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Nyungwea, a new genus of lichen with goniocyst-producing stipes from Rwanda and Uganda (East Africa)

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Abstract: The new genus and species *Nyungwea pallida* is characterized by a thin thallus lichenized with *Trentepohlia* and pale stipes producing goniocysts. Its taxonomic position is uncertain. It is named after the large pristine montane forest of Nyungwe in Rwanda (East Africa) where it was first found; it is also known from the Mabira forest in Uganda.

Key words: consoredia, goniocystangia, Mabira forest, Nyungwe forest

Introduction

Investigations of the lichen collections gathered during recent field trips to the Nyungwe forest in Rwanda and to the Mabira forest in Uganda yielded fascinating specimens with a thin, pale to deep green thallus with *Trentepohlia* and pale stipes producing goniocysts. The combination of such features is so far unknown in lichenized fungi and we have decided to erect a new genus for it. It is formally described in this paper.

Materials and Methods

The material was examined in tap-water or in lacto-phenol cotton-blue (LCB). The measurements always refer to water mounts. Air-dried herbarium material for study by SEM was mounted on polished aluminium stubs using a transparent two-component epoxy glue, gold-coated in a Balzers Union SCD 040 sputter and examined in a Cambridge Stereoscan S 200 scanning electron microscope.

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Results

Nyungwea pallida Sérus., Eb. Fischer & Killmann gen. et sp. nov.

Ab omnibus speciebus generum cum *Trentepohlia* stipitibus pallidis goniocystophoris differt.

Typus: Rwanda, prov. Cyangugu, Nyungwe National Park, Uwinka, trail to the waterfall, 02°28′29″S 29°11′42″E, 2390 m, on trunk of *Ocotea michelsonii*, 7 October 2003, *D. Killmann & E. Fischer* s. n. (LG—holotypus; B, KOBL—isotypi).

(Figs 1 & 2)

Thallus corticolous, crustose, very thin and partly endophloeodal and intermingled with dead cells of the bark on which it grows, continuous or not, pale to deep green (especially when wet), sometimes with a tinge of blue or almost white, without prothallus. *Photobiont*: *Trentepohlia*.

Stipes numerous, up to 0·8–1·0 mm long and 0·1–0·15(–0·2) mm thick when fully developed but already producing goniocysts at a much shorter length, pale yellow to orange, or sometimes white when dry but more vivid yellow or orange to somewhat pinkish when moistened, brush-like with a typically frayed upper part and long white filaments with extremely tiny greenish granules attached along their length (best observed under the dissecting microscope). Young stipes first seen as a tiny, somewhat translucent dot in the centre of small

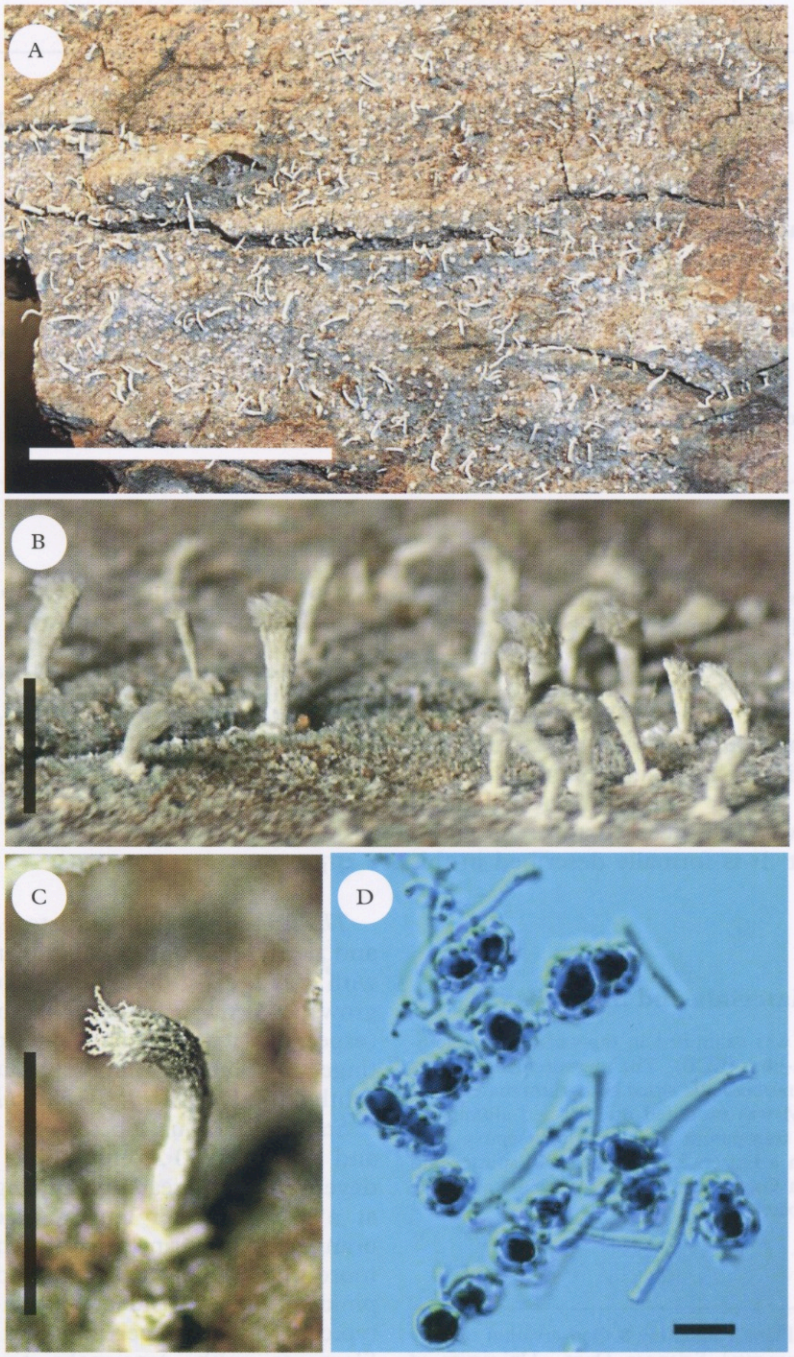

FIG. 1. *Nyungwea pallida* (type). A, general habit; B, lateral view of the goniocysts-producing stipes; C, lateral view of a single stipe with individual goniocysts visible; D, goniocysts in LCB. Scales: A = 10 mm; B = 1 mm; C = 1 mm; D = 10 μm.

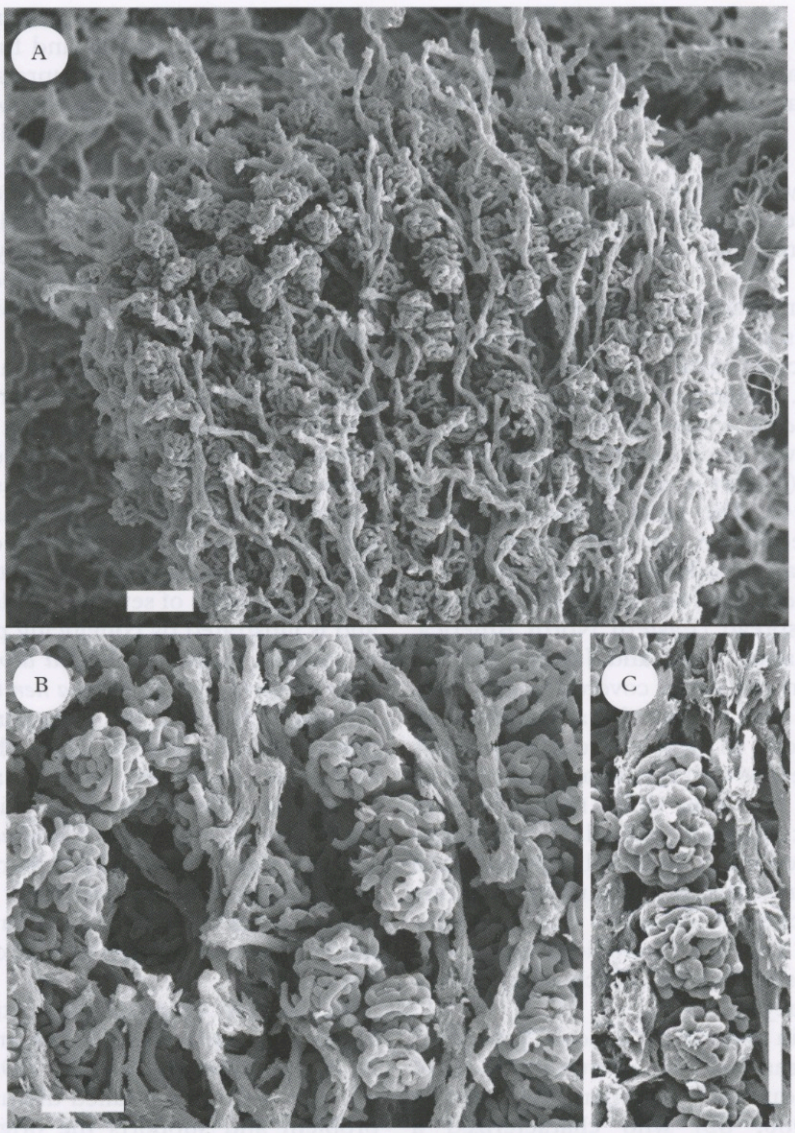

FIG. 2. *Nyungwea pallida* (type), SEM photographs. A, lateral view of a goniocysts-producing stipe with numerous goniocysts; B & C, detail of chains of goniocysts. Scales: A = 20 μm; B–C = 10 μm.

(*c.* 0·2 mm diam), hemispherical or irregular, pale yellow or orange to whitish thallus verrucae which contain colourless crystals. Hyphae forming the stipes simple or rarely branched, ± regularly anastomosed along their length, 1–1·5 μm, septate, with each cell being *c.* 5–15 μm long, longitudinally arranged and mixed with long chains of *Trentepohlia* cells ± strongly constricted at septa. *Goniocysts* numerous on the upper parts of the stipes, formed of a single algal cell (or rarely a couple of them) which has been isolated from a *Trentepohlia* chain and has become tightly embedded in a branched network of short hyphae, 7–12 μm in diam.; these hyphae do not form any structure that could be described as paraplectenchymatous or a cortex of isodiametric cells. In 'mature'

stipes, the goniocysts are easily detached from their 'carrying hyphae' and act as diaspores, and thus 'overmature' stipes typically appear as a brush of long, discrete filaments.

Chemistry. K − , C+ red, Pd − . Lecanoric acid detected by TLC and HPLC (analysis made by Prof. J. A. Elix)

Notes. On examining the plentiful collections of this species, it was initially thought to be a species similar to *Caloplaca calicioides* P. M. Jørg. (Jørgensen 1986), or to *Dictyocatenulata alba* Finley & E. F. Morris, a poorly known genus recently recognized as lichenized (Seifert *et al.* 1987; Lendemer & Harris 2004). The latter is known from a single collection in the high mountains of Venezuela and produces granular soredia at the tips of *c.* 1 mm tall stipes; the former is more widespread (Eastern North America, Cuba, Panama, India and Japan) and has 0·1–1·5 mm tall stipes covered with a conidiogenous layer at their tips and a terminal, hemispherical to globose conidial mass. Both species, however, have a chlorococcoid photobiont and thus differ markedly from the present material. Indeed, its characteristic features are a thallus lichenized with *Trentepohlia* with stipes producing very tiny granules acting as complete diaspores (the mycobiont and the photobiont being dispersed in a single entity) which we suggest to name goniocysts.

The origin and use of the term 'goniocyst' were summarized by Sérusiaux (1985: 2–13). He quoted the modern definition of Vězda (1980: 82) who characterized a goniocyst by its origin (a single algal cell) and its anatomical structure (a paraplectenchymatous envelope completely surrounding the algal colony). In the species dealt with in that paper (*Bacidina mirabilis*), which is lichenized with a chlorococcoid photobiont, the goniocysts form the thallus and moreover are arranged in cup-shaped structures (goniocystangia) to promote their dispersal. However, already in 1985, the use of the term 'goniocyst' was quite unsatisfactory as it was also widely applied to the tiny glomerules with different anatomical structures forming the thallus and further acting as diaspores in several unrelated genera (*Bacidina*, *Lichenomphalia*, *Micarea*, *Placynthiella*, *Vezdaea*, etc.). To avoid any confusion in his paper, Sérusiaux (1985) has suggested restricting *ad interim* the term goniocyst to the diaspores produced in the cup-shaped structures (goniocystangia) of several foliicolous species of *Opegrapha*. He also produced a short comparison between a soredium and a goniocyst.

While the differences between a soredium and a goniocyst have not meanwhile been clarified and without discussing the matter, Tønsberg (1992:34) introduced the term consoredia for "more or less compact, rounded, elongate to somewhat irregular aggregations of soredia encrusted with crystals of lichen substances". The term applies to the structures of several, unrelated species and is illustrated by convincing photographs of soredial masses of *Buellia arborea*, *Megalaria pulverea* and *Pertusaria hemisphaerica*; it is indeed clear that the term goniocysts has never been applied to such characteristic structures. However, in the same paper, "simple soredia with a cortex of isodiametric cells" are illustrated for *Caloplaca sorocarpa* and *Rimularia fuscosora* (Tønsberg 1992:32). Such structures are strikingly similar to goniocysts in the sense of Vězda (1980) but are only genuine diaspores and do not form the thallus.

In his monograph of the corticolous and lignicolous species of *Bacidia* and *Bacidina* in North America, Ekman (1996: 11–12) provides a further detailed discussion of the problem and supports the original use of Ozenda (1963: 32) and subsequent authors, e.g. using the term goniocyst for the tiny thallus granules of many different genera (incl. *Bacidina*). He suggests a functional difference between a soredium and a goniocyst, that is a soredium is only a diaspore and a goniocyst is the main basic unit of a thallus, although it can also be dispersed and thus acts as a diaspore. This option is now widely used in modern treatments of species whose thalli are made of tiny clusters of algal cells surrounded by fungal cells. Two

examples can illustrate that statement: the new genus *Elixiella* Lumbsch (Lumbsch 1997: 62) is, among other characters, distinguished by its thallus made of "goniocysts with a cortex of isodiametric cells"; and the new genus *Pseudocalopadia* Lücking (Lücking 1999: 142) is also characterized by "Thallus mehlig-granulös, aus Goniocysten; [. . .]."

Two cases however require further comments. The first concerns the genus *Gyalidea*, as two recently described species (*G. kawanae* and *G. pacifica*) have been shown to produce small but otherwise typical goniocystangia (Harada & Vězda 1999); these authors maintain the original definition of Vězda (1980). The second concerns the rare foliicolous species *Mazosia sorediifera* (Lücking & Matzer 1996: 129–133), whose pycnidia are surrounded by a rim of soredia; their ontogenesis is remarkably similar to that of the goniocysts of the foliicolous species of the *Opegrapha lambinonii* group (compare fig. 28 in Sérusiaux 1985: 12 to Abb. 11, G in Lücking & Matzer 1996: 131). Indeed, individual cells of the photobiont *Phycopeltis* become isolated and detached from the regular rows of rectangular cells forming the plates which form the typical thallus of that genus, and are wrapped up by hyphae without forming a cortex of isodiametric cells or a paraplectenchyamtous tissue. It is interesting to note that the same ontogenesis is observed in the new taxon dealt with in this paper: the long chains of *Trentepohlia* present in the stipes produced by the thallus break up to form single or groups of two cells; these cells are eventually wrapped up by hyphae and dispersed as single diaspores.

The definition of a goniocyst by Vězda (1980) has thus been explicitly applied to several species producing this type of diaspore developing in cup-shaped structures: the group of species comprizing *Bacidina mirabilis*, which now includes *Bacidina streimanii* and *B. simplex* (Farkas & Vězda 1993; Vězda 1994); the *Opegrapha lambinonii* aggregate; and two species of *Gyalidea*. These species are either lichenized with chlorococcoid algae or with *Phycopeltis*, a genus belonging to the *Trentepohliaceae*.

Although it imperfectly applies, we decided to use the term goniocyst in the sense of Vězda (1980) to describe the diaspores of the species studied here even though our material is not always consistent: the thallus is not made of the tiny granules that are produced in the upper parts of the stipes, each tiny granule originates in a single cell of *Trentepohlia* but the envelope organized by the mycobiont cannot be described as paraplectenchymatous, and the stipes can be described as a means to promote easily their dispersal.

The species studied here cannot be referred to any of the genera mentioned above because: (i) *Bacidina* and *Gyalidea* are lichenized with a chlorococcoid alga, (ii) the species of the *Opegrapha lambinonii* aggregate are lichenized with *Phycopeltis* and show no clear relationship with our material, and (iii) the genus *Mazosia*, lichenized with *Trentepohlia* and now including foliicolous species as well as at least a corticolous one (*M. ocellata*), is clearly circumscribed by its rounded ascocarps, the structure of its exciple, its ascus and ascospore type, and its oblong to cylindrical macroconidia. Although one foliicolous species (*M. sorediifera*) produces soredia with an ontogeny quite similar to the goniocysts produced by the species studied here, we think it unwise to include it in that genus without more convincing evidence.

We thus erect a new genus for it, although we cannot make any sound suggestions on its taxonomic position with the data currently available. A position in the *Arthoniales* is likely. The genus is named after the very famous Nyungwe Forest, where it was first found and which is now protected under the status of National Park in Rwanda. It represents one of the most species-rich montane forests in Africa (Buchbender & Fischer 2004; Ewango 2002; Fischer 1996; Fischer *et al.* 2003).

Ecology and distribution. Nyungwea pallida is a corticolous species currently known from two forest sites: the montane Nyungwe

Forest in Rwanda and the submontane Mabira Forest in Uganda. In the Nyungwe Forest, it is found between 2100 and 2400 m a.s.l. and seems to be mostly restricted to the dry and protected side of large boles of *Beilschmiedia rwandensis*, *Carapa grandiflora*, *Ocotea michelsonii*, *Psychotria mahoni* and *Syzygium guineense*. At the type locality, the forest consists mainly of *Carapa grandiflora*, *Parinaria excelsa*, *Symphonia globulifera* and *Newtonia buchanani*. In the Mabira Forest, it was found on the dry side of a single bole belonging to *Chrysophyllum viridifolium* at 1180 m a.s.l.; dominant tree species in this locality were *Celtis mildbraedii*, *Entandrophragma angolense* and *Pterygota mildbraedii*.

Additional specimens examined. **Rwanda:** same locality as the type, on boles of *Beilschmidia rwandensis*, *Carapa grandiflora*, *Ocotea michelsonii*, *Psychotria mahoni* and *Syzygium guineense*, 2300–2400 m, iv 2005, *D. Ertz*, *Eb. Fischer*, *D. Killmann & E. Sérusiaux* (BR, KOBL, LG). Nyungwe National Park, Kamiranzovu, S 02°29′12·8″, E 29°09′0·92″, on *Carapa grandiflora*, 2100 m, 2005, *D. Ertz* 8107 (BR).—**Uganda:** Mabira Forest Reserve (between Kampala and Jinja), N 0°23′31·5″, E 33°00′59·1″, on *Chrysophyllum viridifolium*, 1180 m, x 2005, *Eb. Fischer*, *D. Killmann & E. Sérusiaux* (KOBL, LG).

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