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Candelariales: Candelariaceae

Cover image: *Candelaria concolor*, on a cut trunk of *Fraxinus excelsior*, Upton Marshes, Norfolk.

Revisions of British and Irish Lichens is a free-to-access serial publication under the auspices of the British Lichen Society, that charts changes in our understanding of the lichens and lichenicolous fungi of Great Britain and Ireland. Each volume will be devoted to a particular family (or group of families), and will include descriptions, keys, habitat and distribution data for all the species included. The maps are based on information from the BLS Lichen Database, that also includes data from the historical Mapping Scheme and the *Lichen Ireland* database. The choice of subject for each volume will depend on the extent of changes in classification for the families concerned, and the number of newly recognized species since previous treatments.

To date, accounts of lichens from our region have been published in book form. However, the time taken to compile new printed editions of the entire lichen biota of Britain and Ireland is extensive, and many parts are out-of-date even as they are published. Issuing updates as a serial electronic publication means that important changes in understanding of our lichens can be made available with a shorter delay. The accounts may also be compiled at intervals into complete printed accounts, as new editions of the *Lichens of Great Britain and Ireland*.

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Candelariales: Candelariaceae

including the genera *Candelaria* and *Candelariella*

by

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CANDELARIACEAE Hakul. 1954

Thallus crustose, placodioid, squamulose, minutely fruticose, small-foliose or peltate, yellow-green to chrome- or brownish-yellow or grey, sometimes soreciate or blastidiate; upper surface corticate, lower surface corticate or not, then arachnoid, sometimes with rhizines, K–. **Photobiont** chlorococcoid. **Ascomata** apothecia, laminal, sessile, lecanorine or rarely biatorine, usually bright yellow. **Thalline margin** usually persistent, **true exciple** rudimentary. **Epithecium** yellow-brown, granular. **Hymenium** colourless, I+ blue. **Hypothecium** colourless. **Hamathecium** of paraphyses, the apices swollen, unbranched. **Asci** 8- or multispored, with an apical dome that is K/I+ blue only in the lower part and penetrated by a broad apical cushion. **Ascospores** colourless, ellipsoidal, aseptate. **Conidiomata** pycnidia, laminal, immersed within raised warts on the thallus surface; the wall colourless. **Conidiogenous cells** elongate bottle-shaped, arising in groups on branched conidiophore cells. **Conidia** ellipsoidal, aseptate, colourless.

Characterized especially by its chemistry, with pulvinic acid derivatives. It and the Pycnoraceae are the only families of the Candelariales, which occupies an isolated position within the Lecanoromycetes (Miądlikowska *et al.* 2006, 2014), within an independent subclass (the Candelariomycetidae; Lücking *et al.* 2017) or within its own class, the Candelariomycetes (Voglmayr *et al.* 2018).

Four genera are currently recognized (Lücking *et al.* 2017), distinguished in morphological terms primarily by thallus form. Indications are that not all are monophyletic and that *Candelariella* in particular is heterogenous (Yakovchenko *et al.* 2017, Kondratyuk *et al.* 2020), but more research is needed to confirm their relationships. Multispored asci are typical of some species in several genera of the Candelariaceae, but this feature appears to have evolved on multiple occasions and both 8- and multispored have been reported within individual apothecia (Nimis *et al.* 1989).

Literature:

Kondratyuk *et al.* (2020), Lücking *et al.* (2017), Miądlikowska *et al.* (2006, 2014), Nimis *et al.* (1989), Poelt (1974), Voglmayr *et al.* (2018), Westberg *et al.* (2007, 2011), Yakovchenko *et al.* (2017).

- 1 Thallus minutely foliose, markedly incised, loosely attached and often with rhizines.....*Candelaria*
 Thallus placodioid to squamulose, ± continuously attached to the substratum*Candelariella*

CANDELARIA A. Massal. (1852)

Thallus squamulose, minutely fruticose or small-foliose, often rosette-forming, usually with narrow repeatedly branching lobes, yellow-green to chrome-yellow, upper surface corticate, lower surface corticate or not, then arachnoid, sometimes with rhizines, K–. **Photobiont** chlorococcoid. **Soralia** or **blastidia** present in some species. **Upper and lower cortices** (where present) composed of isodiametric cells. **Ascomata** apothecia, laminal, sessile, lecanorine. **Thalline margin** persistent. **True exciple** rudimentary. **Epithecium** yellow-brown, granular. **Hymenium** colourless, I+ blue. **Hypothecium** colourless. **Hamathecium** of paraphyses, the apices swollen, unbranched or rarely branched and anastomosing. **Asci** 8- or multispored, *Candelaria*-type, with an apical dome K/I+ blue only in the lower part and penetrated by a broad apical cushion. **Ascospores** colourless, ellipsoidal, aseptate, biguttulate. **Conidiomata** pycnidia, laminal, immersed within raised warts on the thallus

surface; wall colourless. **Conidiogenous cells** elongate bottle-shaped, arising in groups on branched conidiophore cells. **Conidia** ellipsoidal, aseptate, colourless. **Chemistry**: calycin and pulvinic dilactone. **Ecology**: on nutrient-rich bark, rarely on rock.

Characterized by bright yellow foliose, usually rosette-forming thalli with narrow branching lobes, sometimes reduced to squamules. Apothecia are rare in both British species.

Literature:

Gilbert & James (2009a), Westberg & Arup (2010, 2011), Westberg *et al.* (2011).

- 1 Thallus lobes 0.2-0.5 mm broad, neatly branched with a smooth, flattened surface, forming small, adnate rosettes or cushions; lower cortex present, smooth*concolor*
 Thallus lobes usually 0.1-0.3 mm broad, squamulose or minutely foliose to fruticose, often raised and contorted, forming poorly defined coalescing rosettes; lower cortex absent, arachnoid.....*pacifica*

Candelaria concolor (Dicks.) Stein (1879)

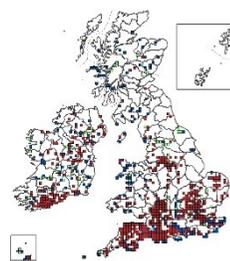
Thallus typically forming small, discrete suborbicular cushions <1 cm across, irregularly spreading, sometimes coalescing or in scattered fragments, ± closely appressed, occasionally dissolved into coarse, ascending granules; lobes flattened, finely divided, *ca* 1 mm long, 0.2–0.5 mm broad, the surface flat or ± wavy, often somewhat raised and fan-like, the margins distinctly crenulate, ± overlapping, entire, often becoming blastidiate or coarsely soresidiate, bright yellowish green to chrome-yellow above; lower surface corticate, matt, almost white beneath; rhizines scattered, unbranched, white. Apothecia 0.4–1 mm diam., rare; disc dull greenish-orange or pale brownish-yellow; thalline margin smooth, becoming ± uneven-granular with age, concolorous with the disc. Ascospores 6–14 × 4–6 μm, aseptate but biguttulate. Conidiomata pycnidia, *ca* 100 μm diam., rare; conidia 1.8–2.7 × *ca* 1 μm. Thallus C–, K–, KC–, Pd–, UV± dull orange. **BLS 0289**.

On nutrient-rich bark of well-lit, wayside broad-leaved trees, especially *Acer*, *Fraxinus*, *Salix* and *Ulmus*, also on wooden fences, occasionally on nutrient-enriched rocks and walls; local but spreading, likely due to its tolerance for nitrogen. Throughout Britain and Ireland, especially in the south.

Forming small delicate yellow intricate patches, often in the branch axils and rain tracks of tree trunks. Irregular cushions may resemble *Xanthoria ulophyllodes* which is less delicate in appearance and has a deeper orange, K+ purple thallus.

The plurivorous *Illosporiosis christiansenii* (B.L. Brady & D. Hawksw.) D. Hawksw. (2001) has been found on this host.

LC



Candelaria pacifica M. Westb. & Arup (2011)

Thallus small, very variable, of scattered, minute squamules or minutely foliose or subfruticose, rarely forming weakly defined rosettes to 5 mm diam., usually coalescing to form extensive colonies. Lobes mostly raised to erect, branched, to 0.5 (–2) mm long and 0.1–0.3 mm broad, shade forms typically consisting of erect, very narrow lobes, lemon yellow (in shade) to bright yellow, smooth to somewhat pulverulent, with copious blastidia 30–100 μm diam. formed primarily from the lobe margins, sometimes almost completely dissolved into blastidia with few visible lobes; thallus corticate above, cortex very uneven, lower surface irregular and ecorticate, arachnoid, white to greenish; rhizines rarely present, minute. Apothecia and conidiomata not known in European material. Thallus C–, K–, KC–, Pd–, UV± dull orange. **BLS 2578**.

On nutrient-enriched bark of broad-leaved trees, sometimes also on worked timber. S.E. England, Shropshire, Scotland (Angus, E. Inverness), probably under-recorded.

Similar to *C. concolor* but with more delicate and copiously blastidiate thallus lobes, which are often coalesced into crusts. Colonies which are densely blastidiate with inconspicuous lobes could be overlooked as well-developed thalli of *Candelariella reflexa*.

NE



CANDELARIELLA Müll. Arg. (1894)

Thallus crustose, granular, nodular to warted, indistinctly or sometimes markedly placodioid and then lobed at the edge, yellow, yellow-orange, yellow-green or rarely citrine. **Photobiont** chlorococcoid. **Cortex** pseudoparenchymatous. **Ascomata** apothecia, sessile. **Thalline margin** thin, persistent. **True exciple** indistinct. Disc bright yellow or rarely citrine, usually flat. **Hypothecium** colourless. **Epithecium** yellow-brown, granular. **Hymenium** 50-75 μm tall, colourless, I+ blue. **Hamathecium** of paraphyses, the apices not or only slightly swollen, mostly unbranched or a few sparingly branched. Asci clavate, 8- to 32-spored, *Candelaria*-type. **Ascospores** colourless, ellipsoidal or rarely spherical, \pm cylindrical with rounded ends, straight or curved, or teardrop-shaped, aseptate, often biguttulate. **Conidiomata** pycnidia, immersed; wall colourless. **Conidiogenous cells** elongate-bottle-shaped. **Conidia** ellipsoidal or bacilliform. **Chemistry**: pulvinic acid derivatives. **Ecology**: varied, favoured by mild eutrophication, some species frequent in urban areas. A few species lichenicolous.

Most yellow, crustose lichens with a K- thallus will belong to this genus. Occasionally strongly citrine-green-coloured chemotypes arise through the suppression of calycin.

Candelariella arctica (Körb.) R. Sant. (syn. *C. crenata* (Nyl.) A.L. Sm.) has not been correctly reported from Britain and Ireland, and GBI records of *C. reflexa* (Nyl.) Lettau appear to refer to *C. xanthostigmoides* (see below). A key to lichenicolous fungi on species of *Candelariella* may be found in Ohmura *et al.* (2014). Diederich (2021) contributed a study of *Intralichen* species, centred on those parasitizing apothecia of *Candelariella*.

Literature:

Gilbert & James (2009b), Westberg (2007a, b, c), Westberg *et al.* (2011), Westberg & Clerc (2012), Yakovchenko *et al.* (2017).

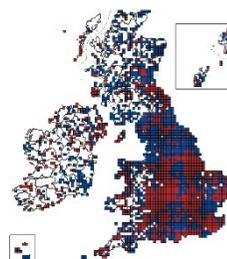
- 1 Lichenicolous, forming scattered yellow apothecia on the thallus of *Lecanora* (*Myriolecis*) *populicola* growing on *Populus tremula* *superdistans*
On rock, bark, soil or man-made substrata 2
- 2(1) Thallus placodioid, \pm orbicular, with closely appressed, radiating marginal lobes *medians*
Thallus crustose, minutely squamulose or indistinct, without marginal lobes 3
- 3(2) Soredia abundant, arising from margins of minute, \pm flattened, \pm crenate granules *xanthostigmoides*
Soredia absent; thallus of corticate granules or subsquamulose 4
- 4(3) Thallus mostly inconspicuous; apothecia frequent, scattered; asci 8-spored *aurella*
Thallus distinct, coarsely granular to subsquamulose; apothecia absent to numerous, often contiguous; asci 12- to 32-spored 5
- 5(4) Thallus granules spherical, 10–50 μm diam., forming a uniform thin continuous crust.....*xanthostigma*
Thallus granules \pm flattened or rounded, 100–500 μm diam., often appearing subsquamulose 6
- 6(5) Thallus bright golden-yellow, \pm continuous, uniform or coarsely cracked, of contiguous coarse spherical granules *coralliza*
Thallus dull yellow-orange, of scattered to compacted, \pm flattened, rounded to crenate, somewhat extended areoles *vitellina*

Candelariella aurella (Hoffm.) Zahlbr. (1928)

LC

Thallus thin, of scattered yellow to green-yellow convex granules 0.5–1.5 mm diam., sometimes inconspicuous; prothallus thin, continuous, dark grey to black, often extensive and dominant especially in urban areas. Apothecia frequent, 0.2–1.2 mm diam., discrete, \pm regularly dispersed or sometimes more crowded, yellow; thalline margin \pm entire. Asci 8-spored. Ascospores 10–18 \times 5–6 μm , cylindrical to ellipsoidal, straight or curved. **BLS 0291**.

On man-made basic substrata, concrete, mortar and asbestos-cement, rarely on hard, dust-impregnated wood and bark, occasionally on natural limestone outcrops;



abundant in lowland Britain especially in urban areas, local elsewhere.

The apothecia are frequently the most conspicuous feature on a thin grey to black (though sometimes inconspicuous) prothallus. A bright citrine-green chemotype, referred to f. *smaragdula* Szat. (1931) [syn. f. *heidelbergensis* (Nyl.) P. James], occasionally occurs interspersed with normal-coloured thalli.

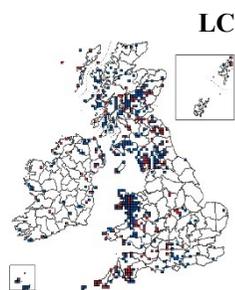
Intralichen lichenicola has been recorded as inhabiting the apothecia (see below under *C. vitellina*).

Candelariella coralliza (Nyl.) H. Magn. (1935)

Like *C. vitellina* but the thick, coarsely rimose-cracked thallus surface is entirely composed of \pm spherical, granular-coralloid granules 0.05–0.3 mm diam. Apothecia 0.6–1.5 mm diam., rare, with a granular thalline margin. Ascospores 10–14 \times 4.5–6 μ m, cylindrical-ellipsoidal, some \pm curved. **BLS 0292**.

Confined to natural siliceous outcrops or isolated boulders frequently used as bird perches, especially in upland areas; it is frequent on sarsen stones and basalt. Throughout Britain and Ireland, but local and scarce in many areas.

Consistently bright golden-yellow without any hint of orange. *Candelariella coralliza* may occur with *C. vitellina* but is not an urban species and has a much more restricted range of habitat. It has been regarded as an ecotype of *C. vitellina* by some authors, but was shown to be distinct phylogenetically by Marthinsen *et al.* (2019). The two species never occur side-by-side, but can be found in the same habitat.

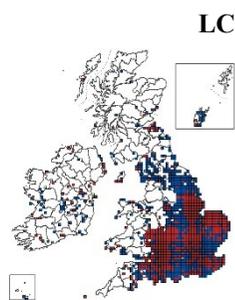


Candelariella medians (Nyl.) A.L. Sm. (1918)

Thallus placodioid, to 3 cm diam., orbicular, radiating, the marginal lobes \pm contiguous, yellow, the surface \pm scabrid or pruinose, the centre granular-areolate to minutely coralloid-isidiate, concolorous or commonly greyish compared with the margin; lobes 0.3–1 mm broad, mostly contiguous, discrete to overlapping, flattened to \pm convex. Apothecia small, 0.3–1.2 mm diam., occasional, dull yellow, flat to slightly convex with a smooth to crenulate margin. Asci 8-spored. Ascospores 11–17 \times 4–6 μ m, aseptate or occasionally appearing 1-septate, rather variable, ellipsoidal, cylindrical, tear-drop- or slipper-shaped. **BLS 0296**.

In shaded to sunny nutrient-rich man-influenced calcareous sites such as churchyards, villages and walls; rare in natural sites on nutrient-rich rock and calcareous bird perches. S. and E. England (abundant), extending to Wales (scarce), N. England and rare in Scotland except in the south-east; scattered in Ireland.

In shaded habitats the thallus is often pale green-grey with only a hint of yellow at the lobe ends. *C. medians* resembles *Caloplaca (Calogaya) decipiens*, which is orange in colour, K+ purple and has delimited soralia. A citrine-green chemotype, f. *steepholmensis* O. Gilbert (1981) occasionally occurs among normal-coloured thalli.



Candelariella superdistans (Nyl.) Malme (1911)

Thallus crustose, granular, areolate or continuous, grey to black but most often inconspicuous on the host thallus. Apothecia small, 0.2–0.8 mm diam., yellow, scattered, lecanorine with a flat to convex disc, the margins eventually excluded; hymenium 50–60 μ m high, paraphyses with swollen tips. Asci 8-spored. Ascospores 16–22 \times 5–7 μ m. Pycnidia not seen. **BLS 2326**.

Lichenicolous on the thallus and apothecia of *Lecanora (Myriolecis) populicola* on bark of *Populus tremula* (aspen). Not a nitrophile. Cairngorms (E. Inverness-shire, Moray and S. Aberdeenshire), also in the central Highlands (E. Perthshire). Rarely reported, but found to be quite frequent in suitable habitat in recent targeted surveys.

With its small, scattered yellow apothecia (no hint of orange) and an inconspicuous thallus, this species appears superficially similar to *Candelariella aurella*. The lichenicolous habit is diagnostic.



Candelariella vitellina (Hoffm.) Müll. Arg. (1894)

Thallus yellow, orange to brown-orange (in dusty habitats or on treated timber), continuous and coarsely cracked or in scattered patches, usually rather thick, composed of dispersed to crowded small convex, often somewhat flattened, rounded to crenate subsquamulose granules 0.5–2 mm diam. Apothecia frequent, 0.5–1.5 mm diam., flat; margin prominent, persistent, smooth to crenulate; disc greyish to bright yellow, sometimes darkening when

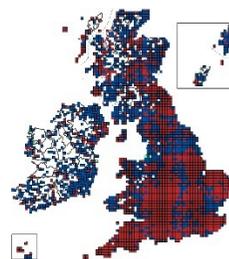
LC

old; thalline margin smooth, crenulate, nodular. Asci (12-) 16- to 32-spored. Ascospores $9\text{--}15 \times 3.0\text{--}6.5 \mu\text{m}$, aseptate or appearing 1-septate. Pycnidia frequent, $80\text{--}100 \mu\text{m}$ diam.; conidia $2.5\text{--}3 \times 1\text{--}1.5 \mu\text{m}$, bacilliform. **BLS 0298**.

On siliceous and calcareous rocks, walls, wood, bark, tarmacadam and occasionally soil, rusting iron or stained glass, particularly well-developed in nutrient-enriched and dusty, man-made habitats; also associated with bird-perching rocks on natural limestone outcrops; often abundant. Throughout Britain and Ireland in suburban and rural areas.

A very variable species in which the thallus, especially when young, may be reduced to a thin inconspicuous \pm continuous crust of scattered to contiguous, convex to spherical granules or compacted into small shortly lobulate clusters of often fertile subsquamulose rosettes; the colour ranges from yellow to dull deep orange. A citrine-green chemotype, f. *flavovirella* (Nyl.) A. Henderson (1981) occasionally occurs in association with normal-coloured thalli but is not persistent. It has a scattered distribution. *Candelariella coralliza* forms thick areolate-cracked golden-yellow crusts on rock.

Moribund thalli occasionally host *Sarcopyrenia cylindrospora* in E. England and E. Scotland. *Carbonea vitellinaria* is occasionally lichenicolous (commensal) on the thallus. *Candelariella vitellina* is the type host of the hyphomycete *Intralichen lichenicola* (M.S. Christ. & D. Hawksw.) D. Hawksw. & M.S. Cole (2002) [syn. *I. christiansenii* (D. Hawksw.) D. Hawksw. & M.S. Cole (2002)], mostly occurring in the hymenium of the host (Diederich 2021). *Tremella candelariellae* Diederich & Etayo (1996) has been recorded from E. Suffolk but is likely to be more widely occurring. There are also single records of *Endococcus propinquus* (Körb.) D. Hawksw. (1979) and *Lichenodiplis lecanorae* (Vouaux) Dyko & D. Hawksw. (1979) on this host.

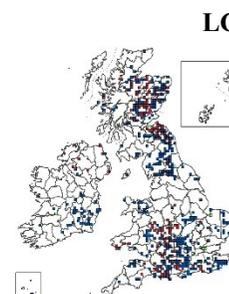


Candelariella xanthostigma (Pers. ex Ach.) Lettau (1912)

Thallus entirely of corticate granules, $70\text{--}100 \mu\text{m}$ diam., which form a \pm uniform effuse continuous dull orange-yellow crust. Apothecia $0.2\text{--}0.9 \text{mm}$ diam., rare, concolorous, scattered. Asci 12- to 32-spored. Ascospores $9\text{--}12 \times 4\text{--}5 \mu\text{m}$, cylindrical or ovoid. **BLS 0299**.

Often forming streaks on the vertical trunks of large old rough-barked well-lit trees, especially *Acer*, *Fraxinus* and *Ulmus*, in parklands, glades or at the margins of woodland, not or only weakly nitrophilous and not occurring near habitation. Sometimes associated with bark wounds. Widely distributed, but local throughout Britain and Ireland, scarce in western districts.

Characterized by the uniformly thin, minutely corticate-granular thallus, its absence from nutrient-enriched sites, its duller colour and lack of true soredia. *Candelariella xanthostigmoides* has flattened squamules, small bright yellow soralia and frequently occurs on markedly nutrient-enriched substrata.



LC

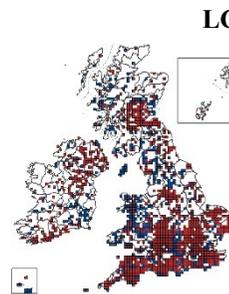
Candelariella xanthostigmoides (Müll. Arg.) R.W. Rogers (1982)

Candelariella reflexa auct. br., non (Nyl.) Lettau (1912)

Thallus of dispersed or \pm contiguous granules or minute squamules, \pm sorediate, sometimes entirely finely sorediate; squamules to 1mm diam., usually smaller, rounded or lobed to substellate, mostly \pm flattened- appressed, dull yellow-green, the margins usually rapidly breaking down into fine-granular soredia; soredia $50\text{--}70 \mu\text{m}$ diam., spherical, bright yellow, often coalescing and covering the entire upper surface of the squamules, then tending to form a continuous, leprose crust. Apothecia $0.5\text{--}1 \text{mm}$ diam., very rare; margin smooth or partly sorediate; disc pale yellow to bright orange-yellow. Asci 8-spored. Ascospores $10\text{--}16 \times 4.5\text{--}5.5 \mu\text{m}$, cylindric-ellipsoidal, slightly curved, aseptate. **BLS 0297**.

Epiphytic in nutrient-enriched habitats, such as the base of trees fouled by dogs, rough-barked trees around farmsteads and villages, on sloping trunks and boughs of large *Salix* and *Sambucus*, also as tiny thalli amongst other lichens on slightly nutrient-enriched broad-leaved trees in woodland; shade- and moderately pollution-tolerant. Throughout Britain and Ireland where it is spreading.

Resembles *Caloplaca* (*Flavoplaca*) *citrina* or *C. (Flavoplaca) flavocitrina*, from which it can easily be separated by the K- reaction of the thallus. *Candelariella xanthostigma* lacks flattened squamules and the rounded, soredia-like but corticate, granules are larger, more constant in size and have a dull orange-yellow colour; this species is also not characteristic of nutrient-enriched substrata.



LC

This species [or at least GBI material identified as such] was treated under the name *Candelariella reflexa* (Nyl.) Lettau (1912) by Purvis *et al.* (1992) and Gilbert & James (2009b). However, Lendemer & Westberg (2010) described European material of *C. reflexa* as having a thallus that is sometimes almost rosette-like, with lobate areoles and laminal, somewhat excavate soralia. GBI populations approximate to North American material identified as *C. xanthostigmoides* by Lendemer & Westberg (2010), and that name is used provisionally here. Molecular data are needed to clarify their identities; initial studies suggest that more species may be involved. It is certainly possible that the genuine *C. reflexa* occurs in our region, at least in S.E. England, as may *C. efflorescens* R.C. Harris & W.R. Buck (1978) which has smaller soredia and polysporous asci (Westberg 2007a, Westberg & Clerc 2012).

A recorded host for the plurivorous *Athelia arachnoidea* (Berk.) Jülich (1972), *Illosporopsis christiansenii* and *Paranectria oropensis* (Ces.) D. Hawksw. & Piroz. (1977).

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