

Usnea flavocardia (Parmeliaceae, lichenized Ascomycota) New to Asia

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Abstract *Usnea flavocardia* is reported as new to Asia. It was collected from Taiwan where it grows on twig of Aquifoliaceae and bark of *Tsuga* sp. at elevation between 1900 and 3100 m. The description is given based on the Taiwanese specimens.

Key words: flora, lichenized fungi, secondary substances, Taiwan, taxonomy.

The genus *Usnea* (Parmeliaceae, Ascomycota) consists of more than 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.

During the course of floristic study of lichens in Taiwan, an interesting *Usnea* species, which has not been reported from Asia so far, was found after the taxonomic examinations of collected specimens.

The purpose of this study is to provide a description based on the Taiwanese materials and to discuss the morphology and chemistry.

Materials and Methods

Field investigations in Taiwan were carried out by the author between 2008 and 2011, and ca. 300 specimens of *Usnea* were collected. This study is based on those specimens which are housed in the National Museum of Nature and Science (TNS), Tsukuba, Japan.

Morphological observations were made using a dissecting microscope and 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 (1984a). The mean (*italic*), standard deviation and extreme values (in parenthesis) of the ratios 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).

Lichen substances were examined using thin layer chromatography (TLC) (Culberson and Kristinsson, 1970). Solvent B system (hexane:methyl tert.-butyl ether:formic acid, 140:72:18) (Culberson and Johnson, 1982) was used for the TLC analysis. Iodine test (I) was performed on an axial section with 0.5% Lugol's iodine solution.

Results and Discussion

Usnea flavocardia Räsänen, *Revista Universitaria* (Santiago) 21(1): 139, 1936.

Type: CHILE. Valdivia: Corral, sobre cercos, 1929, Gunckel 1635 (holotype H, not seen). %C/%M/%A: 4.5/32.5/26 (Clerc, 2004). Chemistry: usnic, norstictic and connorstictic acids, traces of unidentified triterpenoids (Truong *et al.*, 2011).

= *Usnea quercina* Bysrek & Gorzyska, *U. wirthii* P. Clerc (Clerc, 2004).

Thallus fruticose, shrubby, erect, up to 3.5 cm

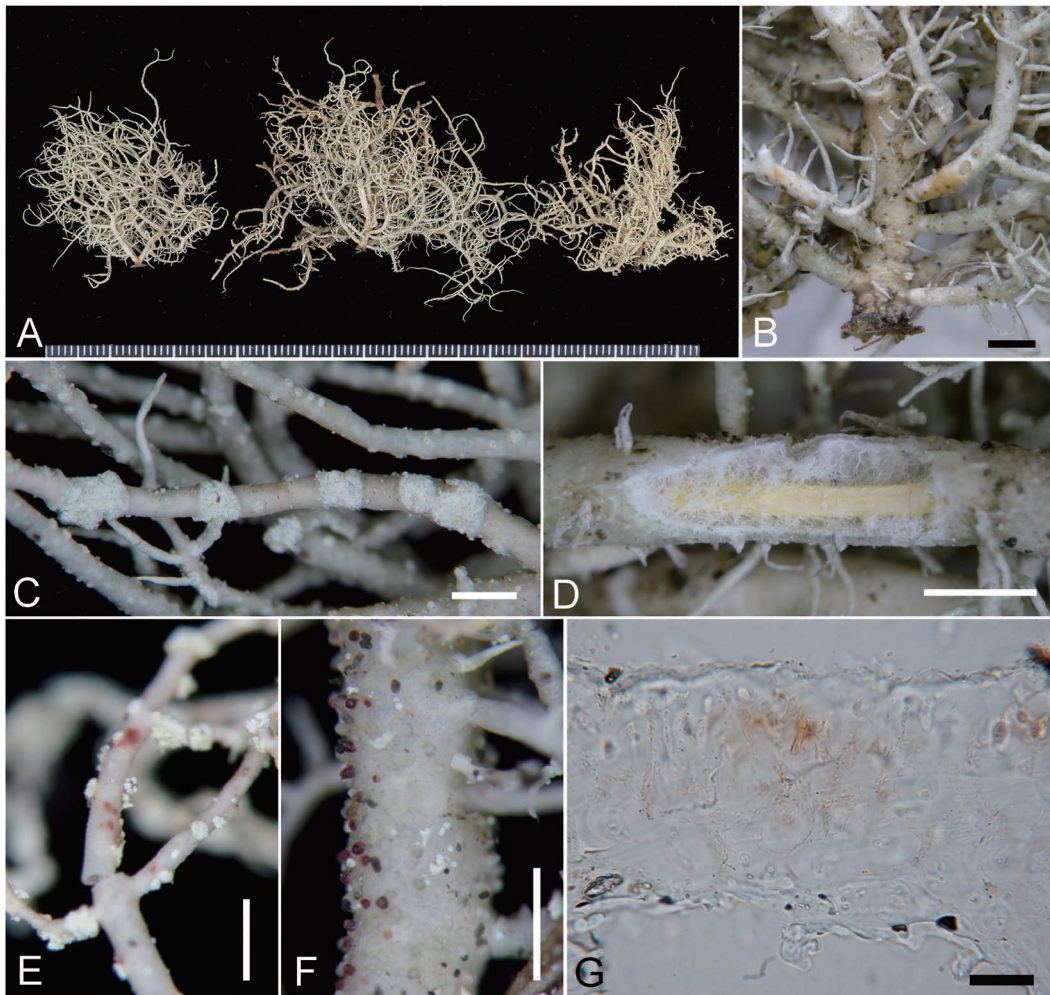


Fig. 1. Morphology of *Usnea flavocardia* (A–D: Y. Ohmura 7008, TNS; E–G: Y. Ohmura 8636A, TNS). A. Erect thallus with anisotomic-dichotomous branching. B. Base of thallus and constricted base of lateral branches. C. Concave soralia with granular soredia, which is larger than the branch diameter. D. Inflated branch with a yellow axis and two-layered medulla. E. Red spots on the cortex. F. Red pigmentation at the tips of papillae. G. *Ceratina*-type cortex with secretion of red pigment into the cell walls around the lumina of cortical hyphae. Scales: A, B, D = 1 mm; C, E, F = 0.5 mm; G = 20 μ m.

long, grayish green with or without scattered red spots, concolor to brownish black at the base; branching anisotomic-dichotomous; branches matt to slightly glossy on the surface, lacking pseudocyphellae and maculae, with or without foveoles, terete, inflated, gradually tapering, with many fibrils and lateral branches, 1.0–1.1 mm in diameter; lateral branches slightly to distinctly constricted at the base; papillae sparse to numerous, verrucose to cylindrical; soralia common,

formed mainly on lateral branches, developed from the top of eroded papillae or cortex, more or less discrete, rounded in shape or confluent each other to form irregular mass of asexual propagules, larger than branch diameter, sessile to slightly stipitate, cortical margin reflexed as growing, concave to slightly convex at the top with granular soredia and occasionally with isidiomorphs. **Cortex** thin, (6.4)–6.3–7.8–9.2–(9.7)% of the radius ($n=4$), *ceratina*-type plectenchy-

matous (see Ohmura, 2001); hyphae pachydermatous, secreting red pigment in the cell wall in part or no pigment, with oblong or turbinate lumina. **Medulla** lax in totality and compact just under the cortex, wide, (27)-27-29-31-(31)% of the radius ($n=4$), white but yellow around the axis. **Axis** solid, thin, (22)-22-26-30-(32)% of the diameter ($n=4$), yellow to pale orange especially on the surface, I-. **Apothecia** not seen.

Chemistry. Usnic, psoromic and 2'-*O*-demethylpsoromic acids.

The diagnostic features of *U. flavocardia* in the material collected in Taiwan are (1) the erect thallus with anisotomic-dichotomous branching (Fig. 1A), (2) the concolor to brownish black base (Fig. 1B), (3) the inflated branches with constricted at the attachment point (Figs. 1B, 1D), (4) the medulla which is lax in totality and compact just under the cortex (two-layered medulla) (Fig. 1D), (5) the concave to slightly convex soralia with granular soredia, which are larger than branch diameter and the cortex margin reflexed as growing (Fig. 1C), (6) the yellow colored axis (Fig. 1D), (7) the red spots on the cortex or papillae when present, (Figs. 1E-G), and (8) the presence of psoromic acid as a major substance.

Six chemotypes have been known in this species: chemotype 1, usnic, psoromic and \pm salazinic acids, and \pm unidentified triterpenoids; chemotype 2, usnic, stictic and \pm norstictic acids; chemotype 3, usnic, norstictic and \pm connorstictic acids, and \pm unidentified triterpenoids; chemotype 4, usnic, salazinic and \pm norstictic acids; chemotype 5, fatty acids; and chemotype 6, no detectible substance by TLC (Clerc, 1984b, 2004, 2007; Clerc and Diederich, 1991; Halonen *et al.*, 1998; Truong *et al.*, 2011). The chemotype 1 (psoromic acid) is common in Europe but also randomly distributed in North America, and other chemotypes were found outside of Europe (Clerc, 1997; Tavares *et al.*, 1998). All Taiwanese specimens belong to the chemotype 1.

The red pigment in *U. flavocardia* is secreted into the cell walls around the lumina of cortical hyphae. This pigmentation mode is similar to

those of *U. rubicunda* Stirt. and *U. rubrotincta* Stirt. (Ohmura, 2001). However, the red pigmentation in *U. flavocardia* is more localized as spots scattered in the cortex or in the tips of papillae. In addition, the red color in *U. flavocardia* is usually darker than those of *U. rubicunda* or *U. rubrotincta* as Tavares *et al.* (1998) also pointed out. The red pigmentation in the four thalli collected from Taiwan varies very much: absent, rare, common as spots on the cortex (Fig. 1E), or commonly localized in the tips of papillae (Fig. 1F) were observed.

Halonen *et al.* (1998) mentioned the occurrence of distinct segments at the branches in the materials from British Columbia, which is a result of annular cracks that often are lined by white medullary rings. But such feature was not clearly observed in the Taiwanese materials.

The two-layered medulla, i.e. compact outer layer and lax inner layer, is known as one of the feature for this species (Tavares *et al.*, 1998; Clerc, 2007). That is, the compact outer layer just under the cortex is composed of conglutinated medullary hyphae, and the inner layer is lax with usual medullary hyphae. The layer of conglutinated medullary hyphae has been sometimes considered as a component of "two-layered cortex" as reported in *U. thomsonii* Stirt. (Asahina, 1955; Awasthi, 1986). Hyphae of medulla in the genus *Usnea* can be conglutinated to form bundles, lumps, or a layer, especially near the algal layer (Ohmura, 2001). Therefore, the term "two-layered medulla" might be better to use than "two-layered cortex".

Usnea flavocardia resembles small size of *U. glabrata* (Ach.) Vain. in the morphology. However, it is distinguished from the latter by the yellow axis and the presence of psoromic acid. In addition, the occurrence of red spots in the cortex or papillae, when present, is also good character to distinguish the species.

This species has been known from Europe, North America, South America, Macaronesia (Clerc, 2007), and the distribution is now extended to Asia. It was found on twig of tree (Aquifoliaceae) or bark of *Tsuga* sp. growing

together with *U. pygmoidea* (Asahina) Y. Ohmura or *U. wasmuthii* Räsänen at elevation between 1900–3100 m in Taiwan. The total number of taxa in the genus *Usnea* in Taiwan is now 40 species and one variety (Ohmura, 2012).

Specimens examined. TAIWAN. Yilan Co.: Lake Cueifong, Mt. Taiping, Nan-ao Township (N24°30', E121°36'), on twig of Aquifoliaceae, ca. 1900 m elev., 30 September 2011, Y. Ohmura 8636A. Nantou Co.: en route from Chengkung No. 2, 3 Cabin to North Peak of Mt. Chilai, Mt. Chilai, Taroko National Park (N24°06'50.0", E121°19'19.3"), on bark of *Tsuga* sp., ca. 3100 m elev., 30 September 2009, Y. Ohmura 7008.

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