

# Contributions to the Foliicolous Lichens Flora of South Korea

Udeni Jayalal<sup>1,†</sup>, Soon Ok Oh<sup>1,†</sup>, Robert Lücking<sup>2</sup>, Santosh Joshi<sup>1</sup>, Jung A Kim<sup>1</sup>, Jung-Shin Park<sup>1</sup> and Jae-Seoun Hur<sup>1,\*</sup>

<sup>1</sup>Korean Lichen Research Institute, Sunchon National University, Suncheon 540-742, Korea

<sup>2</sup>Botany Field Museum, Chicago, IL 60605, USA

**Abstract** South Korea is covered primarily by temperate vegetation; therefore, foliicolous lichens may not be expected to play an important role in its lichen flora. However, this study describes four foliicolous lichen species, *Strigula concreta*, *S. macrocarpa*, *S. melanobapha*, and *S. subelegans*, which are new to South Korea. These findings will lead to further research on foliicolous lichens and provide a better understanding of their distribution within the East Asian region. This is the first detailed report on foliicolous lichens and their distribution in South Korea.

**Keywords** Diversity, Foliicolous, South Korea, Strigula, Taxonomy

South Korea is covered primarily by temperate vegetation [1]; therefore, foliicolous lichens may not be expected to play an important role in its lichen flora. Indeed, more than 100 years after the first lichen record from South Korea reported by Hue [2], the paper “Pyrenocarpous lichens in Korea” published by Moon and Aptroot [3], reported on the presence of two foliicolous lichens, *Strigula nemathora* Mont. and *S. smaragdula* Fr., for the first time in South Korea. No detailed reports on foliicolous lichens have since been published in South Korea. In Japan, the neighboring country, approximately 83 foliicolous lichen species are distributed at the southernmost part under temperate to subtropical climatic conditions [4]. However, a large number of foliicolous lichens, with many recent records, have been reported in neighboring countries like China and Taiwan [5]. According to Thor *et al.* [4], studies on foliicolous lichen flora of Asia are comparatively poor

compared to those reported from America.

In this report, four additional foliicolous lichens are described in detail. All of the species were reported from Jeju Island, the most southern part of South Korea. The foliicolous lichen flora of South Korea remains unexplored and this finding will further improve the knowledge of foliicolous lichen flora of this area. In addition to the taxonomic descriptions, chemical and ecological notes, and comments are provided for each of the newly recorded species. In addition, the distribution patterns of these lichens on Jeju Island are also described.

## MATERIALS AND METHODS

Jeju Island is located between N 33°~34° latitude and E 126°~127° longitude of the geographical midway between Korea, Japan, and China (Fig. 1A). The island lies in the path of the northward-flowing Kuroshio Current (Western Boundary Current of the North Pacific Ocean), which transports a large amount of heat from the tropics to the Jeju Island area. The northward-flowing Kuroshio Current diverges into the North Yellow Sea and the East Sea in the vicinity of the south coast of Jeju Island; therefore, the warm Kuroshio Current has a strong and direct influence on the climate of Jeju Island, as well as Japan and coastal China [6]. Mean annual temperature of the island ranges from 15 to 17°C, except at the highest elevations on Mt. Halla (1,950 m), and mean annual precipitation is 1,550~2,050 mm [7]. There are three main vegetation types: evergreen broadleaved forest (up to 600 m), deciduous broadleaved forest (600~1,400 m), and coniferous forest (1,400~1,950 m) with scattered scrubs and grasslands [8-10].

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**\*Corresponding author**

E-mail: [jshur1@sunchon.ac.kr](mailto:jshur1@sunchon.ac.kr)

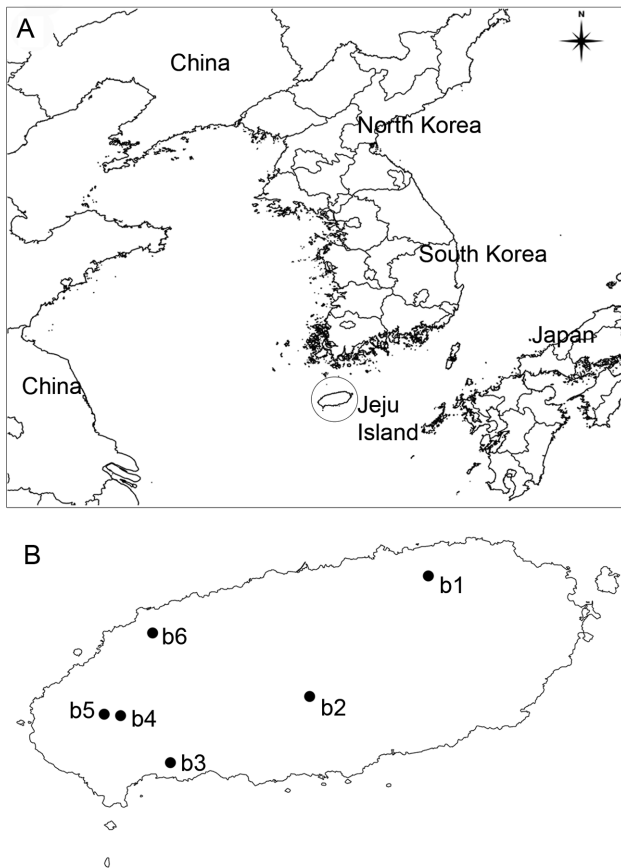
<sup>†</sup>These authors contributed equally to this work.

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**Fig. 1.** A, Geographical location of Jeju Island, South Korea; B, Localities of collection of foliicolous lichens on Jeju Island (b1, Camellia Garden; b2, Donneako Valley; b3, Anduck Valley; b4, Jeoji Gotjawal; b5, Cheongsu Gotjawal; b6, warm temperate forest).

Lichen specimens were collected from different vascular plant species in Camellia Gardens (Dong Beak Dong San) (b1), Seonheul-ri, Jocheon-eup, Jeju-si, Jeju-do; Donneako Valley (b2), Shanghyo-dong, Seogwipo-si, Jeju-do; Anduck Valley (b3), Gamsan-ri, Andeok-myeon, Seogwipo-si, Jeju-do; Jeoji Gotjawal (b4), Jeoji-ri, Hangyeong-myeon, Jeju-si, Jeju-do; Cheongsu Gotjawal (b5), Cheongsu-ri, Hangyeong-myeon, Jeju-si, Jeju-do and warm temperate forest (b6), Nabeup-ri, Aewol-eup, Jeju-si, Jeju-do in June 2012 (Fig. 1B). After drying at room temperature, the lichen specimens were identified using stereo and light microscopes: a NIKON SMZ645 (Nikon, Tokyo, Japan) dissecting microscope was used for identification of morphological characteristics of thallus, reproductive structures, color, size, and shape, while a ZEISS Scope A1 (Zeiss, Jena, Germany) compound microscope was used for study of the anatomy of thalli and fruiting bodies. All measurements were taken from material mounted in water and stained in lactophenol cotton blue. An average of ten measurements per structure was recorded for the sizes of thallus, ascumata, and ascospores and the thicknesses of excipulum and involucrellum. Ascospore dimensions are generally presented as minimum value

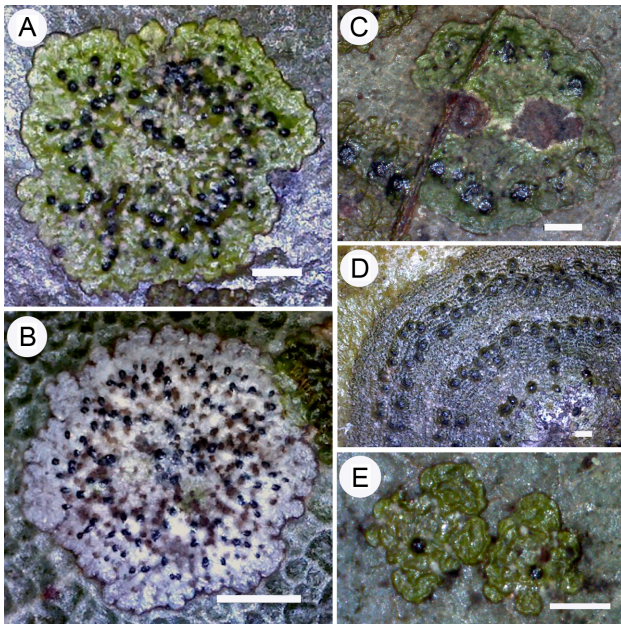
observed - maximum value observed. Spot test reactions were performed on hand sections of thalli and perithecia under a compound microscope. Iodine (I) was used to check the color reactions of the ascus wall and the hymenium. Thin layer chromatography was performed in solvent system C (toluene:acetic acid = 85:15), as described by Orange *et al.* [11]. Terminology used in this study follows that of Lücking [12]. Voucher specimens have been deposited in the herbarium of the Korean Lichen Research Institute (KoLRI), Suncheon National University, South Korea.

**Molecular methods.** Total DNA was extracted directly from thalli of the selected specimens (*S. concreta*-KF553661, *S. macrocarpa*-KF553662, *S. smaragdula*-KF553663, and KF553664), according to Ekman [13], and purified using the DNeasy Plant Mini Kit (Qiagen, Hilden, Germany). The nuclear ribosomal RNA gene region, including internal transcribed spacers (ITS) 1 and 2 and the 5.8S subunit, was amplified using the primers ITS1F [14] and LR5 [15]. Amplification was performed on a Takara JP/TP600 PCR machine (Takara Bio Inc., Otsu, Japan). One initial cycle of 5 min at 94°C was followed by 30 cycles of the following steps: 30 sec at 94°C, 39 sec at 57°C, and 1 min at 72°C. Amplifications were ended with a final cycle at 72°C for 10 min. PCR products were then sent to the sequencing facilities of Genotech Cooperation, Seoul, South Korea, for cleaning and sequencing. Alignment was performed using BioEdit software [16]. Ambiguous regions were delimited [17] and excluded from the alignment. A few other species were selected as out-groups based on BLAST comparison in GenBank. Phylogenetic relationship between taxa was investigated using Mega 5.1 software [18]. Analysis of the dataset was performed using the neighbor joining (NJ) method and support values were obtained using a bootstrap analysis of 1,000 pseudoreplicates.

## RESULTS AND DISCUSSION

There are six lichenogeographical regions: the Neotropics (with subtropical areas of North and South America), Valdivia (southern South American temperate rain forests), Tethyan (Macaronesian and Mediterranean subtropical wet forests of Europe), African Paleotropics, eastern Paleotropics, and Neozelandic-Tasmanian (southeast Australasian temperate rainforests), which are demarcated based on the known worldwide distribution pattern of foliicolous lichen flora [12, 19]. South Korea belongs to the eastern Paleotropic region, where a higher number of local endemic foliicolous lichens have been reported [20].

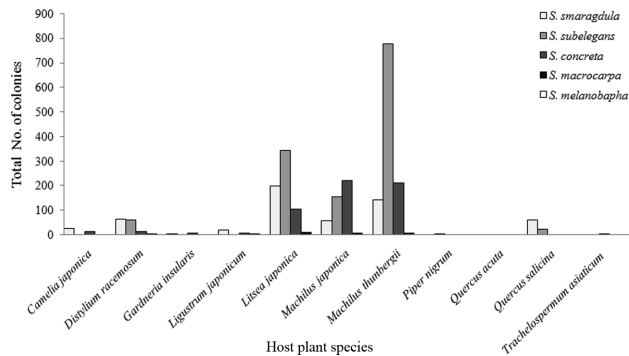
So far, there are a total of six known foliicolous lichen taxa from South Korea; of these, four species, *Strigula concreta* (Fée) R. Sant., *S. subelegans* Vain., *S. macrocarpa* Vain., and *S. melanobapha* (Kremp.) R. Sant., are newly reported South Korean lichen flora (Fig. 2). The other two species, *Strigula nemathora* and *S. smaragdula*, were



**Fig. 2.** Habit of foliicolous species of *Strigula concreta* (A), *S. subelegans* (B), *S. macrocarpa* (C), *S. melanobapha* (D), and *S. smaragdula* (E) (scale bars: A~E = 0.5 mm).

reported by Moon and Aptroot [3] from Jeju Island. So far, the genus *Strigula* is the only known representative of the foliicolous lichen flora in South Korea. Among the recorded species, *S. smaragdula*, *S. subelegans*, and *S. concreta* are abundant and widespread (Fig. 3). Japan, the closest area to Jeju Island, has the same distribution pattern of foliicolous lichens, with *S. melanobapha*, *S. smaragdula*, and *S. subtilissima* [4].

The diversity of foliicolous species does not show a significant difference within the studied sites on Jeju Island. *S. smaragdula* has shown the highest relative abundance (0.34), while *S. melanobapha* showed the lowest relative abundance (0.006) (data not shown). So far, Jeju Island is the only location on the Korean peninsula where foliicolous lichens have been reported. The fact that vegetation and geographical conditions are closer to subtropical climatic



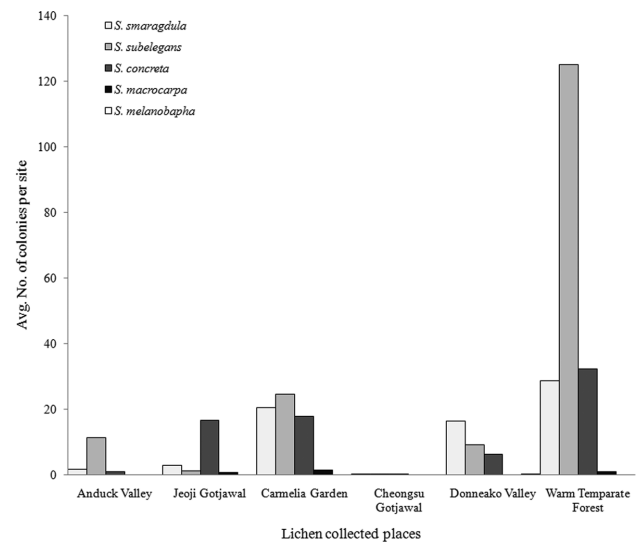
**Fig. 3.** Distribution of foliicolous lichens on different vascular plant species. *S.*, *Strigula*.

conditions appears to favor the occurrence of foliicolous lichens on this island.

Similarly, in Japan, the dominance and low diversity of *Strigula* species together with some other foliicolous genera, such as *Arthonia*, *Byssoloma*, *Calopadia*, *Coenogonium*, *Mazosia*, *Porina*, and *Sporopodium*, indicate that they are also confined to the southernmost subtropical islands [4]. Although foliicolous lichens are somewhat abundant in subtropical habitats, it has been observed that they prefer to inhabit tropical rainforests as well [19, 21].

The warm temperate forest at Nabeup-ri, where almost all *Strigula* species, other than *S. melanobapha*, are represented in the highest average number of colonies in this area, seems to be the most suitable habitat for growth of foliicolous lichens (Fig. 4). The microclimatic conditions, such as high humidity (69.6%), average temperature (19°C), average rainfall (1,500 mm), and low altitude might favor the growth of foliicolous lichens in this area. In addition, the understory layer of this forest is rich in vascular plant species, *Machilus thunbergii* and *Litsea japonica*, whose leaves provide a good habitat for growth of foliicolous species, as they do not shed their leaves seasonally (Fig. 3).

The abundance of foliicolous species in other sites, such as Anduck Valley, Jeoji Gotjawal, Camellia Gardens, Cheongsu Gotjawal, and Donneako Valley is considerably lower than that of the warm temperate forest at Nabeup-ri, which could be mainly due to the low abundance of evergreen vascular plant species and low precipitation (c. 1,150 mm) at those sites. Among the other sites, Camellia Gardens provides relatively favorable conditions for growth of foliicolous lichens compared to the remaining sites (Fig. 4). The vascular plant *Machilus japonica* is more dominant in the understory layer of this forest and provides a good habitat for *Strigula* species. Because there are no defensive structures, such as hair or glands, on the surface of the



**Fig. 4.** Distribution of foliicolous lichens in different localities of collection on Jeju Island. *S.*, *Strigula*; Avg., average.

leaves of these plant species, they provide a proper substrate for growth of *Strigula* species. According to Lücking [12], drip tips, hair, and glands play an important role as potential defense mechanisms used by plants against epiphyllous colonization. In addition, because *Strigula* species develop their thalli below the leaf cuticle [12], they have become dominant in drier habitats [22].

On the other hand, *S. macrocarpa* and *S. melanobapha* were found in two localities, Jeoji Gotjawal, Camellia Gardens, followed by a single locality in Donneako Valley (Fig. 4). These localities harbored other *Strigula* species as well, therefore, providing an appropriate reason for the distribution of *S. macrocarpa* and *S. melanobapha* in those sites is difficult. According to Lücking [12], these two species are more common in understory of lowland rainforests. Three localities, Jeoji, Cheongsu, and Camellia Gardens, are located in a very special geological and ecological habitat, the so called Gotjawal, a unique region created through volcanic activity, where various northern and southern limit plants exist due to abundance of underground water and excellent warming and moisturizing effects. The Gotjawal Forest is an enclave of the eco-region of the southern Korea evergreen forests [23]. The unique environment of Gotjawal Forest may allow for colonization and growth of foliicolous lichens on Jeju Island.

According to the frequencies of all foliicolous lichens found in South Korea, *S. concreta* showed the highest frequency per both tree and site. The second highest frequency was observed for *S. smaragdula* and the least was observed for *S. melanobapha* (Fig. 5). Although *S. concreta* is more common in South Korea, it was only reported from a single locality on Okinoerabu-jima Island in Japan [4]. On the other hand, *S. melanobapha* appears to be an uncommon species in South Korea; however, it is more common in Japan [4].

Pollen studies conducted by Chung [6] reported that changes in vegetation on Jeju Island, due mainly to

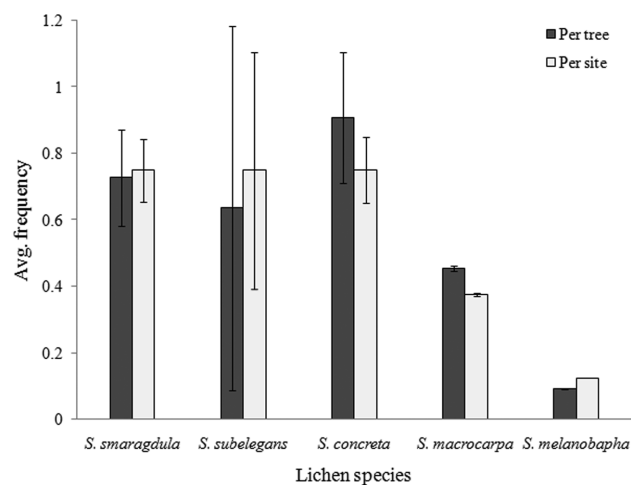


Fig. 5. Variation of foliicolous lichen frequencies with respect to vascular plant species and localities. S., *Strigula*; Avg., average.

deglacial warming and the influence of geographical change, resulted from sea-level rises. In general, all of the foliicolous lichens observed so far were restricted to the southernmost part of South Korea, particularly Jeju Island. The distribution pattern of foliicolous lichens on Jeju Island might be influenced by its geographical setting. One reason could be the close dispersal distances of spores and vegetative propagules from areas such as the southern part of Japan and eastern part of China, where more foliicolous lichens can be found. Thor *et al.* [4] also showed that the southern part of Japan harbors more foliicolous lichens than the northern part. Considering that China is close to Jeju Island, many foliicolous lichens, including *Strigula concreta*, *S. macrocarpa*, *S. nemathora*, and *S. smaragdula*, have been reported from Yunnan province, the southernmost part of China [5]. Geographically, this province is far away from Jeju Island. In other provinces, such as Shandong, Jiangsu, Shanghai, and Zhejiang, which are closer to Jeju Island, no foliicolous lichens have been recorded so far. Therefore, the chance of spores and propagules coming from such closer areas is questionable. Thus, the location of origin of ancestors of foliicolous lichens of South Korea and the time and means of their invasion of this island is controversial. The current study would lead the way to finding answers to the above mentioned questions. However, conduct of more extensive and detailed studies, not only on Jeju Island, but also in other geographical regions, including Japan, China, and Taiwan, is evidently required in order to draw further conclusions.

**Molecular and taxonomic work.** According to the molecular analysis, the NJ tree shows that *Strigula smaragdula* and *S. macrocarpa* are closely related to each other, and *S. concreta* is a sister to the two above mentioned species (bootstrap 99%) (Fig. 6). Because isolation of some gene sequences from species of *S. subelegans* and *S. melanobapha* is difficult, they were not included in the analysis.

### The species.

***Strigula concreta*** (Fée) R. Sant., Symb. Bot. Ups. 12: 177 (1952).

Grey-green subcuticular thallus, 4~8 mm across (Fig. 2A) and 30~40  $\mu$ m thick with a shortly lobulate margin. Perithecia black, prominent with base immersed, hemispherical, 0.2~0.4 mm diam., excipulum 10~15  $\mu$ m thick, brownish black, involucrellum black. Ascospores bacillar, 1-septate, with distinct constrictions at septum, 12~15  $\times$  2~3  $\mu$ m, colorless, often breaking into halves within or outside asci. Pycnidia not observed.

**Chemistry:** Spot test reactions: thallus K-, C-, KC-, P-. Secondary metabolites: not detected.

**Ecology and distribution:** New to South Korea. Pantropical, common species, and frequently found in humid, semi-exposed habitats [12]. Species was found on the leaves of understory young plants of *Camellia japonica*, *Distylium*

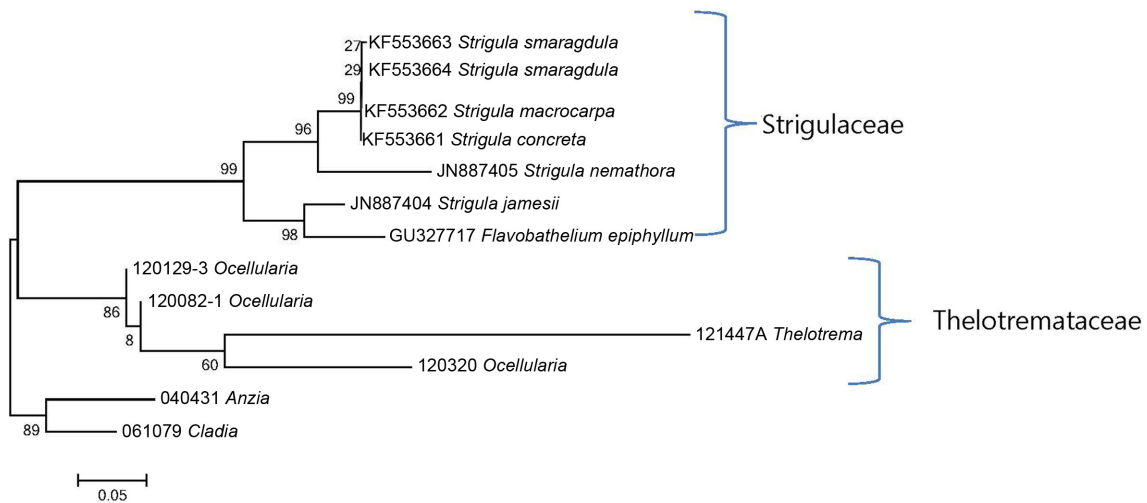


Fig. 6. Phylogenetic tree of foliicolous lichens distributed on Jeju Island.

*racemosum*, *Litsea japonica*, *Machilus thunbergii*, *Piper nigrum*, and *Quercus acuta*, and on a creeper, *Trachelospermum asiaticum* var. *intermedium*, in an evergreen forest patch along with *S. macrocarpa* and *S. smaragdula* in Anduck Valley, Jeoji Gotjawal, Camellia Gardens, Cheongsu Gotjawal, Donneako Valley, and warm temperate forest.

Other than South Korea, this species has been recorded from Japan, Mexico, Guatemala, Costa Rica, Cuba, Colombia, Venezuela, Guyana, French Guiana, Ecuador, Brazil, Argentina [12], Thailand [24], Taiwan [5], Micronesia, Oceania, USA (Hawaii) [25], and Venezuela [26].

**Remarks:** According to Lücking [12], this species is closely related to *S. nitidula* Mont. in perithecial anatomy; however, they differ in their thallus structure. *S. concreta* has a thick, pale grayish green and marginally lobulate thallus, while *S. nitidula* has a very thin, bright metallic green, marginally effuse thallus.

**Selected specimens examined:** Anduck Valley: 121436 on *Distylium racemosum* (33°15'21.4" N, 126°21'16.8" E), 33 m elev., 4 Jul 2012; 121437 on *Machilus thunbergii* (33°15'21.4" N, 126°21'16.8" E), 123 m elev., 4 Jul 2012; Jeoji Gotjawal: 121313, 121315 on *Machilus thunbergii* (33°19'14.5" N, 126°17'09.7" E), 231 m elev., 4 Jul 2012; Camellia Gardens: 121483 on *Quercus acuta* (33°31'00.5" N, 126°42'26.6" E), 231 m elev., 4 Jul 2012; 121303, 121323 on *Camellia japonica* (33°30'47.3" N, 126°42'35.5" E), 121304 on *Gardneria insularis* (33°30'47.3" N, 126°42'35.5" E), 121305, 121316 on *Machilus thunbergii* (33°14'14.2" N, 126°18'47.7" E); Cheongsu Gotjawal: 121326 on *Distylium racemosum* (33°19'21.6" N, 126°15'48.4" E), 141 m elev., 4 Jul 2012; Donneako Valley: 121296 on *Distylium racemosum* (33°20'49.6" N, 126°32'47.1" E), 1,404 m elev., 18 Jun 2012; warm temperate forest: 121085, 121086, 121088, 121090 on *Litsea japonica* (33°26'04.5" N, 126°19'48.5" E), 121087, 121089, 121349, 121350 on *Machilus thunbergii* (33°26'05.6" N, 126°19'49.2" E), 121353 on *Trachelospermum asiaticum* var. *intermedium* (33°26'05.6" N, 126°19'49.2" E), 96 m elev., 2 Jun 2012.

***Strigula macrocarpa*** Vain., Ann. Acad. Sci. Fenn., Ser. A, 19: 20 (1923).

Bright green subcuticular thallus, 4~6 mm across (Fig. 2C) and 30~40 µm thick. Perithecia black, prominent, but covered by a thin thallus layer, hemispherical with base spreading 0.4~0.9 mm diam., excipulum 20~25 µm thick, brownish black, involucrellum black; ascospores fusiform, 1-septate, with distinct constrictions at septum, 15~17 × 3~4 µm, colorless. Pycnidia not observed.

**Chemistry:** Spot test reactions: thallus K-, C-, KC-, P-. Secondary metabolites: none detected.

**Ecology and distribution:** New to South Korea. Pantropical [12]. Species was found on the leaves of species of *Camellia japonica*, *Distylium racemosum*, *Litsea japonica*, *Machilus thunbergii*, *Piper nigrum*, and *Quercus acuta*, and on a creeper, *Trachelospermum asiaticum* var. *intermedium*, in Jeoji Gotjawal, Camellia Gardens, Cheongsu Gotjawal, Donneako Valley, and warm temperate forest along with *Strigula smaragdula*.

Other than South Korea, this species has been recorded from Costa Rica, Panama, Guyana, Ecuador [12], China [27], Malaysia [28], Micronesia, Oceania [25], Papua New Guinea [29], and Venezuela [26].

**Specimens examined:** Jeoji Gotjawal: 121312 on *Machilus thunbergii* (33°19'14.5" N, 126°17'09.7" E), 231 m elev., 4 Jul 2012; Camellia Gardens: 121297 on *Machilus thunbergii* (33°30'47.3" N, 126°42'35.5" E), 121327, 121317 on *Machilus japonica* (33°14'11.8" N, 126°33'38.7" E), 121322 on *Distylium racemosum* (33°30'59.9" N, 126°43'02.1" E), 141 m elev., 4 Jul 2012; warm temperate forest: 121086 on *Litsea japonica* (33°26'04.5" N, 126°19'48.5" E), 96 m elev., 1 Jun 2012.

**Remarks:** *Strigula macrocarpa* is very closely related to *S. smaragdula*, both having a bright green thallus and rather large fusiform ascospores. However, the latter species has a smaller and thicker thallus with semi-immersed perithecia.

***Strigula melanobapha*** (Kremp.) R. Sant., Symb. Bot. Ups. 12: 188 (1952).

Thallus subcuticular, continuous, formed by radiating confluent lobes, 10~12 mm across (Fig. 2D) and 10~12  $\mu$ m thick, individual short lobes bordered by a thin, black, interrupted line, appearing as if forming black papillae. Perithecia are completely exposed but covered by a thin thallus layer up to ostiole. Ascospores fusiform, 1-septate, with distinct constructions at septum, 14~22  $\times$  3~5  $\mu$ m, colorless. Pycnidia basally immersed, wart shaped, those producing macroconidia 0.2~0.5 mm, those producing microconidia 0.03~0.05 mm diam., grayish black. Macroconidia bacilliform, 1-septate 11~13  $\times$  2~4  $\mu$ m. Microconidia not observed.

**Chemistry:** Spot test reactions: thallus K-, C-, KC-, P-. Secondary metabolites: none detected.

**Ecology and distribution:** New to South Korea. Pantropical and most common in the Amazon region [22]. Species was found on the leaves of species *Distylium racemosum* in Donneako Valley along with *Strigula concreata*.

Other than South Korea, this species has been recorded from Japan, French Guiana, Peru, Brazil [12], China [27], Panama [30], Micronesia, Oceania, and USA (Hawaii) [25].

**Specimens examined:** Donneako Valley: 121296 on *Distylium racemosum* (33°20'49.6" N, 126°32'47.1" E), 1,404 m elev., 18 Jun 2012.

**Remarks:** This species is very obvious due to its unusually large thallus. According to Lücking [12], this species is closely related to *S. subtilissima* (Fée) Müll. Arg., however, that species is smaller in all parts, including ascospores, and bordered by a continuous black line.

***Strigula smaragdula*** Fr., Linnaea 5: 50 (1830).

Bright green subcuticular thallus, 0.5~1 mm across (Fig. 2E) and 30~60  $\mu$ m thick. Perithecia black, semi-immersed, hemispherical with base spreading, 0.2~0.4 mm diam., excipulum 5~15  $\mu$ m thick, light brownish, involucrellum black, 15~20  $\mu$ m thick; ascospores fusiform, 1-septate, with distinct constructions at the septum, 11~14  $\times$  2~4  $\mu$ m, colorless. Pycnidia not observed.

**Chemistry:** Spot test reactions: thallus K-, C-, KC-, P-. Secondary metabolites: none detected.

**Ecology and distribution:** Second record for South Korea. This species, which has Pantropical distribution [12], was first reported from Jeju Island by Moon and Aptroot [3]. During the current study, this species was found on the leaves of young, understory plants of *Camellia japonica*, *Distylium racemosum*, *Litsea japonica*, *Machilus japonica*, *M. thunbergii*, *Quercus acuta*, and *Q. salicina* in Anduck Valley, Jeoji Gotjawal, Camellia Gardens, Cheongsu Gotjawal, Donneako Valley, and in warm temperate forests together with *Strigula macrocarpa*.

Other than South Korea, this species has been recorded from Japan, USA, Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Cuba, Dominican Republic, Puerto Rico, Trinidad, Colombia, Venezuela,

Guyana, Surinam, French Guiana, Haiti, Ecuador, Peru, Brazil, Bolivia, Paraguay, Argentina [12], Micronesia, India, Nepal [12], Oceania, USA (Hawaii), Tonga [25], Taiwan [5], and Venezuela [26].

**Specimens examined:** Anduck Valley: 121436 on *Distylium racemosum* (33°15'21.4" N, 126°21'16.8" E), 1,404 m elev., 18 Jun 2012; 121437 on *Machilus thunbergii* (33°15'21.4" N, 126°21'16.8" E), 123 m elev., 4 Jul 2012; Jeoji Gotjawal: 121315 on *Machilus japonica* (33°19'14.5" N, 126°17'09.7" E); Camellia Gardens: 121348 on *Machilus thunbergii* (33°30'59.9" N, 126°43'02.1" E), 96 m elev., 1 Jun 2012; 121482 on *Distylium racemosum* (33°31'00.5" N, 126°42'26.6" E); 121311 on *Machilus japonica* (33°30'47.3" N, 126°42'35.5" E), 121304 on *Gardneria insularis* (33°30'47.3" N, 126°42'35.5" E), 121327 on *Machilus japonica* (33°14'11.8" N, 126°33'38.7" E); Donneako Valley: 121294 on *Litsea japonica* (33°20'49.6" N, 126°32'47.1" E), 121295 on *Distylium racemosum* (33°20'49.6" N, 126°32'47.1" E), 1,404 m elev., 4 Jul 2012; Cheongsu Gotjawal: 121326 on *Ligustrum japonicum* (33°19'21.6" N, 126°15'48.4" E), 141 m elev., 4 Jul 2012; warm temperature forest: 121085-1 on *Machilus thunbergii* (33°26'04.5" N, 126°19'48.5" E), 96 m elev., 1 Jun 2012.

**Remarks:** *Strigula smaragdula* is very closely related to *S. macrocarpa*, both having a bright green thallus and rather large fusiform ascospores. Externally, latter species have a larger, thin thallus with immersed perithecia.

***Strigula subelegans*** Vain., Ann. Acad. Sci. Fenn., Ser. A, 19: 23 (1923).

Whitish green subcuticular thallus, 3~5 mm across (Fig. 2B) and 40~50  $\mu$ m thick, entire to lobulate margins. Perithecia semi-immersed, hemispherical, 0.3~0.8 mm diam., exposed part black., excipulum 8~10  $\mu$ m thick and light brown; ascospores fusiform, 1-septate, with distinct construction at septa, 20~27  $\times$  5~6  $\mu$ m. Pycnidia not observed.

**Chemistry:** Spot test reactions: thallus K-, C-, KC-, P-. Secondary metabolites: none detected.

**Ecology and distribution:** New to South Korea. Pantropical, but much more frequent in the eastern Paleotropics [12]. This species was found on the leaves of species of *Camellia japonica*, *Distylium racemosum*, *Gardneria acuta*, *Litsea japonica*, *Machilus japonica*, *M. thunbergii*, *Piper nigrum*, *Quercus acuta*, and *Q. salicina* in Anduck Valley, Jeoji Gotjawal, Camellia Gardens, Cheongsu Gotjawal, Donneako Valley, and warm temperate forests together with *S. macrocarpa* and *S. smaragdula*.

Other than South Korea, this species has been reported from Japan, Costa Rica, Panama, Puerto Rico, French Guiana, Peru, Brazil [12], China [27], Micronesia, Oceania, Samoa, Tonga [25], Indonesia, and the Philippines [12].

**Specimens examined:** Anduck Valley: 121436 on *Distylium racemosum* (33°15'21.4" N, 126°21'16.8" E), 33 m elev., 4 Jul 2012; 121437 on *Machilus thunbergii* (33°15'21.4" N, 126°21'16.8" E), 123 m elev., 4 Jul 2012; Jeoji Gotjawal: 121314, 121315 on *Machilus japonica* (33°19'14.5" N, 126°17'09.7" E); Camellia Gardens: 121348 on *Machilus*

*thunbergii* (33°30'59.9" N, 126°43'02.1" E), 96 m elev., 1 Jun 2012; 121482 on *Distylium racemosum* (33°31'00.5" N, 126°42'26.6" E), 231 m elev., 4 Jul 2012; 121308, 121311 on *Machilus japonica* (33°30'47.3" N, 126°42'35.5" E); Cheongsu Gotjawal: 121326 on *Distylium racemosum* (33°19'21.6" N, 126°15'48.4" E), 141 m elev., 4 Jul 2012; Donneako Valley: 121294 on *Litsea japonica* (33°20'49.6" N, 126°32'47.1" E), 121295 on *Distylium racemosum* (33°20'49.6" N, 126°32'47.1" E), 1,404 m elev., 18 Jun 2012.

### Key to the known foliicolous species of *Strigula* in South Korea

1. Thallus bluish to greenish white, strongly lobate, with numerous white papillae, involucrellum colorless ..... *S. nemathora*
  - 1a. Thallus of various colors; involucrellum black ..... 2
2. Ascospores breaking into halves within or outside asci, thallus thick, pale greenish to bluish grey, not bordered by a thin black line ..... *S. concreta*
  - 2a. Ascospores not breaking into halves within or outside asci ..... 3
3. Thallus very thin, dark green, bordered by a thin, black, interrupted and wavy line, macroconidia simple ..... *S. melanobapha*
  - 3a. Thallus thick, pale grey to bright green, not bordered by a thin, black line, macroconidia 1-septate ..... 4
4. Thallus pale greenish to bluish grey, perithecia half-immersed, uppermost part black ..... *S. subelegans*
  - 4a. Thallus bright green when living, whitish when dead 5
5. Perithecia 0.4–0.9 mm diam., prominent, ascospores uniseriate ..... *S. macrocarpa*
  - 5a. Perithecia 0.2–0.4 mm diam., erumpent, ascospores biseriata ..... *S. smaragdula*

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