

## Cephalodia found on *Fuscopannaria viridescens*

The genus *Fuscopannaria* (*Pannariaceae*) is characterized by small squamules, often with a black prothallus, a hemiamyloid hymenium, simple ascospores with a smooth episporium, and a tube structure in the ascus tip. Most species are cyanobacterial, but two green-algal species are known; *Fuscopannaria viridescens* M. Jørg & Zhurb. and *F. granulifera* M. Jørg. & Upreti. *Fuscopannaria viridescens* grows terricolously in arctic and alpine habitats in Alaska and Russia (Jørgensen & Zhurbenko 2002), whereas *F. granulifera* is known only from the type locality in India where it grows epiphytically near the tree line in the Himalaya (Jørgensen 2004). *Vahliella globuligera* (Fryday & M. Jørg.) M. Jørg., formerly in *Fuscopannaria*, is another squamulose, green-algal arctic species, distinguished from *F. viridescens* by its granular thallus and amyloid sheets instead of a tube/plug at the ascus apex.

*Fuscopannaria viridescens* has a distinctive habit, with plane, distal lobes that become upright and imbricate centrally (Fig. 1A), aptly likened to “cats-paws” (Jørgensen & Zhurbenko 2002), which is similar to the habit of well-developed *Baeomyces placophyllus* Ach. It is also the only green *Fuscopannaria* in North America, making it hard to mistake for other species, except possibly an overzealous *Psoroma*. The genus *Psoroma* has a dirty blackish blue hymenial amyloid reaction and ascospores with a textured episporium. Collections of *F. viridescens* made recently in the Denali and Gates of the Arctic National Parks and Preserves (Alaska, USA), possess minute, imbricate, darkened lobes (when wet) (Fig. 1E), which, upon further inspection, turned out to be cephalodia. We further studied this material to assess whether it could still be accommodated in *F. viridescens* s. lat., despite having cephalodia.

All specimens were studied using standard light microscopy. Ascum, ascospore and thallus measurements were made on material mounted in distilled water. Hymenial amyloid reactions were observed by staining

apothecia cross-sections with a 2% solution of iodine potassium iodide (IKI). Ascus tip structures were viewed by pretreating cross-sections with potassium hydroxide (K), flushing with distilled water and staining with IKI. Standard cortex and medullary spot test reactions were observed using a 10% aqueous solution of potassium hydroxide (K), para-phenylenediamine dissolved in ethanol (PD), sodium hypochlorite (C) and K followed by C (KC) administered to the thallus with a small pipette.

All our fertile specimens possessed simple ascospores,  $20\text{--}26 \times 7\text{--}10 \mu\text{m}$ , with a smooth episporium (Fig. 1G), a distinct dark blue ascus plug with an indistinct pale central tube, similar in appearance to a poorly developed *Porpidia*-type ascus (*Micarea*-type ascus tip of Spribille & Muggia 2013) (Fig. 1F), and a hemiamyloid reaction in the hymenium. The upper cortex was sometimes composed of a thin, clear, prosoplectenchymatous layer over a more frequent thick, clear paraplectenchymatous lower layer. The cephalodia contained *Nostoc* sp. embedded in a fungal matrix that formed furrows of the cyanobiont (Fig. 1B & C), giving the cephalodia a streaky appearance when viewed from above. All spot tests were negative.

The characteristics we observed in all our Alaskan material matched the descriptions of *F. viridescens* except for the presence of cephalodia and, to a lesser degree, the upper cortex structure and ascospore size. Jørgensen & Zhurbenko (2002) reported the upper cortex of *F. viridescens* to be sclerenchymatous (syn. prosoplectenchyma). This periclinally arranged hyphal layer was not as consistent in our material as the thick paraplectenchymatous layer below it, which Jørgensen & Zhurbenko (2002) did not report. We observed only the thick paraplectenchymatous cortex in the isotype, indicating the periclinally arranged hyphae mentioned by Jørgensen & Zhurbenko (2002) perhaps varies with environmental conditions or is more frequent in certain parts of the thallus. The isotype had ascospores  $12.5\text{--}20.0 \times 7.5\text{--}10.0 \mu\text{m}$  in size, consistent with the species description. However, the range of ascospore

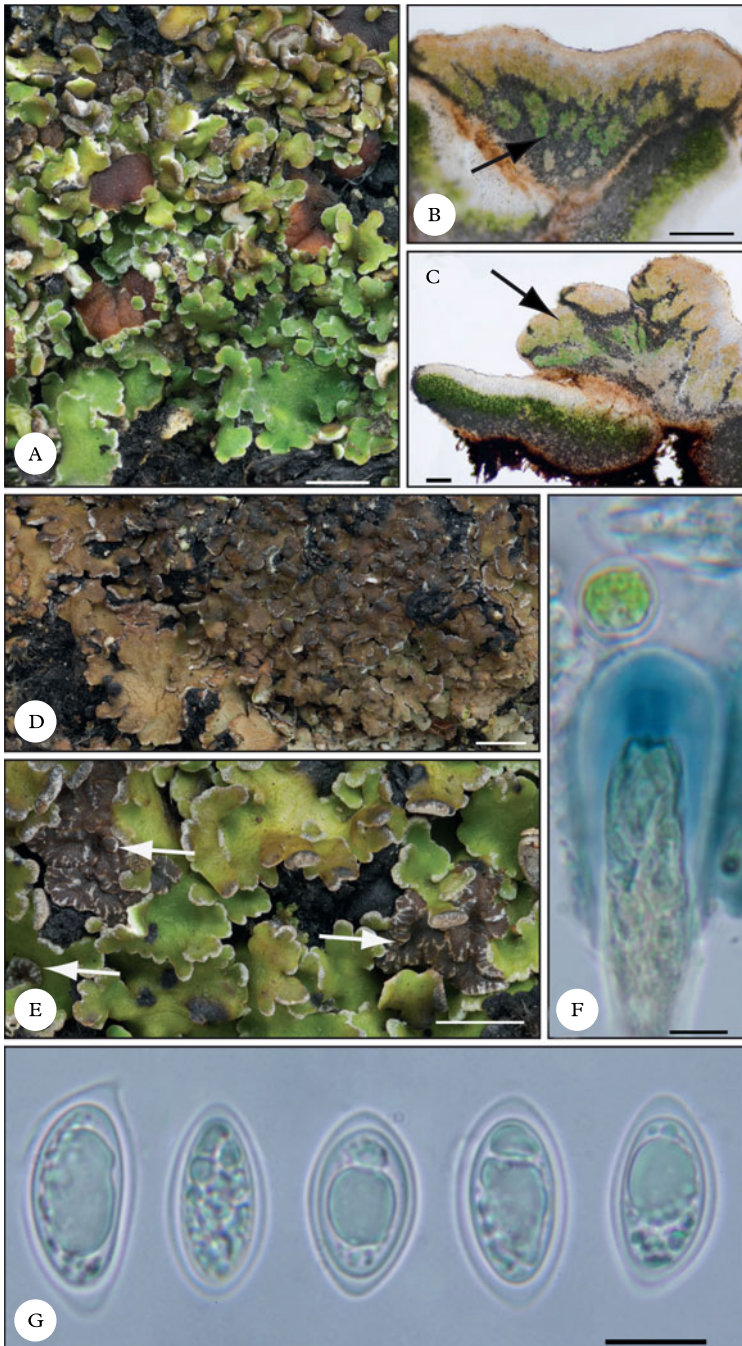


FIG. 1. *Fuscopannaria viridescens*. A, habit, wet, showing green colour and apothecia (*T. Wheeler 4721*); B, cross-section of, and arrow pointing to, centre of cephalodium (*T. Wheeler 4721*); C, cross-section of thallus and arrows pointing to cephalodium (*T. Wheeler 4721*); D, habit, dry, fully exposed brown form (*T. Wheeler 4215*); E, close-up showing cephalodia (arrows) (*T. Wheeler 4721*); F, ascus stain showing tube structure (*T. Wheeler 4721*); G, ascospores with smooth epispore (*T. Wheeler 4721*). Scales: A, D & E = 1 mm; B = 25  $\mu$ m; C = 100  $\mu$ m; F = 10  $\mu$ m.

length observed in our material was six microns longer (Jørgensen & Zhurbenko 2002). We believe our ascospore measurements to be within the range of variation for the species because collections of *F. viridescens* are often infertile specimens and the variation in ascospore dimensions is probably under-recorded. We also confirmed that the isotype had the same laminal cephalodia with *Nostoc* as the other specimens we examined. The cephalodia were most likely overlooked when this species was described because they are often similar in colour to the rest of the thallus, appearing as tiny, laminal, imbricate lobes (Fig. 1E). In the extreme environment where *F. viridescens* occurs, thallus colour can vary from pale green (Fig. 1A) to very dark brown (Fig. 1D), depending on exposure and hydration. We conclude that all of the tripartite *Fuscopannaria* material we examined is attributable to *F. viridescens*. To the best of our knowledge, this is the first case of a *Fuscopannaria* possessing cephalodia.

Our finding of cephalodia on one of only two green-algal species of *Fuscopannaria* is significant but not surprising. Many genera with cyanobacteria as their primary photobiont also have tripartite species (e.g. *Peltigera*, *Pseudocyphellaria*, *Nephroma*). Similarly, many tripartite species occur in *Pannaria*, *Psoroma* and *Degeliella*, primarily in the Southern Hemisphere, in the otherwise cyanobacterial *Pannariaceae*. In North America, the only tripartite species of the *Pannariaceae* other than *Fuscopannaria viridescens* are species of *Psoroma*. However, we were unable to find any species in the *Pannariaceae* worldwide with only a green-algal photobiont, other than *F. granulifera*. This leads us to suspect that *F. granulifera*, like *F. viridescens*, proba-

bly has cephalodia that were overlooked, or it belongs to a different family where green-algal species occur. Pending examination of *F. granulifera*, our finding implies that the entire *Pannariaceae* always has either a primary or secondary cyanobacterial photobiont.

*Specimens examined.* **USA:** Alaska: Denali National Park & Preserve, Primrose Ridge, 63°45'12.92"N, 149°23'08.53"W, alt. 1430 m, *J. Walton* 6069 (ALA); Gates of the Arctic National Park & Preserve, Summit Lake, 68°04'51.68"N, 150°28'29.07"W, alt. 1230 m, *T. Wheeler* 4215 (hb. Wheeler); Kurupa Lake, 68°20'46.56"N, 154°30'29.72"W, alt. 1330 m, *P. R. Nelson* 12-1181 (OSC); Narvak Lake, 66°53'58.02"N, 155°34'17.28"W, alt. 1025 m, *P. R. Nelson* 12-523 (OSC); Upper Nigu River, 67°57'03.99"N, 155°23'26.68"W, alt. 850 m, *T. Wheeler* 4721 (hb. Wheeler); North Slope Borough, Barrow, 79°19'N, 156°36'10"W, alt. 1 m, *A. Fryday* 8234 (MSC); Kobuk Valley National Park, Kobuk River, alt. c. 30 m, *M. Zhurbenko* 00352 (BG—isotype!).

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