

BOCAGIANA

Museu Municipal do Funchal (História Natural)

Madeira

07.VIII.2003

No. 210

NEW DATA ON THE DIVERSITY OF THE MADEIRA ARCHIPELAGO BRYOFLORA. THE *PLAGIOCHILA* (DUMORT.) DUMORT. GENUS (LIVERWORT) ON THE SLOPE COMMUNITIES OF LAURISILVA

M. SIM-SIM ¹, S. CARVALHO ², A. C. FIGUEIREDO ³, G. ESQUÍVEL ⁴,
S. FONTINHA ⁵, C. LOBO ⁶, J. G. BARROSO ³ & L. G. PEDRO ³

With 12 figures & 2 tables

ABSTRACT. Recent fieldwork on the slopes of the Madeira's laurisilva identified 127 bryophyte species, those from the genus *Plagiochila* being the most frequent. Morphological and biochemical studies (isoenzyme banding patterns and essential oil composition analysis) resulted in the recognition of eight different *Plagiochila* species including *P. stricta*, a new species for the Madeira Archipelago. The investigations to date represent the first approach to the study of bryophyte slope formations in the Madeira laurisilva and suggest that the genus *Plagiochila* is an indicator of bryophyte diversity.

¹ Centro de Ecologia e Biologia Vegetal, Departamento de Biologia Vegetal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal. E-mail: msimsim@fc.ul.pt

² Museu de História Natural, Museu e Jardim Botânico de Lisboa, Rua da Escola Politécnica, 58, 1250-102 Lisboa, Portugal.

³ Centro de Biotecnologia Vegetal, Departamento de Biologia Vegetal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal.

⁴ Centro de Botânica Aplicada à Agricultura, Departamento de Botânica e Engenharia Biológica, ISA, Lisboa, Portugal.

⁵ Serviço do Parque Natural da Madeira, Quinta do Bom Sucesso, Caminho do Meio, 9050-251 Funchal, Madeira, Portugal.

⁶ Jardim Botânico da Madeira, Quinta do Bom Sucesso, Caminho do Meio, 9050-251 Funchal, Madeira, Portugal.

KEY WORDS: Madeira Laurissilva, biodiversity, *Plagiochila*, isoenzymes, essential oils.

RESUMO. O trabalho de campo recentemente efectuado na Laurissilva da Madeira permitiu a identificação de 127 espécies de briófitos, de entre as quais se salientam as espécies do género *Plagiochila* devido à sua elevada frequência. O estudo morfológico e bioquímico (determinação dos padrões isoenzimáticos e composição de óleos essenciais) das espécies de *Plagiochila* permitiu o reconhecimento de oito espécies na Laurissilva, sendo *P. stricta*, uma nova espécie para o Arquipélago da Madeira. As investigações desenvolvidas até ao presente constituem uma primeira abordagem ao estudo das comunidades de briófitos dos taludes da Laurissilva da Madeira, e apontam para a utilização do género *Plagiochila* como indicador da diversidade de briófitos.

INTRODUCTION

Due to its insular characteristics the Madeira Archipelago shows an important floristic diversity. In fact its composition is similar to that of the Tertiary period, which dominated southern Europe and northern Africa millions of years ago, the so called laurisilva or subtropical laurel forest. Today, the largest tract of such forest is on Madeira Island, an estimated 15,000 hectares, which was, designated a UNESCO World Heritage Site in 1999 and was one of the sites incorporated into the Natura 2000 Network.

Madeira's laurisilva is located on the cloudy slopes of the island's northern side from 300 to 1,300 meters above sea level and only restricted niches occur on the southern slopes in places of difficult access. These slopes exposed to the NE prevailing winds have more than 3,000 mm annual rainfall and high humidity levels (75-90%) nearly all the year round. Consequently, the laurisilva plays an important role on the island's hydric balance, retaining water from fogs and rainfall. The existence of a climate with few extreme temperatures along with a near constant humidity level is the main reason why bryophytes are abundant in the laurisilva (JARDIM & FONTINHA, 2000). Indeed, this forest hosts a rich and diverse bryoflora including several species endemic to Madeira and to Macaronesia, (SIM-SIM *et al.*, 2000; FONTINHA *et al.*, 2001).

The biodiversity study is based on 50 sampling plots done on the slope formations called "taludes" (rocky or terricolous slopes or ramps), located along water-courses. As species belonging to *Plagiochila* dominated in the sampling areas the main focus of study was on this genus. According to GROLLE & LONG (2000), HEINRICHS *et al.* (1998a), HEINRICHS *et al.* (2002), RYCROFT *et al.* (2001) and RYCROFT *et al.* (2002), seven species are presently known from Madeira, *Plagiochila bifaria* (Sw.) Lindenb., *P. exigua* (Taylor) Taylor, *P. porelloides* (Torrey ex Nees) Lindenb., *P. punctata* (Taylor) Taylor, *P.*

retrorsa Gottsche, *P. spinulosa* (Dicks.) Dumort. and *P. virginica* A. Evans, representing 44% of the total species referred to Europe. It is accepted that in the genus *Plagiochila* the species cannot be separated using morphological characters alone (GROTH *et al.*, 2003). In this context, the interspecific and intraspecific variability of *Plagiochila* was investigated using isoenzyme analysis. The observation of recently collected material, as well as herbarium specimens, coupled with isoenzyme and essential oil analysis, lead to the recognition of eight species of *Plagiochila*, one of which is new to Madeira.

In this study, the final goal was to obtain adequate information on the biodiversity, ecology and biochemical issues of the *Plagiochila* species, and therefore to identify significant sites for conservation of the Madeiran laurisilva. Until now, the relative presence of *Plagiochila* species, on the sampling sites, is showing them to be good indicators of the bryophytes biodiversity.

MATERIAL AND METHODS

The areas sampled are all included in the Laurisilva Site (PTMAD0001) of the Natura 2000 Network. Between August 2001 and July 2003 fieldwork was done, at 11 distinct forest areas corresponding to 28 UTM squares 1 x 1 km (Fig. 1, Table 1). Fifty plots were selected in such a way to represent the main bryophyte vegetation occurring on the slope formations located along watercourses. These slopes were of natural origin or man made, being in this case localized along the “levadas”.

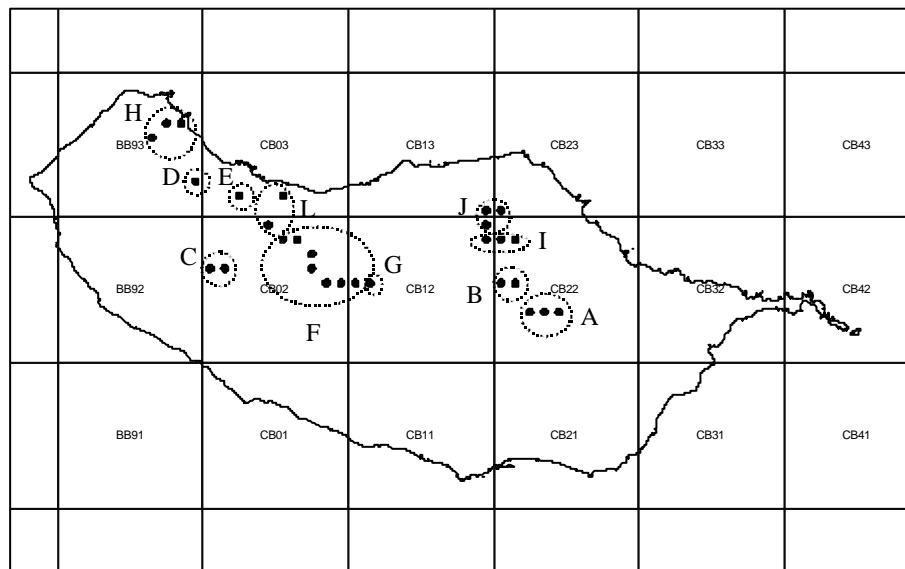


Fig. 1 - Areas sampled in the laurisilva (A-L). ● = the center of an UTM 1 x 1 Km square.

TABLE 1 - Names of the locations where the collections were made.

Area	Location
A	Santana, Balcões
B	Santana, Fajã da Nogueira, Lev. João de Deus
C	Calheta, Rabaçal, Levada do Risco
D	Porto Moniz, Fanal, Lagoa do Fanal
E	Porto Moniz, Seixal, Ribeira do Seixal
F	São Vicente, Levada do Folhadal
G	S. Vicente, Encumeada, Chão da Relva
H	Porto Moniz, Ribeira da Janela
I	Santana, Queimadas, Caldeirão Verde
J	Santana, Ribeiro Bonito
L	S. Vicente, Montado do Pessegueiros

One inventory was made for each sampling plot (2,500 cm²) and the quantitative occurrence of each bryophyte species was estimated in absolute value (%), using a rigid frame. For all plots sampled, several environmental factors, such as position (UTM-squares 1 x 1 Km), altitude, aspect (micro and macro-aspect, topography and cover of the different vegetation layers) and some substrate features were considered.

During the fieldwork for the biodiversity sampling, 250 *Plagiochila* populations were sampled adjacent to the studied plots in order to do the morphological studies. These were carried out by optical microscopy and by scanning electron microscopy (SEM), the latter, as described by FIGUEIREDO & PAIS (1994). In order to update the distribution of the different *Plagiochila* taxa on Madeira, 192 herbarium specimens from MADJ, MADS, LISU, INA, S and Herbarium Rin were also revised.

From the recently collected plant material, 20 *Plagiochila* populations were used to study four enzyme systems (ESQUÍVEL *et al.*, 2003) and 10 populations were investigated for essential oil composition using the methodology described in FIGUEIREDO *et al.* (2002).

For the nomenclature, the acrocarpous mosses followed CORLEY *et al.* (1981) and CORLEY & CRUNDWELL (1991), the pleurocarpous mosses HEDENÄS (1992), and for the liverworts the works of GROLLE & LONG (2000), HEINRICHS *et al.* (1998), HEINRICHS *et al.* (2002), RYCROFT *et al.* (2001) and RYCROFT *et al.* (2002). Acronyms of herbarium collections follow VITT *et al.* (1985).

RESULTS AND DISCUSSION

The fieldwork, done during the last two years in the Madeiran laurisilva has until now, identified 127 different species (Table 2). *Plagiochila* was the most frequent bryophyte genus on the majority of the sampled slopes, being also the one with the largest covering areas. From the morphological, isoenzyme banding patterns and essential oil composition analysis, eight different species were identified, one of them, *Plagiochila stricta*, being a new species for Madeira.

TABLE 2 - List of the bryophyte species collected during this study, * and ** indicate Macaronesia and Madeira endemics, respectively.

Liverworts and hornworts

Acanthocoleus aberrans (Lindenb. & Gottsche) Kruijt
Acrobolbus wilsonii Nees
Aneura pinguis (L.) Dumort.
Aphanolejeunea microscopica (Taylor) A. Evans
Asterella africana (Mont.) A. Evans
Calypogeia arguta Nees & Mont.
Calypogeia fissa (L.) Raddi
Cephalozia lunulifolia (Dumort.) Dumort.
Cephaloziella turneri (Hook.) Müll. Frib.,
Chiloscyphus polyanthos (L.) Corda
Conocephalum conicum (L.) Dumort.,
Diplophyllum albicans (L.) Dumort.
Drepanolejeunea hamatifolia (Hook.) Schiffn.
Dumortiera hirsuta (Sw.) Nees
Fossombronia angulosa (Dicks.) Raddi
Frullania polysticta Lindenb. *
Frullania tamarisci (L.) Dumort. var. *sardoa* (De Not.) De Not
Frullania tamarisci (L.) Dumort. var. *schiffneri* Nichol.
Frullania tamarisci (L.) Dumort.
Frullania teneriffae (F. Weber) Nees
Harpalejeunea molleri (Steph.) Grolle
Jubula hutchinsiae (Hook.) Dumort. var. *hutchinsiae*
Jubula hutchinsiae (Hook.) Dumort. var. *integrifolia* Lind. *
Jungermannia aff. *leiantha* Grolle
Jungermannia gracillima Sm.
Lejeunea cavifolia (Ehrh.) Lindb.
Lejeunea eckloniana Lindenb.
Lejeunea flava (Sw.) Nees subsp. *moorei* (Lindb.) R. M. Schust.
Lejeunea hibernica Bischl. et al. ex Grolle
Lejeunea lamacerina (Steph.) Schiffn.
Lejeunea patens Lindb.
Lophocolea bidentata (L.) Dumort.
Lophocolea fragrans (Moris & De Not.) Gottsche et al.
Lophocolea heterophylla (Schrad.) Dumort.

(Cont. TABLE 2)

Marchantia polymorpha subsp. *ruderalis* Bischl. et Boisselier
Marchesinia mackaii (Hook.) S. Gray
Marsupella emarginata (Ehrh.) Dumort.
Marsupella profunda Lindb.
Metzgeria conjugata Lindb.
Metzgeria furcata (L.) Dumort.
Microlejeunea ulicina (Taylor) A. Evans
Nardia scalaris Gray
Phaeoceros laevis (L.) Prosk.
Plagiochila bifaria (Sw.) Lindenb.
Plagiochila exigua (Taylor) Taylor
Plagiochila punctata (Taylor) Taylor
Plagiochila retrorsa Gottsche
Plagiochila spinulosa (Dicks.) Dumort.
Porella canariensis (F. Weber) Underw.
Porella inaequalis (Gottsche ex Steph.) Perss. **
Porella obtusata (Taylor) Trevis
Radula aquilegia (Hook. f. & Taylor) Gottsche et al.
Radula carringtonii J. B. Jack
Radula lindenbergiana Gottsche ex C. Hartm.
Radula nudicaulis Steph.
Radula wichurae Steph. *
Riccardia multifida (L.) Gray
Saccogyna viticulosa (L.) Dumort.
Scapania compacta (A. Roth) Dumort.
Scapania curta (Mart.) Dumort.
Scapania gracilis Lindb.
Scapania nemorea (L.) Grolle
Scapania undulata (L.) Dumort.
Telaranea nematodes (Gottsche ex Austin) M. Howe
Tylimanthus madeirensis Grolle & Perss. **

Mosses

Amphidium curvipes (C. Müll.) Broth. *
Andoa berthelotiana (Mont.) Ochyra *
Anoetangium aestivum (Hedw.) Mitt.
Atrichum angustatum (Brid.) Bruch & Schimp. var. *muelleri* (Schimp.) Barth.
Atrichum undulatum (Hedw.) P. Beauv.
Brachythecium percurrens Hedenäs **
Brachythecium plumosum (Hedw.) Schimp.
Brachythecium rutabulum (Hedw.) Schimp. & G. var. *atlanticum* Hedenäs
Brachythecium velutinum (Hedw.) Schimp.
Bryum caespiticium Hedw.
Bryum capillare Hedw.
Bryum rufifolium (Dixon) Demaret & R. Wilczek
Campylopus flexuosus (Hedw.) Brid.
Campylopus fragilis (Brid.) Bruch & Schimp.

(Cont. TABLE 2)

Campylopus pyriformis (Schultz) Brid.
Cyclodictyon laetevirens (Hook. & Tayl.) Mitt.
Dicranella heteromalla (Hedw.) Schimp.
Dicranum canariense Hampe ex C. Müll.
Diphyscium foliosum (Hedw.) D. Mohr
Echinodium prolixum (Mitt.) Broth. *
Echinodium spinosum (Mitt.) Jur. *
Epipterygium tozeri (Grev.) Lindb.
Eurhynchium hians (Hedw.) Sande Lac.
Eurhynchium praelongum (Hedw.) Schimp.
Fissidens asplenioides Hedw.
Fissidens luisierii P. Varde *
Fissidens polyphyllus Wils. ex B. , S. & G.
Fissidens rivularis Bruch & Schimp.
Fissidens taxifolius Hedw.
Homalia lusitanica Schimp.
Hookeria lucens (Hedw.) Sm.
Hypnum cupressiforme (Hedw.)
Hypnum uncinulatum Jur.
Lepidopilum virens Cardot
Leucobryum juniperoideum (Brid.) Müll. Hal.
Leucodon sciuroides (Hedw.) Schwaegr.
Neckera intermedia Brid.
Philonotis marchica (Hedw.) Brid.
Philonotis rigida Brid.
Plagiomnium affine (Blandow) T. J. Kop.
Plagiomnium medium (Bruch & Schimp.) T. J. Kop.
Plagiomnium undulatum (Hedw.) T. J. Kop. var. *madeirense* T. Kop. & C. Sérgio *
Plagiothecium nemorale (Mitt.) A. Jaeger
Pogonatum nanum (Hedw.) P. Beauv.
Pohlia elongata Hedw.
Polytrichum formosum Hedw.
Polytrichum juniperinum Hedw.
Polytrichum piliferum Hedw.
Ptychomitrium nigrescens (Kunze) Wijk & Marg.
Ptychomitrium polyphyllum (Sw.) Bruch & Schimp.
Rhizomnium punctatum (Hedw.) T. J. Kop.
Rhynchostegium murale (Hedw.) Schimp.
Rhytidadelphus loreus (Hedw.) Warnst.
Scleropodium purum (Hedw.) Limpr.
Scleropodium touretii (Brid.) L. Koch
Thamnobryum maderense (Kindb.) Hedenäs
Thuidium tamariscinum (Hedw.) Schimp
Tortella flavovirens (Bruch) Broth.
Trichostomum brachydontium Bruch.
Trichostomum brachydontium Bruch. var. *cuspidatum* (Braithw.)
Ulota crispa (Hedw.) Brid.

***Plagiochila stricta* Lindenb.**

The study of the specimens recently collected in the Madeiran laurisilva and those from several herbaria, lead to the identification of a species in some cases resembling *P. spinulosa* (PATON, 1999). However, we have observed the occurrence of leaves exhibiting many teeth, an antical leaf margin scarcely decurrent, a rough cuticle having round to ellipsoidal papillae, smooth oil bodies, thin-walled cells and small trigones (Fig. 2). These features are in accordance with the ones described for the neotropical *P. stricta*, recently recorded from the Canary Islands (HEINRICHS *et al.*, 1998b; RYCROFT *et al.*, 2002). Moreover, those characters coincide with the ones observed on the Herbarium Rin material from Tenerife, incorrectly named as *P. spinulosa*.

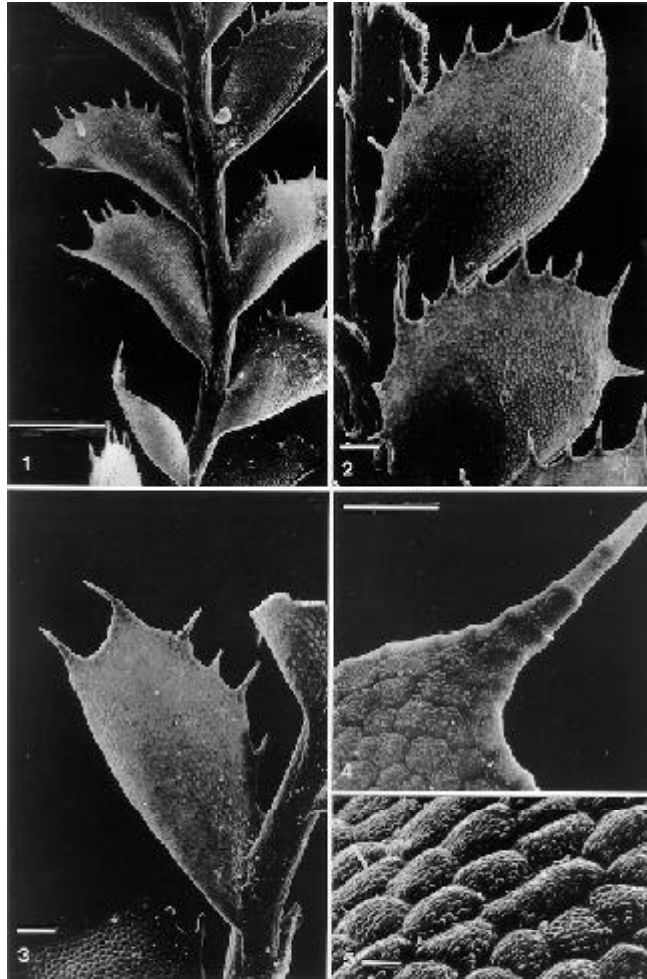


Fig. 2 - *Plagiochila stricta*. 1 and 3 - Dorsal view of gametophyte segment; 2 - Ventral view of gametophyte segment; 4 - Tooth of leaf margin; 5 - Median leaf cells walls with papillae. (Scale bars: 1 = 500 μm ; 2 and 3 = 100 μm ; 4 = 50 μm). (1-5 from: Madeira, Levada do Ribeiro Bonito, SIM-SIM *et al.*, 03/08/2002, LISU 182234).

The isoenzyme study showed the existence of similar profiles for 3 enzyme systems in the populations identified as *P. stricta*, which were distinct from all the other studied populations (ESQUÍVEL *et al.*, 2003). Furthermore, the essential oil extracted from several *P. stricta* specimens revealed the presence of *allo-ocimene* and *neo-allo-ocimene* as the main monoterpenes, compounds also reported by RYCROFT *et al.* (2002) for *P. stricta*. So, it is evident that *P. stricta* is not only a new record for Madeira, but frequent in the laurisilva, as shown on the updated distribution map (Fig. 3). It occurs on shaded slopes located along water rivulets, forming scattered or pure mats, although, in the latter, sometimes associated with other *Plagiochila* spp., especially *P. bifaria*. It has also been found associated with *Lejeunea eckloniana*, *L. lamacerina*, *Porella canariensis*, *Andoa berthelotiana*, *Echinodium prolixum*, *E. spinosum*, *Fissidens luisierii*, *Plagiothecium nemorale* and *Thamnobryum maderense*.

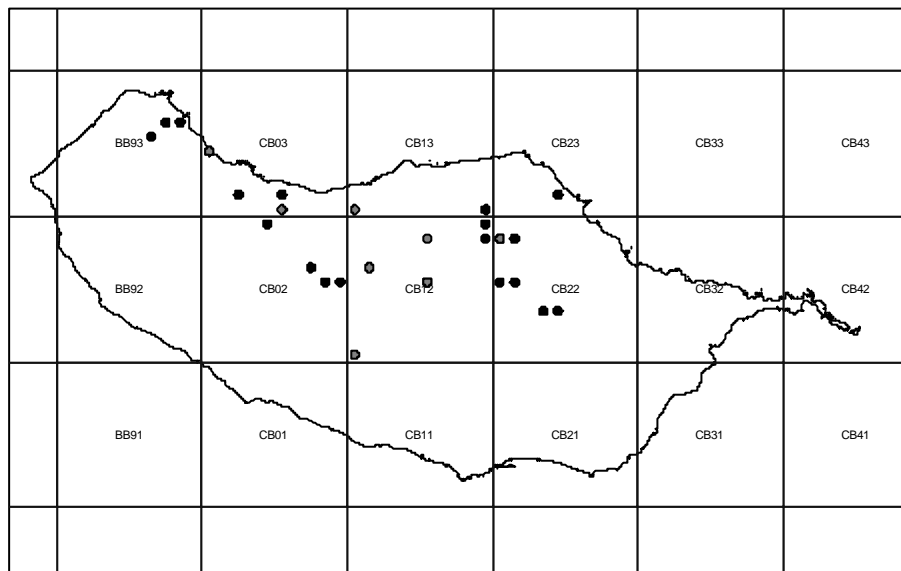


Fig. 3 - Distribution of *Plagiochila stricta* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ● herbarium specimens collected after 1950, ● specimens collected during this study.

***Plagiochila virginica* A. Evans.**

HEINRICHS *et al.* (2002), based on molecular analysis, refer the occurrence of *P. virginica* rather than *P. dubia* Lindenb. & Gottsche in Macaronesia. During the course of this investigation we have never found this species on the plots studied, not even in the ones done at Ribeira da Janela, or Levada do Furado (Table 1), places where other authors have collected some specimens (HEINRICHS *et al.*, 2002). Nevertheless, the study of

herbarium material from MADS and MADJ, and some *P. virginica* specimens from Tenerife, allowed the confirmation of 3 specimens of *P. virginica* occurring in the laurisilva (Fig. 4).

Since we have not found *P. virginica* on the slopes studied, which have a habitat ecology similar to the one described by SCHUSTER (1980), and having not found any reference on the herbarium labels seen, we tend to accept that this species is probably more demanding than the other *Plagiochila* species sampled and therefore rarer on the substrate sampled.

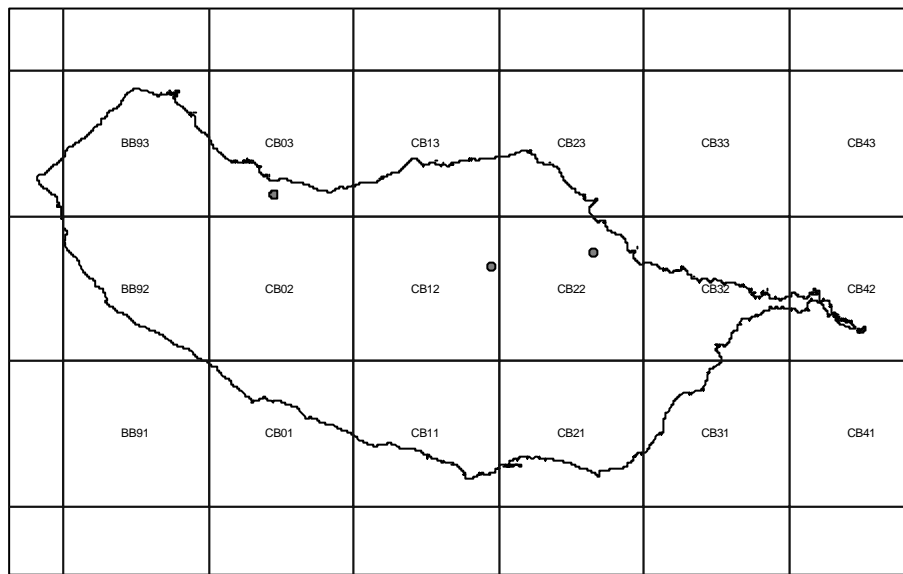


Fig. 4 - Distribution of *Plagiochila virginica* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ● herbarium specimens collected after 1950.

***Plagiochila retrorsa* Gottsche**

The morphological study of the specimens collected lead to the identification of some material as *P. retrorsa*. According to the studies done by RYCROFT *et al.* (2001), this species was reported as new to Europe, including the Madeira archipelago. The diagnostic features of *P. retrorsa* are based on the string appearance of the dried shoots, the leaf teeth somewhat curved and pointing in various directions, the presence at the leaf base of a broad vitta, the existence of nodulose trigones subconfluent with the cell walls, and intermediate thickenings sometimes present (Fig. 5). The presence of homogeneous and smooth oil bodies and occasional scattered underleaves, were also identified on the collected material, and on some Portuguese herbarium specimens previously identified as *P. spinulosa*.

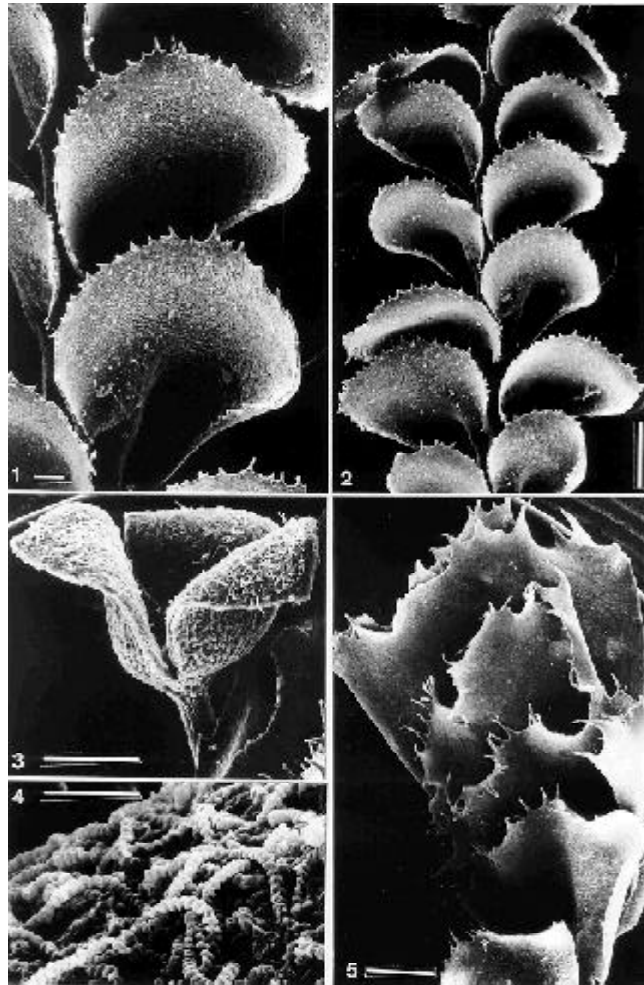


Fig. 5 - *Plagiochila retrorsa*. 1 and 2 - Ventral view of gametophyte segment; 3 - Capsule; 4 - Elaters; 5 - Lateral view of shoot apex with perianth. (Scale bars: 1 = 100 μm ; 2,3 and 5 = 500 μm ; 4 = 50 μm). (1-5 from: Madeira, Fanal, Lagoa do Fanal, SIM-SIM *et al.*, 23/07/2003, LISU 182245).

Concerning the isoenzyme study of *P. retrorsa* populations, a constant profile in the banding pattern of the studied populations was observed (ESQUÍVEL *et al.*, 2003). The essential oil isolated from *P. retrorsa* was dominated by the monoterpene β -phellandrene (FIGUEIREDO *et al.*, 2003). This has also been reported by RYCROFT *et al.* (2001).

Plagiochila retrorsa is often found in the laurisilva where it grows in large and dense mats on rocky slopes and on faces of damp boulders, frequently in the vicinity of temporary lagoons (Fig. 6). It was found in association with *Frullania tamarisci*, *F. teneriffae*, *Lejeunea eckloniana*, *Porella canariensis*, *Radula carringtonii*, *Tylimanthus madeirensis*, *Andoa berthelotiana*, *Brachythecium rutabulum* var. *atlanticum*, *Echinodium prolixum*.

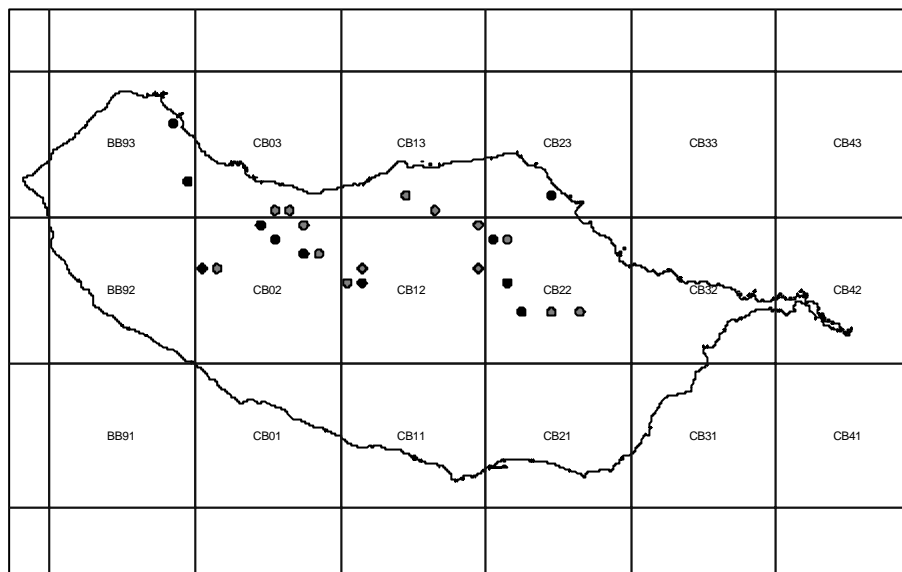


Fig. 6 - Distribution of *Plagiochila retrorsa* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ● herbarium specimens collected after 1950, ● specimens collected during this study.

It should be noted that several *Plagiochila* samples exhibit some morphological features that distinguish them from the typical *P. retrorsa* populations. A slender facies with unrolled shoots can be observed on dry plants along with non imbricate leaves and sometimes remote on the weaker shoots. The vitta is absent near the leaf base and the nodulose trigones and the intermediate thickenings have never been observed. The oil bodies were however similar to the ones found in typical *P. retrorsa* material. Most of these populations were collected in shady and humid conditions, frequently on sheltered sites on the slopes of the “levadas” and on streamside rocks or rocky slopes along trails.

The isoenzyme profile of such populations showed a high level of heterogeneity when compared with those of *P. retrorsa* (ESQUÍVEL *et al.*, 2003).

***Plagiochila bifaria* (Sw.) Lindenb.**

Since 1998, the neotropical *P. bifaria* and the Atlantic European *P. killarniensis* Pearson are considered conspecific (HEINRICHS *et al.*, 1998b). The morphological study of the collected material and the revision of Portuguese herbarium specimens initially identified as *P. killarniensis* and *P. spinulosa*, allowed the recognition of *P. bifaria* in Madeira. During this study it became clear that a vitta differentiation is not a diagnostic feature strong enough to distinguish the species when sterile. Moreover, our examinations of some fertile material, corresponding to leaf shoots having both vitta or not, revealed the occurrence of perianths with similar characteristics. The observed perianths are similar

to the ones mentioned by HEINRICHS *et al.* (1998) showing sometimes a winged dorsal keel on its lower half (Fig. 7).

The isoenzyme study demonstrated banding profiles having many similarities between *P. bifaria* populations and the ones previously identified as *P. spinulosa*, indicating a low interspecificity between both species (ESQUÍVEL *et al.*, 2003). The occurrence of these taxa in Madeira can only be confirmed by analysis involving the use of molecular markers.

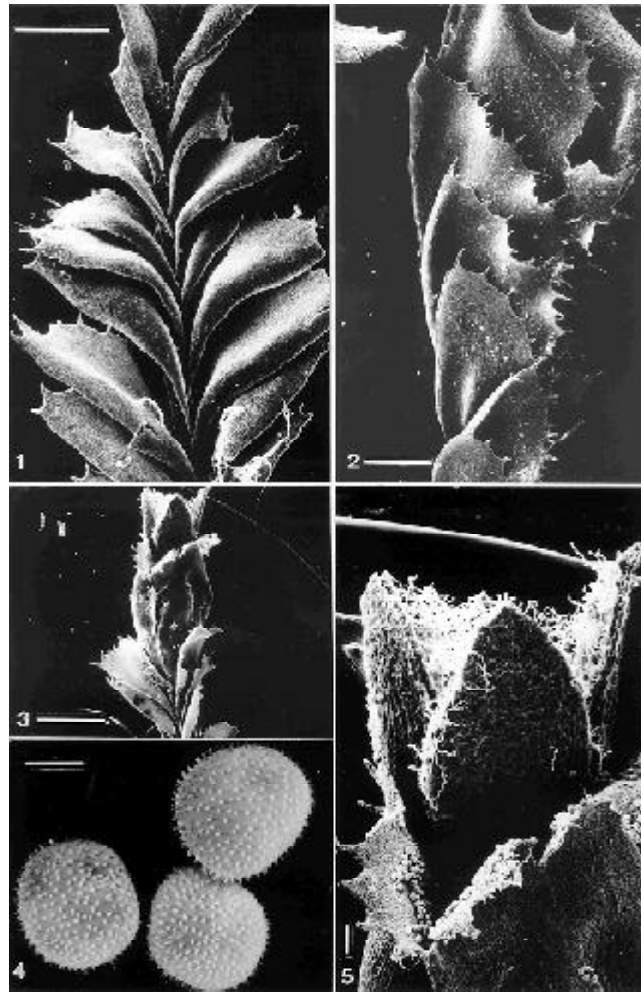


Fig. 7 - *Plagiochila bifaria*. 1 - Dorsal view of gametophyte segment; 2 - Lateral view of gametophyte segment with perianth; 3 - Dorsal view of gametophyte segment with sporophyte; 4 - Spores; 5 - Capsule. (Scale bars: 1 and 2 = 500 μ m; 3 = 1 mm; 4 = 10 μ m; 5 = 100 μ m). (1-5 from: Madeira, Levadinha João de Deus, SIM-SIM *et al.*, 24/07/2003, LISU).

Plagiochila bifaria is the most frequent *Plagiochila* species in Madeira's laurisilva and has recently been collected by us in Porto Santo (Fig. 8). It can be found on rocks,

boulders and stone walls, in sheltered or exposed habitats along watercourses and forming loose to dense patches. It was found in association with *Frullania tamarisci*, *Lejeunea patens*, *Marsupella profunda*, *Plagiochila exigua*, *P. stricta*, *Porella canariensis*, *Andoa berthelotiana*, *Fissidens luisierii* and *Ptychomitrium polyphyllum*.

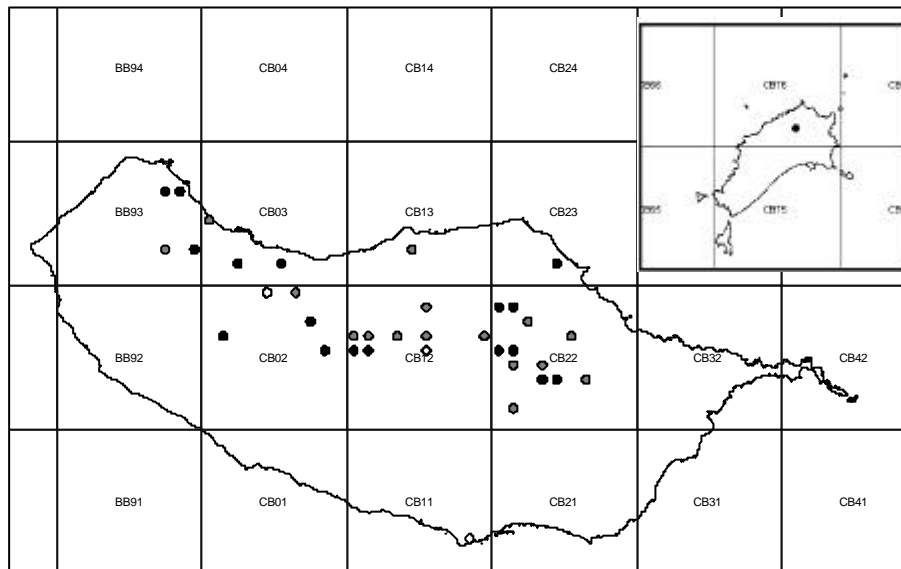


Fig. 8 - Distribution of *Plagiochila bifaria* in Madeira and Porto Santo, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ○ herbarium specimens collected before 1950, ● herbarium specimens collected after 1950; ■ specimens collected during this study.

***Plagiochila exigua* (Taylor) Taylor**

Plagiochila exigua is a common species in the Madeiran laurisilva, as revealed by the study of the collected material and of herbarium material (Fig. 9). The slender plants form loose turfs, growing on moist rock surfaces and slopes near watercourses frequently in association with *Frullania tamarisci*, *Harpalejeunea molleri*, *Lejeunea patens*, *Plagiochila bifaria*, *Porella canariensis*, *Andoa berthelotiana*, *Echinodium prolixum*, *Lepidopilum virens* and *Thuidium tamariscinum*.

***Plagiochila punctata* (Taylor) Taylor**

P. punctata was less frequent in the samples collected during the present study as well as in herbarium material from this environment (Fig. 10). We suggest that other habitats, like the epiphyte ones, should be surveyed in the future to get an accurate distribution of *P. punctata* in Madeira. In the 13 samples studied some material showed gynoecea with perianths as referred by PATON (1999). *P. punctata* specimens were collected

on shaded rocks or rocky slopes near streams or ravines forming small mats in association with *Frullania tamarisci*, *Lejeunea lamacerina*, *Radula nudicaulis*, *Andoa berthelotiana*, *Fissidens luisierii* and *Hookeria lucens*.

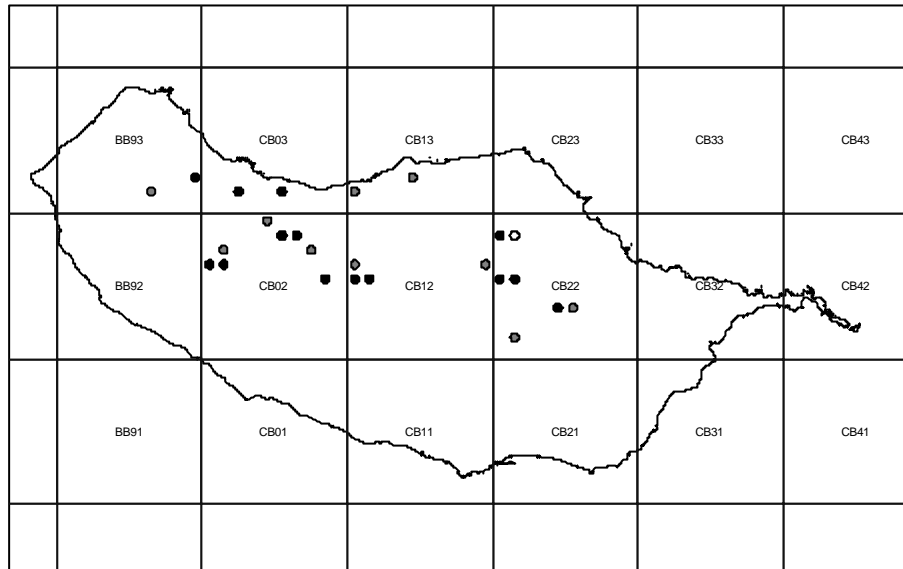


Fig. 9 - Distribution of *Plagiochila exigua* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ○ herbarium specimens collected before 1950, ● herbarium specimens collected after 1950; ■ specimens collected during this study.

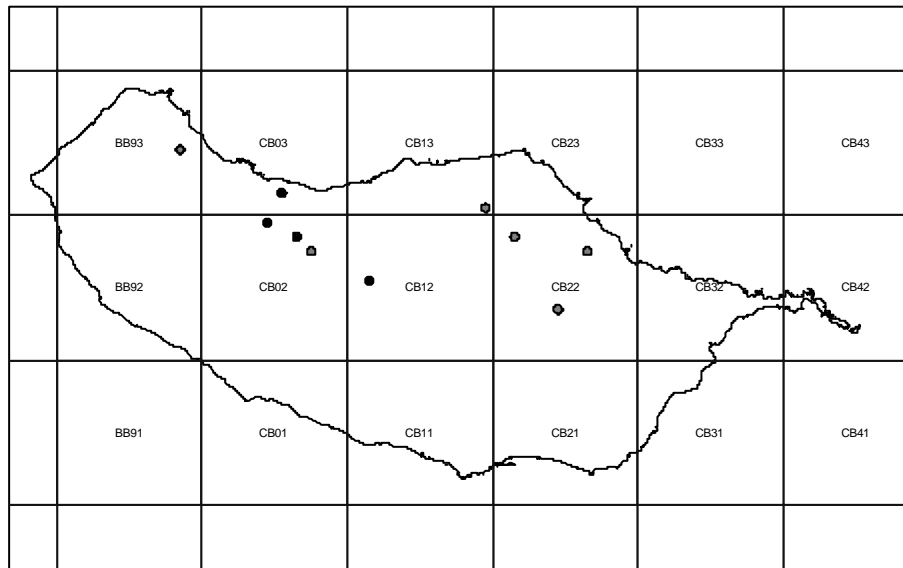


Fig. 10 - Distribution of *Plagiochila punctata* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ● herbarium specimens collected after 1950, ■ specimens collected during this study.

***Plagiochila porelloides* (Torrey ex Nees) Lindenb.**

Though *P. porelloides* has been previously collected in Madeira by Fontinha & Nóbrega (Fig. 11), no specimens were found during this study.

The *P. porelloides* herbarium specimens were apparently sampled in moist and shaded habitats, on rocky slopes and boulders beside watercourses and lakes (PATON, 1999). Similar conditions were surveyed in Madeira's laurisilva during the fieldwork, but until now we have not collected the species. We therefore consider this liverwort not to be frequent in the Madeiran laurisilva.

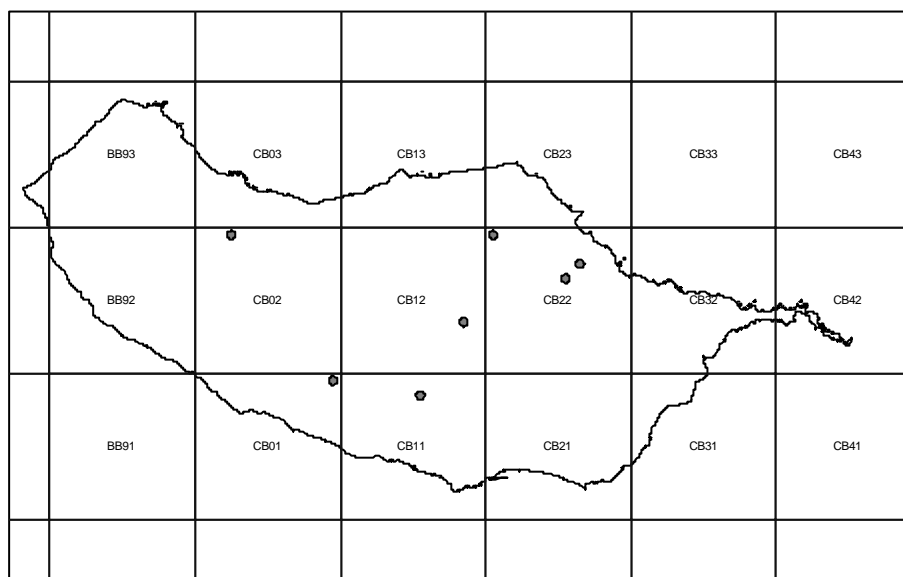


Fig. 11 - Distribution of *Plagiochila porelloides* in Madeira, using a UTM grid (28S, 1 x 1 Km). Studied specimens: ● herbarium specimens collected after 1950.

Biodiversity

The fieldwork done at the 11 sampling areas resulted in the taxonomic identification of 127 bryophytes, 66 liverworts and 61 mosses; from those, 9 taxa are endemic from Macaronesia and 3 from Madeira (Table 2). The presence of this rich bryophyte flora permitted a biodiversity analysis. For each area studied, the mean number of bryophyte species recorded per 1 Km² was determined, as well as the number of endemics and the total number of *Plagiochila* species (Fig. 12). The difference in species diversity between areas depends greatly upon the nature of the sampled slopes. These were either of natural or man-made origin, being in this case placed along the “levadas”. The results obtained showed that the areas exhibiting greater floristic richness, D, L, G and E (Fig. 12), also

have a high proportion of endemic and *Plagiochila* taxa. It is important to state that in these areas, most of the plots sampled were on natural slopes. On the contrary, those slopes with poor floristic richness, recorded mainly on the slopes along the “levadas” (H, F, J, I, A, C and B), had fewer endemics and *Plagiochila* species (Fig. 12).

In conclusion, the investigations until now represent the first approach to the study of bryophyte slope formations in the Laurisilva of Madeira, and suggest that *Plagiochila* may be considered a good indicator of bryophyte diversity.

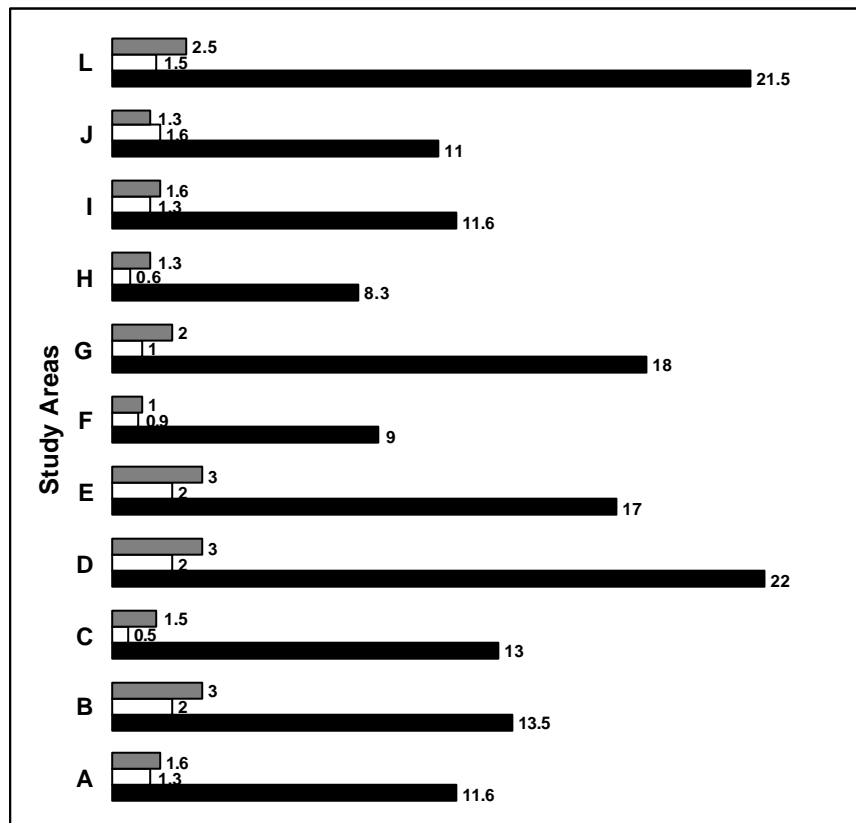


Fig. 12 - Bryophyte diversity in the studied areas. ■ Floristic richness, □ endemic taxa, ■ *Plagiochila* taxa.

ACKNOWLEDGEMENTS

We are indebted to Dr. Dirkse, Dr. David Draper and to all the herbarium curators for the loan of material. Special thanks to Mr. Graham Quinn, for the English revision of the text.

This study was funded by the “Fundação para a Ciência e Tecnologia” (FCT) under the research contract POCTI/AGR/42501/2001.

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Plagiochila retrorsa

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Plagiochila porelloides

Madeira: 28SCB0229, Levada do Seixal, *Nóbrega*, 12/07/1988, MADJ 1426; 28SCB0919, Ponte da Meia Légua, *Nóbrega*, MADJ 1164; 28SCB1425, Pico Ferreira, *Nóbrega*, 02/05/1989, MADJ 2344; 28SCB1518, Corrego dos Açougues, *Nóbrega*, 21/03/1989, MADJ 1492; 28SCB1823, Vereda próxima de Pedra Rija, Pico Arieiro, *Fontinha*, 13/08/1993, MADJ 2555; 28SCB2029, Vereda do Vale da Lapa para a Ribeira, *Nóbrega*,

26/06/1982, MADJ 1142; 28SCB2526, Levada entre os Balcões e a Ribeira da Metade, *Nóbrega & Fontinha*, 22/08/1989, MADJ 1634; 28SCB2627, margem direita da Ribeira Seca do Faial, *Nóbrega*, 03/10/1990, MADJ 2091.

Plagiochila virginica

Madeira: 28SCB0431, Montado dos Pessegueiros, *Nóbrega*, 26/11/1981, MADJ 1150; 28SCB1926, Vereda do Caldeirão Verde ao Pico Ruivo, *Nóbrega & Pita*, 30/06/1982, MADJ 1162; 28SCB2627, Ribeira Seca do Faial, *Nóbrega*, 23/10/1990, MADJ 2083. **Canary Islands:** 205-3070, Prov. de Santa Cruz de Tenerife, El Hierro, Paso de Jinama, *Dirkse*, 26/07/2001, Herbarium Rin 006247; 205-3185, Prov. de Santa Cruz de Tenerife, La Palma, Barranco Gallegos, SW of Barlovento, *Dirkse*, 26/07/2001, Herbarium Rin 005939; 375-3155, Prov. de Santa Cruz de Tenerife, 19 Municipio de La Laguna: Parque rural de Anaga, Pista de las Hiedras near Casas de Vinátigo, *Dirkse*, Herbarium Rin 0011370; BS8010, Prov. de Santa Cruz de Tenerife, Isla de Gomera, Vale del Cedro, Barranco del Cedro, Lomito del Loro, between the Zarcita and Garajonay, *Dirkse*, 26/07/2001, Herbarium Rin 005932.

Plagiochila punctata

Madeira: 28SBB9834, Fanal de Baixo, *Fontinha*, 30/01/1992, MADJ 2328; 28SCB0429, Montado dos Pessegueiros, Fonte do Rentroia, *Sim-Sim et al.*, 06/08/2002, LISU 182254; 28SCB0531, Montado dos Pessegueiros, *Sim-Sim et al.*, 06/08/2002, LISU 182255; 28SCB0628, Levada do Norte, *Sim-Sim et al.*, 05/08/2002, LISU 182256; 28SCB0727, Caramujo, *Nóbrega*, 02/07/1952, MADS 356; 28SCB1125, Vereda do posto Florestal da Encumeada para a Ribeira Grande, *Nóbrega*, 14/10/1981, MADJ 1146; 28SCB1930, Levada do Ribeiro Frio para Santana, *Nóbrega*, 06/07/1952, MADS 358; 28SCB2128, Queimadas, *Fontinha*, 13/04/1994, MADJ 2574; 28SCB2423, Levada do Furado, *Fontinha*, 06/01/1994, MADJ 2352; 28SCB2627, Ribeira Seca do Faial, *Nóbrega*, 23/10/1990, MADJ 2089.

Plagiochila exigua

Madeira: 28SBB9631, Ribeiro do Bonito, *Fontinha*, 03/10/1989, MADJ 1703; 28SBB9932, Lagoa do Fanal, *Sim-Sim et al.*, 08/08/2001, LISU 182257; 28SCB0026, Levada do Risco, *Sim-Sim et al.*, 29/07/2003, LISU 182258; 28SCB0126, Levada do Risco, *Sim-Sim et al.*, 08/08/2001, LISU 182259; 28SCB0127, Fanal, *Fontinha*, 11/10/1989, MADJ 1946; 28SCB0231, Chão da Ribeira, *Sim-Sim et al.*, 28/07/2003, LISU 182260; 28SCB0429, Montado dos Pessegueiros, *Nóbrega*, 26/07/1952, MADS 359; 28SCB0528, Levada do Norte, *Sim-Sim et al.*, 05/08/2002, LISU 182261; 28SCB0531, Montado dos Pessegueiros, *Sim-Sim et al.*, 09/08/2002, LISU 182262; 28SCB0628, Levada do Norte, *Sim-Sim et al.*, 05/08/2002, LISU 182263; 28SCB0727, Ribeira das Feijocas, *Nóbrega et al.*, 12/10/1983, MADJ 1156; 28SCB0825, Levada do Folhadal, *Sim-Sim et al.*, 09/08/2001, LISU 182264; 28SCB1025, Levada do Folhadal, *Sim-Sim et al.*, 09/08/2001, LISU

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