

New species of Dictyonema and Cyphellostereum (lichenized Basidiomycota: Hygrophoraceae) from tropical Africa and the Indian Ocean, dedicated to the late Hildur Krog

Authors: Lücking, Robert, and Timdal, Einar

Source: Willdenowia, 46(1) : 191-199

Published By: Botanic Garden and Botanical Museum Berlin (BGBM)

URL: <https://doi.org/10.3372/wi.46.46115>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

ROBERT LÜCKING^{1*} & EINAR TIMDAL²

New species of *Dictyonema* and *Cyphellostereum* (lichenized *Basidiomycota*: *Hygrophoraceae*) from tropical Africa and the Indian Ocean, dedicated to the late Hildur Krog

Version of record first published online on 6 April 2016 ahead of inclusion in April 2016 issue.

Abstract: A small collection of lichenized fungi belonging in the *Dictyonema* clade from E Africa and Mauritius, tentatively identified as *D. sericeum*, revealed four species new to science, one in the genus *Cyphellostereum* and three in the genus *Dictyonema* s.str. *Cyphellostereum bicolor* from Mauritius is similar to *C. imperfectum* from Guatemala, but differs in the absence of a persistent white hypothallus and the less compact hyphal sheath of the fibrils, as well as the formation of resupinate hymenophores. *Dictyonema album*, also from Mauritius, belongs in the group of shelf-like morphotypes and is characterized within this group by very loose tufts dominated by sterile hyphae with very loosely arranged cyanobacterial fibrils. *Dictyonema krogiae* from Kenya is another new species in the group with shelf-like thalli and is the first species in this group known to form a distinctly layered thallus, with very compact photobiont layer, loose medulla, and more compact lower cortex. Finally, *Dictyonema tricolor* from Tanzania is a crustose taxon with ascending to erect tufts of densely arranged cyanobacterial fibrils, with the hyphal sheath becoming brown and the tip of the tufts whitish. In addition, *Dictyonema coppinsii* is reported from Mauritius.

Key words: *Agaricales*, basidiolichens, *Basidiomycota*, *Cyphellostereum*, *Dictyonema*, *Hygrophoraceae*, tropical Africa, Indian Ocean, Mascarenes, new species

Article history: Received 18 December 2015; peer-review completed 15 February 2016; received in revised form 26 February 2016; accepted for publication 29 February 2016.

Citation: Lücking R. & Timdal E. 2016: New species of *Dictyonema* and *Cyphellostereum* (lichenized *Basidiomycota*: *Hygrophoraceae*) from tropical Africa and the Indian Ocean, dedicated to the late Hildur Krog. – *Willdenowia* 46: 191–199. doi: <http://dx.doi.org/10.3372/wi.46.46115>

Introduction

The systematics, taxonomy and species richness of basidiolichens have long been misunderstood. The genus *Dictyonema* C. Agardh was monographed by Parmasto (1978) with the acceptance of five “lichen” and only two “fungal” species (one with clamps and one without). Parmasto (1978) placed the genus in *Corticaceae*, whereas later it was reclassified in *Atheliaceae* (Oberwinkler 2001). The *Dictyonema* clade is now known to represent five genera (*Acantholichen* P. M. Jørg., *Cora* Fr., *Corella* Vain., *Cyphellostereum* D. A. Reid and *Dictyonema* s.str.) in subfamily *Lichenomphalinoideae* in *Hygrophoraceae* in the order *Agaricales* (Lawrey & al. 2009; Dal-Forno

& al. 2013; Lodge & al. 2014). Within these genera, 60 species are currently recognized, over 250 species are known based on molecular phylogenies, and possibly over 700 are predicted to exist in this lineage (Lücking & al. 2013a, b, 2014a, b; Schmull & al. 2014; Dal-Forno 2015; Dal-Forno & al. 2016). This would place *Hygrophoraceae* among the ten fungal families with the highest number of lichenized species (Jaklitsch & al. 2016). In addition, a novel lineage of cyanobacterial photobionts, namely *Rhizonema* Lücking & Barrie, was discovered in this clade (Lücking & al. 2009, 2014a).

As part of our efforts to critically revise the taxonomy of the *Dictyonema* clade based on these findings, we here describe four new species from tropical Africa (Kenya,

1 Botanischer Garten und Botanisches Museum Berlin, Freie Universität Berlin, Königin-Luise-Str. 6–8, 14195 Berlin, Germany; *e-mail: r.luecking@bgbm.org (author for correspondence).

2 Natural History Museum, University of Oslo, P.O. Box 1172, Blindern, 0318 Oslo, Norway.

Tanzania) and the Indian Ocean (Mauritius), collected by Hildur Krog and Einar Timdal between 1972 and 1991. Contrary to the Neotropics, where most of the data for a broad phylogenetic revision of this clade have been obtained so far (Lawrey & al. 2009; Dal-Forno & al. 2013; Lücking & al. 2013a, 2014b; Dal-Forno 2015), very few collections from the Paleotropics have been critically revised. It is therefore not surprising to detect a high number of novelties in a comparatively small set of gatherings. This is also supported by molecular sequence data, which suggests that paleotropical specimens form lineages quite distinct from neotropical taxa, especially in *Cyphellostereum* and *Dictyonema* s.str. (Dal-Forno 2015).

This paper is dedicated to the late Dr Hildur Krog (1922–2014), who collected lichens on 13 field trips to E Africa and the Indian Ocean. The material was published in a series of taxonomic revisions, often co-authored by Dr T. D. V. Swinscow, with whom she collaborated and often travelled. Their work was summarized in *Macrolichens of East Africa* (Swinscow & Krog 1988).

Material and methods

Specimens were examined with LEICA MS5 and OLYMPUS SZX12 dissecting microscopes and photographed with a JENOPTIC ProgRes C5 microscope digital camera attached to the latter. Sections of thallus and hymenophore were cut by hand with a razor blade and mounted in tap water for examination with ZEISS Axioscop 2 and VISTA VISION VWR V036 compound microscopes. Secondary chemistry was assessed with standardized methods of thin-layer chromatography (TLC) using solvent system C (Orange & al. 2010).

Results and Discussion

Cyphellostereum bicolor Lücking & Timdal, **sp. nov.** – MycoBank #815880 – Fig. 1.

Holotype: Mauritius, Grand Port, Bambou Mountains, 0.5–1 km NNE of Piton Rouge, 20°20'S, 57°44'E, 250–300 m, epiphytic on tree bark, 12 Nov 1991, *H. Krog & E. Timdal* MAU36/02 (O L-21699; isotype: F).

Diagnosis — Differing from *Cyphellostereum imperfectum* Lücking & al. in the absence of a distinct, white hypothallus (not associated with hymenophores) and the loose hyphal sheath around the cyanobacterial filaments.

Description — Thallus epiphytic on tree bark, mostly overgrowing bryophytes (hepatics), appressed filamentous, forming a mat of interrupted patches of densely clustered fibrils connected by a thin to indistinct hypothallus, up to several cm across; fibrils horizontal to irregularly subsending, irregularly oriented, vividly and uniformly aeruginous, intermingled with white patches

of densely woven, byssoid hyphae eventually developing into hymenophores. Fibrils in section solitary, not forming agglutinated tufts, each fibril with its own hyphal sheath, 11–14 µm wide, with hyphal sheath c. 2 µm thick, colourless; cyanobacterial filaments composed of 7–9 µm wide and 5–6 µm high, aeruginous blue cells lacking tubular fungal hyphae as haustoria; heterocytes sparse, hyaline to yellowish, 6–8 µm wide and 4–6 µm high; hyphal sheath formed by loosely arranged, cylindrical, curved hyphae wrapped around cyanobacterial filaments; hyphae of hypothallus and those associated with fibrils or forming apical setae straight, hyaline, 3–5 µm thick, lacking clamp connections. Hymenophore developed on or underneath white, byssoid areas as irregular, resupinate, effuse patches, patches 0.5–1 mm in diam., ± flat, with white, smooth surface but often with cracks and interspaces, without distinct margins; hymenophore in section 30–50 µm thick, composed of a woven, strongly hydrophobic layer resting on agglutinated, 4–6 µm thick, generative hyphae emerging from supporting thallus; hymenium forming protruding, palisade-like basidioles, 20–30 × 5–6 µm; basidia and basidiospores not observed. Chemistry: no substances detected by TLC.

Remarks — *Cyphellostereum bicolor* forms a striking colour contrast between the aeruginous cyanobacterial filaments and the white hyphal patches developing the hymenophore. It is included in *Cyphellostereum* due to the sheath formed by cylindrical hyphae and the absence of fungal haustoria (Dal-Forno & al. 2013; Lücking & al. 2013a); however, the resupinate hymenophore is more reminiscent of *Dictyonema* s.str. Another species confirmed in the latter genus based on molecular data, *D. huaorani* Dal-Forno & al. also lacks jigsaw-puzzle-shaped hyphal cells and haustoria (Schmull & al. 2014). Hence, the phylogenetic placement of the new species must be tested with molecular sequence data. Morphologically, it is most similar to *C. imperfectum*, which differs in the distinct white hypothallus (not associated with hymenophores) and the denser hyphal sheath around the cyanobacterial filaments (Yáñez & al. 2012).

Other lichens collected at the site include *Coccocarpia palmicola* (Spreng.) Arv. & D. J. Galloway, *Parmotrema tinctorum* (Despr. ex Nyl.) Hale, *Phyllopsora breviscula* (Nyl.) Müll. Arg., *Sticta macrophylla* Bory and *S. weigeli* Isert s.lat.

Dictyonema album Lücking & Timdal, **sp. nov.** – MycoBank #815881 – Fig. 2.

Holotype: Mauritius, Savanne, Plaine Champagne, near the viewpoint WNW of Mt Cocotte, 20°26'S, 57°27'E, 650 m, 18 Nov 1991, *H. Krog & E. Timdal* MAU57/04 (O L21992; isotype: F).

Diagnosis — Differing from other species in the *Dictyonema sericeum* (Sw.) Berk. & M. A. Curtis group by the

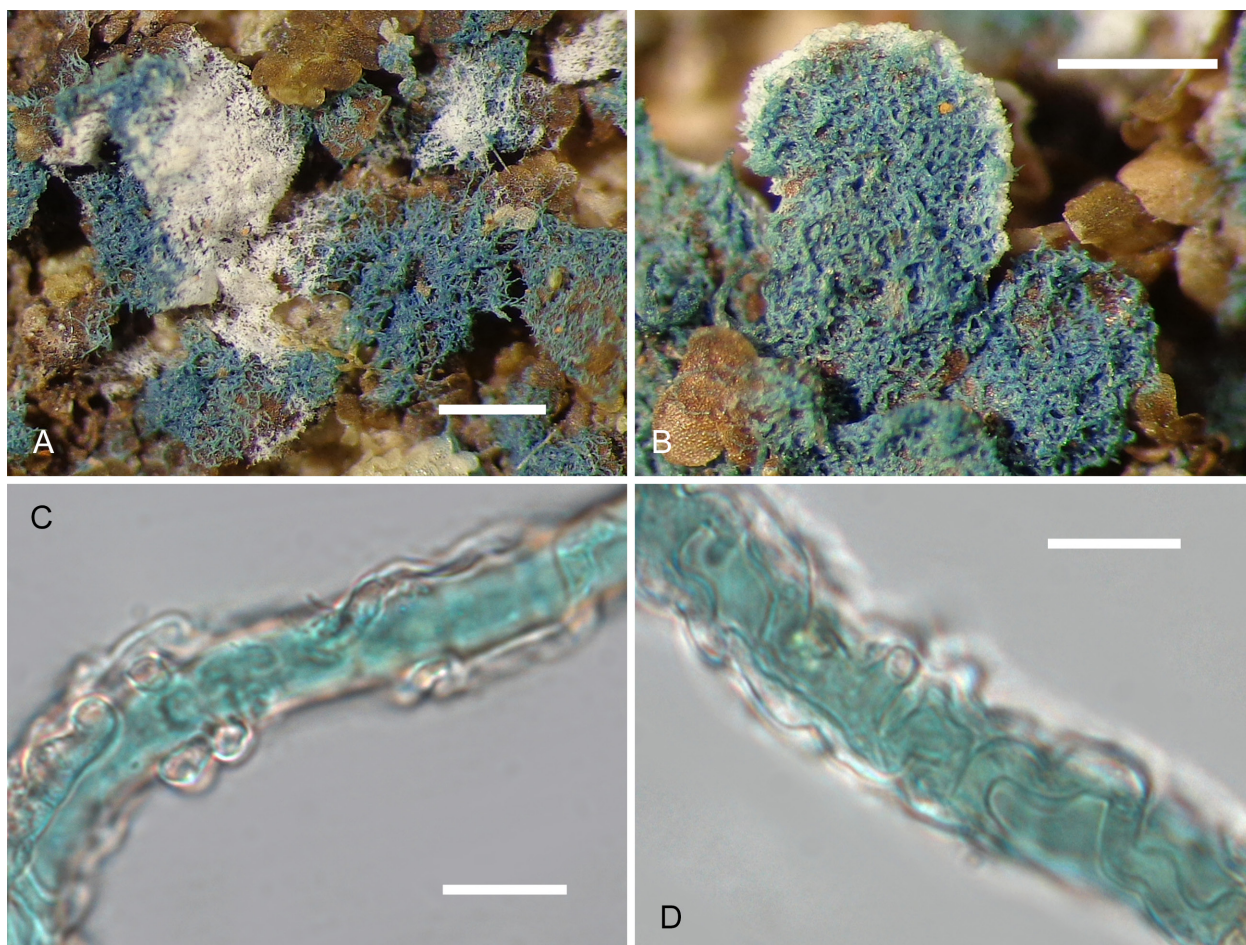


Fig. 1. *Cyphellostereum bicolor* – A, B: thallus fibrils with white basidiocarps and basidiocarp initials; C, D: microscopic view of fibrils with loose hyphal sheath. – Scale bars: A, B = 1 mm; C, D = 10 μ m.

combination of irregularly arranged tufts of fibrils that do not form a distinctly layered thallus, being dominated by sterile, straight hyphae with very few associated cyanobacterial fibrils, giving the thallus a whitish appearance.

Description — Thallus epiphytic on shrubs, filamentous, forming semi-circular, adnate to projecting shelves or in basal parts a crust on substrate, up to 10 cm across, composed of numerous imbricate to partially fused lobes c. 1 cm in diam., individual lobes formed by loosely interwoven, ascending to erect, light aeruginous tufts of fibrils with long, white tips; thallus therefore appearing whitish in surface view. Thallus in section 1–2 mm thick, with tufts of fibrils up to 5 mm long from base, not forming a distinct photobiont layer and medulla but instead fibrils connected at base (underside) to a white, loosely woven hypothallus; tufts formed by densely arranged but not agglutinate, sterile, unbranched to sparsely branched hyphae arranged in parallel fashion, up to 0.5 mm thick, intermingled with few (3–8) cyanobacterial fibrils distant from each other, each fibril with its own hyphal sheath, 14–16 μ m wide, with hyphal sheath 2–3 μ m thick, colourless; cyanobacterial filaments composed of 10–12 μ m wide and 3–5 μ m high, aeruginous cells penetrated by

tubular fungal hyphae; heterocysts frequent, hyaline, 8–10 μ m wide and 4–6 μ m high; cells of hyphal sheath wavy in lateral outline, 3–5 μ m in diam.; hyphae of hypothallus and those associated with fibrils or forming apical setae straight, hyaline, 4–7 μ m thick, lacking clamp connections. Hymenophore not observed. Chemistry: no substances detected by TLC.

Remarks — This new species has the gross morphology of the *Dictyonema sericeum* group, with shelf-like, filamentous lobes (Lücking & al. 2013a). Within that group, it belongs in a complex of species with irregularly arranged tufts of fibrils that do not form a distinctly layered thallus, very different from, for instance, *D. krogiae* described below. The gross morphology is somewhat reminiscent of the non-shelf forming *D. tricolor*, also described below, but the internal anatomy of the tufts is quite distinct in *D. album*, being dominated by sterile, straight hyphae with very few associated cyanobacterial fibrils, giving the thallus a whitish appearance. Such an anatomy is not known from any of the currently recognized species in the *D. sericeum* group (Lücking & al. 2013a, b) and is probably an adaptation to exposed microsites.

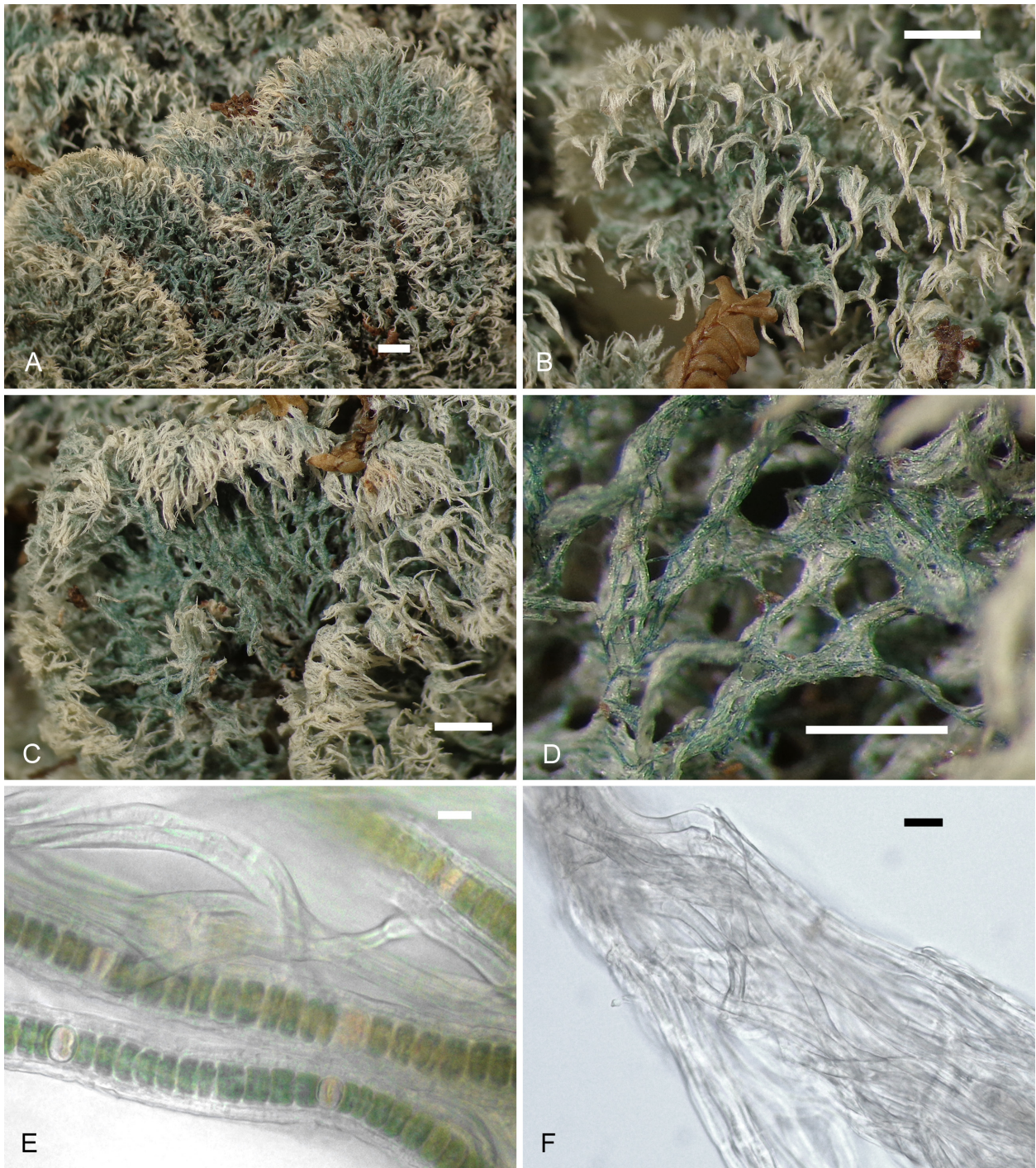


Fig. 2. *Dictyonema album* – A–D: thallus fibrils (enlarged in D); E, F: microscopic view of fibrils with hyphal sheath and associated hyphal tufts. – Scale bars: A–D = 1 mm; E, F = 10 µm.

Other species collected in the forest near the type specimen of *Dictyonema album* include *Bulbothrix suffixa* (Stirt.) Hale, *Pannaria santessonii* Swinscow & Krog, *Sticta macrophylla*, *Usnea baileyi* (Stirt.) Zahlbr., *U. himantodes* Stirt. and *U. rubicunda* Stirt. At the other site, *D. album* was collected together with *Crocynia molliuscula* (Nyl.) Nyl., *Hypotrachyna microblasta* (Vain.) Hale, *Leioderma erythrocarpum* (Delise ex Nyl.) D. J. Galloway & P. M. Jørg., *Pannaria multifida* P. M. Jørg.,

P. ramosii Vain., *Parmeliella endoferruginea* Aptroot, *Phyllopsora buettneri* (Müll. Arg.) Zahlbr., *P. confusa* Swinscow & Krog, *P. porphyromelaena* (Vain.) Zahlbr., *P. swinscowii* Timdal & Krog, *Pseudocyphellaria argyracea* (Delise) Vain., *Psoroma sphinctrinum* (Mont.) Nyl., *Sticta tomentosa* (Sw.) Ach. and *S. weigelii* s.lat.

Additional specimen examined — MAURITIUS: Savanne, along the road between Mt Cocotte and Bassin Blanc,

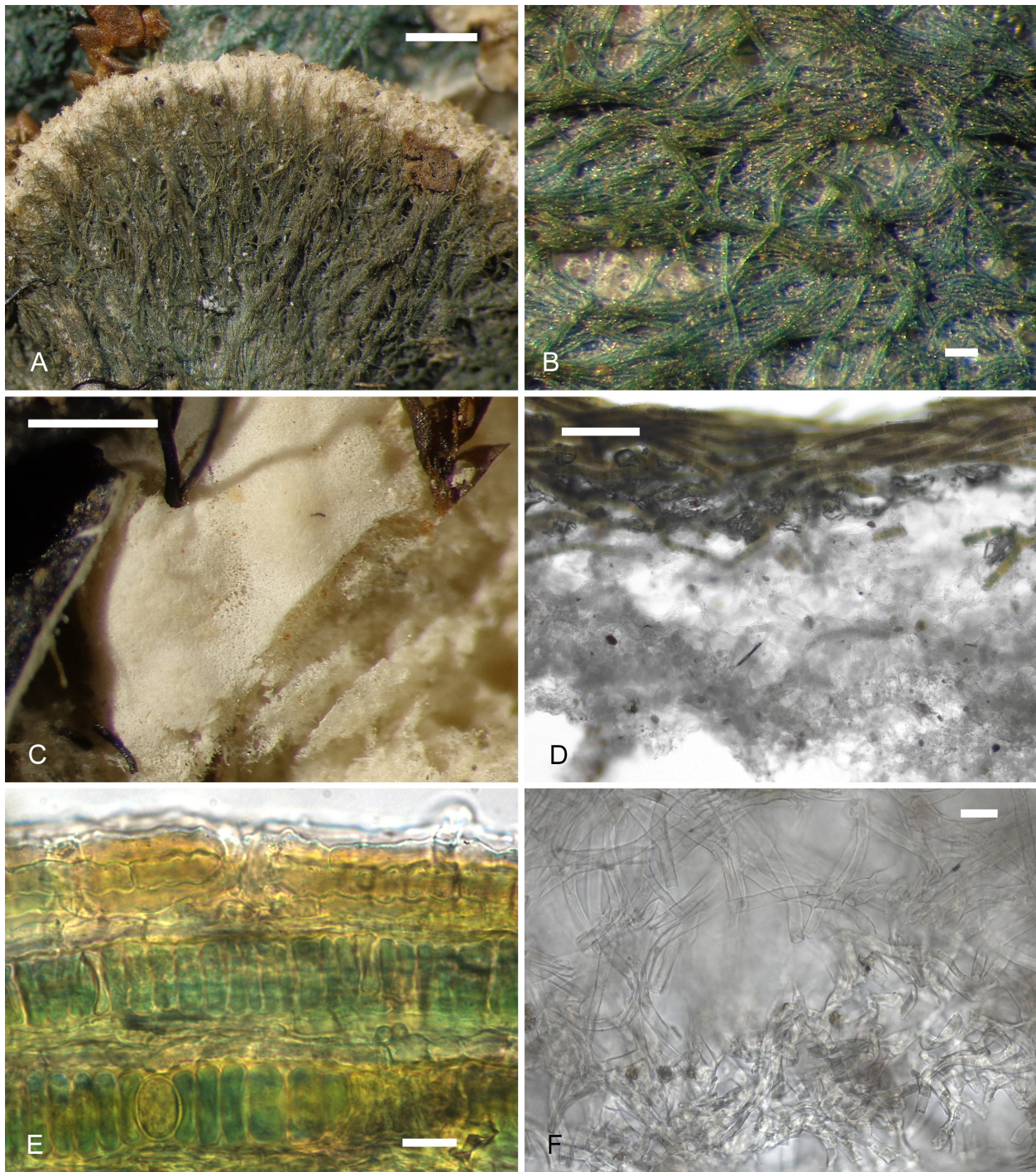


Fig. 3. *Dictyonema krogiae* – A, B: thallus fibrils (enlarged in B); C: basidiocarp; D–F: microscopic sections of thallus showing photobiont (filament) layer (E) and medulla and lower “cortex” enlarged (F). – Scale bars: A, C = 1 mm; B, D = 0.1 mm; E, F = 10 μ m.

20°26'S, 57°28'E, 550–580 m, 18 Nov. 1991, *H. Krog* & *E. Timdal* MAU58/03 (O L-22008).

Dictyonema krogiae Lücking & Timdal, **sp. nov.** – MycoBank #815882 – Fig. 3.

Holotype: Kenya, Central Province, Kirinyaga District, Mount Kenya, 2 km N of Irangi Forest Station, near river Ena, 00°20'S, 37°28'E, 2000 m, moist deciduous forest,

on trees, 9 Feb 1972, *H. Krog* K48/102 (O L-1305; isotype: F).

Diagnosis — Differing from *Dictyonema ligulatum* (Kremp.) Zahlbr. by the lack of clamp connections and the filaments being arranged in dense, parallel, radiating lines, and generally from other species in the *D. sericeum* group in the distinctly layered thallus, including a dense photobiont layer and a loose lower cortex.

Description — Thallus epiphytic on trees, intermingled with other lichens (*Parmotrema* A. Massal.) and bryophytes (*Frullania* Raddi), filamentous, forming semi-circular, adnate to projecting shelves up to 10 cm across, with single lobes 1–6 cm wide, composed of densely arranged, horizontally radiating and parallel, dark aeruginous fibrils without or with indistinct interspaces resting on a thick, byssoid, irregularly interwoven medulla (hypothallus), visible as narrow, c. 0.5 mm wide line along margin, strongly contrasting with aeruginous fibrils. Thallus in section 400–500 µm thick, ecorticate, with a fully exposed, well-defined photobiont layer, 100–150 µm thick, a distinct medulla of very loosely woven hyphae, 200–300 µm thick, and a lower “cortex” of more densely woven hyphae, c. 50 µm thick; photobiont layer composed of numerous, periclinally arranged, parallel fibrils formed by cyanobacterial filaments wrapped in a closed hyphal sheath of jigsaw-puzzle-shaped cells; fibrils 15–20 µm wide, with hyphal sheath 2–3 µm thick, colourless or olive-brown towards thallus centre; cyanobacterial filaments composed of 12–15 µm wide and 5–7 µm high, aeruginous green cells penetrated by tubular fungal hyphae; heterocytes sparse, hyaline to yellowish, 11–13 µm wide and 4–6 µm high; cells of hyphal sheath wavy in lateral outline, 3–5 µm in diam., in surface fibrils and towards thallus margin often shallowly verrucose-papillose; hyphae of medulla, lower “cortex” (hypothallus) and white bordering line (prothallus) straight, much branched, 4–6 µm thick, lacking clamp connections. Hymenophore sparsely developed as soft, irregular, resupinate, effuse patches on underside, patches 0.5–1 mm in diam., slightly convex, with whitish, smooth surface and without distinct margins; hymenophore in section 70–150 µm thick, composed of a paraplectenchymatous layer resting on strongly agglutinated, 4–6 µm thick, generative hyphae emerging from supporting thallus; hymenium composed of numerous, palisade-like basidioles and scattered basidia; basidioles 20–30 × 5–6 µm; basidia 30–40 × 5–7 µm, 4-sterigmate; basidiospores (only few seen) ellipsoid, non-septate, hyaline, 7–10 × 3–4 µm. Chemistry: no substances detected by TLC.

Eponymy — This new species is dedicated to Hildur Krog for her invaluable contributions to African lichenology.

Remarks — The shelf-like filamentous forms of *Dictyonema* were assigned to only two species by Parmasto (1978), presumably with the single difference of presence (*D. ligulatum*) vs absence (*D. sericeum*) of clamp connections. Molecular phylogenetic and morphological studies showed that a number of different species are present in this apparently monophyletic complex, separated by details in their thallus morphology and anatomy (Dal-Forno & al. 2013; Dal-Forno 2015). Among these, thus far three species are known with their cyanobacterial fibrils arranged in a narrow, compact, well-defined photobiont layer resting on a well-defined medulla, resulting in a uniformly blue-green colour contrasting with the white

prothallus and hypothallus: the paleotropical *D. ligulatum* and *D. scabridum* (Vain.) Lücking with clamp connections and the latter additionally with finger-like thallus outgrowths (Lücking & al. 2013a), and the recently described, neotropical *D. huaorani* (Schmull & al. 2014); the latter resembles *D. ligulatum* morphologically but lacks clamp connections and also lacks the jigsaw-puzzle-shaped hyphal sheath cells and the tubular haustoria penetrating the cyanobacterial filaments typical of the other two species. *Dictyonema krogiae* comes morphologically closest to *D. ligulatum*, but lacks clamp connections and the filaments are arranged in dense, parallel, radiating lines, whereas in *D. ligulatum* they are irregularly oriented and leave small interspaces. The distinctly developed layers in *D. krogiae*, including a dense photobiont layer and a loose lower cortex, are not known from any other species in this morphotype.

The type locality was apparently very rich in lichens and Hildur Krog made at least 191 collections there. It is the holotype locality of *Phyllopsora confusa* (Swinscow & Krog 1981). Other species collected include *Anzia afromontana* R. Sant., *Bulbothrix meizospora* (Nyl.) Hale, *Crocodia clathrata* (De Not.) Trevis., *Dirinaria applanata* (Fée) D. D. Awasthi, *Flavoparmelia caperata* (L.) Hale, *Hypotrachyna costaricensis* (Nyl.) Hale, *H. endochlora* (Leight.) Hale, *H. microblasta*, *H. neodissecta* (Hale) Hale, *H. osseoalba* (Vain.) Y. S. Park & Hale, *H. rockii* (Zahlbr.) Hale, *H. subfaticens* (Kurok.) Swinscow & Krog, *H. sublaevigata* (Nyl. ex Tuck.) Hale, *Kroswia crystallifera* P. M. Jørg., *Leprocaulon arbuscula* (Nyl.) Nyl., *Nephroma tropicum* (Müll. Arg.) Zahlbr., *Pannaria fulvescens* (Mont.) Nyl., *Parmelinella wallichiana* (Taylor) Elix & Hale, *Parmotrema arnoldii* (Du Rietz) Hale, *P. cooperi* (J. Steiner & Zahlbr.) Sérus., *P. cryptoxanthum* (Abbeyes) Hale, *P. direagens* (Hale) Hale, *P. eunetum* (Stirt.) Hale, *P. hababianum* (Gyeln.) Hale, *P. nilgherrense* (Nyl.) Hale, *P. sancti-angelii* (Lynge) Hale, *P. subarnoldii* (Abbeyes) Hale, *P. umbrosum* (Krog & Swinscow) Krog & Swinscow, *Phyllopsora chlorophaea* (Müll. Arg.) Zahlbr., *P. porphyromelaena*, *Punctelia neutralis* (Hale) Krog, *Ramalina calcarata* Krog & Swinscow, *R. pusiola* Müll. Arg., *Sticta cyphellulata* (Müll. Arg.) Hue and *Usnea exasperata* (Müll. Arg.) Motyka.

Dictyonema tricolor Lücking & Timdal, **sp. nov.** – MycoBank #815883 – Fig. 4A–D.

Holotype: Tanzania, Southern Highlands, Iringa District, Lulando Forest at NE edge of Mufindi escarpment, 08°36'S, 35°37'E, 1450 m, low montane rain forest, on trees, Apr 1989, H. Krog 3T23/001 (O L-153734).

Diagnosis — Differing from *Dictyonema coppinsii* Lücking & al. in the tricolored, regularly ascending tufts of fibrils and from *D. galapagoense* A. Yáñez & al. also in the much more robust thallus and the presence of fungal haustoria.



Fig. 4. A–D: *Dictyonema tricolor*; A, B: thallus fibrils enlarged; C, D: microscopic view of fibrils with dense hyphal sheath. – E, F: *Dictyonema coppinsii*; E: thallus fibrils; F: basidiocarp. – Scale bars: A, B, E, F = 1 mm; C, D = 10 μ m.

Description — Thallus epiphytic on tree bark, filamentous with ascending to erect fibrils, forming a \pm continuous mat with fibrils evenly dispersed or clustered, up to several cm across; fibrils ascending from a basal, white, densely interwoven, opaque hypothallus, aeruginous with tips or upper part becoming white or (dark) brown, often oriented into same direction, accompanied by irregular strands of white, densely packed hyphae, forming tufts up to 3 mm long and 0.3 mm wide. Fi-

brils in section forming tufts composed of 5–15 individual, strongly agglutinated fibrils, each fibril with its own hyphal sheath, 15–18 μ m wide, with hyphal sheath 2–3 μ m thick, colourless or becoming brown towards apex of fibrils, at tips often minutely and shallowly papillose; fibrils often ending in prolonged setae formed by agglutinate, straight hyphae not associated with photobiont filaments; cyanobacterial filaments composed of 10–12 μ m wide and 4–6 μ m high, aeruginous blue

cells penetrated by tubular fungal hyphae; heterocytes frequent, hyaline to yellowish, 10–13 µm wide and 4–6 µm high; cells of hyphal sheath wavy in lateral outline, 3–5 µm in diam.; hyphae of hypothallus and those associated with fibrils or forming apical setae straight, hyaline, 4–6 µm thick, lacking clamp connections. Hymenophore not observed. Chemistry: no substances detected by TLC.

Remarks — This new species represents a morphotype with filaments that are ascendant to erect, being somewhat intermediate between entirely appressed taxa and those forming semi-circular shelves. Thus far, only a few described species represent this morphotype. Among these, the European *Dictyonema coppinsii* has uniformly blue-green tufts of fibrils that are irregular to (sub-) erect (Lücking & al. 2014a). *Dictyonema galapagoense* also forms (sub-)erect tufts of fibrils but is much more delicate and lacks fungal haustoria, so the photobiont filaments are much narrower, with more or less squared cells (Yáñez & al. 2012). The new species forms a distinct colour contrast between the aeruginous fibrils visible from the base and the either brown or white colour of the apical portions of the tufts. The specimen was first published as *D. sericeum* by Krog (2000).

Other lichens collected at this site include *Canoparmelia texana* (Tuck.) Elix & Hale, *Heterodermia casarettiana* (A. Massal.) Trevis., *Hypotrachyna costaricensis*, *H. horrescens* (Taylor) Krog & Swinscow, *Parmeliella pannosa* (Sw.) Müll. Arg., *Parmotrema amaniense* (J. Steiner & Zahlbr.) Krog & Swinscow, *P. cooperi*, *P. hololobum* (Hale) Hale, *Phyllopsora dolichospora* Timdal & Krog, *P. furfuracea* Zahlbr., *P. martinii* Swinscow & Krog, *P. porphyromelaena*, *Pseudocyphellaria aurata* (Ach.) Vain., *Rimelia cetrata* (Ach.) Hale & A. Fletcher and *Usnea baileyi*.

Dictyonema coppinsii Lücking & al. in *Lichenologist* 46: 262. 2014. – Fig. 4E, F.

Remarks — This species was recently described for the W European taxon previously known under the invalid name “*Dictyonema interruptum*”. The material from Mauritius agrees in all characters with the material from Europe, but molecular data from fresh material are needed to confirm this considerable range extension. Other species collected at the site include *Coccocarpia pruinosa* Arv., *C. smaragdina* Pers., *Lobaria patinifera* (Taylor) Hue, *Parmotrema tinctorum*, *Physma byrsaeum* (Ach.) Tuck., *Pyxine subcinerea* Stirt., *Rimelia reticulata* (Taylor) Hale & A. Fletcher, *Sticta dichotoma* Bory, *S. weigelii* s.lat. and *Usnea rubicunda*.

Specimens examined — MAURITIUS: Grand Port, Mt des Créoles, 20°23'S, 57°40' E, 320–360 m, 12 Nov 1991, *H. Krog & E. Timdal MAU35/10* (F, O L-21661).

Conclusions

The present findings show underline the notion that the *Dictyonema* clade, including the genera *Acantholichen*, *Cora*, *Corella*, *Cyphellostereum* and *Dictyonema* s.str., is highly diverse with a large proportion of regional and local endemics. This diversity was not previously recognized and material from Africa had mostly been labelled *D. sericeum*. The fact that only few collections of *Dictyonema* resulted from the field trips made by Dr Krog and her colleagues, but these few gatherings yielded almost exclusively new taxa, shows that this enigmatic group of lichens remains undercollected and that African wet ecosystems may harbour a large number of unrecognized species in this clade.

Acknowledgements

Financial support for aspects of this study was provided by grant DEB 0841405 from the National Science Foundation to George Mason University: “Phylogenetic Diversity of Mycobionts and Photobionts in the Cyanolichen Genus *Dictyonema*, with Emphasis on the Neotropics and the Galapagos Islands” (Principal Investigator: J. Lawrey; Co-PIs: R. Lücking and P. Gillevet). We thank Manuela Dal Forno (Center for Conservation and Evolutionary Genetics, National Zoological Park, Smithsonian Institution) and James Lawrey (George Mason University) for their reviews of an earlier version of this paper.

References

- Dal-Forno M. 2015: Evolution and diversity of the basidiolichen clade *Dictyonema* (*Agaricales: Hygrophoraceae*). – Fairfax: Ph.D. dissertation, College of Science, Environmental Science and Public Policy, George Mason University. – Published at: <http://hdl.handle.net/1920/9824>
- Dal-Forno M., Lawrey J. D., Sikaroodi M., Bhattarai S., Gillevet P. M., Sulzbacher M. & Lücking R. 2013: Starting from scratch, evolution of the lichen thallus in the basidiolichen *Dictyonema* (*Agaricales, Hygrophoraceae*). – *Fungal Biol.* **117**: 584–598.
- Dal-Forno M., Lücking R., Bungartz F., Yáñez-Ayabaca A., Marcelli M. P., Spielmann A. A., Coca L. F., Chaves J. L., Aptroot A., Sipman H. J. M., Sikaroodi M., Gillevet P. & Lawrey J. D. 2016: From one to six: unrecognized species diversity in the genus *Acantholichen* (lichenized *Basidiomycota: Hygrophoraceae*). – *Mycologia* **108**: 38–55.
- Jaklitsch W., Baral H.-O., Lücking R. & Lumbsch H. T. 2016: *Ascomycota*. – In: Frey W. (ed.), *Syllabus of plant families. A. Engler’s Syllabus der Pflanzenfamilien*, ed. 13, **1/2**. – Stuttgart: Borntraeger.

- Krog H. 2000: Corticolous macrolichens of low montane rainforests and moist woodlands of eastern Tanzania. – *Sommerfeltia* **28**: 1–75.
- Lawrey J. D., Lücking R., Sipman H. J. M., Chaves J. L., Redhead S. A., Bungartz F., Sikaroodi M. & Gillevet P. M. 2009: High concentration of basidiolichens in a single family of agaricoid mushrooms (*Basidiomycota*: *Agaricales*: *Hygrophoraceae*). – *Mycol. Res.* **113**: 1154–1171.
- Lodge D. J., Padamsee M., Matheny P. B., Aime M. C., Cantrell S. A., Boertmann D. M., Kovalenko A., Moncalvo J.-M., Vilgalys R., Vizzini A., Larsson E., Lücking R., Griffith G. W., Smith M., Norvell L., Desjardin D. E., Redhead S., Ovrebo C. L., Lickey E. B., Ercole E., Hughes K. W., Courtecuisse R., Young A., Binder M., Minnis A., Lindner D. L., Ortiz-Santana B., Haight J., Læssøe T., Baroni T. J., Geml J. & Hattori T. 2014: Molecular phylogeny, morphology, pigment chemistry and ecology in *Hygrophoraceae* (*Agaricales*). – *Fungal Diversity* **64**: 1–99.
- Lücking R., Barrie F. R. & Genney D. 2014a: *Dictyonema coppinsii*, a new name for the European species known as *Dictyonema interruptum* (*Basidiomycota*: *Agaricales*: *Hygrophoraceae*), with a validation of its photobiont *Rhizonema* (*Cyanoprokaryota*: *Nostocales*: *Rhizonemataceae*). – *Lichenologist* **46**: 261–267.
- Lücking R., Dal-Forno M., Lawrey J. D., Bungartz F., Holgado Rojas M. E., Hernández M. J. E., Marcelli M. P., Moncada B., Morales E. A., Nelsen M. P., Paz E., Salcedo L., Spielmann A. A., Wilk K., Will-Wolf S. & Yáñez A. 2013a: Ten new species of lichenized *Basidiomycota* in the genera *Dictyonema* and *Cora* (*Agaricales*: *Hygrophoraceae*), with a key to all accepted genera and species in the *Dictyonema* clade. – *Phytotaxa* **139**: 1–38.
- Lücking R., Dal-Forno M., Sikaroodi M., Gillevet P. M., Bungartz F., Moncada B., Yáñez A., Chaves J. L., Coca L. F. & Lawrey J. D. 2014b: A single macrolichen constitutes hundreds of unrecognized species. – *Proc. Natl. Acad. Sci. U.S.A.* **111**: 11091–11096.
- Lücking R., Dal-Forno M., Wilk K. & Lawrey J. D. 2013b: Three new species of *Dictyonema* (lichenized *Basidiomycota*: *Hygrophoraceae*) from Bolivia. – *Acta Nova* **6**: 4–16.
- Lücking R., Lawrey J. D., Sikaroodi M., Gillevet P. M., Chaves J. L., Sipman H. J. M. & Bungartz F. 2009: Do lichens ‘evolve’ photobionts like farmers ‘evolve’ crops? Evidence from a previously unrecognized lineage of filamentous cyanobacteria. – *Amer. J. Bot.* **96**: 1409–1418.
- Oberwinkler F. 2001: Basidiolichens. – Pp. 211–225 in: Hock B. (ed.), *The Mycota IX*. Fungal associations. – Berlin, Heidelberg, New York: Springer.
- Orange A., James P. W. & White F. J. 2010: *Microchemical methods for the identification of lichens*, ed. 2. – London: British Lichen Society.
- Parmasto E. 1978. The genus *Dictyonema* (‘Thelephorolichenes’). – *Nova Hedwigia* **29**: 99–144.
- Schmull M., Dal-Forno M., Lücking R., Cao S., Clardy J. & Lawrey J. D. 2014: *Dictyonema huaorani* (*Agaricales*: *Hygrophoraceae*), a new lichenized basidiomycete from Amazonian Ecuador with presumed hallucinogenic properties. – *Bryologist* **117**: 386–394.
- Swinscow T. D. V. & Krog H. 1981: The genus *Phyllopsora*, with a report on the East African species. – *Lichenologist* **13**: 203–247.
- Swinscow T. D. V. & Krog H. 1988: *Macrolichens of East Africa*. – London: British Museum (Natural History).
- Yáñez A., Dal-Forno M., Bungartz F., Lücking R. & Lawrey J. D. 2012: A first assessment of Galapagos basidiolichens. – *Fungal Diversity* **52**: 225–244.

Willdenowia

Open-access online edition www.bioone.org/loi/will  BioOne

Online ISSN 1868-6397 · Print ISSN 0511-9618 · Impact factor 0.721

Published by the Botanic Garden and Botanical Museum Berlin, Freie Universität Berlin

© 2016 The Authors · This open-access article is distributed under the CC BY 4.0 licence