

New morphospecies of *Chamaesiphon* (Cyanobacteria) from Atlantic rainforest, Brazil

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Abstract: The Atlantic rainforest is considered one of the most important hotspots of biodiversity on Earth. This great diversity results from the variation of climatic conditions (rainy, warm and cold in high mountains), what generates a unique series of rain forest ecosystems quite distinct from each other. Unfortunately, due to the human impact over the centuries, today there are just fragments of preserved native rainforest. During the investigation about the cyanobacterial flora from the Atlantic rainforest, a special *Chamaesiphon* morphotype was found on a rock in streaming water. *Chamaesiphon stratosus* sp. nova is close to *C. britannicus* (FRITSCH) KOMÁREK et ANAGN., *C. geitleri* LUTHER and *C. fuscus* (ROSTAF.) HANSG., and differs from them mainly because of the cells disposition in one layer and exocytes liberation in a sheath at the upper part of cells. These two features belong to different subgenera of *Chamaesiphon* (*Godlewskia* and *Chamaesiphonopsis*). Thus, the Brazilian material displays features of both subgenera and puts in evidence the fragility of these characteristics at subgenus level. Therefore, a discussion about the taxonomy of these subgenera and a proposal for including *Chamaesiphonopsis* as a synonym of the *Godlewskia* were done.

Key words: Brazil, Atlantic rainforest, *Chamaesiphon*, new morphospecies, epilithic habitat

Introduction

The Atlantic rainforest is one of the most important hotspots of biodiversity on Earth (MYERS et al. 2000). This ecosystem is disposed along the Brazilian Atlantic coast from the south to the northeast of the country (RIZZINI 1997), with a great diversity of habitats. Due to the variability of climatic conditions (rainy, warm and cold in high mountains), a series of rain forest ecosystems quite distinct from each other are formed (MITTERMEIER et al. 1999).

The Atlantic rainforest encompasses areas in Brazilian tropical and subtropical regions and in spite of its high diversity of habitats and richness of species, most of its biodiversity related to microorganisms, including that of Cyanobacteria (KOMÁREK 2007; FIORE et al. 2007), is totally unknown. Besides that, the intense deforestation of the Atlantic rainforest has reduced the ecosystem to only 7% of its original coverage (MINISTÉRIO DO MEIO AMBIENTE 2007).

During the investigation about the

cyanobacterial flora in the Atlantic rainforest, a special *Chamaesiphon* morphotype growing on a rock in streaming water was found. The genus *Chamaesiphon* presents heteropolar cells and a special kind of reproduction characterized by asymmetrical binary fission and exocytes liberation. Most *Chamaesiphon* species has been registered to freshwater with epiphytic habit. KOMÁREK & ANAGNOSTIDIS (1998) listed 13 species exclusively epiphytic and submersed, 9 epilithic, and one with subaerophytic habitat. GOLD-MORGAN et al. (1996) found in Central Mexico six taxa (five species and one variety) of *Chamaesiphon* and among them, five are epiphytic and one was growing on artificial substrate in a fountain. Recently, *Chamaesiphon komárekii* Rott, a new epilithic species from a Canadian forest stream (ROTT 2008) was described.

The genus *Chamaesiphon* is very little known in Brazil where there are only few references to its occurrence. UHERKOVICH & FRANKEN (1980) cited *Chamaesiphon* sp. for the Amazonian region, FRANCESCHINI (1983)

mentioned the epiphytic *C. confervicola* A.BRAUN in RABENH. for the State of Rio Grande do Sul, and BICUDO (1988) and AZEVEDO et al. (1996) referred *C. investiens* SKUJA in periphyton of a lake in São Paulo State. Necchi-JÚNIOR & SANT'ANNA (1986) is the most complete work developed in Brazil about *Chamaesiphon* species, presenting description and illustrations of three species (*C. confervicola*, *C. curvatus* Nordst. and *C. incrustans* Grunow in Rabenh.) which are all epiphytes: the first and second on *Batrachospermum* (Rhodophyceae) and the third on *Scytonema* (Cyanobacteria), occurring in streams from São Paulo State. Recently, *Chamaesiphon* species in Brazil are mentioned only in lists of species occurring as epiphytes in streams and rivers (FONSECA & RODRIGUES 2007; NECCHI-JÚNIOR et al. 2008).

The aim of this work is to characterize a new morphospecies of *Chamaesiphon* from a rock substrate in the Atlantic rainforest.

Material and Methods

The State Park of Campos do Jordão (22°41'25"S; 45°28'5"W) is located in São Paulo State, southeastern Brazil. The region is characterized by the presence of *Araucaria* forest located around 2000 m high with temperature average 14 °C (minimal down of 0 °C and maximal 30 °C) (MODENESI 1984).

The material was found on rock coverage by a running water film from a stream in the forest. The samples were gathered with a spatula and fixed in 4% formaldehyde solution. The material was studied under the light microscope to detail the morphological and metrical features of the population (n=30).

Results

Chamaesiphon stratosus sp. nov. (Figs 1–2)

Diagnosis: *Thallus* epilithicus, *stratosus*, *insidens* in *saxis* in *rivulis fluentibus*, *macula fusca*, *olivaceae* vel *ochracea* *formans ad expansus*. *Coloniae condensatae*, *fruticulosae*, *flabelliformes*. *Cellulae paralleliter*

perpendiculariterque, *dense dispositae*, *basim ad substratum affixae*, *plus minusve irregulariter claviformes*, *basim et ad apices rotundatae*, *praecipue in strato uno dispositae*, 9.3–26.8 µm longae, 2.3–6.5 µm latae. *Cellulae contentu fusco vel olivaceo*, *paucim granulatae*. *Pseudovagina U-formata*, *distincta*, *firma*, *sine colore vel ad intense luteo-viridis vel brunescens*, *paucim lamellata*, *vetusta*, *infundibuliformis*, *apice late aperta*, *basim clausa*. *Exocytas* 1.5–2.6 µm diametro, *plerumque in parte superior pseudovaginae in massis agglomerata*, *rare stratum secundum superior formans*, *vel singulares liberantur*.

Habitatio: In *saxis* in *rivulis* cum *aqua rapide fluitans*; *locus classicus:* *Brasilia*, *provincia Sao Paulo*, in *comitatu Campos de Jordão* (22°41'26.3"S; 45°28'51.4"W).

Typus (holotypus): *Exsiccatum* SP400963; *dep. in herbarium (SP) Institute of Botany, SP, Brazil*; *icona typica figurae nostrae* 1.

Thallus forming brown to olive-green spots on rock and stones. Colonies compact, shrub-like, fan-shaped, composed of parallel arranged cells oriented perpendicularly to the substrate. Cell more or less irregular club-shaped, rounded at both ends, organized in one layer or at most two, 9.3–20.6(26.8) × 2.3–4(6.5) µm. Cells content brownish or olive-green, slightly granular. Sheath U-shaped, distinct, firm, colorless to intensely yellowish-green or brownish, slightly lamellate and frayed when old, widely opening at apical end and closed at the basis. Exocytes 1.5–2.6 µm diameter, generally forming mass with variable number of rows and layers on the upper part of the mother cells where they rarely germinate. They can be also singly liberated from the mother cells.

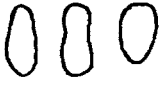


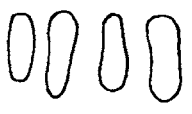
Habitat: On rock coverage by rapid running water from a stream in the forest.

Type locality: Brazil, in State Park, municipality of Campos do Jordão, São Paulo State, Brazil (22°41'26.3"S; 45°28'51.4"W).

Table 1. Comparison between the three sub-genera of *Chamaesiphon* (KOMÁREK & ANAGNOSTIDIS 1998).

<i>Chamaesiphon</i> sub-genera	<i>Chamaesiphon</i>	<i>Chamaesiphonopsis</i>	<i>Godlewskia</i>
Cells arrangement	solitary, not forming layered colonies	± densely and parallelly oriented in one layer colonies	forming shrub-like groupings or large layered colonies
Exocytes disposition and liberation	liberated after formation, not remaining in the colonial mucilage	soon separated or remain for a short time at the margin of sheaths	attached to the margin of sheaths or remain in colonial mucilage

Table 2. Comparison between Brazilian material and its closest *Chamaesiphon* species.

	Subg. <i>Chamaesiphonopsis</i>		Subg. <i>Godlewskia</i>	
	<i>C. britannicus</i>	<i>C. fuscus</i>	<i>C. geitleri</i>	<i>C. stratosus</i>
Colour of mass	brown spots	dark rusty brown to blackish (several cm ²)	dark brown to blackish, irregular spots	olive-green (up to several cm ²)
Cells disposition	densely and paralelly packed in 1-3(4) layers	densely and paralelly arranged in 1-2(3) layers - <i>Dinobryon</i> -like	densely and paralelly arranged in 2(5) layers - shrub-like	compact and paralelly arragend in 1(2) layer - fan-shaped
Cell lenght (µm)	10.5-14	5-13(22)	(4)5-20(30)	9.3-20.6(26.8)
Cell diameter (µm)	3.5-4.5(5)	(2.5)3-7	2.5-6.5(9.6)	2.3-4(6.5)
Sheaths	fine, diffluent	thin to slightly thickened, ± V-shaped	thick, lamellate, V-or-funnel-shaped	firm, thick, lamellate, U-shaped
Cell shape				
Exocytes liberation	1-2	1-2	1-2 or in a short simple row	Forming mass in the upper part of colony or singly
Habitat	Epiphytic in clear stagnant waters (splash zone)	Epilithic (non-calcareous stony) in running waters	Epilithic in streams and waterfalls (always submersed)	Epilithic on rock under a water film
Ocurrence	Temperate zone	Temperate zone	Temperate zone	Tropical zone

The main diacritical features to distinguish *Chamaesiphon stratosus* from its closest species (Table 2) is the parallel cells disposition mainly in one layer, exocytes formation generally in mass and by its occurrence in tropical zone. The frequent formation of a mass of exocytes instead of their liberation one by one might represent a protection mechanism against water flow impact. This characteristic is not normally found in the other *Chamaesiphon* species. Another population of *Chamaesiphon stratosus* growing also on rock in stream was found in different area of Atlantic rainforest located in a State Park, Municipality of Itupeva, São Paulo State (23° 08'54" S and 47° 03'38" W).

Discussion

JANCZEWSKI (1883) described the genus *Godlewskia* as epiphyte on *Batrachospermum*, with bottle shaped cells and rounded exocytes disposed in series on the upper part of the vegetative cells. These exocytes develop attached to the mother cell giving a disorganized aspect to the old colonies. FRITSCH (1929) proposed the genus *Chamaesiphonopsis* based on material described as “parenchymatous basal layer composed of closely fitting polygonal cells with firm but thin membranes, which form a prominent

network”. According to this author, the difference between *Chamaesiphon* and *Chamaesiphonopsis* is the germination of exocytes *in situ* and a large number of exocyte producing cells united to form a compact basal stratum in *Chamaesiphonopsis*. Other characteristic described to this genus is the tendency to develop upright rows. GEITLER (1932) included *Chamaesiphonopsis*, *Godlewskia* and some other genera (*Sphaerogonium* ROSTAF., *Brachythrix* A. BRAUN in RABENH. and *Hyelloccus* SCHMIDLE) as synonymous of *Chamaesiphon*, and divided this genus into three sections: *Brachythrix*, *Euchamaesiphon* and *Godlewskia*. The sections were separated considering the organization of tallus and features of exocyte (amount and liberation process).

Based on the proposal of GEITLER (1932), KOMÁREK & ANAGNOSTIDIS (1995) changed the section *Godlewskia* to a subgenus status and created the subgenus *Chamaesiphonopsis* based on the genus described by FRITSCH (1929). Later, KOMÁREK & ANAGNOSTIDIS (1998) divided the genus *Chamaesiphon* into three sub-genera differentiated by disposition and arrangement of the cells and by formation and liberation of exocytes: *Chamaesiphon* (based on Geitler's concept of *Euchamaesiphon* and *Brachythrix*), *Chamaesiphonopsis* and *Godlewskia* (Table 1). However, the distinction between the two last subgenera is not clear once there are species with

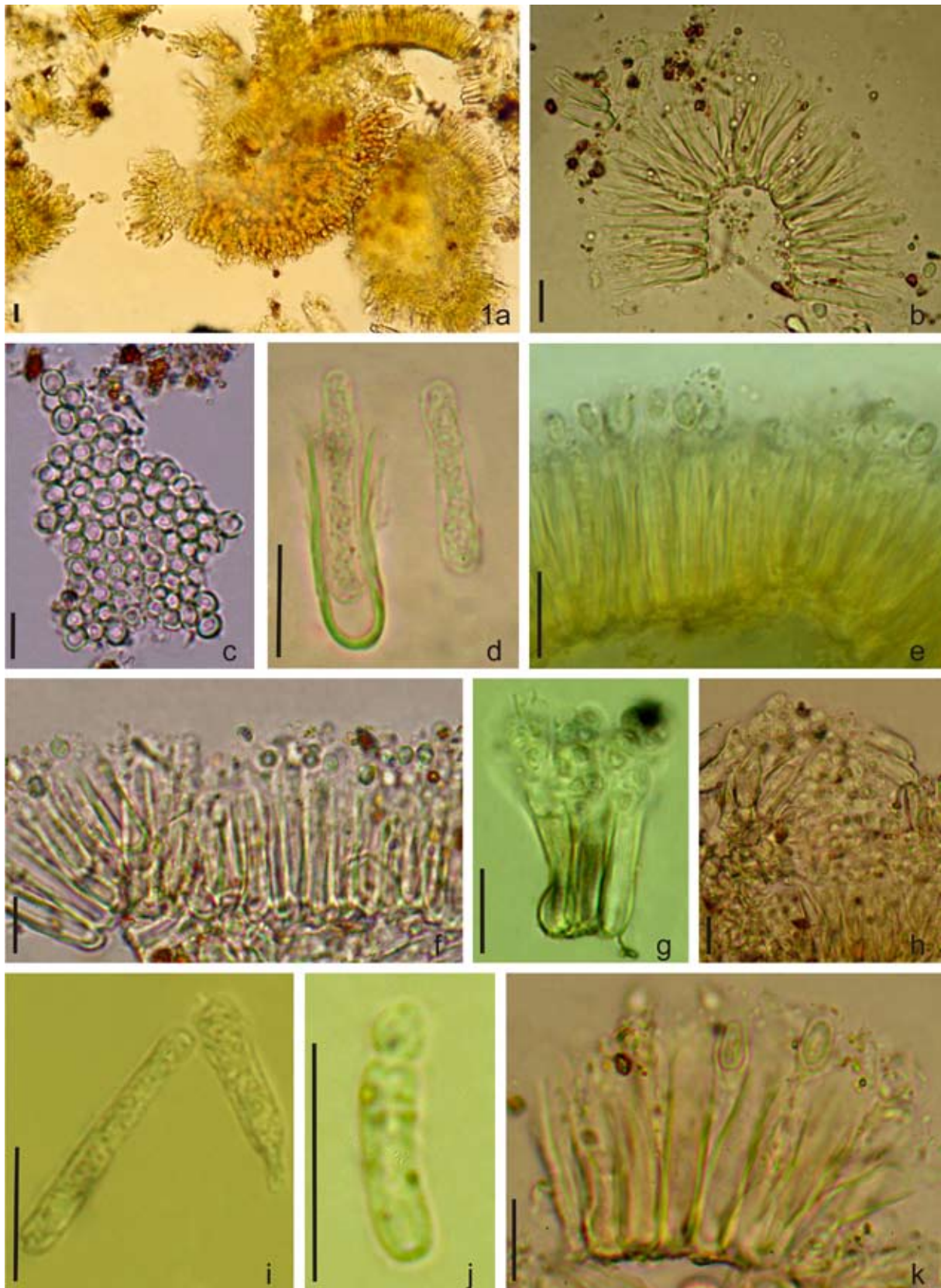


Fig. 1. *Chamaesiphon stratosus*: (a) general aspect of colonies; (b) fan-like colony; (c) apical view of colony; (d) cell showing lamellate sheath; (e) colony with parallel cells disposition; (f) exocytes liberation; (g–h) exocytes forming rows and layers after the liberation from the mother cells; (i) old cells showing club-shaped form; (j) exocyte formation; (k) initial stage of cell development forming the second layer. Scale bar 10 µm.

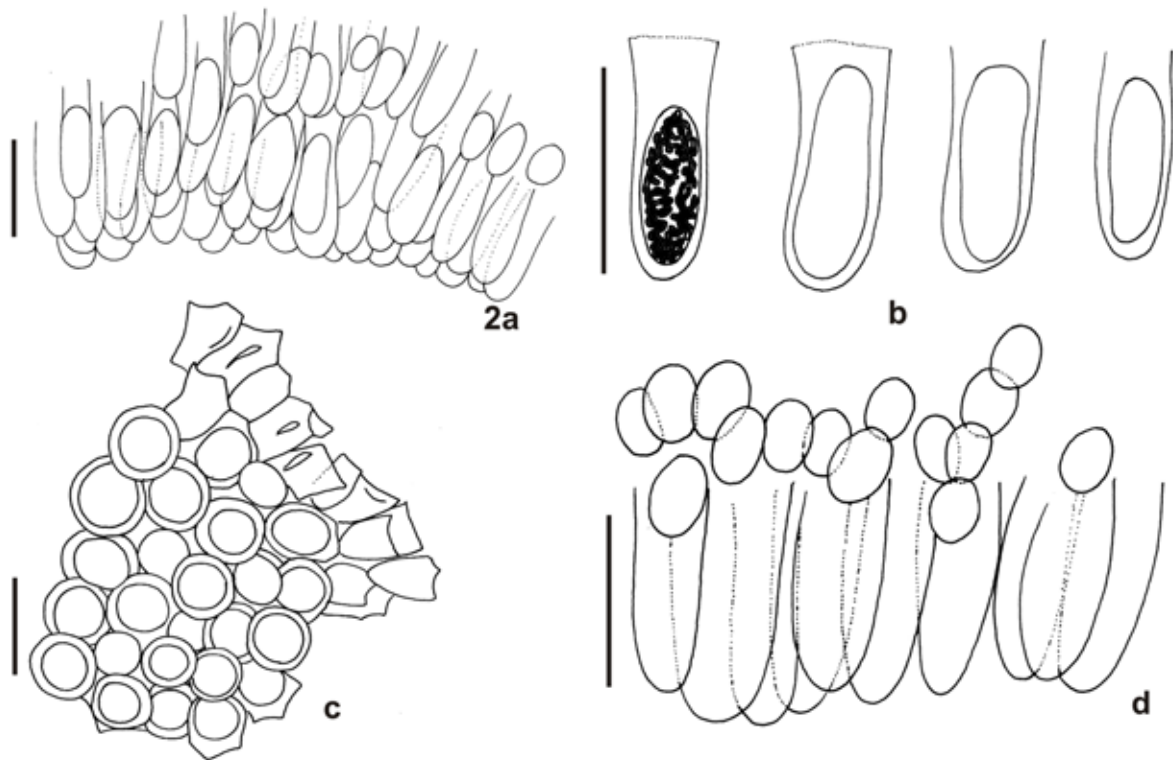


Fig. 2. *Chamaesiphon stratosus*: (a) general aspect of colonies; (b) different kind of cells shape and cell content with granules; (c) apical view of colony; (d) formation and liberation of exocytes. Scale bar 10 µm.

characteristics of both. *Chamaesiphon britannicus* (FRITSCH) KOMÁREK et ANAGN. is the only species of the subgenus *Chamaesiphonopsis* and has the cells organized in one or three layers, rarely four, and so, it is in disagreement with the description of subgenus *Chamaesiphonopsis* (cells disposed in one layer, as described by KOMÁREK & ANAGNOSTIDIS 1998). Thereby, the cells disposition is not a consistent feature in the differentiation of subgenera *Chamaesiphonopsis* and *Godlewskia* (layered colonies). Besides, both subgenera can display exocytes attached to the mother cells after liberation.

Considering that the distinction between *Chamaesiphonopsis* and *Godlewskia* is not reliable, we propose to consider the first as synonym of the second (concept of priority according to the Code of Botanic Nomenclature). Thus, the genus *Chamaesiphon* should be composed of two subgenera: *Chamaesiphon* (unicellular tallus) and *Godlewskia* (colonial tallus formed by cells disposed in one or more layers). The species *Chamaesiphon britannicus* should be transferred to the subgenus *Godlewskia*. *Chamaesiphon komárekii* has to be also included in *Godlewskia* because the material forms colonies, and not in the subgenus *Chamaesiphon*

as proposed originally (ROTT 2008). The Brazilian morphotype has one-layer colonies as it is typical of *Chamaesiphonopsis* and exocytes attached in the mucilage on the upper part of the cells as in the subgenus *Godlewskia*. Thus, the Brazilian new morphotype displays characteristics of both subgenera, further strengthening the fragility of the features used for distinguishing these subgenera and should be placed also in the subgenus *Godlewskia*.

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