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NOTE

Notes to Pannariaceae species in Taiwan

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ABSTRACT: Ten species in the lichen family Pannariaceae were identified based on the examination of Taiwanese collections housed in the National Museum of Nature and Science, Japan. Among them, seven species are new records to Taiwan: *Fuscopannaria ahlneri*, *F. dispersa, F. sorediata, Kroswia gemmascens*, *Pannaria asahinae, P. rubiginosa* and *Parmeliella pannosa*. Their morphology, ecology, and phytogeography are discussed. *Vahliella leucophae* was deleted from the Taiwan list of Pannariaceae lichens.

KEY WORDS: Biodiversity, Asia, rain forest, tropics, subtropics, disjunction, rare species.

INTRODUCTION

Taiwan, a subtropical island situated on the Tropic of Cancer is located off the south-east coast of mainland China and on the western Pacific border with a length of 448 km, maximum width of 144 km and with a total area of 36,000 km^2. The island has a distinct mountainous topography with several peaks over 3500 m, plains below 100 m occupy 31% of the total island surface. Taiwan lies within the monsoon region. The climate of the island has typical tropical features with high temperatures, heavy rains and seasonal monsoons (Lai and Hsueh, 2001; Li *et al.*, 2013). The vegetation exhibits a marked vertical zonation which can be summarized in terms of climatic factors along an elevational gradient (Su, 1984). The original primeval forest of foothills and lowlands have been mostly destroyed except in some restricted areas. Vegetation structure shows that it is evergreen broad-leaved forest with mainly tropical taxa and larger lianas which was termed as "Subtropical Rain Forest" by Richard (1952). Representative genera are *Ficus*, *Cinnamomum*, *Turpinia*, *Bischofia*, *Sapindus*, *Gordonia*. Mixed stands of conifers and broad-leaved trees range from 500 to 1500 m and form a forest formation peculiar to the Far East dominated by evergreen trees of the oak and laurel families (Lai and Hsueh, 2001). In subalpine and temperate boreal montane zones above 3200 m coniferous woodlands and forests are dominated by *Cupressaceae* and *Pinaceae* (Hämet-Ahti *et al*., 1974; Li *et al.*, 2013).

The family Pannariaceae Tuck. is the second most species-rich family of the Peltigerales and includes more than 300 known species (Kirk *et al*., 2008). According to Ekman *et al.* (2014) Pannariaceae includes 30 genera with *Pannaria* and *Lepidocollema* being the two largest genera mostly tropical with some extensions through subtropical into warm temperate regions. The first Pannariaceae list for Taiwan included only five species under the following names: *Pannaria leucosticta* (Tuck. ex E. Michener) Nyl. (current name: *Fuscopannaria leucosticta* (Tuck. ex E. Michener) P.M. Jørg.), *P. lurida* (Mont.) Nyl., *P. caeruleobadia* (Schleich. ex Lam.) A. Massal. (current name: *P. conoplea* (Ach.) Bory), *P. mariana* (Fr.) Müll. Arg. (current name: *Lepidocollema marianum* (Fr.) P.M. Jørg.), *P. stylophora* Vain. var. *perconfluens* Vain. (current name: *L. stylophorum* (Vain.) P. M. Jørg.) (Wang-Yang and Lai, 1973). Several species were added later – *P. microphylla* (Sw.) A. Massal. (current name: *Vahliella leucophae* (Vahl) P. M. Jørg.) (Wang-Yang and Lai, 1976), *P. formosana* P. M. Jørg. (Jørgensen, 2001), *Kroswia crystalifera* P.M. Jørg. (Jørgensen, 2002) and *Physma hondoanum* Asahina (Jørgensen and Aptroot, 2002).

In this study 10 species of the family Pannariaceae were identified based on examination of Taiwanese collections housed in the herbarium of National Museum of Nature and Science (TNS), Tsukuba, Japan. Seven of them are reported here as new to Taiwan and discussed in the present study.

MATERIALS AND METHODS

Lichen samples were collected in Taiwan by Dr. H. Kashiwadani and Dr. S. Kurokawa between 1965 and 2003. All voucher specimens are housed in TNS. The material was examined using standard microscopic techniques with a dissecting microscope (Olympus SZX16) and a differential interference contrast microscope (Olympus BX51). Photographs were taken with a digital camera (Sony α 6300) for normal

photography of specimens and the other camera (Canon Kiss X7i) for microscopy. Lichen substances were studied by spot-tests using potassium hydroxide solution (K), sodium hypochlorite solution (C), 1,4-p-phenylenediamine (PD), and iodine (I). Identifications were done with the help of published keys such as Jørgensen (1978, 2000a, 2001, 2007) and Jørgensen and Kashiwadani (2001). Chemical substances of lichens were examined using thin layer chromatography (TLC) (Culberson and Johnson, 1982) with solvent systems B′ (hexane: methyl tert-butyl ether: formic acid, 140: 72: 18) (Culberson and Kristinsson, 1970) and C (toluene: acetic acid = 170: 30) (Mietzsch *et al*., 1994). Species new to Taiwan are indicated by (*) asterisk mark.

THE SPECIES

***Fuscopannaria ahlneri** (P.M. Jørg.) P.M. Jørg.

Fig. 1B

The species is characterized by a foliose rosette-like, scabrous thallus and hemispheric soralia and is mainly confined to moist boreal conifer and cool temperate deciduous forests of N. America, Europe and Asia including Japan and Far Eastern Russia (Jørgensen, 1978, 2000a; Ezhkin and Jørgensen, 2018; Ohmura and Kashiwadani, 2018). In Taiwan, it was collected in the upper montane zone.

***Specimen examined**:* Taiwan, Taizhong County: en route from Siyuan to Duojiatun Shan, Mt. Nanhu Dashan, Hoping, alt. 2700–2950 m, on bark of *Abies*, November 11, 1989, *H. Kashiwadani 36035* (TNS).

***Fuscopannaria dispersa** P.M. Jørg.

Fig. 1E

The thallus is characterized by widespread small elongated squamules to 2 mm diam., scattered over a distinct blackish prothallus with apothecia being common. *Fuscopannaria dispersa* belongs to the *F. leucosticta* group, but differs from other taxa in the group by its small-squamulose thalli and smaller spores (10)15–17 × (6)9–10 µm. *F. dispersa* is a corticolous species, from bark of coniferous trees, and is known from upper montane zones of southwestern China (Jørgensen, 2000b). In Taiwan, it was collected in the upper montane zone.

Specimens examined: Taiwan, Nantou County: just below Luoying Lodge along Route 14, Mt. Hehuan Shan, Shi-Lin Village, 24°17′N, 121°30′E, alt. 2560 m, on bark of *Pinus taiwanensis*, March 9, 2003, *H. Kashiwadani 45493*, *45482* (TNS). Taichung County: Daxueshan Forest Park, on road to nearby summit areas of Mt. Daxueshan, Hopen, 24°17′N, 121°02′E, alt. 2980 m, on bark of tree, November 29, 2002, *H. Kashiwadani 45072* (TNS).

***Fuscopannaria sorediata** (P.M. Jørg.) P.M. Jørg.

Fig. 1F

The species is characterized by squamulose thalli, to 3 mm diam. Brown upper surface often with paler ‘‘frosted’’ margins with farinose soralia often being isidioid. Apothecia are rare. *Fuscopannaria sorediata* can be confused with *F. ahlneri* from which it differs in its more squamulose thallus and more farinose soralia. *F. sorediata* is a mainly corticolous species on temperate deciduous trees, known from India, Chinese Xizang, the Russian Far East, Japan and North America (Jørgensen, 2000a, 2000b). In Taiwan, it was collected in upper montane zone.

Specimens examined: Nantou County: just below Luoying Lodge along Route 14, Mt. Hehuan Shan, Shi-Lin Village, 24°17′N, 121°30′E, alt. 2560 m, on bark of *Tsuga*, March 9, 2003, *H. Kashiwadani 45497* (TNS). Ibid, 10 km SE from Lishan, along Route 8, Ren’ai Town, 24°17′N, 121°30′E, alt. 2100 m, on rock along road, March 10, 2003, *H. Kashiwadani 45685* (TNS).

***Kroswia gemmascens** (Nyl.) P.M. Jørg.

Fig. 1A

The species is characterized by squamulose small thalli up to 3 mm diam., strongly wrinkled with marginal bluish gymnidia with terpenoid crystals. All chemical reactions are negative, containing terpenoids. Apothecia are unknown. *Kroswia gemmascens* is a mostly bryophilous species growing on tree trunks in montane forests, known from Japan and China (Jørgensen and Kashiwadani, 2001; Jørgensen, 2002; Liu *et al.*, 2016). In Taiwan, it was collected in the montane to upper montane zone. The species can be mistaken for *Pannaria globigera* Hue from which it is distinguished by the absence of a true cortex, pannarin and wrinkled upper surface of the thallus. It is very similiar to *K. crystallifera* P.M. Jørg. which differs by sharp wrinkles with white patterns and elongated, partly fenestrate lobes (Jørgensen, 2002). The status of the genus is still not clear. Phylogenetic research confirmed that the generitype of *Kroswia* is related to the genus *Fuscopannaria* (Magain and Sérusiaux, 2014). The discovery of fertile material revealed characters in the hymenium, suggesting a close relationship with *Fuscopannaria*, but the globose, brown-pigmented ascospores are unique in the family (Jørgensen, 2007). All Taiwanese material is sterile.

***Specimens examined**:* Taiwan, Nantou County: ca. 10 km SE from Lishan, along Route 8, Mt. Hehuan Shan, Ren’ai Town, 24°17′N, 120°30′E, alt. 2100 m, on rock along road, March 10, 2003, *H. Kashiwadani 45683*, *45684*; 24°24′N, 121°28′E, alt. 3300 m, on bark of *Abies kawakamii*, March 8, 2003, *H. Kashiwadani 45577* (TNS). Taizhong County: en route from Siyuan to Duojiatun Shan, Mt. Nanhu Dashan, Hoping, alt. 2700–2950 m, on bark of *Abies*, November 11, 1989, *H. Kashiwadani 36062* (TNS).

Lepidocollema stylophorum (Vain.) P.M. Jørg.

The species is characterized by a squamulose thallus, forming orbicular rosettes with coralloid isidia resting on a thick blackish prothallus. No lichen substances (TLC). The species is subtropical, occurs on oaks in swampy lowland areas, known from southern parts of Northern America, widespread in the West Indies, Africa and Asia (China) (Jørgensen, 2000a; 2003; Zhang *et al*., 2021). The species was reported previously by Wang-Yang and Lai (1973) without indication of locality.

Specimen examined: Taiwan, Pingdong County: 5 km south-east of So Pass, alt. 450 m, February 12, 1965, *S. Kurokawa 3021* (TNS).

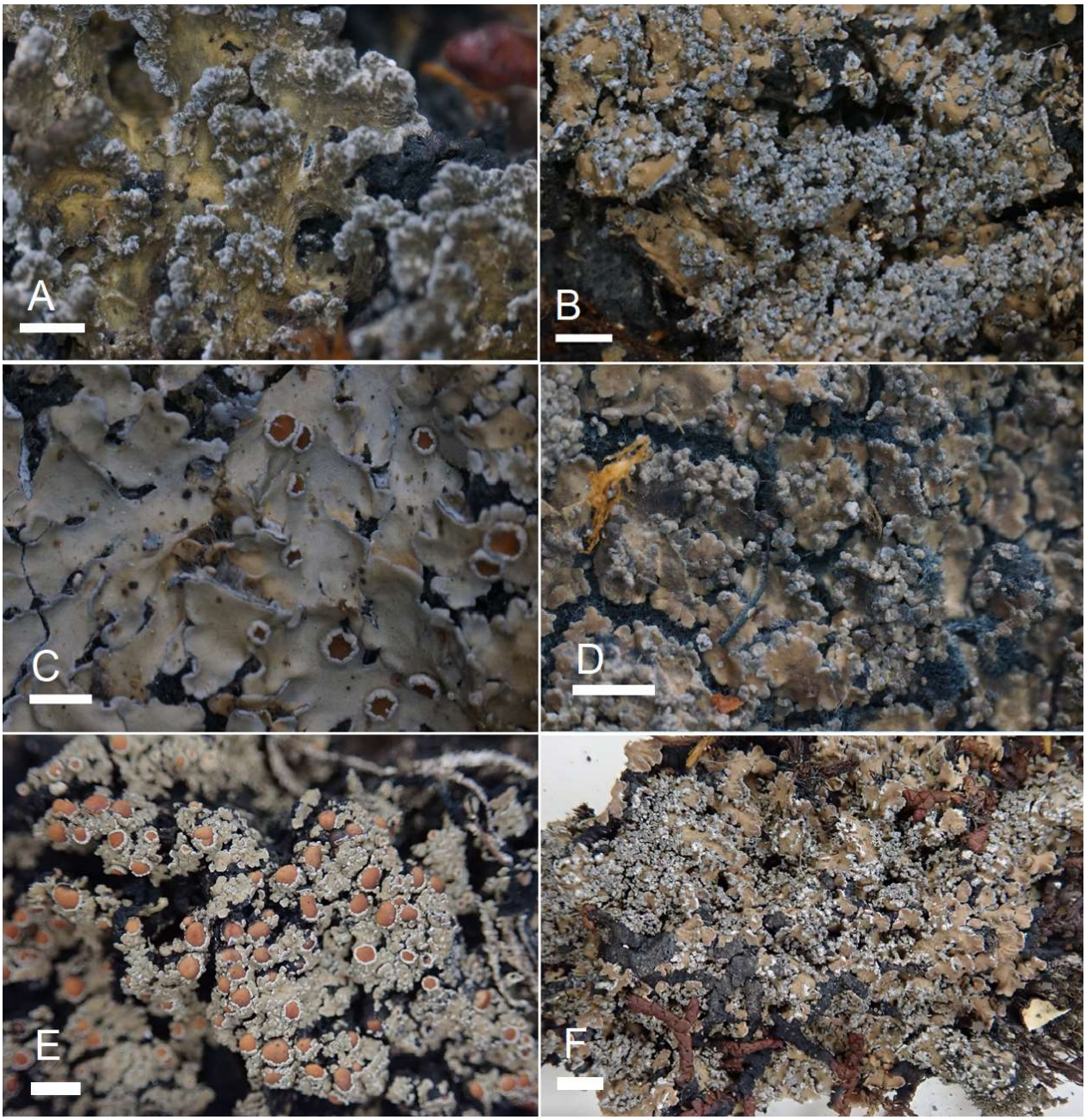

Fig. 1. Pannariaceae lichens from Taiwan. **A**. ***Kroswia gemmascens*** (H. Kashiwadani 45577, TNS). **B**. ***Fuscopannaria ahlneri*** (H. Kashiwadani 36035, TNS). **C**. ***Pannaria asahinae*** (H. Kashiwadani 36088, TNS). **D**. ***Parmeliella pannosa*** (H. Kashiwadani 45516, TNS). **E**. ***Fuscopannaria dispersa*** (H. Kashiwadani 45493, TNS). **F**. ***Fuscopannaria sorediata*** (H. Kashiwadani 45497, TNS). Scales: A, B, C, D, E, F = 1 mm.

****Pannaria asahinae*** P.M. Jørg.

Fig. 1C

The species is characterized by small brown and fertile squamulose thalli up to 3 mm in diam. All chemical reactions are negative. Apothecia common. The species is close to *P. rubiginosa* (Ach.) Delise from which it differs by brownish color, small-squamulose central parts, no lichen acids and smaller spores. *P. asahinae* is mainly corticolous in temperate deciduous forests, known only from Japan where it appears to be most common in southern parts of Honshu (Jørgensen and Kashiwadani, 2001). In Taiwan, it was collected in the upper montane zone.

Specimen examined: Taiwan, Taizhong County: en route from Siyuan to Duojiatun Shan, Mt. Nanhu Dashan, Hoping, alt. 2700–2950 m, on bark of *Abies*, November 11, 1989, *H. Kashiwadani 36088* (TNS).

Pannaria lurida (Mont.) Nyl.

The species is characterized by foliose thalli up to 5 cm, wrinkled when dry, often fertile, PD+ orange

(pannarin). *P. lurida* is a widespread corticolous species, known from warm and cool temperate moist forests of North America, Africa and Asia (Jørgensen, 1978, 2000a, 2003; Jørgensen and Kashiwadani, 2001; Wu *et al.*, 2020). The species was reported earlier for Taiwan without information (Wang-Yang and Lai, 1973), however, the localities presented here are in the upper montane zone.

Specimens examined: Taiwan, Taizhong County: en route from Duojiatun Shan to Shenmazhen Shan, Mt. Nanhu Dashan, Hoping, alt. 2500–2900 m, November 11, 1989, *H. Kashiwadani 35943* (TNS). Nantou County: along Route 820, Mt. Hehuan Shan, Ren'ai Town, 24°17′N, 121°31′E, alt. 2590 m, on bark of *Rhododendron* sp., March 9, 2003, *H. Kashiwadani 45433* (TNS).

****Pannaria rubiginosa*** (Ach.) Delise

The species is characterized by a foliose thallus being partly pruinose or scabrous, not wrinkled, 3–5 cm in diam., with positive reaction with PD+ orange (pannarin). Apothecia common, particularly centrally. *P. rubiginosa* is a mostly corticolous species known from all continents except Australia (Jørgensen, 1978, 2000a, 2003; Smith *et al*., 2009; Wu *et al*., 2020). In Taiwan, it was collected in montane zone.

Specimen examined: Taiwan, Taizhong County: en route from Siyuan to Duojiatun Shan, Mt. Nanhu Dashan, Hoping, alt. 1900–2250 m, November 9, 1989, *H. Kashiwadani 35872* (TNS).

Pannaria formosana P.M. Jørg.

The species is characterized by light brownish thalli, forming flat circular patches up to 5 cm diam. with slightly enlarged peripheral lobes which have marginal white-pruinose, isidioid, secondary lobules and a positive PD+ orange reaction indicating the presence of pannarin. The species is close to *P. insularis* P.M. Jørg. which has much darker, squamulose and smaller thalli. *P. formosana* is a corticolous species known only from the lowland forests of Southeastern China (Zhejiang), Southern Taiwan and and Japan (Jørgensen, 2001; Wu *et al.*, 2020). In Taiwan, it was collected in the lowland zone.

Specimen examined: Taiwan, Pingtung County, Kural, 21°57'33"N 120°48'43"E, alt. 250 m. February 1, 1964, 1471 *S. Kurokawa* (TNS).

****Parmeliella pannosa*** (Sw.) Müll. Arg.

Fig. 1D

The species is characterized by brownish orbicular patches, squamulose centrally, up to 5 cm diam. formed on brownish black hypothallus, with ascending margins, sometimes obscured by secondarily lobules. No lichen substances (TLC). The species can be confused with *Lepidocollema marianum* which differs in having a thinner, phyllidiate thallus and is more often fertile. *Parmeliella pannosa* is widespread in subtropical parts of the world, including China (Jørgensen, 2000a; Zhang *et al*., 2021). In Taiwan, it was collected in the upper montane zone.

Specimens examined: TAIWAN. Nantou County: along Route 820, Mt. Hehuan Shan, Ren'ai Township, 24°17′N, 121°31′E, alt. 2590 m, on bark of *Rhododendron* sp., March 9, 2003, *H. Kashiwadani 45516* (TNS). Taizhong County: en route from Siyuan to Duojiatun Shan, Mt. Nanhu Dashan, Hoping, alt. 2700-2950 m, on bark of coniferous tree, November 11, 1989. *H. Kashiwadani 36112* (TNS).

DISCUSSION

This study revealed 10 species of the family Pannariaceae for Taiwan. So, the list of Pannariaceae for Taiwan including our additions counts 15 species. One species - *Pannaria microphylla* noted by Wang-Yang and Lai (1973) was excluded from the list as it belongs in a family of its own, *Vahliellaceae*. The Pannariaceae species recorded from Taiwan can be divided in two main groups by their distribution patterns. *The subtropical group* of lichens typical for lowland forests includes *Lepidocollema marianum*, *L. stylophorum* and *Pannaria formosana.* These species are confined to moist, tropical, rain forests, an ecosystem strongly reduced and poorly known lichenologically. *The montane temperate-boreal group* of lichens is more diverse. *Kroswia gemmascens*, *K. crystallifera*, *Fuscopannaria dispersa* and *Physma hondoanum* show restricted distributions and can be classified as subtropical montane species typical for montane and upper montane cloud forests in Japan, Taiwan and China. *Fuscopannaria ahlneri*, *F. leucosticta*, *F. sorediata*, *Pannaria conoplea*, *P. lurida* and *P. rubiginosa* have a wide distribution from North America to Asian Far East. They can all be characterized as cool temperate species typical for meridional and cool temperate boreal and deciduous forests. *Fuscopannaria leucosticta* and *F. sorediata* are well known Tertiary relic patterns (Culberson, 1972; Jørgensen, 1978). *Pannaria asahinae* and *Parmeliella pannosa* appear to be in a transition between the first and second group and can classified as subtropical and warm temperate to montane species.

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