

Chimeras occur on the pantropical Lichinomycete *Phyllopettula corticola*

André APTROOT and Felix SCHUMM

Abstract: Chimeras with green algae are reported for the first time from a lichen outside the *Peltigerales*, viz. the cyanophilous Lichinomycete *Phyllopettula corticola*. The species is reported here to be pantropical, based on additional collections from Hawaii, Puerto Rico, Thailand and the Philippines.

Introduction

Phyllopettula Kalb, a genus in the Lichinomycetes, comprises two species. The type species, *Phyllopettula corticola* (Büdel & R. Sant.) Kalb, was originally described from a single locality in Kenya as *Peltula corticola* Büdel & R. Sant. (in Büdel 1987). It has since been reported from the Seychelles (Seaward & Aptroot 2006), Aldabra (Seaward & Aptroot 2009), Namibia, Yemen, California (Büdel *et al.* 2007) and Taiwan, where it is rather common (Aptroot & Sparrius 2003). The other species, *P. steppae* Kalb, is known only from two collections from South America (Kalb 2001).

Both *Phyllopettula* species occur on exposed, dusty trees, except in Taiwan, where *P. corticola* was mostly found on dry rock. During our collecting trips we found the type species mostly in the lowlands (below 40 m alt. except in Taiwan, where it was once found at 700 m alt.), generally in coastal areas, but in countries as far apart as Hawaii, Puerto Rico, Taiwan, Thailand and the Philippines. Together with the known records from Africa, this shows that *Phyllopettula corticola* is pantropical. When found, it is usually quite abundant and covers most of a tree trunk (or rock face) and may quite often be found even in cities on roadside

trees, such as in Honolulu and in San Juan. The species is probably generally overlooked or mistaken, for *Phaeophyscia* species, which have a somewhat similar colour and lobe configuration, but which differ by the presence of rhizines and green algae instead of cyanobacteria.

In one locality in the Philippines, part of the material bears a multitude of peculiar, simple or branched dorsiventral lobes with an internal structure similar to normal *Phyllopettula corticola*, but differing markedly by soredia being formed all over the lower surface of the lobes rather than in lip-shaped soralia and by the marked papillose cells of the lower cortex, but especially by the presence of green algae instead of cyanobacteria. Virtually all specimens of *Phyllopettula corticola* on one tree bear one or more (up to many dozens per specimen) of such lobes. In total, many thousands of such folioles have been collected and many more have been left undisturbed. Significantly, these lobes are found only on specimens of *Phyllopettula corticola*, not directly on the bark or on other lichens.

Material and Methods

Identification and descriptive work was carried out in Soest using an Olympus SZX7 stereomicroscope and an Olympus BX50 compound microscope with interference contrast, connected to a Nikon Coolpix digital camera and in Wangen using a Wild A. M3 stereomicroscope, a PZO Biolar compound microscope with interference contrast, a Canon EOS 40D camera with MP-E 65 mm and a Mic HM 560 cryotome. The materials are preserved in ABL, BM, F, and hb. Schumm.

A. Aptroot: ABL Herbarium, Gerrit van der Veenstraat 107, NL-3762 XK Soest, The Netherlands. Email: andreaptroot@gmail.com

F. Schumm: Mozartstrasse 9, D-73117 Wangen, Germany.

Selected specimens studied. *Phyllopettula corticola*. **Hawaii:** Oahu: Honolulu, Waikiki beach, 1989, A. & M. Aptroot 26258 (ABL).—**Puerto Rico:** San Juan, Punta Piedrita, May 1989, A. & M. Aptroot 24901 (ABL); Ponce, Reserva forestal de Guanica, May 1989, A. & M. Aptroot 25815 (ABL).—**Seychelles:** Bird Islands, 4 iv 2001, J. Gerlach (ABL, BM).—**Aldabra:** Bassin Flamant, 1973, R. J. Hnatiuk (BM).—**Taiwan:** Kaohsiung County: Kaohsiung, Tsaishan, 2001, Aptroot 53033 (F). Pingtung County: Kenting, near Frog Rock, 2001, Aptroot 53340 (F). Taichung County: 30 km E of Taichung, 5 km W of Kukwan, 2001, Aptroot 53530 (F). Taipei County: 25 km N of Taipei, near Sanji, 2001, Aptroot 53600 (F).—**Thailand:** Kanchanaburi, 2002, F. Schumm 9527 (ABL, hb. Schumm).—**Philippines:** Negros: Negros Oriental, Dumaguete, 2000, F. Schumm 7349 & Schwarz (ABL, hb. Schumm).

Phyllopettula steppae. **Venezuela:** Lara, Torres, 35 km E of Barquisimeto, 1989, K. & A. Kalb, distributed in Kalb, *Lichenes Neotropici* no. 469 sub *Physcia crisa* (ABL—*isotype*).

Description of the green algal parts

Lobes containing green algae originating from thalli of *Phyllopettula corticola* containing cyanobacteria, are usually situated on the soredia. Lobes (Fig. 1A & C) grey, dorsiventrally applanate, simple to repeatedly dichotomously to flabellately branched, 0.2–0.4 mm wide, up to 2 mm long, usually slightly curved downward, on the lower surface and on the tips with granular soredia of *c.* 20–40 µm diam. Soredia (fig 1E) originating on lower surface mostly green, those originating on lobe tips grey, cells with papillae. Upper cortex dull, smooth, paraplectenchymatous, not deviating from cyanobacteria-containing *Phyllopettula corticola* (Fig. 1D). Medulla (Fig. 1B) with green algae with cells *c.* 5 µm diam. Lower cortex dull, paraplectenchymatous, cells *c.* 5 µm diam., strongly papillose (Fig. 1E). Papillae on lower cortex and on soredia hemispherical, *c.* 1 µm wide and high, with up to 30 papillae per cell.

Discussion

Given the similarity in upper cortex structure between *Phyllopettula corticola* and the folioles, and the strict association of the two elements, we have no doubt that the folioles

represent another manifestation of the same lichen. Such photosymbiodemes, where cyanobacterium-containing species bear folioles with green algae, have been called chimeras and have so far been reported from only a few genera in the *Peltigerales* in the Lecanoromycetes (James & Henssen 1976; Armaleo & Clerc 1991). In the inverse cases, where green algae-containing lichens bear structures with cyanobacteria, the structures (which can be foliole-shaped or not) are called cephalodia or sometimes also chimeras in a wider sense. They are more common than chimeras with green algae and known from various lichen orders (James & Henssen 1976), though so far equally unknown from the Lichinomycetes. The genus *Euopsis*, which is only doubtfully classified in the *Lichinales*, is the only known possible member of this order that can contain cyanobacteria and algae simultaneously. However, its thallus is crustose and the sections containing algae are not morphologically recognizable. As *Phyllopettula* belongs to the *Peltulaceae* (Kalb 2001), which is classified in the *Lichinales* in the Lichinomycetes, a lichen group unrelated to the *Peltigerales* or even the Lecanoromycetes, this implies the first observation of chimeras in a totally unrelated group. The classification of at least the type species of *Phyllopettula* in the *Peltulaceae* has been confirmed with molecular methods (Rauhut 2006); it even clusters within the genus *Peltula*.

Strongly papillose cells are rare in lichenized ascomycetes (and unknown in non-lichenized ascomycetes). They occur only in the *Verrucariaceae* genus *Agonimia* Zahlbr. (including the synonymous genera *Agonimiella* H. Harada and *Flakea* O. Erikss., see Aptroot *et al.* 1997) and in the only doubtfully different genus *Psoroglaena* Müll. Arg. (see Lücking 2008). Virtually indistinguishable but markedly larger structures occur in the monospecific lichenized basidiomycete *Acantholichen* P. M. Jørg. (Jørgensen 1998).

Harrie Sipman is warmly thanked for a discussion of the species and a valued second opinion on the specimen with chimeras.

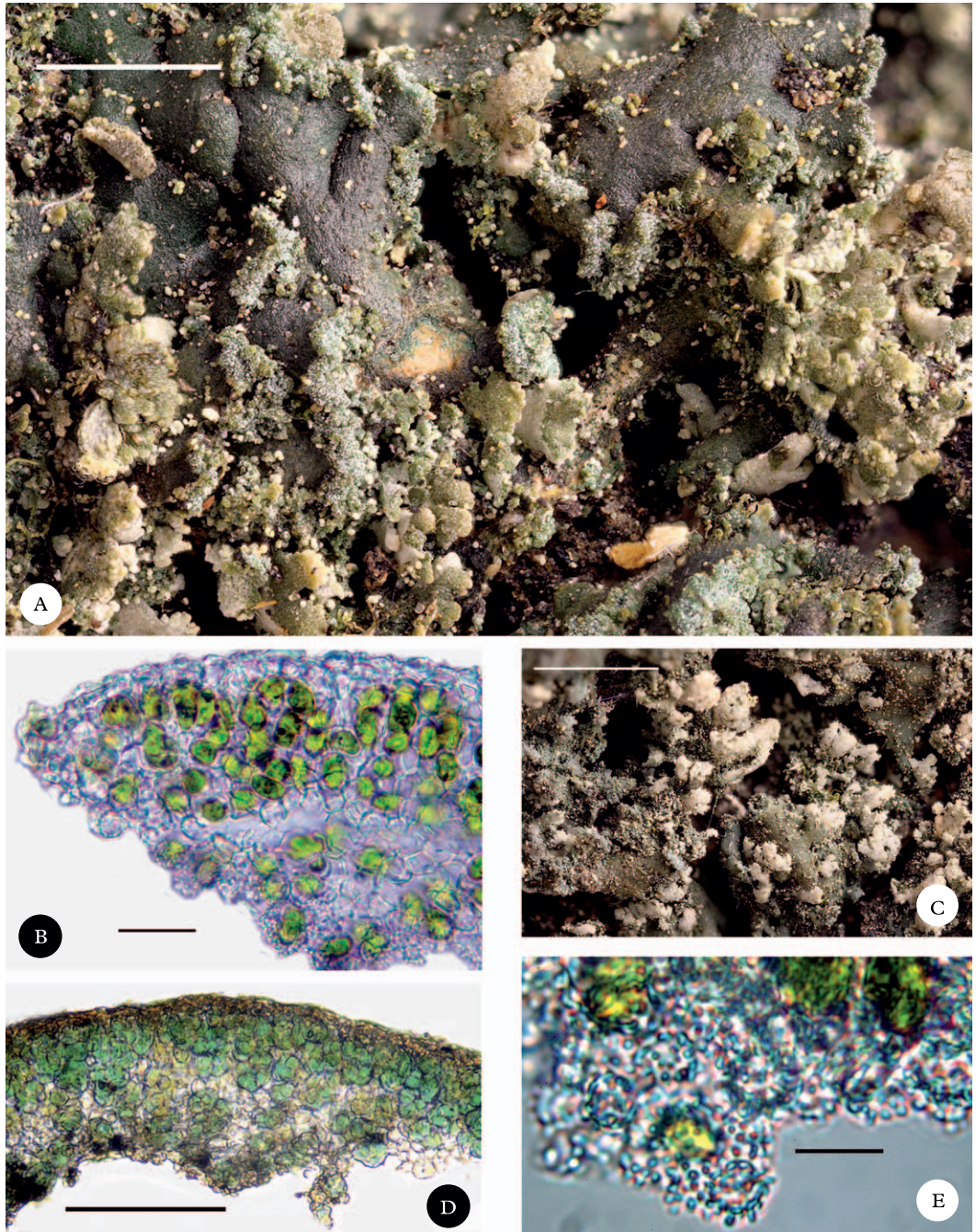


FIG. 1. *Phyllopetula corticola* with chimeras (Schumm 7349 & Schwarz). A & C, habitus; B, section through chimera; D, section through cyanobacteria-containing thallus; E, soredia with green algae and papillose cells. Scales: A = 1 mm; B = 20 µm; C = 2 mm; D = 100 µm; E = 10 µm.

REFERENCES

- Aptroot, A. & Sparrius, L. B. (2003) New microlichens from Taiwan. *Fungal Diversity* **14**: 1–50.
- Aptroot, A., Diederich, P., Sérusiaux, E. & Sipman, H. J. M. (1997) Lichens and lichenicolous fungi from New Guinea. *Bibliotheca Lichenologica* **64**: 1–220.
- Armaleo, D. & Clerc, P. (1991) Lichen chimeras: DNA analysis suggests that one fungus forms two morphotypes. *Experimental Mycology* **15**: 1–10.
- Büdel, B. (1987) Zur Biologie und Systematik der Flechtengattungen *Heppia* und *Peltula* im südlichen Afrika. *Bibliotheca Lichenologica* **23**: 1–105.
- Büdel, B., Rauhut, A. & Schulz, M. (2007) *Peltula*. In *Lichen Flora of the Greater Sonoran Desert Region. Volume III*. (T. H. Nash, C. Gries & F. Bungartz, eds): 388–389. Tempe: Lichens Unlimited.
- James, P. W. & Henssen, A. (1976) The morphological and taxonomic significance of cephalodia. In *Lichenology: Progress and Problems*. (D. H. Brown, D. L. Hawksworth & R. H. Bailey, eds): 27–77. London: Academic Press.
- Jørgensen, P. M. (1998) *Acantholichen pannarioides*, a new basidiolichen from South America. *Bryologist* **101**: 444–447.
- Kalb, K. (2001) New or otherwise interesting lichens. I. *Bibliotheca Lichenologica* **78**: 141–167.
- Lücking, R. (2008) Foliicolous lichenized fungi. *Flora Neotropica* **103**: 1–866.
- Rauhut, A. C. (2006) *Molekulare Phylogenie der Flechtensfamilie Peltulaceae (Lichinales, Ascomycota)*. Ph.D. thesis, University of Kaiserslautern (http://kluedo.ub.uni-kl.de/volltexte/2007/2090/pdf/Dissertation_Rauhut_2007.pdf).
- Seaward, M. R. D. & Aptroot, A. (2006) A preliminary checklist of lichens for the Seychelles group. *Journal of the Hattori Botanical Laboratory* **100**: 755–781.
- Seaward, M. R. D. & Aptroot, A. (2009) Checklist of lichens for the Seychelles group. *Bibliotheca Lichenologica* **99**: 335–366.

Accepted for publication 05 August 2009