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***Sporopodium isidiatum* (Pilocarpaceae), new from Papua New Guinea and Sri Lanka, with a key to the world's *Sporopodium* lichen species**

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Abstract — The new lichen species *Sporopodium isidiatum* is described from Papua New Guinea and Sri Lanka. A key to all known species of *Sporopodium* is provided, as well as a synoptic table of their secondary chemical compounds.

Key Words — *Ectolechiaceae*, *Micareaceae*

Introduction

The lichen family *Pilocarpaceae* was reinstated by Vězda (1986) to accommodate mainly foliicolous species in the genera *Byssoloma*, *Fellhanera* and *Byssolecania*. However, Lücking & al. (1994) and Lücking (1999) suggested that the family should be emended to include *Ectolechiaceae*, i.e. taxa with characteristic campylidioid anamorphs centered in the genus *Sporopodium*. A recent molecular phylogenetic analysis, based on Bayesian tree sampling and maximum likelihood analysis of mtSSU sequences (Andersen & Ekman 2005), not only confirmed this view but showed that also *Micareaceae* have to be submerged within *Pilocarpaceae*.

Whereas the phylogenetic relationships of genera within this large and diverse clade remain unclear, inventories of tropical regions continuously yield new and undescribed species, especially in the large genera *Byssoloma* and *Fellhanera*, but also in the smaller genera, such as *Sporopodium*. The latter is distinguished by the following combination of characters (Lücking 1999, Santesson 1952, Sérussiaux 1986, Vězda 1986): finely farinose thallus, sometimes with verrucae; branched and anastomosed paraphyses; usually a single muriform spore per

ascus (8 in one species); campylidia hood-like, made of a conidia-producing cavity connected to a tiny platform which seems to be covered under a hood-like lobe; and conidia non-septate, ellipsoid to guttuliform (1-septate, with the distal cell rounded and the proximal one ellipsoid-bacillar in a single species). Photobiont cells are present in the epithecium and the conidiogenous layer in some species.

In his world-wide monograph on foliicolous lichens, Santesson (1952) recognized six taxa of *Sporopodium* (four species and two varieties); several further species have eventually been recognized (Aptroot & Sipman 1993, Aptroot & al. 1997, Elix & al. 1995, Lücking 1999 & 2008, Lücking & Kalb 2002, Lücking & Lumbsch 2001, Lücking & Santesson 2002, Øvstedal & Elix 2007, Santesson & Lücking 1999). Most species are foliicolous but many can also occur on twigs, and two species are so far only known from bark.

A very conspicuous species, with verrucose-isidiate thalli and large campylidia with a black lobe, is here described as new to science; it is known from Papua New Guinea and Sri Lanka. A key to all described species in the genus is presented, as well as a synopsis of the diverse secondary chemical compounds they produce.

The species

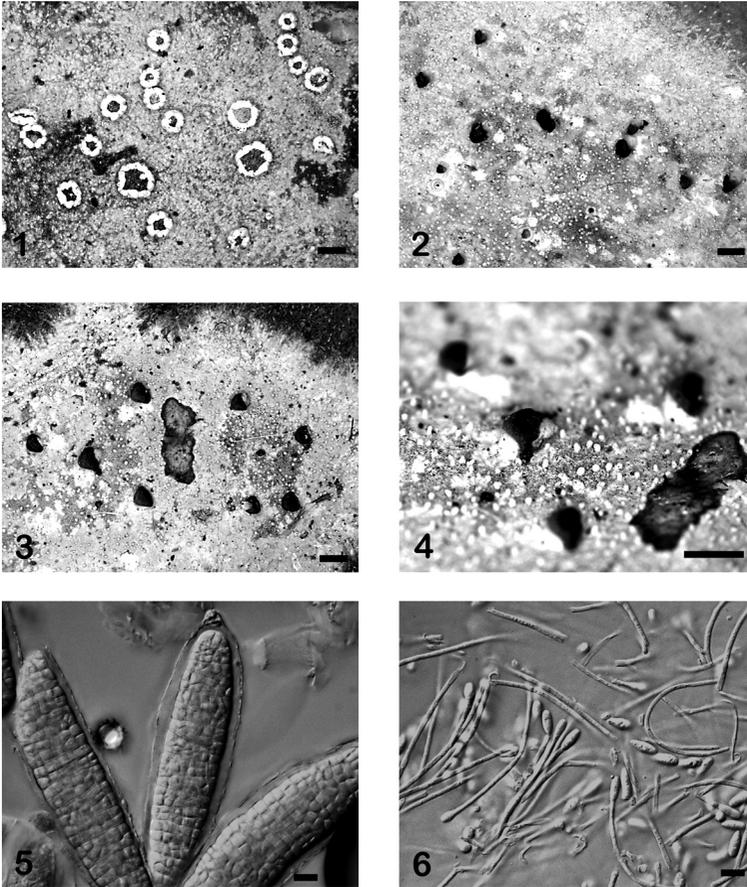
Sporopodium isidiatum Sérus. & Lücking sp. nov

Figs. 1-6

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Ab aliis speciebus Sporopodium differt thallo isidiato et campylidiis atris.

THALLUS corticolous or foliicolous, usually circular, c. 1.0-1.5 cm in diam. (largest seen: c. 2.5 cm), hardly delimited at the margins where free-living radiate hyphae may occur and thus form a whitish prothallus, continuous but formed of scattered to aggregated tiny patches at the margins; surface finely farinose, not corticated and rather matt, pale greenish to pale grey, usually with a bluish hue; verrucae always present, most probably representing genuine isidia, cylindrical and erect, c. 0.1-0.2(-0.3) mm in height and 0.05-0.1 mm in diam., regularly distributed over the thallus surface, albeit more numerous towards the center of the thallus, never branched, nor aggregated, of the same color as the thallus, filled with large, irregular oxalate crystals. PHOTOBIONT a species of the *Chlorococcaceae*, most probably *Trebouxia*. CYANOBACTERIA always present on the thallus surface, forming loose to compact, vermicular to granular, bluish grey to almost turquoise blue cephalodia, extensively covering large parts of the thallus; cyanobacterium a species of *Scytonema* with rare false branching, almost all trichomes with heterocysts, densely embedded by hyphae. CAMPYLIDIA present on thalli not producing apothecia, all pointing in the same direction and looking like the ventilating pipes of a steamer; made of a



Figs. 1-6. *Sporopodium isidiatum*. 1. Thallus with apothecia. 2-4. Thallus with campylidia. 5. Ascospores. 6. Conidia and conidiogenous cells. 1 & 5: holotype; 2-4 & 6: Papua New Guinea, Gahavisuka, E. Sérusiaux 13762-81. Scale bars: 1-4 = 1 mm; 5-6 = 10 μ m.

robust „socle“ containing the conidia-producing cavity vertically connected to a tiny, laterally laid down cupula which is almost completely covered by a hood-like lobe; socle 0.4-0.5(-0.6) mm in diam., campylidium (when mature) total height 0.7-1 mm, and (seen from above) 0.5-0.8 mm for the largest dimension (width of the cupula); outer surface pale orange to brownish at the socle level, turning into dark brown to almost pure black on the covering lobe and the cupula; inner parts of the tissues forming the covering lobe and the cupula, as well as the bottom of the conidiogenous layer, with numerous, tiny, orange brown crystals that do not dissolve in K; conidiogenous cells cylindrical, 20-25

× 1-1.5 µm; conidia abundantly produced, apically arising one at a time, ellipsoid to slightly clavate, usually lacrimiform (the distal end rounded and the proximal one pointed, usually with an apiculus), hyaline, non-septate, 8-10 × 3(-3.5) µm; conidia accumulating in a globose, pale orange mass at the „mouth“ of the campylidium; no photobiont cells seen in the conidiogenous layer, nor in the conidial mass. APOTHECIA present on thalli not producing campylidia, biatorine, rounded or slightly irregular, strongly constricted at their base, 0.9-1.2 mm when fully mature, 0.3-0.4 mm in height; margin persistently strongly prominent, 0.1-0.15(-0.2) mm thick, whitish, or with a very pale yellowish-orange hue, smooth to downy, crenulate and somewhat swollen, with a few radial fissures; disc greyish to almost black, not or slightly pruinose, plane. Excipulum well-developed, typically paraplectenchymatous in its inner parts, containing numerous, tiny, orange brown crystals that do not dissolve in K, 90-100 µm thick under the hypothecium, up to 140 µm in lateral parts; hypothecium orange to brownish, not significantly changing in K; hymenium dark under the dissecting microscope for unknown reason, but hyaline when examined with the photonic microscope, c. 110-130 µm thick; paraphyses numerous, branched and anastomosed, c. 1 µm thick; asci clavate, of the *Sporopodium*-type, 100-125 × c. 25 µm; ascospores single in the asci, strongly muriform, narrowly ellipsoid, with a distinct halo (easily seen in water), 91-118 × 19-25 µm.

CHEMISTRY: 2,7-dichlorolichexanthone (major), zeorin (major), pannarin (minor), 7-chloro-6-O-methylnorlichexanthone (minor), 2,7-dichloro-6-O-methylnorlichexanthone (minor) and 2-chlorolichexanthone (determined by HPLC and HPTLC).

NOTES — *Sporopodium isidiatum* is readily recognized by its verrucose-isidiate thallus, and large and conspicuous campylidia and (when present) apothecia. Moreover the almost black color of the campylidia lobes forms a strong contrast with the white to slightly bluish thallus, and this feature is characteristic of the species.

As summarized in Tab. 1, the secondary chemical compounds produced in the genus are numerous and diverse. *Sporopodium isidiatum* is characterized by the production as major compounds of 2,7-dichloro-lichexanthone and zeorin, a combination not found in any other species.

DISTRIBUTION AND ECOLOGY — *Sporopodium isidiatum* is known from two localities in Papua New Guinea, in the montane forest zone (1300-2450 m), where it grows on living leaves in well-preserved stands. It must be quite rare as — although many rainforest localities have been studied in several parts of the country — *S. isidiatum* has been detected in only two. Interestingly, it was also found corticolous at a much lower elevation in Sri Lanka. The species is thus likely to be widespread in tropical S-E Asia.

TABLE 1. Secondary chemical compounds produced by *Sporopodium* species

COMPOUNDS/SPECIES	ae	an	au	ci	fl	is	li	lm	lu	ma	ph	pi	xa
XANTHONES													
Arthothelin	xx	x	xxx		x		x						x
Isoarthothelin		x	xx		x		x	x		xx			x
Asemone		x	x		x		x						x
3-O-methylasemone								x					
2-Chlorolichexanthone						x							
4-Chlorolichexanthone				x									
4-Chloro-3-O-methylnorlichexanthone				x									
4-Chloro-6-O-methylnorlichexanthone				x									
5-Chloronorlichexanthone				x									
2,5-Dichlorolichexanthone								x					
2,7-Dichlorolichexanthone					x	xxx							x
4,5-Dichlorolichexanthone				x									
5,7-Dichlorolichexanthone					x			x					x
2,7-Dichloro-6-O-methylnorlichexanthone						x							
4,5-Dichloro-6-O-methylnorlichexanthone				x									
5,7-Dichloro-3-O-methylnorlichexanthone					x			x	xx	xxx	x		x
4,5-Dichloronorlichexanthone	xx												
5,7-Dichloronorlichexanthone					x								x
2,4,5-Trichlorolichexanthone								x					
2,5,7-Trichlorolichexanthone					x								x
2,5,7-Trichloro-3-O-methylnorlichexanthone					x				xx	xxx	x		x
4,5,7-Trichlorolichexanthone								x					
7-Chloro-6-O-methylnorlichexanthone						x							
Chodatin													
Thiophanic acid	xxx	x	xxx		x		x						x
Vinetorin				x									
DEPSIDES AND DEPSIDONES													
Atranorin													x
Methylbarbate								xxx					
Argopsin		x					x						
Pannarin					x	x			xx		x	x	x
TRITERPENOIDS													
Zeorin		x	xx	x	x	xxx	x				x	x	x
VULPINIC ACID DERIVATIVES AND DIBENZOFURANES													
Vulpinic acid									xxx				
Isousnic acid	xx												
Usnic acid	xxx												

ae= *aeruginascens*, an = *antonianum*, au = *aurantiacum*, ci = *citrinum*, fl = *flavescens*,
 is = *isidiatum*, li = *leprieurii*, lm = *leprosum*, lu = *lucidum*, ma = *marginatum*,
 ph = *phyllocharis*, pi = *pilocarpoides*, xa = *xantholeucum*.

SPECIMENS EXAMINED — PAPUA NEW GUINEA: Madang prov., S side of Ramu river, Bundi village, along the road to Bundi Gap, 5°44.9'S 145°14.1'E, 1300-1500 m, forested slope, foliicolous, Nov. 1995, E. Sérusiaux 16609 (LG—holotypus, F—isotypus). Eastern Highlands prov., Gahavisuka Provincial Park, 11 km N of Goroka, 6°01'S 145°25'E, 2300-2450 m, little disturbed mossy mountain forest, Aug. 1992, E. Sérusiaux 13762-81 (LG, F). SRI LANKA: Southern prov., Galle distr., Kanneliya Forest, 1 km N of forestry bungalows, 6°15'N 80°22'E, 90 m, corticolous, March 1978, G. Thor 583 (S).

Key to all known species of *Sporopodium*

- 1a Thallus or reproduction organs distinctly (citrine) yellow or orange 2
- 1b Thallus or reproduction organs not distinctly yellow or orange [campylidia and apothecial margins sometimes pale yellow to pinkish orange] 7
- 2a Thallus (at least parts of it, mainly near apothecia and campylidia), campylidia and apothecia yellow or orange 3
- 2b Thallus bluish, apothecial margin grey to whitish, campylidia bright yellow 4
- 3a Thallus, apothecia (mainly margins) and campylidiapale to bright orange; apothecial margin smooth [pantropical] *Sp. aurantiacum* (Zahlbr.) Lücking
- 3b Thallus lemon green, apothecia (mainly margins) and campylidia bright lemon yellow; apothecial margin slightly crenulate. [tropical Asia, New Guinea] *Sp. lucidum* Aptroot & Sipman
- 4a Thallus distinctly verrucose; apothecial margin irregular or slightly crenulate . . . 5
- 4b Thallus smooth or with scattered, indistinct, low verrucae; apothecial margin smooth or almost so 6
- 5a Verrucae irregularly papillose, with a thinly pruinose to pilose surface; thallus with usnic and isousnic acid, and dichloro- and trichlorolichexanthones [neotropical] *Sp. aeruginascens* Lücking & Lumbsch
- 5b Verrucae regular and smooth; thallus with zeorin, together with chloro- and dichlorolichexanthones [pantropical] *Sp. citrinum* (Zahlbr.) Elix & al.
- 6a Thallus smooth or with scattered, indistinct, low verrucae; base of campylidia well-developed, usually broader and larger than the lobe, and thus the most conspicuous part of the campylidium [eastern paleotropics] *Sp. flavescens* (R. Sant.) Vezda
- 6b Thallus smooth; base of campylidia reduced and thus the lobe being the most conspicuous part of the campylidium ... [amphipacific] *Sp. subflavescens* Lücking
- 7a Verrucae always distinct; thallus usually greyish to pale greenish grey or with a bluish tinge 8
- 7b Verrucae absent, or scattered, indistinct or low; thallus usually bluish grey 13
- 8a Thallus coarsely verrucose to isidiate; campylidia with a blackish brown to pure black lobe; thallus with a bluish tinge [tropical Asia and New Guinea] *Sp. isidiatum*
- 8b Thallus finely verrucose, not isidiate; campylidia with a light to dark brown lobe; thallus usually without a bluish tinge 9

- 9a Prothallus typically present, woolly, of loosely interwoven hyphae, very similar to that produced by *Lasioloma* species; apothecial margin with tiny hairs. [pantropical] *Sp. antonianum* Elix & al.
- 9b Prothallus not woolly; apothecial margin without hairs 10
- 10a Apothecial margin smooth or almost so, hardly raised 11
- 10b Apothecial margin irregular or thick, crenulate, and raised 12
- 11a Apothecial disc non-pruinose; campylidia with a distinct socle and a rather small, usually dark brown lobe. [pantropical] *Sp. leprieurii* Mont.
- 11b Apothecial disc pruinose; campylidia without a distinct socle and with a large, brownish lobe [neotropical and Africa] *Sp. pilocarpoides* (Zahlbr.) Lücking & Kalb
- 12a Apothecia 0.8-1.4 mm in diam., disc with spreading masses of torulose hyphae [New Guinea] *Sp. muscicola* Lambley & Sérus.
- 12b Apothecia 0.5-0.8 mm in diam., disc smooth. [tropical Asia] *Sp. argillaceum* (Müll. Arg.) Zahlbr.
- 13a Thallus C and KC + orange, (containing methyl barbatate); apothecia unknown [neotropical] *Sp. leprosum* Øvstedal & Elix
- 13b Thallus C and KC -; apothecia present or absent 14
- 14a Ascospores 8/ascus; campylidia unknown *Sp. octosporum* Lücking
- 14b Ascospores single in the ascus; campylidia usually present 5
- 15a Conidia 1-septate, distal cell rounded and proximal cell ellipsoid-bacillar; campylidia with reduced socle and a large, greyish lobe with a whitish gray pruina [tropical Africa] *Sp. podosphaera* Lücking & R. Sant.
- 15b Conidia non-septate, ellipsoid to guttuliform; campylidia without pruina 16
- 16a Apothecia irregular, with thickly pruinose margin; campylidial wall para-plectenchymatous throughout; campylidia often pale yellowish [pantropical] *Sp. xantholeucum* (Müll. Arg.) Zahlbr.
- 16b Apothecia regularly rounded; campylidial wall in most parts prosoplectenchymatous; campylidia usually pale grey 17
- 17a Apothecial margin prominent, pale orange to pinkish; pannarin and zeorin absent [amphipacific] *Sp. marginatum* Lücking
- 17b Apothecial margin not prominent, pale grey to whitish, pannarin and zeorin present [pantropical] *Sp. phyllocharis* (Mont.) A. Massal.

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