

Bryophytes on Fernando de Noronha island, South Atlantic

Denise Pinheiro da Costa, Diego Knop Henriques, Micheline Carvalho Silva, Jeff Duckett and Silvia Pressel recount the bryological delights of this tropical oceanic island

In July 2016 Denise, Diego, Micheline, Jeff and Silvia joined forces to explore the bryophyte flora of Fernando de Noronha, the main island of the homonymous archipelago within the territorial waters of Brazil in the South Atlantic Ocean (Figs. 1, 2). The trip was part of our ongoing project Cryptogamic Diversity, Biology and Conservation on South Atlantic Islands (Newton Fund sponsored by FAPERJ and RUCK-CONFAP) which saw some of us travelling, a year later, to the even more remote island of St Helena – but that is another story. The main research objective of this project is to increase the understanding of the cryptogamic diversity and biogeography of the South Atlantic Oceanic Islands, through the establishment of a

network between institutions from Brazil and the United Kingdom, sharing expertise in taxonomy, and leading to the production of full inventories and illustrated floras for these islands: Ascension Island, St Helena, Tristan da Cunha, Trindade and Fernando de Noronha.

The archipelago of Fernando de Noronha lies about 350 km east of the Brazilian coast, between 03°51' S and 32°25' W. It has a tropical climate with an average temperature of 26.5

△Fig. 1. The north end of the archipelago of Fernando de Noronha. ▷Fig. 2. The Brazilian-UK team collecting on the church steps in Vila dos Remédios. All pictures by the authors.





△Fig 3. The endemic lizard *Mabuya atlantica*.



△Fig 4. The white (or fairy) tern *Gygis alba*.

°C and an average annual rainfall of 1,350 mm. The rainy season is from February to July, with the most rainfall in March and May and a dry season stretching from August to January (Almeida *et al.*, 2002; Montenegro *et al.*, 2009). The archipelago consists of 21 oceanic volcanic islands, with a total area of 26 square kilometres and a sea depth of 4000 m. The highest point is Morro do Pico on the main island, at 400 m a.s.l. The archipelago is biologically rich and diverse, with a considerable number of endemic vertebrates. It is also a very important breeding and feeding ground for many marine bird species in the Atlantic Ocean (ICMBio, 2013) as well as for dolphins such as the spinner dolphin (*Stenella longirostris* Gray) and other marine species

including the green turtle *Chelonia mydas* L. Indeed, the ocean surrounding the archipelago is home to more than 200 species of teleost fish, 15 coral species and many species of sharks and manta rays. Ashore, one can easily spot the endemic lizards *Mabuya atlantica* Schmidt (Fig. 3) and *Amphisbaena ridleyi* Boulenger, and the widespread tern *Gygis alba* (Sparrman) (Fig. 4).

History

While controversies still abound on the exact timing of its discovery and those responsible for this, it is generally accepted that the archipelago was officially discovered in 1503 by an expedition led by Captain Gonçalo Coelho and financed by the rich Lisbon merchant Fernão de Loronha. The

▽Fig 5. Some of the ruins of the prison in Aldeia dos Sentenciados.





△Fig. 6. Forte dos Remédios.

archipelago was eventually named after Loronha. The expedition was accompanied by the Italian explorer and cartographer Amerigo Vespucci, who provided the first description of Fernando de Noronha, or St Lawrence as he named it: “We found this isle to be uninhabited, with many living springs of fresh water, innumerable trees, full of so many birds of the sea and land that they were without number...” (Vespucci, 1504).

Subsequently the archipelago was variously claimed by the English, French, and Dutch and only permanently reclaimed by the Portuguese in 1737. The Portuguese built an extensive defense system of some ten forts and used it mainly as a penal colony with the first permanent settlement on the island, Vila dos Remédios, founded in

1770 (Figs. 5–6). Human occupation, as it is most often the case especially on small islands, led to the wholesale clearing of trees (Pressel *et al.*, 2017), to make space for grazing animals and, allegedly, to prevent prisoners from building rafts and escaping their captivity, resulting eventually in the near obliteration of the original vegetation (Teixeira *et al.*, 2003). Nevertheless, at the time Charles Darwin briefly visited Fernando de Noronha in 1832, during the voyage of the *Beagle*, there were still enough trees and vegetation to impress him, by contrast to the ‘cinder’ of Ascension Island which he visited in 1836 (Darwin, 1839; Pressel *et al.*, 2014). Indeed, in his account of his visit to Fernando de Noronha Darwin wrote: “The whole island is one forest,

▽Fig 7. The City Hall of Fernando de Noronha in Vila dos Remédios.





△Fig. 8. The endemic *Ficus noronhae* is an important substrate for corticolous bryophyte species and also provides shade for terricolous ones.

and this is so thickly intertwined that it requires great exertion to crawl along. — The scenery was very beautiful, and large magnolias and laurels and trees covered with delicate flowers.....”. H.R. Ridley visited the archipelago some 55 years after Darwin, on board of the steamship Nasmyth from Pernambuco, and spent a month there, gathering several important natural history collections including botanical collections with six bryophytes later identified by A. Gepp (Ridley, 1890), which are now housed in the Natural History Museum herbarium.

Since 1988, the island administration has been under the responsibility of Pernambuco State,

Brazil. The city hall is in Vila dos Remédios (Fig. 7) and there is also a scientific station run by ICMBio (Biodiversity and Conservation Institute of Chico Mendes, Brazil).

Today the economy of Fernando de Noronha depends on tourism, with numerous visitors attracted by its superb wildlife and beautiful beaches. In order to protect its fragile environment, the Marine National Park of Fernando de Noronha, comprising 70% of the main Island and the remaining 20 islands of the archipelago, was established in 1988. The Park is an important place for scientific research, including ongoing projects on the marine turtle (TAMAR) and spinner dolphin (Golfinho Rotador), both managed by ICMBio. In 2001 Fernando de Noronha was designated as a World Heritage Site by UNESCO.

Vegetation

The island’s vegetation is characterised by Dry

◁Fig. 9. The critically endangered liverwort *Riccia ridleyi* growing on a shaded bank near the Baía dos Golfinhos trail.



Forest with a single small Mangrove located in Sueste Bay (ICMBio, 2013). The flora is similar to the Caatinga Domain (xerophilous forest and scrub of the drylands of northeastern Brazil), consisting, mainly, of short trees, shrubs and grass (Pessenda *et al.*, 2008).

The introduction of numerous species during the last 400 years has led to a dramatic change in the island's terrestrial ecosystem (Pessenda *et al.*, 2005). A few localities still hold their original



△Fig. 10. The introduced *Kerodon rupestris* near the trail of Baía dos Golfinhos.

List of bryophytes recorded for Fernando de Noronha

This list of species is based on our own collections and herbarium samples. The wider range of the species is given in brackets.

ANTHOCEROTOPHYTA (Hornworts)

Notothyladaceae

Notothylas breutelii (Gottsche) Gottsche (Neotropical)

Notothylas orbicularis (Schwein.) Sull. (Africa, Brazil)

BRYOPHYTA (Mosses)

Bartramiaceae

Philonotis cernua (Wilson) D.G. Griffin & W.R. Buck (Widespread)

Bryaceae

Bryum apiculatum Schwägr. (Widespread)

Bryum atense R.S. Williams (Bolivia, Brazil)

Bryum coronatum Schwägr. (Widespread)

Bryum subapiculatum Hampe (Widespread)

Calymperaceae

Calymperes palisotii Schwägr. (Widespread)

Dicranaceae

Dicranella varia (Hedw.) Schimp. (Widespread)

Fissidentaceae

Fissidens angustifolius Sull. (Widespread)

Fissidens bryoides (Widespread)

Fissidens curvatus Hornsch. (Neotropical)

Fissidens crispus Mont. (Pantropical)

Fissidens flaccidus Mitt. (Pantropical)

Fissidens goyazensis Broth. (Neotropical)

Fissidens hornschurchii Mont. (Neotropical)

Fissidens lagenarius Mitt. (Neotropical)

Fissidens lindbergii Mitt. (Neotropical)

Fissidens palmatus Hedw. (Neotropical)

Fissidens subrmaginatatus Bruch (Neotropical)

Fissidens zollingeri Mont. (Widespread)

Pottiaceae

Plaubelia sprengelii (Schwägr.) R.H. Zander (Americas)

Hyophiladelphus agrarius (Hedw.) R.H. Zander (Widespread)

Splachnobryaceae

Splachnobryum obtusum (Brid.) Müll. Hal. (Widespread)

Stereophyllaceae

Entodontopsis leucostega (Brid.) W.R. Buck & Ireland (Widespread)

MARCHANTIOPHYTA (Liverworts)

Frullaniaceae

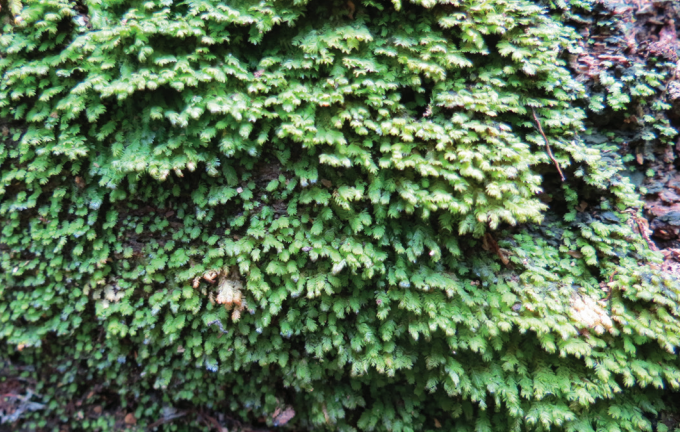
Frullania ericoides (Ness) Mont. (Pantropical)

Lejeuneaceae.

Lejeunea laetevirens Nees et Mont. (Neotropical)

Ricciaceae

Riccia ridleyi A.Gepp (Northern South America)



<Fig. 11 (top). A typical *Fissidens* bank. Figs. 12, 13 (middle and bottom). The only two corticolous liverwort species, *Frullania ericoides* (middle) and *Lejeunea laetevirens* (bottom).

were made by Ridley (1890), who collected six species, five mosses and one liverwort, the latter named by Gepp (1890) in his honour *Riccia ridleyi* Gepp, with the original material housed at Geneva (Fig. 9). One hundred and one years later, the first bryological survey was published by Vital *et al.* (1991), citing 22 species of bryophytes (3 liverworts, 17 mosses and 2 hornworts).

In 2015, Pereira & Câmara published an updated bryological report citing 28 species (3 liverworts, 23 mosses and 2 hornworts), but none endemic to Fernando de Noronha. However, *Riccia ridleyi* is considered critically endangered in Brazil, having been recorded only from Fernando de Noronha (CR B2ab[i,ii,iii], Costa *et al.*, 2013) with a recent potential new record from the mainland requiring confirmation (D.P. Costa pers. comm.). During our exploration of the island we stumbled upon *R. ridleyi* (Fig. 9) only once, while trying to photograph the rather cute, albeit invasive, rock cavy (*Kerodon rupestris* Wied-Neuwied) (Fig. 10) by the tourist lookout at Baía dos Golfinhos, a place very much exposed to random trampling by tourists.

During our stay on the island we were able to rekind most of the species reported by Pereira & Câmara (2015), although our hope of adding new species to their list was left unfulfilled. Nevertheless, along the way we made some interesting new observations on the bryoflora of Fernando de Noronha, enabling some intriguing comparisons with those of other South Atlantic oceanic islands.

With a total of 28 species, the bryophyte flora of Fernando de Noronha is considerably less diverse than those of Ascension Island (87 spp.), St Helena (110 spp.) and Tristan da Cunha

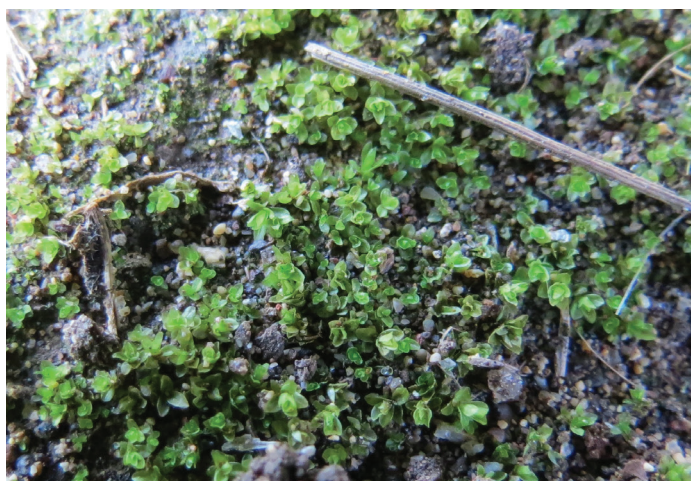
vegetation, including Ponta da Sapata, Morro do Pico, Sancho, Baía dos Golfinhos and Praia do Leão.

Of the 450 flowering plant species recorded to date, only three are considered endemic to the island: *Combretum rupicola* Ridl., *Ficus noronhae* Oliv. (Fig. 8) and *Cereus insularis* Hemsl. (Abdala *et al.*, 2008).

Bryophytes

The first bryological records from the island

▷Figs. 14–16. Common rupicolous species found on the island: *Bryum* sp. (top) *Plaubelia sprengelii* (middle) and *Splachmobryum obtusum* (bottom).



(160 spp.), but almost the same as the flora of Trindade (33 spp.) (Wage & Dickson, 1965; Faria *et al.*, 2012; Wigginton, 2013; Pressel *et al.*, 2017; Câmara & Carvalho-Silva, 2018). Also in common with Trindade is the remarkable lack of endemic species on Fernando de Noronha, whilst St Helena, Tristan da Cunha and Ascension all boast high levels of endemism, with 29, 18 and 16 endemic bryophytes respectively. The two Brazilian islands share four species, *Fissidens hornschuchii*, *F. zollingeri*, *Hyophiladelphus agrarius* and *Lejeunea laetevirens* (Figs. 11–13). However, while *Fissidens*, with 12 species, is by far the most speciose genus on Fernando de Noronha (only two species occur on Trindade), *L. laetevirens* is the only representative of the Lejeuneaceae on the island; whereas Lejeuneaceae is the most diverse family on Trindade with 11 species. This reflects the more general abundance of mosses on Fernando de Noronha (23 species vs. 3 liverworts), whilst liverworts outstrip mosses 20 to 12 on Trindade, being especially plentiful in the highland Giant Fern Forest (Câmara & Carvalho-Silva, 2018). Indeed, on Fernando de Noronha the richness of terricolous

▽Figs. 17, 18. Some of the fertile species found on the island during our survey: *Entodontopsis leucostega* (left), *Calymperes palisotii* (right).





△Figs. 19, 20. The abundantly fertile *Hyophiladelphus agrarius* on a brick wall.

taxa, e.g. Notothyladaceae, Ricciaceae, Bryaceae, Fissidentaceae, Pottiaceae, Splachnobryaceae, is in sharp contrast to the very low numbers of corticolous ones (*Calymperes palisotii*, *Frullania ericoides* and *L. laetevirens*).

The vegetation of Fernando de Noronha is very similar to mainland Brazilian coastal vegetation and most of the bryophyte species have a worldwide distribution (39%) for example *Bryum coronatum*, *Entodontopsis leucostega* and *Hyophiladelphus agrarius*, followed by those with a Neotropical distribution (35%). The fact that 50% of the moss species found on the island have a worldwide distribution, strongly suggests that the present bryophyte flora may be far from the original one, in contrast to St Helena (Wigginton, 2013) and particularly Ascension Island (Pressel

et al., 2017) where weedy cosmopolitan species, which may have been introduced by humans, are significantly under-represented.

Fissidentaceae aside, the Bryaceae and Pottiaceae are over-represented on the island, being particularly common in disturbed areas and urban environments such as walls and broken ground around Vila dos Remédios (Figs. 14–16). On the other hand, there is but a single species of pleurocarpous moss on the island: *Entodontopsis leucostega* grows abundantly on rocks and soil in less disturbed areas especially along the Ponta da Sapata and Capim Açú trails.

A survey of our own and previous collections has revealed that, in common with St Helena, Ascension and oceanic islands in general, the bryophytes of Fernando exhibit reduced fertility

▽Fig. 21. Denise and Micheline sampling along the suspended trail of Baía do Sancho.





△Figs. 22, 23. Extensive patches of *Notothylas* spp. covering the soil by the suspended trail. Detail of *Notothylas* spp.

compared to their mainland counterparts. We have seen sporophytes only in one hornwort (*Notothylas orbicularis*) and three mosses (*Calymperes palisotii*, *Entodontopsis leucostega* and *Hyophiladelphus agrarius*) in our survey. Except for *N. orbicularis*, which is restricted to the state of Pernambuco, all other species are widespread in Brazil and are often found bearing sporophytes (Figs. 17–20).

Bryophyte Conservation

Despite the wholesale destruction of natural habitats in the past, only two bryophytes might be considered as possibly threatened at present.

Fissidens curvatus is known for Fernando de Noronha from one herbarium collection (RB, SP) made in 1989 in Ponta da Sapata, It was not rediscovered in the last bryological survey (Pereira & Câmara, 2015) nor during our fieldwork in 2016. However, *F. curvatus* has a widespread distribution in the Brazilian Atlantic Rainforest (Bordin, 2015, Fissidentaceae in Flora do Brasil 2020 in preparation). We saw the critically

endangered *Riccia ridleii* at just one location where it is highly vulnerable; however, according to Pereira & Câmara (2015), *R. ridleii* can be found forming extensive populations at various sites on the island during the rainy season. All the known sites should be monitored during the rainy season and the tourist trails managed to maintain this species.

Paradoxically, large-scale engineering works associated with the construction of the extensive suspended trail of Baía do Sancho have actually promoted the establishment of new populations of the two *Notothylas*, *Fissidens* spp. and *Philonotis cernua* (Figs. 21–23). In fact, here we find probably the most extensive hornwort populations on the island. The bare, shady and, in some places, almost continuously damp soil appears to be an optimum habitat for these bryophytes. Any terrestrial conservation programme should embrace maintaining this open habitat where excessive trampling is now prevented.

▽Fig. 24. Spot the difference...the team and their trusted beach buggy, valiantly driven by Denise to every corner of the island.





△Fig. 25. The team relaxing after a hard day's work by one of Fernando de Noronha's beautiful beaches.

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▽Fig. 26. Morro do Pico, the highest point of Fernando de Noronha.



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