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Phylogeny and morphology of Fissidentaceae Schimp. in the South Atlantic Islands and description of a new species

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ABSTRACT

Phylogenetic and morphological analyzes were used to compare the samples collected in the Fernando de Noronha and Trindade Islands with the continental ones. A phylogenetic tree comprising 37 representatives of *Fissidens* Hedw. was constructed using plastid gene data (trnG and rps4). Specimens of *F. flaccidus* Mitt. and *F. hornschurchii* Mont. on the islands appeared to be genetically and morphologically similar to samples from the continent. Together these studies showed that the specimens identified as *F. crispus* Mont. from Fernando de Noronha differ from both those previously recorded on islands and those on the continent, leading us to describe a newly species. Furthermore *F. steerei* Grout is new recorded for Fernando de Noronha, Brazil.

RÉSUMÉ

Phylogénie et morphologie des Fissidentaceae Schimp. dans les îles de l'Atlantique Sud et description d'une espèce nouvelle.

Des analyses phylogénétiques et morphologiques ont été utilisées pour comparer les échantillons prélevés dans les îles Fernando de Noronha et Trindade avec les échantillons continentaux. Un arbre phylogénétique comprenant 37 représentants de *Fissidens* Hedw. a été reconstruit en utilisant les données des gènes plastidiens (trnG et rps4). Des spécimens de *F. flaccidus* Mitt. et *F. hornschurchii* Mont. récoltés sur les îles sont génétiquement et morphologiquement similaires aux échantillons du continent. Ensemble, ces études ont montré que le *F. crispus* Mont. présent sur Fernando de Noronha est une espèce qui diffère à la fois de celles précédemment recensées sur les îles et de celles du continent, ce qui nous amène à décrire une nouvelle espèce. En outre, *F. steerei* Grout est un nouvel enregistrement à Fernando de Noronha, Brésil.

KEY WORDS

Endemism,
Fissidens,
Fernando de Noronha
Islands,
Trindade Island,
rps4 marker,
trnG marker,
new species.

MOTS CLÉS

Endémisme,
Fissidens,
îles Fernando de
Noronha,
île de Trindade,
rps4,
trnG,
espèce nouvelle.

INTRODUCTION

The South Atlantic Islands are widely dispersed and extend from the Tropic of Cancer to the Southern Ocean, they are largely volcanic, some rise close to the crest of the Atlantic while other mountain ranges are built on submarine banks closer to the continental margins (Baker 1973).

Among the islands of the South Atlantic, are the Trindade Island and the Archipelago of Fernando de Noronha. According to Soto (2009), from the XVI century onwards, the Trindade and Fernando de Noronha Islands offered conditions for human occupation, causing profound environmental changes through the introduction of exotic species; deforestation; mineral exploration and infection of water bodies. However, the biodiversity of these islands is still remarkable; the percentage of endemic species is high and the vulnerability of these species is high compared to those of the continent, due to the restricted and unique geographical space (Walter 2004).

Trindade Island was discovered in 1502 and between 1700 to 1926 it was occupied, abandoned and reoccupied many times (Alves 1998). It is located about 1200 km from the Brazilian coast, with a maximum altitude of 620 m and its area totaling 9.28 km², the climate is tropical Atlantic, mitigated by east and southeast trade winds with an annual average temperature of 27°C (Serafini *et al.* 2010). The island currently has a great diversity of vascular plants with approximately 130 taxa, including 11 endemic species (Alves 2006). The mosses are represented by 11 taxa, distributed in 8 families, the richest in number of species of which are Fissidentaceae, Leucobryaceae and Pottiaceae with two species each. For the Fissidentaceae these are *Fissidens zollingeri* Mont. and *F. hornschurchii* Mont. (Faria *et al.* 2012).

The Archipelago of Fernando de Noronha was discovered in 1503 (Teixeira *et al.* 2003) and is located 345 km from the Brazilian coast and comprises a total of 21 islands and islets. The climate is tropical, with two well-defined seasons, the dry (August to February) and the rainy (March to July), with an average precipitation of 1400 mm and an average temperature of 25°C (Serafini *et al.* 2010). The phanerogam flora is represented by 450 species (Batistella 1993) and the bryoflora has 28 species, of which 23 are mosses distributed in 8 families, the Fissidentaceae being best represented with 12 species (Pereira & Câmara 2015).

Fissidentaceae Schimp. is one of the largest and most wide spread families of mosses, with approximately 440 species (Crosby *et al.* 2000). In the Neotropics there are 93 species, of which 62 % are endemic (Pursell 2007). In Brazil the family is represented by 72 taxa, occurring in all biomes (Bordin & Yano 2013).

The family is monogeneric and characterized by distichous, equitant leaves, the distinctive leaf is composed of two vaginant laminae, one ventral lamina and one dorsal lamina (Pursell 2007). Despite being well delimited, the genus *Fissidens* is taxonomically difficult and highly variable (Iwatsuki & Suzuki 1982; Pursell 2007) due to differences in size, cell ornamen-

tation and other characteristics that overlap in many species (Bordin & Yano 2013).

Several molecular phylogenetic studies have been carried out to clarify the relationships within closely related species, such as *F. bryoides* Hedw., *F. dubius* P. Beauv. and *F. adiantoides* Hedw. (Hassel *et al.* 2013), and the geographical relationships of the endemic moss *Fissidens luisieri* P. Varde from Macronesia (Werner *et al.* 2009), as well as the species of Fissidentaceae from Japan (Suzuki *et al.* 2018). So far, no molecular study has been carried out for *Fissidens* on the South Atlantic Islands and phylogenetic relationships between species occurring on these islands and on the continent are unknown.

In this context, the present study aimed to understand the evolutionary value and the morphological and genetic variations found between island and continental populations of the species of *Fissidens*.

MATERIAL AND METHODS

Samples of 37 specimens of *Fissidens* from Archipelago of Fernando de Noronha, Trindade Island and Brazilian continent were selected, all deposited in the UB and SP Herbaria (Table 1). To confirm the identity of the specimens semi-permanent slides were mounted with Hoyer (Anderson 1954) and observed with an optical microscope.

DNA was extracted using the mini-CTAB method (Doyle & Doyle 1987), with adaptations (Câmara 2009). Two phylogenetic markers were selected for the present analyses, chloroplast ribosomal protein S4 (rps4) and trnG intron. For the amplification, the polymerase chain reaction (PCR) technique was used, and the annealing temperature modified to 51/52°C for the rps4 marker (Suzuki *et al.* 2018) and 58°C for trnG (Werner *et al.* 2009). The sequencing was done by MACROGEN INC. (South Korea).

Sequences of the two genes were aligned separately by using the ClustalX 2.1 (Thompson *et al.* 1997) and MAFFT 7.0 (Katoh *et al.* 2002). When necessary, they were adjusted manually, with PhyDe v0.9971 (Müller *et al.* 2006). The analyzes were made by Maximum Parsimony, Maximum Likelihood and Bayesian analysis using the following softwares, respectively: PAUP * v. 4.0b10 for Macintosh (Swofford 2002), RAXML v. 8.2.X and MrBayes v. 3.2.2 (Ronquist *et al.* 2012).

Clade support was evaluated using the non-parametric bootstrap (Felsenstein 1985). The Bayesian Inference (BI) support was evaluated using posterior probabilities. For the likelihood and Bayesian analyzes, the evolution models were obtained using the JModeltest 2.1.1 software (Guindon & Gascuel 2003). In addition to substitutions, indels were coded based on "Simple Indel Coding" (SIC; Simmons & Ochoterena 2000) using the Seqstate 1.4.1 software (Müller 2005). Maximum likelihood scores were calculated for topologies with and without restriction. The significance of the difference between the two hypotheses was given by the SH test (Shimodaira & Hasegawa 1999). *Dicranum scoparium* was chosen as an outgroup, based on the results of Cox *et al.* (2010).

TABLE 1. — List of material used in phylogenetic analysis. Abbreviations: **GO**, Goiás; **RS**, Rio Grande do Sul; **MT**, Mato Grosso; **DF**, Distrito Federal; **MG**, Minas Gerais; **BA**, Bahia.

Species (last name)	Species (names used here)	Locality	Voucher	rps4	trnG
<i>F. angustifolius</i> Sull.	<i>F. noronhensis</i> sp. nov.	Fernando de Noronha	Pereira, 480 (UB)	x	x
<i>F. angustifolius</i> Sull.	<i>F. noronhensis</i> sp. nov.	Fernando de Noronha	Pereira, 460 (UB)	x	x
<i>F. angustifolius</i> Sull.	<i>F. noronhensis</i> sp. nov.	Brasil (GO)	Faria, 710 (UB)	x	—
<i>F. bryoides</i> Hedw.	<i>F. noronhensis</i> sp. nov.	Fernando de Noronha	Pereira, 235 (UB)	x	x
<i>F. bryoides</i> Hedw.	<i>F. bryoides</i>	USA	Shevock, 32994 (UB)	x	—
<i>F. crispus</i> Mont.	<i>F. crispus</i>	USA	Shevock, 29721 (UB)	x	x
<i>F. crispus</i> Mont.	<i>F. crispus</i>	Brasil (RS)	Bordin 3887 (UB)	x	x
<i>F. crispus</i> Mont.	<i>F. crispus</i>	Brasil (RS)	Bordin, 3779 (UB)	x	x
<i>F. crispus</i> Mont.	<i>F. noronhensis</i> sp. nov.	Fernando de Noronha	Pereira, 95 (UB)	x	x
<i>F. crispus</i> Mont.	<i>F. noronhensis</i> sp. nov.	Fernando de Noronha	Pereira, 452 a (UB)	x	x
<i>F. flaccidus</i> Mitt.	<i>F. flaccidus</i>	Brasil (GO)	Teixeira, 50 (UB)	x	x
<i>F. flaccidus</i> Mitt.	<i>F. flaccidus</i>	Brasil (MT)	Pinheiro, 619 (UB)	x	x
<i>F. flaccidus</i> Mitt.	<i>F. flaccidus</i>	Brasil (DF)	Teixeira, 85 (UB)	x	x
<i>F. flaccidus</i> Mitt.	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 501 (UB)	x	x
<i>F. flaccidus</i> Mitt.	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 71 (UB)	x	x
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Ilha da Trindade	Faria, 277 (UB)	x	x
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Ilha da Trindade	Faria, 278 (UB)	x	x
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Ilha da Trindade	Faria, 256 (UB)	x	—
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Brasil (DF)	Meneguzzo, 212 (UB)	x	—
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Ilha da Trindade	Faria, 82 (UB)	x	x
<i>F. hornschurchii</i> Mont.	<i>F. hornschurchii</i>	Ilha da Trindade	Faria, 111 (UB)	x	x
<i>F. hornschurchii</i> Mont.	<i>F. steerei</i>	Fernando de Noronha	Pereira, 68 (UB)	x	x
<i>F. lagenarius</i> Mitt.	<i>F. steerei</i>	Fernando de Noronha	Pereira, 70 b (UB)	x	x
<i>F. lagenarius</i> Mitt.	<i>F. steerei</i>	Fernando de Noronha	Pereira 299 (UB)	x	x
<i>F. lagenarius</i> Mitt.	<i>F. steerei</i>	Fernando de Noronha	Pereira, 296 (UB)	x	x
<i>F. lagenarius</i> Mitt.	<i>F. lagenarius</i>	Brasil (MG)	Bordin 2134 (SP418702)	x	—
<i>F. lindbergii</i> A. Jaeger	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 341 (UB)	x	x
<i>F. lindbergii</i> A. Jaeger	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 323 (UB)	x	x
<i>F. lindbergii</i> A. Jaeger	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 367 (UB)	x	x
<i>F. lindbergii</i> A. Jaeger	<i>F. lindbergii</i>	Brasil (BA)	Teixeira, 17 (UB)	x	x
<i>F. lindbergii</i> A. Jaeger	<i>F. flaccidus</i>	Fernando de Noronha	Pereira, 243 (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. zollingeri</i>	Brasil (BA)	Teixeira, 44 (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. zollingeri</i>	Fernando de Noronha	Pereira, 146 (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. zollingeri</i>	Fernando de Noronha	Pereira, 113 (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. zollingeri</i>	Fernando de Noronha	Pereira, 131 a (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. zollingeri</i>	Fernando de Noronha	Pereira, 120 (UB)	x	x
<i>F. zollingeri</i> Mont.	<i>F. trindadensis</i>	Ilha da Trindade	Faria, 420 (UB)	x	—

RESULTS

Based on the morphological and molecular analyses carried out in this study, we confirmed the presence of four species in the Fernando de Noronha Islands: viz. *F. flaccidus* Mitt., *F. zollingeri* Mont., *F. steerei* Grout and, *F. noronhensis* sp. nov. and two species in the Trindade Island: viz. *horschuchii* Mont. and *Fissidens* sp.

The concatenated data matrix had a total length of 1120 bp, which one 668 bp for the *trnG* and 452 bp for the *rps4*. There was no incongruity between the trees when the markers were analyzed separately. The nucleotide substitution model used was GTR (General Time Reversible) for all trees. The resulting tree (Fig. 1) separates the species that occur on the Trindade Island, Fernando de Noronha and the continent.

Clades A and F present the specimens identified as *F. crispus* continental and insular, respectively. The insular specimens are genetically (Table 2), and morphologically (Fig. 2) different from the specimens of the continent forming two distinct, separate clades with high support: clade A (96/100/1), and clade F (100/93/1). The island specimens are described as *Fissidens noronhensis* sp. nov.

Clade B includes the species *F. hornschurchii* from Trindade Island with high support (90/95/1). We found no morphological or genetic differences with the specimens of the continent, although one specimen from Trindade Island (*F. hornschurchii* T VI) is outside the clade. The monophilia test Shimodaira-Hasegawa (SH) was performed and showed that the tree without restriction is significantly better than the tree with restrictions, with values greater than 0.5, thus the null hypothesis of non-monophyly of the specimens separately is not rejected.

Clade C is well supported (100/88/1) and includes the species *F. steerei*.

Clades D and E comprise the species *F. flaccidus* and *F. zollingeri*, respectively, and include specimens from the Fernando de Noronha as well as continental ones. These clades are well resolved with high support (99/99/1), (100/99/1), respectively.

The material from the Trindade Island that was identified as *F. zollingeri*, is paraphyletic and is genetically and morphologically distinct (Table 3) from the specimens of *F. zollingeri* on Fernando de Noronha and the continent.

TABLE 2. — Genetic distance obtained from specimens identified as *F. crispus* on the Fernando de Noronha Island and on the continent. Abbreviations: **FN**, Fernando de Noronha; **C**, continental; **FN I**, *Fissidens bryoides* FN I; **FN II**, *Fissidens goyazensis* FN II; **FN V**, *Fissidens crispus* FN V; **FN VI**, *Fissidens crispus* FN VI; **FN III**, *Fissidens angustifolius* FN III; **C I**, *Fissidens crispus* C I; **C II**, *Fissidens crispus* C II; **C III**, *Fissidens crispus* C III; **C IV**, *Fissidens crispus* C IV.

	1	2	3	4	5	6	7	8	9
1. FN I	—	—	—	—	—	—	—	—	—
2. FN II	0.000	—	—	—	—	—	—	—	—
3. FN V	0.000	0.000	—	—	—	—	—	—	—
4. FN VI	0.000	0.000	0.000	—	—	—	—	—	—
5. FN III	0.000	0.000	0.000	0.000	—	—	—	—	—
6. C I	0.049	0.049	0.049	0.049	0.049	—	—	—	—
7. C II	0.049	0.049	0.049	0.049	0.049	0.004	—	—	—
8. C III	0.054	0.054	0.054	0.054	0.054	0.009	0.004	—	—
9. C IV	0.054	0.054	0.054	0.054	0.054	0.013	0.009	0.004	—

TABLE 3. — Genetic distance obtained from *F. zollingeri* specimens from the oceanic and continental islands. Abbreviations: **FN**, Fernando de Noronha; **C**, continental; **T**, Trindade Island.

	1	2	3	4	5	6
1. FN II	—	—	—	—	—	—
2. FN III	0.0000	—	—	—	—	—
3. FN IV	0.0000	0.0000	—	—	—	—
4. T I	0.0337	0.0337	0.0337	—	—	—
5. C VI	0.0000	0.0000	0.0000	0.0337	—	—
6. FN V	0.0000	0.0000	0.0000	0.0337	0.0000	—

Family FISSIDENTACEAE Schimp.

Genus *Fissidens* Hedw.

Fissidens noronhensis

Teixeira, Bordin & M. Carv.-Silva, sp. nov.

(Fig. 2)

DIAGNOSIS. — The new species differs from *Fissidens crispus* by its small plants (± 2 mm versus 4–35 mm alt.), thin-walled and inconspicuously papillose (papillae present on some cells but hardly visible with an optical microscope and visible in a few cells only when observed with SEM). The new species resembles *F. lindbergii*, but can easily be distinguished by its much smaller cells ($7.5 \times 5 \mu\text{m}$ versus $27\text{--}67 \mu\text{m}$ in *F. lindbergii*) and its almost smooth cells. When observed with an optical microscope and even when observed with SEM the papillae are visible in a few cells only, whereas in *F. lindbergii* papillae are easily visible in the center of the cells.

HOLOTYPE. — **Brazil.** Pernambuco, Fernando de Noronha, Trilha para Baía dos Golfinhos, $3^{\circ}51'25''\text{S}$, $32^{\circ}26'37''\text{W}$, 09.V.2014, *Pereira & Santos* 480 (holo-, UB1029235; iso-, SP).

TYPE LOCALITY. — Trilha para Baía dos Golfinhos, Fernando de Noronha, Pernambuco (Brazil).

ETYMOLOGY. — From latin *noronhensis*, referring to the name of Fernando de Noronha Archipelago.

ADDITIONAL MATERIAL. — **Brazil.** Pernambuco, Fernando de Noronha, $3^{\circ}86'55.56''\text{S}$, $32^{\circ}42'44.44''\text{W}$, 09.V.2014, *Pereira & Santos* 460 (UB); $3^{\circ}85'80.56''\text{S}$, $32^{\circ}44'27.78''\text{W}$, 04.V.2014, *Pereira & Santos* 235 (UB); $3^{\circ}85'75''\text{S}$, $32^{\circ}44'41.67''\text{W}$, 10.II.2014, *Pereira & Santos* 95 (UB); $3^{\circ}51'56''\text{S}$, $32^{\circ}25'28''\text{W}$, 09.V.2014, *Pereira & Santos* 452 (UB).

DESCRIPTION

Plants light to dark green. Stems monomorphic, unbranched or branched, quite variable in length, 2–3 mm long $\times$ 1.35–1.5 mm wide often dark brown red or castaneous proximally; weak axillary hyaline nodules present; epidermis and outer tiers of cortical cell small, incrassate, pigmented, inner cortical cells larger, thin-walled, hyaline, central strand present or absent; rhizoids basal, branched, smooth, brownish to castaneous; leaves crispate when dry, as many as 6 pairs, distant to imbricate, oblong to lanceolate, 0.7–0.10 mm long $\times$ 0.2–0.3 mm wide, acute apex, margin entire, typically limbate on all laminae, limbidium usually ending slightly below leaf apex and typically reaching the leaf insertion (shorter in Fig. 2F), limbidial cells uni-to tristratose, intramarginal by 1–3 rows of quadrate to oblong chlorophyllose cells on the proximal parts of vaginant laminae, costa percurrent, bryoides type, dorsal lamina variable, even on the same plant, ceasing at to ending slightly above the insertion to long decurrent, vaginant laminae of cauline leaves $\frac{1}{2}$ leaf length, acute, equal or nearly so; lamina cells eguttulate, unistratose, firm walled inconspicuously unipapillose, papillae not to hardly visible with an optical microscope, cells $7.5 \times 5 \mu\text{m}$ hexagonal, often arranged in distinct rows in dorsal and ventral laminae. Sporophyte not observed.

REMARKS

Fissidens noronhensis sp. nov. shows morphological resemblance to *F. crispus* and *F. lindbergii*, but is genetically distant from both. With high support (100/93/1), comprising 36 mutations using the markers rps4 e trnG, being 26 transitions and 10 transversions when compared to *F. lindbergii* and 34 mutations, 23 transitions and 11 transversions compared to *F. crispus*.

DISCUSSION

Several island records proved to be based on incorrectly identified material. This is not unexpected as *Fissidens* is a taxonomically difficult and variable taxon (Iwatsuki & Suzuki 1982; Pursell 2007; Bordin & Yano 2013), which causes a lot of conflict in the identification and circumscription of species.

On Fernando de Noronha Island, 12 species of Fissidentaceae were listed by Pereira & Câmara (2015), however, after re-examination and molecular analysis, this number is reduced to seven. All the samples identified by Pereira & Câmara (2015) as *Fissidens lindbergii* A. Jaeger, were re-identified as *F. flaccidus*. The specimens identified as *F. biformis* Mitt. (as *F. angustifolius* Sull.), *F. bryoides* Hedw. and *F. goyazensis* Broth. all appeared to be one and the same undescribed species: *Fissidens noronhensis* sp. nov. The specimens named *F. hornsuschuchii* and *F. lagenarius* Mont. appeared to be *F. steerei*, a new occurrence for the Fernando de Noronha Island (Fig. 1).

The updated list comprises four species studied in this paper: viz. *F. flaccidus* Mitt., *F. zollingeri* Mont., *F. steerei* Grout and, *F. noronhensis* sp. nov. *Fissidens lindbergii*, *F. biformis* (as

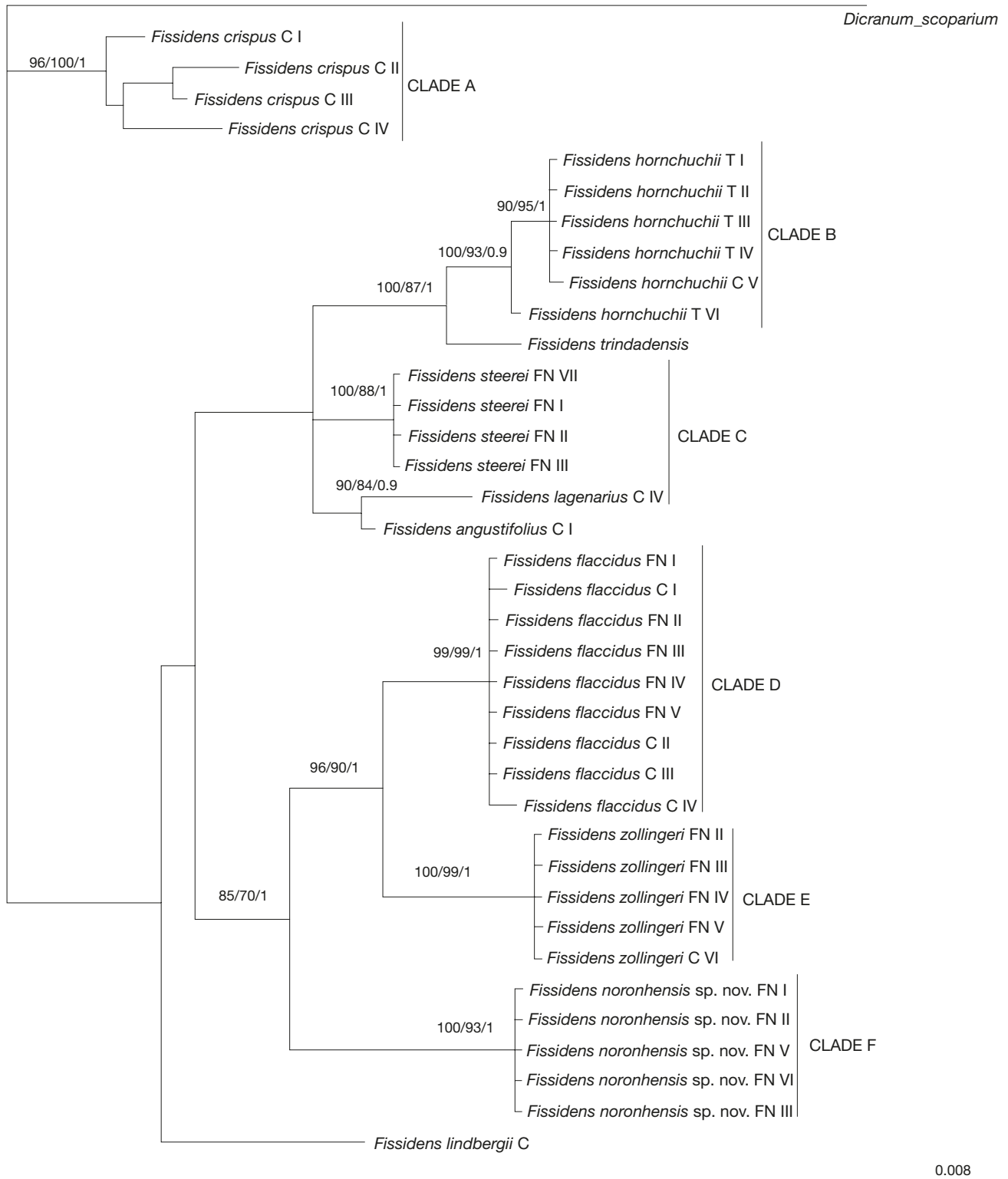


FIG. 1. — Phylogenetic tree based on analysis with the concatenated sequences of chloroplast *rps4* and *trnG* genes. The numbers next to the branches are the bootstrap values for Maximum Parsimony, Maximum Likelihood and later probabilities for Bayesian, respectively. Abbreviations: **C**, continental; **T**, Trindade Island; **FN**, Fernando de Noronha.

F. angustifolius Sull.), *F. bryoides*, *F. hornschurchii*, *F. lagenarius* and *F. goyazensis* are excluded from the bryoflora of the Fernando de Noronha Island.

Clade D, includes one species *F. flaccidus*. The specimens in this clade were cited as *F. lindbergii* by Pereira & Câmara (2015). However, *F. lindbergii* has papillose cells whereas these

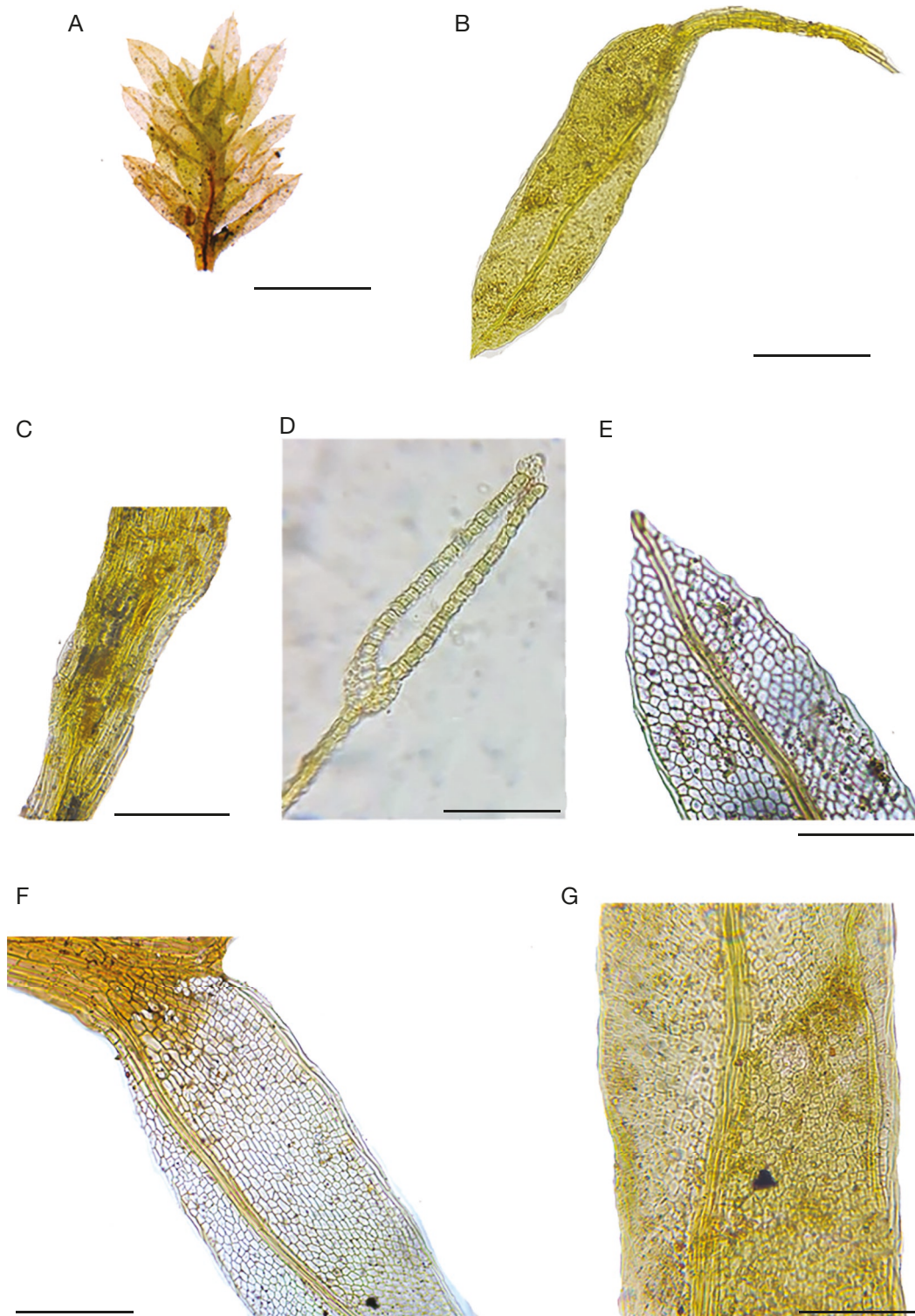


FIG. 2. — *Fissidens noronhensis* Teixeira, Bordin & M. Carv.-Silva, sp. nov.: **A**, vegetative plant; **B**, oblong leaf; **C**, axillary nodules; **D**, cross section vaginant laminae; **E**, leaf with acute apex; **F**, basal part of leaf; **G**, mid leaf with hexagonal cells. Scale bars: A, 500 µm; B, 200 µm; C, E-G, 100 µm; D, 50 µm.

specimens have smooth cells. The correct name appeared to be *F. flaccidus*. Mainland specimens of *F. flaccidus* are morphologically and genetically identical to the island species.

Clade C includes the specimens *F. steerei* from Fernando de Noronha Island. *Fissidens steerei* has a wide distribution, occur-

ring in Mexico, Central America, and South America, growing on soil, limestone and sandstone, usually close to watercourses (Pursell 2007) and are also found on islands, such as Mona Islands (Reyes-Colón & Sastre 1998). In Brazil, *F. steerei* is known only in Goiás and São Paulo states (Bordin & Yano 2013).

The clades of *F. crispus* from the continent and from Fernando de Noronha are not monophyletic (Clades A and F). Moreover, they are morphologically different. *Fissidens noronhensis* sp. nov. has smaller gametophytes, an acute apex, thin-walled and papillose (papillae inconspicuous in optical microscope). These differences separate *F. crispus* from the continent from island specimens, thus allowing the recognition of a new species, *Fissidens noronhensis* sp. nov. from Fernando de Noronha Island, with a genetic distance of 0 between them.

Although Fernando de Noronha is a small island of approximately 26 km² but very close to the Brazilian continent, about 545 km, it shares three species of *Fissidens* with the continent (*F. flaccidus*, *F. zollingeri*, *F. steerei*). *Fissidens noronhensis* sp. nov. is endemic to the island and *Fissidens zollingeri* and *F. flaccidus* are also known from Pernambuco, one of the closest states to the island, suggesting that these species may have arrived on the island due to the flow of people caused by the strong tourism occurring in Noronha, as well as long distance dispersion (LDD). The spores suggest to the LDD, mainly, the monoecious species (like the two mentioned) that present larger ranges than the dioecious species (Longton & Schuster 1983). Evidence suggests that vegetative propagules may also contribute to LDD by the wind over more than 4000 km (Karlin *et al.* 2011).

All species registered for Trindade and Fernando de Noronha Islands are monoecious species with a rhizautoicous system (male branches attached to the female ones by the rhizoid), this condition favors a greater pre-zygotic investment directed to the male function (Santos *et al.* 2018). In bryophytes it can be explained by the segregation of sexual functions observed in the rhizautoicous and dioicous systems.

These characteristics reveal that the law of Baker (1973) applies to bryophytes, because there is a predominance of bisexual species in the islands, this feature allows intra-gametophytic self-fertilization (fusion of gametes produced by adult gametophytic shoots of the same protonema, and therefore originating from the same sporophyte), thus being able to quickly eliminate harmful recessive mutations and avoid the demographic effect of inbreeding depression (Patiño *et al.* 2013).

For the Trindade Island, the occurrence of two species of Fissidentaceae was confirmed, *Fissidens* sp. and *F. hornschi*. The latter is also found in the Brazilian continent corroborating the hypothesis that this species may have arrived through the flow of people visiting the island or through LDD (Karlin *et al.* 2011). The lower number of species could be explained by the small size of the island when compared to Fernando de Noronha.

The new species *Fissidens noronhensis* sp. nov. has also been inserted in other analyzes with other species of Fissidentaceae (Teixeira *et al.* in press). The results support the present clades. As Trindade and Fernando de Noronha are oceanic islands, endemic species are common due to their geolocation, as well as the eventuality of speciation occurring quickly (Stuessy & Ono 1998). Other endemic species have been recorded on other islands as Society Islands (Whittier & Miller 1967), Easter Island (Ireland & Bellolio 2002), and Macronesia (Lobo *et al.* 2011).

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