AZOREAN BRYOPHYTE COMMUNITIES - A REVISION OF DIFFERENTIAL SPECIES

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Bryophyte alliances and associations of the nine Azorean islands have been described by the author in publications extending from 1978 to 1997. The present paper includes a revision of their differential species and their differential values.

Alliances treated with suggestions of their associations (differential species of the alliances and associations in the relevé tables):
- Echinodion prolxi Sjn. 93 (epiphytic; mostly above 600 m in native cloud-zone forest types);
- Lepidozion azoricae Sjn 96 (epixylic; presence as the Echinodion prolxi);
- Aphanolejeuneo-Colurion Sjn. 78 (epiphyllous; presence as the Echinodion prolxi);
- Andoae-Nardion scalaris Sjn. 95 (epigeic; from ± 200-1000 m a.s.l.)
- Ptychomitrion azorici Sjn. 93 (epilithic; in strongly exposed habitats, in coast-near localities to altitudes above 1000 m.;
- Heterocladio-Jubulion Sjn. 95 (epilithic; in weakly exposed habitats, from about 300 to 800 m a.s.l.).

It has been stressed that differential species occur with different values, both at various altitudes on the individual islands and also with generally reduced values from E to W in the archipelago, due to climatic differences. Only few differential species are restricted to one bryophyte alliance. Also, few bryophyte species are restricted in their presence to one type of substrate.

Some of the bryophytes treated are more or less severely threatened as to their survival. Several of these species are differential species of alliances or associations, which mainly occur in mature native forests at altitudes above 500 m. During the last century these forests have become progressively reduced and are now restricted to some of the Azorean islands. Their preservation is highly important and urgent, not only as endemic ancient forest types but also due to their constitution with a large number of endemic vascular plants and bryophytes. LIFE-projects in 1995-1997 have given considerable support to this statement.

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INTRODUCTION

The Azorean bryo-flora of today comprises about 430 species of mosses and hepatics, existing on nine islands with a total size of 2328 km². The islands of São Miguel and Terceira have the largest number of documented species, 310 and 311 respectively. The small islands of Graciosa, Santa Maria, and Corvo are the most species-poor islands, Graciosa with about ⅓, Santa Maria with ⅔, and Corvo with ½ of the number of species on São Miguel. Considering the small size of these three islands the diversity of bryophyte species is, however, much higher than on the other islands (SJÖGREN 1990). The total number of species in the archipelago is not exceptionally high. But it is worth mentioning that this number includes 29 mosses and 10 hepatics recorded during the last 30 years as new to the Azores (cf. SJÖGREN 2001).

Bryo-sociological investigations in the Azores have been conducted since 1965 (SJÖGREN 1978 ff.; v. HÜBSCHMANN 1973; GABRIEL 1994, 1997). Apparently the islands have not been focused upon by bryologists concerned with sociology and ecology of the bryophyte vegetation. One of the principal reasons has certainly been the large number of species with wide ecological ranges and poorly pronounced substratum preferences. Another obstacle has been the fairly frequent
participation in the vegetation types of endemic bryophytes, either endemic to the Azores or to Macaronesia, producing a large number of endemic species constellations on different types of substrates.

Another important obstacle to bryosociological work in the Azores is the considerable climatic differences, on individual islands with changes with increasing altitude, and from E to W in the archipelago. Both these features produce difficulties when selecting differential species, as their differential values become different on the individual islands as well as on different islands.

**MATERIAL AND METHODS**

The present paper is a review of bryophyte alliances, with their presence linked to habitat conditions and to certain types of substrates. The species constellations have been treated as phorophyte-bound if growing on leaves of trees/shrubs, on fronds of ferns or on other vascular plant species (epiphyllous); if growing on the bark of living trees/shrubs (epiphytic); and on stems, branches or bark pieces on the ground, variously decomposed, or on slightly decomposed carpet of leaf litter (epixylic). The total amount of relevés (1965-1997) has been 1466. Some have been published (Sjögren 1978 ff.) and those published in this paper thus represent a small selection from as many islands as possible.

Relevé sizes for the epiphyllous have been 10-50 cm². The very small sizes were possible to use where the alliance is present under optimal habitat conditions. For all other species constellations a size of ¼ m² has been used.

Alliances were differentiated using in a strict manner differential species of various discriminating value, like in the modern Central European approach. Associations of alliances have been treated in my earlier papers, and differential species of associations have been included in Tables 1-8. The sociological level of alliances means a theoretical presence on all the islands of the archipelago. Some are, however, absent on the small, comparatively dry islands of Graciosa and Santa Maria. The associations may also be recorded within the whole archipelago, but several have a more or less geographically restricted presence. The associations occur with a rich variation of dominant species, which often obscures their typical constitution, as well as their belonging to a certain alliance.

There are few differential bryophyte species in the Azores, which are strictly confined to only one association or alliance. This is especially the case for species within their total altitude range. Most differential species are either epiphyllous/epiphytic/epixylic or epilithic/epigeic.

**NOMENCLATURE**

Changes of nomenclature and of taxonomic treatment of the Macaronesian bryophytes have been numerous during the last 30 years. Here hepatics and mosses are treated according to Grolle (1982), Grolle & Long (2000), Corley et al. (1981) and Corley & Crundwell (1991). Valuable discussions on the taxonomy of several Macaronesian bryophyte taxa have been provided by e.g. Düll (1983, 1992) and Hedenäs (1992); recently on several species by Schumacker (2001); see also Sjögren (2001).

**Abbreviations**

Mac. Macaronesia
Az Azores islands
S Santa Maria
M São Miguel
T Terceira
G Graciosa
J São Jorge
P Pico
F Faial
L Flores
C Corvo
ass. association
all. alliance
diff. sp. differential species
diff. val. differential value
pref. preferentially
The epiphytic Echinodion prolixi (cf. Sjögren 1993)

Diff. spp. of the alliance: Echinodium prolixum, Lepidozia cupressina, Lejeunea flava subsp. moorei. - Diff. spp. of associations: Dicranum scottianum, Hypnum uncinulatum, Bazzania azorica, Porella canariensis, Neckera intermedia. - Diff. spp. with reduced diff. val. of the alliance: Cololejeunea minutissima, Drepanolejeunea hamatifolia, Lejeunea lamacerina, Metzgeria furcata, Plagiochila exigua, Radula aquilegia, Metzgeria leptoneura, Plagiochila longispina. - Accompanying spp.: Large number of hepatics but few mosses. 188 relevés on TJPF (1965-1997).

The epiphytic ass. Echinodio-Lepidozietum cupressinae Sjn. 78 is physiognomically characterized by the same dominant species as those listed as diff. spp. It may become possible to differentiate also a Neckera intermedia - ass. The very rare Radula nudicaulis vegetation (Pico) is probably at the level of subassociation. The initial stage of development of the Echinodion prolixi is represented by an association, dominated by small hepatics, which otherwise occur mostly as epiphyllous (Lejeuneaceae). This successional stage is also characterized by the mosses Hypnum uncinulatum and Dicranum scottianum, often growing in small patches and eventually becoming outcompeted by large hepatics. Neckera intermedia is a highly competitive species and carpets dominated by this species are species-poor. In ecologically optimal habitats, stages of development of the Echinodion are qualitatively much less separated than at the edge of the ecological range of the alliance. The telescopic effect upon the successional stages becomes evident. Transitions towards the epiphylic Lepidozietum azoricae, and on treebases towards the epigeic Andoae-Nardion scalaris occur frequently.

The epiphytic Echinodion prolixi occurs principally on trunks of Erica azorica, Laurus azorica, Juniperus brevifolia, and Ilex parado subsp. azorica, more rarely on Cryptomeria japonica and Pittosporum undulatum and in that case being impoverished. The alliance is present in all types of native forest, preferably at altitudes above 600 m. It also occurs in small relict stands of Erica/Juniperus in the high-altitude seminatural grazingland, where annual precipitation is generally more than 3000 mm, supplemented locally by large amounts of mist-rain (cf. Dias 1996). The alliance is principally a part of the native forest-phytocenoses at high altitudes, dominated in the tree-layer by Laurus, Erica, Juniperus, and Ilex.

The Echinodion is also an epiphytic alliance of the native forests of Madeira (Clethro-Laurion Sjn. 72), but is represented there by other associations. The Echinodietum prolixi v. HÜBSCHMANN 71 represents a fraction of the Echinodio-Lepidozietum cupressinae. Other epiphytic associations described by v. HÜBSCHMANN (1973) from São Miguel have not been possible to record in other parts of the archipelago. They are poorly differentiated, mostly by only one diff. sp., such as Leucobryum juniperoides.

Presence on the islands

Corvo: The presence of the Echinodion prolixi on Corvo was studied in several localities in 1978 (Sjögren 1993). The most prominent differences, if compared with the constitution of the all. on the islands of the central island group, are the low number of species and the absence in sample plots of some diff. spp. at various levels of diff. val. (Lepidozia cupressina, Bazzania azorica). Primary stages of development of the all. are frequently present. Old phorophytes (Erica, Juniperus) are rare and have scattered occurrence in the landscape. Fractions of the Echinodion may occur even at unusually low altitudes (at 300 m). The young stages of the all. are locally richly equipped with small hepatics of the Lejeuneaceae.

Flores: The Echinodion prolixi was not studied by the author. Information provided by V. & P. Allorge (1948) give little evidence of the presence of the all. even if phorophytes (Juniperus) were much more frequently present in the 1930s than today. Diff. spp. recorded by the authors (op. cit.) are generally of low diff. val.
and it is interesting to notice that characterizing species of the all. are more frequently recorded also as epiphytic than on islands of the central group. Both Corvo and Flores are islands where most of the all. has apparently suffered extinction due to far-reaching cutting of the native forests of the Juniperion brevifoliae Sjn. 73.

**Faial:** Presence almost restricted to the interior of the big Caldeira. All stages of development of the all. exist both on Erica and on Juniperus. Initial stages are characterized by Hypnum uncinulatum and Dicranum scottianum and especially by a high frequency of small hepatics, mostly recorded as epiphyllous (Table 1 on appendix: relevé 14).

**Pico:** The island with the highest frequency of localities with maturely developed Echinodion. Lepidozia cupressina is very common especially at altitudes above 700 m. Ilex is locally a frequent phorophyte. Late stages of the all. are dominated by Bazzania azorica, Porella canariensis, Lepidozia cupressina, Frullania tamarisci or in scattered localities also by Myurium hochstetteri. Initial colonization by Hypnum uncinulatum, Dicranum scottianum and species of the Lejeuneaceae. There is a rare presence of Cheilolejeunea cedercreutzii (endemic to the Azores) and Acrobothus wilsonii (only on four islands), treated as endangered in RDB (ECCB, 1995). The restriction of the all. to dark, mature native forests is evident, although individual species, with few exceptions, do not appear with this restriction. Accidental dominance of large highly competitive species results in a frequently species-poor presence of the all., and its "complete" constitution mostly becomes revealed, using sample plots, representing stages of development of the alliance.

**Graciosa:** The all. is absent on this low, comparatively dry island, with no native Juniperion-forest. Echinodion prolrum occurs as epiphyte on the island but Lepidozia cupressina has not been recorded as well as some other diff. spp. with variously strong diff. val.

**São Jorge:** The all. occurs only in remnants of the Juniperion, which are almost restricted to river ravines in the E part of the island. Some ravines contain luxuriant populations of Hyocomium armoricum, which in some localities invade the Echinodion on basal parts of trunks of Erica and Juniperus.

**Terceira:** Mature Echinodion occurs mainly inside the Caldeira de Santa Bárbara and in ravines on the N exterior slopes of the Caldeira. Localities are also numerous above 500 m, in patches of Juniperion to the E of the Caldeira.

**São Miguel:** Native Juniperion- forest types are nowadays almost restricted to the Pico da Vara mountains, within small areas. The Echinodion occurs there but the constitution is impoverished in species and only scattered tree trunks are occupied by mature types of the alliance. All diff. spp. of the all. have been recorded on São Miguel but groups of species forming the Echinodion have a restricted presence. The native forest stands have been extensively diminished during the last century and substituted by pastures and plantations of alien tree species, mainly Cryptomeria japonica. The Cryptomeria trunks may locally become colonized by initial colonizers of the Echinodion (above 600 m) but mature stages of the all. are never reached. The survival of the Echinodion may be regarded as threatened on São Miguel and also on the islands of São Jorge, Corvo, and Flores.

**Santa Maria:** The all. is absent on the island. Only two localities of Echinodium prolrum and Dicranum scottianum as epiphytic above 550 m were recorded in 1996 (LIFE-project, SIÖGREN 1995). The epiphytic vegetation on the island is dominated by the Marchesinicion alliance.

The epiphytic Marchesinicion Sjn. 96

The very common *Frullanietum azoricae* Sjn. 96 has only a few dominant species, which are also diff. spp. of the alliance. *Cololejeunea minutissima* and *Harpalejeunea molleri* are small hepatics with weak diff. val. of the association. The *Zygodietum* (cf. SJÖGREN 1996) is restricted to trunks of tree species with naturally high bark-pH (e.g. *Ulmus*) or dust-impregnated acid barks, e.g. of *Platanus*. This association is geographically very much restricted in the archipelago. Diff. spp. are *Zygodon viridissimus*, *Leucodon trelaesei* and *Homalia webbiana*, all being favoured by high pH values above 5.5 (also recorded on cement and on coast-near lava boulders in stone fences in strongly exposed habitats).

Successional stages are difficult to distinguish, as the primary stages are composed of the same species as the mature ones, at least generally. Bases of trees with high bark-pH may show transitions towards an impoverished epigeic *Andoae-Nardion scalari*. The epiphytic *Frullanietum azoricae* of the *Marchesinion* occurs e.g. on *Myrica faya*, *Pittosporum undulatum* and *Erica azorica*, almost from the coast to about 400 m a.s.l. Above that altitude its diff. spp. tend to become less frequent. The alliance becomes progressively more mixed with species of the *Echinodion*. The *Zygodietum* with the characteristic diff. sp. *Homalia webbiana* is highly drought tolerant. Both associations occur in densely shaded habitats as well as at borders of forest stands and on alley trees along roads.

A first indication of the presence of the *Marchesinion* was given by V. HÜBSCHMANN (1973), describing a low-altitude hepatic community characterized in the first place by *Frullania microphylla* and by one other diff. sp. of the alliance, *Harpalejeunea molleri*.

V. Hübschmann’s recordings on São Miguel have affinity to epiphytic associations (presence of *Riccardia* spp., *Sematophyllum substrimalus*, *Pseudotaxiphyllum elegans*) on tree bases with moist, porous, easily detached, bark.

**Presence on the islands**

**Graciosa:** The *Marchesinion* is present in localities with dense stands of *Persea*, *Pittosporum* and *Eucalyptus*. The community occurs on stem bases in strongly shaded habitats but also on trees around light gaps in the forest stands. The species diversity is characteristically low. The highly frequent presence of *Harpalejeunea molleri* in the relevés should be observed.

**Santa Maria:** Presence spread all over the island. The diversity is higher than on Graciosa, due to the presence also on tree species with high-pH bark and on tree trunks with raised pH due to dust impregnation. In such habitats, the all. is found, e.g. with *Homalia webbiana* as highly dominant. Still, the *Frullanietum azoricae* is the most frequent association on the island.

The *Marchesinion* has not been recorded in relevés on the other Azorean islands but has been documented by the author also on São Jorge, Terceira and Faial and will eventually certainly be found on all the islands in the archipelago. The *Zygodietum*, on the other hand, has only been recorded on Santa Maria.

The epiphylic *Lepidozion azoricae* Sjn. 96


The *Lepidozietum azoricae* Sjn. 78 is the most common species constellation, although physiognomically very varied, on substrates subject to different degrees of decay. Records on Santa Maria may represent another association, characterized by *Tetrastichium virens*, *Sematophyllum substrimalus* and *Pseudotaxiphyllum elegans*. It is dominated by mosses and the number and cover percentage of
hepatics are comparatively low. Impoverished species combinations at low altitudes occur frequently, with *Nowellia curvifolia* as dominant species.

Succession depends on degree of decay of tree stumps, dead trunks and litter layer of leaves and field-layer plants. There is naturally a progressive transition towards the epigeic *Andoae-Nardion scalaris*, a slow process at low altitudes but very fast at high altitudes, above 600 m. In general, the successional process is accompanied by an increase in number of mosses.

The epixylic *Lepidozion azoricae* is present in sheltered habitats in different forest types. The typical constitution of the all. is restricted to the native high-altitude forests. Impoverished types of the community also occur in low-altitude *Myrica/Pittosporum* forests and in *Cryptomeria* plantations at various altitude levels.

**Presence on the islands**

*Faial:* Epixylic *Lepidozietum azoricae* occurs within the big Caldeira and in a few localities on its north-facing exterior slopes. The community is dominated, as to cover, by hepatics. The dominance of one or two species varies and seems to be accidental.

*Pico:* Most of the relevés of epixylic vegetation were recorded on Pico. The all. has a wide altitude range on the island but the typical constitution becomes obscured or impoverished below 500 m. The epixylic species are more or less the same on various phorophyte species, provided the trunks have reached late stages of decay. Epixylic vegetation was also recorded on senescent ferns like *Blechnum spicant* and *Calcita macrocarpa*; on such phorophytes, however, getting frequently mixed with pref. epiphyllous and epigeic species. The species diversity in the *Lepidozieta azoricae* is unusually high on Pico, especially in craters, narrow ravines and in caves within rough lava streams.

*São Jorge:* Epixylic bryo-vegetation, as also the epiphytic and epiphyllous one of the mature high-altitude forests, is restricted to the E part of the island, where remains of the *Juniperion brevifoliae* occur, on Pico dos Frades and in narrow river ravines. The composition of the epixylic vegetation there does not differ from that on the other islands of the central island group and the average species richness is almost as high as on Pico. Phorophytes are mostly *Erica* and *Juniperus*. Telaranea nematodes occurs on *São Jorge* but has not been recorded as epixylic.

*Graciosa:* The mature *Lepidozion azoricae* is absent on the island, where small dense forest stands occur at low altitudes only. Fractions of the all. occur in *Pittosporum-Persea* stands with some *Lophocolea* and *Radula* species, but in general the number of hepatics is very low on the island.

*Terceira:* The epixylic bryo-vegetation occurs in the Caldeira de Santa Bárbara, on its north-facing exterior slopes and scattered to the E of the Caldeira. The diversity in available relevés is mostly lower than on Pico and *São Jorge*, but all diff. spp. suggested occur on the island. Some habitats suitable to the presence of the all. are absent on Terceira, like small explosion craters and very rough lava flows with maturely developed *Juniperus* stands.

*São Miguel:* All diff. spp. of the *Lepidozion azoricae* occur on *São Miguel* but the community has not been recorded. Epixylic bryo-vegetation featuring the all. is probably nowadays restricted to altitudes above 700-800 m in the E part of the island.

Santa Maria:* Epixylic vegetation occurs on trunks of *Cryptomeria* and *Pittosporum* at altitudes above 400 m. Three records have been included in Table 3 of the Appendix. They show clearly the comparatively impoverished constitution, which means that the complete range of development of the all. does not occur on the island. This is also the case with other phorophyte-bound species constellations, endemic to the Azores islands and with their most typical and frequent development at high altitudes on the islands of the central island group (except for Graciosa).
The epiphyllous *Aphanolejeuneo-Colurion* (cf. Sjögren 1978)


The *Aphanolejeuneetum azoricae* (cf. Sjögren 1978) is the only Azorean ass. distinguished. In initial and mature stages are qualitatively poorly differentiated. Primary stages are dominated, e.g. by *Drepanolejeunea hamatifolia*, *Aphanolejeunea* spp. and *Cololejeunea minutissima*, mature stages by *Lejeunea lamacerina*, *Radula* spp. and *Frullania* spp. The tiny hepatics of the initial stages of development of the all. cover altogether only small parts of the phorophyte surfaces. The epiphyllous ass. on Madeira, the *Aphanolejeuneo-Frullanietum microphyllae* (cf. Sjögren 1975), differs from the Azorean ass. due to its presence of the diff. spp. *Frullania polyactis* and *Metzgeria fruticulosa* and the more frequent presence of *Lejeunea ulicina*.

Succession proceeds from the first tiny hepatics to appear, towards a dense colonization of large highly competitive hepatics. When postmature stages are reached, a rapid invasion of pref. epixylic bryophytes takes place, followed by some pref. epigeic ones. The successional rate is probably very fast, as leaves of trees and fronds of ferns get colonized in general when the first signs of their senescence occur. As also for the epiphytic *Echinodion*, initial and mature stages of development of the *Aphanolejeuneo-Calurion* are much less distinctly separated qualitatively under optimal habitat conditions (generally above 600 m) than at lower altitudes.

The mature, completely developed, epiphyllous all. is the ecologically most specialized bryo-community in the Azores. Optimal conditions including high precipitation, mist-rain and almost permanently high air humidity and efficient shelter are principally available in dense native forests at high altitudes (Sjögren 1997). The epiphyllous all. offers species combinations with sociologically discriminating diff. values and thus of the utmost value to become incorporated in phytocoenoses with dominant *Laurus, Ilex* or *Juniperus*.

**Presence on the islands**

**Corvo:** Scattered presence above 300 m. Phorophytes are mostly represented by the fern *Trichomanes speciosum*. Rapid invasion of *Lejeunea lamacerina* into initial stages of the all., which obscures the mature constitution of the community. Diff. spp. are the same as on the islands of the central group. *Aphanolejeunea madeirensis* has still not been recorded on Corvo (cf. Sjögren 1993, Table 7 of the Appendix).

**Flores:** No records of the all. due to reduced areas of cloud-zone forest of various types. Species listed by V. & P. Allorge (1948) as epiphyllous may indicate a former presence of the all. on *Laurus*-leaves, on fronds of ferns and on large bryophyte species.

**Faial:** Maturely developed epiphyllous all. only in a few localities. Most records on the N-facing interior slope of the big Caldeira and impoverished in a few localities on the N-facing exterior slope, all records above 600 m. *Aphanolejeunea madeirensis* is rare as diff. sp. The number of phorophyte species is high only within the Caldeira (cf. Sjögren 1997).

**Pico:** Epiphyllous vegetation on Pico occurs in more localities than on any other island. Diversity of species is also higher than in other parts of the archipelago. A large number of phorophyte species have been recorded between 600-900 m (op. cit.). Most localities of mature epiphyllous vegetation are located to dense stands of *Juniperus, Ilex* and *Viburnum*. Some localities have also been recorded in ravines and in explosion craters (such as in the Mistério da Prainha), provided that efficiently sheltering tree canopies are available. Such favourable habitat conditions occur also above and below the preferred altitude range mentioned.
São Jorge: Remaining stands of the native cloud-zone forest types are few and small. They are concentrated to the S-facing slopes of Pico dos Frades and to nearby river ravines, above 600 m in the E part of the island. In spite of the restricted forest areas it is still possible to find mature Aphanolejeunea-Colurion in several efficiently sheltered localities. All diff. spp. of the all. occur on São Jorge. Today’s localities with epiphyllous vegetation will be strongly threatened by extinction if changes by thinning of the sheltering tree canopies takes place (cf. Echinodion).

Terceira: The presence of epiphyllous bryophytes is widespread on the exterior N slopes of and inside the Caldeira de Santa Bárbara and also in scattered localities E of the Caldeira at altitudes above 500 m. All diff. spp. occur on the island but Cheilolejeunea and Aphanolejeunea azorica are rare. A large number of phorophyte species get colonized. The average number of species in relevés becomes progressively larger towards 800 m a. s. l.

Graciosa: Epiphyllous communities have not been recorded. Cloud-zone forest does not exist on this comparatively dry island. On the other hand, dense stands of Persea, Pittosporum and Acacia offer suitable habitat conditions for accidental presence on stem bases of some of the diff. spp. of the Aphanolejeunea-Colurion (e.g. Cololejeunea minutissima, Aphanolejeunea azorica and Drepanolejeunea hamatifolia).

São Miguel: Epiphyllous species combinations are nowadays restricted to a few localities due to disappearing of the mature cloud-zone forest types, being today present only with small stands in the Pico da Vara area. Extremely rich epiphyllous vegetation was found 30 years ago in the crater area of Lagoa do Congro, at exceptionally low altitude, due to efficient shelter and maintained high air humidity in the small crater with steep sides. Mature epiphyllous all. is otherwise restricted to altitudes above 700 m and to dense forest stands. Former records of Cheilolejeunea were not possible to confirm after 1965. All other listed diff. spp. of the epiphyllous all. exist on the island. The average number of pref. epiphyllous species in the relevés is high but the number of phorophyte species colonized is comparatively low.

Santa Maria: The low and dry island of Santa Maria has no epiphyllous vegetation, except for the probably accidental presence at altitudes around 500 m of Aphanolejeunea sintenisii, Aphanolejeunea azorica and Lejeunea lamacerina on Hedychium gardnerianum. As on Graciosa, however, there are several recently (SJÖGREN 1996) recorded localities with epiphytic/epixylic presence of a few pref. epiphyllous species, e.g. Cololejeunea minutissima, Fruillania microphylla, Lejeunea lamacerina, Lophocolea fragrans and Aphanolejeunea sintenisii. Even at 500 m a. s. l., habitat conditions with precipitation of about 1600 mm/y and at least periodically high air humidity values are not sufficient, even in efficiently sheltered habitats, for development of an epiphyllous bryo-vegetation on various kinds of phorophytes.

NOT PHOROPHYTE-BOUND COMMUNITIES

The epigeic Andoae-Nardion scalaris Sjn. 95


The alliance was described by SJÖGREN (1995) from Flores, Faial, Pico and São Jorge. It is the most species-rich bryo-community in the archipelago and includes several associations. One rare ass. on thin soil-covered level lavastones, with Anastrophyllum minutum as characterizing species, may become differentiated.
There is one Nardia-Andoa-Saccogyna ass. on moderately moist soil escarpments. One Odontoschisma prostratum - Myurium hochstetteri ass. occurs on wet soil escarpments. The dry strongly exposed soil escarpments become colonized by a Pogonatum-Polytrichum-Fissidens asplenioides ass., at low as well as high altitudes. One impoverished ass. on level, fairly dry, soil is characterized by Scleropodium purum, S. touretii and Thuidium tamariscinum. A more far-reaching differentiation may become relevant. Species combinations, which are only locally homogeneous, are numerous, and the consequence is that diff. spp. with high diff. val. are difficult to find.

Also other species combinations occur more or less frequently, such as the primarily colonizing Philonotis rigida - Fossombronia angulosa one on fine soil layers appearing on soil escarpments. The Breutelia-Alophosia community forms one type of final stage of development of the all. at high altitudes and on wet substrates. Alophosia is a "pseudoeuplithic" species, also common on lava boulders with some accumulation of dust/soil (cf. Dias 1996). It is necessary to stress the eminent danger that the Andoa-Nardion scalaris gets split into a very large number of associations, which split or more or less local and distinguished by frequently dominant species only (see also below).

Successional sequences vary according to substrate structure, exposition, inclination, etc. Experimental investigations of the rate and direction of succession within the Andoa-Nardion scalaris are easily carried out on soil escarpments of different age, subject to different habitat conditions and situated at different altitudes. All investigations of Azorean vegetation lack more precise information on succession and dynamics in general, founded on repeated checking of permanent plots.

Transitional species combinations towards both epixylic and epilithic communities are numerous, getting highly frequent especially at high altitudes, in native cloud-zone forest types.

The association-rich Andoa-Nardion scalaris has been attributed several diff. spp. of different value. The number of large, highly competitive and easily recognized diff. spp. is high. However, the highest characterizing values belong to some tiny mosses, e.g. Epiphygium tozeri, Enhostodon attenuatus, and Rhhamnidium purpuratum, species that frequently manage to survive together with large species of final successional stages.

The ecological range of the Andoa-Nardion scalaris is very wide (see associations). Species combinations vary according to exposition and water supply. The all. is consequently represented by its associations from coast-near localities to high altitudes, in native forest types. The species-poor Thuidium-Scleropodium ass. belongs to the open semi-natural grazingland. The Breutelia-Alophosia ass. belongs to more or less sheltered habitats within the native forest types at high altitudes. Other associations are difficult to link to certain phytocoenoses. However, one Sphagnum lescuri ass. seems to have certain affinity to open grassland vegetation, locally on slopes in the fumarol area (Terceira) but is also present on wet soil escarpments at high altitude levels on the islands of the central group.

From the island of São Miguel, v. Hübschmann (1973) described 14 epigeic bryocommunities (associations), 12 of them accompanied by relevés in his Tables no. 13-20. All these associations are each characterized by only one highly frequent and dominant differential species ("Kennart"). With this approach, it may be possible to define a very large number of local epigeic "communities" in the Azores, which are just short-lived miniassociations.

Using differential species at various levels of differential value, it is possible to unite all the miniassociations of v. Hübschmann (op. cit.) within the epigeic Andoa-Nardion scalaris (except for his coast-bound Trichostomo-Aloinetum Ericaeofoliae, a high-pH community on boulders in stone fences, probably to be referred to the epilithic Ptychomitirion azoricum; see below).

Presence on the islands

Corvo: The epigeic all. on Corvo is, as on Flores, much more heterogeneous than in other parts of the archipelago. It is comparatively species-rich and there are frequent transitions especially to epilithic communities. All diff. spp. recorded on other islands are present but some occur with reduced diff. val. Species with low drought...
tolerance like *Myurium hochstetteri* and *Odontoschisma prostratum* are more frequent than on other islands, at similar altitudes. The lack of *Breutelia azorica* on the island is remarkable (recently recorded for the first time on Flores; leg. Paulo J. M. Barcelos, Angra do Heroísmo).

**Flores:** Almost the same constitution and frequency as on Corvo, with localities from 100 m a. s. l. to the highest altitudes. *Epipterygium* and *Odontoschisma prostratum* have not yet been recorded as diff. spp. probably just due to under-recording of relevés. The all. occurs at high altitudes, dominated by poorly drought tolerant species, on escarpments in the vegetation dominated by *Juniperus* and *Sphagnum* spp. in the bottom layer (cf. DIAS 1996).

**Faial:** Highly frequent presence on soil escarpments, preferably above 400 m a. s. l. All diff. spp. listed have been recorded, except for *Anastrophyllum minutum*. Less species-rich than on Corvo and Flores and with hygrophilous species groups more clearly differentiated. Scattered presence of *Breutelia* at high altitudes. Diff. values of diff. spp. as on Pico and São Jorge. Species combinations transitional to epilithic ones are comparatively rare and occur principally within the big Caldeira and on its north-facing exterior slopes.

**Pico:** The all. is very species-rich. Soil escarpments of different size and aspect get colonized even at altitudes below 200 m. All diff. spp. listed occur on Pico. Their diff. values become weakened above 600 m a. s. l. Species combinations with a very large number of hepatics occur mainly at high altitudes above 600 m, where also transitions towards epilithic communities are highly frequent. The most hygrophilous ass. is dominated by *Odontoschisma prostratum* and *Myurium*. The *Anastrophyllum*-dominated ass. on poorly soil-covered level lavaflows with comparatively smooth surfaces have been recorded locally. The ass. characterized by *Breutelia* and *Alophosia* is restricted to high altitudes (above 700 m). This ass. is one of the highly precious endemic bryo-communities of the Azores. A split of the all. into associations is more successful below 600 m than above, as the high-altitude species combinations exhibit numerous transitions between associations.

**São Jorge:** The same high frequency and richly varied constitution as on Pico, but species diversity is not equally high. *Alophosia, Anastrophyllum, Enthostodon* and *Epipterygium* occur on São Jorge but have not yet been recorded as diff. spp. The all. becomes maturely developed in general only above 500 m a. s. l. and the *Breutelia-Alophosia* ass. must be looked for above 600 m. Low-altitude species combinations are the same as in other parts of the archipelago.

**Graciosa:** The dry and low island of Graciosa has a frequent presence of the *Andoae-Nardion scalaris* but the relevés, all from below 300 m, are characterized by few species and few diff. spp. Hygrophilous species combinations are rare, although scattered *Myurium*-dominated patches occur on moist or almost permanently wet soil escarpments.

**Santa Maria:** The constitution of the *Andoae-Nardion scalaris* is very similar to that on Graciosa. Relevés have been investigated between 200-550 m a. s. l. A large number of diff. spp. of the all. occur on the island. Species of hygrophilous associations are rare and *Myurium* is present only in scattered localities. The most frequently dominant species are *Andoa berthelotiana, Nardia scalaris, Fissidens taxifolius* subsp. *pallicaudalis*, and *Calypogeia muelleriana*. Several of the epigeic species of the all. were earlier not documented on the island, such as *Atrichum* spp., *Calypogeia* spp., *Odontoschisma* (cf. SJÖGREN in LIFE-project report 1996).

Differences in the constitution of the all. due to insularity occur on Santa Maria, e.g. with presence in one locality only, on a dry soil escarpment, of *Eurhynchium striatum*, formerly only known from São Miguel. Species combinations transitional towards epilithic communities are very rare on Santa Maria, even at the highest altitudes, a significant difference from the high-altitude presence of the all. on islands of the central group.
The epilithic *Ptychomitrium azorici* Sjn. 93


The most frequent association is characterized by *Ptychomitrium* spp. and *Grimmia lisa*. The ass. becomes in shaded and sheltered habitats invaded by several ecologically wide-range species of the genera *Frullania*, *Hypnum* and *Campylopus*. Among the dominant species are *Ptychomitrium* spp., *Grimmia lisa*, *Radula carringtonii*, *Hypnum resupinatum* and *Campylopus pilifer*. One ass. is restricted to calcareous stone substrates with *Barbula* spp. and *Tortula* spp. as characterizing species. Impoverished low-altitude species combinations are frequently dominated by *Trichostomum* spp.

Succession is comparatively slow on non-sheltered boulders at altitudes below 600 m. The *Grimmia-Ptychomitrium* species combination may remain almost unchanged for at least five years. Dust and soil-deposition, colonization of large highly competitive species, and even a few vascular plant species, may then rapidly obscure the typical composition of the *Ptychomitrium azorici*, due to autogenic effects linked to the progressively growing moss carpet. Transitional species combinations towards the epigeic *Andoae-Nardion scalaris* occur frequently, especially at altitudes above 600 m.

The epilithic *Ptychomitrium azorici* all. is common in strongly exposed habitats. It contains a large number of highly drought tolerant species and mature stages may become more or less accidentally invaded by vascular plants, especially on the top of stone fences. Large boulders may be covered by the all. on the top whereas the vertical sides, more sheltered towards desiccation, frequently become invaded by large hepatics and mosses. They are less drought tolerant than, e. g. *Ptychomitrium* spp., *Hypnum resupinatum* and *Scorpiurium cinctum*. The minimum size of relevés with a homogeneous *Ptychomitrium* is locally as small as 1 dm² but the size required is generally between 1/8 and 1/4 m².

The *Ptychomitrium azorici* includes the two associations *Ptychomitrietum polyphylli* and *Grimmieta azoricae* of v. HÜBSCHMANN (1971, 1973). These associations are impossible to maintain as separate units in the Azores.

**Presence on the islands**

**Corvo:** The epilithic *Ptychomitrium azorici* was recorded in localities almost from the coast to 650 m a. s. l. on strongly exposed stone surfaces. The relevés are fairly species-rich and altogether equipped with all diff. spp. listed. The all. may be split into several miniassociations. A special feature on Corvo is the highly frequent presence within the all. of *Racomitrium aciculare*. One ass. which should be regarded as a miniassociation, the *Grimmietum acicularae*, has been described by SJÖGREN (1993). This ass. appears with transitions towards the *Heterocladio-Jubilion* (see SJÖGREN 1993, Table 4 in the Appendix). The accidental presence of species with their highest preference to occur as epiphytic or epigeic is typical both on Corvo and Flores. There is also an impoverished ass. at low altitudes characterized by *Frullania azorica* and *Zygodon viridissimus*, both species mostly present in the epiphytic *Marchesinio* in other parts of the archipelago. Altogether the two westernmost islands have several localities with the *Ptychomitrium azorici*, but several of the species of the all. occur with reduced substratum preference if compared with their presence on the central and eastern islands. This naturally means that transitions to species combinations generally linked to other substrates are fairly common.

**Flores:** The same constitution of the all. as on Corvo. One ass. characterized by *Didymodon* spp., *Barbula unguiculata* and *Tortula muralis* is more common than on Corvo, on calcareous substrates.
Faial: The all. is comparatively species-poor with rare presence of *Racomitrium* spp. *Tortula-Brabula* species combinations are common on cement-covered stone fences. The low-altitude constitution is characterized by *Frullania azorica* but the high-pH species *Zygodon viridissimus*, common on Corvo, rarely occurs as epilithic on the island. Transitions towards the *Heterocladio-Jubulion* and the *Andoae-Nardion scalaris* are rare.

Pico: The strongly exposed epilithic bryophytes, present from below 100 m to at least 900 m a.s.l. is very species-rich and species-constellations are numerous. The all. has a frequent presence of the low-altitude ass. with *Frullania azorica* and *Scorpiurum cirkinatum*, of the *Ptychomitrium*-dominated ass. at higher altitudes, of the calcicolous *Tortula-Brabula* species combinations at various altitudes and of the *Racomitrium*-dominated ass. with e.g. *R. elongatum* and *R. fasciculare* above 600 m. Transitions towards the *Andoae-Nardion* and the *Echinodion prolixum* become progressively more frequent towards higher altitudes and are fairly frequently met with above 600 m. Transitions towards the *Heterocladio-Jubulion* have not been recorded, as this all. is restricted to weakly exposed stone surfaces in narrow river ravines and in the bottom of some explosion craters. Naturally, transitions towards epigeic species combinations occur where soil is accumulated on stone surfaces (facilitating presence e.g. of *Myurium, Alophosia* and *Pogonatum aloides*). There is a scattered presence in the all. of *Echinodium prolizum*. Flat level lava surfaces with few fissures get locally colonized by *Anastrophyllum*, even where the accumulated soil layer is very thin.

São Jorge: The *Ptychomitrium* is comparatively species-poor but the all. occurs from 200-800 m a.s.l., represented by some associations. Hygrophilous species combinations (cf. Corvo and Flores) are absent and also the *Racomitrium*-characterized ass. (cf. Pico). Calcicolous species groups (with *Tortula* and *Brabula*) occur frequently. The most common ass. is the *Ptychomitrietum azorici* although *Ptychomitrium* spp. are locally rare. Transitions towards epigeic and epiphytic high-altitude species combinations are comparatively rare, at least as compared with Pico.

Santa Maria: The all. occurs at almost all altitude levels on the island, although with a reduced number of diff. spp. if compared with other islands in the archipelago. At the level of association, the number of diff. spp. is also reduced. High percentages of cover are reached by, e.g. *Grimmia lasiae, Ptychomitrium nigrescens, Campylopus pilifer, Andoa berthelotiana* (soil-covered boulders) and *Frullania tamarisci*. There are few hepatics within the alliance. Transitions towards epigeic communities are less frequent than on the central islands. The mean number of associated species is also low (cf. SJÖGREN in LIFE-project report; 1996, Table 2 in the Appendix).

There is a scattered presence of the calcicolous ass. of the alliance, characterized by, e.g. *Tortula muralis* and *Didymodon vinealis* (in a few localities joined by *Leucodon treleasei*). One stone wall at 350 m, efficiently sheltered by shrub canopies, has got *Neckera intermedia* as dominant species in the moss cover. The species may be a relict from a formerly much more densely wooded landscape (leg. Fernando E. A. P. Pereira in 1996). The *Ptychomitrium*-dominated species groups are most frequent, whereas the hygrophilous species combinations are absent.

The epilithic *Heterocladio-Jubulion* (cf. SJÖGREN 1995)

Diff. spp. of the alliance: *Heterocladium heteropterum, Jubula hutchinsiae, Fissidens rivularis, Rhynchostegium riparioides, Schistidium apocarpum* var. - Diff. spp. of associations: *Fissidens serrulatus, Thamnobryum alopecurum, Dumortiera hirsuta, Conocephalum conicum, Hyococium armoricum*. - Diff. spp. with reduced diff. val. of the alliance: *Rhynchostegium megapolitanum, Tylimanthus azoricus, Rhizomnium punctatum, Riccardia chamedryfolia, Brachythecium plumosum, Tetrastichium fontanum, Andoa berthelotiana, Brachythecium rivulare, Fissidens taxifolius*
subsp. pallidicaulis. - Accompanying species: Both hepatics and mosses but few species. The low number is mainly due to local, more or less accidental dominance of highly competitive species. 107 relevés on TJPFL (1975-1997).

Only one association the Heterocladio-Jubuletum is common in the Azores. It is dominated by Heterocladium heteropterum and Jubula hutchinsiae. In initial stages of colonization of river boulders, small mosses occur such as Rhizomnium punctatum, Schistidium apocarpum var. and Fissidens rivularis. The dominant species of mature stages of development of the all. tend to obscure the typical constitution of the all., especially on boulders that have got, and have maintained, a more or less thick soil cover. Boulder surfaces subject to almost permanent supply of water get frequently colonized by Rhynchostegium riparioides, Eurhynchium praelongum, Brachythecium rivulare, Andoa berthelotiana, Brachythecium plumosum, Tetrastichium fontanum). Already in 1948 P. & V. Allorge distinguished a community including Dumortiera hirsuta, Heterocladium heteropterum, Tetrastichium fontanum, and Jubula hutchinsiae.

Transitions towards epigeic communities are highly frequent.

The ecological range of the epilithic Heterocladio-Jubulion is narrow. The all. may be found only on boulders in the bottom of deep and narrow ravines, with periodically running water and strongly sheltering tree canopy. If these habitat conditions prevail, there is almost no altitude restriction of the all., being recorded from 200 to 800 m a.s.l. There are no species within the all. that can be used as characterizing species of certain forest-phytocoenoses.

Under the name of "watermoss communities" v. HÜBSCHMANN (1973) described four associations. They are all miniassociations. His Fissidens rivularis - ass. belongs to the Heterocladio-Jubuletum as an initial stage of development of the association. V. Hübschmann’s Platychypnidi um riparioides is almost equivalent to the Rhynchostegium - ass. suggested above, but that ass. has an Azorean constitution, which indicates that it belongs to the endemic Heterocladio-Jubulion (presence of endemic species such as Tetrastichium fontanum, Tylimanthus azoricas, Andoa berthelotiana). Other epilithic associations described from São Miguel (op. cit.), the Fegatelletum conice, the Dumortiera hirsuta-Jubula hutchinsiae - ass. and the Thamnitetum alopecuri are fractions of the Heterocladio-Jubulion, which are impossible to separate sociologically and also from ecological points of view, due to their similar habitat preferences. Their separation seems to have been founded on only one highly frequent and dominant species, a most hazardous approach when distinguishing Azorean bryo-communities, leading to a large number of associations that are founded only on a number of more or less accidentally present species, which might possibly have been the first on the spot as colonizers (e. g. Dumortieria hirsuta, Conocephalum conicum, Thamnobryum alopecurum, Fissidens serrulatus, F. taxifolius var. pallidicaulis, Eurhynchium praelongum, Brachythecium rivulare, Andoa berthelotiana, Brachythecium plumosum, Tetrastichium fontanum). Already in 1948 P. & V. Allorge distinguished a community including Dumortiera hirsuta, Heterocladium heteropterum, Tetrastichium fontanum, and Jubula hutchinsiae.

Presence on the islands
Flores: The epilithic ravine-community was first described by SJÖGREN (LIFE-project report 1995). Its presence on Flores is generally at altitudes above 400 m. The habitat is boulder surfaces in the bottom of narrow ravines sheltered by tree/shrub canopies. The community does not need permanently running water but is equipped with at least some species resistant to mechanical effects of running water. Several species may reach dominance, which means that the community varies physiognomically. The number of relevés on Flores was too small and consequently all diff. spp. were not recorded. Among the species frequently becoming dominant on permanently water-supplied boulder surfaces, are Rhynchostegium riparioides and Tetrastichium fontanum. On rarely wet surfaces Jubula hutchinsiae and Heterocladium heteropterum are frequently dominant (and Echinodium renauldii accidentally). Transitions towards the epigeic Andoae-Nardion scalaris are numerous.

Faial: Recorded presence of the Heterocladio-Jubulion in several localities between 350 and
750 m, in river ravines. Efficient shelter of tree canopies is required (several tree species involved). The most frequent diff. spp. are *Jubula hutchinsiae*, *Heterocladium heteropterum* and *Tetrastichium fontanum*. A large number of locally highly dominant species has been recorded (e.g. *Thamnobryum alopecurum*, *Dumortiera hirsuta*, and *Conocephalum conicum*).

**Pico:** Highly frequent presence, especially between 500 and 800 m, in ravines with periodically running water. All listed diff. spp. are present within the alliance, although with locally very varying frequency. High-cover species are the same as in other parts of the archipelago. Transitions towards the epigeic *Andoae-Nardion scalaris* are highly frequent. *Jubula hutchinsiae*, *Heterocladium heteropterum*, *Fissidens serrulatus*, and *Tetrastichium fontanum* are the most frequent diff. spp. The all. has been recorded also on stones and boulders in the bottom of explosion craters, if a dense sheltering tree canopy is present of, e.g. *Laurus*, *Frangula*, *Ilex* and *Juniperus*. Some small-size diff. spp. occur in primary stages of development of the all. (e.g. *Fissidens rivularis*, *Schistidium apocarputum*, *Rhizomnium punctatum*). They get easily outcompeted by large species which become dominant in late stages of the alliance.

**São Jorge:** Several localities have been recorded, mostly above 500 m and with concentration to the E parts of the island, where numerous N-S ravines occur. These ravines are mostly very narrow and deep and in most cases still sheltered by tree canopies of, e.g. *Juniperus*, *Erica*, *Ilex* and *Frangula*. Constitution of the all. is almost the same as on Pico. The local dominance of *Hyocomium armoricum* is exceptional, as the species has been recorded only on São Jorge, in spite of numerous suitable localities for the species being available on the nearby island of Pico.

The narrow ravines mentioned still provide refugia for some of the last remains of cloud-zone forest fractions on the island. They also include several of the precious endemic vascular plants of the Azores. It has been documented by the author that even scattered thinning of the tree canopies in these ravines presents a serious threat to the refugial survival of several plant species and plant communities. This includes, of course, bryo-communities on various types of substrates, species-rich and comprising several species endemic to the Azores or to Macaronesia. Epiphyllous species constellations are especially sensitive to sudden rise of exposition due to thinning of the sheltering tree canopy.

**Graciosa:** Only a fragmentarily developed *Heterocladio-Jubulion* has been recorded, with presence, e.g. of *Heterocladium*, *Tetrastichium fontanum* and *Dumortiera*. There is still no record of *Jubula* on the island.

**São Miguel:** No record by the author. The all. occurs in several localities (cf. v. HÜBSCHMANN 1973) but has become dissected into several mini-associations characterized by "Kennarten", reaching high cover percentages. These communities have local relevance but are impossible to distinguish from each other in other parts of the archipelago. Transitions towards pref. epigeic species constellations are numerous.

**SOME CATEGORIES OF DIFFERENTIAL SPECIES**

Differential species with uneven differential value within the archipelago

Socio-ecological studies of bryophytes in the Azores, if restricted to one or just a few islands of the central group, rapidly encounter the risk of revealing only local conditions. This has unfortunately affected the communities distinguished on São Miguel by v. HÜBSCHMANN (1973). During my studies of bryo-communities of the Azores since 1965 the aim has always been to try to check the diff. values of species on all islands where they exist. The results have been both positive and negative.

The islands of the Azores are very well known to be subject to different climatic conditions from E to W in the archipelago. The effects of increasing precipitation with increasing altitude on the individual islands influence the distribution of vascular plants as well as of bryophytes. The actual altitude ranges of several forest-species,
e.g. on Flores and Corvo, extend to lower altitudes than on Terceira and on São Miguel.

The substratum preference of many bryophyte taxa is less distinct under optimal habitat conditions than where they occur at the margin of their survival ability. For example, the high-altitude presence above 700 m of *Lejeunea lamacerina* involves all types of substrates with only a weak preference for the species to grow as epiphyte and as epiphyllous. The low-altitude presence, on the other hand is almost restricted to stem bases of trees and to epiphytic growth. On the westernmost islands the substratum preference is generally less distinct than on the central and eastern islands. The recordings of bryophytes on Corvo and Flores (Sjögren 1993, 1995) have documented such decreasing preferences.

It is, consequently, quite natural that such differences in habitat preferences also influence the diff. values of several bryophytes. For example, the presence of *Aphanolejeunea azorica* on Santa Maria is only epiphyllous, on Pico it is also epixylic (at 700 m a.s.l.), and on Corvo it is epiphyllous and epiphytic down to 200 m. *Radula aquilegia* is a diff. sp. of the *Aphanolejeunea-Colurion* and the *Echinodion prolíxi* on São Miguel and the central islands but its diff. val. of the epiphyllous all. is lost or at least reduced on Corvo and Flores, where it grows also as epilithic and epigeic at altitudes around 400 m.

The consequences of the climatic differences within the archipelago are in general, comparing e.g. Santa Maria, Terceira and Corvo/Flores, a reduction towards W of distinguishing features between epigeic/epiphytic/epixylic bryocommunities and between epigeic/epilithic ones. Some other sociological differences are that the epilithic *Heterocladio-Jubulion* on Corvo/Flores is less distinct, being invaded by highly competitive epigeic species; the epilithic *Ptychomitrium azorici* also becomes invaded by epigeic species and the altitude range is restricted to coast-near levels; the epiphytic *Echinodion prolíxi* becomes mixed with epiphylic and epiphyllous species at least in its mature stages; the epigeic *Andoae-Nardion scalaris* becomes obscured after its very early successional stages by accidental dominance of highly competitive species; the low-altitude epiphytic *Marchesinion* suffers invasion of *Echinodion* species; the epiphyllous *Aphanolejeunea-Colurion* becomes more rapidly invaded by epiphytic and epixylic species on all sorts of phorophytes. A recording of bryo-communities consequently leads to documented differences according to altitude of localities and following differences in habitat conditions. The limits between communities on various types of substrates become progressively obscured above 500-600 m, provided the communities reach their optimal habitat conditions at 800-1000 m. The same effects occur from E to W in the archipelago. Also the successional rate from primary colonization of the substrates becomes influenced. The primary stages of development of bryophyte vegetation on various types of substrates have on the westernmost islands a much more frequent, more or less accidental presence of final-stage species. The different stages of development are poorly separated qualitatively and overlap in a "telescopic" manner. Such overlapping is progressively less pronounced towards suboptimal habitat conditions. These features should be remembered, otherwise perhaps leading to a differentiation of too many non-mature species combinations under suboptimal conditions. In fact, such combinations represent more or less short-term stages of succession, where the accidentally colonizing species may be numerous, before the maturely stabilized species groups occur.

For example: the low-altitude constitution of the epiphytic *Echinodion prolíxi* is frequently represented on bark-patches by primary stages of development of the all., where small-size hepatics are the first invaders. Such patches are comparatively smaller and less frequent at high altitudes, above 700 m, and are characterized by fairly frequent presence (not necessarily with high cover) of large highly competitive hepatics of the genuses *Frullania*, *Lepidozia*, *Radula* and *Lejeunea* and of mosses of the genuses *Echinodium*, *Hypnum* and *Dicranum*.

The epilithic *Ptychomitrium azorici* occurs typically developed in strongly exposed habitats, at altitudes below 600 m (central island group). The all. also occurs above this altitude but the typical constitution is of short duration, with *Grimmia lisa* and *Ptychomitrium* spp. getting rapidly added by species with less distinct
substratum preference, e.g. of the genuses *Andoa, Myurium, Radula, Bazzania* and *Campylopus*.

Distribution and value of differential species

Several differential species appear with a certain differential value on some of the Azorean islands although they occur on all or almost all of the islands. Most of these species have still not been recorded, and probably never will be, on Santa Maria and Graciosa (in the following, abbreviations of the islands), the two low and comparatively dry islands in the archipelago.

A large number of the phorophyte-bound alliances with their occurrence concentrated to the high-altitude native forest types have diff. val. only on islands of the central island group (TJPF). These islands have the largest and most richly differentiated native forests, as remains of a formerly much wider distribution. Among the diff. spp. of the *Echinodion prolixi* with geographically restricted diff. val. are, e.g. *Bazzania azorica* (TJP), *Lejeunea patens* (TJP), *Lepidozia cupressina* (TJP), *Neckera intermedia* (JPF), *Metzgeria leptoneura* (TP), *Plagiochila longispina* (TP). Also the epiphyllous *Aphanolejeuneo-Colurion* has diff. spp. with geographically restricted diff. val., e.g. *Aphanolejeunea madeirensis* (TJPF), *Colura calyptrifolia* and *Cheilolejeunea cedercreutzii* are almost only epiphyllous but presence is also recorded in the epiphytic *Echinodion prolixi*. *Colura* is a fairly frequent species but *Cheilolejeunea* is very rare and only known from MTPF. All the species mentioned are closely linked to dense native forests at high altitudes above 700 m in the Azores.

The epiphyllic *Lepidozoniazoricae* has no diff. spp. with restricted presence as epilithic only. There are, on the other hand, some species that are epilithic/epiphyllous, present in the epiphytic *Echinodion prolixi* also, namely *Acrbobilus wilsonii, Daltonia stenophylla* and *Metzgeria leptoneura*. These three species also belong to the native cloud-zone forest.

An extension of the diff. values of these diff. spp. to become valid also on other islands in the archipelago where they occur is naturally possible after continued socio-ecological investigations. For many diff. spp. this may, however, occur only if rapid actions for conservation of remains of native forest types take place. It is, e.g. quite possible that further decrease of the presence of native forest in ravines on the island of São Jorge may erode the number of phorophyte-bound diff. spp., decreasing their value or even exterminating some of them. Several bryophyte species and vascular plants with few localities and small populations live on the brink of survival today on the island of São Jorge.

Differential species with high differential value

There are extreme difficulties in the Azores to record bryophyte species restricted to one type of substrate or to one alliance only, thus complicating possibilities to rank them as epiphytic, epilithic etc.

Some of the species are, furthermore, restricted to a few islands in the archipelago. Even the number of species strictly linked to only two of the described alliances is very low. On the other hand, there are several diff. spp. more or less clearly restricted in their presence to the group of phorophyte-bound alliances (epiphyllous/epilithic/epiphytic) or to the group of epilithic/epigeic alliances.

The epiphyllous *Aphanolejeuneo-Colurion* has only two diff. spp. restricted to the all., *Aphanolejeunea madeirensis* and *Acanthocoleus aberrans*. The last-mentioned species is, however, very rare and only recorded on J and P (no documentation by the author on J). *Colura calyptrifolia* and *Cheilolejeunea cedercreutzii* are almost only epiphyllous but presence is also recorded in the epiphytic *Echinodion prolixi*. *Colura* is a fairly frequent species but *Cheilolejeunea* is very rare and only known from MTPF. All the species mentioned are closely linked to dense native forests at high altitudes above 700 m in the Azores.

The epiphyllic *Lepidozoniazoricae* has no diff. sp. with restricted presence as epilithic only. There are, on the other hand, some species that are epilithic/epiphyllous, present in the epiphytic *Echinodion prolixi* also, namely *Acrbobilus wilsonii, Daltonia stenophylla* and *Metzgeria leptoneura*. These three species also belong to the native cloud-zone forest.

The epiphyllic *Echinodion prolixi* has, like the *Lepidozoniazoricae*, no exclusive diff. sp. The three species mentioned as also epilithic, may be added with *Radula nudicaulis* (epiphytic / epiphyllic), *Neckera intermedia* (epiphytic / epilithic), *Lejeunea ulicina* (epiphytic also in the low-altitude epiphytic *Marchesinion*), *Colura*
calyptrifolia and Cheilolejeunea cedercreutzii (epiphytic/epiphyllous). Among these species, Radula nudicaulis is very rare and restricted to MPF (not seen by the author on M and F). All the species mentioned occur preferably in mature native forests at high altitudes above 700 m.

The epigeic Andoae-Nardion scalaris has several species restricted to the alliance, namely Anthoceros punctatus, Breutelia azorica, Enthostodon attenuatus, Epipogium tozeri, Nardia scalaris, Pogonatum aloides, Rhamphidium purpuratum. Among these diff. spp. only Breutelia is geographically restricted in the archipelago (MJPTF; recently found also on L). Among the diff. spp. that are more or less frequently present as epilithic, are Anastrophyllum minutum, Campylopus pilifer, Andoa berthelotiana, Myurium hochstetteri, and Fissidens asplenioidei.

The epilithic ravine-boulder all., the Heterocladio-Jubulion, characterized by a wide altitude range, has two diff. spp. restricted to the all., namely Fissidens rivul aris and Schistidium apocarpum. Some species also occur in other alliances, e.g. Acerobolbus wilsonii, Daltonia stenophylla, Metzgeria leptoneura. The presence in other alliances of Heterocladium heteropterum, and Rhynchostegium spp. is, on the other hand, very rare. Schistidium apocarpum var. is still known only from P and L. Diff. spp. of the all. are not restricted to the high-altitude native forest phytocoenoses.

The epilithic Ptychomitron azorici is the bryo-community in the Azores with the largest number of diff. spp. restricted to one all. only, namely Grimmia lisae, Ptychomitrium polyphyllum, and nigrescens, Racemitrium fasciculare and Scorpiurium cinnaturn. Diff. spp. with some presence also in other communities are Aphanobolbus azorica, Anastrophyllum minutum, Campylopus pilifer, Leucodon treleaei, and Neckera intermedia. Among these species, only Leucodon and Neckera are rare. Provided the substrate is calcareous, some additional species occur frequently, e.g. Tortula muralis, Barbula unguiculata and Didymodon vinealis.

The epiphtic Marchesinio, a low-altitude all., is equipped with few diff. spp. Only Leucodon treleaei and Lejeunea ulicina occur in two alliances only. The three diff. spp. of the all., Cololejeunea minutissima, Marchesinia mackaii and Frullania microphylla, are highly frequent although only keeping the all. separated from epigeic and epilithic alliances.

A suggestion of potential differential species

Several species of the Azorean bryo-flora have narrow ecological ranges and potential differential values from sociological points of view. A few of these species (not listed in List of differential species of bryophyte alliances – in the Appendix) are treated below, as they may support future socio-ecological descriptions of Azorean bryo-vegetation.

The epiphytic Aphanolejeuneo-Colurion has got accidental presence of Lejeunea hibernica (MTPL), also found in other phorophyte-bound communities. The species Lejeunea eckloniana, recently recorded in the Azores, should be paid attention to as a potential diff. sp. of phorophyte-bound communities. The presence on São Miguel (sampled by the author in 1982) is as epiphyllous on Thamnobryum alopecurum (S JÖGREN 1997). See also DÍRKSE et al. (1993).

The epiphtic Lepidozion azoricae may be equipped also with Pseudotaxiphyllum laetevirens (SMTJP), however, also recorded as epigeic. Leptoscyphus azoricus (MTPL), is also phorophyte-bound but is very rare and has also been recorded with accidental presence as epigeic.

The epiphytic Echinodion prolixi may become better differentiated using also the phorophyte-bound species mentioned above as epiphyllous and epixylic.

The epiphytic low-altitude Marchesinio has one high-pH ass., the Zygodietum. This ass. may become equipped with some differential species, which are, however, geographically restricted in the archipelago: Orthotrichum diaphanum (SMTFL), O. tenellum (M) and Ulota calvescens (MTP). All these species are probably restricted to tree species with high-pH barks (pH above 5.5).

The Andoae-Nardion scalaris on strongly exposed soil escarpments may eventually become characterized by some more species than those
mentioned. Such species are *Pallavicinia lyellii* (TJPC), *Brachymenium notarisii* (MGFL) and *Amphidium mougeotii* (TJPL). The alliance, with its wide altitudinal range and consequently large number of associations, also includes other potential diff. spp., especially on the association level.

The *Heterocladio-Jubulion* has a scattered presence of *Rhizomnium punctatum* (MTJPF) and *Porella obtusata*. Both species are closely linked to the ecologically specialized all. The epilithic *Ptychomitrion azorici* is almost as species-rich as the *Andoae-Nardion scalaris* and the altitude range is equally wide. The potential number of associations of the epilithic all. is consequently high (cf. the epigeic all. above). Homogeneous species combinations have a scattered presence on individual islands if composed of calcicolous species. The association dominated by species of the genus *Racomitrium* is present on T, P and F only, at altitudes above 600 m. The *Ptychomitrion azorici* is characterized by a rich presence of *Bryum* species. The differential role of these species has not yet been investigated.

Only few of the additional diff. spp. mentioned above have also characterizing values from phytocoenotic points of view, namely *Pallavicinia lyellii*, *Leptoscyphus azoricus* and *Lejeunea hibernica*. They are all high-altitude species, preferably growing in mature native forest types, generally in dense stands in strongly sheltered habitats. *Pallavicinia* has, however, also been recorded on T, and on P as epigeic (at 1050 m) at edges of mature stands of *Ilex*, *Juniperus* and *Erica*.

The value of the additional species suggested is worthy of consideration mainly if combined with the value of the diff. spp. mentioned in Tables 1-8. Thorough field-work may eventually, of course, reveal also other species suitable to assign with differential value.

**AZOREAN BRYOPHYTES FOR PRESERVATION**

Several of the bryophytes of the Azores have been treated in RBD (ECCB 1995). These species have been categorized as rare, vulnerable or endangered (some as insufficiently known). Comments on distribution and categorization of the species have been given by Sjögren (1997, 2001), where some species have been ranked as more distinctly threatened and also some as not threatened (for hepatics cf. Schumacker 2001).

A study of the threatened species, considering (1) their distribution (presence outside Macaronesia), (2) their more or less restricted presence within the Azorean archipelago, and (3) their sociological/ecological restriction, provides valuable information.

1. Among the species treated as rare - endangered are species endemic to the Azores or to Macaronesia. Some species also occur, though rarely, in W Europe and a few only in other parts of the world.

2. Most of the species have a wide distribution in the Azores, being either recorded on all islands or at least on MTJPFL, or on almost all these six islands. A few species have a very restricted presence, as *Fissidens azoricus*, *F. luisieri*, *F. sublineatifolius*, *F. ovatifolius*, *F. coacervatus*, *Jamesoniella rubricaulis* (MP), *Tetraplodon perssoniorum* (M). Among the species not listed in RBD, with very restricted presence are *Cyclodictyon laetevirens* (MTJP), *Homalia webbiana* (SGJL), *Hyocomium armoricum* (J); and *Aulacomnium palustre* (MJP), all with some value as differential species of the Azorean bryo-communities at the level of association or alliance.

3. Among the threatened bryophytes in the Azores, a majority are phorophyte-bound and these species occur with preference in the high-altitude native forests above 700 m. Several of the species, more than 20, occur with differential value at the level of alliance or association of the epiphyllous *Aphanolejeuneo-Colurion*, the epiphytic *Echinodion prolixi* or the epixylpic *Lepidozon azoricae* (cf. Tables 1, 3, 4). The epigeic *Andoae-Nardion scalaris* has got a few threatened species such as *Pallavicinia lyellii*. A few species met upon as epilithic and as epiphytic such as *Echinodium renauldii*, *Tylimanthus azoricus*, and *Hyocomium armoricum* may be treated as threatened. Also, these three species and the mentioned *Pallavicinia* are generally confined to the rare
relicts of high-altitude native forest types, mostly at altitudes above 600 m.

This information on threatened bryophytes of the archipelago leads to the conclusion that a proportionally high percentage of the bryoflora consists of species that are more or less severely threatened as to their survival. Several species are potential objects for conservation. They are at least rare but still insufficiently known as to their distribution, number of localities, and size of the populations. Some species either endemic to the Azores or to Macaronesia are on the other hand fortunately not threatened, such as Breutelia azorica, Alophosia azorica, and Andoa berthelotiana.

ACKNOWLEDGEMENTS

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REFERENCES


ECCB 1995 (see SCHUMACKER & MARTINY 1995)


GROLLE, R. 1983. Hepatics of Europe including the Azores; an annotated list of species, with synonyms from the recent literature. Journal of Bryology 12: 403-459.

GROLLE, R. & D.G. LONG 2000. An annotated check-list of the Hepaticae and Anthocerotae of Europe


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## APPENDIX

Table 1
The epiphytic *Echinodium proliscum*. a) differential species of the alliance; b) species with differential value of associations; c) species with moderately high differential value of the alliance; d) accompanying species

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a)
- *Echinodium proliscum* | x | x | x | x | x | . | . | x | x | x | x | x | x |
- *Lepidozia cupressina* | . | . | . | . | . | x | x | x | x | . | x | x |
- *Lejeunea flavia ssp. moorei* | x | x | x | x | . | . | . | x | x | . | . | . | . |

b)
- *Dicranum scottianum* | . | . | x | . | x | x | x | . | x | x | x | x | x | x |
- *Hymnum uncinalium* | x | x | x | x | x | x | x | x | x | . | . | x | . | . |
- *Bazzania azorica* | . | . | . | . | . | . | . | . | . | x | x | . | . | . |
- *Porella canariensis* | . | . | . | . | . | . | . | . | x | . | . | . | . | . |

c)
- *Coleolejeunea minutissima* | . | . | x | . | . | . | x | . | . | . | x | . | . |
- *Drepanolejeunea hamattifolia* | . | . | . | . | . | x | . | . | . | x | x | . | . |
- *Lejeunea lamacerina* | . | . | x | x | x | . | . | . | . | . | x | x | . | . |
- *Metzgeria furcata* | x | x | x | x | x | x | . | x | . | . | x | x | . |
- *Plagiochila exigua* | . | . | . | . | . | . | . | . | x | . | . | . | x | . |
- *Radula aquilegia* | . | . | . | . | . | x | x | . | x | . | . | . | x |

d)
- *Frullania tamarisci* | . | . | x | . | . | . | . | . | . | x | x | x | . | . |
- *Frullania tenerrima* | x | x | x | x | x | x | x | . | . | . | . | . | . | . |
- *Plagiochila bifaria* | x | . | . | x | x | x | x | x | x | x | x | . | . | . |
- *Nowellia curvifolia* | . | . | . | . | x | . | . | x | x | . | . | . | . | . |
- *Scapania undulata* | . | . | . | x | x | . | . | . | . | . | . | . | . | . |
- *Lophozia ventricosa* | . | . | . | . | x | . | . | x | . | . | . | . | . | . |
- *Calyptogea muelleriana* | . | . | . | . | x | . | . | . | . | . | . | . | x | . |
- *Adelanthus decipiens* | . | . | . | . | . | x | . | . | . | . | . | . | . | . |
- *Scapania sp.* | . | . | . | . | . | . | . | . | x | . | . | . | . | . |
- *Aphanolejeunea microscopica* | . | . | . | . | . | . | . | . | x | . | . | . | . | . |
- *Myriopteris hochstetteri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
- *Lophocolea fragrans* | . | . | . | . | . | . | . | . | . | x | x | . | . | . |
- *Scapania gracilis* | . | . | . | . | . | . | . | . | . | . | . | . | x | . |
- *Telaranea nematodes* | . | . | . | . | . | . | . | . | . | . | . | . | . | . |


Table 2
The epiphytic Marchesinion (a-d, see Table 1)

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a) Frullania azorica.
Cololejeunea minutissima.
Marchesinia mackaii.
Frullania microphylla.

b) Zygodon viridissimus.
Leucodon treleasei.
Homalia webbiana.

Other accompanying species: Hypnum resupinatum (5), Andoa berthelotiana, Fissidens taxifolius subsp. pallidicaulis (6), Aphanolejeunea sintenisii (8), Pseudotaxiphyllum elegans (9), Lejeunea ulicina, Lophocolea fragrans (12), Radula lindenbergiana (13), Hypnum uncinitatum, Radula vichetae (15). Abreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo. Phorophytes: E – Erica azorica; J – Juniperus brevifolia; Pu – Pittosporum undulatum; Ac – Acacia melanoxylen; Eu – Eucalyptus globulus; U – Ulmus procera; Po – Populus alba; T – Trichomanes speciosum; B – Blechnum spicant; I – Ilex perado spp. azorica; L – Laurus azorica; H – Hedera helix spp. can.; D – Diplazium caudatum.
### Table 3
The epixylic *Lepidozian azoricae* (a-d, see Table 1).

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#### a)
- Cyclocladion laetevirens
- Riccardia chamedryfolia
- Dicranum scottianum
- Andoa berthelotiana
- Drepanolejeunea hamatifolia
- Lejeunea lamacerina
- T. substrumulosum
- Scapania gracilis
- Lepidozia azorica
- Lepidozia reptans

#### b)
- Nowellia curvifolia
- Plagiochila exigua
- Tetrastichium virens

#### c)
- Hypnum uncinulatum
- Odontochisma prostratum
- Sematophyllum subtrumulosum
- Calypogea muelleriana
- Cephalozia crassifolia
- Pseudotaxiphyllum elegans

#### d)
- Bazzania azorica
- Lejeunea lamacerina
- Plagiocline bifaria
- Saccogyna vitulosa
- Thuidium tamariscinum
- Drepanolejeunea hamatifolia
- Frullania tamarisci
- Harpalejeunea mollerii
- Metzgeria leptoneura
- Andoa berthelotiana
- Lophozia ventricosa
- Dicranum scottianum
- Aphanolejeunea microsperma
- Chloroclypha polyanthos
- Lejeunea patens

The epiphyllous *Apanolejeuneo-Colurion* (a-d, see Table 1).

| island | C | C | F | F | P | P | P | P | J | J | J | J | T | T | T | T | M | M | M |
| altitude | 300 | 300 | 675 | 675 | 700 | 1050 | 600 | 675 | 750 | 600 | 550 | 500 | 550 | 500 | 550 | 500 | 425 | 700 | 700 |
| phorophyte | T | T | B | B | I | T | I | L | H | T | T | T | T | D | H | B | L | L | |
| date | 6 | 6 | 7 | 7 | 26 | 5 | 13 | 13 | 27 | 27 | 1 | 2 | 2 | 2 | 18 | 13 | 13 | |
| month | 7 | 7 | 7 | 7 | 4 | 5 | 7 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 5 | 6 | 6 | |
| year | 78 | 78 | 75 | 75 | 65 | 65 | 68 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 65 | 85 | 85 |
| sample no. | 32 | 33 | 10 | 12 | 3 | 14 | 12 | 12 | 14 | 31 | 11 | 8 | 9 | 11 | 13 | 28 | 2 | 2 | |
| table no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |

a)

Colura calyptrifolia  
*Aphanolejeunea madeirensis*  
*Aphanolejeunea microscopica*

b)

*Aphanolejeunea sintenisii*  
*Aphanolejeunea azorica*  
*Aphanolejeunea microscopica*  
*Colura calyptrifolia*  
*Cololejeunea minutissima*  
*Frullania microphylla var.*  
*Lejeunea patens*  
*Lophocolea fragrans*  

Abreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo. Phorophytes: E – Erica azorica; J – Juniperus brevifolia; Pu – Pittosporum undulatum; Ac – Acacia melanoxylon; Eu – Eucalyptus globulus; U – Ulmus procera; Po – Populus alba; T – Trichomanes speciosum; B – Blechnum spicant; I – Ilex perado spp. azorica; L – Laurus azorica; H – Hedera helix spp. can.; D – Diplazium caudatum.
Table 5

The epigeic *Andoae-Nardion scalaris* on Corvo, Flores, Graciosa, and Santa Maria (a-d, see Table 1).

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</table>

a) *Andoa berthalotiana*  
*Myriagramma hochstetteri*  
*Fissidens taxifolius subsp. pal.*  
*Nardia scalaris*  
*Rhamphidium purpuratum*

b) *Fissidens asplenioideis*  
*Philonotis rigida*  
*Anthoceros caucasicus*  
*Odontochisma prostratum*

c) *Enthostodon attenuatus*  
*Saccogyna viticulosus*  
*Pogonatum aloides*  
*Epityriygium tuzeri*  
*Calyptogea muelleriana*  
*Scapania undulata*  
*Diplophyllum albicans*  
*Anastrophyllum minutum*  
*Calyptogea fissa*

d) *Campylopus sp.*  
*Polytrichum commune*  
*Leucobryum juniperoides*  
*Polytrichum juniperinum*  
*Reboulia homotheca*  
*Rhabdula carringtonii*  
*Frullania tamarisci*  
*Lejeunea lamacerina*  
*Cephaloziella bicuspidata*  

Table 6
The epigeic *Andoae-Nardion scalaris* on Pico, Faial, and São Jorge (a-d, see Table 1).

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</table>

a)  
- *Andoa berthelotiana*  
- *Myrium hochstetteri*  
- *Fissidens taxifolius* subsp. pal.  
- *Nardia scalaris*  
- *Rhamphiodium purpuratum*  

b)  
- *Fissidens aspleniodes*  
- *Philonotis rigida*  
- *Anthoceros caucasicus*  
- *Alophasia azorica*  
- *Breutelia azorica*  
- *Odontoschisma prostratum*  

c)  
- *Enthostodon attenuatus*  
- *Saccogyna viticulosa*  
- *Pogonatum aloides*  
- *Calypogeia muelleriana*  
- *Scapania undulata*  
- *Anastrophyllum minutatum*  
- *Calypogeia fissa*  
- *Diplophyllum albicans*  

d)  
- *Campylopus fragilis*  
- *Fulvia tamarisci*  
- *Conocephalum conicum*  
- *Atrichum angustatum*  
- *Anomobryum fulaceum*  
- *Brachythecium plumosum*  
- *Hypnum cupressiforme*  

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</table>

a)  
- *Grimmia lisa*  
  - *Hymnnum resupinatum*  
  - *Psychomitrium nigrescens*  
  - *Psychomitrium polyphyll. s. l.*  
  - *Campylium pilifer*  
  - *Scorpiurium circinatum*  
  - *Psychomitrium sp.*

b)  
- *Frullania azorica*  
  - *Racomitrium acciculare*  
  - *Racomitrium fasciculare*  
  - *Tortula muralis*  
  - *Brachythecium plumosum*

c)  
- *Brachythecium populeum*  
- *Trichostoma brachydontium*  
- *Radula carringtonii*  
- *Anastrophyllum minutum*  
- *Racomitrium elongatum*  
- *Racomitrium lanuginosum*

d)  
- *Frullania teneriffae*  
- *Bryum donianum*  
- *Myrium hochstetteri*  
- *Lejeunea lamacerina*  
- *Echinodium proliscum*  
- *Andoa bertholottiana*  
- *Bryum torquescis*  
- *Porella canariensis*  
- *Frullania tamurisci*  
- *Campylium sp.*  
- *Scapania undulata*  
- *Plagiochila bifaria*


Abreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo.  

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Table 8

The epilithic *Heterocladium-Jubulion* (a-d, see Table 1).

| island | L  | L  | L  | L  | F  | F  | F  | F  | P  | P  | P  | P  | J  | J  | J  |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| altitude | 500 | 320 | 430 | 400 | 620 | 620 | 500 | 500 | 800 | 800 | 800 | 800 | 800 | 800 |
| date    | 14 | 16 | 17 | 17 | 2  | 2  | 3  | 3  | 7  | 7  | 8  | 8  | 13 | 13 |
| month   | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  |
| year    | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 |
| sample no. | 8  | 10 | 11 | 2  | 9  | 17 | 7  | 8  | 3  | 21 | 18 | 6  | 7  | 10 |
| table no. | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |
|         | 15 | 16 | 17 |    |    |    |    |    |    |    |    |    |    |    |

a) *Heterocladium heteropterum*  
*Jubula hutchiniae*  
*Fissidens rivularis*  
*Rhyynchostegium riparioides*  
*Schistidium apocarpum var.*  

b) *Fissidens serrulatus*  
*ThamnobarbＨymoaplocarnum*  
*Dumortiera hirsuta*  
*Conocephalum conicum*  
*Hylocomium armoricum*  

c) *Rhynochostegium megapolitanum*  
*Tylanthus acoricus*  
*Rhizomnium punctatum*  
*Riccardia chamedryfolia*  
*Brachythecium plumosum*  
*Tetrastichium fontanum*  
*Andoa berthelotiana*  
*Brachythecium rivulare*  
*Fissidens taxifolius subsp. pall.*  

d) *Eurhynchium praetelum*  
*Lejeunea lamacerina*  
*Saccogyna viticulosa*  
*Scapania undulata*  
*Fissidens asplenioides*  
*Plagiomnium undulatum*  
*Cirephylum piliferum*  

List of differential species (h=hepatic) of bryophyte alliances and associations.

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<td>Anastrophyllum minutum h</td>
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<td>Andoa berthelotiana h</td>
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