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ARTICLE

Racoleus, a new genus of sterile filamentous lichen-forming fungi from the tropics, with observations on the nomenclature and typification of *Cystocoleus* and *Racodium*

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Abstract: *Racoleus trichophorus* gen. sp. nov. is described for a tropical sterile filamentous lichenized fungus which overgrows various crustose lichens on bark. It shares some features with *Cystocoleus* and *Racodium*, but is unique in having non-lichenized long lateral spines. The genus, which is known from China, the Ivory Coast, and Peru, is of uncertain systematic position; on the basis of morphological similarities, however, it may be referred to "? *Capnodiales* (*incertae sedis*)" *ad interim*. In addition, the nomenclature and typification of the monotypic genera *Cystocoleus* and *Racodium* are reviewed, and lectotypes selected for the type of each. The available information on the ecology and distribution of these two genera is also summarized, and scanning electron micrographs (SEM) of all three species are presented for the first time.

Key words:
Ascomycota
Capnodiales
Coenogonium
lichens
Racoleus trichophorus
scanning electron microscopy
tropical fungi

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INTRODUCTION

The enigmatic sterile filamentous lichens placed in *Cystocoleus* and *Racodium* are characterized by fungal hyphae, which surround a filament of the green alga *Trentepohlia*. The algal filaments determine the shape, and the enveloping hyphal layer is generally only single, the hyphae being parallel to the axis with elongate rectangular cells in *Racodium,* and irregularly twisted around the algal filament in *Cystocoleus*. Both genera comprise a single species, and occur, often together, on inclined to vertical siliceous rocks in recesses where it is cool and there is no direct rain but a high humidity. They are scarcely distinguishable macroscopically. Nevertheless, despite their anatomical similarity, molecular data have now shown that the two genera are not part of a single monophyletic group (Muggia *et al.* 2008). Both were found to belong to *Capnodiales*, with *Racodium rupestre* basal to the clade containing *Cystocoleus ebeneus*, which is close to *Mycosphaerellaceae*. These results have been confirmed by subsequent molecular phylogenetic analyses (Crous *et al.* 2009, Ruibal *et al.* 2009) with *Cystocoleus* now being recognised as a member of *Teratosphaeriaceae* and the more basal *Racodium* as *incertae sedis.*

A similar filamentous method of forming a lichen structure is seen otherwise only in a few genera. In *Coenogonium,* a leaf and bark dwelling member of the *Gyalectaceae*, the photobiont is a species of *Trentepohlia* in most species but can also be a filamentous species of *Physolinum*; in the corticolous sterile genus *Pyrenothrix* (syn. *Lichenothrix*) the filamentous photosynthetic partner belongs to the cyanobacterial genus *Scytonema*; *Ephebe,* a genus mainly of riverside rocks and belonging to the *Ephebaceae,* where the photosynthetic partner is *Stigonema*; and also in some species of the mainly tropical basidiomycete genus *Dictyonema* where the photosynthetic partner also belongs to *Scytonema*. A *Physolinum* forming lichen-like threads in which the algal cells can be in two or more rows, has also been documented from a dimly lit limestone cave, but the fungus involved has not been identified (Davis *et al.* 1989). In general, filamentous lichen associations are extremely rare, and no new genus of filamentous lichens has been described since the 19th century.

Here we describe a third genus of sterile filamentous lichens, *Racoleus,* for a tropical bark-inhabiting species known to R.S. for over 50 years, and differing in the development of long hair-like lateral spines which are not seen

in *Cystocoleus* and *Racodium*, and also in the arrangement of the hyphae and the way they interlock. In addition, we take the opportunity to present some other observations aimed at clarifying and fixing the nomenclature and typification of *Cystocoleus ebeneus* and *Racodium rupestre.*

MATERIALS AND METHODS

Microscopic examinations were made with either a Wild or an Olmpus BH2 research microscope, both fitted with drawing tubes and the latter with a Nikon Coolpix 4500 digital camera and Nomarski interference contrast optics. All measurements were made in water mounts.

Scanning electron micrographs were prepared from air-dried specimens which had been gold-coated during rotation under vacuum, and examined in a Stereoscan (Cambridge Scientific Instruments) operating at 30 kv.

DNA extraction was attempted on a fragment of the Ivory Coast isotype of *Racoleus trichophorus* in GZU, carefully removed under a dissecting microscope, using the method of Cubero *et al*. (1999), but was unsuccessful. Molecular methods and results obtained with *Cystocoleus ebeneus* and *Racodium rupestre* have been reported separately (Muggia *et al*. 2008).

Specimen citations for *Cystocoleus ebeneus* and *Racodium rupestre* are restricted to those discussed in relation to typifications or distributed in exsiccatae.

TAXONOMY

Racoleus R. Sant. & D. Hawksw., **gen. nov.**
MycoBank MB561239

Etymology: From the generic names *Rac*[*-odium*] and [*Cysto*]-*coleus*, with which the genus has some features in common.

Similis *Racodiis rupestris*, sed differt in cellulis verrucosis et in spinulis lateralis non-lichenibus instructis.

Typus: *Racoleus trichophorus* R. Sant. & D. Hawksw. 2011.

Thallus superficial, fluffy, brown, filamentous. *Photobiont Trentepohlia,* single filaments of which are ensheathed by fungal hyphae. *Filaments* suberect to decumbent or spreading, sympodially branched, outer wall undulating and irregularly corrugated, with numerous lateral spines. *Hyphae* in a single layer surrounding the algal filament, orientated vertically along and always parallel to the axis of the filament, brown, septate, thick-walled, uneven and undulate to corrugated, not ornamented. *Spines* arising at broadly acute to almost right angles to the vertical axis, brown, stiff, thick-walled, smooth-walled, not ornamented or corrugated. *Conidiogenous cells* and *conidia* unknown.

Observations: While in the absence of any sexual state and molecular data no definite opinion on the systematic position of the new genus can be expressed, in view of the similarities to both *Cystocoleus* and *Racodium* it seems likely that it will also prove to belong to *Capnodiales*; we therefore suggest that it is listed as "? *Capnodiales* (*incertae sedis*)" until fresh data become available.

Racoleus trichophorus R. Sant. & D. Hawksw., **sp. nov.**
MycoBank MB561240
(Figs 1, 2C–E, 3E–F)

Etymology: the epithet recalls the spiny hair like outgrowths.

Thallis lichenibus cum filamentis 7-9 µm latis, et spinis lateralis arcuatis non-lichenibus usque 50–70 x 1.5–3 µm instructis.

Typus: **Ivory Coast:** Abidjan, in the forest of Banco (*ca* 5 km north of Abidjan), 5° 30' N, 4° 0' W, on trunk of a large tree in a very dark rainforest, overgrowing *Dichosporidium brunnthaleri,* 29 July 1954, *R. Santesson 10344a* (UPS-holotypus; GZU - isotypus).

Thallus superficial, forming dense fluffy patches recalling cotton-wool, to 5 mm diam, pale to fuscous brown, filamentous. *Photobiont Trentepohlia,* single filaments of which are ensheathed by fungal hyphae. *Filaments* suberect to decumbent or spreading on the surface, sympodially branched, 7–9 µm wide, outer wall undulating and irregularly corrugated, reflecting the morphology of the fungal hyphae, with numerous lateral spines. *Hyphae* in a single layer surrounding the algal filament, orientated vertically along and always parallel to the axis of the filament, brown, 2–3 µm wide, septate, septa generally 10–15 µm apart, thick-walled, uneven and undulate to corrugated, corrugations tending to interlink with those of adjacent hyphae, not ornamented. *Spines* arising at broadly acute to almost right angles to the vertical axis, brown, stiff, thick-walled, smooth-walled, not ornamented or corrugated, arcuate to straight, directed outwards and upwards, mainly 50–70 µm in length and 1.5–3 µm wide, gradually tapered towards the tip which is 1–1.5 µm wide, the base expanded into a foot-like cell adhering to the algal filament and measuring 4–7 µm in length. *Conidiogenous cells* and *conidia* unknown.

Ecology: All collections are on tree trunks in dense shade in tropical rain forests and on whitish crustose lichens, notably *Dichosporidium brunnthaleri, D. nigrocinctum, Pyrgillus indicus,* an unidentified arthonioid lichen (probably a species of *Cryptothecia*). The *Racoleus* overgrows the crustose lichens and has no intimate contact with them and is easily removed. We do not consider it lichenicolous, and its occurrence on whitish lichens is perhaps a sampling artefact, possibly due to it being more easily visible against a white background.

Distribution: Africa (Ivory Coast), Asia (China), and South America (Peru). The disjunct localities suggest that the species will prove to be pantropical.

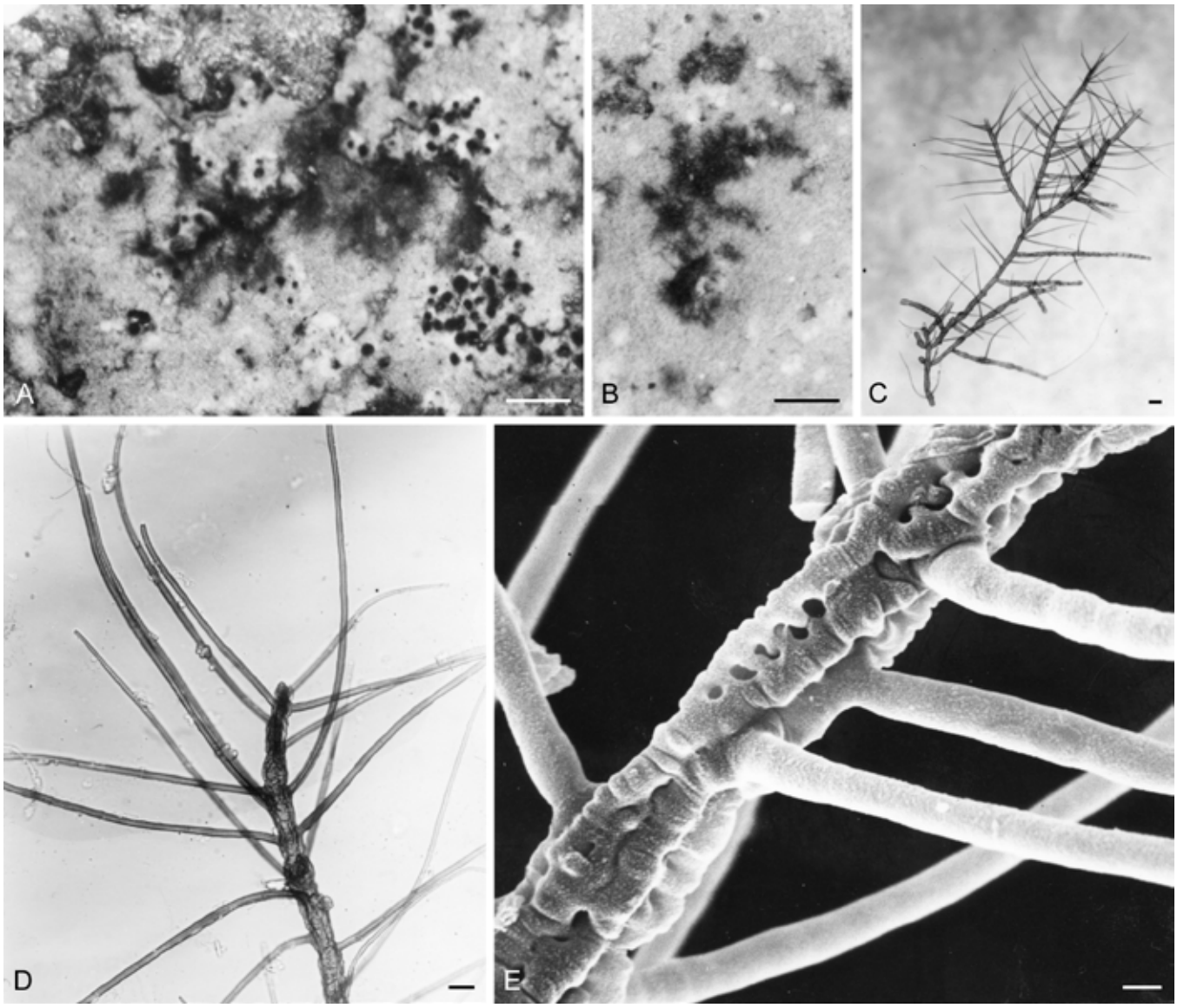

Fig. 1. *Racoleus trichophorus*. **A, B.** Habit, overgrowing *Dichosporidum brunnthaleri* on bark. **C, D.** Detail of lichenized filaments. **E.** SEM micrograph showing the dentate walls of the hyphae over the algal filament and also the characteristic lateral spines. **A-D** (*Santesson 10344a*, UPS – holotype), **E.** (*Santesson P7:4*, UPS). Bars **A** = 225 µm, **B** = 50 µm, **C** = 14 µm, **D** = 7 µm, **E** = 2 µm.

Observations: This new genus differs from both *Cystocoleus* and *Racodium* in the presence of lateral spines (Fig. 1C–E, 2C, E), as well as in its ecology and distribution. In addition, the hyphae surrounding the algal filament differ in that they are orientated parallel to the filament axis with interlocking corrugations, the surface of the hyphae is smooth in the SEM. In *Cystocoleus*, similar corrugation occurs but is less pronounced and the hyphae are more irregularly arranged, tending to wrap around the algal filament rather than be strictly orientated along its axis, giving it a more knobbly appearance (Figs 2A, 3A); the surface of the hyphae also appear ornamented in the SEM (Fig. 3A). In *Racodium* the hyphae lack interlocking corrugations, are thicker-walled than in the other genera, and fused to form elongated rectangular cells orientated vertically along the axis of the algal filament (Fig. 2B) giving an overall smooth rather than a knobbly appearance; the hyphal walls are completely smooth in the SEM (Fig. 3B). The differences between these three genera are summarized in Table 1.

No description of a fungus recalling *Racoleus trichophorus* could be found in the lichenological or wider mycological literature we examined. However, as we are less familiar with phycological publications, we cannot totally exclude the possibility that the dual organism has been given a name in an old algological work.

Santesson (1952: 404) had noted that Dodge (1933: 400) mentioned a filamentous lichen with brown hyphae from Costa Rica, and it is conceivable that could have been this species, but no illustration was provided and the material has not been re-examined. Dodge treated this lichen under the name *Coenogonium heterotrichum* Müll. Arg. (Müller 1893: 162), but as Dodge noted that species has colourless hyphae.

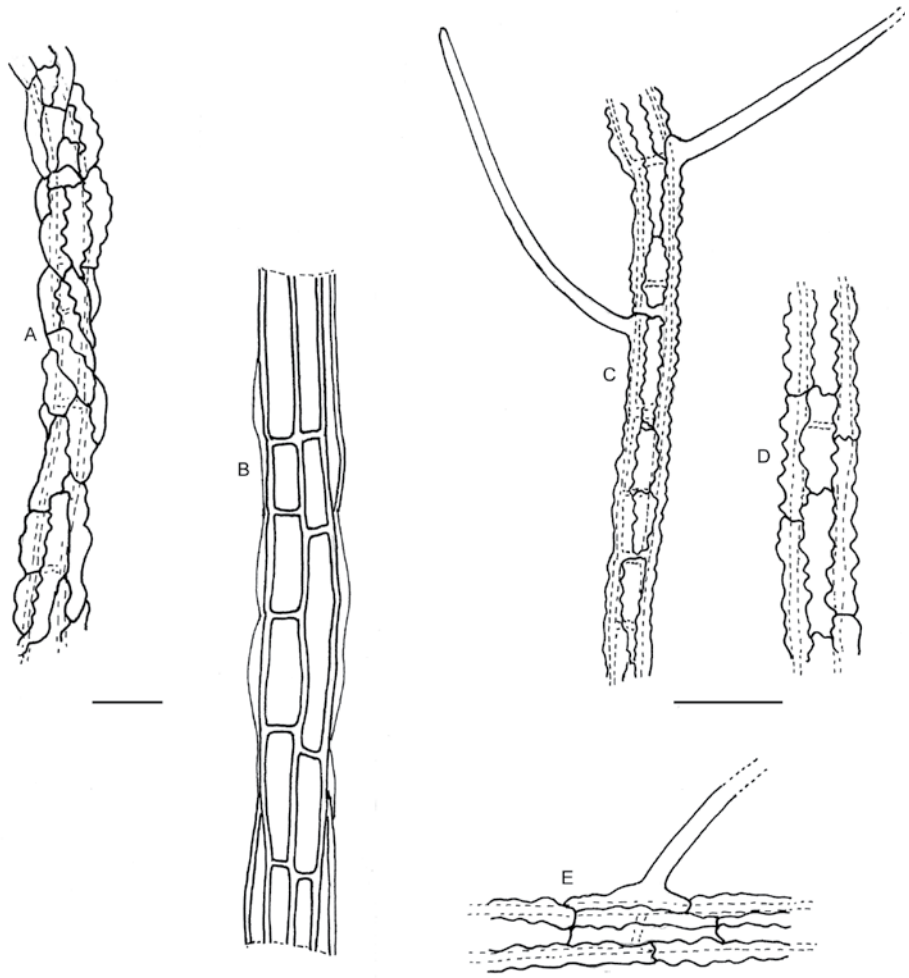

Fig. 2. **A**. *Cystocoleus ebeneus* filament (*Hawksworth*, K(M) 82043). **B.** *Racodium rupestre* filament (*Dalhem*, UME 627 10). **C-E**. *Racoleus trichophorus* (*Santesson,* K(M) 165036. **C**. Filament. **D**. Detail of dentate hyphal walls. **E**. Detail of origin of a lateral spine. Bars = 10 µm.

This was confirmed in the type material (**Costa Rica:** *San José:* San Marcos de Dota, Tonduz, alt. 1200 m, on thallus of *Pyxine* sp., 1890, *Pitt 6115*, G-00293681 – holotype) which has algal filaments with some encrusting hyaline hyphae, some of which grow out away from the filaments, but no regular structure is evident with no brown hyphae or any forming jig-saw like patterns on the surface.

Other specimens examined: **China:** *Yunnan Province*: Xishuangbanna District, Jinghong Co., Menglun, Electric Station, Monsun forest valley, 21 ° 55' N, 101 ° 16'E, alt. *ca* 500-600 m, on a tree in a rather dark forest in a narrow valley, overgrowing an arthonioid lichen (probably *Cryptothecia*), 15 Sept. 1987, *R. Santesson 32036b* (UPS). – **Peru:** *Dept. Loreto*: Iquitos, Explorama Lodge (*ca* 50 km NE of Iquitos), Lake Trail, 3 ° 27' S 72 ° 57' W, alt. *ca* 100 m, on a tree trunk in a tropical rainforest, overgrowing *Dichosporidium nigrocinctum,* 23 Jan. 1981, *R. & B. Santesson P7:4* (K(M) 165036, S, UPS); *Dept. San Martin*: Prov. Lamas, Cerro Blanco (*ca* 63 km on road W-WNW of Tarapoto), *ca* 6 ° 25' S 76 ° 40' W, alt. *ca* 1200 m, on a tree trunk in a dark rainforest, overgrowing *Pyrgillus indicus,* 17 Mar. 1981, *R. Santesson & G. Thor P77:11* (S, UPS).

Cystocoleus Thwaites, *Ann. Mag. nat. Hist., ser. 2* **3**: 241 (1849).

Type: *Cystocoleus ebeneus* (Dillw.) Thwaites 1849.

Cystocoleus ebeneus (Dillw.) Thwaites, *Ann. Mag. nat. Hist., ser. 2* **3**: 241 (1849).
Basionym: *Conferva ebenea* Dillw., *Br. Confervæ*: pl. 101 (1809).
Synonyms: *Croolepus ebeneus* (Dillw.) C. Agardh, *Syst. Alg.*: 36 (1824).
Racodium ebeneum (Dillw.) Fr., *Summa Veg. Scand*. **1**: 122 (1846).
Coenogonium ebeneum (Dillw.) A.L. Sm., *Mongr. Br. Lich*. **2**: 3 (1911).
Coenogonium germanicum Glück, *Flora* **82**: 268 (1896).
Coenogonium schmidlei Simmer, *Allgem. Bot. Zeit*. **5**: 190 (1899).
Byssus nigra auct. p. p., non Huds., *Fl. Anglica*: 487 (1762).
Conferva nigra auct. p. p., non (Huds.) Roth, *Catal. Bot*. **3**: 299 (1805).
Cystocoleus nigra auct. p. p., non (Huds.) Hariot, *J. Bot*. **4**: 91 (1890); as "*niger*".
Coenogonium nigrum auct. p. p., non (Huds.) Zahlbr., *Ann. Naturhist. Mus. Wien* **25**: 241 (1911).

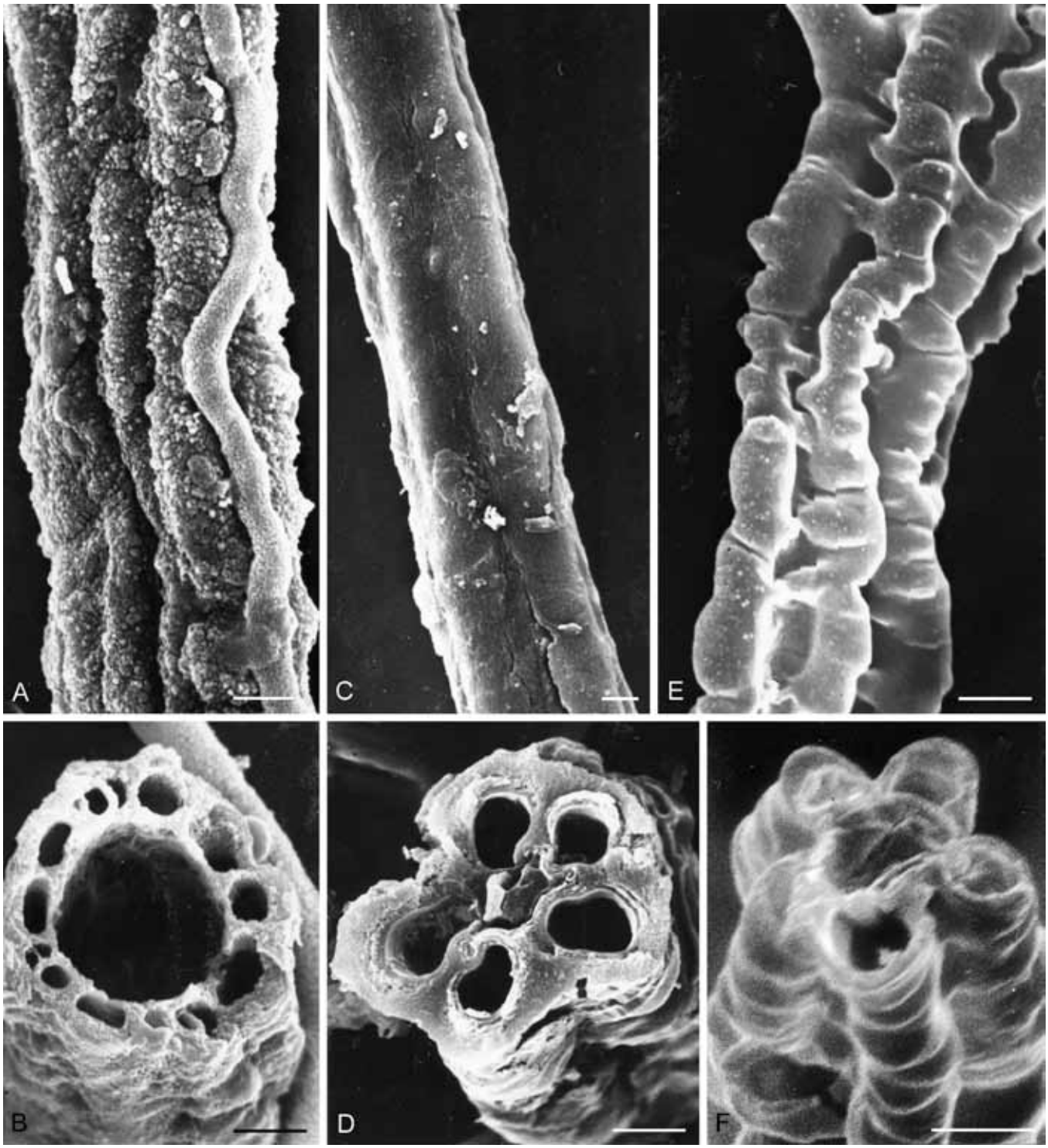

Fig. 3. SEM micrographs of filaments. **A-B**. *Cystocoleus ebeneus* (*Santesson 22339,* UPS). **C-D.** *Racodium rupestre* (*Santesson 14386*, UPS). **E-F**. *Racoleus trichophorus* (*Santesson P7:4*, UPS). **A, C**, and **E,** Surface views. **B, D**, and **F.** Transverse sections. Bars = 2 µm.

Type: **United Kingdom**: *Morayshire*: "On the stump of a tree [*sic*!] in Macbeth's Wood [Brodie] nr Forres", Aug. 1807, *W. J. Hooker* (BM – ***lectotypus hic designatus***).

Descriptions and illustrations (selected): Glück (1896), Jørgensen (1986), Schade (1932), Skuja & Ore (1935), Smith (1926), Smith *et al*. (2009), and Wirth (1995).

Exsiccatae: Anzi, *Lich. Langob.* no. 495 (BM, UPS); *Krypt. Exs. Vindob.* no. 1638 (BM, UPS): Mougeot & Nestler, *Stirps Crypt.* no. 400 (BM, UPS; with *Racodium rupestre*); Rabenhorst, *Lich. Eur.* no. 841 (BM, UPS; with *Racodium rupestre*); and Räsänen, *Lichenotheca Fenn.* no. 360 (BM, UPS).

Table 1. Main anatomical characters distinguishing the genera *Cystocoleus, Racodium,* and *Racoleus*.

Character	*Cystocoleus*	*Racodium*	*Racoleus*
Hyphal arrangement	Twisted	Vertical	Vertical
Hyphal wall corrugation	Present	Absent	Present
Hyphal wall ornamentation	Warted	Smooth	Smooth
Lateral spines	Absent	Absent	Present
Distribution	Temperate/Subboreal	Temperate/Subboreal	Tropical

Number of species: Monotypic.

Ecology: On vertical or somewhat inclined or underhanging siliceous rocks out of direct rain, but also on soil or eroded moss cushions in the subantarctic islands (Jørgensen 1986). The species often grows mixed with *Racodium rupestre.* Ecological, including quadrat, data are provided by several authors, including James *et al*. (1977), Schade (1932), and Wirth (1972). The communities formed, black felt-like patches over extensive areas of rock, are so conspicuous that they have been given the phytosociological name *Racodietum rupestris* Schade 1924. The most commonly associated lichens are species of *Lepraria* and *Leproloma.*

Distribution: Europe (partly mapped by Wirth 1972), North America (Canada, USA), South America (Argentina, Bolivia, Chile, Colombia, Peru), Africa (Kenya), Asia (Mongolia), Australasia (New Zealand, Tasmania), and Antarctica (subantarctic islands).

Observations: We wish to draw attention to the overlooked and painstaking work on the culture of this fungus reported by Skuja & Ore (1935) and illustrated by colour plates. After two months in pure water, fungal hyphae grew free from the algal filaments, spreading irregularly, branching, and retaining a nodulose appearance (*loc. cit.*: table I fig. 4), quite unlike the lateral hairs in *Racoleus.* These workers also found that the *Trentepohlia* also grew out separately when cultured on Beneckeís agar (*loc. cit.*: table I figs 5-8). In fresh material in the field, tufts of hyphae similar to those reported by Skuja & Ore are occasionally encountered.

There is also an interesting observation recorded in an annotation by W Watson (1872-1960) on a mixed collection with *Racodium rupestre* from near Shepley in BM that "When treated with strong nitric acid the *Coenogonium* [i.e. *Cystocoleus*] appears reddish with the filament hyphae twisted, whilst the *Racodium* remains dark with hyphae parallel".

Øvstedal & Smith (2001) comment that: "The Antarctic populations differ somewhat from the North European ones and may be an undescribed taxon" but do not elaborate further, and no divergences were noted by Lindsay (1971). Material from Antarctica was not included in the molecular study of Muggia *et al*. (2008).

Glück (1896), in a critical but little-cited study, distinguished *Coenogonium germanicum* from *Cystocoleus rupestris* on the basis of the differences in the arrangement of the hyphae which he also illustrated in transverse sections. He cultured the algal partners, which he referred to different species of *Trentepohlia*. However, Glück's critically executed illustrations leave no doubt as to the application of his species name; one of these could be designated as lectotype (e.g. Pl. 7 figs 1–5) if no original material can be located in HEID or M where specimens could be located. Simmer (1899) illustrated *Coenogonium germanicum* and compared it with his newly described *C. schmidlei*; both had the irregular hyphal arrangements typical of *Cystocoleus ebeneus,* and he seems to have separated them because of the proliferation of non-lichenized hyphae in *Coenogonium germanicum*. Original material of *C. schmidlei*, ex-herb. Reimers in B, examined by R.S. and L.T. is indeed *Cystocoleus ebeneus,* so confirming the synonymy.

Lindau (1913, 1923) used Glück's name in the sense of *Cystocoelus ebeneus*, according to his description, and Zahlbruckner (1924) listed it as a synonym of the present species.

Lindsay (1971) commented that *Coenogonium kerguelense*, described by Dodge (1966) from Kerguelen Island, could either be a *Coenogonium* or the *Cystocoleus*. Through the courtesy of Alan Fryday, D.L.H. was able to examine photomicrographs of one of the two syntypes (Cote 1000, tapissant les alveoles de la face N.E. du Mont Campbell, 6 Nov. 1952, *Albert de la Rue # 64*) in FH. This comprised a creamy yellowish buff felted colony which microscopically comprised algal filaments *ca* 20 µm wide with an encrusted surface. No distinctive *Cystocoleus* or other dematiaceous hyphae were apparent in the photomicrographs, and the width of the filaments is outside the normal 19-15 µm range of *C. ebeneus*. Dodge's name consequently appears to be based on a colony of a non-lichenized *Trentephohlia* species.

Nomenclature: The name *Byssus nigra* is of uncertain application and never appears to have been formally typified, but some authors have used the epithet for *Cystocoleus ebeneus* in the past. The name was introduced by Hudson (1762) for a stiff filamentous organism found on calcareous rocks near Ingleborough and Settle in Yorkshire; a most improbable habitat for this lichen. However, he subsequently amended the notes on ecology and distribution to "in rupibus et saxis grandioribus in boreali parte Angliae et in Wallia" and referred to it as the "Anglis black byssus" (Hudson 1778). *Byssus nigra* was featured as "Black rock byssus" in *English Botany* (Smith & Sowerby 1800), with a reference back to

Hudson (1778), but not Hudson (1762) from the page number cited (i.e. p. 606 and not 487), and some earlier usages and polynomials. The original material on which Sowerby's illustration was based could not be located in BM, but an index to the original plates and specimens held there gives the modern name as *Racodium rupestre* and not *Cystocoleus ebeneus* or any of its synonyms.

Hudson's binominal was listed as a synonym of *Conferva ebenea* by Dillwyn (1809) when introducing that name, but, interestingly from his citing "p. 606" he was also referring to the second edition of Hudson's work as had Smith – who is not mentioned by Dillwyn. Smith's text indicates that it is most likely he was dealing with either *C. ebeneus* or *Racodium rupestre* from his description of the habitat and comment that "it is always found on a micaeous or quartzose stone". It appears to have been applied to both species by early authors and so is best listed as a "pro parte" usage under each pending any formal typification.

A complication in the nomenclatural situation arises from the existence of a nomenclaturally independent name *Conferva nigra* Huds. 1762 based on a different type – indeed, that taxon was described as abundant on the seashore in Yorkshire. Dillwyn (1809) indicated that he had seen authentic specimens of that taxon, and considered to represent a seaweed which he called *Conferva atro-rubescens* Dillw. 1809 – a red alga for which the current name is *Polysiphonia nigra* (Huds.) Batters 1902, following neotypification of this binominal of Hudson's by Maggs & Hommersand (1993). The existence of this name means that Dillwyn's citing of *Byssus nigra* as a synonym does not render *Conferva ebenea* as superfluous and illegitimate under Art. 52.1 as a combination of *Byssus nigra* into *Conferva* would have created a homonym to be rejected under Art. 53.1.

In introducing the generic name *Cystocoleus,* "with the sanction of my friend, the Rev. M. J. Berkeley", Thwaites (1849) listed "*Byssus nigra*, *E.B*. t. 702!" as a synonym. However, as he did not refer to Hudson at all and it is clear that he was listing the *English Botany* usage (see above), rather than treating the name as a synonym. In this, Thwaites was perhaps following Hooker (1844: 385) who did not mention Hudson and attributed the binominal *Byssus nigra* only to "Sm." in his index (Hooker 1844: 422). The legitimacy of Thwaites' combination is not therefore threatened by Hudson's name as he did not treat it as a synonym, merely listing the usage in *English Botany*.

We see no nomenclatural obstacle to the continued use of the name *Cystocoleus ebeneus*. If Hudson's original material or a later typification of his name were discovered, and that indeed proved to belong to this taxon or to *Racodium rupestre*, the epithet should be proposed for rejection in order to maintain whichever of the two currently used names was threatened.

Typification: In the original account of Dillwyn (1809), three specimens were mentioned: (1) "*Dillenius.* – On Rocks in the Highlands. *James Brodie, Esq.*"; (2) On the stump of a dead tree in Mackbeth's Wood, at Brodie, near Forres, N.B. *W.J. Hooker, Esq.*"; and (3) "On Birch trees, at Coftefy near Norwich. *Mr. S. Wilkins.*" The second collection is present in BM (labelled "On the stump of a tree in Macbeth's Wood nr Forries [sic!], Aug. 1807"), and despite the unusual habitat reported it is an appropriate lectotype for Dillwyn's name. However, the specimen is not on a piece of bark or wood, does not have any evident adhering woody fragments, but does have some granitic crystals intermixed; this causes us to doubt that it was growing directly on a tree-stump. That Thwaite's (1849: pl. 8 figs 1–3) actually illustrated a specimen of *Racodium rupestre* does not affect the application of the generic name as "Conferva ebenea*, Dillw.* t. 101" was given as the basionym of *Cystocoleus ebeneus.*

Racodium Fr., *Syst. Mycol.* **3**: 229 (1829); *nom. cons.*
Synonyms*: Rhacodium* Spreng., *Linn. Syst. Veg., 16th edn,* **4**: 557 (1827); *orth. var.*, *nom. illegit*. (Arts. 52.1, 60.1)
Rhacodiopsis Donk, *Persoonia* **8**: 276 (1975); *nom. illegit*. (Art. 52.1).
Non *Racodium* Pers., *Neues Mag. Bot.* **1**: 123 (1794) : Fr., *Syst. Mycol.* **1**: xlvi (1821); *nom. rej.*

Type: *Racodium rupestre* Pers. 1794.

Racodium rupestre Pers., *Neues Mag. Bot.* **1**: 123 (1794).
Synonyms: *Byssus rupestris* (Pers.) DC., *in* Lamarck & DeCandolle, *Fl. Franç*. 3rd edn **2**: 592 (1805).
Dematium rupestre (Pers.) Nees, *Syst. Pilze*: 76 (1816).
Cystocoleus rupestris (Pers.) Rabenh., *Krypt.-Fl. Sachsen* **2**: 75 (1870).
Rhacodiopsis rupestris (Pers.) Donk, *Persoonia* **8**: 276 (1975).
Byssus nigra auct. p. p., non Huds., *Fl. Anglica*: 487 (1762).
Conferva nigra auct. p. p., non (Huds.) Roth, *Catal. Bot*. **3**: 299 (1805).
Cystocoleus nigra auct. p. p., non (Huds.) Hariot, *J. Bot*. **4**: 91 (1890); as "*niger*".
Coenogonium nigrum auct. p. p., non (Huds.) Zahlbr., *Ann. Naturhist. Mus. Wien* **25**: 241 (1911).

Type: **United Kingdom**: *Wales*: "*Racodium rupestre* P. *Byssus nigra* Engl. Bot. Wales. Hb. Pers" (L 910.263-1045 pro parte – ***lectotypus hic designatus***).

Descriptions and illustrations (selected): Brodo *et al*. (2001), Glück (1896), Smith (1926), Smith *et al*. (2009), Thwaite's (1849, as *Cystocoelus ebeneus*).

Exsiccatae: De Thümen, *Mycotheca Univ.* no. 198 (BM, UPS); Kunze & Lahm, *Myc. Exs.* no. 25 (BM); Mougeot & Nestler, *Stirps Crypt.* no. 400 (BM, UPS; with *Cystocoleus ebeneus*); Rabenhorst, *Lich. Eur.* no. 841 (BM, UPS; with *C. ebeneus*); Moberg, *Lich. Sel. Upsal.* no. 45 (BM, UPS); Tobolewski, *Lichenotheca Polon.* fasc. 3 no. 6 (BM): Vězda, *Lich. Sel. Exs.* no. 450 (BM, UPS).

Number of species: Monotypic.

Ecology: As for *Cystocoleus ebeneus*.

Distribution: Europe (most countries), North America (Canada, USA), South America (Argentina, Chile), Africa (South Africa), Asia (Japan), and Australia (Tasmania).

Observations: Zahlbruckner (1905, 1926), Vainio (1921), Dodge (1933) and Christiansen (1947) mention the alga in *Racodium* as belonging to the genus *Cladophora* rather than to *Trentepohlia*, but the basis for this is obscure. In order to resolve this matter, the alga was isolated into pure culture by Koch (1962) who found it to be a member of the *Trentepohlia aurea* group.

Nomenclature: The nomenclatural issues surrounding this name are complex. Riedl (1968) and Hawksworth (1970) independently noted that "*Racodium*" was being used for a sterile filamentous lichen by lichenologists, and for a quite different non-lichenized hyphomycete by mycologists. These authors both concluded that the name should be typified by the lichenized element (i.e. *R. rupestre*) rather than the conidial fungus (i.e. *R. cellare* Pers. 1794), but in a posthumous publication Donk (1975) disagreed. In order to resolve the matter, Hawksworth & Riedl (1977) proposed the name for conservation for the lichenized fungus, their proposal was accepted and it is now list as conserved in the *Code*. The name *Rhinocladiella ellisii* D. Hawksw. 1977 was introduced for the conidial state of the "cellar fungus". However, sterile material of the same species, which does not form conidia, had been referred to as *Zasmidium cellare* (Pers.) Fr. 1829 and was considered a synanamorph. De Hoog (1979) did not consider these names as synanamorphs as the conidiogenous cells were micronematous and not markedly different from the sterile hyphae and consequently commend the use of *Zasmidium cellare* for this fungus. This interpretation has been followed in the molecular phylogenetic study of Arzanlou *et al*. (2007), who found that it clustered with *Ramichloridum* species and published photographs of the conidiogenous cells and conidia.

Donk (1975) noted that "*Rhacodium*" was orthographically the more correct spelling of the generic name, as derived from the Greek "ραχος" (rag), but the form "*Racodium*" is that conserved in accordance with general usage.

Vainio (1921: 238) listed *Coenogonium germanicum* as a synonym of *Racodium rupestre,* but the original illustrations of Glück (1896) and those of Simmer (1899) are of *Cystocoleus ebeneus* as interpreted here.

Henssen & Jahns (1973) evidently regarded this species as congeneric with *Cystocoleus*, but did not explain why; molecular data show that view to be unsupportable.

Typification: The typification of the name *Racodium rupestre* has not been addressed and a formal typification published. In order to clarify the issue, the specimens in Persoon's collection in L were studied by R.S. in 1956 who did not publish his results at that time. R.S. found that there were four specimens under this name:
(1) L 910.264-801: "210 *Racodium rupestre* Pers. Syn. in rupibus umbrosis Moug. in hb. Pers.". This is *Cystocoleus ebeneus* (with sparse *R. rupestre*).
(2) L 910.263-1045: "*Racodium rupestre* P. *Byssus nigra* Engl. Bot. Wales. Hb. Pers." This is *R. rupestre* (with sparse *C. ebeneus*).
(3) L 910.264-922: "*Racodium rupestre* Pers. Hb. Pers.". This is *C. ebeneus* with no *Racodium*.
(4) L 910-264-701: "No. 75. An Sandhalen. M. Aug. *Racodium rupestre.* Hb. Pers." This consists only of non-lichenized fungal hyphae.

Three of the collections were mixed with *Cystocoleus ebeneus,* and it is evident that in practice Persoon applied *Racodium rupestre* in a sense embracing both genera. This is hardly surprising as the species commonly grow mixed together and require microscopic study to separate them with confidence. In order to fix the application of Persoon's name in the sense in which it is currently used, L 910.263-1045 is consequently designated as lectotype here as that is the only one in which the *Racodium* predominates.

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