Rodriguésia 71: e01612018. 2020
http://rodriguesia.jbrj.gov.br
DOI: http://dx.doi.org/10.1590/2175-7860202071064

Original Paper

The genus *Cladonia* (Lichenized Ascomycota) from Restinga Vegetation of Espírito Santo state, Brazil: Supergroups *Crustaceae* and *Perviae*

Cladonia *(Ascomycota liquenizados) das Restingas do Espírito Santo, Brasil: Supergrupos* Crustaceae e Perviae)

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Abstract

In this paper we recognize a total of 11 species of *Cladonia*, five belonging to Supergroup *Crustaceae* and six to Supergroup *Perviae*, occurring in the Restinga vegetation of Espírito Santo state, Brazil. We confirm the occurrence of *C. sprucei* and *C. rangiferina* to Espírito Santo state Restinga, being their most austral record in Brazil so far. Four species are new records to the state: *C. consimilis, C. dendroides, C. salzmannii*, and *C. sphacelata*. Here we expand the number of known species of *Cladonia* of Supergroup *Perviae* from three to five, and of Supergroup *Crustaceae* from three to six in the studied environment. An identification key, comments and illustrations are provided.

Key words: Atlantic rainforest, *Cladoniaceae*, dimorphic lichens, lichenized fungi, taxonomy.

Resumo

Neste trabalho reconhecemos um total de 11 espécies de *Cladonia*, sendo cinco pertencentes ao Supergrupo *Crustaceae* e seis ao Supergrupo *Perviae*, ocorrentes na vegetação de Restinga do estado do Espírito Santo, Brasil. Nós confirmamos a ocorrência de *C. sprucei* e *C. rangiferina* para as Restingas do Espírito Santo, sendo este o seu registro mais austral até o momento. Quatro espécies são novos registros para o estado: *C. consimilis, C. dendroides, C. salzmannii* e *C. sphacelata*. Expandimos o número de espécies conhecidas de *Cladonia* do Supergrupo *Perviae* de três para cinco, e do Supergrupo *Crustaceae* de três para seis espécies presentes na vegetação local. São fornecidos comentários, ilustrações e uma chave de identificação.

Palavras-chave: Mata Atlântica, *Cladoniaceae*, liquens dimórficos, fungos liquenizados, taxonomia.

Introduction

This work gives sequence to an investigation of the genus *Cladonia* P. Browne occurring in Restinga vegetation in Espírito Santo state, southeast Brazil (Fraga Jr. *et al.* 2017). Here, we discuss about the remaining Supergroups *Crustaceae* and *Perviae*, proposed by Stenroos *et al.* (2002).

The Supergroup *Crustaceae* nowadays comprises the species previously treated under the genus *Cladina* (Nyl.) Nyl., together with all species of the section *Unciales*, both *sensu* Ahti (2000) (Stenroos *et al.* 2002). In this Supergroup the species are characterized by the evanescent primary thallus, esorediate and usually much branched podetia, besides the production of fatty acids, depsides, depsidones and dibenzofurans (Ahti 2000; Stenroos *et al.* 2002; Bungartz & Ahti 2009). The Supergroup *Perviae* includes species that have an evanescent to persistent primary thallus, podetia often with dilated apical openings (funnels) and open axils (Hammer 1996), brown hymenial discs as well as the production of β-orcinol depsides (Stenroos *et al.* 2002; Bungartz & Ahti 2009).

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So far, Supergroup *Crustaceae* is represented by the following species in the Espírito Santo state Restinga vegetation: *C. confusa* R. Sant., *C. kalbi* (Ahti) Ahti & DePriest and *C. substellata* Vain., while the Supergroup *Perviae* is represented by: *C. crispatula* (Nyl.) Ahti, *C. rugicaulis* Ahti and *C. turgidior* (Nyl.) Ahti, all According to Ahti (2000).

Material and methods

The studied area, including map, its geographical and climatic data is described in Fraga Jr. *et al.* (2017). For the collection and preservation of the specimens the usual methodology in lichenology was followed. The specimens were deposited in the Herbarium of the Universidade Federal do Paraná (UPCB) and Universidade Federal do Espírito Santo (VIES). The morphological and anatomical analyses were performed under stereomicroscope (20–40×) and optical microscope (40–1000×). Spot tests (K, C, and KC), Thin Layer Cromatography (TLC) with solvent system C as well observation under UV Light (Orange *et al*. 2001) were performed to identify the lichen chemistry.

Results and Discussion

Five species belonging to the Supergroup *Perviae* were found: *C. crispatula*, *C. polystomata* Ahti & Sipman, *C. turgidior*, *C. salzmannii* Nyl., *C. sphacelata* Vain. The latter two being new records to Espírito Santo state, and *C. polystomata* is registered for the first time for the local Restinga vegetation, expanding its range of occurrence from the highlands (Ahti 2000) to the coastal region.

Six species of the Supergroup *Crustaceae* were found: *C. confusa, C. consimilis* Vain., *C. dendroides* (Abbayes) Ahti, *C. rangiferina* (L.) Weber *ex* F.H. Wigg., *C. sprucei* Ahti and *C. substellata*. We confirmed the occurrence of *C. sprucei* Ahti and *C. rangiferina* subsp. *abbayesii* (Ahti) Ahti & DePriest in Restinga vegetation from Espírito Santo state, which were mentioned by Marcelli (1998) but without a stored specimen, being their most austral record so far in Brazil. *Cladonia dendroides* and *C. consimilis* are also new records for the state.

Even though *C. bahiana* Ahti (Marcelli 1998), *C. kalbii* (Ahti) Ahti & DePriest and *C. rugicaulis* (Ahti 2000) were previously reported to this environment of Espírito Santo state, we were not able to find them in the fieldwork. Here we increase the number of known species of *Cladonia* of Supergroup *Perviae* from three to five, and of Supergroup *Crustaceae* from three to six in the Restinga vegetation of Espírito Santo.

Key to *Cladonia* species of Supergroups *Crustaceae* and *Perviae* from Restinga vegetationin Espírito Santo state

1. Podetia ecorticate or rarely corticioid, often arachnoid to slightly compact, never squamulose 2
1'. Podetia corticioid to mainly corticate, at least in patches, often with squamules 5
2. Apices of branches slightly to strongly incurved, podetia forming flattish domes 3
2'. Apices of branches erect or divaricate, podetia forming distinct rounded heads 4
3. Apices of branches conspicuously unilaterally deflexed; hyaline conidial slime .... 6. *Cladonia rangiferina* subsp. *abbayesii*
3'. Apices of branches not conspicuously unilaterally deflexed; red conidial slime .... 9. *Cladonia sprucei*
4. Thallus yellowish, without distinct main axis, with usnic and perlatolic acids (K–) .... 1. *Cladonia confusa*
4'. Thallus whitish to brownish gray, main axis somewhat distinct, with atranorin and fumarprocetraric acid (K+ yellow à reddish) ..... 4. *Cladonia dendroides*
5. Podetia yellowish green (usnic acid present) ..... 10. *Cladonia substellata*
5'. Podetia greenish gray to whitish (usnic acid absent) 6
6. Podetia fairly 1.5–4 mm thick, funnels and axils open dilated 7
6'. Podetia usually up to 1.5 mm thick, funnels and axils closed to open, inconspicuous 8
7. Surface of podetia dull, corticioid, smooth to slightly rugose, apices with star like branching pattern ..... 7. *Cladonia salzmannii*
7'. Surface of podetia glossy, corticate, rugose to occasionally verruculose, apices without star like branching ..... 11. *Cladonia turgidior*

8. Podetia little branched, apices subulate to scyphose 9
8'. Podetia fairly to strongly branched, apices always ascyphose 10
9. Surface of podetia mostly covered with a shiny cortex, axils closed, funnels absent ..... 8. *Cladonia sphacelata*
9'. Surface of podetia usually ecorticate, cortex matt, axils usually open, funnels often present ..... 5. *Cladonia polystomata*
10. Podetia 1–2 mm thick, grayish green to browned, densely branched ..... 3. *Cladonia crispatula*
10'. Podetia up to 1 mm thick, whitish, fairly branched .....2. *Cladonia consimilis*

1. *Cladonia confusa* R. Sant., Ark. Bot. 30 A (10): 13. 1942. Fig. 1a

Descriptions: see Ahti (2000), Gumboski & Eliasaro (2012).

Chemistry: K–; C–; KC–; UV–; TLC: usnic, perlatolic, homosekikaic and 4-*O*-demethylbarbatic acids plus unidentified compounds with Rfc 35, 62 (orange) and 72.

Selected specimens examined: Itaóca, Areial Rui Barbosa, 16.I.2015, *Fraga Jr. 696a* (UPCB); Vila Velha, Parque Natural Municipal de Jacarenema, 24.II.2015, *Fraga Jr. 406, 410 d, 438b* (UPCB; VIES).

Cladonia confusa is a fair widely distributed species in the Neotropics, occurring from sea level up to the mountains (3000 m) (Ahti 2000). It's characterized by the totally ecorticate, yellowish, and much branched podetia, usually forming semiglobose heads in the top of the colonies, as well as by the production of usnic and perlatolic acids (Ahti 2000; Gumboski & Eliasaro 2012). In the specimens analysed we found a diverse secondary chemistry: homosekikaic and 4-*O*-demethylbarbatic acids, in addition, some unidentified compounds with Rfc approximately to 35, 62 and 72 (*Fraga Jr. 410 d*). In one specimen (*Fraga Jr. 406*) we detected only production of perlatolic acid.

Cladonia evansii Abbayes and *C. signata* (Eschw.) Vain. are similar to *C. confusa* due the ecorticate and much branched podetia, without distinct main axis. However, in both species the ramification pattern is mostly dichotomic, and they can respectively produce atranorin and fumarprotocetraric acids, compounds absent in *C. confusa* (Vainio 1887; Ahti 2000).

This species occurs mainly in shaded places, bellow some shrubs, growing on sand or litter, often forming extensive colonies around four meters wide in Parque Natural Municipal de Jacarenema, growing mostly seldom or together with *C. crispatula, C. dendroides* or *C. verticillaris* (Raddi) Fr.

2. *Cladonia consimilis* Vain., Acta Soc. Fauna Fl. Fenn., 4: 292. 1887. Fig. 1b

Descriptions: see Vainio (1887), Ahti (2000).

Chemistry: K+ bright yellow; C–; KC–; UV–; TLC: thamnolic and decarboxythamnolic acids.

Selected specimens examined: Conceição da Barra, Parque Estadual de Itaúnas, 27.I.2015, *Fraga Jr. 474, 542, 544* (UPCB); Área de Proteção Ambiental de Conceição da Barra, 28.I.2015, *Fraga Jr. 600* (UPCB; VIES)*, 601* (UPCB).

Cladomia consimilis is characterized by the equally cylindrical and esorediate podetia, whitish, smooth, fairly dichotomously branched, ascyphose, with closed to open axils, red conidial slime, and by the production of thamnolic or barbatic acids (Vainio 1887; Ahti 2000).

Cladonia polytypa Vain. is morphologically very similar but exhibits a pronounced melanotic base of podetia and the conidial slime is hyaline (Ahti 2000).

Among the *Cladonia* species analysed in this study, *C. consimilis* can be easily confused with some slender morphs of *C. crispatula* and *C. salzmannii*. However, *C. consimilis* have thinner podetia, hardly reaching up to 1 mm thick, besides *C. crispatula* and *C. salzmannii* usually exhibits podetium over 1 mm thick, with a more scarcely branching pattern, predominantly dichotomic anisotomic, whereas in the previously mentioned species the branching pattern can be up to polytomic, with some isotomic tendency. *Cladonia consimilis* can exhibit some polytomic branching in the apices, which in some cases can be confused to *C. salzmannii* but this latter bears larger and conspicuous funnels, absent or very tiny in *C. consimilis.*

It was found only in northern places of Espírito Santo state, mostly colonizing bare sand or decayed wood. It's an inconspicuous species, growing seldom or with *C. crispatula*, *C. salzmannii* and/or *C. polystomata.*

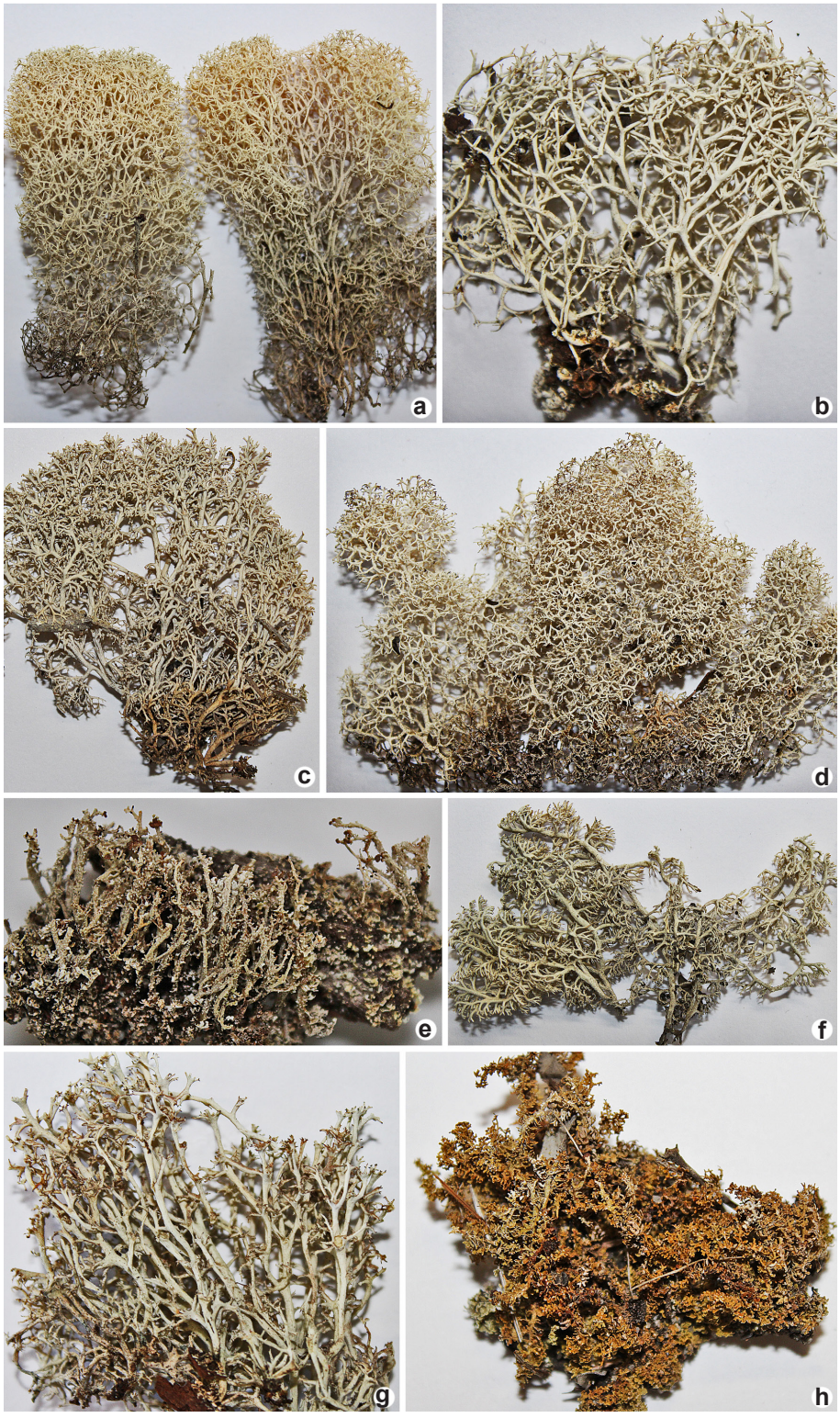

Figure 1 – a-h. Species of *Cladonia* in Restinga vegetation from Espírito Santo state – a. *Cladonia confusa*; b. *C. consimilis*; c. *C. crispatula*; d. *C. dendroides*; e. *C. polystomata*; f. *C. rangiferina* subsp. *abbayesii*; g. C. *salzmannii*; h. *C. sphacelata.* (a. *C.A.V. Fraga Jr. 438*; b. *C.A.V. Fraga Jr. 474*; c. *C.A.V. Fraga Jr. 580*; d. *C.A.V. Fraga Jr. 624*; e. *C.A.V. Fraga Jr. 634*; f. *C.A.V. Fraga Jr. 666*; g. *C.A.V. Fraga Jr. 422*; h. *, C.A.V. Fraga Jr. 717*). Scale bars = 1cm.

3. *Cladonia crispatula* (Nyl.) Ahti, Lichenologist 9: 14. 1977. Fig. 1c

Descriptions: See Ahti (1977, 2000), Gumboski & Eliasaro (2012).

Chemistry: K+ yellow; C-; KC-; UV-; TLC: thamnolic and decarboxythamnolic acids.

Selected specimens examined: Conceição da Barra, Área de Proteção Ambiental de Conceição da Barra, 28.I.2015, *Fraga Jr. 553*, *580*, *592* (UPCB); Guarapari, Parque Estadual Paulo Cesar Vinha, 10.II.2015, *Fraga Jr. 345* (UPCB); Área de Proteção Ambiental de Setiba, 02.III.2015, *Fraga Jr. 643*, *650* (UPCB; VIES); Itaóca, Areial Rui Barbosa, 16.I.15, *Fraga Jr. 691*, *702* (UPCB); Presidente Kennedy, Praia das Neves, 15.1.15, *Fraga Jr. 234, 278* (UPCB); Vila Velha, Parque Natural Municipal de Jacarenema, 24.II.2015, *Fraga Jr. 385, 388* (UPCB).

This species is characterized by the fairly anisotomic dichotomic, rarely tetrachotomic, branched podetia, with distinct main axis (0.8–1.5 mm thick), whitish, bluish to brownish gray, surface smooth to slightly rugulose in older parts, usually maculate, with areolate patches, with some scattered squamules, red conidial slime, and also by producing thamnolic acid (Ahti 1977, 2000; Gumboski & Eliasaro 2012).

According to Ahti (2000), some specimens of *C. crispatula* can be confused with species of the Group *Cladinae sensu* Stenroos *et al.* (2002) by their secondary thallus size and branching pattern. However, *C. crispatula* exhibits traces of rudimentary cortex, occasionally some squamules, and produces thamnolic and decarboxythamnolic acid, which are absent in species of the Group *Cladinae sensu* Stenroos *et al.* (2002) (Ahti 2000).

Cladonia sipmanii Ahti is another similar species to *C. crispatula*, but exhibits slender podetia (0.5–1 mm thick), more brownish in color, with axils always closed, and its distribution is currently restricted to Venezuela and Guyana (Ahti 2000).

Cladonia crispatula is very similar to *C. rugicaulis* in chemistry, overall morphology and branching pattern. However, *C. rugicaulis* can exhibit thicker podetia (up to 4 mm thick), a more distinctive rugulose surface (Ahti *et al.* 1993) without squamules (Ahti 2000), an ecorticate, fibrillose and non-maculate apex, often forming globose heads, besides having also a hyaline conidial slime (Ahti *et al.* 1993; Ahti 2000).

Some specimens displayed a notable morphological variation that even some that even approaches *C. rugicaulis* description aforementioned. However, none of the specimens displayed all those strict characteristics combined. We consider that the *C. rugicaulis* and *C. crispatula* of southeast and northeast Brazil are in need of a more detailed study to reveal a potential phenotypic plasticity of these species.

In this study, the majority of specimens collected correspond to *C. crispatula s. str.* in accordance to the descriptions of Ahti *et al.* (1993), Ahti (2000) and Gumboski & Eliasaro (2012).

Some variant specimens found (*Fraga Jr. 553*, *702*) are very similar to *C. crispatula*, exhibiting a more thickened podetia (2 mm), and short sided branches. Two specimens presented more isotomic branching pattern, also short side branches, with parallel running podetia, clearly smooth surface, wide openings mainly in apex, a constantly and distinct grayish layer up to half of the podetia, and forms flat topped colonies, rather than semiglobose. Some specimens yet exhibited a hyaline slime. We hypothesize that these morphologically variable specimens could represent distinct taxa closely related to *C. crispatula*, and thus, specific studies should be conducted with a larger number of specimens and employing molecular data to evaluate and clarify the taxonomic status of these distinct populations.

4. *Cladonia dendroides* (Abbayes) Ahti, Ann. bot. Soc. Zool.-Bot. fenn. Vanamo 32(1): 29. 1961. Fig. 1d

Description: see Ahti (1961; 2000).

Chemistry: K+ yellow reddish; C–; KC–; UV–; TLC: atranorin and fumarprotocetraric acid.

Selected specimen examined: Conceição da Barra, Área de Proteção Ambiental de Conceição da Barra, 28.I.2015, *Fraga Jr. 624* (UPCB; VIES).

The ecorticate podetia, densely isotomic dichotomic branched forming rounded heads on top of colonies, the blackened dead basal parts and the production of fumarprotocetraric acid and atranorin characterize this species (Ahti 2000).

According to Ahti (2000), is possible to confuse with *C. kalbii,* due the ecorticate and much branched thallus, but *C. dendroides* have a more isotomic branching pattern, forming denser heads. Besides, *C. dendroides* have a red conidial slime instead of purple like in *C. kalbii* (Ahti 2000).

Due the globose heads, this species can also be confused with *C. confusa*, but this latter has larger podetia, forming larger domes and produces usnic acid, giving a yellow tinge, whereas *C. dendroides* is ashy white, with small heads and have a hyaline slime instead red.

It's a conspicuous and very rare species, and only one specimen was found in the northern part of the state, at the borders of an open shrub formation, growing alone but near to *C. clathrata* and *C. crispatula*, on sand. It's a new record for Espírito Santo state.

5. *Cladonia polystomata* Ahti & Sipman, Fl. Neotrop., Monogr. 78: 294. 2000. Fig. 1e

Descriptions: see Ahti (2000), Gumboski & Eliasaro (2012).

Chemistry: K+ weakly yellow; C–; KC–; UV–; TLC: Thamnolic acid plus unidentified compound with Rfc 26.

Selected specimens examined: Conceição da Barra, Parque Estadual de Itaúnas, 27.I.2015, *Fraga Jr. 472, 550* (UPCB); Área de Proteção Ambiental de Conceição da Barra, 28.I.2015, *Fraga Jr. 625b, 634* (UPCB).

Cladonia polystomata is characterized by the mostly ecorticate, pale gray and short podetia (1–3 cm tall), few branched, esorediate, covered with reflexed squamules, with open axils, usually becoming narrow scyphoid funnels, with cylindrical conidiomata containing hyaline slime, and by the production of thamnolic acid (Ahti 2000; Gumboski & Eliasaro 2012).

This species can be confused with *C. sphacelata* by the absence of soredia or granules, by the squamulose surface, and the production of thamnolic acid (Ahti 2000; Gumboski & Eliasaro 2012). However, the latter exhibits a developed, smooth and cartilaginous cortex, red conidial slime, closed axils and do not bear scyphoid funnels (Ahti 2000; Gumboski & Eliasaro 2012). Besides, *C. polystomata* is usually less squamulose in direct comparison than *C. sphacelata*.

It also can be confused with *C. squamosa* Hoffm., by the squamulose and ecorticate podetia, however, *C. squamosa* tends to be even more ecorticate and exhibits a granulose cover, which is absent in *C. polystomata* (Vainio 1887; Ahti 2000).

Cladonia furfuracea Vain. commonly occurs together with *C. polystomata* in Restinga vegetation (Ahti 2000; Gumboski & Eliasaro 2012) and is also very similar morphologically due the ecorticate, esorediate and squamulose surface of podetia. However, *C. furfuracea* does not have funnels nor open axils, and produces fumarprotocetraric acid (Ahti 2000; Fraga Jr. *et al.* 2017).

In Espírito Santo state, this species is only referred to highlands environment (Ahti 2000). Here, we expand its range of distribution to the coastal area.

6. *Cladonia rangiferina* subsp. ***abbayesii*** (Ahti) Ahti & DePriest, Mycotaxon 78: 501. 2001. Fig. 1f

Descriptions: see Ahti (1961, 2000).

Chemistry: K+ yellow; C–; KC–; UV–; TLC: Atranorin and fumarprotocetraric acid.

Selected specimen examined: Guarapari, Área de Proteção Ambiental de Setiba, 2.III.15, *Fraga Jr. 666* (UPCB).

This subspecies is defined by the ecorticate podetia, browning in some dead or apical parts, mostly with an anisotomic dichotomic to tetrachotomic branching pattern, with distinct main axis and unilaterally deflexed falcate apices ("combed"), hyaline conidial slime, besides the production of fumarprotocetraric acid and atranorin. It is a widely distributed species with several subspecies (Ahti 1961, 2000).

In Brazil, the geographical distribution of this subspecies is quite enigmatic, with only *Cladonia rangiferina* subsp. *abbayesii* being registered for the country (Ahti *et al.* 1993; Ahti 2000). Ahti *et al.* (1993) mentioned its occurrence to northern states of Amazonas and Roraima, and the northeast states of Bahia and Sergipe. Marcelli (1998) mentioned its occurrence to the northern coast of Espírito Santo and other states above. Although, this same paper does not report any specimen, being field observations as written by Marcelli. Ahti (2000) records this subspecies only to northern Brazil (Roraima state), and refers similar lowland specimens to *C. kalbii*, and also affirms that *C. rangiferina* is securely absent from southeast Brazil, not mentioned directly *Cladonia rangiferina* subsp. *abbayesii*.

Besides this statement, the specimen found easily fits onto Ahti (1961, 2000) description of *Cladonia rangiferina* subsp. *abbayesii*, which is characterized by the mostly dichotomic tendency, with rather erect apices and more robust main axis, plus, the specimen found have clearly deflexed apices. In contrast, other species of *C. rangiferina* are hardly differentiated; being the branching pattern, color of podetia and geographical distribution the characteristics for its taxonomy. It is morphologically close to *C. kalbii,* in the branching pattern, with distinct main axis, and ecorticate arachnoid surface with smoothed apices (Ahti 2000). However, *C. kalbii* have a purple conidial slime, instead of hyaline, and the branching pattern in the apices is usually divaricate rather combed (Ahti 2000).

Moreover, even though *C. kalbii* was recorded to the local Restinga (Ahti 2000), we did not find any specimen with these strict characteristics. Since both are close related species, the presence of the unilaterally deflexed apices and the colour of slime were diagnostic characters about this consideration besides Ahti (2000) statement of its distribution.

Cladonia argentea (Ahti) Ahti & DePriest is also morphologically and chemically close related species related species, that resembles a robust morphotype of *C. rangiferina*, but do not exhibits any browned color and the conidial slime is also purple (Ahti 2000).

The specimen was found growing seldom in a well-lit area, on sand. It is locally a very rare species. Thus, we confirm the occurrence of this species for the Espírito Santo state.

7. *Cladonia salzmannii* Nyl., Acta Soc. Fauna Flora Fenn. 4(1): 310. 1860. Fig. 1g

Description: see Ahti (2000).

Chemistry: K+ yellow; C–; KC–; UV–; TLC: thamnolic, decarboxythamnolic and barbatic acids.

Selected specimens examined: Conceição da Barra, Parque Estadual de Itaúnas, 27.I.2015, *Fraga Jr. 542* (UPCB); Área de Proteção Ambiental de Conceição da Barra, 28.I.2015, *Fraga Jr. 582*, *602*, *618*, *625*, *626*, *627*, *632b* (UPCB); Vila Velha, Parque Natural Municipal de Jacarenema, 24.II.15, *Fraga Jr. 422* (UPCB); Presidente Kennedy, Praia das Neves, *Fraga Jr. 251* (UPCB).

Cladonia salzmannii is characterized by its thin (0.5–2.0 mm) and fairly branched podetia, with distinct main axis, scyphoid openings at the apex in star like form, red conidial slime, and by the production of barbatic and/or thamnolic acids (Ahti 2000). We found specimens producing barbatic acid, thamnolic acid and one specimen producing both acids (*Fraga Jr. 627*).

According to Ahti (2000), this species is closed related to *C. crispata* (Ach.) Flot. and *C. carassensis* Vain., but has narrower scyphoid funnels (2–6 mm in diameter), longer marginal proliferations (usually 0.5 mm) and normally produces barbatic acid.

In field it is easily confused with *C. crispatula* by the branched thallus and by the habitat. However, the star like apices with long proliferations and more dilated funnels are good features to separate them.

The analysed specimens exhibited a somewhat areolate and rugulose apex and a corticioid surface unlike the description of Ahti (2000), which describes with a smoothly corticated surface. We also observed a much more developed medulla (40–125 µm thick) than previously reported by the same author (10–15 µm thick).

This species grows mostly in decayed woods, sand, litter or organic soil, in fairly shaded areas. It forms distinct colonies in northern state, mainly in Área de Proteção Ambiental de Conceição da Barra. This is the first record of this species for Espírito Santo state.

8. *Cladonia sphacelata* Vain., Acta Soc. Fauna Flora Fenn. 4(1): 456. 1887. Fig. 1h

Description: see Ahti (2000).

Chemistry: K+ yellow; C–; KC–; UV–; TLC: thamnolic and decarboxythamnolic acids plus unidentified compounds with Rfc 0 (UV + blue), 27 (yellow), 43 (gray), 44 (yellow).

Selected specimens examined: Conceição da Barra, Parque Estadual de Itaúnas, 27.I.2015, *Fraga Jr. 556*, *574* (UPCB); Guarapari, Parque Estadual Paulo Cesar Vinha, 11.II.15, *Fraga Jr. 294* (UPCB); Itaóca, Areial Rui Barbosa, 16.I.15, *Fraga Jr. 717*, *722* (UPCB); Vila Velha, Parque Natural Municipal de Jacarenema, 24.II.15, *Fraga Jr. 432* (UPCB).

Cladonia sphacelata has a smoothly cartilaginous corticate podetia, rarely a little decorticate, also being moderately branched, squamulose, ascyphose without soredia or granules, and usually with closed axils, commonly producing thamnolic acid (chemotype I), other compounds such as squamatic (chemotype II), barbatic and didymic acids and related compounds (chemotype III) (Ahti 2000).

We found an uncommon chemistry, with high number of secondary metabolites, and even a combination of chemotype I and III, which is not yet reported. In addition, some unidentified compounds were observed: with Rfc approximately 0 (spot UV + blue), and gray spots with Rfc approximately 35, 39, 43 and a UV+ yellow with Rfc approximately 44.

This species is often confused with *C. polystomata* (Ahti 2000). Both have an esorediate and egranulose podetia covered with squamules, but *C. sphacelata* has a more continuous cortex and the axis is usually closed (Ahti 2000; Gumboski & Eliasaro 2012). They also differ in the color of slime, which is red in *C. sphacelata* and is hyaline in *C. polystomata* (Ahti 2000; Gumboski & Eliasaro 2012). In this study, besides the little morphological differences, *C. sphacelata* presented a higher number of secondary metabolites than *C. polystomata* (see discussion under *C. polystomata*).

Besides this species being reported for the northeast to southern Brazil, mostly in the coastal region in Restinga vegetation (Ahti 2000; Gumboski & Eliasaro 2012), it was not yet recorded to Espírito Santo state. It was found colonizing bare sand or organic soil, in well-lit areas, forming conspicuous and browned colonies with about one meter wide.

9. *Cladonia sprucei* (Ahti) Ann. bot. fenn. 32: 01. 1961. Fig. 2a

Description: see Ahti (2000).

Chemistry: K+ yellow; C–; KC–; UV–; TLC: atranorin and fumarprotocetraric acid.

Selected specimens examined: Guarapari, Parque Estadual Paulo Cesar Vinha, 12.II.15, *Fraga Jr. 354b* (UPCB); Itaóca, Areial Rui Barbosa, 16.I.15, *Fraga Jr. 678a, 688* (UPCB), *Fraga Jr. 733* (UPCB; VIES).

Cladonia sprucei is characterized by forming dense and flat-topped colonies, with as anisotomic branching pattern, blackened apices on dead parts, red conidial slime and by the production of fumarprotocetraric acids and related compounds and atranorin (Ahti 2000).

According to Ahti (2000), this species is morphologically very similar to *C. rangiferina* subsp. *abbayesii* and *C. kalbii*, differing in the color of slime, which is hyaline and purple respectively, besides the more isotomic branching tendency and more compact and acuminate apices.

The presence of a red conidial slime and fairly compact apices were the diagnostic characteristics to separate *C. sprucei* from other species of the Group *Cladinae sensu* Stenroos *et al.* (2002) as *C. rangiferina,* and *C. dendroides,* in Restinga from Espírito Santo.

It is an uncommon species, growing on sand and litter in shaded to exposed areas. Marcelli (1998) mentioned its occurrence in Restinga vegetation from Espírito Santo, also without referring an herborized specimen. However, this species is only recorded to northern Brazil, in Amazonas state by Ahti (2000). So, we could confirm its occurrence in Restinga vegetation, being its first record for this environment and the most austral in the Neotropics so far.

10. *Cladonia substellata* Vain., Acta Soc. Fauna Flora Fenn. 4(1): 271. 1887. Fig. 2b

Descriptions: see Vainio (1887), Ahti (2000), Charnei (2013).

Chemistry: K+ weakly yellow or K–; C–; KC–; UV–; TLC: usnic, stictic and norstictic acids.

Selected specimen examined: Itaóca, Areial Rui Barbosa, 16.I.2015, *Fraga Jr. 716* (UPCB; VIES).

Additional specimens examined: BRAZIL. PARANÁ: Guaratuba, Serra do Araçatuba, Morro dos Perdidos, 15.IV.2011, *Charnei et al. 36, 81* (UPCB).

Cladonia substellata is characterized by the slender and branched podetia, being pale yellow to grayish green, ascyphose, with closed to open axils, a corticioid surface, without propagules, with a fibrose stereome, and by the production of usnic and stictic acid often with related compounds (Vainio 1887; Ahti 2000; Charnei 2013). This species may occasionally lack stictic acid complex, producing fumarprotrocetraric instead (Ahti 2000; Stenroos *et al.* 2002). Besides the stictic acid, we also found one compound with Rfc approximately 14, probably related with stictic acid complex.

Cladonia uncialis (L.) Weber *ex* F.H. Wigg. can resemble *C. substellata*, but has a more corticate surface and does not produce stictic acid (Ahti 2000; Brodo *et al.* 2001). Moreover, *C. uncialis* does not occur in Restinga vegetation (Ahti 2000).

According to Ahti (2000), *C. peltastica* (Nyl.) Müll. Arg. is quite similar to *C. substellata* in gross podetia morphology. However, *C. peltastica* exhibits a corticated surface, does not produce stictic acid and is confined so far to the Amazon region (Ahti 2000).

In this investigation, we found some specimens in Parque Estadual Paulo Cesar Vinha that fits close to Ahti (2000) description of *C. substellata*. These specimens have a strongly adpressed secondary thallus, and the podetia are never squamulose, with smooth to clearly rugulose surface. However, they are anatomic and chemically similar, producing usnic and stictic acid, and related compounds. It's possible that some environmental conditions, such as sunlight exposure on white sand, salty spray winds and large dry periods led to that growing pattern. Due its morphological distinction, like in *C. crispatula* (see discussion under *C. crispatula*), specific studies should be conducted using a more comprehensive number of specimens and molecular data to evaluate the taxonomic status of these distinct populations.

It's a rare species, not really forming extensive colonies. It grows on bare sand, in open and well-lit areas around some bushes.

11. *Cladonia turgidior* (Nyl.) Ahti, Lichenologist 9 (1): 14. 1977. Fig. 2c

Descriptions: see Ahti (1977, 2000).

Chemistry: K+ yellow; C–; KC–; UV–; TLC: thamnolic and decarboxythamnolic acids.

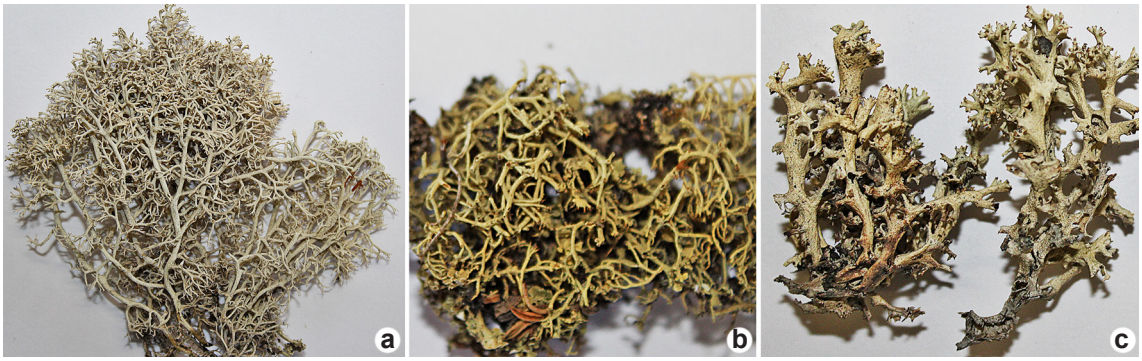

Figure 2 – a-c. Species of *Cladonia* in Restinga vegetation from Espírito Santo state – a. *Cladonia sprucei*; b. *C. substellata*; c. *C. turgidior*. (a. *C.A.V. Fraga Jr. 678a*; b. *C.A.V. Fraga Jr. 716*; c. *C.A.V. Fraga Jr. 561*). Scale bars = 1cm.

Selected specimens examined: Conceição da Barra, Parque Estadual de Itaúnas, 27.I.2015, *Fraga Jr. 495, 526* (UPCB)*, 560*, *561* (UPCB; VIES); Guarapari, Parque Estadual Paulo Cesar Vinha, 10.II.2015, *Fraga Jr. 285b, 310, 353* (UPCB); Área de Proteção Ambiental de Setiba, 02.III.2015, *Fraga Jr. 640, 665, 898, 905* (UPCB); Itaóca, ARB, 16.II.15, *Fraga Jr. 692* (UPCB); Vila Velha, Parque Natural Municipal de Jacarenema, 24.II.2015, *Fraga Jr. 473* (UPCB).

Cladonia turgidior is characterized by the turgid podetia, with much dilated openings, smooth and glossy surface in the upper half and rugulose to verruculose lower down, as by production of thamnolic acid (Ahti 1977, 2000).

It is a distinct species in the field, forming fairly large clumps mainly in exposed areas. The thick podetia with large openings are characters that easily distinguish it from the other species. It grows mostly seldom, but few times was observed intermixed with thalli of *C. crispatula*.

Some underdeveloped specimens can resemble *C. crispatula*, but the floccose inner surface of podetia, and the glossy surface are diagnostic to separate them (Ahti 2000).

Acknowledgements

We are thankful to the geologist Daniel Goetze for the great help in field excursion. To the anonymous reviewers for ther precious considerations. To the Instituto Estadual de Meio Ambiente (IEMA), to Secretaria de Desenvolvimento Sustentável de Vila Velha (SEMDESU) for the collection licences, and to CAPES (Coordenadoria de Aperfeiçoamento do Pessoal do Ensino Superior) for the financial support.

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Editor de área: Dr. Anibal de Carvalho Junior
Artigo recebido em 20/05/2018. Aceito para publicação em 09/11/2018.