



Ten new species of *Cladonia* (Cladoniaceae, Lichenized Fungi) from the Guianas and Venezuela, South America

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Abstract

The diversity of the lichen family Cladoniaceae in the Neotropics is apparently underestimated. A revision of the family for the Flora of the Guianas resulted in the description of 10 species new to science from Northern South America: *Cladonia cayennensis*; *Cladonia flavocrispata*; *Cladonia isidiifera*; *Cladonia maasii*; *Cladonia mollis*; *Cladonia persphacelata*; *Cladonia recta*; *Cladonia rupununii*; *Cladonia subsphacelata*; *Cladonia termitarum*.

Key words: new species, endemic species, Guyana, Suriname, French Guiana, Guyana Highland

Introduction

The lichen family Cladoniaceae is studied by us for the Flora of the Guianas (Ahti & Sipman 2013, in press). The area covered by our treatment includes Guyana, Suriname and French Guiana and, because this area shares most of the species, also the Venezuelan Guayana with its tepuis. In this way we got a good coverage for the whole Guiana Shield, well-known as one of the biodiversity hotspots in the world. Both of us were able to study most species ourselves in situ, during field work in Guyana and Venezuela, HS also in French Guiana, on several expeditions.

The treatment is based on the recent monograph of Cladoniaceae of the whole Neotropics (Ahti 2000). However, we were astonished to encounter no less than ten undescribed species in the area. Indeed, a few of them were recognized earlier but due to sparse or poor material they were not published. The new species recognized during our study are described separately here.

Material and methods

About 900 specimens from the study area were examined, collected by us during several expeditions or obtained on loan mainly from the herbaria B, H, NY and US. For morphological character analysis air-dried specimens were observed under the stereomicroscope. Anatomical details were studied by compound microscope. The chemistry was analysed by standard TLC (Orange, James & White 2001).

Result: Taxonomic Treatment

Cladonia cayennensis Ahti & Sipman, *sp. nov.* (Fig. 1)

Mycobank # MB 803520

Thallus primarius squamulosus, viridifuscus, rotundatus, squamulae 1–2 mm latae, infra solediosae. Conidiomata et apothecia ignota. Acidum usnicum (parce) et zeorinam (crystallis numerosis in speciminibus diu conservatis) continens. Species epiphytica.

Type:—FRENCH GUIANA. Cayenne: Botanical Garden, on palm, sea level, 04°56'N, 52°20'W, Mar 1985, A. Aptroot 15098 (holotype L!, isotypes B!, H!).

Primary thallus persistent, consisting of flat to concave, even involute squamules, 1–2 mm wide, soft and fragile, with rounded lobes, entire or little divided; upper side greenish-brown, lower side white, floccose and loosely solediate, specially along margins; occasionally squamules provided with short basal, brownish-veined stalk. Podetia, conidiomata and hymenial discs unknown. Chemistry: usnic acid (in low concentration) and zeorin (needle-like crystals abundant on old herbarium specimens!). Colour reactions: P–, K–, KC–.

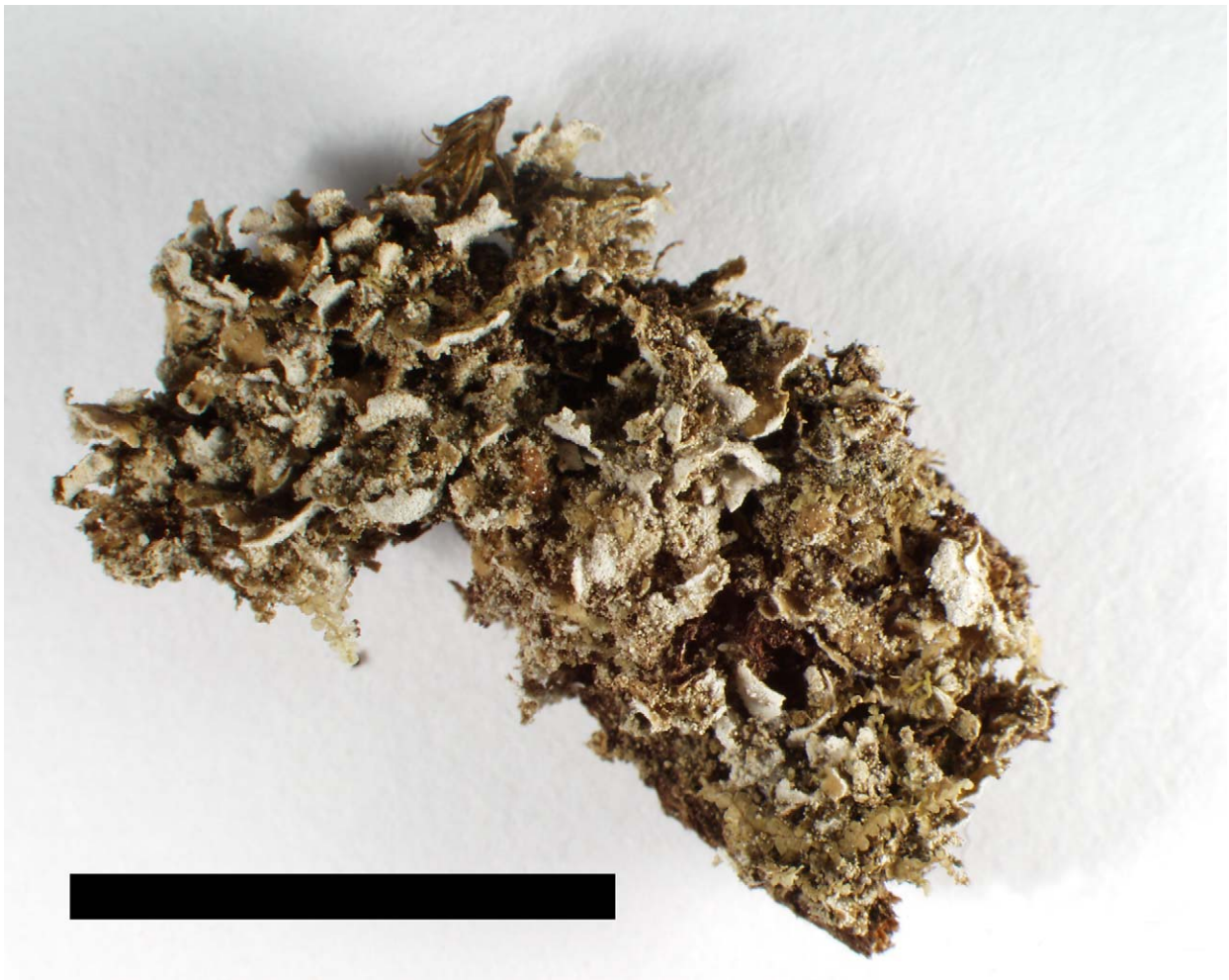


FIGURE 1. *Cladonia cayennensis*, holotype. Bar = 1 cm.

Distribution and ecology:—Known so far only from the Guianas, but in view of its occurrence in secondary habitats, the species is probably more widespread. Perhaps it was once reported as *C. ahtii* S. Stenroos (1989: 252) from adjacent Venezuela, in Bolívar near Canaima, epiphytic at 550 m elev.; this record was excluded from *C. ahtii* by Ahti (2000). The species was found exclusively epiphytic on hepatic film on smooth, living palm stems in plantations along the coast.

Additional specimen examined (paratype):—SURINAME. Paramaribo: Palmgarden, sea level, *Aptroot 14829* (L!).

Remarks:—*Cladonia cayennensis* is a sorediate representative of the group of *Cladonia miniata* G. Meyer (1825: 149), similar to *C. ahtii*, from which it differs by the thinner thallus lobes and different chemistry (Ahti 2000). It is also close to *C. meridionalis* Vainio in Zahlbruckner (1909: 136), but that species has much larger thallus lobes, which are sorediate over much of their lower side. *Cladonia termitorum* (see below) is also rather similar, due to its slightly sorediate thallus lobes. It differs by its thinner and more finely divided squamules, its chemistry and the regular presence of small podetia and red hymenial discs.

In the absence of apothecia and podetia its systematic position is tentative. It is based on the similarity of its thallus squamules with the *miniata* group of the genus *Cladonia*, and its chemistry which occurs in *Cladonia* rather than in other squamulose lichen genera. *Cladonia cayennensis* is easily overlooked because it is known only in squamulose, sterile state. However, having a distinct morphology and chemistry, it cannot be any other species of *Cladonia* recognized by Ahti (2000) in tropical America. Herbarium specimens are easily identified by the soredia and abundant zeorin crystals on the lower surface of the squamules (crystals expected to be absent from fresh material). The presence of a low amount of usnic acid causes hardly any yellowish colour.

Cladonia flavocrispata Ahti & Sipman, *sp. nov.* (Fig. 2)

Mycobank # MB803521

Sicut Cladonia hians sed axillae non inflatae et acidum usnicum continens.

Type:—VENEZUELA. Bolívar: Cerro Guaiquinima, near NE edge of upper plateau, 05°54'N, 63°27'W, ca. 1250 m elev., rocky sandstone area with scrub on exposed ridge, 8 Febr. 1990, *H. Sipman 26772* (holotype VEN!, isotypes B!, H!).



FIGURE 2. *Cladonia flavocrispata*. A. isotype (B); B. Guyana specimen of uncertain affinity (*Sipman 40299* (B)). Bar = 2 cm.

Primary thallus evanescent, pale green, restricted to scattered, small squamules in the lower part of the podetia, ca. $0.2\text{--}0.5 \times 1$ mm, simple or somewhat split up irregularly into crenulate laciniae, esorediate. Podetia 5–12 cm tall, of indeterminate growth, pale greenish grey, in lower parts strongly variegated, with alternating pale greenish grey and brown to black patches, usually forming cushions composed of dense, erect, 1.0–1.5 mm wide main stems; stereome soon brownish but not blackening inside; branching type anisotomous tricho- to polytomy; axils always perforated and only slightly swollen; branchlet tips short and darkbrown, usually under 0.5 mm long. Podetial surface matt, discontinuously very thinly corticate, with most of the stereome becoming bare with age, usually esquamose but some squamules may occur, particularly in fallen podetia; podetial squamules up to ca. 1.5 mm wide, divided in ca. 0.5 mm wide, elongate and crenulate lobes. Podetial wall 125–175(–200) μm thick, cortex 0–35 μm ; medulla mostly absent; stereome 125–150 μm , pellucid, well-delimited. Conidiomata and hymenial discs not observed. Chemistry: thamnolic and usnic acids, sometimes with barbatic acid (TLC of 3 specimens). Colour reactions: P+ yellow, K+ yellow, KC+ yellow.

Distribution and ecology:—The available samples suggest that this is a Guayana Highlands endemic, known so far with certainty only from Venezuela. It is found in humid sandstone tableland, and it grows on sandstone flats with open bog vegetation between ca. (400–)1000 and 2500 m elev. From the Guianas only three doubtful collections are known, from the sandstone plateau of the Kaieteur Falls (see notes).

Additional specimens examined (paratypes):—VENEZUELA. Amazonas, Depto. Atabapo: Cerro Marahuaca, Cumbre, 2480–2580 m, 1982, *M. Guariglia et al. 1512* (H!, VEN!); Bolívar: Chimantá, Toronotepui, 2100 m, 1985, *Ahti et al. 45255* (H!, VEN!); Chimantá, 2130 m, *Vareschi 9209* (H!, VEN!); Auyantepuí-Massif, Guayaraca, 1100 m, 1956, *Vareschi & Foldats 6303* (H!, VEN!); Cerro Guaiquinima, 1000 m, 1990, *Sipman 26514* (B!, H!, VEN!); id., 1500 m, 1990, *Sipman 27101, 27105* (B, H, VEN).

Remarks:—*Cladonia flavocrispata* is very similar to *C. hians* Ahti (2000: 284) and could be considered its usnic acid-strain. However, it is also larger in size. Like *C. hians*, it belongs in section *Perviae*, as demonstrated by the regular perforations of the axils. The species can be also easily confused with *C. vareschii* Ahti (1986: 218). The latter has a more intense yellow tinge and its cortex is somewhat thicker. Its apical branchlets stand at an obtuse angle ($>90^\circ$) and bend away from each other immediately. A very reliable difference is the (often scarce) presence of squamules in *C. flavocrispata*.

Three Guianas specimens (GUYANA, Potaro-Siparuni Region, Kaieteur Falls National Park, around the airstrip, ca. 400 m elev., *Sipman 40299, 40300, 40336* (B!, BRG!)) show a considerable resemblance, but deviate by the mostly closed axils not developing into funnels and the complete absence of squamules. In this respect they agree more with *C. vareschii* but lack the obtuse-angled apical branchlets and brownish colour. They may be more close to *C. spinea* Ahti (1986: 215), which lacks main stems, however.

Cladonia isidiifera Ahti & Sipman, *sp. nov.* (Fig. 3)

Mycobank #MB 803522

Sicut Cladonia ahtii sed sorediis absentibus et isidiis cylindricis praesentibus.

Type:—GUYANA. Upper Mazaruni Distr.: E-bank of Waruma R., 20 km S of confluence with Kako R., in ca. 20 m tall, virgin, riverine forest, on overhanging tree along river, ca. 550 m elev., 11 Feb. 1985, *H. Sipman & A. Aptroot 18671* (holotype B!).

Primary thallus persistent, consisting of 1–4 mm long, horizontal to ascending squamules which are deeply divided in ca. 0.5–1.0 mm wide and ca. 0.3 mm thick, slightly crenulate lobes, with flat to concave, green upper side and white or pale brown, shiny lower side, with pale hypothallus, often isidiate along the tips of erect, up to 5 mm long and 2 mm wide extensions of the lobes; isidia short-cylindrical, ca. 0.3 mm long and 0.15 mm wide, glossy. Podetia, conidiomata and hymenial discs not known. Chemistry: barbatic and 4-O-demethylbarbatic (minor) acids. Colour reactions: P–, K–, KC–.



FIGURE 3. *Cladonia isidiifera*, holotype. Bar = 1 cm.

Distribution and ecology:—Known only from a single specimen found in the Upper Mazaruni Distr., Guyana, on an overhanging trunk along a stream at ca. 550 m elev. in mossy forest.

Additional specimens examined:—known from the type only.

Remarks:—The presence of cylindrical isidia is so unusual in the genus *Cladonia*, that there is no doubt that the only available specimen belongs to an undescribed species. The thallus squamules show that it is related to *C. miniata*. Morphologically it bears most similarity with *C. ahtii*. This species is sorediate instead of isidiate, and it lacks the peculiar lobe extensions. In the *C. miniata*-group there is one more isidiate species, *C. caribaea* S. Stenroos (1989: 256). This has coralloid to flattened, not cylindrical isidia.

Cladonia maasii Ahti & Sipman, *sp. nov.* (Fig. 4)

Mycobank #MB 803528

Sicut Cladonia peltastica sed differt ramulis rufescentibus et crassioribus et acidum fumarprotocetraricum continente.

Type:—SURINAME. 2 km N of Kamisa Falls in Nickerie R., shrub savanna, 2 July 1968, *P.J.M. Maas* 3378 (holotype B!, isotype H!, L!).

Primary thallus squamulose, evanescent, squamules ca. 0.1 mm diam. Podetia 4–6(–10) cm tall, 0.3–1 mm thick, rarely with scattered, small squamules, of indeterminate growth, basic colour whitish grey but exposed parts may become dark brown, forming erect, dense, flat, interwoven mats; branching type anisotomous

dichotomy, to a lesser degree trichotomy or tetrachotomy; main stems in part distinguishable; axils commonly perforated; tips erect, divaricate, acute. Podetial surface clearly corticate; cortex smooth to somewhat rugulose, dull, with some ecorticate patches; soredia and squamules lacking. Podetial wall thin, ca. 100–200 μm ; cortex 50 μm ; medulla 50–100 μm ; stereome ca. 100 μm . Hymenial discs not seen. Conidiomata scarce, at the end of podetia, 200–300 \times 100–150 μm , ovoid to ampullaceous, constricted at base, black, content not seen. Chemistry: fumarprotocetraric, tr. protocetraric, homosekikaic and/or sekikaic acids. Colour reactions: P+ red, K–, KC–.



FIGURE 4. *Cladonia maasii*, holotype. Bar = 2 cm.

Distribution and ecology:—A Guianan endemic, as far as presently known, represented only by two collections from Suriname and one from Guyana, in shrub savanna, from ca. 200 to 1000 m elev.

Additional specimens examined (paratypes):—GUYANA. Ituru Yawaruki savanna, white sand areas, *Abraham 123* (BM!) (TLC (F. Oberli, G): with fumarprotocetraric, protocetraric, homosekikaic, and sekikaic acid). SURINAME. Natuurreservaat Brinckheuvel, Sabanpasi savanne complex, *Teunissen & Wildschut LBB 11403* (L!).

Remarks:—*Cladonia maasii* is named in honour of the collector, Prof. Dr. Paul J.M. Maas, who discovered several important *Cladonia* sites in the Guianas. The lichen resembles *C. peltastica* (Nylander 1874: 70) Müller Argoviensis (1880: 260) but contains fumarprotocetraric acid and tends to get slightly brown and has no usnic acid. Its branchlets are also more robust, with perforated axils, and the ramification is less dense than in *C. peltastica*. A specimen from Guyana (Mt. Latipu near Kamarang, *Sipman & Aptroot 19164*, B!) is included here with doubt. It agrees in chemistry but the podetia are more slender.

Cladonia mollis Ahti & Sipman, *sp. nov.* (Fig. 5)

Mycobank # MB 475357

Thallus primarius laciniatus, viridis. Podetia 1–2(3) cm alta, pallide vel viride flavescentia, semper scyphosa, scyphis 1–4 mm latis. Superficie fere toto granuloso-sorediata et microsquamulosa, toto vel fere ecorticata. Disci hymeniales coccinei. Acidum usnicum, acidum thamnolicum et acidum rhodocladonicum continens.

Type:—GUYANA. Demerara-Mahaica Region: on Linden Highway, km 7 from Soesdyke, by end of trail to Marudi Creek Resort, 06°31'N, 58°12'W, 10 m elev., on burnt stump in secondary woodland with savanna patches on white sand, 1996, *T. Ahti, R. Lüicking & H. Sipman 52910* (holotype BRG!, isotypes B!, H!, US!, VEN!).

Primary thallus squamulose, consisting of green, flattish squamules with convex lobes and necrotic bases turning orange. Podetia 1–2(–3) cm tall, of determinate growth, whitish to greenish yellow, always forming scyphi; scyphi 1–4 mm wide, usually single but with age proliferating from the margins and sometimes forming a second scyphus at the end of the proliferations, just below the short-stalked apothecia. Podetial surface totally ecorticate or little corticate at the very base, otherwise very rough due to coarse granules and often very densely beset with microsquamules, all of which dissolve into a thick layer of loose, finely granulate soredia towards the tops. Podetial wall not measured. Conidiomata formed on margins of young scyphi, typically black, cylindrical, shortly stipitate; with purple slime inside. Hymenial discs unusual, at margins of scyphi, forming 1–2 mm wide purple disks. Chemistry: K+ yellow, PD+ yellow, containing usnic and thamnolic acids, as well as the purple pigment rhodocladonic acid in hymenial discs and conidiomata.

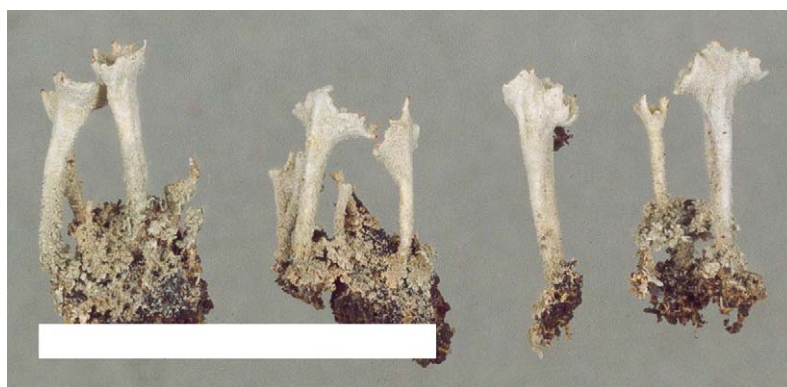


FIGURE 5. *Cladonia mollis*, isotype (B). Bar = 2 cm.

Distribution and ecology:—*Cladonia mollis* is known from the Guianas and northern Brazil, but is expected to be more widespread in Amazonia. It was observed on rotten wood and white sand in forest clearings and savannas, from 10 to 500 m elev.

Additional specimens examined (paratypes):—GUYANA. Demerara-Mahaica Region: type locality, *Ahti 52900* (B!, BRG!, H!, US!), 52912 (BRG!, H!, US!); Cuyuni-Mazaruni Region, Bartica, *Linder 810* (FH!, TUR-V 14099!, W!, as “*Cladonia Guiana* Vain.” in herb.); Potaro-Siparuni Region, Kaieteur Falls National Park, *DePriest 9316* (BRG!, H!, US!); Tukeit, *DePriest 9361* (BRG!, H!, US!); Basin of Essequibo R., Kurupukari, *A.C. Smith 2178* (NY!); Upper Demerara-Berbice Region, Mabura Hill, along logging road WS 1200, Waraputa compartment, *DePriest 9179* (BRG!, H!, US!); Upper Mazaruni Region, Makwaima savanna near Mayaropai, at Kako R., wet savanna on white sand, *Sipman & Aptroot 18538* (H!, L!). FRENCH GUIANA. Inselberg de Montagne de la Trinité, NE summit, on dead wood in rock savanna, *de Granville et al. 6252* (B!, L!). SURINAME. No locality, [1827–28] C. Weigelt in Herb. Schweinitz (PH!); Sabanpasi savanna complex, Nature Reserve Brinckheuvel, summit of Brinckheuvel, on coarse, white sand, *Teunissen & Wildschut LBB 11933* (H!, L!); Jodensavanne, *Benjamins* (L!), *Stahel* (L!, REN!). BRAZIL. Amazonas: Manaus-Itacoatiara road km 18, under 100 m elev., in secondary campina forest, *Richards 6949* (BM!); Pará: Serra do Cachimbo, Base Aérea do Cachimbo, ca. 20 km N of the border with Mato Grosso on Cuiabá-Santarém highway (RB-163), ca. 09° 22'S, 54° 54'W, broad, sandy, level riverine plain, *Brako & Dibben 5810* (H!, INPA, NY!).

Remarks:—The species is distinguished from the very similar *C. corallifera* (Kunze 1827-1828) Nylander (1874: 70) by the production of distinct soredia almost throughout the surface of the podetia. However, it may be difficult to distinguish from granulate morphs of *C. corallifera*. In Guiana we encountered the two species growing together in some places, where they appeared to be distinct. Also E. A.

Vainio recognized the species under an unpublished herbarium name (see above). All the specimens of *C. mollis* that were chemically studied contained thamnolic acid, while in *C. corallifera* the chemistry is more variable (Ahti 2000).

Cladonia mollis is also closely related to *C. prancei* Ahti (2000: 223), another sorediate derivative of *C. corallifera*, which in addition has podetia forming narrow scyphi, sometimes becoming subulate, with a low content of usnic acid often giving the podetia a pale grey colour without yellowish tinge.

Sorediate squamules have been found only in the specimen *Sipman & Aptroot 18538*.

***Cladonia persphacelata* Sipman & Ahti, sp. nov. (Fig. 6)**

Mycobank # MB 803523

Sicut Cladonia sphacelata, sed podetia cornea, fusca, incrassata, squamulis elongatis; acidum didymicum et acidum thamnolicum continens.

Type:—GUYANA. Upper Mazaruni Distr.: Mt. Latipu, ca. 8 km N of Kamarang, at ca. 1000 m elev., in scrub on summit plateau, on white sand on open spot, 25 Feb 1985, *H. Sipman & A. Aptroot 19149* (holotype B!, isotype BRG!) (TLC: thamnolic, tr. didymic acid).

Primary thallus persistent to evanescent, consisting of up to 0.5 cm long squamules which are deeply divided into ca. 0.5 mm wide, elongate laciniae, attenuated and often almost stalk-like at the base, on the lower side with rather smooth surface to corticoid and sometimes with ochraceous streak. Podetia up to 5 cm tall and 0.5–1.5 mm thick, of determinate growth, grey to usually more or less brown, in lower part almost black, horny and swollen, somewhat branched; branching type irregular anisotomous dichotomy, rarely trichotomy or tetrachotomy; axils closed or with usually small openings; tips often divided into 2–10 short branchlets. Podetial surface smooth and often shiny, denudated even at the tips, finally being rather densely squamulose, smooth inbetween, esorediate; mature squamules narrow, lacinate and imbricate, up to 4 mm long, pointing downward but with recurved tips, often glossy. Podetial wall 200–290 µm thick; cortex (0–)25–40 µm, consisting of large cells; medulla very thin, (0–)10–25 µm (including the algae); stereome distinctly delimited, very horny, thick, 200–250 µm, inner surface glossy. Conidiomata terminal on tiny apical branchlets, often grouped, 200–250 × 100–150 µm, dolioliform, constricted at the base, shortly pedicellate, containing red slime. Hymenial discs not seen. Chemistry: thamnolic acid sometimes with a trace of didymic acid (TLC of 6 specimens). Colour reactions: P+ yellow, K+ yellow, KC–; UV–.

Distribution and ecology:—A Guayana Highland endemic, known only from Venezuela and Guyana. It is widespread in the Guayana Highland of Venezuela in light, mossy forest over sandstone at ca. 600–1100 m elev. In Guyana found on mossy sandstone rocks in light forest, rather shade-tolerant and avoiding open spots, from 400 to 1000 m elev.

Additional specimens examined (paratypes):—GUYANA. Upper Mazaruni Distr., 2 km N of Kamarang, 500 m, *Sipman & Aptroot 18241* (B!); E-bank of Waruma R., ca. 20 km S of confluence with Kako R. (campsite 4), *Sipman & Aptroot 18241, 18660* (B!); trail from Kamarang R. to Pwipwi Mt., ca. 10 km N of Waramadan, *Sipman & Aptroot 19322, 19494* (B!); Potaro-Siparuni Region, Kaieteur Falls National Park, around the airstrip, *Sipman 40447* (B!, BRG!); Region 7 (Upper Mazaruni Distr.), N of Paruima Mission, Aymatoi savanna, *Sipman 39860* (B!, BRG!, US!); Cuyuni-Mazaruni Region, Partang R., 8.6 km NE of Imbadamai, *Hoffman 1722* (H!). VENEZUELA. Bolívar: Cerro Guaiquinima, in central part of upper plateau, along Río Carapo (near camp 3-nuevo), *Sipman 27065* (B!, H!, VEN!); in central part of upper plateau (near camp 4), *Sipman 26487* (B!, VEN!); near NE edge of upper plateau (near camp 2), *Sipman 26890* (B!, VEN!); near west end of upper plateau (near camp 5), *Sipman 27102* (B!, H!, VEN!); Canaima, at Río Carrao, *Sipman 27256* (B!, VEN!).



FIGURE 6. *Cladonia persphacelata*, holotype. Bar = 2 cm.

Remarks:—*Cladonia persphacelata* belongs to a group of closely related species including in the Guianas *C. polystomata* Ahti & Sipman in Ahti (2000) and *C. subsphacelata* (see below), and the Brazilian *C. sphacelata* Vainio (1887: 456). *C. polystomata* grows on soil or litter and forms wide funnels on top of more

or less corticated, up to ca. 1 cm thick, little branched podetia with short squamules. *C. subsphacelata* has largely corticate, less than 1 mm wide podetia, and shares with *C. persphacelata* the saxicolous habit and very elongated squamules. *C. sphacelata* has short podetial squamules, the podetia remain thin, under 1 mm wide, and do not become horny.

Richly squamulose forms of *C. subdelicatula* Vainio ex Asahina (1963: 1) can also resemble *C. persphacelata*. They differ by their felty rather than smooth surface and their preference for tree bark as substrate (in the Guianas).

Cladonia recta Ahti & Sipman, *sp. nov.* (Fig. 7)

Mycobank # MB 803524

Sicut Cladonia peltastica sed podetiis gracilioribus albo-cinereis; conidiomata gelatinam purpuream continentia; acidum squamaticum continens.

Type:—GUYANA. Upper Takutu Distr.: ca. 35 km S of Aishalton, ca. 5 km N of Kuyuwini Landing, along track to Karaudanawa, ca. 2°08'N, 95°15'W, ca. 250 m elev., on sandy soil among scattered shrubs and trees along and on small savanna, 1 Nov. 1992, *H. Sipman 57134* (holotype B 60 0164014!, isotype BRG!).



FIGURE 7. *Cladonia recta*, holotype. Bar = 2 cm.

Primary thallus evanescent, consisting of very small, to 0.2 mm long, slightly crenulate squamules. Podetia 2–5 cm tall, 0.2–0.5(–1) mm thick, of indeterminate growth, whitish grey, basal parts darker but not melanotic, extreme tips black, forming dense mats with individual podetia erect and very straight, branched by irregular anisotomous dichotomy, rarely trichotomy, main stems distinct but somewhat anastomosing, equally thick;

axils normally closed but occasionally perforated; tips erect or slightly bent, acuminate. Podetial surface continuously corticate, cortex smooth or somewhat rugulose, especially towards the base, occasionally slightly squamulose, dull to slightly shiny, somewhat maculate, with some brownish, ecorticate patches near the base; soredia lacking. Podetial wall anatomy not studied; stereome distinct, central canal very narrow. Conidiomata on tips of podetia, ca. $200 \times 100 \mu\text{m}$, cylindrical, not constricted at the base, black, containing purple slime. Hymenial discs at tips of slightly swollen podetia, very small (ca. 0.1 mm diam.), pale brown; spores not observed. Chemistry: squamatic acid. Colour reactions: P–, K–, KC–.

Distribution and ecology:—As far as known a Guianan endemic, collected only in Guyana on sandy soil and rotten wood in savanna, at ca. 250 m elev.

Additional specimens examined (paratypes):—GUYANA. Upper Takutu Distr., ca. 35 km S of Aishalton, ca. 5 km N of Kuyuwini Landing, along track to Karaudanawa, ca. $2^{\circ}08'N$, $95^{\circ}15'W$, ca. 250 m, Sipman 57127, 57132 (B!, BRG!).

Remarks:—*Cladonia recta* resembles most *C. peltastica*, but is much more slender and forms conspicuous, straight, erect colonies. However, it is possible that it represents an usnic acid-free chemotype of that species.

Cladonia rupununii Ahti & Sipman, *sp. nov.* (Fig. 8)

Mycobank # MB 803525

Sicut Cladonia macilenta, sed podetia regulariter ramosa, in parte applanata, toto sorediosa; disci hymeniales coccinei; acidum didymicum et acidum barbaticum continens.

Type:—GUYANA. Upper Takutu Distr.: southern Rupununi savanna, Kusad Mt., SE side, $2^{\circ}47'N$, $59^{\circ}51'W$, 450 m elev., forest along stream in upper part of valley, on *Curatella* trunk, 29 Sept. 1992, H. Sipman 57749 (holotype B!, isotype BRG!).



FIGURE 8. *Cladonia rupununii*, holotype. Bar = 2 cm.

Primary thallus persistent, consisting of very small, 0.5–2 mm long, dissected squamules, veined below; often slightly soresiate along margins. Podetia up to 2 cm tall, 0.3–1 mm thick, of determinate growth, very slender, whitish grey, dichotomously or digitately branched, especially in upper parts; branchlets divergent; axils closed; tips bluntish; ascyphose. Podetial surface abundantly farinose-soresiate throughout. Podetial wall anatomy not studied. Hymenial discs red, not seen in maturity. Conidiomata born on basal squamules or at tips of podetia, ampullaceous, black, containing purple slime. Chemistry: didymic, barbatic, trace of demethylbarbatic acids. Colour reactions: P–, K–, KC–.

Distribution and ecology:—A Guyana endemic, so far as known, collected once in a forest island on a hilltop in the Rupununi savanna in SW Guyana, on rotten log in clearing along a stream, at 450 m elev.

Additional specimens examined:—known from the type only.

Remarks:—Very similar and apparently closely related to *Cladonia macilenta* Hoffmann (1796: 126), but more branched. Also similar to *Cladonia prancei*, which is much more robust, forms narrow scyphi, and always contains thamnolic acid. Chemically, it is similar to *C. didyma* (Fée 1825: 118, 101) Vainio (1887: 137), but that species has smooth, pellucid podetia producing granules or squamules and lacks soredia.

Cladonia subsphacelata Sipman & Ahti, *sp. nov.* (Fig. 9)

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Sicut Cladonia persphacelata, sed podetia tenuiora, ad 0.8 mm crassa, plerumque corticata; acidum didymicum et acidum squamaticum continens.

Type:—FRENCH GUIANA. Savane Roche de Virginie, Bassin de l'Approuague, 120 m elev., Fourré isolé de savane roche, 12 Feb. 1991, G. Cremers & P. Petronelli 11900 (holotype B!).



FIGURE 9. *Cladonia subsphacelata*, holotype. Bar = 2 cm.

Primary thallus persistent, consisting of up to 0.5 cm long squamules which are deeply divided into ca. 0.5 mm wide, elongate laciniae, attenuated and often almost stalk-like at the base, with rather smooth to corticoid surface towards the base and sometimes with ochraceous streak. Podetia up to 3 cm tall and 0.3–0.8 mm thick, of determinate growth, grey to usually more or less brown, at base almost black, somewhat branched; branching type irregular anisotomous dichotomy, rarely trichotomy or tetrachotomy; axils closed or with usually small openings; tips often divided into 2–10 short branchlets; central canal very thin, ca. 0.1 mm wide. Podetial surface smooth and mostly corticate, not shiny, finally being rather densely squamulose, smooth inbetween, esorediate; mature squamules narrow, lacinate and imbricate, up to 4 mm long, pointing downward but with recurved tips, often glossy. Podetial wall 200–300 µm thick; cortex (0–)25–40 µm; medulla thin, 10–25 µm (including the algae); stereome distinctly delimited, horny, thick, 200–250 µm, inner surface glossy. Conidiomata not seen. Hymenial discs not seen. Chemistry: squamatic and didymic acids (TLC of 4 specimens). Colour reactions: P–, K–, KC–; UV+ white.

Distribution and ecology:—Species known so far only from French Guiana and Guyana, found in sananna over rock from 100 to 400 m elev.

Additional specimens examined (paratypes):—GUYANA. Potaro-Siparuni Region, Kaieteur Falls National Park, around the airstrip, *Sipman 40326* (B!, BRG!); *Ahti et al. 53048a* (B!, H!, US!); trail to Johnson's View, *dePriest 9375* (H!). FRENCH GUIANA. Savane Roche de Virginie, Bassin de l'Approuague, *Cremers & Petronelli 11899* (B!).

Remarks:—For differences with related species see under *C. persphacelata*.

Cladonia termitarum Ahti, *sp. nov.* (Fig. 10)

Mycobank # MB 803527

Thallus squamulosus, aggregatus, squamulae minutae (0.3–1 mm longae), crustaceae, crassae, subteretia, marginibus crenulatis, interdum parce sorediosis. Podetia brevissima (0.5–2 mm), laevia, granulosa vel squamosissima, semper fertilia. Conidiomata subsphaerica, demum ostiolum hians, gelatinam coccineam continens. Disci hymeniales applanati, coccinei. Acidum fumarprotocetraricum et acidum rhodocladonicum continens.

Type:—GUYANA. Potaro-Siparuni Region: Kaieteur Falls National Park, S side of airstrip, 0.5°10'N, 59°29'W, 400 m elev., on termite structure on premontane sclerophyll forest floor, 1996, *T. Ahti et al. 53023* (holotype BRG!, isotypes B!, H!, US!).

Primary thallus persistent, appearing crustose but consisting of 0.3–1 mm long, 0.1–0.5 mm wide, pale greenish to brownish grey squamules, usually very short and irregular, convex, thick, often warty or almost cylindrical, often densely aggregated, crenulate at ends and margins, with eroded, granulose patches extending on the underside of the squamules; necrotic basal parts becoming orange. Podetia often numerous, very short (0.5–2 mm), of determinate growth, greenish grey; stalk smooth (little corticate), granulose or densely squamulose. Podetial surface areolate-verruculose. Podetial wall not measured. Conidiomata scattered, subspherical, black, 0.2 mm tall, after ejaculation of conidia ostiolum gaping open with black, toothed margins and red slime visible inside. Hymenial discs sparsely produced, on very short (0.5–2 mm), smooth, granulose or squamulose podetia, flat, purple. Chemistry: PD+ fast brick red, containing the fumarprotocetraric acid complex; the purple pigment rhodocladonic acid in hymenial discs and conidiomata.

Distribution and ecology:—A Guianas endemic, known so far only from three collections made near the Kaieteur Falls, Guyana. It was exclusively observed on old forest floor termite structures, at ca. 400 m elev. These structures are very common in the Amazonian and associated lowland rainforests, therefore the species is expected to be more widespread.

Additional specimens examined (paratypes):—GUYANA. Potaro-Siparuni Region, type locality, termite mound, *Ahti 53020* (BRG!, H!, US!); Kaieteur Falls National Park, N side of airstrip, termite mound, *Ahti 53035* (B!, BRG!, H!).



FIGURE 10. *Cladonia termitarum*, isotype (B). Bar = 1 cm.

Remarks:—The short-stalked, bright red ascomata in combination with the presence of fumarprotocetraric acid set this species well apart from all Guianas lichens. The only similar species is *Cladonia ahtii* Stenroos, known from SE Brazil, which belongs to the group of *C. miniata*, and differs by the shape of the squamules, thick and rounded, with a flat to concave upper surface.

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References

- Ahti, T. (1986) New species and nomenclatural combinations in the lichen genus *Cladonia*. *Annales Botanici Fennici* 23: 205–220.
- Ahti, T. (2000) Cladoniaceae. *Flora Neotropica Monograph* 78: 1–363.
- Ahti, T. & Sipman, H.J.M. (2013) Cladoniaceae (Lichens) incl. guide to the Cladoniaceae of the Guayana Highland. In Mota de Oliveira, S. (ed.), *Flora of the Guianas*, ser. E, 3 (in press).
- Asahina, Y. (1963) Lichenologische Notizen (186–187). *Journal of Japanese Botany* 38(10): 1–3.
- Fée, A.L.A. (1825) *Essai sur les cryptogames des écorces exotiques officinales*. Paris, vii–xiv, 167 pp.
- Hoffmann, G.F. (1796) *Deutschlands Flora oder Botanisches Taschenbuch*. Zweyter Theil für das Jahr 1795. Cryptogamie.

- Erlangen, 200 pp.
- Kunze, G. in C. Weigelt (1827–1828) [Unnumbered exsiccate].
- Meyer, G.F.W. (1825) *Die Entwicklung, Metamorphose und Fortpflanzung der Flechten*. Göttingen.
- Müller Argoviensis, J. (1880) Lichenologische Beiträge, XI. Schluss. *Flora (Regensburg)* 63: 259–268, 275–290.
- Nylander, W. (1874) Animadversiones circa Spruce, Lichenes Amazonicos et Andinos. *Flora (Regensburg)* 57: 70–73.
- Orange, A., James, P. W. & White, F. J. (2001) *Microchemical methods for the identification of lichens*. British Lichen Society, 101 pp.
- Stenroos, S. (1989) Taxonomic revision of the *Cladonia miniata* group. *Annales Botanici Fennici* 26: 237–261.
- Vainio, E.A. (1887) Monographia Cladoniarum universalis: 1. *Acta Societatis pro Fauna et Flora Fennica* 4: 1–509.
- Zahlbruckner, A. (1909) Lichenes (Flechten), in: Schiffner, V. (ed.), Ergebnisse der botanischen Expedition der kaiserlichen Akademie der Wissenschaften nach Südbrasilien, 1901, 2. Band. *Denkschrifte der Kaiserliche Akademie der Wissenschaften* 83: 85–211.