Cryptogamie, Bryologie, 2012, 33 (3): 271-277

Andreaea flexuosa R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim (Andreaeaceae), a new *taxon* from Madeira Island

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(Received 1 September 2011, accepted 10 January 2012)

Abstract – A taxonomic study of critical plants belonging to the ecostate *Andreaea* from Madeira Island is presented. A new *taxon*, *Andreaea flexuosa* R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim, is proposed based on material from upland areas in the central ridge of Madeira. Characters discriminating the two subspecies are presented and illustrated; data on ecology and distribution of the two subspecies are discussed.

Bryopsida / *Andreaea*/new taxa / Taxonomy / Distribution / Madeira Island / Portugal

INTRODUCTION

While studying *Andreaea* from Madeira Island for preparation of the Iberian and Macaronesian cartography (Casas *et al.,* 1996) and more recently for the Iberian Bryophyte Flora (Cros & Sérgio, 2007), we observed that some herbarium collections, most provisionally named *Andreaea heinemannii* Hampe *et* Müll. Hal. or *A. alpestris* (Thed.) Schimp., presented distinctive characteristics that allowed to describe a new *taxon* of *Andreaea*. These plants present slight similarities with other ecostate *Andreaea* like *Andreaea acutifolia*, *A. mutabilis* and *A. rupestris* complexes studied by Vitt in Hawaii (1980). Recently, Murray (2006) in Flora of Australia considered that some Madeiran specimens examined at different herbaria corresponded to *A. flexuosa* R. Brown bis, a species mainly distributed in the Southern Hemisphere.

After a re-examination of all available collections of ecostate *Andreaea* from Madeira Island, we confirm that the majority corresponds to *A. flexuosa,* although the Madeiran plants have important diagnostic characters that support a new infraspecific *taxon* of *A. flexuosa*. Therefore, we consider this Macaronesian *taxon* a distinct subspecies, *Andreaea flexuosa* R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim subsp. nov.

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TAXONOMIC DESCRIPTION

***Andreaea flexuosa* R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim subsp. nov.**
Figs 1-13

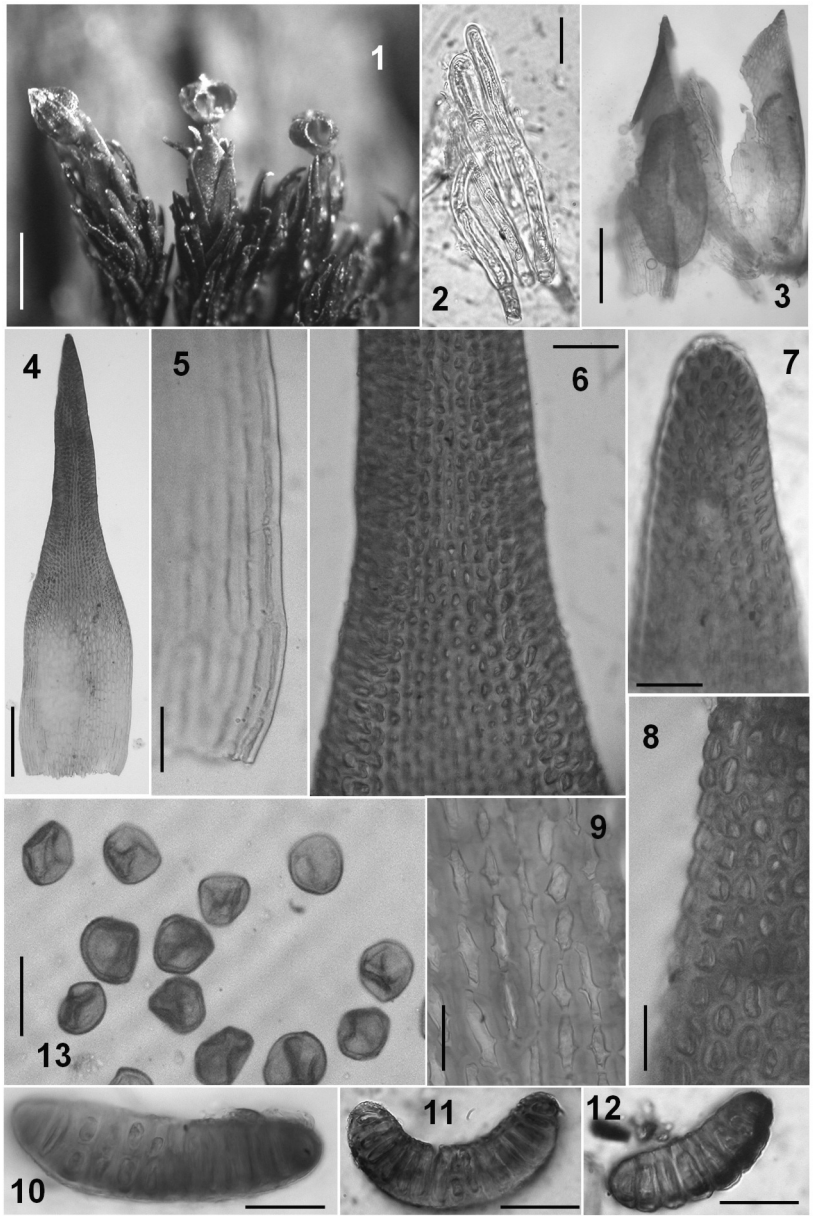
Type: Madeira: Bica da Cana, 12.08.1936, *Luisier* (LISU234214 **holotype** and LISF s.n. **isotype**); Paúl da Serra, Bica da Cana, ± 1500 m, 12.08.1936, *Luisier* (S B80885 **isotype** sub *A. flexuosa,* rev. B. Murray 1993).

Planta parva Andreaea flexuosa similis, sed differens: 1) foliis ovatis-lanceolatis 1:3.5 to 1:5.5; 2) apice obtuso; 3) foliorum laminaribus cellulis infra supraque unistratosis, supra saepe bistratosis; 4) sporis minutissime papillosis, 15-22(24) µm.

Plants small, dark-brown frequently reddish in upper juvenile leaves, *ca* 4-8(10) mm long, in dense turfs. Leaves rigid, frequently broken at the apex, slightly appressed when dry, erect-spreading, some apices slightly flexuose-twisted when moist, ecostate, ovate-lanceolate, not panduriform, concave, tapering to an obtuse apex, *ca* (0.70-) 0.9-1.3 mm long, (0.17-) 0.20-0.35 mm wide, 1:3.5 to 1:5.5 as long as wide; margins entire in upper part with small rounded projections of cell walls (bulging), distal margins slightly incurved, clearly incurved at apex or slightly cucullate, obtuse rarely apiculate; lamina in section unistratose from base to one third length, frequently with small bistratose areas in upper half, margins in upper part thicker than those at the middle lamina (mostly in one margin); upper laminal cells rounded to quadrate 3-5 µm long, 4-6.5 µm wide, with low papillae or with strongly bulging walls at the dorsal side; median laminal cells thick-walled, rectangular to rhomboid, slightly pitted, gradually increasing in length to mid leaf, *ca.* 12-18 (-20) µm long, (3-) 4.0-6.5 µm wide; all basal (median and marginal) cells long rectangular, lumen 15-25 (-32) µm long, (3) 4.0-6.5 (-8) µm wide, irregularly thickened with sinuose walls and pitted, lumina often scalariform; perichaetial leaves oblong-lingulate, convolute, scarcely sheathing the pseudopodium, not much longer than the adjacent leaves, 0.9-1.3 mm long. Perigonial paraphyses absent. Pseudopodium suberect, *ca.* 0.7-1.0 mm long. Capsules elliptic, 0.4-0.7 mm, long exerted, 4 valves, splitting from tip to two thirds. Turgid spores rounded to polyhedric, light brown, weakly papillose, (15-)19-22(24) µm diameter. Spore abortion not observed.

DIFFERENTIATION

Andreaea flexuosa is part of the *A. rupestris* complex, which includes species with ecostate leaves that have been recently considered as independent *taxa*. According to Murray (2006) it was not recognized in Australasia since its description in 1893 although it is a widespread and locally common plant. The Madeiran subsp. *luisieri* is a small plant with straight and rigid leaves rarely slightly flexuose-twisted when moist, and frequently with fragile apices. On the other hand, tips of intact leaves are rounded or blunt (Figs 1-11). The leaf apices are in addition, as Murray described for Australian plants, slightly incurved, but in subsp. *luisieri* they can be sometimes weakly cucullate and with more clearly incurved margins. However, one of the major features differentiating subsp. *luisieri* from subsp. *flexuosa* is the frequent occurrence of bistratose laminal cells, mainly in the marginal areas of the upper half of leaves (Figs 1-11). The above leaf



Figs 1-13. *Andreaea flexuosa* R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim subsp. nov. **1.** Plants with capsules; **2.** Axillary hairs; **3.** Perigonial leaves and antheridia (paraphyses absents). **4.** Sterile leaf; **5.** Leaf basal marginal cells; **6.** Upper and median part of leaf; **7.** Leaf apex; **8.** Leaf distal margins cells; **9.** Leaf basal median cells; **10**-**12.** Transversal section of leaf at upper part; **13.** Moist spores. Scale 1= 1 mm; 2, 5 to 13 = 25 µm; 3 and 4 = 200 µm. [From: 1, 2, 3, 8, 9 and 10. Pico Ruivo zum Pico do Juncal, *Düll 34* Bryophyta Exsiccata Madeira (NY); 11-12. Pico Ruivo, 30.07.1935, *Luisier* (INA, LISU); 4, 5, 6, and 11. Pico do Areeiro, *Romariz 748* (LISU161982)].

character was not mentioned by Vitt (1980) for any *taxon* of this group, but Murray (2006) considered that some specimens of *A. flexuosa* could present locally bistratose laminal cells.

The leaves are lanceolate or oblong-lanceolate in the two subspecies. However, in subsp. *flexuosa* the vegetative leaves are mainly 1:5 to 1:8-times as long as wide (Murray, 2006) in the Australian plants, while they are shorter in subsp. *luisieri*: 1:3.5 to 1:5.5-times as long as wide. On the other hand, the two subspecies can be readily distinguished when fertile since subsp. *luisieri* produces smaller spores. The larger turgid spores observed in subsp. *luisieri* were 15-22(24) µm diameter, while subsp. *flexuosa* had turgid spores 22-32 µm in Australian plants (Murray, 2006). We also have observed spores with a diameter ranging from 24 to 34 µm in some studied specimens from New Zealand and Australia.

In conclusion, the morphological distinction involving Murray's description of *A. flexuosa* from Australia and New Zealand, as well as recent observations of subsp. *luisieri* by us are clear (Fig. 1), and some key characters support their discrimination (Table 1). Consequently, we consider the plant populations from Madeira Island a distinct subspecies representing an important northern geographic extension of *A. flexuosa.*

Table 1. Diagnostic characters of *Andreaea flexuosa* subsp. *flexuosa* and *A. flexuosa* subsp. *luisieri* Sérgio *et* Sim-Sim subsp. nov.

	Andreaea flexuosa* subsp. *flexuosa [*data based on Murray 2006] [•revised material]	***Andreaea flexuosa* subsp. *luisieri*** [data based on Madeira specimens studied] (Fig. 1)
Plant size (mm)	2.5-5.0 (-9.0) *	3-10 (12)
Mature leaf form	linear-lanceolate wider at base, blade gradually narrowed to apex (ribbon-like), straight, flexuose - twisted when moist, sinus hardly contracted *•	ovate-lanceolate, not flexuose-twisted when moist, sinus often contracted
Mature leaf size		
long (mm)	0.8-1.5•	0.7-1.0 (1.3)
- width (mm)	0.20-0.25•*	0.20-0.35
Leaf length/width ratio	1:5 to 1:8•*	1:3.5 to 1:5.5
Leaf apex	acute, often rounded, margin distally plane and not cucullate*	apices rounded and with clearly incurved margins in distal part, weakly cucullate tips
Upper laminal cells transverse section	Entirely 1-stratose, or only with locally 2-stratose cells in sporadic areas in the upper half•*	Frequently 2-stratose in patches, mainly in margins or in laminal areas in the upper half
Turgid spore size (diameter/ µm)	22-32* or 24-34•	15-22(24)

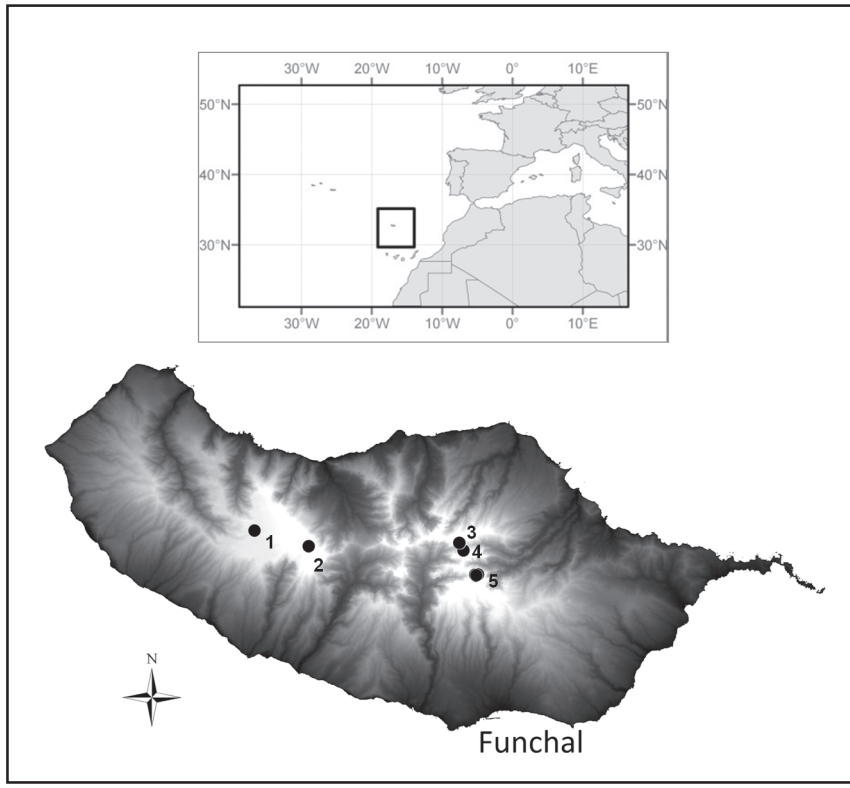


Fig. 14. Map of Madeira Island and the Archipelago location (altitudinal level, white colour maximum altitude, 1700-1860 m). Distribution of *Andreaea flexuosa* R. Brown bis subsp. *luisieri* Sérgio *et* Sim-Sim. Black dots correspond to the more important areas corresponding to the studied specimens: **1.** Paúl da Serra; **2.** Bica da Cana; **3.** and **4.** Pico Ruivo and Pico do Juncal; **5.** Pico Areeiro.

ECOLOGY AND DISTRIBUTION

Andreaea flexuosa subsp. *luisieri* grows on rocks forming dense red to brown tuffs. Even though we revised more than 15 specimens collected by different collectors at different dates, all Madeiran records appeared in upland areas in the central ridge of the Island in a small number of localities (Fig. 14). A large part of this collection is old, so our knowledge on the ecology of this *Andreaea* is still incomplete. However, we can establish that the plants mainly grow above 1400 to 1850 m in very small crevices of large and isolated volcanic blocks, generally in shady slopes. The colonies develop in very restricted microhabitats associated with *Andreaea heinemannii* and different species of immature tuffs of *Grimmia* spp., such as *Grimmia ovalis* (Hedw.) Lindb and *G. trichophylla* Grev. Other species found in the vicinity included *Isothecium prolixum* (Mitt.) Stech, Sim-Sim, Tangney *et* D. Quandt, *Pseudotaxiphyllum*

elegans (Brid.) Z. Iwats., *Encalypta vulgaris* Hedw., *Scleropodium touretii* (Brid.) L.Koch, *Racomitrium elongatum* Frisvoll, *Marsupella adusta* (Ness emend. Limpr.) Spruce and *M. emarginata* (Ehrh.) Dum.

Presently *Andreaea flexuosa* subsp. *luisieri* is only known from Madeira Island although in Madeira the genus *Andreaea* includes 5 species: *A. alpestris* (Thed.) Schimp., *A. heinemannii* Hampe *et* Müll. Hal., *A. rothii* F. Weber *et* D. Mohr. and *A. rupestris* Hedw. (Sérgio *et al.,* 2006). Its occurrence in the Azores is very unlikely according the study of different collections since only *A. rupestris* Hedw. has been reported from two Azorean Islands (Gabriel *et al.,* 2005). For the Canary Islands only *A. heinemannii* had been indicated in three islands (González-Mancebo, 2008) until recently Dirkse & Losada-Lima (2010) considered the presence of *A. crassifolia* Luisier on this archipelago. From a conservation perspective *A. flexuosa* subsp. *luisieri* appears to be particularly endangered for having a very restricted area on Madeira Island. This taxon was perhaps overlooked due to the small size of its colonies; anyway the area for potential occurrence is without doubt very limited.

Andreaea flexuosa subsp. *flexuosa* has a wide temperate distribution in the Southern Hemisphere including South Australia, Tasmania and New Zealand. It was also reported from New Guinea, Chile and Argentina, Gough Islands, Falkland Islands, Reunion, Madagascar, Southern Africa and Hawaii (Murray, 2006). In this latter area it has been reported as *A. acutifolia* by Vitt & Hoe (1980).

The present geographic distribution patterns of paleoaustral *taxa* results from a combination of factors acting in place and time, which include vicariance due to continental isolation, and step by step transoceanic dispersal, specific evolutionary rate and species extinction events (Devos & Vanderpoorten, 2009). Conjectures proposed by Sim-Sim *et al.* (2005) suggest that the occurrence of endemic or relic bryophytes in Madeira might be due to a combination of events during the quaternary lineage extinction in the Northern Hemisphere and postglacial expansion.

Selected specimens examined

More important areas according to Fig. 14.

Paratypes designated: MADEIRA: Paúl da Serra, CB0426, 1926, *Barreto* (S B72081 sub *A. rupestris* Hedw.); Pico Ruivo, CB1824, 31.07.1935, *Luisier 6951* (LISU 171112, LISU 234218) and LISFA sub *A. alpestris* (Thed.) Schimp.; Pico Ruivo, CB1824, 30.07.1935, *Luisier* (INA sub *A. alpestris,* LISU 234217); Pico Ruivo, CB1824, 1935, *Luisier* (S B72080 sub *A. rupestris*); Paul da Serra, CB0426, 1936, *Luisier* (S B72082 sub *A. rupestris* Hedw.); Paúl da Serra, CB0426, 1936, *Luisier* (INA, LISU 234215 and 234216); Pico Ruivo, CB1824, 10.1941, *Carvalho*, (LISU 171113, LISE, LISI s/n sub *A. petrophylla* Ehrh., LISU 234219); Pico do Areeiro, 1800 m, CB1923, 23.06.1951, *Romariz 748* (LISU 161982, rev. B. Murray 1988 as *A.* aff. *acutifolia* Hook. F. & Wils.); Pico do Juncal, CB2121, 1800 m, 12.05.1979, *Sérgio 2344* (LISU 161981); Felsen am Weg vom Parkplatz am Pico Ruivo zum Pico do Juncal, 20.09.1989, *Düll 34 Bryophyta Exsiccata Madeira* (NY sub *A. heinemannii* Hampe & Müll. Hal.); Pico do Areeiro, CB1923, 1800 m, 13.09.1991, *Nieuwkoop* (LISU 171107 sub *A. rupestris* Hedw); Pico Areeiro, CB1923, 1800 m, 16.03.1992, *Sérgio & Fontinha 7907a* (LISU 171115); próximo da Bica da Cana, vereda para o Lombo do Mouro, CB0725, 1500 m, 17.03.1992, *Sérgio & Fontinha 8014a* (LISU 213626); Trilho para o Pico Ruivo, CB1822, 1850 m, 07.10.2009, *Sim-Sim* (LISU 238484).

Additional specimens

***Andreaea flexuosa* R. Brown bis**

NEW ZEALAND: The Wilderness, open *Dacrydium bidwillii* scrubland, *ca* 1000 ft., 06.06.1972, *Schofield 48621* (S B80897, rev. B. Murray 1996); Kelly's Hill, 03.1874,

Berggren 721 (S B80899, rev. B. Murray 1996); Wellington distr., Gentle Annie Road, ca 1000 m, 23.12.1973, *van Zanten 731261* (S B80903, rev. B. Murray 1996).

AUSTRALIA: Victoria, Mt Buller, 36 km ESE of Mansfield, 1790 m, 30.12.1992, *Strelmann 50716* (KRAM 137325, det. Murray 1993).

TASMANIA: Mt. Wellington, 4000 ft, 1903, *Weymougth* (BM000919878); Mt. Wellington, Hobart, along the trail to Fern Glade and Silver Falls, 740-800 m, 04.12.1981, *Vitt 28995* (ALTA sub *A. acutifolia*); Mt Wellington, Hobart, along the trail to Fern Glade and Silver Falls, 04.12.1981, *Vitt 28994* (ALTA sub *A. acutifolia*); Mt. Field National Park, Lake Dobson area, 3400 ft, 06.12.1981, *Vitt 29157* (ALTA sub *A. acutifolia*).

MARION ISLAND: Feldmark 60 m, *Huntley 180* (BM sub *A. acutifolia* det. *van Zanten*).

HAWAII: Maui, Haleakala National Park, between Kipahulu Valley and Paliku, 7000 ft., *Hoe 3792.0* (NY sub *A. acutifolia* det.Vitt).

Acknowledgements. Grateful thanks are addressed to the curators of the herbaria ALTA, BM, G, INA, LISE, LISF, LISI, NY, MO and S for the loan of specimens. Ryszard Ochyra is gratefully acknowledged for his suggestions and for specimens loan (KRAM). The author is also grateful to Min S. Chaud-Petiot for providing some African samples, to Jurgen Nieuwkoop for a specimen of his herbarium from Madeira, to Sarah Stow for helpful remarks on the English text and to César Garcia for the map of Madeira.

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