

# BRYOPHYTES (MUSCI) UNEXPECTEDLY RARE OR ABSENT IN THE AZORES

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Search for bryophytes in the Azores has until now resulted in a recording of about 430 species of mosses and hepatics. A few of these species are endemic to the Azores or to the Macaronesian island groups. The majority of the other species includes cosmopolitan or oceanic/suboceanic European species. This paper treats some mosses (Musci) which have not managed to get established in the Azorean bryovegetation. Some are just unexpectedly rare and frequently recorded as present in only one or two of the nine Azorean islands. All such species must overcome the gap between the Azorean islands and/or between the islands and the continents. This is quite possible, especially for richly diaspore-spreading species. However, I hypothesize that the principal hinder to the establishment of new bryophyte species, in the remote islands of the Azores, is the potent competition of already established bryo-communities on all sorts of substrates. Also, the influx of diaspores may not be large enough to secure an establishment there. The recent (last 50 yrs) influx of new species to the Azores has mainly been to sites within the low-altitude, profoundly man-influenced landscape. There, competition from already established bryophyte species is much less potent than in the native plant communities in forest/shrub vegetation at altitudes above 500 m (cf. SJÖGREN 2003). Far-reaching changes of the composition of endemic Azorean bryo-communities within the remains of native *Juniperus-Laurus-Erica* forests are consequently not likely to take place within the near future. However, continued man-made changes within the Azorean high-altitude landscape, such as plantation of alien tree species, construction or improvement of roads and tracks, extension of areas of managed grasslands, plantation of invasive alien vascular plants may facilitate the influx of new bryophyte species, even there.

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## INTRODUCTION

There is a strong representation of cosmopolitan and of oceanic/suboceanic species among the unexpectedly rare or absent bryophytes (Musci) in the Azores, treated in this paper. Almost 50% of these species have never been recorded by bryologists in the Azores or are today at least looked upon as doubtful elements of the Azorean bryoflora. Many records carried out before 1950 have not been confirmed later, though bryological

investigations in the Azores have become very much intensified especially after 1965. Most of the species treated in this paper were recorded in the Canary Islands and in Madeira or at least in one of these Macaronesian island groups.

Most of the species treated in this work were recorded in the islands of São Miguel and Pico only, or/and in one or more of the islands of the central group of the archipelago (Faial, Pico, Terceira, São Jorge, Graciosa). Only two of the species were also found in the western island of Flores and two in the easternmost island of Santa Maria. Among the noncosmopolitan species several also occur in Asia and Africa, and four also in America.

The absent or poorly represented cosmopolitan species are of course especially

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**Abbreviations:** Az. - Azores Islands; Mad. - Madeira; Can. - Canary Islands.

**Azorean islands:** S - Santa Maria; M - São Miguel; T - Terceira; G - Graciosa; J - São Jorge; P - Pico; F - Faial; L - Flores; C - Corvo.

worth attention. The recent, after 1950, tremendously increasing communications between continents and the Azores and between the individual nine islands may in the near future support an invasion of these species to the archipelago, or at least, a spreading within the islands. Consequently such species as *Hedwigia ciliata* and *Climacium dendroides* may become new invaders and e.g. *Funaria hygrometrica*, and *Pohlia nutans* may extend their distribution within the archipelago.

The actual bryoflora of the Azores comprises about 438 species (GABRIEL et al. 2005). A typical feature, both of the vascular plant flora and the bryoflora, is that several genera and even families are represented by only one or two species in the islands. For mosses such examples can be given as the Thuidiaceae with *Thuidium tamariscinum* and *Heterocladium heteropterum*, the Aulacomniaceae with *Aulacomnium palustre* only, the Seligeriaceae with *Blindia acuta*. This is one of the typical features of insularity and of accidental influx of diaspores.

#### ECOLOGY OF SOME OF THE PROBABLY ABSENT OR RARE SPECIES

Most of the probably absent species of bryophytes (Musci) in the Azores are shade or shelter requiring species in Europe. They are mostly found in forests, such as *Bartramia pomiformis*, *Dicranum polysetum*, *Neckera crispa*, and *Plagiothecium undulatum*. Some of the species also occur in wet/moist nonsheltered habitats, such as *Climacium dendroides*, *Fissidens adianthoides*, and *Amblystegium serpens*. Several of the species treated in this paper use shelter for compensation of a too low supply of substrate moisture in localities in central Europe. They appear, however, also in open nonsheltered localities in westernmost Europe due to higher precipitation and less draught risks there (as is the case e.g. for *Rhytidiadelphus loreus*).

Several of the species treated as examples of unexpectedly absent species in the Azores, are preferentially epigeic. Only *Bartramia pomiformis*, *Paraleucobryom longifolium*, and *Hedwigia ciliata*, are strongly preferentially

epilithic and *Neckera crispa*, *Leucodon sciuroides*, and *Antitrichia curtipendula* are epiphytic/epilithic. Other species have just a weak or even no substrate preference at all, such as *Amblystegium serpens*, *Drepanocladus uncinatus*, and *Plagiomnium cuspidatum*. Most of the unexpectedly rare mosses in the Azores are preferentially epilithic/epigeic; *Aulacomnium palustre* and *Calliergonella cuspidata*, however, are preferentially epigeic. Some species, though very rare, may be listed as less substrate-bound in the Azores than in continental Europe, such as *Hookeria lucens* and *Hyocomium armoricum*. A lot of mosses, common in the Azores, have no distinct substrate preference, resulting in several species combinations hardly possible to record on the European continent (cf. SJÖGREN 2003).

Most of the species selected to become treated in this paper are acidicolous but some are widerange species as to pH of the substrate. Available substrates in the Azores including barks of trees and shrubs are, with few exceptions, acid or very acid and consequently one can not expect to find a great number of basicolous species. Such species have a more or less accidental presence on cement walls and on a few tree species with less acid barks. A few examples of rare basicolous mosses in the Azores are *Orthotrichum tenellum*, *Grimmia pulvinata*, *Schistidium apocarpum*, and *Tortula ruralis*. Sites providing high-pH substrates are larger and more numerous in Madeira and in the Canary Islands where a much higher number of basicolous mosses has been recorded than in the Azores. So far, not present in the Azores but present in Madeira are e.g. *Orthotrichum affine*, *Cratoneuron filicinum*, *Homalia trichomanoides* and present in the Canary Islands as well are e.g. *Encalypta vulgaris*, *Plagiomnium affine*, and *Tortella tortuosa* (cf. SJÖGREN 2001).

#### ABSENT SPECIES AND SPECIES COMBINATIONS

A successful invasion of new species of bryophytes becomes generally possible into ecosystems characterized by instability. Unstable bryophyte communities are those which have a short duration of their “final stage” of

development. They generally comprise within small surfaces also a high frequency of initial stages of succession. Easily eroding bryocommunities occur frequently on strongly sloping substrate surfaces. If the succession from initial stages to “final stages” of the communities is slow, invasion and establishing of species alien to the community may become successful and last for a long period of years. On the other hand, unstable fractions of a community characterized by a rapid succession are less easily invaded by sociologically alien species. Such bryophyte communities are numerous and usually predominant in the Azores, at least at cloud-zone altitudes above 500-600 m a.s.l. where native forests are subject to optimal environmental conditions.

The Azorean bryovegetation includes a group of species growing as epiphyllous. These species are to 90% hepatics and have not been included in this paper. However, a comparison between the epiphyllous *Aphanolejeuneo-Colurion* (Sjögren 1978, 2003) of the Azores and of Madeira shows differences, with absence in the Azores of species such as *Frullania polysticta*, *Frullania fragilifolia*, and *Lejeunea mandonii*. On the other hand, some of the Azorean epiphyllous hepatics have not been recorded in Madeira, such as *Aphanolejeunea sintenisii* and *Cheilolejeunea cedercreutzii* (cf. SJÖGREN 2003).

The predominant epigeic and epilithic species combinations of the native cloud-zone forests, the *Andoe-Nardion scalaris* and the *Heterocladio-Jubulion* (SJÖGREN 1995, 2003) occur frequently on soil and on rocks. Several of the missing unexpectedly rare species of mosses have been looked for within these communities where their demands for moisture and shade are supplied. Today these communities are characterized by a high number of species, which may occur more or less hazardedly as dominants and which have a strong competitive ability.

In several localities the dominance is accidental due to a “first on the spot colonization”. Wounds in the moss-carpet are generally healed by species colonizing rapidly from the margins of the eroded or denuded spots. Consequently an intrusion on soil of such species as *Amblystegium serpens*, *Cirriphyllum piliferum*, and *Plagiothecium undulatum* will probably be

difficult. Also rock surfaces in ravines, in volcanic explosion holes and sheltered under a canopy of native *Erica azorica*, *Juniperus brevifolia*, and *Laurus azorica* get rapidly colonized both by hepatics and mosses and wounds in the moss-carpet heal rapidly within a time period of a few years. An invasion of such species as *Antitrichia curtipendula*, *Bartramia pomiformis* or *Rhytidiadelphus loreus*, absent or rare in the Azores, has weak possibilities to lead to a stable presence if the supply of diaspores is not very abundant and longlasting.

The epiphytic *Echinodion prolixum* (SJÖGREN 1993, 2003) is subject to frequent erosion but also rapid recolonization of denuded spots on the tree stems in the native cloud-zone forests. The epixylic *Lepidozium azoricae* (SJÖGREN 1995), with at least finally a dominance of mosses on tree stumps and dead trunks, is less frequently subject to wounds in the moss-carpet. There is a progressive development from species combinations close to those of the *Echinodion* to those more close to epigeic communities. Consequently an intrusion of such species as *Aulacomnium androgynum*, *Plagiomnium cuspidatum* or *Drepanocladus uncinatus* may today hardly become successful.

As to the epiphytic communities in the Azores a presence of e.g. *Antitrichia curtipendula*, *Leucodon sciuroides*, and *Neckera crispa* was expected. However, there are no records of *Antitrichia* on any type of substrate, *Leucodon sciuroides* has been “substituted” by *Leucodon treleasei* in all the nine Azorean islands and *Neckera crispa* by *Neckera intermedia*.

The unshaded, unsheltered biotops at high altitudes in the Azores are represented by wet/moist grasslands, where a few bryophytes occur as dominants. These species are mostly *Scleropodium* spp., *Sphagnum* spp., *Thuidium tamariscinum*, and *Campylopus* spp. Expected species in these grasslands are e.g. *Rhytidiadelphus loreus*, *Calliergonella cuspidata*, and *Climacium dendroides*. *Rhytidiadelphus loreus* has got two small but stable populations in the island of Pico and one has been recently recorded in Terceira. *Eurhynchium striatum* has so far got one small population in one locality in the island of Santa Maria (SJÖGREN 1996, 1997). *Aulacomnium palustre* has got a few but

specimen-rich localities in São Miguel, São Jorge and Pico. The two Pico-populations are large and have remained stable since 1965 when I recorded them for the first time. *Climacium dendroides* has not yet been recorded in the Azores. The epigeic species mentioned above are rare and only *Aulacomnium palustre* has developed large populations. The hummock population of *Rhytidiadelphus loreus* in Pico island in a mire at 1000 m a.s.l. which covers only about 4 dm<sup>2</sup> has not managed to spread to nearby hummocks in the mire, since 1965, when I first recorded it. Apparently the nowadays dominant species of mosses in the moist grasslands in the Azores do not allow any further intrusion of such epigeic species as those mentioned above.

There is in the Azores a widespread boulder/rock bryo-community, the endemic *Ptychomitrium azorici* (SJÖGREN 1993, 2003). It is mostly dominated by *Ptychomitrium* spp., *Grimmia lisae*, *Campylopus pilifer* or *Hypnum resupinatum*. The community occurs under fairly strongly exposed habitat conditions. The species diversity is generally high and an invasion of preferentially epigeic bryophytes due to sand and dust accumulation mostly occurs in late successional stages of development of the community. The strongly exposed, acid, basaltic boulders get invaded comparatively slowly, leaving mostly a mosaic of moss-cover and uncolonized patches. A presence in this community, at least in its early stages of development, of such preferentially epilithic species as *Hedwigia ciliata* and *Paraleucobryum longifolium* was expected but there are no records of these two species in the Azores, until now. *Hedwigia* occurs in Madeira and in the Canary Islands, *Paraleucobryum* in Madeira only. The often rough boulder and rock surfaces in the Azores with a lot of holes and fissures would provide excellent substrates for the attachment of diaspores of these two cosmopolitan mosses. *Hedwigia* and *Paraleucobryum* are typical examples of insularity obstacles governing the spreading of bryophytes to the Azores.

#### DIASPORE SPREADING AGENCIES AND THE AZOREAN BRYOVEGETATION

The spreading of plants takes place by wind,

water and accidentally by animals as birds, and by man. The most secure way of spreading is, however, stepwise over land. Consequently remote island groups are frequently subject to accidental influx of diaspores. The insularity of the Azores, remote from other Macaronesian island groups of Madeira and the Canary Islands, and from the continents has obviously provided considerable problems to the supply of diaspores to the islands and between the islands. Besides, the distance between the easternmost and the westernmost islands of the Azores is about 600 km.

The plantgeographically extremely varied diaspore influx to the Azores has been supported by the strategic position of the islands, providing possibilities to become reached by diaspores for example from surrounding continents, from Nordic countries and from the Westindies (cf. SÉRGIO 1984; DIAS 1996). The diaspore rain has been going on for no more than 10 million years, considering the calculated ages of different islands. Diaspore supply by man has occurred during only the 600 years of colonization of the islands. The recent 100 years of progressively increasing communications with the islands has brought a lot of new species within a comparatively very short period of time.

Mosses and hepatics have more efficient facilities for spreading than vascular plants as they can use spores, as well as detached leaves, gemmae, etc. However, the light, minute, spores are the most efficient long-distance diaspores. Their successful spreading of several mosses to calcareous substrates in the Azores is worth mentioning.

Walls covered with cement get rapidly colonized by species belonging to the Pottiaceae family, especially by *Tortula* species. Even small patches of cement surrounded by basaltic acid stone surfaces get rapidly invaded. There are, however, several basicolous or calcicolous species, which have not managed to reach the Azores yet, such as *Encalypta vulgaris*, *Anomodon viticulosus*, *Plagiomnium affine*, and *Tortella tortuosa*, all species present in other Macaronesian island groups.

The wind-spreading of diaspores of mosses is favoured by dry climatic conditions. The spreading in the Azores, from one locality to

another or from one island to another is surely checked by high air humidity, substrate humidity and frequent rains, typical of the oceanic climatic conditions of the islands. Fertile specimens of mosses are in the Azores mostly recorded in communities of comparatively dry unshaded habitats. An available richness of spores of such more or less xerocolous species has promoted their presence in all or almost all the nine Azorean islands. Examples are *Campylopus pilifer*, *Tortula muralis*, *Grimmia lisae*, and *Ptychomitrium* spp. On the other hand, species of sheltered moist/wet habitats in the cloud-zone forests with restricted presence are numerous. Further comments on some of these species are given in this paper (see *Hyocomium armoricum*, *Hylocomium brevirostre*, *Hookeria lucens*, and *Eurhynchium striatum*).

It is more likely that species to become treated as new to the Azores islands will eventually appear in the open landscape, even as more or less antropochorous ones, than in the fairly stable vegetation of the relicts of native forests.

*Rhytidiadelphus loreus* was once reported by LUISIER (1945) as new to the Azores and Madeira but he did not mention the presence of *Aulacomnium palustre* in the Azores. Both these species may be looked upon as fairly recent invaders to the Azores (cf. CARDOT 1897). The probable recent influx of more or less antropochorous species to the Azores, or as new to individual islands, has been documented by CRUNDWELL et al. (1994) and by BATES & GABRIEL (1997). Several of these species, mostly of the Bryaceae family, are acrocarpous and exist in unsheltered habitats. A good example of the recent influx of antropochorous species to the Azores is *Leptophascum leptophyllum* (pers. comm. Cecília Sérgio).

#### POTENTIAL CHANGES OF THE AZOREAN BRYOFLORA IN THE NEAR FUTURE (cf. also SJÖGREN 1973).

Additions to the flora of vascular plants of the Azores during the last 150 years increased the number of taxa probably by at least 100 %. For example, WATSON (1844) mentioned 350 species

and PALHINHA (1966) 699 species. The number has now reached about 1100 species (SILVA et al. 2005). Most of the additional species were introduced, deliberately or accidentally. Reasons for spreading of the “new species” are associated with improved communications between the individual islands and between the islands and the continents. Furthermore, the man-made landscape has become considerably extended in all the Azorean islands, offering localities with new habitat conditions.

The areas occupied by the natural, endemic plant communities of the Azores have decreased progressively, especially during the last 100 years. Genuine natural vegetation is nowadays extinct or at least transformed into seminatural grassland in some of the nine islands. Coastal vegetation has become pushed aside where constructions of new roads and settlements have taken place.

The native forests at high altitudes, above 500 m a.m.s.l., have become fragmented and also transformed into cultivations of introduced tree species, especially *Cryptomeria japonica*. The transformation is over large areas also due to a potent spreading of introduced plants, originally for ornamental purposes in gardens and along roads, such as *Hedychium gardnerianum* and *Lantana camara*. The coastal *Myrica faya* forests have become strongly transformed due to the potent spontaneous spreading of *Pittosporum undulatum*, an Australian tree species introduced to create hedges.

It is evident, that the composition of the bryoflora and bryovegetation of the Azores has become progressively subject to changes. The spreading of bryophytes of the high-altitude native forests has become checked by the present delimited area of suitable habitats in the remains of the forests. Their presence has become deadlocked to a few of the islands, while the opened landscape at all altitudes has become the recipient of new colonizing species.

The potential of the future bryovegetation of the Azores to accept a colonization of “new species” has decreased at high altitudes in the opened landscape but also in the relicts there of native forests. Only a few of the species selected and treated below, which are expected to invade the archipelago or to spread in the individual

islands or between them, have done so successfully during the last 50 years.

The native bryo-communities include several highly competitive species, frequently appearing as dominants. So the nowadays potential natural bryo-vegetation will hardly change much in quality in the near future. Alterations will probably be due to changes of dominant species and such changes may often be just accidental and not persist for long periods of time. On the other hand, a progressive thinning of relict native forests or further fragmentation caused by new roads, will most probably threaten the future survival of several bryophyte species, nowadays well established in forests where habitat conditions have remained almost unchanged for long periods of time.

The situation for the bryo-vegetation that may be found in low-altitude areas, that is, below 500 m on the central group islands, is quite different. The locally, densely populated areas, are open for colonization of bryophytes, formerly not recorded in the Azores. Several of these species are acrocarpous, often fertile, invasive and looked upon as cosmopolitan.

The distribution-limiting factors, acting upon a future supply of species "new" to the Azores may be summarized as follows. The insularity obstacle is the main problem to overcome for the bryophyte diaspores. Diaspores reaching the islands have to compete with already well established groups of species on all types of substrates. Denuded spots of substrates become normally rapidly colonized by species from surrounding moss-carpet. The recolonization becomes progressively more rapid with increasing altitude in the islands. For calcicolous species the lack of high-pH substrates becomes a limiting factor. Consequently the colonization and survival of such species becomes mostly accidental. Human interferences progressively diminish the range of habitats and consequently also the number of ecologically differentiated species of bryophytes, possible as future invaders.

Bryophytes which have the ability to supply a high number of diaspores are naturally favoured as possible invaders. Such species are often found within the opened landscape and especially at low levels of altitude, below 500 m.

The composition of the endemic bryo-communities of the Azores may be looked upon as fairly stable but minor changes in their composition may of course take place as a consequence of spreading of species between the islands. Changes may be centred to habitats of the man-made landscape, where a lot of accidental colonizations takes place. However, the geographical situation of the Azores islands suggests possible invasions from surrounding continents (SÉRGIO 1984). For vascular plants see also SUNDING (1970, 1979). There are already established taxa of bryophytes in the islands with main distribution, e.g. in South and Central America (SCHUMACKER 2001), and several of them may be accidental. There is consequently a pronounced difference in the colonization and spreading between bryophytes and certain vascular plant species. The deliberate introduction of species such as *Hedychium gardnerianum*, *Cyrtomium falcatum*, *Lantana camara*, and *Gunnera tinctoria* have provided potent changes of the native Azorean vegetation during only one century.

#### A SELECTION OF SOME MISSING OR RARE MOSSES IN THE AZORES

*Amblystegium serpens* (Hedw.) B.S.G.  
(Amblystegiaceae)

Az.: M.-Can. - In most European countries. Almost cosmopolitan. The presence in the Azores of *A. serpens*, in one island only is unexpected (ALLORGE & PERSSON 1938). Other *Amblystegium* species have been recorded as present each in two islands only (ALLORGE & ALLORGE 1952), namely *A. riparium*, *A. tenax*, and *A. varium* (see also SILVEIRA 1937).

In general *A. serpens* is a species represented in Europe on all types of substrates, under shaded and moist habitat conditions (cf. e.g. FREY et al. 1995; SMITH 1978).

*A. serpens* may be expected to occur in the Azores as preferentially epixylic or epiphytic on tree bases. However, ALLORGE & ALLORGE (1952) recorded the species on a stone wall. However the species is, probably epixylic (like *Drepanocladus uncinatus* and *Aulacomnium*

*androgynum*), prevented to appear due to a rapid recolonization of denuded spots by bryophytes belonging to the community *Lepidozion azoricae* (community endemic to the Azores; SJÖGREN 1996, 2003). This community is frequently dominated by highly competitive hepatics, such as *Riccardia chamedryfolia*, *Scapania* spp., and *Calypogeia* spp. Tree bases, if efficiently shaded get in the Azores rapidly recolonized where succession becomes repeated by such highly competitive species as *Hypnum uncinulatum*, *Frullania* spp., *Andoa berthelotiana* (endemic to Macaronesia) and *Brachythecium* spp. The moss cover on more or less strongly exposed tree bases at low altitudes (below 500 m a.s.l.) gets frequently dominated by specimen-rich hepatics such as *Marchesinia mackaii*, *Frullania azorica*, *Frullania microphylla*, *Radula carringtonii*, and *Lejeunea lamacerina*. Also a colonization of *A. serpens* as epigeic is today probably mostly prevented by highly competitive bryophytes of the epigeic community *Andoa-Nardion scalaris* (SJÖGREN 1995, 2003).

*Antitrichia curtispindula* (Hedw.) Brid.  
(Leucodontaceae)

Mad. Can. - Species present from south European countries to the southern parts of Scandinavia; AS, AFR, AM. Suboceanic species.

*A. curtispindula* occurs in Madeira in some localities (LUISIER 1932; CASAS et al. 1989). Not recently recorded in the Azores. A related species, *A. californica*, occurs in Madeira and in the Canary Islands.

*A. curtispindula* has been looked upon as a species susceptible to air pollution. The species is epilithic, less common as epiphytic and grows both on acid and calcareous rocks. As a highly competitive species it becomes easily dominant in a mosscover where it has invaded. In Madeira tree species of the “Laurisilva” are phorophytes. In the Azores, where air pollution is weak, suitable habitat conditions are available in several localities in all islands. Phorophytes of the “Laurisilva” are, however, mostly colonized by the *Echinodion prolixum* community (SJÖGREN 1993, 2003). This community is characterized by highly competitive bryophytes, such as

*Echinodion prolixum*, *Dicranum scottianum*, *Frullania* spp., and *Lepidozia cupressina*. These species will probably prevent the colonization of *A. curtispindula*, at least in final stages of development of the *Echinodion*. The absence of *A. curtispindula* on shaded rock surfaces in the Azores is, however, less easily explained.

*Aulacomnium androgynum* (Hedw.) Schwaegr.  
(Aulacomniaceae)

Can. - A common temperate species in Europe. Also present in AS, AFR and AM. Still no records in the Azores and in Madeira.

The first record in the Canary Islands dates back to DIXON (1911). A few more recent records are also available (CASAS et al. 1989).

*A. androgynum* is an easily recognizable species due to its frequent club-shaped heads of gemmae on stalks. The species grows in continental Europe on several types of substrates but may be looked upon as preferentially epixylic. Suitable habitats for *A. androgynum* are richly available in the Azores, on decaying wood and on tree bases, where the bark is often easily detachable, moist and porous. Such habitats are, however, mostly occupied, in native cloud-zone forests, by the endemic *Lepidozion azorici* community (SJÖGREN 1996, 2003) with several highly competitive hepatics (see also *Amblystegium serpens*). – In spite of the high frequency of propagules and the common presence in continental Portugal this species has apparently not managed to reach or establish in the Azores.

*Aulacomnium palustre* (Hedw.) Schwaegr.  
(Aulacomniaceae)

Az.: M, J, P. - Cosmopolitan. A few localities on Pico. One at 950 m a.s.l. in the Caveiro area, one on the shores of Lagoa do Caiado. After 2000 some new ones according to R. Schumacker (pers. comm.). One locality on São Jorge at 800 m on the S slope of Pico dos Fachos.

The European presence of this species is in mires, also on heaths and occasionally on fairly dry ground (dwarf specimens). *A. palustre* has a

wide pH-range. No sociological affinity of the species has been recorded in the Azores, where the localities are in mires or wet meadows. Associated species are frequently the endemic species *Breutelia azorica* and also *Sphagnum palustre*.

The restricted presence of *A. palustre* in the Azores is remarkable, as large areas with suitable habitat conditions exist in all the islands, maybe with the exception of Santa Maria and Graciosa. It is also worth mentioning that the species has still not reached Madeira or the Canary Islands. The recording on Pico dates back to ALLORGE & PERSSON (1938) whereas the recording in São Jorge was carried out by Sjögren in 1978. Specimens in the Caveiro-mire on Pico have unusually long stems. *A. palustre* is a common species in Spain and in continental Portugal (CASAS et al. 1989). Dispersal of diaspores from there has apparently not created any frequent presence in the Macaronesian island groups. There is also a restricted dispersal in individual islands and between islands in the Azores. Among bryophytes *A. palustre* is a typical example on the effects of double insularity (DIAS 1996).

*Bartramia pomiformis* Hedw. (Bartramiaceae)

Mad. Can. - In most European countries. Almost cosmopolitan. Azorean presence in Terceira according to BARROS (1958) and CASAS et al. (1992). Not recently documented and therefor suggested to become excluded from the Azorean bryoflora (SJÖGREN 2001). Presence in the Canary Islands according to DIRKSE et al. (1993). First published by CUNHA & BARROS (1942).

In general a species of acid rocks in sheltered habitats, also on accumulated soil in rock crevices. There are consequently numerous potential localities in the Azores, where habitat conditions are suitable enough to the presence of *B. pomiformis*. However, such sites are today mostly colonized by dense carpets of e.g. *Conocephalum conicum*, *Fissidens serrulatus*, *Thamnobryum alopecurum*, and *Heterocladium heteropterum*. The community including such species has been described as the *Heterocladio-Jubulion* (SJÖGREN 2003). Other bryophytes,

which have not managed to compete with species of that community in the Azores are e.g. *Pohlia cruda*, *Fissidens adianthoides*, and *Paraleucobryom longifolium*. *B. pomiformis* may of course have existed in the Azores during a short time period but not managed to create diaspores enough to become permanently established with sufficiently large populations. – In spite of its high frequency in continental Portugal, there are still no recent records of *B. pomiformis* in the Azores. This species is consequently just one example of the obstacles of insularity in the Azores to the dispersal of common species of continental Europe to these islands.

*Calliergonella cuspidata* (Hedw.) Loeske (Amblystegiaceae)

Az.: S, M, J, L. - Mad. Can. - In most European countries. Almost cosmopolitan.

The presence of *C. cuspidata* in the Azores is scattered. The first record in São Jorge was done by SJÖGREN (1995). In the Azores the species is present in a few localities only and always with small populations. The presence in Europe is generally in mires, wet meadows, ditches etc. The competition in Azorean mires of *Sphagnum* spp., *Breutelia azorica*, *Polytrichum* spp., and *Campylopus* spp. is probably an obstacle to the colonization and survival of *C. cuspidata*. Wet soil escarpments have become locally colonized but in such habitats there is a potent competition of bryophytes, mostly hepatics. Fully exposed moist or wet depressions in the open grasslands at high altitudes, where *C. cuspidata* is expected to occur, are in the Azores frequently covered by carpets of *Rhytidiadelphus* spp. (not *R. loreus*) and *Scleropodium* spp. On surrounding hummocks there is mostly a dominance of *Polytrichum* spp., *Campylopus* spp. and *Thuidium tamariscinum*, leaving little space for other bryophytes to intrude.

*Cirriphyllum piliferum* (Hedw.) Grout. (Brachytheciaceae)

Az.: F - In most parts of Europe. Almost



cosmopolitan. The species was recorded as new to Macaronesia (SJÖGREN 1995).

*C. piliferum* occurs in Faial at an altitude of 700 m a.s.l., on a slightly shaded moist escarpment of a narrow ravine at the levada to the N of the main Caldeira. The population found was very small and there were no other patches of the species nearby.

The species is very common on soil in woods, on shaded escarpments and in ditches in continental Europe. *C. piliferum* has been looked upon as a basicolous species but it is better described as a species with a wide pH-range (see SJÖGREN 1964). The rare and probably occasional presence of *C. piliferum* in the Azores may to some extent be due to the rather scarce presence of habitats with substrates with a moderately high soil-pH, above 5.5. – Mostly a boreal species in Europe (not present in Spain and Portugal) and rarely with sporophytes, thus with limited possibilities to reach the Azores.

*Climacium dendroides* (Hedw.) Web. et Mohr.  
(Climaciaceae)

Probably present in all European countries. Almost cosmopolitan. Until now no record in Macaronesia (see CASAS et al. 1985).

*C. dendroides* generally grows in wet or moist sites, in meadows, mires and in moist depressions in forests. The dendroid phenotype is typical but some small densely branched ecotypes occur. *C. dendroides* is easily recognizable and probably not overlooked in the Azores, where suitable habitat conditions are available in numerous localities in all the nine islands. The bottom layer in open grasslands in the Azores is, however, mostly dominated by dense carpets of bryophytes such as *Thuidium tamariscinum*, *Scleropodium* spp., *Polytrichum* spp. and *Campylopus* spp. A recent intrusion of *C. dendroides* (cf. also *Calliergonella cuspidata*) into such a moss carpet, locally very dense, may become restrained by such highly competitive and now already well established species.

*Dicranum polysetum* Sw. (Dicranaceae)

A common boreal species of middle and northern

Europe; also present in Siberia and in N. and S. America. Not recorded in Macaronesia.

Only a few *Dicranum* species have been recorded in Macaronesia. All of them are rare except for *Dicranum scottianum*.

*D. polysetum* occurs as epigeic for example in conifer forests in W. Europe. The species is acidicolous and could be expected to occur in the numerous *Cryptomeria japonica* plantations in the Azores. The presence and survival of an epigeic mosscover is, however, efficiently restrained in these plantations by a thick and slowly decomposing litter carpet. According to EGGERS (1982) there has been one record of *D. polysetum* in the island of São Miguel (HÜBSCHMANN 1973) but the specimen shall be treated as *D. bonjeani*.

Among the *Dicranum* species expected to occur in the Azores can also be mentioned *D. majus*. This species has until now only two localities, in the island of Terceira, and became a new species to Macaronesia when recently recorded by SJÖGREN (1997). One locality is in Serreta (650-700 m) and one at 800 m a.s.l. on the northern slope of Santa Bárbara. *D. majus* is in W. Europe a calcifuge species, growing on various types of substrates in sheltered habitats.

*Drepanocladus uncinatus* (Hedw.) Warnst.  
(Amblystegiaceae) (= *Santonina uncinata*)

Mad. Can. - In most parts of Europe.

*D. uncinatus* has been mentioned by DÜLL (1984-1985) as present in all the northern Macaronesian island groups. In HEDENÄS (1992) only a presence in the Canary Islands is mentioned (cf. also EGGERS 1982). The record in Tenerife dates back to BRYHN (1908).

In continental Europe *D. uncinatus* generally occurs as epixylic or epiphytic, more rarely as epilithic. It is the only *Drepanocladus* species which is not preferentially a mire species. My records of epixylic bryo-communities in the Azores have so far not produced any locality for *D. uncinatus*. The epixylic community *Lepidozium azoricae* (SJÖGREN 1996, 2003) occurs on *Erica azorica*, *Juniperus brevifolia*, the fern *Culcita macrocarpa* (litter of senescent specimens) and on the alien tree species

*Pittosporum undulatum* and *Cryptomeria japonica*. This community is dominated by hepatics, such as *Riccardia chamedryfolia*, *Scapania gracilis* or *Lejeunea lamacerina*.

Almost all the Azorean islands offer numerous localities with suitable habitat conditions for *D. uncinatus*, nowadays especially in remains of native forests at high altitudes (above 500 m a.s.l.). It is, however, important to stress that the bryo-succession in the native cloud-zone forests from epiphytic towards epixylic species combinations is very rapid. An invasion of such a species as *D. uncinatus*, becoming established with large populations has to overcome important obstacles, especially the competition of other already firmly established species.

*Eurhynchium striatum* (Hedw.) Schimp.  
(Brachytheciaceae)

Az.: S, M. - Can. - Present in most European countries. Mostly in the W parts of continental Europe. Suboceanic species. The presence of *E. striatum* in the Canary Islands and Madeira (DÜLL 1984-1985) is questionable (HEDENÄS 1982; DIRKSE et al. 1993).

This *Eurhynchium* species is preferentially epigeic and occurs occasionally on tree bases and on other types of substrates. The recent record in Santa Maria (leg. SJÖGREN 1996; teste HEDENÄS) is in one locality only, where the population is large and dominant in the moss-cover of a slightly shaded soil escarpment (Fontinha at altitude 400 m). The related *Eurhynchium meridionale* is widely spread in the Azores and is present in the Canary Islands and in Madeira also. In the locality in Santa Maria *E. striatum* occurs together with *Scleropodium purum* and *Thuidium tamariscinum*.

*Fissidens adianthoides* Hedw. (Fissidentaceae)

Mad. Can. - In all parts of Europe: AS, AFR, AM, AU. Almost cosmopolitan. The Faial-record (RUSSEL 1862) is uncertain, as a confusion with *Fissidens luisieri* is possible, a species endemic to Macaronesia (POTIER DE LA VARDE 1955,

SÉRGIO et al. 1997). The record in the Canary Islands was carried out by DIXON (1911). Later records by WIJENS (1987) shall be treated as *Fissidens serrulatus* (see DIRKSE et al. 1993).

The European presence of *F. adianthoides* is generally as epilithic or epigeic on moist or wet substrates in shaded habitats in forests, mires or meadows.

The genus *Fissidens* is one of the few bryophyte genera which is rich in species in the Azores. It includes one species endemic to the Azores and three to Macaronesia (see SJÖGREN 2001). The localities in the Azores, offering suitable habitat conditions to *F. adianthoides* on wet soil escarpments and on cliffs and boulders in shaded ravines, are frequently occupied by *Fissidens serrulatus* and/or *F. asplenioides* or *F. taxifolius* subsp. *pallidicaulis*. These are the most common species of the genus in the Azores. They constitute together with some preferentially epilithic species of the *Heterocladio-Jubulion* (SJÖGREN 1995, 2003) dense moss-carpets, where an invasion today of *F. adianthoides* seems hardly possible. A maintained colonization of *F. adianthoides* in the epigeic *Andoa-Nardion scalaris* (op. cit.) on soil escarpments may also become efficiently prevented by strongly competitive mosses such as *Andoa berthelotiana*, *Myurium hochstetteri*, *Fissidens* spp. and by several hepatics such as *Nardia scalaris*, *Calypogeia* spp. and *Scapania* spp.

*Funaria hygrometrica* Hedw. (Funariaceae)

Az.: M, T. - Mad. Can. - Cosmopolitan. Presence in the Canary Islands confirmed by MALME (1988).

Epigeic species on cultivated ground, on spots which have been subject to fire (see e.g. SMITH 1978, FREY et al. 1995). European presence also as epilithic. Probably to be looked upon as a nitrocolous species.

The presence of *F. hygrometrica* in the Azores was already mentioned by LUISIER (1931) but still it is only recorded in two of the nine islands. As the species is frequently fertile a further spreading is probable. The also frequently fertile *Ceratodon purpureus*, a species with similar habitat preferences as *F. hygrometrica*, is

on the other hand today present in all the Azorean islands.

*Hedwigia ciliata* (Hedw.) P.Beauv.  
(Hedwigiaceae)

Mad. Can. - Species mentioned as present in the Azores, Madeira and the Canary Islands (LUISIER 1932). In CASAS et al. (1996) only records from Madeira and the Canary Islands. The species occurs in most European countries and may be treated as cosmopolitan. *H. ciliata* has not recently been recorded in the Azores although easily recognizable and thus hardly overlooked. Documentation from Madeira dates back to 1846 and 1880 according to CASAS et al. (1996). The documentation from the Canary Islands is on the other hand fairly recent.

*H. ciliata* is a preferentially epilithic species in Europe, growing on acid rocks, mostly in strongly exposed habitats. Presence in strongly shaded habitats in forests is an indication of a formerly more open landscape.

Localities with suitable habitat conditions are richly available in the Azores. Strongly exposed sites in lavaflows and on isolated rocks are, however, mostly occupied by species such as *Ptychomitrium* spp., *Grimmia lisae*, *Campylopus pilifer*, and *Hypnum resupinatum*. These species belong to the ecologically specialized community *Ptychomitrium azorici* (SJÖGREN 1993, 2003), which exists in all the Azorean islands. A successful colonization of *H. ciliata* into the *Ptychomitrium* would need a presence of numerous diaspores to compensate for the strong competition of e.g. the species mentioned above. They are frequently fertile and successful primary colonizers.

*Hookeria lucens* (Hedw.) Sm. (Hookeriaceae)

Az.: M, T, P, L. - Mad. - In most European countries; AS, AM, AFR. Suboceanic species.

The European presence of *Hookeria* is mostly as epigeic in moist and efficiently shaded habitats, in the bottom of river ravines, on escarpments close to the high water level.

This large, pale, easily recognizable and

attractive bryophyte can hardly have been overlooked by bryologists working in the Azores. Still *H. lucens* has only been recorded in four of the nine islands and altogether there are few localities. The record in Terceira within the Caldeira da Serra de Santa Bárbara is recent and by Rosalina Gabriel in 1998. Another recent record is by Erik and Berit Sjögren and I. B. Gonçalves in Pico in 1965 (in a deep ravine at 800 m a.s.l. to the S of Cais do Pico). One record in São Miguel (questionable according to Herman Persson; see also LUISIER 1938, 1945). Records in the Azores mentioned by CASAS et al. (1992) are only those from Pico.

The very rare presence of *H. lucens* in the Azores must be looked upon as unexpected. In most of the islands narrow and deep river ravines are numerous, offering excellent habitat conditions to the presence of this species. Furthermore a lot of explosion craters, holes and fissures in the lava streams offer suitable spots for colonization in their damp and strongly shaded bottoms. In such places there is today mostly a dense moss-cover of other species of the Hookeriaceae family, namely *Cyclodictyon laetevirens* and *Tetrastichium fontanum*. *Cyclodictyon* is a rare species, also present in westernmost Europe, and *Tetrastichium fontanum* is endemic to Macaronesia. These species belong to the *Heterocladio-Jubulion* community (SJÖGREN 1995, 2003), which is frequently dominated by *Thamnobryum alopecurum* and locally by hepatics such as *Conocephalum conicum*, *Riccardia chamedryfolia*, and *Jubula hutchinsiae*.

Specimens of *H. lucens* recorded by me in the 1960s in Madeira were richly fertile which has apparently not supported a further spreading of the species to the Azores.

*Hylocomium brevirostre* (Brid.) B.S.G.  
(Hypnaceae)

Az.: M,T,J,F. - Still not recorded in Madeira and the Canary Islands. A suboceanic/submediterranean species.

First only recorded in São Miguel (Lagoa do Congro at 575 m a.s.l. ; leg. Sjögren 1965; see also HÜBSCHMANN 1973). Record in São Jorge

(N of Caldeirinhas at 750 m a.s.l.: leg Sjögren 1975). Also recorded in Terceira (BATES & GABRIEL 1997) and in Faial (CRUNDWELL et al. 1994).

*H. brevirostre* is preferentially epigeic in continental Europe but occurs in the Azores in a few scattered localities on all types of substrates. Substratum preference of several suboceanic/oceanic bryophytes weakens towards the western parts of Europe and is almost lost in sites where they occur in the Azores.

The lack of presence or rather lack of recent records of this species in the island of Pico is especially remarkable as suitable habitat conditions prevail in numerous sites in this island. Species growing together with *H. brevirostre* in São Jorge were *Scleropodium purum*, *Thuidium tamariscinum*, *Philonotis fontana*, *Hyocomium armoricum*, and *Reboulia hemisphaerica* just to mention a few of the most frequently dominant species.

*Hyocomium armoricum* (Brid.) Wijk et Marg. (Hypnaceae)

Az.: J., T. - Mad. - Western and central parts of Europe; AS. Oceanic species. The first record in São Jorge dates back to 1937 and was carried out by Allorge. The author has checked the presence in the deep river ravine Ribeira dos Vimes at 650-675 m a.s.l. in 1965, 1978 and 1995. There are also a few other localities in São Jorge (see SJÖGREN 1978). Apparently this species was also referred to Terceira by FONTINHA & SÉRGIO (1995), as accompanying species of *Eucladium verticillatum*.

The European presence of *H. armoricum* is generally on rocks, tree roots and on soil in strongly shaded habitats. The presence of this species in the Azores could be expected but its presence is restricted to a few localities in one island only. As epigeic *H. armoricum* grows in São Jorge together with e.g. *Dumortiera hirsuta*, *Eurhynchium praelongum*, and *Leucobryum juniperoideum*, as epilithic together with *Heterocladium heteropterum*, *Fissidens serrulatus*, and *Brachythecium plumosum*.

Several sites with habitat conditions suitable to *H. armoricum* are available in the nearby

islands of Faial and Pico. Among bryophytes *H. armoricum* provides a good example of the so called double insularity (DIAS 1996), that is, the isolation from the continents and in the Azores also between the individual islands. Dispersal within and to the Azores has apparently not been promoted by the fairly frequent presence of this species in continental Portugal.

*Leucodon sciuiroides* (Hedw.) Schwaegr. (Leucodontaceae)

Az.: F. - Mad. Can. - Present in most European countries; AS, AFR. Temperate species. For the presence in the Canary Islands see DIRKSE et al. (1993).

Apparently this species was also referred to Terceira Island by FONTINHA & SÉRGIO (1995), as accompanying species of *Eucladium verticillatum*.

The documentation of *L. sciuiroides* in the island of Faial dates back to RUSSELL (1862) and there have been no recent records in that island. *L. sciuiroides* in Europe is preferentially epiphytic and grows more rarely as epilithic on basic cliffs. Tree species with high-pH barks, such as *Fraxinus* and *Ulmus* are preferentially colonized. Air pollution affects the presence of *L. sciuiroides* negatively. Tree species with high-pH barks are rare in the Azores. There is, on the other hand, a more or less potent salt-impregnation of exposed basaltic cliffs and boulders, which may at least locally help to create suitable habitat conditions.

The closely related *Leucodon canariensis* (Brid.) Schwaegr. is probably absent in the Azores (cf. HEDENÄS 1992) but is present as a Macaronesian endemic species in Madeira and in the Canary Islands. However this species (*L. c.*) is referred for the Azores by HÜBSCHMANN, 1973 and others.

The only *Leucodon* species being a "substitute" for *L. sciuiroides* in the Azores is the Macaronesian endemic species *Leucodon treleasei* (Card.) Par. (= *Leucodon canariensis* var. *treleasei* (Card.) Fleisch.). This species exists in all the Azorean islands as epiphytic and as epilithic. The most frequently associated species on rocks and boulders are *Ptychomitrium* spp., *Scorpiurium circinatum* and *Radula carringtonii*,

members of the endemic Azorean community *Ptychomitrium azorici* (SJÖGREN 1993, 2003). The absence of *L. sciuroides* var. *sciuroides* in the Azores is probably due to the basicolous properties of this species, which are apparently less pronounced for *Leucodon treleasei*.

*Neckera crispa* Hedw. (Neckeraceae)

Az.: M. - Mad? - A presence of *N. crispa* in Macaronesia has been suggested now and then (see DÜLL 1992). This temperate species occurs in several European countries, where it is mostly epilithic and occasionally epiphytic. It has been looked upon as basicolous. Apparently it has also been referred to Faial (LÜPNITZ 1975: 241).

Presence of *N. crispa* in Macaronesia is questionable (cf. HEDENÄS 1992 and DIRKSE et al. 1993). Most records can be referred to *Neckera intermedia*. That species is mostly a member of the epiphytic *Echinodion proluxi* but has in the Azores also been recorded as epilithic at fairly low altitudes, such as in the islands of Corvo and Santa Maria (cf. SJÖGREN 1993, 1996). The rare presence in the Azores of basic substrates probably acts as an obstacle to the presence of *N. crispa* and *Leucodon sciuroides* and several other basicolous bryophytes.

*Paraleucobryum longifolium* (Hedw.) Loeske (Dicranaceae)

Mad. Can. - Presence in most European countries; AS, AFR, AM. Still not recorded in the Azores. Present in Madeira according to LUISIER (1943). The documentation in the Canary Islands (GAITSKELL 1965) is still questionable (DÜLL 1992). – Not in continental Portugal.

*P. longifolium* occurs in Europe generally as epilithic, both in shaded and strongly exposed habitats. The species is a primary colonizer as *Hedwigia ciliata*. A colonization and survival of *P. longifolium* in the Azores may today be obstructed by the already well established or successfully invading primary colonizers of the community *Ptychomitrium azorici* (cf. *Hedwigia ciliata*).

*Plagiomnium cuspidatum* (Hedw.) T.Kop. (Mniaceae)

A species present in most European countries; AS, AFR, AM. Subboreal species.

The presence in the Azores of species of the Mniaceae family is scarce and nowadays limited to four species. *Plagiomnium undulatum* occurs in eight of the nine islands but the number of localities is altogether small. *P. cuspidatum* has not yet become recorded although this species has a much wider pH-range than *Plagiomnium undulatum* (cf. SJÖGREN 1962). *P. cuspidatum* occurs on almost all types of substrates in northern and central Europe. The species is frequently fertile. However, diaspores in amounts necessary have apparently not reached Macaronesia to some extent, probably due to insularity obstacles. Substrates and suitable habitat conditions are richly available in the Azores.

*Plagiothecium undulatum* (Hedw.) B.S.G. (Plagiotheciaceae)

Still no record in Macaronesia. - In most European countries, preferentially growing in the oceanic westernmost parts of the continent; AS, AM. Several records in continental Portugal and in Spain (see CASAS et al. 1992).

The European presence of *P. undulatum* is on rock surfaces and on acid soil in forests, also in heath vegetation and on peat in mires. This large and nice looking species is easily recognizable due to morphology and colour. It occurs frequently in patches of large populations and has consequently hardly have been overlooked in the Azores.

The bottom layer in Azorean native forests at high altitudes, where habitat conditions are suitable for *P. undulatum*, is mostly occupied by species such as *Tetrastichium fontanum* and *Cyclodictyon laetevirens*. Today, on sloping, sheltered escarpments, where one might expect the presence of *P. undulatum*, there is on the other hand a dominance of *Nardia scalaris*, *Andoa berthelotiana*, *Fissidens* spp. or/and *Alphosia azorica* and several hepatics, leaving

little space for an intrusion of alien species of bryophytes. – *P. undulatum* is an acidicolous mountain species in S Europe, unexpectedly absent (or still not recorded) in the Azores, where it can be a member of several vegetation types.

*Pohlia cruda* (Hedw.) Lindb. (Bryaceae)

Az.: P. - Can. - In most European countries; AS, AFR, AU, OC, ANT. Cosmopolitan.

This acidicolous species is preferentially epilithic. It grows e.g. in fissures of shaded steep rocks. The actual presence of *P. cruda* in the Azores is questionable. The species has not been recorded by the author during fieldwork carried out since 1965 although carefully looked for. The bright metallic sheen of the leaves of this species is typical. Localities with suitable habitat conditions for the species are available in all the nine Azorean islands.

*Rhytidiadelphus loreus* (Hedw.) Warnst. (Hypnaceae)

Az.: P, T. - Mad. - In several European countries, getting progressively more frequent towards the oceanic parts; AS, AM.

Three localities on Pico. One as epigeic on a hummock in a mire at Caveiro (1000 m a.s.l.), two in Bocas do Fogo in the Mistério de Santa Luzia, at 1050 and 1150 m of altitude, on the steep walls of the craters. One recent (1997) locality on the western exterior slopes of Serra de Santa Bárbara, Terceira, where the species grows on a vertical escarpment in a narrow strongly shaded ravine at 600 m (SJÖGREN 1997). The Caveiro-locality in Pico was found by the author in 1965 and has been documented at several occasions since then. It has remained unchanged for almost 40 yrs, with a small population covering about 1/4 m<sup>2</sup>.

*R. loreus* is also a rare species in Madeira and was considered as new to Macaronesia when it was first recorded (LUISIER 1927, 1945).

*R. loreus* is a common species in forests in western Europe. The species grows on almost all types of substrates and is acidicolous. Suitable habitat conditions prevail in several localities at

high altitudes in the Azores both in the native *Juniperion*-forests and in the mires and in the seminatural grazing land. In spite of that *R. loreus* is still one of the most rare bryophytes in the Azores.

## DISCUSSION

The establishment of plant species in a locality is a result of their dispersal ability (differentiation of diaspores), the supply of suitable habitat conditions and the ability to compete initially with species already established in a locality.

It is naturally impossible to describe in detail how the Azorean islands have progressively become colonized by bryophytes in coordination with vascular plants. It is much easier to give prognoses for a future development, including both the appearance of new species and of their possibilities to become established in species groups or plant communities.

A bryotaxonomist, working on recordings in the Azorean islands, has the aim to record as many species as possible in the individual islands. There will soon appear questions why certain species occur just in a few islands in the archipelago and eventually also why certain species do not appear at all or at least are not recorded yet. The bryoecologist includes under such circumstances experiences on habitat preferences of species. The richness of different habitat conditions is not the same in the nine Azorean islands.

The statement that a bryophyte species does not occur in one island should naturally better become substituted by the information that the species has not yet become recorded. The report on the non-existence of a certain species is, however, generally a product of frequent search in the field with the elimination of areas offering quite unsuitable habitat conditions.

Here are a few examples: The presence of *Rhytidiadelphus loreus* in the Azores has been expected, due to the habitat demands of this oceanic species. It has become recorded in Pico in three localities only. The recently recorded presence in the island of Terceira (SJÖGREN 1997) was expected but the “absence” in the high islands of São Jorge and Faial and the two

westernmost islands of Flores and Corvo is puzzling.

The recorded presence of *Hookeria lucens*, a suboceanic species, in the Azores is in São Miguel, Terceira, Pico and Flores. Its “absence” in São Jorge, Faial, and Corvo, where suitable habitat conditions are available in a lot of localities, is less sure than the “absence” in the two dry islands of Santa Maria and Graciosa. Still the low number of localities and the small populations of *Hookeria* in the four islands mentioned, is puzzling.

The absence in the Azores of several cosmopolitan or in continental Europe widespread bryophytes is remarkable. There are for example no records in the Azores of *Hedwigia ciliata* although the species is present both in Madeira and in the Canary Islands. This epilithic, not shade tolerant, species has many suitable sites in the Azores and the “absence” may just be explained by difficulties for diaspores to reach these remote islands. However, the most probable and important reason for the “absence” of *Hedwigia* may be the actual occupation of rocks and boulders, in nonshaded habitats, by strongly competitive species creating the epilithic endemic bryo-community *Ptychomitrium azorici*. This community is composed of several richly diaspore-creating bryophytes, mostly mosses.

The possible influx to “new species” today to the Azores, expected to establish themselves due to available suitable habitat conditions, is most probably checked by the competition of already firmly established species.

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