

AZOREAN BRYOPHYTE COMMUNITIES - A REVISION OF DIFFERENTIAL SPECIES

ERIK SJÖGREN

SJÖGREN, E. 2003. Azorean bryophyte communities - A revision of differential species. *Arquipélago*. Life and Marine Sciences 20A: 1-29

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 prolix* Sjn. 93 (epiphytic; mostly above 600 m in native cloud-zone forest types); *Lepidozion azoricae* Sjn. 96 (epixylic; presence as the *Echinodion prolix*); *Aphanolejeuneo-Colurion* Sjn. 78 (epiphyllous; presence as the *Echinodion prolix*); *Andoe-Nardion scalaris* Sjn. 95 (epigeic; from \pm 200-1000 m a.s.l.) *Ptychomitrium 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.

Erik Sjögren (e-mail: be.sjogren@telia.com), Evolutionary Biology Center, Dept. of Plant Ecology, Uppsala University, Villavägen 14, SE - 75236 Uppsala, Sweden.

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 $\frac{1}{3}$, Santa Maria with $\frac{2}{3}$, and Corvo with $\frac{1}{2}$ 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
RDB	Red Data Book of European Bryophytes (1995) (ECCB 1995).

PHOROPHYTE-BOUND COMMUNITIES

The epiphytic *Echinodion prolix* (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 prolix* 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 epixylic *Lepidozion azoricae*, and on treebases towards the epigeic *Andoe-Nardion scalaris* occur frequently.

The epiphytic *Echinodion prolix* 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-phytocoenoses 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 prolix* 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 juniperoideum*.

Presence on the islands

Corvo: The presence of the *Echinodion prolix* 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 prolix* 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 epilithic 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 *Acrobolbus 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. *Echinodium prolixum* 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 prolixum* and *Dicranum scottianum* as epilithic above 550 m were recorded in 1996 (LIFE-project, SJÖGREN 1995). The epiphytic vegetation on the island is dominated by the *Marchesinion* alliance.

The epiphytic *Marchesinion* Sjn. 96

Diff. spp. of the alliance: *Frullania azorica*, *Cololejeunea minutissima*, *Marchesinia mackaii*, *Frullania microphylla*. Diff. spp. of associations: *Zygodon viridissimus*, *Leucodon treleasei*, *Homalia webbiana*. - Diff. spp. with reduced diff. val. of the alliance: *Harpalejeunea mollerii*. - Accompanying species: A few hepatics and mosses with wide ecological range. 46 relevés on SGC (1995, 1996).

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 treleasei* 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 *Andoeae-Nardion scalaris*.

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 epixylic associations (presence of *Riccardia* spp., *Sematophyllum substrumulosum*, *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 epixylic *Lepidozion azoricae* Sjn. 96

Diff. spp. of the alliance: *Cyclodictyon laetevirens*, *Riccardia chamedryfolia*, *Telaranea nematodes*, *Scapania gracilis*, *Lepidozia azorica*, *Lepidozia reptans*. - Diff. spp. of associations: *Nowellia curvifolia*, *Plagiochila exigua*, *Tetrastichium virens*, *Sematophyllum substrumulosum*, *Pseudotaxiphyllum elegans*. - Diff. spp. with reduced diff. val. of the alliance: *Hypnum uncinulatum*, *Odontoschisma prostratum*, *Calypogeia muelleriana*, *Cephalozia crassifolia*, *Daltonia stenophylla*, *Metzgeria leptoneura*. - Accompanying spp.: A very large number of hepatics. 166 relevés on SMTJPF (1968-1997).

The *Lepidozion 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 substrumulosum* 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 *Andoea-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 *Lepidozium 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 *Lepidozium 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 *Culcita macrocarpa*; on such phorophytes, however, getting frequently mixed with pref. epiphyllous and epigeic species. The species diversity in the *Lepidozium 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 *Lepidozium 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 *Lepidozium 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 *Aphananolejeuneo-Colurion* (cf. Sjögren 1978)

Diff. spp. of the alliance: *Colura calyptrifolia*, *Aphanolejeunea madeirensis*, *A. microscopica*. - Diff. spp. of associations: *Aphanolejeunea sintenisii*, *Aphanolejeunea azorica*. - Diff. spp. with reduced diff. val. of the alliance: *Cololejeunea minutissima*, *Drepanolejeunea hamatifolia*, *Frullania microphylla*, *Lejeunea patens*, *Lophocolea fragrans*. - Accompanying species: Several hepatics; in postmature stages of development of the all. also a few mosses. 568 relevés on SMTJPFLC (1965-1997).

The *Aphanolejeuneetum azoricae* (cf. SJÖGREN 1978) is the only Azorean ass. distinguished. 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 polysticta* 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 Praínha), 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 *Aphanolejeuneo-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 *Aphanolejeuneo-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*, *Frullania 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 *Andoe-Nardion scalaris* Sjn. 95

Diff. spp. of the alliance: *Andoa berthelotiana*, *Myurium hochstetteri*, *Fissidens taxifolius* subsp. *pallidicaulis*, *Nardia scalaris*, *Rhamphidium purpuratum* - Diff. spp. of associations: *Fissidens asplenioides*, *Philonotis rigida*, *Breutelia azorica*, *Odontoschisma prostratum*. - Diff. spp. with reduced diff. val. of the alliance: *Enthostodon attenuatus*, *Saccogyna viticulosa*, *Pogonatum aloides*, *Calypogeia muelleriana*, *Scapania undulata*, *Anastrophyllum minutum*, *Calypogeia fissa*, *Diplophyllum albicans*. - Accompanying species: A very large number of hepatics and mosses. Dominance of mosses on dry soil and of hepatics on moist/wet. 250 relevés on SMTGJPFLC (1975-1997).

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

(Pico). 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 "pseudoepilithic" 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 are 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. *Epipterygium tozeri*, *Entostodon attenuatus*, and *Rhamphidium 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 lescurei* 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 Ericaefoliae*, a high-pH community on boulders in stone fences, probably to be referred to the epilithic *Ptychomitrium azorici*; 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 lavaflores 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 *Andoeae-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 *Andoeae-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 *Andoea berthelotiana*, *Nardia scalaris*, *Fissidens taxifolius* subsp. *pallidicaulis*, 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

Diff. spp. of the alliance: *Grimmia lisae*, *Hypnum resupinatum*, *Ptychomitrium nigrescens*, *P. polyphyllum* s. l., *Campylopus pilifer*, *Scorpiurium circinatum*. - Diff. spp. of associations: *Frullania azorica*, *Racomitrium aciculare*, *Tortula muralis*, *Brachythecium plumosum*. - Diff. spp. with reduced diff. val. of the alliance: *Brachythecium populeum*, *Trichostomum brachydontium*, *Radula carringtonii*, *Anastrophyllum minutum*, *Racomitrium elongatum*, *R. lanuginosum*. - Accompanying spp.: Several hepatics and mosses, mostly species with wide ecological range, some of them highly competitive. 141 relevés on SGJPFLC (1975-1995).

The most frequent association. is characterized by *Ptychomitrium* spp. and *Grimmia lisae*. 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 lisae*, *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 *Andoe-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 circinatum*. 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 *Grimmietum 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 *Marchesinion* 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-Barbula* 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 *Andoe-Nardion scalaris* are rare.

Pico: The strongly exposed epilithic bryo-vegetation, 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 *Scorpiurium circinatum*, of the *Ptychomitrium*-dominated ass. at higher altitudes, of the calcicolous *Tortula-Barbula* 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 *Andoe-Nardion* and the *Echinodion prolixi* 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 prolixum*. 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 *Barbula*) occur frequently. The most common ass. is the *Ptychomitrium 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 lisae*, *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*, *Hyocomium 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* and *Brachythecium rivulare*, probably representing another ass., which has to be further investigated. 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 *Platyhypnidietum 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 azoricus*, *Andoa berthelotiana*). Other epilithic associations described from São Miguel (op. cit.), the *Fegatelletum conicae*, the *Dumortiera hirsuta-Jubula hutchinsiae* - ass. and

the *Thamnietum 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. *Dumortiera 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 *Andoe-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 *Andoeae-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 apocarpum*, *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 refuges 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 rize 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 epixylic 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 prolix* 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 bryo-communities and between epigeic/epilithic ones. Some other sociological differences are that the epilithic *Heterocladia-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 prolix* becomes mixed with epixylic and epiphyllous species at least in its mature stages; the epigeic *Andoe-Nardion scalaris* becomes obscured after its very early successional stages by accidental dominance of highly competitive species; the low-altitude epiphytic *Marchesinium* 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 prolix* 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 genera *Frullania*, *Lepidozia*, *Radula* and *Lejeunea* and of mosses of the genera *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 lisae* and *Ptychomitrium* spp. getting rapidly added by species with less distinct

substratum preference, e. g. of the genera *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 diff. spp. 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 prolixum* 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), *Lophocolea fragrans* (JP), *Radula aquilegia* (MTJP); and the epixylic *Lepidozium azoricae*, e.g. *Adelanthus decipiens* (P), *Cephalozia crassifolia* (TJP), *Metzgeria leptoneura* (TP). Bryo-communities, not phorophyte-bound ones, are also equipped with this category of differential species.

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/epixylic/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 prolixum*. *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 epixylic *Lepidozium azoricae* has no diff. sp. with restricted presence as epixylic only. There are, on the other hand, some species that are epixylic/epiphytic, present in the epiphytic *Echinodion prolixum* also, namely *Acrobolbus wilsonii*, *Daltonia stenophylla* and *Metzgeria leptoneura*. These three species also belong to the native cloud-zone forest.

The epiphytic *Echinodion prolixum* has, like the *Lepidozium azoricae*, no exclusive diff. spp. The three species mentioned as also epixylic, may be added with *Radula nudicaulis* (epiphytic / epiphyllous), *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 *Andoa-Nardion scalaris* has several species restricted to the alliance, namely *Anthoceros punctatus*, *Breutelia azorica*, *Enthostodon attenuatus*, *Epipterygium 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 also more or less frequently present as epilithic, are *Anastrophyllum minutum*, *Campylopus pilifer*, *Andoa berthelotiana*, *Myurium hochstetteri*, and *Fissidens asplenioides*.

The epilithic ravine-boulder all., the *Heterocladio-Jubulion*, characterized by a wide altitude range, has two diff. spp. restricted to the all., namely *Fissidens rivularis* and *Schistidium apocarpum*. Some species also occur in other alliances, e. g. *Acrobolbus wilsonii*, *Daltonia stenophylla*, *Metzgeria leptoneura*. The presence in other alliances of *Heterocladium heteropterum*, and *Rhynchostegium* spp. is, on the other hand, very scarce. *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 *Ptychomitrium 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*, *Racomitrium fasciculare* and *Scorpiurium circinatum*. Diff. spp. with some presence also in other communities are *Alophosia azorica*, *Anastrophyllum minutum*, *Campylopus pilifer*, *Leucodon treleasei*, 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 epiphytic *Marchesinion*, a low-altitude all., is equipped with few diff. spp. Only *Leucodon treleasei* 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 epiphyllous *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* (SJÖGREN 1997). See also DIRKSE et al. (1993).

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

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

The epiphytic low-altitude *Marchesinion* 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 *Andoa-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* (TJPFL). 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 *Ptychomitrium azorici* is almost as species-rich as the *Andoe-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 *Ptychomitrium 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. luisierii*, *F. sublinaefolius*, *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 epixylic *Lepidozium azoricae* (cf. Tables 1, 3, 4). The epigeic *Andoe-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

I would like to express a special acknowledgement to all those who have patiently provided invaluable help during my excursions with sampling and relevé documentation: My wife Berit Sjögren (in 1965 and 1995), my son Jonas (1978 and 1982), my daughter Anna (1985); Fernando E. A. P. Pereira, Luis Vasco Nunes, Paulo J. M. Barcelos (1995-1997) and to Mário Ávila Gomes on several occasions during the last 20 years. Eduardo Dias provided important help, suggesting valuable localities for endemic Azorean forest vegetation and also laboratory facilities at the university in Angra do Heroísmo. For most valuable discussions and suggestions I like to express my sincere thanks to René Schumacker (Liège) and to Rosalina Gabriel (Angra do Heroísmo).

Fieldwork and examination of herbarium material leading to recording of several species new to individual islands and also some new to the Azores have been generously supported by LIFE B4-3200/94 and LIFE B4-3200/96/540.

Layout and various kinds of computer work have patiently been suggested and carried out by Helen R. Martins, Rogério Ferraz (Horta) and by Berit Sjögren (Uppsala).

REFERENCES

- ALLORGE, V. & P. ALLORGE 1948. Végétation bryologique de l'île de Flores (Açores). *Revue Bryologique et Lichénologique* 17: 126-164.
- BISCHLER, H. 1970. Les espèces du genre *Calypogeia* sur le continent africain et les îles africaines. *Revue Bryologique et Lichénologique* 37: 63-134.
- CORLEY, M.F.V. & A.C. CRUNDWELL 1991. Additions and amendments to the mosses of Europe and the Azores. *Journal of Bryology* 16: 337-356.
- CORLEY, M.F.V., A.C. CRUNDWELL, R. DÜLL, M. Hill & A.J.E. Smith 1981. Mosses of Europe and the Azores: an annotated list of species, with synonyms from the recent literature. *Journal of Bryology* 11: 609-689.
- DIAS, E. 1996. *Vegetação natural dos Açores. Ecologia e sintaxonomia das florestas naturais*. Universidade dos Açores. Departamento de Ciências Agrárias. Angra do Heroísmo (unpublished thesis).
- DIRKSE, G.M., A.C. Bouman & A. Losada-Lima 1993. Bryophytes of the Canary Islands, an annotated checklist. *Cryptogamie, Bryologie Lichénologie* 14: 1-47.
- DÜLL, R. 1983. Distribution of the European and Macaronesian liverworts (*Hepaticophytina*). *Bryologische Beiträge* 2: 1-115.
- DÜLL, R. 1992. Distribution of the European and Macaronesian mosses (*Bryophytina*). *Bryologische Beiträge* 8/9: 1-232.
- ECCB 1995 (see SCHUMACKER & MARTINY 1995)
- GABRIEL, R.M.A. 1994. *Briófitos da Ilha Terceira (Açores). Ecologia, distribuição e vulnerabilidade de espécies seleccionadas*. Universidade dos Açores, Departamento de Ciências Agrárias. Angra do Heroísmo (unpublished thesis).
- Gabriel, R.M.A. 1997. *Ecophysiology of Azores forest bryophytes*. Ph.D Thesis. Imperial College of Science, Technology and Medicine, London University, UK. Departamento de Ciências Agrárias, Universidade dos Açores, Portugal. 89 pp.
- 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 checklist of the *Hepaticae* and *Anthocerotae* of Europe

- and Macaronesia. *Journal of Bryology* 22: 103-140.
- HEDENÄS, L. 1992. Flora of Madeiran pleurocarpous mosses. (*Isobryales*, *Hypnobryales*, *Hookeriales*). *Bryophytorum Bibliotheca* 44: 1-165.
- HÜBSCHMANN, A.v. 1971. Bryosoziologische Studien auf der Insel Madeira. *Nova Hedwigia* 22: 423-467.
- HÜBSCHMANN, A.v. 1973. Studien auf der Azoreninsel São Miguel. *Revista da Faculdade de Ciências de Lisboa*, 2a Série, C 17: 627-702.
- Schumacker, R. 2001. The hepatic flora of the Azores: Brief historical outline, present knowledge, endemics and phytogeographical aspects. *Belgian Journal of Botany* 134(1): 51-63
- SCHUMACKER, R. & Ph. MARTINY 1995. *Red Data Book of European bryophytes. threatened bryophytes in Europe including Macaronesia*. Edited by the European Committee for Conservation of Bryophytes. Trondheim. Pp. 31-193.
- SJÖGREN, E. 1972. Vascular plant communities of Madeira. *Boletim do Museu Municipal do Funchal* 26: 45-125.
- SJÖGREN, E. 1973. Recent changes in the vascular flora and vegetation of the Azores Islands. *Memórias da Sociedade Broteriana* 22: 1-468.
- SJÖGREN, E. 1975. Epiphyllous bryophytes of Madeira. *Svensk Botanisk Tidskrift* 69: 217-288.
- SJÖGREN, E. 1978. Bryophyte vegetation in the Azores Islands. *Memórias da Sociedade Broteriana* 26: 1-273.
- SJÖGREN, E. 1990. Bryophyte flora and vegetation on the island of Graciosa (Azores). *Arquipélago. Life and Earth Sciences* 8: 63-96.
- SJÖGREN, E. 1993. Bryophyte flora and vegetation on the island of Corvo (Azores). *Arquipélago. Life and Marine Sciences* 11A: 17-48.
- SJÖGREN, E. 1995. *Report on investigations of the bryoflora and bryovegetation in 1995 on the Azorean islands of Faial, S. Jorge, Pico and Flores*. LIFE-project. 30 pp (mimeogr.) Angra do Heroísmo.
- SJÖGREN, E. 1996. *Report on investigations of the bryoflora and bryovegetation on the Azorean island of Santa Maria*. LIFE-project. 24 pp. (mimeogr.) Angra do Heroísmo.
- SJÖGREN, E. 1997. Epiphyllous bryophytes in the Azorean Islands. *Arquipélago. Life and Marine Sciences* 15A: 1-49.
- SJÖGREN, E. 2001. Distribution of bryophytes in the Azores Islands (1999) – with information on their presence on Madeira, in the Canary Islands and in the world. *Boletim do Museu Municipal do Funchal (História Natural)* Suplemento 7: 1-89.
- STEWART, N. 1995. *Red Data Book of European bryophytes. Part 1. Introductory section & background*. Edited by The European Committee for Conservation of Bryophytes. Trondheim. 1-28.

Accepted 10 November 2003.

APPENDIX

Table 1

The epiphytic *Echinodion prolixum*. 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															
island	C	C	C	C	P	F	P	P	P	P	P	F	T	F	P	P
altitude	500	500	500	500	625	600	825	1050	825	600	600	600	850	600	825	1000
phorophyte	E	E	E	E	E	J	J	J	E	E	J	E	J	E	I	J
date	29	29	29	29	7	23	13	13	13	6	6	8	2	8	13	14
month	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7
year	78	78	78	78	65	68	68	68	68	68	68	75	75	75	75	75
sample no.	1	2	3	4	30	3	22	20	18	6	4	11	2	10	10	17
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

a)

<i>Echinodion prolixum</i>	x	x	x	x	x	x	.	.	.	.	x	x	x	x	x	x
<i>Lepidozia cupressina</i>	.	.	.	.	.	.	x	x	x	x	.	.	x	.	x	x
<i>Lejeunea flava</i> ssp. <i>moorei</i>	x	x	x	x	.	.	.	.	.	x	.	x	.	.	.	.

b)

<i>Dicranum scottianum</i>	.	.	x	.	x	x	x	x	.	x	x	x	x	x	.	x
<i>Hypnum uncinulatum</i>	x	x	x	x	x	x	x	x	x	x	.	x	.	x	.	.
<i>Bazzania azorica</i>	.	.	.	.	.	.	.	.	x	.	.	.	x	.	x	.
<i>Porella canariensis</i>	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.

c)

<i>Cololejeunea minutissima</i>	.	.	x	.	.	.	.	.	.	x	.	.	.	x	.	.
<i>Drepanolejeunea hamatifolia</i>	.	.	.	.	.	x	.	.	.	x	x	x	.	x	.	.
<i>Lejeunea lamacerina</i>	.	.	x	x	x	.	.	.	.	.	.	.	x	x	x	.
<i>Metzgeria furcata</i>	x	x	x	x	x	x	.	x	.	.	.	x	.	x	x	.
<i>Plagiochila exigua</i>	.	.	.	.	x	.	.	.	.	x	.	.	.	.	x	.
<i>Radula aquilegia</i>	.	.	.	.	x	x	.	.	.	.	x	x	.	x	.	.

d)

<i>Frullania tamarisci</i>	.	.	x	.	.	.	.	.	.	x	x	x	.	x	.	.
<i>Frullania teneriffae</i>	x	x	x	x	.	x	x	x	x	.	.	.	.	.	.	.
<i>Plagiochila bifaria</i>	x	.	.	x	x	x	.	x	x	x	x	.	x	x	.	.
<i>Nowellia curvifolia</i>	.	.	.	.	x	.	x	.	x	x	x	.	.	.	.	x
<i>Scapania undulata</i>	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.
<i>Lophozia ventricosa</i>	.	.	.	.	x	.	.	x	.	x	.	.	.	.	.	.
<i>Calypogeia muelleriana</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x
<i>Adelanthus decipiens</i>	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.
<i>Scapania</i> sp.	.	.	.	.	.	.	x	.	.	.	x	.	.	.	.	.
<i>Aphanolejeunea microscopica</i>	.	.	.	.	.	.	.	x	.	.	.	x	.	.	.	.
<i>Myurium hochstetteri</i>	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
<i>Lophocolea fragrans</i>	.	.	.	.	.	.	.	.	.	x	x	.	.	.	x	.
<i>Scapania gracilis</i>	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
<i>Telaranea nematodes</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x

Other accompanying species: *Cephalozia bicuspidata* (5), *Cheilolejeunea cedercreutzii* (6), *Campylopus shawii* (7), *Thuidium tamariscinum*, *Polytrichum formosum* (8), *Andoa berthelotiana*, *Acrobolbus wilsonii* (9), *Lepidozia reptans*, *Saccogyna viticulosa* (10), *Frullania microphylla* var. (12), *Metzgeria leptoneura* (15), *Blepharostoma trichophyllum*, *Cephalozia lunulifolia*, *Plagiothecium nemorale*, *Sematophyllum substrumulosum*, *Eurhynchium praelongum*, *Tetrastichium fontanum* (16). Abbreviations: 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 2
The epiphytic *Marchesinia* (a-d, see Table 1)

island	S	S	S	S	S	S	S	S	S	S	S	G	G	G	G
altitude	110	150	150	400	350	200	250	250	220	220	180	200	200	200	200
phorophyte	Pu	Ac	Eu	Pl	Pu	Eu	U	U	Po	U	Pu	Pu	Pu	Pu	Pu
date	8	9	9	11	12	12	12	15	15	17	6	8	8	8	?
month	8	8	8	8	8	8	8	8	8	8	8	6	6	6	6
year	96	96	96	96	96	96	96	96	96	96	96	78	78	78	78
sample no	3	28	29	10	17	1	8	10	6	10	4	36	18	19	22
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

a)

<i>Frullania azorica</i>	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.
<i>Cololejeunea minutissima</i>	X	X	X	.	.	X	.	.	.	.	X	.	X	X	.
<i>Marchesinia mackaii</i>	X	.	.	X	X	X	X	X	X	X	.	.	.	.	.
<i>Frullania microphylla</i>	.	X	X	X	.	X	.	.	.	.	X	X	X	X	X

b)

<i>Zygodon viridissimus</i>	X	.	X	.	.	.	X	.	.	.	X	.	.	.	.
<i>Leucodon treleasei</i>	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.
<i>Homalia webbiana</i>	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.

c)

<i>Harpalejeunea mollerii</i>	X	X	X	X
-------------------------------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

d)

<i>Lejeunea lamacerina</i>	X	X	.	.	X	.	.	.	.	X	X	.	X	X	.
<i>Sematophyllum substrumulosum</i>	.	X	.	.	.	.	X	.	.	X	.	.	.	.	.
<i>Radula carringtonii</i>	.	X	X	X	.	X	X	.	X	.	X	.	.	X	.
<i>Frullania tamarisci</i>	.	.	X	.	.	.	.	.	.	.	.	X	.	X	X
<i>Porella canariensis</i>	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.

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 uncinulatum*, *Radula wichurae* (15). Abbreviations: 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 3
The epixylic *Lepidozion azoricae* (a-d, see Table 1).

island	P	P	P	P	P	T	P	P	J	J	J	T	F	S	S	S
altitude	700	675	250	775	775	850	775	800	850	850	700	850	800	450	520	520
phorophyte	E	E	E	J	Cm	B	Cm	Cm	Cm	Cm	Cm	J	J	Cj	Cj	Pu
date	5	7	8	13	13	3	13	13	31	31	26	3	8	10	10	10
month	5	5	7	7	7	7	7	7	7	7	7	7	7	8	8	8
year	65	65	68	68	68	68	75	68	68	75	75	75	75	96	96	96
sample no.	17	17	5	20	13	24	5	17	14	19	2	11	4	12	36	37
table no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

a)

<i>Cyclodictyon laetevirens</i>	x	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.
<i>Riccardia chamedryfolia</i>	x	x	.	.	.	.	.	.	x	.	.	.	.	x	x	.
<i>Telaranea nematodes</i>	.	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.
<i>Scapania gracilis</i>	.	.	x	.	.	.	.	x	.	x	x	.	x	.	.	x
<i>Lepidozia azorica</i>	.	.	x	.	x	.	.	x	.	x	x	x	x	.	.	.
<i>Lepidozia reptans</i>	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.

b)

<i>Nowellia curvifolia</i>	.	.	x	.	x	.	.	x	.	x	.	.	.	.	.	.
<i>Plagiochila exigua</i>	.	.	.	.	x	.	.	x	x	x	.	.	.	.	.	.
<i>Tetrastichium virens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x

c)

<i>Hypnum uncinulatum</i>	x	.	x	x	x	.	.	.	.	x	.	x	.	.	x	.
<i>Odontoschisma prostratum</i>	.	.	x	.	.	.	x	.	x	x	x	x	.	.	.	.
<i>Sematophyllum substrumulosum</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
<i>Calypogeia muelleriana</i>	x	x	x	x	x	.	.	.	x	x	x	.	.	.	.	.
<i>Cephalozia crassifolia</i>	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.
<i>Pseudotaxiphyllum elegans</i>	.	.	.	.	.	.	x	.	.	.	x	x	x	.	.	.

d)

<i>Bazzania azorica</i>	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.	.
<i>Lejeunea lamacerina</i>	x	.	.	.	.	x	x	x	x	.	.	x	.	x	x	x
<i>Plagiochila bifaria</i>	x	.	x	x	.	.	x	.	x	.	.	x	.	.	.	.
<i>Saccogyna viticulosa</i>	.	x	x	.	.	.	.	.	.	.	.	.	x	.	.	.
<i>Thuidium tamariscinum</i>	.	x	.	x	.	.	.	x	.	.	.	.	.	.	.	.
<i>Drepanolejeunea hamatifolia</i>	.	.	x	.	.	.	x	x	x	.	x	.	.	.	.	.
<i>Frullania tamarisci</i>	.	.	x	.	x	.	x	x	x	x	.	.	.	.	x	.
<i>Harpalejeunea molleri</i>	.	.	x	.	.	.	x	.	.	.	.	.	.	.	.	.
<i>Metzgeria leptoneura</i>	.	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.
<i>Andoa berthelotiana</i>	.	.	.	x	.	.	.	.	.	.	.	.	.	.	x	.
<i>Lophozia ventricosa</i>	.	.	.	x	.	.	.	.	.	.	.	.	x	.	.	.
<i>Dicranum scottianum</i>	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
<i>Aphanolejeunea microscopia</i>	.	.	.	.	x	x	x	x	x	x	.	.	x	.	.	.
<i>Chiloscyphus polyanthos</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	x	.	.
<i>Lejeunea patens</i>	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.

Other accompanying species: *Cephalozia bicuspidata*, *Plagiomnium undulatum* (2), *Frullania teneriffae* (4), *Adelanthus decipiens*, *Lophocolea fragrans*, *Hypnum cupressiforme* (5), *Lophocolea heterophylla* (6), *Frullania microphylla*, *Riccardia latifrons* (7), *Radula aquilegia* (8), *Scapania undulata* (9), *Diplophyllum albicans* (11), *Calypogeia fusca* (12), *Metzgeria furcata* (14), *Eurhynchium praelongum*, *Brachythecium rivulare* (15), *Radula carringtonii*, *Brachythecium plumosum*, *Metzgeria furcata* (16). Abbreviations: 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 4
The epiphyllous *Apanolejeunea-Colurion* (a-d, see Table 1).

island	C	C	F	F	P	P	P	P	J	J	J	J	T	T	T	M	M	M
altitude	300	300	675	675	700	1050	600	675	750	600	550	500	550	500	550	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	31	27	1	2	2	2	18	13	13
month	7	7	7	7	4	5	7	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	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)

<i>Colura calyptrifolia</i>	x	x	x	x	x	.	x	.	x	.	x	.	.	x	.	.	x	x
<i>Aphanolejeunea madeirensis</i>	.	.	.	.	.	x	.	.	x	x	x	x	.	.	.	.	.	.
<i>Aphanolejeunea microscopica</i>	.	.	x	x	.	.	x	x	.	x	.	x	.	.	x	.	x	x

b)

<i>Aphanolejeunea sintenisii</i>	x	x	x	x	.	.	.	x	.	.	.	.	.	x	x	x	x	x
<i>Aphanolejeunea azorica</i>	x	x	.	.	x	.	x	.	x	.	x	.	.	.	.	x	.	.

c)

<i>Cololejeunea minutissima</i>	x	x	.	.	x	x	x	x	.	x	x	x	x	x	x	x	x	x
<i>Drepanolejeunea hamatifolia</i>	.	.	.	.	x	x	x	x	x	.	.	.	.	x	x	.	x	x
<i>Frullania microphylla</i> var.	.	.	x	.	x	.	.	x	.	.	.	.	.	x	x	x	x	x
<i>Lejeunea patens</i>	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.
<i>Lophocolea fragrans</i>	.	.	.	.	.	.	.	.	.	x	.	x	.	.	.	.	.	.

d)

<i>Hypnum uncinatum</i>	x	.	.	.	x	.	x	.	.	x	.	.	.	.	.	.	.	.
<i>Frullania tamarisci</i>	.	.	x	.	.	x	x	.	.	x	.	.	.	.	.	.	x	x
<i>Lejeunea lamacerina</i>	.	.	x	x	x	x	.	.	.	x	x	x	x	x	.	.	.	.
<i>Pseudotaxiphyllum elegans</i>	.	.	.	x	x	.	.	.	.	x	.	.	x	.	.	.	.	.
<i>Frullania teneriffae</i>	.	.	.	.	x	x	.	.	x	.	.	.	.	.	.	.	.	.
<i>Metzgeria furcata</i>	.	.	.	.	x	.	x	.	.	.	.	.	.	.	x	x	.	.
<i>Plagiochila bifaria</i>	.	.	.	.	.	x	.	.	.	.	.	x	x	.	.	.	.	.
<i>Jubula hutchinsiae</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.
<i>Thuidium tamariscinum</i>	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.
<i>Echinodium prolixum</i>	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
<i>Marchesinia mackaii</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.

Abbreviations: 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 *Andoeae-Nardion scalaris* on Corvo, Flores, Graciosa, and Santa Maria (a-d, see Table 1).

island	C	C	C	C	C	L	L	L	L	G	G	G	G	S	S	S	S
altitude	425	425	425	425	275	600	500	125	440	220	300	140	200	220	550	330	330
date	29	29	29	29	23	14	15	16	17	12	13	6	8	9	10	12	12
month	6	6	6	6	6	8	8	8	8	6	6	6	6	8	8	8	8
year	78	78	78	78	78	95	95	95	95	78	78	78	78	96	96	96	96
sample no.	.	.	.	.	9	9	2	1	3	9	12	14	11	17	15	13	17
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

a)

<i>Andoa berthelotiana</i>	.	.	.	.	X	.	.	X	X	X	X	X	X	.	.	X	X
<i>Myurium hochstetteri</i>	X	.	.	.	.	.	.	.	X	X	.	.	X	.	.	.	.
<i>Fissidens taxifolius</i> subsp. pal.	X	.	.	.	.	.	.	.	X	.	X	.	X	X	.	.	.
<i>Nardia scalaris</i>	X	X	X	X	X	X	X	.	.	.	.	.	.	.	X	.	.
<i>Rhamphidium purpuratum</i>	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.

b)

<i>Fissidens asplenioides</i>	.	X	X	X	X	.	.	X	X	.	.	.	.	.	.	X	X
<i>Philonotis rigida</i>	.	.	X	X	.	X	.	.	.	.	.	.	.	X	.	.	.
<i>Anthoceros caucasicus</i>	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.
<i>Odontochisma prostratum</i>	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.

c)

<i>Enthostodon attenuatus</i>	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.
<i>Saccogyna viticulosa</i>	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	X
<i>Pogonatum aloides</i>	.	X	.	X	.	X	.	.	.	.	.	.	.	X	.	.	.
<i>Epipterygium tozeri</i>	.	.	X	X	.	.	.	.	.	.	X	.	.	X	.	.	X
<i>Calypogeia muelleriana</i>	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	X
<i>Scapania undulata</i>	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.
<i>Diplophyllum albicans</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X
<i>Anastrophyllum minutum</i>	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
<i>Calypogeia fissa</i>	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.

d)

<i>Campylopus</i> sp.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polytrichum commune</i>	.	X	X	.	.	.	X	.	.	.	.	.	.	X	.	.	.
<i>Leucobryum juniperoideum</i>	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X
<i>Polytrichum juniperinum</i>	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.
<i>Reboulia hemisphaerica</i>	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.
<i>Radula carringtonii</i>	.	.	.	.	.	.	.	X	X	X	.	X	X	.	.	.	.
<i>Frullania tamarisci</i>	.	.	.	.	.	.	.	.	X	X	.	X	.	?	X	.	.
<i>Lejeunea lamacerina</i>	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.
<i>Cephalozia bicuspidata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X

Other accompanying species: *Campylopus flexuosus* (1), *Sematophyllum substrumulosum* (3), *Eurhynchium praelongum* (5), *Odontoschisma denudatum* (6), *Brachythecium plumosum*, *Scapania gracilis*, *Racomitrium aquaticum* (7), *Dumortiera hirsuta*, *Lunularia cruciata* (8), *Campylopus cygnaeus* (9), *Porella canariensis*, *Plagiochila bifaria*, *Plagiochila exigua* (10), *Fossombronina* sp., *Fissidens bryoides*, *Marchantia paleacea* (11), *Riccardia chamedryfolia* (12), *Hypnum uncinulatum* (13), *Conocephalum conicum* (14), *Lepidozia reptans*, *Campylopus fragilis*, *Calliergonella cuspidata* (15). Abbreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo.

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

island	P	P	P	P	P	P	F	F	F	F	F	J	J	J	J	J	J
altitude	150	900	250	950	800	800	470	620	620	620	500	900	940	600	400	400	600
date	6	10	12	9	12	12	1	2	2	2	3	19	19	20	21	21	19.
month	8	8	8	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	95	95	95
sample no.	2	6	6	4	13	17	7	4	5	7	1	13	14	11	1	7	9
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

a)

<i>Andoa berthelotiana</i>	x	.	.	x	x	x	x	.	.	x	.	.	.	.	x	.	.
<i>Myurium hochstetteri</i>	.	.	.	.	x	.	x	.	.	x	.	.	.	.	.	.	.
<i>Fissidens taxifolius</i> subsp. pal.	x	.	.	x	.	x	x	.	.	.	.	.	.	.	.	.	.
<i>Nardia scalaris</i>	.	x	x	.	.	.	x	x	x	x	x	x	.	x	.	x	x
<i>Rhamphidium purpuratum</i>	x	.	.	.	.	.	.	x	x	.	.	.	x	.	.	x	x

b)

<i>Fissidens asplenioides</i>	.	x	.	.	.	.	x	.	x	.	.	x	.	.	x	.	.
<i>Philonotis rigida</i>	.	.	x	.	.	.	x	x	x	x	.	.	.	.	.	.	x
<i>Anthoceros caucasicus</i>	x	.	.	.	.	.	.	.	.	.	x	.	.	.	.	x	.
<i>Alophosia azorica</i>	.	.	.	x	.	x	.	.	.	.	x	.	.	.	.	.	.
<i>Breutelia azorica</i>	.	x	x	.	.	.	.	x	.	.	.	.	x	.	.	.	.
<i>Odontoschisma prostratum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.

c)

<i>Enthostodon attenuatus</i>	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Saccogyna viticulosa</i>	.	.	.	.	.	x	x	x	.	.	.	.	.	.	x	.	.
<i>Pogonatum aloides</i>	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
<i>Calypogeia muelleriana</i>	x	.	.	.	.	.	.	.	.	.	.	.	.	x	.	x	x
<i>Scapania undulata</i>	.	x	x	.	x	.	.	x	.	.	.	x	.	.	.	.	x
<i>Anastrophyllum minutum</i>	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Calypogeia fissa</i>	.	.	.	.	.	x	.	.	.	.	x	.	.	x	.	.	.
<i>Diplophyllum albicans</i>	.	x	x	.	x	.	.	.	.	.	.	.	.	x	.	.	x

d.

<i>Campylopus fragilis</i>	x	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	.
<i>Frullania tamarisci</i>	.	.	.	x	x	.	x	.	.	x	.	.	.	.	.	.	.
<i>Conocephalum conicum</i>	.	.	.	.	.	.	x	.	.	.	.	.	x	.	.	.	.
<i>Atrichum angustatum</i>	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.
<i>Anomobryum julaceum</i>	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.
<i>Brachythecium plumosum</i>	.	.	.	.	.	.	.	.	.	x	.	x	.	.	.	.	.
<i>Hypnum cupressiforme</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.

Other accompanying species: *Trichostomum brachydontium*, *Reboulia hemisphaerica* (1), *Campylopus brevipilus* (3), *Radula wichurae*, *Porella canariensis* (4), *Plagiochila bifaria* (5), *Dicranella heteromalla* (7), *Hypnum uncinulatum* (10), *Scleropodium purum*, *Cephalozia crassifolia* (11), *Philonotis fontana* (13), *Diphyscium foliosum* (14), *Campylopus pilifer* (15), *Polytrichum juniperinum*, *Blepharostoma trichophyllum*, *Odontoschisma denudatum* (17). Abbreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo.

Table 7
The epilithic *Ptychomitrium azorici* (a-d, see Table 1).

island	C	C	C	L	L	L	F	F	P	P	P	J	J	G	G	S
altitude	225	600	425	200	200	170	250	150	50	800	600	400	750	140	140	350
date	23	2	22	15	15	17	31	30	6	12	10	19	22	6	6	13
month	6	7	6	8	8	8	7	7	8	8	8	8	8	6	6	8
year	78	78	78	95	95	95	95	95	95	95	95	95	95	78	78	96
sample no.	17	3	43	13	15	9	10	14	1	16	8	6	1	13	23	4
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
a)																
<i>Grimmia lisae</i>	x	x	x	x	x	.	.	.	x	x	x	x	x	x	x	x
<i>Hypnum resupinatum</i>	x	.	.	.	x	x	.	x	.	.	.	x	.	x	x	x
<i>Ptychomitrium nigrescens</i>	.	.	.	x	.	.	x	.	x	.	x	.	.	x	.	x
<i>Ptychomitrium polyphyl.</i> s. l.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
<i>Campylopus pilifer</i>	x	.	.	.	.	.	.	x	.	x	x	.	x	x	.	.
<i>Scorpiurium circinatum</i>	.	.	.	.	.	.	x	.	.	.	.	.	.	x	.	.
<i>Ptychomitrium</i> sp.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
b)																
<i>Frullania azorica</i>	x	.	.	.	x	x	.	.	x	.	.	.	.	.	x	x
<i>Racomitrium aciculare</i>	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.
<i>Racomitrium fasciculare</i>	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.
<i>Tortula muralis</i>	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
<i>Brachythecium plumosum</i>	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.
c)																
<i>Brachythecium populeum</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.
<i>Trichostomum brachydontium</i>	.	.	.	.	.	.	x	x	x	.	.	x	.	.	.	x
<i>Radula carringtonii</i>	x	.	.	x	.	x	x	x	.	.	.	.	.	.	x	x
<i>Anastrophyllum minutum</i>	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
<i>Racomitrium elongatum</i>	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
<i>Racomitrium lanuginosum</i>	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.
d)																
<i>Frullania teneriffae</i>	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Bryum donianum</i>	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
<i>Myurium hochstetteri</i>	.	x	x	.	.	.	.	.	.	.	x	.	.	.	.	.
<i>Lejeunea lamacerina</i>	.	.	x	.	.	.	.	x	.	.	.	.	.	.	.	.
<i>Echinodium proluxum</i>	.	x	x	.	.	.	.	.	.	.	x	.	.	.	.	.
<i>Andoa berthelotiana</i>	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.
<i>Bryum torquescens</i>	.	.	.	.	.	x	.	x	.	.	.	x	.	.	.	.
<i>Porella canariensis</i>	.	.	.	.	.	x	.	.	.	.	.	.	.	.	x	.
<i>Frullania tamarisci</i>	.	.	.	.	.	.	x	.	.	x	x	.	.	.	x	.
<i>Campylopus</i> sp.	.	.	.	.	.	.	.	x	.	.	x	.	x	.	.	.
<i>Scapania undulata</i>	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.
<i>Plagiochila bifaria</i>	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.

Other accompanying species: *Didymodon insulanus* (1), *Marsupella emarginata* (2), *Diphyscium foliosum*, *Thamnobryum alopecurum*, *Polytrichum juniperinum*, *Rhamphidium purpuratum* (3), *Marchesia mackaii*, *Bryum capillare* (7), *Anomobryum julaceum*, *Harpalejeunea molleri* (8), *Alophosia azorica* (11), *Hypnum cupressiforme* (12), *Racomitrium heterostichum* (13), *Tortella nitida*, *Eurhynchium praelongum*, *Leucodon treleasei*, *Saccogyna viticulosa* (15), *Radula lindenberiana* (16).
Abbreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo.

Table 8
The epilithic *Heterocladio-Jubulion* (a-d, see Table 1).

island	L	L	L	L	F	F	F	F	P	P	P	P	P	J	J	J	J
altitude	500	320	430	400	620	620	500	500	800	500	600	800	800	560	700	700	750
date	14	16	17	17	2	2	3	3	7	7	8	13	13	19	20	20	22
month	8	8	8	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	95	95	95
sample no.	8	10	11	2	9	17	7	8	3	21	18	6	7	10	15	16	6
table no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

a)

<i>Heterocladium heteropterum</i>	x	x	.	.	x	x	x	.	x	x	x	x	x	x	x	x	x
<i>Jubula hutchinsiae</i>	.	x	.	.	x	x	x	x	x	x	x	.	.	.	.	x	.
<i>Fissidens rivularis</i>	.	.	.	.	.	.	.	.	.	x	.	x	.	.	x	.	.
<i>Rhynchostegium riparioides</i>	.	.	x	x	.	.	.	.	.	.	x	.	.	.	x	.	.
<i>Schistidium apocarpum</i> var.	.	.	.	x	.	.	.	.	.	.	.	x	x	.	.	.	.

b)

<i>Fissidens serrulatus</i>	.	.	.	.	x	.	x	x	x	x	x	.	.	.	.	.	x
<i>Thamnobryum alopecurum</i>	.	.	x	.	.	x	.	x	.	.	.	.	.	x	.	.	.
<i>Dumortiera hirsuta</i>	x	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.
<i>Conocephalum conicum</i>	.	.	.	.	x	.	x	.	.	x	.	x	.	.	.	.	.
<i>Hyocomium armoricum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.

c)

<i>Rhynchostegium megapolitanum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
<i>Tylimanthus azoricus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
<i>Rhizomnium punctatum</i>	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.
<i>Riccardia chamedryfolia</i>	x	.	.	.	.	x	x	.	.	x	.	.	.	x	x	.	x
<i>Brachythecium plumosum</i>	x	x	x	.	.	.	.	.	.	.	.	.	x	.	.	x	.
<i>Tetrastichium fontanum</i>	.	x	.	x	x	x	x	x	x	x	x	.	.	.	.	.	.
<i>Andoa berthelotiana</i>	.	.	.	.	x	x	x	.	.	.	.	x	.	.	.	.	.
<i>Brachythecium rivulare</i>	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.
<i>Fissidens taxifolius</i> subsp. <i>pall.</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.

d)

<i>Eurhynchium praelongum</i>	x	x	.	.	.	x	x	x	x	.	.	x	x	x	.	.	.
<i>Lejeunea lamacerina</i>	x	x	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.
<i>Saccogyna viticulosa</i>	.	x	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.
<i>Scapania undulata</i>	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.
<i>Fissidens asplenioides</i>	.	.	.	x	.	.	.	.	.	.	.	x	x	x	x	.	x
<i>Plagiomnium undulatum</i>	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.
<i>Cirriphyllum piliferum</i>	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.

Other accompanying species: *Plagiochila bifaria* (1), *Radula carringtonii* (2), *Bryum pseudotriquetrum* (4), *Calypogeia fissa* (7), *Eurhynchium speciosum* (8), *Odontoschisma prostratum*, *Pellia epiphylla*, *Blepharostoma trichophyllum* (17). Abbreviations: S – Santa Maria; M – São Miguel; T – Terceira; G – Graciosa; J – São Jorge; P – Pico; F – Faial; L – Flores; C – Corvo.

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

<i>Acanthocoleus aberrans</i> h	<i>Drepanolejeunea hamatifolia</i> h	<i>Nowellia curvifolia</i> h
<i>Acrobolbus wilsonii</i> h	<i>Dumortiera hirsuta</i> h	<i>Odontoschisma prostratum</i> h
<i>Adelanthus decipiens</i> h	<i>Echinodium prolixum</i>	<i>Philonotis rigida</i>
<i>Alophosia azorica</i>	<i>Enthostodon attenuatus</i>	<i>Plagiochila longispina</i>
<i>Anastrophyllum minutum</i> h	<i>Epipterygium tozeri</i>	<i>Plagiochila exigua</i> h
<i>Andoa berthelotiana</i>	<i>Fissidens asplenioides</i>	<i>Pogonatum aloides</i>
<i>Anthoceros caucasicus</i> h	<i>Fissidens rivularis</i>	<i>Porella canariensis</i> h
<i>Aphanolejeunea azorica</i> h	<i>Fissidens serrulatus</i>	<i>Pseudotaxiphyllum elegans</i>
<i>Aphanolejeunea madeirensis</i> h	<i>Fissidens taxifolius</i> ssp. <i>pall.</i>	<i>Ptychomitrium nigrescens</i>
<i>Aphanolejeunea microscopica</i> h	<i>Frullania azorica</i> h	<i>Ptychomitrium polyphyllum</i> s.l.
<i>Aphanolejeunea sintenisii</i> h	<i>Frullania microphylla</i> h	<i>Racomitrium aciculare</i>
<i>Atrichum angustatum</i>	<i>Grimmia lisae</i>	<i>Racomitrium fasciculare</i>
<i>Barbula unguiculata</i>	<i>Harpalejeunea molleri</i> h	<i>Radula aquilegia</i> h
<i>Bazzania azorica</i> h	<i>Heterocladium heteropterum</i>	<i>Radula carringtonii</i> h
<i>Brachythecium plumosum</i>	<i>Homalia webbiana</i>	<i>Radula nudicaulis</i> h
<i>Brachythecium populeum</i>	<i>Hyocomium armoricum</i>	<i>Rhamphidium purpuratum</i>
<i>Brachythecium rivulare</i>	<i>Hypnum resupinatum</i>	<i>Rhynchostegium confertum</i>
<i>Breutelia azorica</i>	<i>Hypnum uncinulatum</i>	<i>Rhynchostegium riparioides</i>
<i>Calypogeia fissa</i> h	<i>Jubula hutchinsiae</i> h	<i>Riccardia chamedryfolia</i> h
<i>Calypogeia muelleriana</i> h	<i>Lejeunea flava</i> spp. <i>moorei</i> h	<i>Saccogyna viticulosa</i>
<i>Campylopus cygnaeus</i>	<i>Lejeunea lamacerina</i> h	<i>Scapania gracilis</i> h
<i>Campylopus pilifer</i>	<i>Lejeunea patens</i> h	<i>Scapania undulata</i> h
<i>Campylopus shawii</i>	<i>Lejeunea ulicina</i> h	<i>Schistidium apocarpum</i>
<i>Cephalozia crassifolia</i> h	<i>Lepidozia azorica</i> h	<i>Scorpiurium circinatum</i>
<i>Cheilolejeunea cedercreutzii</i> h	<i>Lepidozia cupressina</i> h	<i>Sematophyllum substrumulos</i>
<i>Cololejeunia minutissima</i> h	<i>Lepidozia reptans</i> h	<i>Telaranea nematodes</i> h
<i>Colura calyptrifolia</i> h	<i>Leucodon treleasei</i>	<i>Tetrastichium fontanum</i>
<i>Conocephalum conicum</i> h	<i>Lophocolea fragrans</i> h	<i>Tetrastichium virens</i>
<i>Cyclodictyon laetevirens</i>	<i>Marchesinia mackaii</i> h	<i>Thamnobryum alopecurum</i>
<i>Daltonia stenophylla</i>	<i>Metzgeria furcata</i> h	<i>Tortula muralis</i>
<i>Dicranum scottianum</i>	<i>Metzgeria leptoneura</i> h	<i>Trichostomum brachydontium</i>
<i>Didymodon vinealis</i>	<i>Myurium hochstetteri</i>	<i>Tylimanthus azoricus</i> h
<i>Diphyscium foliosum</i>	<i>Nardia scalaris</i> h	<i>Zygodon viridissimus</i>
<i>Diplophyllum albicans</i> h	<i>Neckera intermedia</i>	