hehuan-shan Mts., Taroko National Park, on dried stem of *Sasa* sp., 3,094 m, 28.8.2008, Y. Ohmura 6172, 6174; Hehuan-shan Service Station, Hehuan-shan Mts., Taroko National Park, on bark of *Tsuga chinensis*, 3,014 m, 28.8.2008, Y. Ohmura 6205, 6206; Mt. Dasheue, on bark of *Pinus* sp., 2,595 m, 2.9.2008, Y. Ohmura 6048, 6051, 6063, 6114; Mt. Shi-San, Mt. Shin-Kao-San, 3,300–3,600 m, 3.1.1964, S. Kurokawa 451. Taichung Co.: between 6.8 km point of mountain trail and Mt. Duojiatun-shan, en route from Shiyuan Yakou to Mt. Nanhu, on trunk of broad-leaf deciduous tree, 2,439 m, 30.9.2010, Y. Ohmura 7415; en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, 1,900–2,250 m, 9.11.1989, H. Kashiwadani 35876; ditto, c. 2,500 m, 10.11.1989, H. Kashiwadani 36004; ditto, 2,500–2,900 m, 11.11.1989, H. Kashiwadani 35899; ditto, on twigs of *Salix* sp., 2,400–2,800 m, 10.11.1989, H. Kashiwadani 35751; ditto, 2,700–2,950 m, 11.11.1989, H. Kashiwadani 36097; ditto, on bark of *Ilex* sp., H. Kashiwadani 36023; Hsuehshan, 3,200–3,600 m, on tree, 2.9.1995, C.-K. Lin 4995 (TNM, TNS); on roadside at breeding field of Chuanshinshan, Anmashan, Tungshih, 2,100 m, 26.7.1994, C.-K. Lin 3906 (TNM, TNS). Pingtung Co.: Chinpenkutao, Wutai, 1,700 m, on *Pasania konishii*, 7.2.1995, C.-K. Lin 4456 (TNM, TNS).

Race 2. TAIWAN. Nantou Co.: Hohu-

anshan, at East peak, 3,250 m, on *Tsuga chinensis*, 22.7.1995, C.-K. Lin 4824. Taichung Co.: between 0 km and 6.8 km point of mountain trail, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 2,322 m, 30.9.2010, Y. Ohmura 7413; between Yunleng Cabin and Shenmajhen Cabin, en route from Shiyuan Yakou to Mt. Nanhu, on bark of *Pinus* sp., 2,890 m, 1.10.2010, Y. Ohmura 7465; ditto, on trunk of *Pinus* sp., 2,889 m, 4.10.2010; en route from Ssu-yuan to To-chia-tun Shan, Mt. Nanhuta Shan, Hoping, c. 2,500 m, 10.11.1989, H. Kashiwadani 36005.

#### 40. *Usnea wasmuthii* Räsänen, Flecht. Estlands I, 34: 19. 1931.

For a description, illustrations and synonyms, see Ohmura & Kashiwadani (2000) and Ohmura (2001).

Chemistry: Race 1, usnic and salazinic acids; Race 2, usnic, barbatic, 4-O-demethylbarbatic and salazinic acids.

The distinguishing features of *U. wasmuthii* are (1) the erect to subpendent thallus, (2) the jet black base, (3) the uninflated branches with cylindrical papillae on the surface, (4) the elliptic soralia with concave top, (5) the presence of granular soredia, (6) the *florida*-type plectenchymatous cortex, and (7) the presence barbatic and/or salazinic acids as major substances.

Although three chemical races (Race 1, salazinic acid; Race 2, salazinic and barbatic acids; and Race 3, thamnolic acid) have been recognized in Ohmura (2001), Race 3 has not been found in Taiwan.

*U. wasmuthii* resembles *U. subfloridana*, from which it can be distinguished by the concave top soralia. It also resembles *U. fragileszens*, *U. fulvoreaens* and *U. glabrescens*, because they all have concave top soralia. However, it can be distinguished from *U. fragileszens* by the uninflated branches and the *florida*-type plectenchymatous cortex; from *U. fulvoreaens* by having isidiomorphs and the absence of norstictic acid; and from *U.*

*glabrescens* by the confluent soralia and the absence of norstictic acid.

Representative specimens examined. Race 1: TAIWAN. Taichun Co.: Mt. Nan-Fu-Ta-San, 1,500–2,400 m, 19.1.1964, S. Kurokawa 962; ditto, on twigs of *Osmanthus bitoritsuensis*, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1107.

Race 2: TAIWAN. Nantou Co.: Mt. Chien-San, Mt. Shin-Kao-San, 3,100–3,300 m, 1.1.1964, S. Kurokawa 286. Taichun Co.: Mt. Nan-Fu-Ta-San, 2,400–2,600 m, 20.1.1964, S. Kurokawa 1100; Tashuashan Forest Park, Hopen, on bark of *Prunus* sp., c. 2,000 m, 28.10.2008, H. Kashiwadani 55009C.

### Excluded species

#### *Usnea mutabilis* Stirt.

Aptroot *et al.* (2002) reported this species based on the specimen collected from Taiwan (L. B. Sparrius 6115). However, morphological and chemical examinations of the specimen in this study proved it to be *U. rubicunda* which contains usnic, norstictic, menegazziaic and stictic acids. In addition, its red pigment presents in the cortex of thallus. Therefore, *U. mutabilis* is excluded from the lichen flora of Taiwan although this species is widely distributed in temperate regions in Japan, Europe and North America (Clerc, 1994; Ohmura, 2001).

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## 台湾産サルオガセ属（ウメノキゴケ科，子囊菌門）について

大村嘉人

台湾産サルオガセ属 40 分類群 (39 種 1 亜種) について，検索表，薄層クロマトグラフィー（溶媒 B 液）による化学成分のスポット判別，各種の特徴を示した．台湾新産種として *Usnea articulata*（フシサルオガセ，新称）を報告する．本種はこれまでに，アフリカ，ヨーロッパ，オーストラリア，ニュージーランド，インド，東南アジアに分布することが知られていた．*U. articulata* は *U. himalayana*（ナヨナヨサルオガセ）や *U. nidifica*（フクレサルオガセ）に似るが，擬盃点や粉芽を持たず，フマルプロトセトラール酸を持つことでそれらの種から区別される．*U. mutabilis*（ウスベニヒゲゴケ）は過去に報告された文献の引用標本を検討した結果，*U. rubicunda*（アカヒゲゴケ）であることが判明したため，台湾産種のリストから除外した．*U. shimadae*（シマダサルオガセ，新称）および *U. pseudogatae*（ニセオガタサルオガセ，新称）の学名は国際植物命名規約に基づいて，語尾を修正した．