Article

Lichen genus *Porina* in Vietnam

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Abstract: An identification key to twenty-nine species of *Porina* known from the country is provided. In addition, new records of *Porina interstes*, *P. nuculastrum*, and *P. rhaphidiophora* are described from the protected rain forests in southern Vietnam. A detailed taxonomic account of each species is provided and supported by its ecology, distribution, and illustrations.

Keywords: corticolous; Dong Nai; Nam Cat Tian National Park; Porinaceae; taxonomy

1. Introduction

The cosmopolitan genus, *Porina* (*Porinaceae*: *Ostropales*), with more than 320 species worldwide, is most diverse in rather shaded habitats of tropical and subtropical regions [1–9]. The tropical climate of Vietnam is supported by prolonged humid conditions because of the large coastline surrounded by the South China Sea in the east and the Pacific Ocean in the south. These conditions are favorable to the growth of *Porina* on a range of substrates in tropical rainforests, seasonal forests, and wet lands in the country. The present study on this genus is a continuation of previous studies [10–15], and was conducted in Nam Cat Tien National Park (Figure 1). The national park includes one of the largest areas of lowland tropical rainforests in southern Vietnam and is comprised mainly of *Dipterocarpus alatus*, *D. intricatus*, *Dalbergia alata*, *D. mammosa*, *Afzelia xylocarpa*, *Pterocarpus macrocarpus*, *Lagerstroemia calyculata*, *Tetrameles nudiflora*, *Anogeissus acuminata*, *Bambusa procera* and *Gigantochloa* sp.

The checklist and preceding works on Vietnamese lichens reflect the great diversity of foliicolous species of *Porina* in the country (ca. 25 species), while a few were also reported on rock and bark [16,17]. Two species stated in the earlier account have now been accommodated in the genus *Strigula* as *S. phyllogena* (Müll. Arg.) R. C. Harris (=*Porina phyllogena* Müll. Arg.) and *S. platypoda* (Müll. Arg.) R. C. Harris (=*Porina platypoda* Müll. Arg.), whereas the previous report of *Porina consanguinea* Müll. Arg. from the country was uncertain in subsequent studies [16]; hence, it was not included in the current account.

The salient taxonomic features of *Porina* species are mostly shiny (corticate or ecorticate) thallus in different shades of greenish grey to olivaceous grey, containing algae either *Trentepohlia* (for bark and rock inhabiting species) or *Phycopeltis* (for leaf inhabiting species); perithecia present on thallus or immersed in thallus-dominated verrucae [Harada [6] proposed the term 'prominent thalloid exciple' replacing the 'thallus-dominated verrucae', applied previously to categorize the perithecial morphology by McCarthy [1]]; pale brown to reddish brown or black, vestigial to well-developed involucrellum and hyaline, transversely three or more septate to muriform ascospores [1]. The genus is usually devoid of chemical compounds, but some species can give a K+ reddish or yellowish reaction on the thallus or on the fruiting bodies.

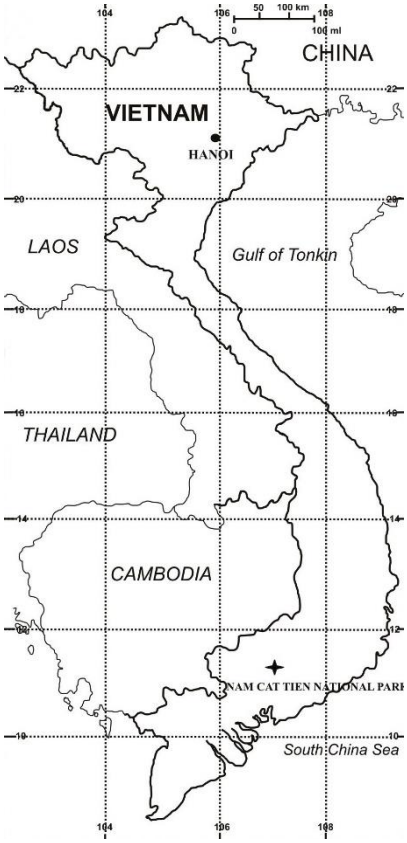

Figure 1. Map of Vietnam showing the study area (Nam Cat Tien National Park).

2. Materials and Methods

The study is based on collections made by one of the authors (JSH) from the three provinces (Dong Nai, Lam Dong and Binh Phuoc) that circumscribed the national park in December 2015. The field trip was organized by Dr. Nguyen Thi Thanh at Tay Nguyen University, Vietnam. The trip was conducted in the frame of internal joint program between Korea and Vietnam, supported by Korea National Research Foundation. The field studies did not involve any endangered or protected species. The material was preserved in the herbarium of the Korea National Arboretum, Korea (KH). The material was made available for taxonomic treatment in the Lichenology laboratory of CSIR-National Botanical Research Institute, Lucknow, India. The standard protocols were followed for identification. The morphological and anatomical characters were studied using a Leica S8APO stereo-zoom microscope and Leica DM500 compound microscope, respectively. Thin, hand-cut sections (10–15 sections) of perithecia, initially mounted in water, were studied for a range of structures and measurements. Cotton blue, 5% KOH and Lugol's iodine solution were used wherever required. Thin layer chromatography was performed in solvent system A according to the report by Orange et al. [18]. Illustrations were prepared using Corel Draw (ver. 12).

3. Results and Discussion

Porina interstes (Nyl.) Harm., Bull. Séanc. Soc. Sci. Nancy, sér. 3 12: 126. 1911. Figure 2(A–C)

Thallus epiperidermal, greenish grey to pale greenish grey, smooth to slightly verruculose, ± glossy, delimited by brownish black prothallus, 50–100 µm thick, ecorticate; algal layer *Trentepohlioid*, 20–50 µm thick, medulla white, crystalline, ≤50 µm thick; ascomata perithecioid, emergent, subglobose, 0.2–0.3 mm in diam.; ostiole pale brown 0.03–0.05 mm in diam.; involucrellum covered completely by a prominent thalloid exciple, brownish; proper exciple hyaline to pale brown, 15–20 µm thick; centrum clear, 0.2–0.4 mm wide; asci 8-spored, 120–150 × 20–25 µm; ascospores hyaline, fusiform, transversely 7-septate, 40–57 × 7–9 µm, perispore lacking.

Chemistry: No lichen substances detected by thin layer chromatography.

Known distribution: In Vietnam, this species was found growing on tree twigs and most commonly associated with *P. internigrans* in the wet tropical complex of the national park. Species are also found in New Guinea, Caledonia and South Asia (India) [19].

Material examined: Vietnam, Dong Nai Province, Tan Phu district, Nam Cat Tien National Park, 11°26′37″N 107°24′56″E, alt. 148 m on bark, 19 December 2015, Hur & Woo VN150369 (KH).

Notes: The Vietnamese specimen closely matches the original description of *Porina interstes*, except that the examined sample has slightly larger ascospores, which were measured to be 34–46 × 4–7 μm in the first description provided by Nylander as *Verrucaria interstes* Nyl. in 1873. Upreti [19] recorded the same species with ascospores measuring 32–48 × 4–7 μm. *Porina internigrans* (Nyl.) Müll. Arg. is comparable but produces 11–14 μm wide ascospores with (7–)9–11(–13)-septation [1].

Porina meridionalis P. M. McCarthy, Nova Hedwigia 58: 397. 1994. Figure 2(D–E)

Thallus epiperidermal, pale greenish grey, smooth, matt, continuous in large patches of ≤10 cm, flaking away from the bark in the middle part, delimited by brownish black prothallus, ecorticate, 50–70 μm thick; algal layer *Trentepohlioid*, 20–40 μm thick; medulla not apparent; ascomata perithecioid, semi-immersed to slightly emergent, hemispherical to subglobose, 0.1–0.3 mm in diam.; ostiole black, 0.01–0.03 mm in diam.; involucrellum dimidiate, covered mostly by a prominent thalloid exciple, 60–70 μm thick; proper exciple hyaline to pale brown, 20–30 μm thick; centrum clear, 0.25–0.27 mm thick; asci 8-spored, 90–130 × 10–17 μm; ascospores hyaline, elongate fusiform to subacicular, transversely 10–14-septate, 25–52 × 5–8 μm, perispore absent.

Chemistry: No lichen substances detected by thin layer chromatography.

Known distribution: This species appears to grow luxuriantly in large patches near coastal areas or mangroves in Vietnam and are collected from the thick and smooth trunk of trees in the protected forests of the park. The species was previously described in Tasmania [1].

Material examined: Vietnam, Dong Nai Province, Tan Phu district, Nam Cat Tien National Park, 11°27′27″N 107°22′11″E, alt. 174 m, on bark, 19 February 2015, Hur & Woo VN150389 (KH).

Notes: This species is distinct in producing elongate fusiform transversely 11–17(–21)-septate ascospores usually broader towards the distal end. McCarthy [1] reported the species with an inconspicuous ostiolar region, which is slightly conspicuous (0.01–0.03 mm in diam.) in this specimen. Although such minor variations may be acceptable within the broad concept of species delimitation, more collection is needed to observe the actual variations between the Vietnamese sample and the only report of this species from Tasmania. The Vietnamese sample is close to *Porina rhaphidiophora* (Nyl.) Müll. Arg., which differs mainly in the size of the perithecia and ascospores [1].

Porina nuculastrum (Müll. Arg.) R. C. Harris, More Florida Lichens: 74. 1995. Figure 2(F–G)

Thallus epiperidermal, pale grey, smooth to verruculose due to emerging ascomata, glossy, continuous with black prothallus, <100 μm thick; cortex 5–10 μm thick; algal layer *Trentepohlioid*, 10–20 μm thick; medulla white, crystalline, <60 μm thick; ascomata perithecioid, scattered, distinctly emergent, convex to subglobose, 0.3–0.5 mm in diam., ostiole pale brown to dark brown, 0.1–0.3 mm; involucrellum apical to dimidiate, pale brown, covered completely by a prominent thalloid exciple; proper exciple hyaline to yellowish brown, 25–30 μm thick; centrum clear, 0.3–0.5 mm wide; asci 8-spored, 200–250 × 30–35 μm; ascospores narrowly to broadly fusiform, muriform (12–15 transverse septa and 1–3 longitudinal septa), 50–76 × 12–20 μm, perispore 2–3 μm thick.

Chemistry: No lichen substances detected by thin layer chromatography.

Known distribution: This species was found growing in small and irregular patches on rough barked trees of the protected rainforests in Vietnam. The species has a common occurrence on tree bark as well as on rocks. Worldwide, it is distributed in the Neotropics, Madagascar, the Philippines, Hong Kong and neighboring countries [1].

Material examined: Vietnam, Dong Nai Province, Tan Phu district, Nam Cat Tien National Park, 11°26′35″N 107°24′19″E, alt. 150 m on bark, 18 December 2015, Hur & Woo VN150198 (KH).

Notes: The species with muriform ascospores was assigned previously to the genus *Clathroporina* Müll. Arg. but later following the conservative concept outlined by Santesson [20] and McCarthy & Malcolm [21]; Lücking & Vězda [22] included them in *Porina*. McCarthy [1] described this species

with an inconspicuous ostiolar region. In contrast to the Australian specimens with an inconspicuous ostiole, the Vietnamese sample contains perithecia with a rather conspicuous ostiolar region. The ostiole conspicuity in the present sample may be the result of over maturity because only a single specimen from Vietnam was observed.

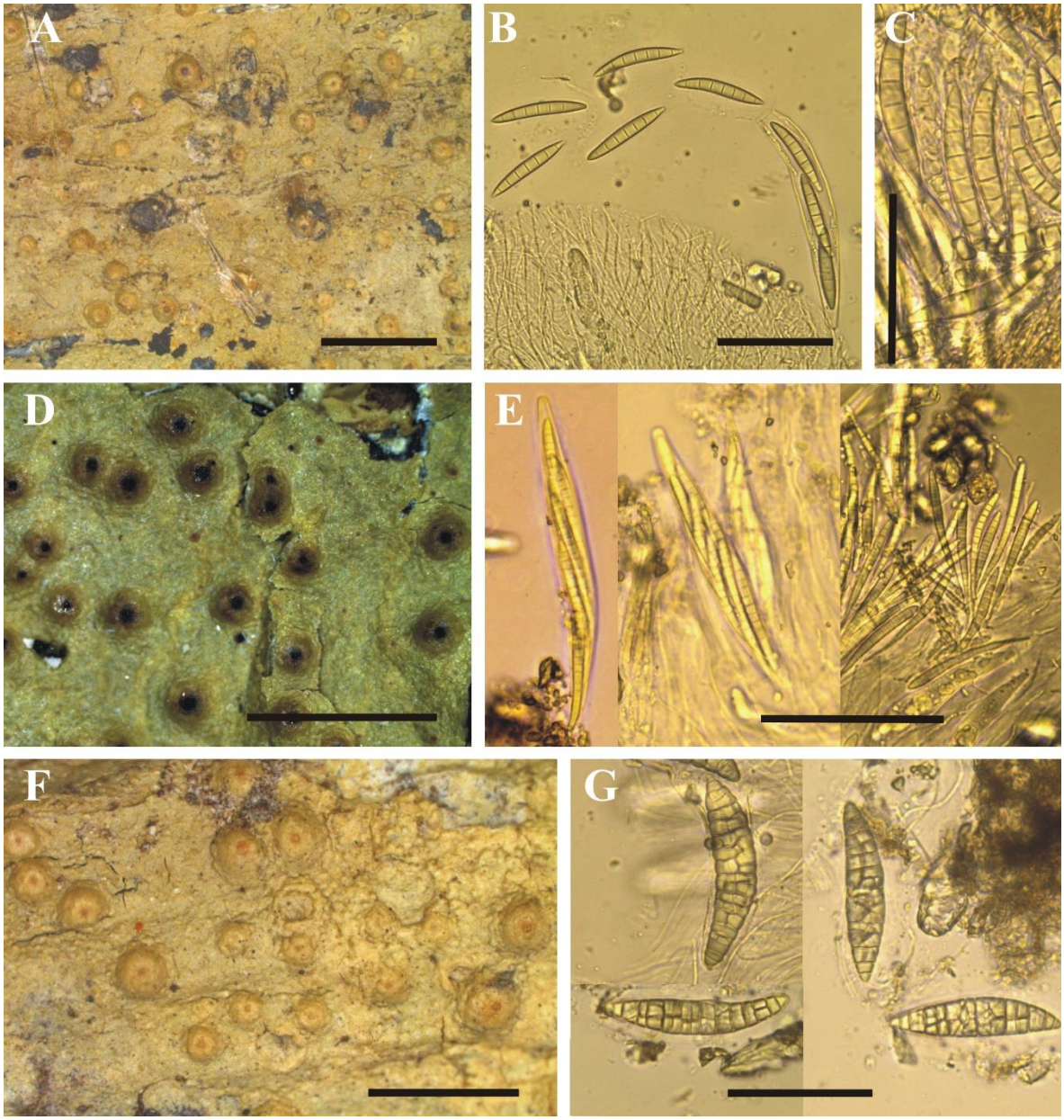

Figure 2. New records from Vietnam. A–C. *Porina interstes*. A. habitus; B & C. ascospores; D & E. *P. meridionalis*; D. habitus; E. asci and ascospores; F & G. *P. nuculastrum*; F. habitus; G. ascospores. Scale bars: A, D, F = 1 mm; B, C, E, G = 50 μm.

Key to *Porina* species recorded from Vietnam

The taxonomic key characters of twenty-nine species are discussed. The previously known taxa were characterized following the descriptions provided by Upreti [19], Lücking & Vězda [22], McCarthy [1] and Harada [6], and presented below with some modifications.

1. Thallus foliicolous; algae *Trentepohlia* or *Phycopeltis* 2

-Thallus corticolous or saxicolous; algae *Trentepohlia* 23

2. Algae *Trentepohlia*; prothallus broad bluish black to grey black 3

-Algae *Phycopeltis*; prothallus if present translucent or whitish; thallus fertile 4

3. Thallus sterile, isidiate; isidia abundant, cylindrical to coralloid ..... ***Porina distans***
- Thallus fertile; perithecia applanate, large, 0.6–1 mm in diam.; ascospores broadly fusiform, transversely 7(–9)-septate, 38–64 × 6.5–10 µm ..... ***Porina imitatrix***
4. Perithecia immersed in thallus-dominated verrucae (thalloid exciple), mainly pale grey green, pale yellowish green or pale greyish brown 5
- Perithecia ± superficial, yellowish white, in shades of brown or black, not immersed in thallus dominated verrucae (thalloid exciple) 11
5. Ascospores 3-septate, 12–18 × 2–3.5 µm; perithecia 0.15–0.2 mm in diam. ..... ***Porina albicera***
- Ascospores 7- or more septate 6
6. Thallus and perithecia furnished with dense cushions of soft hairs; perithecia convex to hemispherical; ascospores 7–15-septate, 45–74 × 4–7 µm ..... ***Porina virescens***
- Thallus and perithecia glabrous; perithecia variously shaped; ascospores exclusively 7-septate (with a few exceptions), mostly less than 50 µm long 7
7. Perithecia subconical to conical; apex with a short flat-topped cylindrical extension; ascospores 28–46 × 3–5 µm ..... ***Porina conica***
- Perithecia lens-shaped, hemispherical, or wart-shaped; if conical then apex lacking short flat-topped extension 8
8. Perithecia applanately lens-shaped; thallus with whitish short-stalked deeply concave disciform isidia, 0.1(–0.15) mm in diam.; ascospores (35–)40–45 × 3–4.5 µm ..... ***Porina mirabilis***
- Perithecia lens-shaped to hemispherical; thallus lacking isidia 9
9. Perithecia lens-shaped, 0.2–0.35(–0.4) mm in diam., with a blackish apical spot or a brownish apical cap; ascospores 20–35 × 3–5 µm ..... ***Porina atriceps***
- Perithecia hemispherical, concolorous or pale reddish brown at apices 10
10. Perithecia 0.2–0.3 mm in diam.; phycobiont cell rectangular, arranged in radiating rows; ascospores 21–27 × 3 µm ..... ***Porina epiphylloides***
- Perithecia 0.25–0.4(–0.5) mm in diam.; phycobiont cells round to angular, irregularly arranged; ascospores 25–35 × 3–4.5 µm ..... ***Porina epiphylla***
11. Perithecia very small, 0.08–0.1 mm in diam., yellowish white; ascospores bacillar, 1-septate, 10–12 × 2–2.2 µm ..... ***Porina diaphana***
- Perithecia comparatively larger 12
12. Perithecia in shades of brown; involucrellum often containing algae 13
- Perithecia ± black; involucrellum not or rarely containing algae 16
13. Perithecia finely and sparsely furnished with cushions of soft hairs, 0.2–0.26 mm; ascospores 7-septate, 25–33 × 3–5 µm ..... ***Porina octomera***
- Perithecia not pilose; ascospores 3-septate 14
14. Perithecia subglobose, 0.17–0.26 mm in diam., constricted at the base; sides often with a slightly rough covering of thallus material; ascospores 17–26 × 3–6 µm ..... ***Porina semecarpi***
- Perithecia convex to subconical 15
15. Perithecia 0.2–0.4 mm in diam.; ascospores 18–28 × 2.5–4.5 µm ..... ***Porina limbulata***
- Perithecia 0.13–0.21 mm in diam.; ascospores 13–21 × 2–3 µm ..... ***Porina rubentior***
16. Ascospores muriform, 85–110 × 17–22 µm; perithecia 0.35–0.50 mm in diam. ... ***Porina foliicola***
- Ascospores transversely 3- or more septate 17
17. Ascospores 3-septate, 15–24 × 3–4.5 µm; perithecia applanate towards the margins, but usually with a conical to hemispherical centre, 0.2–0.41 mm in diam. ..... ***Porina chrysophora***

- Ascospores more than 3-septate 18
18. Perithecia convex to hemispherical; base usually spreading 19
- Perithecia subglobose to globose and attenuated at the base 22
19. Perithecia overgrown almost to the apex by a thin layer of thallus; ascospores 5(–7)-septate, 20–32 × 4–5 µm ..... ***Porina corruscans***
- Perithecia not overgrown by the thallus; ascospores 5- or more septate 20
20. Ascospores 5-septate, 15–30 × 5–7 µm ..... ***Porina subnitidula***
- Ascospores (5–)7-septate 21
21. Ascospores (5–)7-septate, 20–23 × 3–4 µm ..... ***Porina cupreola***
- Ascospores 7-septate, 20–35 × 3–5 µm ..... ***Porina karnatakensis***
22. Perithecia 0.14–0.25 mm in diam.; sometimes greyish tomentose, ascospores 5-septate, 20–32 × 3.5–6 µm ..... ***Porina nitidula***
- Perithecia 0.16–0.31 mm in diam.; ascospores mostly 7-septate, 22–42 × 3.5–7 µm ..... ***Porina atrocoerulea***
23. Thallus saxicolous; perithecia hemispherical to subglobose, black, 0.23–0.48 mm in diam.; involucrellum uniformly black lacking algal cells; ascospores (3–)5–7(–9)-septate, 22–49 × 3.5–6.5 µm ..... ***Porina guentheri***
- Thallus corticolous 24
24. Ascospores muriform, 50–76 × 12–20 µm; perithecia convex to subglobose, brown to dark brown, 0.3–0.5 mm in diam. ..... ***Porina nuculastrum***
- Ascospores transversely septate 25
25. Ascospores elongate fusiform to subacicular, 10–14-septate, 25–52 × 5–84 µm; perithecia hemispherical to subglobose, 0.1–0.3 mm in diam. ..... ***Porina meridionalis***
- Ascospores fusiform 26
26. Ascospores (7–)9–11(–13)-septate, 51–92 × 9–17 µm ..... ***Porina internigrans***
- Ascospores consistently 7-septate 27
27. Perithecia subglobose, 0.2–0.3 mm in diam.; ascospores 40–57 × 7–9 µm ..... ***Porina interstes***
- Perithecia convex to hemispherical, ≥0.3 mm in diam. 28
28. Perithecia 0.3–0.6 mm in diam.; ascospores 34–42 × 4–7 µm ..... ***Porina tetracerae***
- Perithecia 0.3–0.9 mm in diam.; ascospores 20–23 × 3–4 µm ..... ***Porina mastoidea***

Acknowledgments: This study was supported by a grant from the National Research Foundation of Korea (NRF-2015K2A1B7A01069080) and the Korea National Research Resource Center Program (NRF-2017M3A9B8069471). SJ thanks Director, CSIR-National Botanical Research Institute, Lucknow, India for providing laboratory facilities.

Conflicts of Interest: The authors declare no conflict of interest.

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