

EPIPHYLLOUS BRYOPHYTES IN THE AZORES ISLANDS

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Epiphyllous vegetation is typical of tropical rainforests. The extratropical presence of a large number of epiphyllous bryophytes on the Macaronesian Island groups of the Azores, Madeira and the Canary Islands is thus remarkable. The present paper deals with Azorean epiphyllous flora and vegetation. The material treated consists of 963 samples (568 epiphyllous) with presence of preferentially epiphyllous bryophytes, mostly hepatics. Several species belong to the families Lejeuneaceae and Radulaceae (sampling time 1965-1995 on all nine Azorean islands). The epiphyllous samples originate from 30 different host plants or phorophytes. Information has been provided on ecology, sociology and vulnerability of the species. The high frequency of epiphyllous bryophytes in localities suggested for protection has been discussed, the selection being in many cases only founded on presence of endemic vascular plants. Among the 89 species recorded as epiphyllous, 21 species are preferentially epiphyllous and 14 species are endemic either to the Azores or to Macaronesia. They are more or less frequent members of the endemic epiphyllous bryo-community, the *Cololejeuneo-Colurion: Cololejeuneetum azoricae* Sjn. 78. Optimal habitat conditions for epiphyllous bryophytes are between 700-1000 m (central island group). Within that altitude range have been recorded the largest numbers of colonized phorophyte species and as well the largest numbers of associated preferentially epiphyllous species in the samples (means of more than 3.5 species). The phorophytes recorded as preferentially colonized by the epiphyllous bryophytes are: (1) *Blechnum*, *Trichomanes*, *Elaphoglossum* (pteridophytes); (2) *Ilex*, *Laurus* (trees/shrubs); (3) *Hedera* (herbs); (4) *Thamnobryum* (bryophytes). A few areas with endemic native forest (*Juniperion brevifoliae*) have been considered for preservation in the Azores. The presence within these forest areas of epiphyllous bryophytes is characterized by: (1) high diversity of species, (2) several preferentially epiphyllous species also occur as epiphytic and as epixylic, (3) a large number of different phorophyte species, (4) a large number of Azorean/Macaronesian endemic species, (5) a large number of species with status as rare, vulnerable or endangered according to "Red Data Book of European Bryophytes" (several changes of status suggested in this paper).

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A vegetação epífila é típica das florestas tropicais húmidas. A presença extratropical de um grande número de briófitos epífilos nos arquipélagos da Macaronésia, Açores, Madeira e Canárias, torna-se, por isso, notável. Este artigo refere-se à flora e vegetação epífila dos Açores. O material em análise consiste em 963 amostras (568 epífilos) incluindo os epífilos preferenciais, na sua maioria hepáticas. Muitas destas espécies pertencem às famílias Lejeuneaceae e Radulaceae. As amostras foram colhidas entre 1965 e 1995, em todas as nove ilhas dos Açores. Estas amostras foram recolhidas de 30 plantas-suporte (ou forófitos) diferentes. Aqui fornece-se informação sobre a ecologia, sociologia e vulnerabilidade destas espécies de briófitos. Por outro lado, discute-se a sua alta frequência em locais já sugeridos para protecção, mas com base apenas em plantas vasculares endémicas. Entre as 89 espécies encontradas como epífilas, 21 são preferencialmente epífilas e 14 são endémicas, quer dos Açores, quer da Macaronésia, sendo membros mais ou menos

frequentes da brio-comunidade epífila *Cololejeuneo-Colurion: Cololejeuneetum azoricae* Sjn. 78. As condições ótimas de habitat para estas espécies encontram-se entre os 700 a 1000 m de altitude (nas ilhas do grupo central). Dentro destes limites de altitude, tem sido encontrado o maior número de diferentes espécies forófitas colonizadas, bem como o maior número de espécies preferenciais epífilas associadas (médias de mais de 3,5 espécies). Os dados apontam como sendo forófitos preferenciais: (1) *Blechnum*, *Trichomanes*, *Elaphoglossum* (pteridófitos); (2) *Ilex*, *Laurus* (árvores/arbustos); (3) *Hedera* (herbaceas); (4) *Thamnobryum* (briófitos). Algumas áreas com floresta nativa endémica dos Açores (*Juniperion brevifoliae*), tem sido apontadas para áreas protegidas. A presença, nestas áreas, dos briófitos epífilos caracteriza-se por: (1) alta diversidade de espécies, (2) várias espécies de epífilos preferenciais também ocorrem como epífitos e como epixílicos, (3) um grande número de espécies forófitas, (4) possuírem um grande número de espécies endémicas açorico/macaronésicas, (5) possuírem um grande número de espécies com o status de rara, vulnerável ou em perigo, de acordo com o "Red Data Book of European Bryophytes" (algumas alterações do status são sugeridas neste artigo).

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INTRODUCTION

Comprehensive lists of literature on epiphyllous bryophytes have been provided by, e.g. ALLORGE, V. & ALLORGE, P. (1938), WINKLER (1967), SJÖGREN (1975), POCS (1978), BOECKER et al. (1993). Early papers treating epiphyllous bryovegetation were published by, e.g., HERZOG (1926), SCHIFFNER (1929), RICHARDS (1932).

The presence of bryophytes, mostly hepatics, on leaves of evergreen trees is a characteristic feature of tropical rainforests and mistforests. The first comprehensive publication on a species-rich epiphyllous bryo-vegetation existing in Europe, namely in the Azores Islands (ALLORGE, V. & ALLORGE, P. 1938), was consequently sensational and certainly promoted interest among bryologists

to carry out more studies of the Azorean bryoflora. Investigations by the Swedish bryologist Herman Persson, mainly in the 1930s, which led to several publications treating new species as well as phytogeographically remarkable bryophytes, also acted as an important source of inspiration.

The diminutive size of the epiphyllous bryophytes and difficulties to determine many of the species of the families Lejeuneaceae, Frullaniaceae, Radulaceae and Metzgeriaceae probably hindered early studies of epiphyllous vegetation in Macaronesia. Only a few more or less preferentially epiphyllous hepatics were, e.g., documented by MITTEN (1870) namely *Radula aquilegia* (Madeira, Azores), *Lejeunea lamacerina* (Canaries, Madeira, Azores), *Cololejeunea minutissima* (Madeira), *Dicranolejeunea johnsoniana* (Madeira), *Drepanolejeunea hamatifolia* (Madeira; on *Porella canariensis*), *Heteroscyphus denticulatus* (Madeira). Even the much later comprehensive studies by ADE & KOPPE (1942) include only a few of the preferentially epiphyllous Azorean species.

The present paper deals with all bryophytes recorded by the author as epiphyllous in the Azores (89 species). Not only strongly preferentially epiphyllous species have been treated, which facilitates the understanding of transitions to, e.g., epiphytic or epixylic communities, transitions which are mostly stages

of development or of degradation of the epiphyllous bryo-communities.

Studies of bryo-communities of continental Europe in general show a tendency to overemphasize the presence of "pure", strictly delimited communities. A few studies of Macaronesian bryo-vegetation (v. HÜBSCHMANN 1971, 1974) are unfortunately examples of this tendency, leading to descriptions of numerous more or less local miniassociations, mostly characterized by dominant species. The aims to range Macaronesian endemic bryo-communities, synsystematically under Central-European alliances and orders has also led to unfortunate results. This approach seems especially dubious, considering the high frequency of Azorean/Macaronesian endemic species in most of the Azorean communities described. Also bryo-communities of central and northern Europe tend in a westward direction to become less easily characterized by differential species with high differential values. This feature of importance to the work on bryo-ecology and bryo-sociology becomes strongly accentuated in Macaronesia.

Man does not like chaos. Azorean bryo-vegetation may appear highly chaotic in several aspects, with numerous transitions between communities and numerous different primary stages of succession on various substrates, linked to accidental diaspore supply and "first on the spot" effects. In general, it is unwise to try to explain all combinations of species using ecological correlations. This is naturally also the case with epiphyllous bryo-communities, which mostly consist of short-term presence of primarily colonizing, weakly competitive and very small hepatics. The constitution of these communities and the species dominance is often accidentally linked to diaspore supply (cf. OLARINMOYE 1975b) and the frequency of colonizing species rapidly becoming fertile.

Establishment of the epiphyllous hepatics depends on the season of diaspore supply. Survival and development at the beginning of the rainy season is usually less successful than at the end, when diaspores do not get so easily washed away from glabrous leaf-surfaces (cf. WINKLER 1967). There are also habitat conditions with

accidental properties (wind, temperature, moisture supply etc.) of extreme nature, difficult to measure, but of great importance to colonization and survival of the epiphyllous bryophytes. They invade and die hardly as a consequence of mean values of environmental conditions. Mean values of annual precipitation and air humidity are thus only rough indications of habitat conditions, favourable to the existence or not of optimally or suboptimally developed epiphyllous vegetation.

The material treated in this paper consists of 963 samples (568 epiphyllous). The sampling was carried out between 1965 - 1995, on all the Azorean islands (samples now in UPSV). Absence or very scarce presence of epiphyllous species on Santa Maria and Graciosa and insufficient recording on Flores had the consequence that material from these islands has not been reported in the tables. Non-epiphyllous samples have been treated only if containing one or more preferentially epiphyllous species. The epiphyllous samples were mostly collected in order to study the sociology of the epiphyllous bryo-vegetation. Each sample required determination of up to 12 different species. In order to provide information on ecological preferences and ranges of individual species and species combinations, information was regularly collected on type of substrate, on hostplants or *phorophytes* (cf. OCHSNER 1927), on degree of senescence of the *phorophyte* substrate, on altitude of the localities, shelter, etc.

The presence of the species on various types of material has been treated as follows: as *epiphyllous* are treated species growing on leaves of trees and shrubs, on fronds and stems of ferns and other vascular field layer plants or on large bryophytes (specimens of ferns and bryophytes may grow both on the ground, on cliffs and on tree trunks); as *epiphytic* on stems of trees and shrubs; as *epixylic* on stems, branches or pieces of bark on the ground or on a slightly decomposed leaf litter carpet; as *epilithic* on stone and rock surfaces with no or almost no accumulation of soil or litter; as *epigeic* on mineral soil of more or less coarse material and on strongly decomposed litter carpet (cf. SJÖGREN 1975, p. 218). Transitions between substrate types occur frequently.

Presence, e.g. on tree trunks with loosely attached and highly decomposed pieces of bark, at bases of trunks, is more epixylic than epiphytic; presence on ferns where senescence has affected more than 50 % of the fronds is more epixylic than epiphyllous.

The fairly large size of the epiphyllous material treated and studied within the time period mentioned of a very large number of samples for differentiation of epigeic, epilithic and epixylic bryo-communities have formed a platform for suggestions of the rarity of several Azorean bryophytes and their status in the discussion on the need for protection (see chapters "Ecology, sociology, vulnerability" and "Threatened bryophytes in the Azores").

NOMENCLATURE AND TAXONOMY

Hepatics and mosses are in general treated according to GROLLE (1983) and CORLEY et al. (1981); vascular plants according to HANSEN & SUNDING (1985).

The following mosses and hepatics of the Azorean bryoflora appear with new names (due to changes of nomenclature or taxonomic revision). A few species are new to the archipelago or have been newly described (cf. CORLEY & CRUNDWELL 1991; DÜLL 1983, 1992; HEDENÄS 1992; SMITH 1990). For comparison see EGGERS (1982). As a guide to bryologists investigating the Azorean bryo-flora also nonepiphyllous species have been listed below:

Mosses

- Sphagnum denticulatum* Brid.
(*S. lescurii* Sull. var. *auriculatum*)
Fissidens coacervatus Brugg.-Nann.
(n. sp.)
Fissidens sublineaefolius (P. Varde) Brugg.-Nann.
(new to the Azores)
Fissidens dubius P. Beauv.
(*F. cristatus* Wills. - ex Milde)
Microcampylopus laevigatus (Thér.) Giese et Frahm

- (*Campylopodium euphorocladum* (C. Müll.) Besch.)
Campylopus pyriformis (Schultz) Brid.
(*C. calvatus* Dix.)
Campylopus cygneus (Hedw.) Brid.
(*C. setaceus* Card.)
Campylopus shawii Wils. - ex Hunt.
(*C. carreiroanus* Card.)
Campylopus flaccidus Ren. et Card.
(*C. ampliretis* (C. Müll.) Ren. et Card.)
Ptychomitrium polyphyllum (Sw.) B. et S.
(incl. *P. azoricum* (Card.) Par.)
Brachymenium notarisii (Mitt.) Shaw
(*Haplodontium notarisii* (Mitt.) Broth.)
Homalia webbiana (Mont.) Schimp.
(*Neckera webbiana* (Mont.) Düll)
Homalia lusitanica Schimp.
(*H. surrecta* (Mitt.) Jaeg.)
Tetrastichium virens (Card.) Churchill
(*Lepidopilum virens* Card.)
Warnstorfia fluitans (Mitt.) Loeske
(*Drepanocladus fluitans* (Hedw.) Warnst.)
Rhynchostegium surrectum (Mitt.) Jaeg.
(*Rhynchostegiella surrecta* (Mitt.) Broth.)
Rhynchostegiella tenella (Dicks.) Limpr.
(*R. bourgeana* (Mitt.) Broth.)
Pseudotaxiphyllum elegans (Brid.) Iwats.
(*Isopterygium elegans* (Brid.) Lindb.)
Pseudotaxiphyllum laetevirens (Koppe et Düll) Hedenäs
(*Isopterygium elegans* var. *laetevirens* Koppe et Düll)
Andoa berthelotiana (Mont.) Ochyra
(*Allorgea berthelotiana* (Mont.) And.

Hepatics

- Riccia huebeneriana* Lindenb.
(new to the Azores)
Lophozia bicrenata (Schmid. - ex Hoffm.) Dum.
(*Isopaches bicrenatus* (Schmid. - ex Hoffm.) Buch)
Anastrophium minutum (Schreb.) Schust.
(*Sphenolobus minutus* (Schreb.) Berggr.)
Plagiochila exigua (Tayl.) Tayl.
(*P. corniculata* (Dum.) Dum.)
Plagiochila killarniensis Pears.

(incl. <i>P. spinulosa</i> var. <i>macaronesiana</i> Allorge)	S	Santa Maria
<i>Lophocolea bidentata</i> (L.) Dum.	M	São Miguel
(<i>L. cuspidata</i> (Nees) Limpr.)	T	Terceira
<i>Chiloscyphus polyanthos</i> var. <i>pallidus</i> (Ehrh. - ex Hoffm.) Hartm.	G	Graciosa
(<i>C. pallidus</i> (Ehrh. - ex Hoffm.) Dum.)	J	São Jorge
<i>Heteroscyphus denticulatus</i> (Mitt. in Godman) Schiffn.	P	Pico
(<i>Chiloscyphus denticulatus</i> Mitt.)	F	Faial
<i>Cephalozia crassifolia</i> (Lindenb. et Gott.) Fulf.	L	Flores
(<i>C. hibernica</i> Spruce - ex Pears.)	C	Corvo
<i>Cephalozia bicuspidata</i> var. <i>lammersiana</i> (Hüb.) Breidl.	m	m a.s.l. = metres above sea level
(<i>C. lammersiana</i> (Hüb.) Spruce)	ass.	association
<i>Calypogeia azurea</i> Bischl. et Crotz	all.	alliance
(<i>C. trichomanis</i> (L. em. K. Müll.) Corda)	diff. sp.	differential species
<i>Aphanolejeunea madeirensis</i> (Schiffn.) Grolle	diff. val.	differential value
(<i>Cololejeunea madeirensis</i> (Tayl.) Schiffn.)	distrib.	distribution
<i>Aphanolejeunea microscopica</i> (Tayl.) Evans	preferentially	preferentially
(<i>Cololejeunea microscopica</i> (Tayl.) Schiffn.)	u.c.	together with
<i>Aphanolejeunea teotonii</i> Jov.-Ast. et V. All.	RDB	Red Data Book of European Bryophytes (SCHUMACKER & MARTINY 1995; STEWART 1995)
(<i>Cololejeunea teotonii</i> (Jov.-Ast. et V. All.) Grolle)		

Abbreviations

EUR (C W S)	central, western, southern parts of Europe
AS 1-4	Asia
AFR 1-5	Africa
AU 1, 2	Australia
AM 1-6	America
OC	Oceania
Az	Azores Islands
Br	Britain
Cn	Canary Islands
Cv	Cabo Verde Islands
Hb	Ireland
Hs	Spain
Lu	Portugal
Ma	Madeira
Mac	Macaronesia
CAZ	Central island group (TJPGF)
EAZ	Eastern island group (MS)
WAZ	Western island group (LC)

DISTRIBUTION OF SPECIES

The Azorean epiphyllous community may be looked upon as the most remarkable and precious of all bryo-communities in the archipelago. Among the species recorded as more or less preferentially epiphyllous (Table 1) are 5 species endemic to the Azores and 9 species endemic to Macaronesia. Only a few of the Azorean/Macaronesian endemics, which are preferentially epigeic or epilithic, do not occur as epiphyllous (e.g. *Alophosia*, *Breutelia*, *Echinodium renauldii*). Several of the species are exclusively Macaronesian - West European, with only few localities on the European continent (e.g. *Acrobolbus*, *Harpalejeunea*, *Marchesinia*, *Lejeunea holtii*, *Radula holtii*). The main distribution of *Calypogeia fusca* is in Africa/Asia. *Campylopus cygneus* is an Azorean/Caribbean species and *Radula nudicaulis* is a Macaronesian/South American species. For further information on the phytogeographical elements in the Azorean bryo-flora, see ALLORGE, V. & ALLORGE, P. (1948).

In general, there are a large number of geographically remarkable taxa among the

Table 1

Bryophytes recorded as epiphyllous in the Azores; actual presence on the nine islands; sampled on different types of substrate, preference underlined (p- epiphyllous, f- epiphytic, x- epixylic, g- epigeic, l- epilithic; world distribution (abbreviations according to the "Red Data Book" 1995); other abbreviations see Introduction.

The table shows: the predominance of hepatics (h); the low number of epiphyllous species on the low altitude islands of Santa Maria (S), Graciosa (G) and Corvo (C); the high number of endemic species within the group of species with recorded epiphyllous growth and the large number of oceanic/euocenic (Europe) species. (Records of the species after 1995 as new to individual islands or island groups not introduced.)

epiphyllous species	Azorean distr.	substrate	world distribution
h Acrobolus wilsonii Nees	.M..JP...	p f x g l	Ma - Br Fa Hb
h Adelanthus decipiens (Hook.) Mitt.	.MT..PFL.	p f x g l	Ma - W EUR, AFR 24, AM 34
Andoa berthelotiana (Mont.) Ochyra	SMTGJPFLC	p f x g l	Ma Cn - <u>endemic Macaronesia</u>
h Aphanolejeunea madeirensis (Schiffn.) Grolle	.MT.JPFL.	p f x g l	Ma - <u>endemic Macaronesia</u>
h Aphanolejeunea microscopica (Tayl.) Evans	.MT.JPFL.	p f x . .	Ma Cn - W EUR, AFR 2, AS 4
h Aphanolejeunea teutonii Jov.-Ast et V. All.	.MTGJPFLC	p f x . .	Ma Cn - <u>endemic Macaronesia</u>
h Bazzania azorica Buch et H. Perss.	.MT.JPFL.	p f x g l	<u>endemic Azores</u>
Brachythecium populeum (Hedw.) B.S.G.	.MTGJPFL.	p f x g l	- EUR, AFR 12, AS 1235, AM 1
Brachythecium velutinum (Hedw.) B.S.G.	.MT..PFLC	p f x . l	Ma Cn - EUR, AFR 1, AS 125, AM 1
h Calypogeia fissa (L.) Raddi	SMTGJPFLC	p f x g l	Ma Cn - almost cosmopolite (not AU)
h Calypogeia fusca (Lehm.) Steph.	.MT.JPFL.	p f x g l	- AFR 234, AS 4
h Calypogeia muelleriana (Schiffn.) K. Müll.	.MT.JPFLC	p f x g l	Ma Cn - EUR, AFR 1, AS 1, AM 1
h Calypogeia neesiana (Mass. et Carest.) K. Müll.	.MT.J..L.	p . . g l	- EUR, AS 12, AM 1
h Campylopus cygneus (Hedw.) Brid.	SMT.JPFL.	p f x g l	- AM 3
h Cephalozia crassifolia (Lindenb. et Gott.) Fulf.	.MT.JPFL.	p f x g l	Ma - Hb Hs, AM 234
h Cheilelejeunea cedercreutzii (Buch et H. Perss.) Grolle	.MT..PF..	p f x . .	<u>endemic Azores</u>
h Chilosecyphus polyanthos v. pallescens (Ehrh.) Hartm.	.MT.J...C	p . x . .	Ma - EUR, AFR 1, AS 12, AM 1
h Cololejeunea azorica V. All. et Jov.-Ast	.MTGJPFLC	p f x . .	Ma - <u>endemic Macaronesia</u>
h Cololejeunea minutissima (Sm.) Schiffn.	SMTGJPFLC	p f x . l	Ma Cn - W EUR, AFR 1234, AM 13
h Colura calyptrifolia (Hook.) Dum.	.MT.JPFLC	p f x . .	Ma Cn - W EUR, AFR 2, AM 456
h Cyclodictyon laetevirens (Hook et Tayl.) Mitt.	.MT..P...	p f x . l	Ma Cn - Br Hb Hs, AFR 24, AS 2
h Daltonia splachnoides (Sm.) Hook. et Tayl.	.MT.JP...	p f x . .	Ma - Br Hb, AFR 2, AM 23, AS 2, AU 12
h Dicranolejeunea johnsoniana (Mitt.) Grolle	..T.JP...	p . . g .	Ma Cn - <u>endemic Macaronesia</u>
h Dicranum scottianum Turn. s.l.	.MT.JPFLC	p f x . l	Ma Cn - W + C EUR
h Diplophyllum albicans (L.) Dum.	SMT.JPFLC	p f x g l	Ma Cn - EUR, AFR 1, AS 125, AM 1, OC
h Drepanolejeunea hamatifolia (Hook.) Schiffn.	.MTGJPFLC	p f x g l	Ma Cn - Br Ga Hb Hs Lu, AFR 24
h Dumortiera hirsuta (Sw.) Nees	.MTGJPFLC	p f x g l	Ma Cn - W EUR, cosmopolite
h Echinodium prolixum (Mitt.) Broth.	.MTGJPFLC	p f x g l	Ma - <u>endemic Macaronesia</u>
h Eurhynchium praelongum (Hedw.) B.S.G. s.l.	SMTGJPFLC	p f x g l	Ma Cn - almost cosmopolite
h Fissidens serrulatus Brid.	SMTGJPFLC	p f x g l	Ma Cn - W EUR, AFR 1
h Frullania microphylla v. decuduifolia Grolle	.MTGJPFLC	p f x . l	Ma Cn - Lu
h Frullania tamarisci (L.) Dum.	SMTGJPFLC	p f x g l	Ma Cn - EUR, AFR 12, AS 125
h Frullania teneriffae (F. Web.) Nees	.MT.JPFLC	p f x g l	Ma Cn - W EUR, AFR 1
h Harpalejeunea ovata (Hook.) Schiffn.	SMTGJPFLC	p f x g l	Ma Cn - W EUR
h Herbertus azoricus (Steph.) Richards	.MT.JPFLC	p f x g l	<u>endemic Azores</u>
h Heterocladium heteropterum B.S.G. s.l.	.MT.JPFLC	p f . g l	Ma Cn - EUR, AFR 1, AM 1
h Heteroscyphus denticulatus (Mitt.) Schiffn.	.M.GJPFLC	p . . g l	Ma Cn - <u>endemic Macaronesia</u>
h Hylocomium splendens B.S.G.	.MT.JP...	p . . g .	Ma Cn - cosmopolite
h Hylocomium armoricum (Brid.) Wijk et Marg.	....J....	p f x g l	Ma Cn - EUR, AS 125
h Hypnum uncinulatum Jur.	SMTGJPFLC	p f x g l	Ma Cn - Hb Lu
h Jubula hutchinsiae (Hook.) Dum.	.MT.JPFLC	p f x g l	Ma Cn - Br Fa Ga Hb Hs, AFR 2 (Cv)
h Lejeunea cavifolia (Ehrh.) Lindb.	.MT.....	p	Ma Cn - EUR, AFR 1, AS 15, AM 1
h Lejeunea eckloniana Lindenb.	.MT.....	p . . g l	Ma Cn - AFR 2 (Cv) 34

(cont.)

(Table 1 continued)

epiphyllous species	Azorean distr.	substrate	world distribution
h <i>Lejeunea flava</i> ssp. <i>moorei</i> (Lindb.) Schust.	.MT.JPFLC	p f x g l	Ma Cn - Hb, AFR 2 (Cv)
h <i>Lejeunea holtii</i> Spruce	SMT.JPFLC	p f x g l	Ma Cn - Hb Hs
h <i>Lejeunea lamacerina</i> (Steph.) Schiffn.	.MTGJPFLC	p f x g l	Ma Cn - W EUR
h <i>Lejeunea patens</i> Lindb.	SMT.JPFLC	p f x g l	Ma Cn - W EUR, AS 5
h <i>Lejeunea ulicina</i> (Tayl.) Gott. et al.	.MTGJP.L.	p f . . l	Ma Cn - EUR, AFR 24, AS 25, AM 1
h <i>Lepidozia azorica</i> Buch et H. Perss.	.MT.JPFLC	p f x g .	<u>endemic Azores</u>
h <i>Lepidozia cupressina</i> (Sw.) Lindenb. in Gott.	.MT.JPFL.	p f x g l	Ma Cn W EUR, AS 23, AM 34
h <i>Lepidozia reptans</i> (L.) Dum.	.MT.JPFLC	p f x g l	Ma - EUR, AS 12345, AM 14, OC
h <i>Leptoscyphus azoricus</i> (Buch et H. Perss.) Grolle	.MT.JP...	p f . . .	<u>endemic Azores</u>
h <i>Leucobryum juniperoides</i> (Brid.) C. Müll.	SMT.JPFLC	p f x g l	Ma Cn - W EUR, AS 23, AM 34
h <i>Lophocolea bidentata</i> (L.) Dum.	.M.GJPFLC	p f x g .	Ma Cn - almost cosmopolite
h <i>Lophocolea fragrans</i> (Moris et De Not.) Gott.	.MTGJPFLC	p f x g l	Ma Cn - W EUR, AFR 123
h <i>Lophocolea heterophylla</i> (Schrad.) Dum.	.MTG..FL.	p f x g .	Ma Cn - EUR, AFR 1, AS 1235, AM 1
h <i>Lophozia ventricosa</i> (Dicks.) Dum.	.T.JPFL.	p f x g l	- EUR, AS 12345, AM 1
h <i>Marchesia mackaii</i> (Hook.) S. Gray	.MTGJPFL.	p f x g l	Ma Cn - W EUR
h <i>Metzgeria conjugata</i> Lindb.	....JPFC	p f x . .	Ma Cn - EUR, almost cosmopolite
h <i>Metzgeria furcata</i> (L.) Dum.	.MT.JPFLC	p f x g l	Ma Cn - cosmopolite
h <i>Metzgeria leptoneura</i> Spruce	.MT.JPFL.	p f x g l	Ma Cn - almost cosmopolite
h <i>Myurium hochstetteri</i> (Schimp.) Kindb.	SMTGJPFLC	p f x g l	Ma Cn - Br
h <i>Nardia scalaris</i> S.F. Gray	.MT.JPFLC	p f . g l	Ma Cn - EUR, AFR 1, AS 123, AM 1
h <i>Nowellia curvifolia</i> (Dicks.) Mitt.	.MT.JPFL.	p f x . .	Ma - EUR, AS 12345, AM 124
h <i>Odontoschisma denudatum</i> (Nees et Mart.) Dum.	.MT.JPFLC	p f x g l	Ma - EUR, AS 123, AM 1235
h <i>Odontoschisma sphagni</i> (Dicks.) Dum.	.MT.JPFLC	p f x g l	Ma - EUR, AM 1
h <i>Plagiochila allorgei</i> Herz. et H. Perss.	.MT.JPFL.	p f x g l	<u>endemic Azores</u>
h <i>Plagiochila exigua</i> (Tayl.) Tayl.	.MTGJPFLC	p f x g l	Ma Cn - W EUR, AM 126
h <i>Plagiochila spinulosa</i> (Dicks.) Dum. s.l.	.MTGJPFLC	p f x g l	Ma Cn - W EUR
h <i>Plagiomnium undulatum</i> (Hedw.) T. Kop.	.MT.JPFLC	p . x g l	Ma Cn - EUR, AFR 13, AS 12345
h <i>Plagiothecium nemorale</i> (Mitt.) Jaeg.	.MT.JPFL.	p f x . l	Ma Cn - EUR, AFR 1, AS 125, AM 1
h <i>Pseudotaxiphyllum elegans</i> (Brid.) Iwats.	.MT.JPFLC	p f x g l	Ma - EUR, AFR 1, AS 1, AM 1, AU 2
h <i>Pseudotaxiphyllum laetevirens</i> (Koppe et Düll.) Hedenäs	.MT.J....	p . x g l	Ma - Hs
h <i>Radula aquilegia</i> (Hook. f. et Tayl.) Gott.	.MT.JPFLC	p f x g l	Ma Cn - W EUR, AS 3
h <i>Radula carringtonii</i> Jack.	SMTGJPFLC	p f x g l	Ma Cn - W EUR, AM 2
h <i>Radula holtii</i> Spruce	.MT.JPFL.	p f x g l	Ma Cn - Hb Hs Lu
h <i>Radula lindenberghiana</i> Gott. - ex Hartm.	SMTGJPFL.	p f . g l	Ma Cn - EUR, AFR 134, AS 1235, AM 1
h <i>Radula nudicaulis</i> Steph.	.M...PF..	p f . g l	Ma - AM 45
h <i>Radula wichurae</i> Steph.	SMTGJPFL.	p f . g l	Ma Cn - <u>endemic Macaronesia</u>
h <i>Rhynchostegiella tenella</i> (Dicks.) Limpr.	.M...F..	p . . g l	Ma Cn - EUR, AFR 12, AS 25
h <i>Riccardia multifida</i> (L.) S.F. Gray	.MT.JPFL.	p f x g l	Ma Cn - almost cosmopolite (not AU)
h <i>Saccogyna viticulosa</i> (L.) Dum.	SMT.JPFLC	p f x g l	Ma Cn - W + S EUR
h <i>Scapanis gracilis</i> Lindb.	.MT.JPFL.	p f x g l	Ma Cn - W + S EUR, AFR 1
h <i>Sematophyllum substrumulosum</i> (Hampe) Britt.	SMTGJPFLC	p f x g l	Ma Cn - W + S EUR, AFR 1
h <i>Telaranea nematodes</i> (Gott. et Aust.) Howe	.MT.JPFL.	p f x g l	Ma Cn - W EUR, AFR 234, AM 12345
h <i>Tetrastichium fontanum</i> (Mitt.) Card.	SMTGJPFLC	p f x g l	Ma Cn - <u>endemic Macaronesia</u>
h <i>Tetrastichium virens</i> (Card.) Churchill	.MTGJPFLC	p f x g l	Ma Cn -
h <i>Thamnobryum alopecurum</i> (Hedw.) Nieuwl. s.l.	.MT.JPFLC	p f x g l	Ma Cn - EUR, AFR 1, AS 1235, AM 1
h <i>Thuidium tamariscinum</i> (Hedw.) B.S.G.	.MT.JPFLC	p f x g l	Ma - EUR, AFR 124, AS 25, AM 235

epiphyllous species, especially those with a widely disjunct distribution. These species belong to a Macaronesian/Tropical Element (cf. GREIG-SMITH 1950). Nowadays they have a fragmented, widely scattered distribution in W. Europe, probably due to postglacial periods with unfavourable less humid and cooler climatic conditions (cf. FRAHM 1995). The occurrence of

these European/Tropical species in Macaronesia, being a link between impoverished European and abundant tropical presence, is important to the understanding of the history of the West-European bryo-flora. Several of the species belong to the large tropical family Lejeuneaceae, with most of its species restricted to tropical areas.

The distribution of several of the epiphyllous species within the Azorean archipelago (Table 1) is restricted to the islands of Faial, Pico, S. Jorge, Terceira and S. Miguel, avoiding the low comparatively dry islands of Santa Maria and Graciosa. Several species are absent from Corvo where most of the cloud-zone forest has disappeared.

Several of the epiphyllous species are listed in the "Red Data Book of European Bryophytes" (see "Threatened bryophytes in the Azores"). All mature presence of epiphyllous vegetation in the island group depends on very special habitat conditions, presence of suitable phorophyte species and is more or less threatened by extinction or impoverishment and consequently worthy of protection.

ADDENDA TO TABLE I

Since the compilation of Table 1 was carried out in 1995 the following taxa have been added by the author as new to the island of Santa Maria in 1996: *Aphanolejeunea microscopica*, *A. teotonii*, *Chiloscyphus polyanthos* var. *pallidus*, *Cololejeunea azorica*, *Frullania microphylla* var. *deciduiifolia*, *Lejeunea flava* var. *moorei*, *Lepidozia reptans*, *Lophocolea bidentata*, *Lophocolea fragrans*, *Lophocolea heterophylla*, *Metzgeria furcata*, *Nardia scalaris*, *Odontoschisma sphagni*, *Plagiochila allorgei*, *Plagiochila spinulosa*, *Plagiomnium undulatum*, *Riccardia multifida*.

Only *Aphanolejeunea teotonii*, *Cololejeunea minutissima*, *Lejeunea lamacerina* and *Cololejeunea azorica* were recorded as epiphyllous, growing above 450 m on large leaves of *Hedychium gardnerianum*, in dark and very sheltered habitats. The annual precipitation in the localities is estimated to be ± 1600 mm, thus below the minimum amount required for development of a species-rich and sociologically mature *Cololejeuneetum azoricae*. (Samples of *Plagiomnium undulatum* were taken by Fernando E.A.P. Pereira; Universidade dos Açores, Angra do Heroísmo.).

SOCIOLOGY AND ASSOCIATED SPECIES

The composition of the Azorean epiphyllous bryo-community, with remarks on differential species and dominants, has been treated by the author (SJÖGREN 1978, 1993). Remarks on differential values of individual species have been given in this paper (see chapter "Ecology, sociology and vulnerability"). Consequently, some other aspects of coexistence of Azorean bryophytes, with preferentially epiphyllous species involved, will be treated below.

Table 2 lists all bryophytes recorded in the samples growing together with at least one of 15 preferentially epiphyllous hepatics. About 1/3 of the total number of Azorean bryophytes (± 450 spp.) occur in that list. Considering the large number of samples involved from six islands, sampled under various habitat conditions and on all types of substrates, this number is unexpectedly small. The reasons are that only few samples are epigeic and epilithic, and most of the preferentially epiphyllous species have fairly narrow ecological ranges.

Several of the listed species, known as preferentially epilithic, epixylic or epiphytic occur together with preferentially epiphyllous species only where the latter accidentally grow as nonepiphyllous (e.g. *Anastrophylum*, *Brachythecium plumosum*, *Fissidens asplenioides*). Only few species occur associated with preferentially epiphyllous species, restricted to the *Cololejeuneetum azorica* (e.g. *Dicranolejeunea johnsoniana*, *Heteroscyphus denticulatus*, *Radula nudicaulis*). The majority of the associated species are listed both from epiphyllous samples and from samples on other substrates. These species indicate the difficulties in the Azores to describe substrate-restricted bryo-communities equipped with characteristic species, only present on one or two substrate types. Even strongly preferentially epiphyllous species occur more or less accidentally, on several islands, also on other substrate types (e.g. *Aphanolejeunea teotonii*, *Cololejeunea azorica*,

Table 2

Bryophytes recorded on six Azorean islands, growing together with species which are more or less strongly preferentially epiphyllous; (1) epiphyllous presence, (2) on other substrates. h = hepatic.

	Islands Substrate	C		F		P		J		T		M	
		1	2	1	2	1	2	1	2	1	2	1	2
<i>Acrobolus wilsonii</i>	h	.	.	.	.	1	2	.	.	.	.	.	2
<i>Adelanthus decipiens</i>	h	.	.	.	.	1	2	.	.	.	.	1	2
<i>Anastrophyllum minutum</i>	h	.	.	.	.	.	.	2	.	.	.	.	.
<i>Andoa berthelotiana</i>		.	2	1	2	.	2	1	2	1	.	1	2
<i>Aneura pinguis</i>	h	.	.	.	.	.	2	.	.	.	.	.	.
<i>Anomobryum julaceum</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Aphanolejeunea madeirensis</i>	h	.	.	1	.	1	2	1	.	1	.	.	.
<i>Aphanolejeunea microscopica</i>	h	.	.	1	2	1	2	1	2	1	2	1	2
<i>Aphanolejeunea teotonii</i>	h	1	2	1	2	1	2	1	2	1	.	1	2
<i>Bazzania azorica</i>	h	.	.	.	.	1	2	.	2	1	2	.	.
<i>Bazzania trilobata</i>	h	.	.	.	.	.	.	.	2	.	.	.	2
<i>Blepharostoma trichophyllum</i>	h	.	.	.	.	.	.	.	2	.	.	.	.
<i>Brachythecium mildeanum</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Brachythecium plumosum</i>		.	2	.	2	.	2	.	2	.	.	.	.
<i>Brachythecium populeum</i>		.	.	.	.	.	2	1	2	.	.	.	.
<i>Brachythecium rivulare</i>		.	.	.	.	.	2	.	.	.	.	.	.
<i>Brachythecium rutabulum</i>		.	.	.	.	.	.	.	2	.	.	.	.
<i>Brachythecium salebrosum</i>		.	.	.	.	.	2	.	2	.	2	.	.
<i>Brachythecium velutinum</i>		.	2	1	2	.	2	.	.	.	2	.	.
<i>Bryum capillare</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Bryum torquescens</i>		.	.	.	.	.	.	.	2	.	.	.	.
<i>Calypogeia arguta</i>	h	.	.	.	2	.	.	.	.	.	.	.	.
<i>Calypogeia fissa</i>	h	.	.	.	2	.	2	1	.	.	.	.	2
<i>Calypogeia fusca</i>	h	.	.	.	.	1	2	.	2	.	.	.	.
<i>Calypogeia muelleriana</i>	h	.	.	.	2	.	2	1	2	1	2	.	2
<i>Calypogeia neesiana</i>	h	.	.	.	.	.	.	.	2	.	1	.	.
<i>Campylopus cygneus</i>		.	.	.	.	.	.	.	.	1	2	.	2
<i>Campylopus flexuosus</i>		.	.	.	.	.	.	.	2	.	.	.	.
<i>Campylopus pilifer</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Campylopus pyriformis</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Cephalozia bicuspidata</i>	h	.	.	.	.	.	2	.	.	1	.	.	.
<i>Cephalozia crassifolia</i>	h	.	.	.	.	1	2	.	2	1	2	.	.
<i>Cephaloziella divaricata</i>	h	.	.	.	.	.	.	.	.	.	2	.	.
<i>Cheilolejeunea cedercreutzii</i>	h	.	.	.	2	1	.	.	.	.	.	.	.
<i>Chiloscyphus polyanthos</i> var.	h	.	.	.	.	.	.	1	.	1	.	.	.
<i>Cirriphyllum piliferum</i>		.	.	.	2	.	.	.	.	.	.	.	.
<i>Cololejeunea azorica</i>	h	1	2	1	.	1	2	1	2	.	2	1	2
<i>Cololejeunea minutissima</i>	h	1	2	1	2	1	2	1	2	1	2	1	2
<i>Colura calyptrifolia</i>	h	1	.	1	.	1	2	1	2	1	2	1	.
<i>Conocephalum conicum</i>	h	.	2	.	2	.	2	.	.	.	.	.	.
<i>Daltonia splachnoides</i>		.	.	.	.	.	2	.	2	1	.	1	2
<i>Dicranolejeunea johnsoniana</i>	h	.	.	.	.	1	.	.	.	1	.	.	.
<i>Dicranum scottianum</i>		1	2	.	2	1	2	1	2	1	2	.	2
<i>Diplophyllum albicans</i>	h	.	.	.	.	.	2	1	2	1	2	1	2

(cont.)

(Table 2 continued)

	Islands Substrate	C		F		P		J		T		M	
		1	2	1	2	1	2	1	2	1	2	1	2
Drepanolejeunea hamatifolia	h	.	2	1	2	1	2	1	2	1	2	1	2
Dumortiera hirsuta	h	.	.	.	2	1	2	1	.	1	.	.	.
Echinodium prolixum		.	2	1	2	1	2	.	2	1	2	.	.
Echinodium renauldii		.	2	.	.	.	.	.	.	.	.	.	.
Eurhynchium hians		.	.	.	.	.	.	2	.	.	.	.	.
Eurhynchium praelongum		1	2	1	2	1	2	1	2	1	2	.	.
Eurhynchium pumilum		.	.	.	.	.	2	.	.	.	.	.	.
Eurhynchium speciosum		.	.	.	.	.	2	.	.	.	.	.	.
Fissidens asplenioides		.	.	.	2	.	2	.	2	.	.	.	.
Fissidens bryoides		.	.	.	2	.	.	.	.	.	.	.	.
Fissidens pallidicaulis		.	.	.	2	.	2	.	.	.	.	.	.
Fissidens rivularis		.	.	.	.	.	2	.	.	.	.	.	.
Fissidens serrulatus		.	.	1	2	.	2	1	2	1	.	.	2
Frullania microphylla	h	1	2	1	2	1	2	1	2	1	2	1	2
Frullania tamarisci	h	1	2	1	2	1	2	1	2	1	2	1	2
Frullania teneriffae	h	1	2	1	2	1	2	1	2	1	2	1	2
Grimmia trichophylla		.	.	.	.	.	2	.	.	.	.	.	.
Harpalejeunea ovata	h	.	2	.	2	1	2	.	2	.	2	1	.
Herbertus azoricus	h	.	.	.	.	1	.	.	2	.	.	.	.
Heterocladium heteropterum		.	2	.	2	1	2	.	2	.	.	.	.
Heteroscyphus denticulatus	h	.	.	.	.	.	.	1	.	.	.	.	.
Hylocomium splendens		.	.	.	.	.	.	.	.	1	.	.	.
Hylocomium armoricum		.	.	.	.	.	.	.	2	.	.	.	.
Hypnum cupressiforme		.	.	.	2	.	2	.	.	.	2	.	2
Hypnum resupinatum		.	2	.	2	.	.	.	2	.	2	.	.
Hypnum uncinulatum		1	2	1	2	1	2	1	2	1	2	1	2
Jubula hutchinsiae	h	.	.	1	.	1	2	1	2	1	.	1	.
Jungermannia pumila	h	.	.	.	.	.	2	.	.	.	.	.	.
Lejeunea cavifolia	h	.	.	.	.	.	.	.	.	1	.	.	.
Lejeunea eckloniana	h	.	.	.	.	.	.	.	.	.	.	1	.
Lejeunea flava	h	1	2	.	2	.	2	.	2	1	.	.	.
Lejeunea holtii	h	.	.	1	2	.	.	.	2	.	.	1	2
Lejeunea lamacerina	h	1	2	1	2	1	2	1	2	1	2	1	2
Lejeunea patens	h	1	.	.	2	1	2	1	2	.	2	1	2
Lejeunea ulicina	h	.	.	.	.	.	.	.	2	.	.	1	.
Lepidozia azorica	h	.	.	.	.	1	2	.	.	1	.	.	.
Lepidozia cupressina	h	.	.	.	.	1	2	.	.	1	2	.	.
Lepidozia reptans	h	.	.	.	2	1	2	1	.	.	2	1	.
Leptoscyphus azoricus	h	.	.	.	.	1	.	.	.	.	.	.	.
Leucobryum juniperoideum	.	2	.	.	.	.	.	2	1	.	.	2	.
Lophocolea bidentata	h	.	2	.	2	.	2	1	.	.	.	.	.
Lophocolea fragrans	h	.	.	1	2	1	2	1	2	1	2	.	2
Lophocolea heterophylla	h	.	.	.	2	.	.	.	.	1	.	.	2
Lophozia ventricosa	h	.	.	.	.	.	2	.	.	.	.	.	.
Marchesia mackaii	h	.	.	1	2	1	2	1	2	.	2	1	.
Metzgeria conjugata	h	.	2	1	2	1	2	1	.	.	.	.	2
Metzgeria furcata	h	.	2	1	2	1	2	1	2	1	2	1	2

(cont.)

(Table 2 continued)

	Islands Substrate	C		F		P		J		T		M	
		1	2	1	2	1	2	1	2	1	2	1	2
Metzgeria leptoneura	h	.	.	1	.	1	2	1	.	1	.	.	.
Myurium hochstetteri	l	2	1	2	.	2	.	2	1	2	1	2	.
Mylia cuneifolia	h	.	.	.	.	.	2	.	.	.	.	.	.
Nardia scalaris	h	.	.	.	.	.	.	1	.	.	.	.	.
Neckera intermedia		.	.	.	2	.	2	.	2	.	.	.	.
Nowellia curvifolia	h	.	.	.	.	.	2	.	2	.	.	.	.
Odontoschisma denudatum	h	.	.	.	.	1	2	1	2	1	.	.	.
Odontoschisma sphagni	h	.	.	.	.	1	2	.	2	.	2	.	.
Pallavicinia lyelli	h	.	.	.	.	.	2	.	.	.	.	.	.
Pellia epiphylla	h	.	.	.	2	.	.	.	.	.	.	.	.
Philonotis rigida		.	.	.	2	.	2	.	.	.	.	.	.
Plagiochila allorgei	h	.	.	.	.	1	2	.	.	.	.	.	.
Plagiochila exigua	h	.	.	1	.	1	2	1	2	1	2	1	2
Plagiochila punctata	h	.	.	.	.	.	2	.	.	.	.	.	.
Plagiochila spinulosa	h	1	2	.	2	1	2	1	2	1	2	1	2
Plagiomnium undulatum		.	.	.	2	1	2	.	2	.	.	.	.
Plagiothecium nemorale		.	.	1	.	1	2	1	2	1	.	.	.
Porella canariensis	h	.	2	.	2	.	2	.	2	.	.	.	2
Pseudotaxiphyllum elegans		.	.	1	2	1	2	1	2	1	2	.	.
Ptychomitrium nigrescens		.	.	.	2	.	.	.	.	.	.	.	.
Ptychomitrium polyphyllum		.	.	.	.	.	.	.	2	.	.	.	.
Radula aquilegia	h	1	2	1	2	1	2	1	2	1	2	1	2
Radula carringtonii	h	.	2	1	2	1	2	1	2	1	.	1	2
Radula holtii	h	.	.	1	2	1	2	1	.	.	.	.	.
Radula lindenbiana	h	.	.	.	.	1	.	.	2	.	.	.	.
Radula nudicaulis	h	.	.	.	.	1	.	.	.	.	.	.	.
Radula wichurae	h	.	.	.	.	1	.	.	.	.	.	.	.
Rehoulia hemisphaerica	h	.	.	.	2	.	2	.	.	.	.	.	.
Riccardia latifrons	h	.	.	.	.	.	2	.	.	.	2	.	.
Riccardia multifida	h	.	.	1	2	1	2	1	2	.	.	1	.
Rhynchostegiella tenella		.	.	.	.	.	.	.	.	.	.	1	.
Rhynchostegium riparioides		.	.	.	.	.	2	.	2	.	.	.	.
Saccogyna viticulosa	h	1	2	1	2	1	2	1	2	1	2	1	2
Scapania curta	h	.	.	.	.	.	2	.	.	.	.	.	.
Scapania gracilis	h	.	.	.	.	.	2	.	2	1	2	.	.
Scapania undulata	h	.	.	.	.	.	2	.	2	.	.	.	.
Scorpiurium circinatum		.	.	.	2	.	.	.	2	.	.	.	.
Sematophyllum substrumulosum		.	.	1	.	.	2	1	2	1	2	.	.
Telaranea nematodes	h	.	.	.	.	1	2	.	.	1	2	1	2
Tetrastichium fontanum		.	2	1	2	1	2	.	2	.	.	.	.
Tetrastichium virens		.	.	.	2	.	2	.	.	.	.	.	.
Thamnobryum alopecurum		.	2	.	2	.	2	1	2	.	.	.	.
Thuidium tamariscinum		.	.	1	2	1	2	1	2	1	2	.	2
Tortella flavovirens		.	.	.	2	.	.	.	.	.	.	.	.
Trichostomum brachydontium		.	.	.	2	.	2	.	2	.	.	.	.
Tylimanthus azoricus	h	.	.	.	.	.	2	.	.	.	.	.	.
Zygodon viridissimus		.	2	.	2	.	.	.	.	.	2	.	.

Colura calyptrifolia). Some preferentially epigeic species occur together with preferentially epiphyllous species only where they are accidentally epiphyllous (e.g. *Nardia scalaris*, *Hylocomium splendens*, *Andoa berthelotiana*), which is expected, as preferentially epiphyllous species are generally absent in the epigeic bryo-communities.

The decreasing substratum preference of several bryophytes towards W. in the Azorean archipelago has already been treated (cf. SJÖGREN 1993, Table 2). Consequently, differential values of these species also decrease from E. to W. The *Cololejeuneetum azoricae* is thus very rare and impoverished and present only on few phorophyte species on the island of Santa Maria; it is typically developed on the central islands and, on the island of Corvo, it also appears slightly impoverished due to, among other things, a rapid colonization of leaves and fronds of ferns by non preferentially epiphyllous bryophytes. Such species have been observed as colonizers even in primary stages of development of the epiphyllous bryo-community, which is much more rarely the case on islands of the central island group.

The development of a mature *Cololejeuneetum azoricae* requires at least 10 cm² of phorophyte surface. That is where habitat conditions are optimal (at least an annual precipitation of 2500 mm, supplemented by a mist-precipitation reaching at least 1000 mm (cf. KÄMMER 1974); where air humidity is maintained permanently high and efficient shelter is available). Examination of phorophyte surfaces larger than 50 cm² rarely provides a higher species diversity, making the composition of the association more richly equipped with preferentially epiphyllous species and/or differential species.

The association reaches a mature constitution on smaller surfaces where habitat conditions are optimal, whereas suboptimal conditions have the effect that larger surfaces are required. Alternatively, the epiphyllous association may only be completely represented if several phorophyte species in a locality or several leaves or fronds of ferns of the same phorophyte species are examined. Where habitat conditions are clearly insufficiently favourable, e.g., where

precipitation is close to 1500 mm, a rise of the phorophyte surface or of the number of phorophyte specimens is no longer sufficient to facilitate the recording of a maturely developed association.

The mature *Cololejeuneetum azoricae* is a community with a species diversity generally of 5-10 spp. (see SJÖGREN 1978, Tables 1-4). Under suboptimal habitat conditions the number of species is hardly more than 1-4 spp., mostly with presence only of such species that do not have a pronounced preference to grow as epiphyllous (e.g. *Drepanolejeunea hamatifolia*, *Aphanolejeunea microscopica*, *Harpalejeunea ovata*).

Samples with a large number of preferentially epiphyllous hepatics growing on one phorophyte specimen (one frond of *Blechnum*, or one leaf of *Laurus*) are generally possible to obtain at altitudes above 600 m in the central island group, on the western island of Corvo also at 300 m, on the eastern island of S. Miguel generally at higher altitudes than on the central islands. A few examples of preferentially epiphyllous hepatics and their association in samples at various altitudes on six islands have been summarized (Table 3). Average numbers of more than 3.0 associated preferentially epiphyllous species are generally possible to register above 600 m. Comparatively few samples with, on average, more than 4.0 associated species of the same kind have been found. Some of the most restricted epiphyllous species in the Azores only join other preferentially epiphyllous species at altitudes above 700 m (e.g. *Dicranolejeunea johnsoniana*, *Cheilolejeunea cedercreutzii*, *Radula nudicaulis*).

Localities with on average (at least 10 samples on various phorophyte species and on different phorophyte specimens) 3.0 - 4.0 associated preferentially epiphyllous hepatics, may be considered as primary objects for more close examination with regard to protection. In such localities, scattered specimens of rare endemic Azorean vascular plants in mature types of the *Juniperion brevifoliae* forest are generally also found. On the island of Pico, for example, a few such areas still have scattered presence e.g. of *Melanoselinum decipiens*, *Sanicula azorica*,

Table 3

A-H. Eight preferentially epiphyllous hepatics and their association in the samples to other preferentially epiphyllous species. Mean numbers if more than 1 sample, with number of samples within brackets. - The species involved in the calculations are: *Aphanolejeunea madeirensis*, *A. microscopica*, *A. teotonii*, *Cololejeunea azorica*, *C. minutissima*, *Colura calyptrifolia*, *Drepanolejeunea hamatifolia*, *Frullania microphylla*, *Harpalejeunea ovata*, *Jubula hutchinsiae*, *Lejeunea ulicina*, *Lepidozia azorica*, *Lophocolea fragrans*, *Marchesinia mackaii*, *Radula aquilegia*. - The largest number of associated hepatics recorded was 6 spp. - C - M = Azorean islands; eph. = epiphyllous samples; al. = other samples.

A. Aphanolejeunea microscopica

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	al.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	1.8 (5)	1.0 (3)	2.1 (23)	2.5 (4)	.....	.....
	al.	.....	1.0 ..	.....	.....	3.5 (2)	.....	1.0 ..	2.0 (2)	.....	.....
P.	eph.	.....	.....	.....	.....	.....	3.3 (8)	2.8 (19)	2.3 (72)	3.0 (3)	2.9 (9)
	al.	.....	.....	.....	.....	.....	2.0 ..	2.7 (3)	2.4 (21)	2.1 (7)	2.3 (4)
J.	eph.	.....	.....	.....	.....	1.4 (5)	2.4 (14)	2.7 (10)	.....	2.4 (10)	.....
	al.	.....	.....	.....	.....	.....	2.0 (2)	3.9 (2)	.....	1.2 (6)	.....
T.	eph.	.....	.....	.....	1.0 (2)	2.4 (17)	1.9 (9)	.....	.....	2.7 (18)	.....
	al.	.....	.....	.....	.....	.....	1.0 ..	1.3 (3)	.....	.....	.....
M.	eph.	.....	.....	.....	.....	3.0 ..	2.9 (13)	4.3 (4)	4.0 (4)	.....	3.7 (20)
	al.	.....	.....	.....	.....	.....	.....	.....	2.4 (7)	.....	3.0 ..

B. Aphanolejeunea teotonii

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	2.5 (4)	.....	1.0 ..	2.0 ..	.....	.....	.....	.....
	al.	.....	.....	3.0 (2)	1.0 ..	.....	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	1.8 (6)	.....	2.0 (12)	.....	.....	.....
	al.	.....	.....	.....	1.0 ..	.....	.....	.....	.....	.....	.....
P.	eph.	.....	.....	.....	.....	.....	2.3 (18)	4.0 ..	.....	.....	.....
	al.	.....	.....	.....	.....	.....	2.5 (2)	.....	.....	.....	.....
J.	eph.	.....	.....	.....	.....	.....	2.3 (4)	2.8 (19)	.....	.....	.....
	al.	.....	.....	.....	.....	1.0 ..	.....	1.5 (2)	.....	.....	.....
T.	eph.	.....	.....	.....	.....	2.8 (4)	2.0 ..	.....	.....	2.0 ..	.....
	al.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
M.	eph.	.....	.....	.....	.....	3.9 (7)	2.0 (8)	2.4 (12)	3.7 (7)	.....	4.1 (15)
	al.	.....	.....	.....	.....	3.0 (3)	.....	.....	3.5 (2)	.....	3.0 (3)

C. Cololejeunea minutissima

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	3.5 (4)	.....	2.0 (2)	4.0 ..	.....	.....	.....	.....
	al.	.....	1.0 (5)	1.8 (6)	.....	1.0 (2)	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	2.5 (2)	1.0 ..	2.5 (8)	2.4 (5)	.....	.....
	al.	.....	2.0 ..	.....	2.0 ..	3.0 (2)	2.0 (2)	2.0 (2)	1.0 ..	.....	.....
P.	eph.	.....	.....	.....	.....	.....	3.0 (14)	2.6 (16)	2.7 (34)	2.2 (6)	2.8 (9)
	al.	.....	.....	.....	1.0 ..	.....	3.0 (2)	3.0 ..	2.9 (7)	2.7 (3)	3.0 ..
J.	eph.	.....	.....	.....	.....	4.0 ..	2.5 (11)	2.3 (13)	.....	.....	.....
	al.	.....	.....	.....	.....	1.0 ..	1.5 (4)	2.3 (4)	.....	.....	.....
T.	eph.	.....	.....	.....	.....	2.6 (16)	2.1 (8)	.....	.....	2.6 (9)	.....
	al.	.....	.....	.....	.....	.....	1.0 ..	1.5 (2)	.....	.....	.....
M.	eph.	.....	.....	.....	.....	3.3 (8)	4.5 (4)	2.6 (11)	3.7 (7)	.....	3.8 (16)
	al.	.....	.....	.....	.....	3.0 ..	.....	.....	3.5 (2)	.....	.....

(cont.)

(Table 3 continued)

D. Colura calyptrifolia

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	3.0 (3)	.....	.....	.....	.....	.....	.....	.....
	al.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	2.0 ...	.....	2.2 (9)	2.5 (2)	.....	.....
	al.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
P.	eph.	.....	.....	.....	.....	.....	.....	3.0 (2)	2.9 (17)	4.0 ...	3.2 (5)
	al.	.....	.....	.....	.....	.....	.....	3.8 (4)	.....	.....	.....
J.	eph.	.....	.....	.....	.....	3.5 (2)	3.0 (7)	2.7 (3)	.....	2.8 (6)	.....
	al.	.....	.....	.....	.....	.....	.....	2.7 (3)	.....	.....	.....
T.	eph.	.....	.....	.....	.....	3.0 (5)	3.3 (4)	.....	.....	3.2 (13)	.....
	al.	.....	.....	.....	.....	.....	.....	.....	.....	4.0 ...	.....
M.	eph.	.....	.....	.....	.....	4.3 (4)	4.2 (5)	4.3 (3)	4.3 (9)	.....	3.6 (21)
	al.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

E. Drepanolejeunea hamatifolia

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	al.	.....	.....	3.0 ...	.....	1.0 ...	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	2.1 (7)	2.0 ...	2.3 (11)	2.0 (8)	4.0 (3)	.....
	al.	.....	.....	.....	1.5 (2)	3.0 ...	2.0 (2)	2.7 (3)	1.7 (3)	.....	.....
P.	eph.	.....	.....	.....	.....	.....	2.5 (8)	2.7 (19)	2.4 (58)	2.8 (5)	2.7 (11)
	al.	.....	.....	.....	1.0 (2)	.....	1.7 (3)	2.7 (3)	2.5 (22)	3.0 (2)	1.4 (10)
J.	eph.	.....	.....	.....	.....	2.5 (2)	2.6 (13)	3.0 (10)	2.0 (8)	.....	.....
	al.	.....	.....	.....	.....	.....	2.0 (2)	1.9 (7)	.....	.....	.....
T.	eph.	.....	.....	.....	.....	3.3 (8)	2.6 (5)	.....	.....	2.5 (22)	.....
	al.	.....	.....	.....	1.0 ...	.....	.....	1.5 (2)	.....	.....	.....
M.	eph.	.....	.....	.....	.....	3.0 (9)	3.8 (6)	3.6 (5)	3.5 (12)	.....	3.7 (21)
	al.	.....	.....	.....	.....	2.3 (4)	.....	.....	2.5 (8)	.....	2.7 (3)

F. Frullania microphylla

altitude (m)		100	200	300	400	500	600	700	800	900	1000
C.	eph.	.....	.....	5.0 ...	2.0	.....	.....	.....	.....	.....	.....
	al.	.....	1.0 (5)	1.6 (5)	.....	1.0 ...	.....	.....	.....	.....	.....
F.	eph.	.....	.....	.....	.....	2.0 (3)	1.5 (3)	1.8 (8)	.....	.....	.....
	al.	.....	2.0 ...	.....	2.0 ...	2.7 (3)	.....	2.0 (3)	.....	.....	.....
P.	eph.	.....	.....	.....	.....	.....	3.4 (14)	4.0 (3)	2.8 (25)	.....	2.5 (2)
	al.	.....	.....	.....	.....	.....	4.0 ...	2.7 (3)	2.5 (8)	4.0 ...	.....
J.	eph.	.....	.....	.....	.....	4.0 ...	2.6 (7)	3.0 (8)	.....	4.0 (6)	.....
	al.	.....	.....	1.0 ...	2.0 ...	2.0 ...	2.0 ...	2.7 (3)	.....	.....	.....
T.	eph.	.....	.....	.....	.....	3.7 (6)	5.0 ...	.....	.....	3.7 (9)	.....
	al.	.....	.....	.....	1.3 (2)	.....	.....	.....	.....	.....	.....
M.	eph.	.....	.....	.....	.....	.....	3.7 (7)	3.3 (10)	4.7 (7)	.....	4.6 (8)
	al.	.....	.....	.....	.....	3.0 (3)	.....	.....	.....	.....	.....

(cont.)

(Table 3 continued)

G. Lejeunea lamacerina

altitude (m)	100	200	300	400	500	600	700	800	900	1000
C	eph. ....	....	2.0 (3)	....	2.0 (3)	3.0 (2)	....	....	....	....
	al.	2.0 ...	2.0 (7)	2.0 ...	1.3 (3)	....	....	....	....	....
F.	eph. ....	....	....	....	2.8 (8)	2.3 (5)	2.4 (31)	3.2 (5)	....	....
	al.	1.4 (7)	2.0 ...	1.5 (4)	2.0 (3)	1.3 (3)	1.6 (5)	2.3 (4)	....	....
P.	eph. ....	....	....	....	....	3.4 (18)	3.3 (18)	3.2 (37)	2.5 (9)	3.3 (6)
	al. 1.0 ...	....	1.0 ...	2.0 ...	1.0 ...	4.5 (2)	3.3 (7)	3.3 (14)	2.4 (5)	2.7 (3)
J.	eph. ....	....	....	....	1.7 (11)	3.1 (18)	3.2 (12)	....	3.2 (6)	....
	al.	1.0 (2)	2.0 ...	3.0 ...	1.6 (5)	2.3 (4)	2.2 (11)	....	2.0 ...	....
T.	eph. ....	....	....	2.0 (2)	2.7 (19)	2.7 (10)	....	....	2.5 (17)	....
	al.	2.0 (3)	....	....	....	2.0 ...	2.0 (2)	....	1.5 (4)	....
M.	eph. ....	....	....	....	4.3 (6)	3.5 (8)	2.8 (10)	3.8 (11)	1.0 (2)	4.2 (21)
	al. ....	....	....	2.0 ...	3.5 (4)	....	....	3.2 (9)	....	2.6 (5)

H. Radula aquilegia

altitude (m)	100	200	300	400	500	600	700	800	900	1000
C	eph. ....	....	....	....	....	3.0 ...	....	....	....	....
	al. ....	....	....	1.0 ...	....	....	....	....	....	....
F.	eph. ....	....	....	....	2.7 (3)	....	3.4 (5)	1.8 (5)	....	....
	al. ....	....	....	....	2.0 (2)	2.0 (2)	1.5 (2)	2.0 ...	....	....
P.	eph. ....	....	....	....	....	....	3.0 (5)	3.1 (7)	2.5 (2)	2.7 (3)
	al. ....	....	....	....	....	2.0 ...	2.0 (2)	4.0 (2)	....	1.0 ...
J.	eph. ....	....	....	....	3.0 ...	....	....	....	1.5 (2)	....
	al. ....	....	....	....	....	....	....	....	1.0 ...	....
T.	eph. ....	....	....	....	....	....	....	....	3.0 (6)	....
	al.	2.0 ...	....	2.0 ...	1.0 ...	....	....	....	....	....
M.	eph. ....	....	....	....	3.8 (5)	3.1 (7)	4.0 ...	4.7 (6)	....	4.9 (9)
	al. ....	....	....	....	1.0 ...	....	....	1.0 ...	....	2.7 (3)

Ranunculus cortusifolius, *Chaerophyllum azoricum*, *Bellis azorica*, *Euphrasia grandiflora*, *Carex hochstetterorum*, *Holcus rigidus* and *Platanthera micrantha*. The bryo-communities, epigeic, epilithic and epiphytic, are characterized by scattered presence of species endemic to the Azores or to Macaronesia, such as *Herbertus azoricus*, *Leptoscyphus azoricus*, *Tylimanthus azoricus*, *Breutelia azorica*, *Echinodium renauldii* and *Tetrastichium fontanum*.

Several preferentially epiphyllous species are included in the bryophyte zonation suggested for the Azores by ALLORGE, V. & ALLORGE, P. (1938). The authors described "l'étage du *Echinodium* et du *Neckera intermedia*" (at 300-600 m) characterized by the presence of the first appearing epiphyllous species, which then reach their optimum within "l'étage de *Sphagnes*, des grands *Campylopus* et du *Breutelia azorica*" (at 600-1000 m). Unfortunately, the suggested zonation was characterized by several species

with a highly restricted presence in the archipelago. "L'étage d'*Adelanthus decipiens* et *Daltonia splachnoides*" (at 1000-1500 m) was characterized by species that are also present in the zone below at 600-1000 m, where the mature cloud-zone forest has its optimum. The general feature of an impoverishment of the forest both towards lower and higher altitudes was not sufficiently stressed. However, the information on the optimal development of the epiphyllous vegetation between 600-1000 m is quite correct.

SUBSTRATE PREFERENCES

One of the most pronounced characteristics of Azorean bryo-vegetation is the difficulty to find bryophyte species with distinct substrate preferences. Species recorded on only one type of substrate are extremely few. The only bryo-community that includes several species with a

fairly distinct substrate preference is the endemic epiphyllous *Cololejeuneetum azoricae* of the Macaronesian *Cololejeuneo-Colurion* (Table 1).

The group of species that are preferentially epiphyllous, includes species that have also more or less accidental presences as epiphytic and epixylic. Most of these species belong to the family Lejeuneaceae and are small species with low competitive ability. Also *Frullania microphylla*, *Radula aquilegia*, *Lophocolea fragrans*, *Lepidozia azorica* and *Jubula hutchinsiae* are recorded as more or less strongly preferentially epiphyllous (*Jubula* also highly frequent as epilithic).

A comparison of the substrate preferences of epiphyllous species in the Azores and in western parts of continental Europe indicates a less pronounced substrate preference in the Azores, or alternatively, a totally different preference (see chapter "Ecology, sociology and vulnerability"). For example, *Harpalejeunea ovata* is generally epiphytic and epilithic in continental Europe, but in the Azores it is present on all types of substrates, with a preference to occur as epiphyllous and epiphytic. *Jubula hutchinsiae* is epiphytic and epilithic in continental Europe but in the Azores it is present on all types of substrates, although with an unusual preference to occur as epiphyllous and as epilithic. Several of the Azorean epiphyllous species have also been recorded as epilithic and epiphytic on the Isle of Skye (cf. BIRKS & BIRKS 1974).

Most epiphyllous species have a clear preference to occur at altitudes above 500 m and have their highest frequencies at 700-1000 m (cf. ALLORGE, V. & ALLORGE, P. 1938), at least within the central island group. They occur with reduced substratum preference within the altitude range, where optimal habitat conditions are provided. For example, the presence of *Drepanolejeunea hamatifolia*, is recorded on all types of substrates. Epilithic and epigeic presence is mainly recorded above 500 m in the central island group, but below that altitude epiphytic and epixylic presence is predominant.

The substrate preference of epiphyllous species may also be compared on islands from E. to W. in the archipelago and related to increasing

precipitation westwards. The general feature of the bryophytes is an increased frequency towards W. at altitudes below 500 m and also a reduced substrate preference (e.g. *Radula aquilegia*; SJÖGREN 1993).

The surface structure of the phorophyte species colonized by the epiphyllous species varies. Densely hairy leaves or fronds almost never get colonized. The leaves of *Hedera* and *Ilex* are glabrous, the fronds of *Elaphoglossum* are covered by scattered fimbriate scales (Fig. 5), the fronds of *Blechnum* and *Woodwardia* have channelled nerves (Fig. 3). A comparison of the presence of the epiphyllous hepatics at various altitudes shows them to be more frequent close to nerves and scales at low altitudes, where ecological conditions are suboptimal and thus there is a greater need for retained water on the phorophyte surfaces (cf. KAMIMURA 1939). For the same reason, there is also a more frequent presence at leaf bases and at margins of holes developing especially in wilted leaves (Fig. 2). Margins of holes and leaf bases retain water longer during mist-precipitation (cf. KÄMMER 1974). Optimal habitat conditions, on the other hand, favour the presence of the small epiphyllous hepatics also on smooth parts of the substrate surface, where the diaspores get less easily attached. The developing specimens are attached by rhizoids from stem cells or from amphigastria (SCHIFFNER 1929). The rhizoids attach the bryophytes to the substrate efficiently during periods of dry weather but are much less efficient during humid periods when the phorophyte surfaces are almost permanently wetted, e.g. due to mist-precipitation. During such periods, the epiphyllous specimens live precariously and their survival is most accidental.

The presence of epiphyllous hepatics, mainly of the family Lejeuneaceae, on other bryophytes is not very common. The colonized species and also the colonizing species are few. It is generally under optimal habitat conditions that a colonization may take place of such large species as *Thamnobryum*, *Polytrichum* spp., *Porella canariensis*, *Fissidens serrulatus* and *Echinodium* spp. The presence of epiphyllous hepatics (*Drepanolejeunea hamatifolia*) on *Porella*

canariensis was already mentioned by MITTEN (1870). A colonization by *Lejeunea lamacerina*, becoming abundant, on other bryophytes generally hinders invasion by other species with weak competitive ability, such as *Aphanolejeunea* spp. and *Cololejeunea* spp. (Fig. 6).

The epiphytic presence of preferentially epiphyllous species occurs on several tree species (see chapter "Phorophytes") but only a few of them get colonized frequently, such as *Erica*, *Cryptomeria* and *Acacia*. These tree species are more or less frequently equipped with loosely attached bark, where colonization of *Lejeunea*, *Radula*, *Aphanolejeunea* and *Cololejeunea* is locally frequent. The most frequent species on these tree/shrub species, even at low altitudes are *Cololejeunea minutissima*, *Harpalejeunea ovata* and *Lejeunea lamacerina*. Several localities with epiphytic presence of *C. minutissima*, even at low altitudes, were recorded recently (1996) on Santa Maria. Loosely attached, moist bark pieces get colonized in the first place, whereas firmly attached dry bark rapidly gets colonized by large pleurocarpous mosses, which rapidly outcompete the small hepatics mentioned.

The abundance of epiphyllous bryophytes, of varied preference levels, occurring on a variety of phorophytes, is indicative of favourable habitat conditions such as those also favouring the development of mature types of *Juniperion brevifoliae*. Possibly their frequent presence on smooth or irregular phorophyte surfaces also indicates optimal or suboptimal habitat conditions. The wettability of leaves increases with age and old leaves are thus more frequently colonized under suboptimal than optimal habitat conditions. It is preferable to assess the protection value of habitats by examining epiphyllous bryophyte communities from several angles.

Knowledge of habitat preferences of epiphyllous species, gained from prior studies, facilitates habitat assessments. Species-richness and abundance increase markedly above certain altitudes which differ in the western, central and eastern island groups. Essential shelter can be provided by caldeiras, explosion craters, ravines and dense forests. Sufficient shelter is also provided by the canopies of a mature *Juniperion*

brevifoliae forest which affords good conditions of shade and humidity.

PHOROPHYTES

Good knowledge of the phorophyte species preferred by the epiphyllous bryophytes is the principal requirement for finding and describing the epiphyllous flora and vegetation.

A comprehensive recording of epiphyllous bryophytes in the Azores has resulted in a fairly long list of phorophyte species registered.

Phorophytes with recorded presence of preferentially epiphyllous bryophytes; species within brackets () supported only epiphytic and epixylic presence:

pteridophytes:

Blechnum spicant (L.) Roth.
Christella dentata (Forssk.) Brownsey et Jermy
Culcita macrocarpa C. Presl.
Deparia petersenii (Kunze) M. Kato
Diplazium madeirense (Wilce) Roth.
Diplazium caudatum (Cav.) Jermy
Elaphoglossum semicylindraceum (Bowd.) Benl
Huperzia selago (L.) Bernh. - ex Schrank et Mart.
Hymenophyllum tunbrigense (L.) J.E. Sm.
Hymenophyllum wilsonii Hook.
Phyllitis scolopendrium (L.) Nees.
Pteridium aquilinum (L.) Kuhn.
Pteris incompleta Cav.
Stenogramma pozoi (Lag.) K. Iwatsuki
Trichomanes speciosum Willd.
Woodwardia radicans (L.) J.E. Sm.

trees and shrubs:

(*Acacia melanoxylon* R. Br.)
(*Buxus sempervirens* L.)
(*Cryptomeria japonica* (L. fil.) D. Don.)
(*Daphne laureola* L.)
(*Erica azorica* Tutin et Warb.)
(*Eucalyptus globulus* Labill.)
Frangula azorica Grubow
(*Hydrangea macrophylla* (Thunb.) Ser.)
(*Hypericum foliosum* Ait.)
Ilex perado ssp. *azorica* (Loes.) Tutin
(*Juniperus brevifolia* (Seub.) Antoine)
Laurus azorica (Seub.) Franco

Myrsine africana L.

Persea indica (L.) K. Spreng.

(*Pittosporum undulatum* Vent.)

(*Picconia azorica* (Tutin) Knobl.)

(*Platanus x hybrida* Brot.)

(*Populus alba* L.)

Prunus lusitanica ssp. *azorica* (Mouillef.) Franco

Viburnum tinus ssp. *subcordatum* (Trel.) P. Silva

(*Ulmus procera* Salisb.)

herbs and grasses

Carex vulcani Hochst. in Seub.

Hedera helix ssp. *canariensis* (Willd.) Cout.

Hedychium gardnerianum Rosc.

Luzula purpureo-splendens Seub.

(*Rubus hochstetterorum* Seub.)

bryophytes:

Polytrichum formosum Hedw.

Thamnobryum alopecurum (Hedw.) Nieuwl.

Echinodium renauldii (Card.) Broth.

The principal information provided by this list is the clear dominance of ferns among the phorophytes. Only seven tree species occur as phorophytes and the number of herbs, grasses and bryophytes is fairly low. Several tree species, on the other hand, have an epiphytic moss vegetation, in which preferentially epiphyllous species may occur more or less accidentally. It is here of interest to mention that some Azorean tree/shrub species, more or less frequent in native forests, do not appear as phorophytes for epiphyllous bryophytes on their leaves, namely *Vaccinium cylindraceum*, *Myrica faya*, *Pittosporum undulatum* (introduced) and *Picconia azorica*. Some common species of Azorean ferns have also until now not been recorded with epiphyllous species on their fronds, e.g. *Dryopteris aemula*, *D. affinis*, *Polystichum setiferum*, *Athyrium filix-femina*, *Asplenium monanthes*.

A careful search for epiphyllous bryophytes at different altitudes shows that the number of phorophytes colonized increases with increasing altitude (cf. Table 4). In the central group of islands and on S. Miguel in the eastern group, the presence of epiphyllous species generally starts at 500 m and

there is an increase in number of phorophytes towards 800-1000 m. Only on Corvo in the western group is there a start of colonization of epiphyllous bryophytes already at 300 m. Islands with especially large numbers of species on several phorophytes are Pico, S. Jorge, Terceira and S. Miguel. On the 'dry' island of Graciosa no epiphyllous moss-cover has been recorded and on the island of Santa Maria only a few epiphyllous hepatics occur between 400-500 m, on *Hedychium* according to recent records, in 1996.

Consequently, a large number of recorded phorophytes means that mature stages of the Azorean endemic epiphyllous bryo-community are present and also mature stages of the native *Juniperion brevifoliae* forest, probably worth consideration for protection.

Certain phorophytes are distinctly preferred by the epiphyllous bryophytes (Tables 5, 6), namely among the ferns *Blechnum*, *Trichomanes* and *Elaphoglossum* and among other plants *Hedera*, *Ilex* and *Laurus*. In general, these phorophyte species are colonized by epiphyllous species already at 500 m of altitude. The preferred phorophyte species are generally those that also get colonized where habitat conditions are suboptimal (cf. 'host-species' in OLARINMOYE 1975a). The highest numbers of bryophytes recorded on these phorophytes occur, however, mostly between 700-900 m, and almost always at some distance from the forest margin, protected by the dense tree canopies (cf. HERZOG 1926). The recorded presence of altogether 35 spp. at 500 m on *Trichomanes* is exceptional. The reason why, e.g. *Blechnum*, is preferred to *Diplazium* and e.g. *Ilex* to *Viburnum* has still no satisfactory explanation.

The presence of a selection of epiphyllous species (Table 6) on various phorophytes is very uneven. The preferentially epiphyllous species, mainly those of the Lejeuneaceae family, have been recorded on the largest numbers of phorophytes. Other species with no preference to grow as epiphyllous (e.g. *Eurhynchium praelongum*, *Bazzania azorica*, *Plagiochila spinulosa*) occur on just a few phorophyte species.

Table 4

Examples of variation in number of phorophyte species (at altitudes (Alt.) 100-1000 m) with recorded presence in epiphyllous samples of some hepatics, frequently present in *Cololejeuneetum azoricae*. - C-M = Azorean islands (abbreviations in Introduction). - Species treated: *Aphanolejeunea microscopica*, *Cololejeunea minutissima*, *Colura calyptrifolia*, *Drepanolejeunea hamatifolia*, *Frullania microphylla*, *Frullania tamarisci*, *Lejeunea lamacerina*, *Radula aquilegia*.

Alt. (m)	100	200	300	400	500	600	700	800	900	1000	100	200	300	400	500	600	700	800	900	1000
<i>A. microscopica</i>											<i>C. minutissima</i>									
C	1	1	.	1	.	.	.	.
F	2	1	5	2	.	.	.	.	.	.	2	1	4	3	.	.
P	5	4	11	3	7	.	.	.	.	.	6	4	6	4	7
J	6	6	5	.	6	.	.	.	.	.	1	5	5	.	7	.
T	2	2	.	1	5	.	.	.	.	1	4	2	.	.	5	.
M	2	3	2	3	1	6	.	.	.	2	3	2	2	4	.	5
<i>C. calyptrifolia</i>											<i>D. hamatifolia</i>									
C	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	1	.	2	2	.	.	.	.	.	.	3	.	4	4	.	.
P	1	1	6	1	2	.	.	.	.	.	7	4	10	3	8
J	2	7	1	.	3	.	.	.	.	.	2	6	6	.	5	.
T	2	2	.	.	5	.	.	.	.	.	3	.	.	.	6	.
M	3	2	1	3	1	6	.	.	.	.	4	3	3	5	1	6
<i>F. microphylla</i>											<i>F. tamarisci</i>									
C	.	.	1	1	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.
F	2	1	4	1	.	.	.	.	.	.	2	1	4	4	.	.
P	5	4	9	.	2	.	.	.	.	.	.	3	8	3	3
J	1	5	6	.	5	.	.	.	1	2	1	3	.	5	.	.
T	3	2	.	.	4	.	.	.	.	.	1	.	.	.	6	.
M	.	.	1	3	3	3	2	3	.	4	.	.	.	.	.	2	2	1	.	.
<i>L. lamacerina</i>											<i>R. aquilegia</i>									
C	.	.	1	3	1	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.
F	3	1	5	4	.	.	.	.	.	.	2	.	3	3	.	.
P	8	5	10	3	6	.	.	.	.	.	.	4	2	2	4
J	.	.	1	6	6	7	.	6	.	.	.	.	.	1	.	.	.	.	1	.
T	.	.	1	5	3	.	.	7	.	.	.	.	.	.	.	.	.	.	2	.
M	.	.	3	3	3	4	5	1	6	.	.	.	.	.	3	3	2	3	.	2

MACARONESIAN VEGETATION

The Macaronesian epiphyllous presence of bryophytes is not restricted to the Azores but exists both on Madeira (SJÖGREN 1975) and in the Canary Islands (BOECKER et al. 1993).

The epiphyllous moss-cover recorded on Madeira, if compared from various aspects with the Azorean, may be characterized in the following way: species diversity on Madeira is not as high as in the Azores, where especially the accidental presence of not preferentially epiphyllous species is frequent.

EPIPHYLLOUS

Most species, generally hepatics, are the same as in the Azores. The dominant species are also the same with the exception of the frequently dominant species *Metzgeria fruticulosa* (Dicks.) Evans and in secondary stages of colonization *Frullania polysticta* Lindenb. The former species has only one, possibly accidental locality in the Azores, on the island of Terceira; the latter has probably not yet been recorded in the island group. Also *Frullania microphylla* is highly frequent as epiphyllous on Madeira but much less frequent in the Azores. Furthermore, *Lejeunea mandonii* (Steph.) K. Müll. is a rare epiphyllous species on Madeira, not yet recorded in the Azores. On the

Table 5

Total number of epiphyllous species found on the phorophytes at various altitudes on the islands of Faial, Pico, S. Jorge and Terceira.

	400	500	600	700	800	900	1000
phorophytes:							
Blechnum	.	17	14	20	18	24	12
Culcita	7	2	.
Diphasium	4	.	.
Diplazium	.	8	7	2	1	9	.
Elaphoglossum	.	5	13	20	35	24	16
Huperzia	.	.	.	1	.	20	10
Hymenophyllum	.	.	10	.	14	.	.
Phyllitis	.	.	2	.	.	.	.
Pteris	.	.	7	7	.	.	.
Stenogramma	.	.	14	.	.	.	.
Trichomanes	5	35	30	32	24	30	.
Woodwardia	.	.	.	11	.	.	.
Carex	.	.	2	.	.	.	.
Hedera	.	.	8	15	18	7	1
Hedychium	.	9	4	9	.	6	.
Luzula	.	.	2	.	2	.	.
Ilex	.	10	12	18	19	11	11
Laurus	.	.	12	6	11	9	6
Myrsine	.	.	.	1	.	.	.
Viburnum	8	.	.
Polytrichum	.	6	.	.	.	.	.
Thamnobryum	4	9	8	9	7	1	10
lichens	.	3	.	.	.	.	.

other hand, several species endemic to the Azores (Table 1) accentuate the difference in constitution of the epiphyllous bryo-communities of the two island groups.

The substrate preference of the epiphyllous species is generally the same on Madeira and in the Azores. Only a few species have a distinctly less pronounced preference in the Azores than on Madeira, e.g. *Drepanolejeunea hamatifolia*, *Harpalejeunea ovata* and *Metzgeria leptoneura*.

In the Azores, the endemic epiphyllous association *Cololejeunea-etum azoricae* is highly frequent only above 500 m (central island group) and within the native cloud-zone forest, the *Juniperion brevifoliae*, where precipitation is more than 2000 mm.

The endemic epiphyllous association on Madeira, the *Cololejeuneetum microphyllae* is highly frequent only in the native *Clethro-Laurion* forest. Localities are concentrated in the forest on

slopes and in river ravines of the northern part of the island where precipitation is high and air humidity also maintained high. Favourable habitat conditions occur above 700 m, where precipitation is more than 1700 mm.

The constitution of the native forests of the two island groups is highly different in all vegetation layers (SJÖGREN 1972, 1973), although several species are in common. Consequently, a search for epiphyllous vegetation has to be centred on different possible phorophyte species. Some phorophytes are the same as in the Azores, such as *Blechnum*, *Elaphoglossum*, *Laurus*, *Trichomanes* and *Thamnobryum*, whereas some frequently colonized Madeirensian species such as *Ocotea foetens*, *Ruscus streptophyllus* and *Semele androgyna* are absent in the Azores.

The sociological similarities of the epiphyllous associations in the Azores and on Madeira have justified placing them within one alliance, the *Cololejeuneo-Colurion*.

Epiphyllous bryophytes in the Canary Islands (La Gomera and Tenerife) appear on a large number of phorophyte species (BOECKER et al. 1993). The most frequently colonized ones are almost the same as on Madeira and in the Azores, only with a few additional species (op. cit., Tables 1 and 2). In general the epiphyllous vegetation in the *Laurus*-forests of the Canary Islands is probably less species rich than on Madeira and especially than in the Azores. A *Cololejeuneetum microphyllae* exists apparently also in the Canary Islands, although in several localities and on several phorophytes with an impoverished constitution as compared with its mature stages on Madeira.

In general, the Macaronesian epiphyllous vegetation of the three island groups has several characterizing hepatics in common, such as *Aphanolejeunea microscopica*, *Cololejeunea minutissima*, *Colura calyptrifolia*, *Drepanolejeunea hamatifolia*, *Frullania microphylla*, *Harpalejeunea ovata*, *Lejeunea ulicina* and *Plagiochila exigua*.

Table 6

A selection of 25 bryophytes with recorded presence on various phorophytes on the islands of Faial, Pico, S. Jorge and Terceira. Largest numbers of phorophytes are colonized by diff. species of the epiphyllous bry-community.

epiphyllous species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
pteridophytes:																									
Blechnum	.	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x
Christella	.	.	.	x	x	x	x	x	.	x	.	x	.	.	.	x	.	.	.	.	x	.	.	x	.
Culcita	.	.	x	x	.	x	x	.	x	.	.	.	.	.	x	.	.	.	.	x	.	.	.	.	.
Diplazium	.	.	.	x	.	.	.	x	.	x	.	.	.	.	.	x	.	.	.	.	.	.	x	.	.
Diplazium	.	x	.	x	x	x	x	x	.	x	x	x	.	x	.	x	x	.	.	x	x	.	.	.	x
Elaphoglossum	x	x	.	x	x	.	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Huperzia	x	.	.	x	x	.	.	x	x	.	x	x	.	x	.	x	x	x	.	.	.	x	x	x	x
Hymenophyllum	x	.	x	x	x	x	.	x	.	x	x	.	.	x	x	x	x	x	x	.	.	x	x	x	x
Phyllitis	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.
Pteris	.	.	.	x	x	x	.	x	.	x	.	x	.	.	.	x	.	.	.	x	.	.	.	.	.
Stenogramma	.	.	.	x	.	x	x	x	x	x	.	.	.	.	.	x	.	.	x	x	.	.	.	.	.
Trichomanes	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x
Woodwardia	.	x	.	x	x	x	x	x	.	x	x	x	x	x	.	x	.	.	.	.	x	.	x	x	.
trees/shrubs:																									
Ilex	.	x	.	x	x	.	x	x	.	x	x	x	x	x	.	x	x	.	.	x	x	.	x	x	x
Laurus	.	x	.	x	x	x	x	x	.	x	x	x	x	x	.	x	x	.	.	x	x	.	.	x	x
Myrsine	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Persea	.	x	.	x	x	x	.	x	.	x	.	x	.	x	.	x	.	.	.	x	x	.	.	x	x
Viburnum	.	.	.	x	.	x	x	x	.	x	x	x	.	x	.	x	.	.	.	.	.	.	.	.	.
herbs/grasses:																									
Carex	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hedera	.	x	.	x	x	x	x	x	.	x	x	x	.	x	.	x	x	x	x	x	x	.	x	x	x
Hedychium	.	x	x	x	x	x	x	x	.	x	x	x	.	.	.	x	.	.	.	.	x	.	.	x	.
Luzula	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.
bryophytes/lichens:																									
Polytrichum	.	.	.	x	.	.	.	.	.	.	x	.	.	.	.	x	.	.	.	.	.	x	.	.	.
Thamnobryum	.	.	.	x	.	x	.	.	x	.	x	x	.	.	x	x	x	.	x	x	x	x	x	x	.
lichens (Peltigera)	.	.	.	x	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Species treated in table:

1. *Bazzania azorica*; 2. *Cololejeunea azorica*; 3. *Aphanolejeunea madeirensis*; 4. *Aphanolejeunea microscopica*; 5. *Cololejeunea minutissima*; 6. *Aphanolejeunea teotonii*; 7. *Colura calyptrifolia*; 8. *Drepanolejeunea hamatifolia*; 9. *Eurhynchium praelongum*; 10. *Frullania microphylla*; 11. *Frullania tamarisci*; 12. *Frullania teneriffae*; 13. *Harpalejeunea ovata*; 14. *Hypnum uncinulatum*; 15. *Jubula hutchinsiae*; 16. *Lejeunea amacerina*; 17. *Lejeunea patens*; 18. *Lepidozia azorica*; 19. *Lophocolea fragrans*; 20. *Marchesinia mackaii*; 21. *Metzgeria furcata*; 22. *Plagiochila exigua*; 23. *Plagiochila spinulosa*; 24. *Radula aquilegia*; 25. *Radula carringtonii*.

ECOLOGY, SOCIOLOGY AND VULNERABILITY

Groups of plants that regularly grow together within small areas often become described as plant communities. Plant sociology generally becomes concentrated on description of such species groups that tend to occur under more or less equal habitat conditions. The communities are made up of species with similar preferences and ranges with respect to various ecological parameters. Consequently it is often more appropriate to treat ecological preferences and species association together, e.g. as the 'ecosociology' of the species.

Epiphyllous bryo-communities in Macaronesia are almost the only communities forming fairly monotonous groups of species with unusually similar habitat preferences. All sociological investigations reveal that plant communities have a more restricted presence than almost all their species. That is naturally also the case with the endemic epiphyllous association in the Azores, the *Cololejeuneetum azoricae*. The remarks in the following under 'Ecology' and 'Sociology' are thus aimed to show the often unexpectedly wide habitat ranges of the species recorded as epiphyllous, as to altitude range, substrate and phorophyte colonization. The wide ranges of the individual species contrast to the restricted habitat conditions where the mature community occurs. In such places, phorophyte species are numerous and samples with several preferentially epiphyllous species growing together may be obtained. Information has also been given on presence of the species in different stages of development of the epiphyllous community. Late stages get gradually more species-poor and invaded by species which are not preferentially epiphyllous. The typical constitution of the community gets obscured.

In 'Comments', the rarity of the species as compared with the information provided in the "Red Data Book of European Bryophytes" has been treated (cf. also chapter 'Threatened bryophytes in the Azores'). Some aspects on taxonomy have been added. For some species, the different substrate preference in continental

Europe has been mentioned, information of importance to the sociological application of the species as differential species with more or less strong differential value. The world distribution of the species, if mentioned (cf. Table 1) is mainly according to DÜLL (1983, 1992) and the Red Data Book (1995). The restriction of the species to one or several bryo-communities is according to publications by the author (see below), with some amendments due to results of recent sampling (1995-96), especially on the islands of Flores, Faial, Pico, S. Jorge and Santa Maria. (nomenclature, taxonomic revisions and abbreviations in "Introduction")

The following plant communities, described by Sjögren between 1972 and 1995 have been mentioned in the text accompanying the individual species:

phytocoenoses (native forest):

Juniperion brevifoliae 1973 (Azores)

Clethro-Laurion 1972 (Madeira)

bryophyte communities:

(epiphyllous)

Cololejeuneo-Colurion 1978, 1993 (Azores, Madeira)

Cololejeuneetum azoricae 1978 (Azores)

Cololejeuneetum microphyllae 1975 (Madeira)

(epigeic)

Andoe-Nardion 1990, 1995 (Azores)

(epiphytic):

Echinodion 1993 (Azores)

Echinodio-Lepidozietum cupressinae 1978 (Azores)

(epixylic)

Lepidozion azoricae 1997 (in press) (Azores)

Lepidozietum azoricae 1978 (Azores)

(epilithic)

Heterocladium hutchinsiae 1995 (Azores)

Tetrastichium-Dumortiera - ass. 1990 (Azores)

Ptychomitrium azoricae 1995 (Azores)

Acrobolbus wilsonii Nees
(Acrobolbaceae)

ECOLOGY: At altitudes between 600-1200 m. Rarely as epiphyllous. Recorded on *Trichomanes* in a secondary stage of development of the epiphyllous community. On all types of substrates with no distinct preference.

SOCIOLOGY: No diff. val. However, restricted to the cloud-zone forest (*Juniperion brevifoliae*).

COMMENTS: As endangered (E) in RDB in the Azores, which is correct. Very scattered localities and only small populations, on three islands; recently recorded on J (SJÖGREN 1995).

Adelanthus decipiens (Hook.) Mitt.
(Adelanthaceae)

ECOLOGY: From 500-1500 m, generally between 500-1000 m. Rarely as epiphyllous and on few phorophyte species. A late-stage colonizer. In continental Europe preferentially epiphytic and epilithic but in the Azores preferentially epiphytic/epixylic/epiphyllous (SMITH 1990).

SOCIOLOGY: No diff. val. but almost only in strongly sheltered habitats in the *Juniperion brevifoliae*.

COMMENTS: Few localities and small populations. At least in the Azores to be treated as vulnerable (V). The species has not been mentioned in RDB. Recently recorded on L (SJÖGREN 1995). Tropical species with northern limit of distrib. in W. Europe (GROLLE 1969, 1972 b).

Andoa berthelotiana (Mont.) Ochyra
(Hypnaceae)

ECOLOGY: From the coast - 1500 m. On all types of substrates but rarely as epiphyllous, mostly in final stages of development of the epiphyllous community. Only on few phorophytes.

SOCIOLOGY: Diff. sp. of the epigeic *Andoe-Nardion*.

COMMENTS: Endemic to Macaronesia. In RDB treated as rare in Portugal. At least in the Azores not threatened (NT), as on all islands frequently present and in many localities with large populations.

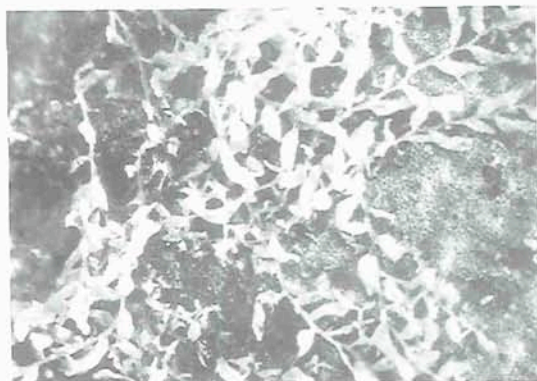


Fig. 1. *Aphanolejeunea madeirensis* (Schiffn.) Grolle, on frond of *Blechnum spicant*. - Magnification $\pm \times 28$. Sample locality at 600 m a.s.l. on the island of S. Jorge.

Aphanolejeunea madeirensis (Schiffn.) Grolle
(Lejeuneaceae)

ECOLOGY: Distinctly preferentially epiphyllous (Fig. 1). Once recorded as epixylic, on an *Erica*-stem covered by *Hymenophyllum*. Due to rarity of the species only recorded on a few phorophyte species, mostly on *Trichomanes*. *A. m.* requires equally specialized habitat conditions within the cloud-zone forest as *A. teotonii*.

SOCIOLOGY: Diff. sp. of the *Cololejeuneetum azoricae* in the Azores and of the *Cololejeuneetum microphyllae* on Madeira.

COMMENTS: *A. m.* is endemic to Macaronesia. In RDB mentioned as rare (R), but the species should at least be treated as vulnerable (V) both in the Azores and on Madeira, as very rare in mature *Juniperion brevifoliae* as well as in the Madeirensian cloud-zone forest (cf. SJÖGREN 1975). Young specimens of *A. m.* may be mistaken for the more common *A. teotonii*, but the projecting cells of the postical leaf lobes of the two species are different (op. cit.).

Aphanolejeunea microscopica (Tayl.) Evans
(Lejeuneaceae)

ECOLOGY: From 200-1100 m. Recorded as epiphyllous, epiphytic and epixylic but preferentially as epiphyllous. The largest numbers of phorophyte species occur between 600-1000 m (Table 4). Preferentially in the first stages of development of the epiphyllous community. Also

on leaves of some bryophytes (ALLORGE, V. & ALLORGE, P. 1938).

SOCIOLOGY: The largest numbers of associated preferentially epiphyllous species are recorded in samples at altitudes above 600 m (Table 3). *A. m.* is a diff. sp. of the *Cololejeuneo-Colurion*, but with diff. val. reduced due to the epiphytic and epixylic presence.

COMMENTS: Young specimens may be mistaken for *A. teotonii*, a species which is, however, much less common and has a narrower ecological range. *A. m.* occurs in general u.c. the same species on Madeira as in the Azores. No preferentially epiphyllous hepatic is equally common even at low altitudes or has been recorded on so many bryo-phorophyte species (op. cit.).

Aphanolejeunea teotonii Jov.-Ast. et V. All.
(Lejeuneaceae)

ECOLOGY: Recorded from 200-1000 m. Preferentially above 600 m. The presence at very low altitudes (SJÖGREN 1990) is probably more unstable and threatened than at high altitudes. Preferentially epiphyllous, also as epiphytic and epixylic but rarely as epilithic. Several phorophyte species, especially above 500 m.

SOCIOLOGY: Diff. sp. of the *Cololejeuneetum azoricae* and probably also of the *Cololejeuneetum microphyllae*, epiphyllous associations in the Azores respectively on Madeira. Most records in mature *Juniperion brevifoliae*.

COMMENTS: In RDB treated as rare (R) in the Azores; the correct status is vulnerable (V), although *A. t.* is present on all the Azorean Islands (recorded on Santa Maria in 1996). Its cloud-zone habitats are easily transformed in a way that is negative for the species. *A. t.* was regarded as endemic to the Azores, at least until 1982 (cf. EGGERS 1982). In RDB (1995) mentioned as endemic to Macaronesia, as vulnerable (V) in the Canary Islands, as not threatened (NT) on Madeira. Altogether given the status vulnerable (V) in Europe. *A. t.* is probably vulnerable (V) also on Madeira, where the species has not been documented by the author (cf. SJÖGREN 1975). Taxonomy and illustrations by ALLORGE, V. &

JOVET-AST (1950).

Bazzania azorica Buch et H. Perss.
(Lepidoziaceae)

ECOLOGY: Most records above 600 m. On all types of substrates, preferentially epiphytic/epixylic. Rarely epiphyllous. Only on wilted specimens of phorophytes, in late stages of development of the moss-cover. *B. a.* is a comparatively big hepatic and may occasionally itself become colonized by the small *Cololejeunea* species.

SOCIOLOGY: Most frequent within the *Juniperion brevifoliae*. Thus, missing on the low islands of Santa Maria and Graciosa; as to the absence on Corvo, see SJÖGREN (1993). Diff. val. of epiphytic/epixylic bryo-communities of the cloud-zone forest.

COMMENTS: In RDB treated as rare (R) in Portugal. Fortunately *B. a.* is not threatened (NT) in the Azores, being thus one example of incorrect estimation of the rarity of threatened bryophytes in the Azores, an unfortunate result of insufficient examination of literature and of bryo-communities in the field. Description and illustration by BUCH & PERSSON (1941); taxonomic remarks by GROLLE (1972 a).

Brachythecium populeum (Hedw.) B.S.G.
(Brachytheciaceae)

ECOLOGY: Preferentially epilithic. Accidental epiphyllous presence, on senescent fronds of ferns.

SOCIOLOGY: Diff. sp. of the epilithic *Ptychomitrium azoricae*.

Brachythecium velutinum (Hedw.) B.S.G.
(Brachytheciaceae)

ECOLOGY: Preferentially epilithic and epiphytic. Accidental presence as epiphyllous. Only one record, on *Trichomanes*.

SOCIOLOGY: No. diff. val.

COMMENTS: Remarkably rare in the archipelago, possibly underrecorded. Recent record on L (SJÖGREN 1995).

Calypogeia fissa (L.) Raddi
(Calypogeiaceae)

ECOLOGY: Wide altitude range (SJÖGREN 1975). On all types of substrates but preferentially as epigeic. Accidentally as epiphyllous. The epiphyllous presence, as for all preferentially epigeic species, is recorded on low-growing ferns (*Hymenophyllum*) and on large bryophytes (*Polytrichum*).

SOCIOLOGY: Moderately strong diff. val. of the epigeic *Andoe-Nardion*, alliance endemic to the Azores and common on soil escarpments.

COMMENTS: Shape of leaves and underleaves help to distinguish the species from *C. muelleriana* but intermediate forms exist.

Calypogeia fusca (Lehm.) Steph.
(Calypogeiaceae)

ECOLOGY: Wide altitude range, preferentially between 700-900 m. Preferentially epixylic/epiphytic, rare as epiphyllous.

SOCIOLOGY: Diff. val. of the *Juniperion brevifoliae*.

COMMENTS: Remarkable outpost in the Azores of a hepatic with its main distrib. in Africa. In RDB treated as rare (R) in the Azores, which is correct. Always small populations, few localities; presence on four islands confirmed by BISCHLER (1970). See also description and illustration in BUCH & PERSSON (1941).

Calypogeia muelleriana (Schiffn.) K. Müll.
(Calypogeiaceae)

ECOLOGY: Preferences like *C. fissa*. Rarely as epiphyllous. Recorded on three species of phorophytes, in late stages of development of the epiphyllous *Cololejeuneetum azoricae*.

SOCIOLOGY: Diff. sp. of the epigeic *Andoe-Nardion*.

Calypogeia neesiana (Mass. et Carest.) K. Müll.
(Calypogeiaceae)

ECOLOGY: Undefined, due to exceptional rarity of the species. One epiphyllous sample, on wilted specimen of *Trichomanes*, in postmaturely

developed *Cololejeuneetum azoricae*.

Campylopus cygneus (Hedw.) Brid.
(Dicranaceae)

ECOLOGY: On all types of substrates. Accidentally as epiphyllous, on old fronds of ferns (*Trichomanes*, *Blechnum*) only with short stems.

SOCIOLOGY: Probably to become distinguished as a diff. sp. of one association of the epigeic *Andoe-Nardion*.

COMMENTS: Remarkable outpost of this species with its main distrib. in Middle-America. In RDB looked upon as insufficiently known (K), which is true, due to the still ill-defined ecology and distribution of the species. Probably not threatened (NT) in the Azores, as frequently present in seminatural open grassland vegetation, at altitudes above 600 m.

Cephalozia crassifolia (Lindenb. et Gott.) Fulf.
(Cephalaziaceae)

ECOLOGY: On all types of substrates, preferentially epixylic/epiphytic, preferentially above 600 m. Epiphyllous presence is scarce; only recorded on *Elaphoglossum* and *Trichomanes*.

SOCIOLOGY: Diff. sp. of epixylic/epiphytic bryocommunities of the cloud-zone forest (cf. SJÖGREN 1978); frequently present in the epixylic *Lepidozietum azoricae*.

COMMENTS: In RDB treated as vulnerable (V) in Europe and as not threatened (NT) in the Azores. Continued thinning or felling of the native *Juniperion brevifoliae* forest in the Azores will rapidly move the species into the category rare (R). For taxonomy see e.g. SMITH (1990) and VANA (1988).

Cheilolejeunea cedercreutzii (Buch et H. Perss.) Grolle (Lejeuneaceae)

ECOLOGY: Recorded between 700-1000 m. Preferentially epiphyllous and epiphytic. Only in mature *Juniperion brevifoliae* forest, like in the Caldeira do Faial and in Caldeira do Santa Barbara on Terceira.

SOCIOLOGY: No diff. val. due to extreme rarity.

COMMENTS: This easily distinguished epiphyllous hepatic (cf. BUCH & PERSSON 1941) may be regarded as one of the most precious endemic species in the archipelago. In RDB treated as vulnerable (V) Its presence on only four islands, in few localities and with small populations must be sufficient justification for the species becoming treated as endangered (E). The habitat conditions in the localities known are easily influenced in a negative way which may extinguish *C. c.* from the Azorean flora. As compared with other epiphyllous species, *C. c.* is, for example, much more endangered than *Cololejeunea azorica*, which has also been given the status vulnerable. This is just one of several examples, suggesting that the RDB of 1995 must be regarded as a preliminary opus, which should become revised at regular intervals (cf. e.g. *Bazzania azorica*).

Chiloscyphus polyanthos var. *pallescent* (Ehrh. - ex Hoffm.) Hartm.
(Geocalycaceae)

ECOLOGY: Preferentially epigeic, rarely as epiphyllous. Altitude range unknown. On wilted specimens of a few fern phorophytes, in late stages of development of the epiphyllous community.

Cololejeunea azorica V. All. et Jov.-Ast
(Lejeuneaceae)

ECOLOGY: Preferentially epiphyllous, also recorded as epiphytic and epixylic. Between 200-900 m (extended range after sampling on Graciosa and Corvo (cf. SJÖGREN 1990, 1993). Largest numbers of associated preferentially epiphyllous species at 700-900 m (Table 3). Large number of phorophyte species above 600 m, few below that altitude. Among the phorophytes recorded are also introduced species, in gardens, such as *Phoenix* sp. and *Camelia* sp. (S. Miguel: Furnas).

SOCIOLOGY: Diff. sp. of the *Cololejeuneetum azoricae*. The documentation of *C. a.* on Madeira (SJÖGREN 1975) as diff. sp. also of the *Cololejeuneetum microphyllae* suggests that the species should be treated as a diff. sp. of the Macaronesian epiphyllous alliance *Cololejeuneo-*

Colurion. For taxonomy and description of *C. a.* see ALLORGE, V. & JOVET-AST (1955).

COMMENTS: Easily distinguished species due to blunt antical leaf lobes; only possible to mistake for *Lejeunea ulicina* (when dry), which has, however, underleaves. In RDB treated as rare (R) in the Azores and as vulnerable (V) on Madeira, which is correct. The status vulnerable may rapidly become appropriate if habitat changes are created within the mature *Juniperion brevifoliae*. Even extensive thinning or strip cutting of the cloud-zone forest may locally almost extinguish the epiphyllous bryo-community and *C. a.* is one of the most susceptible of its species. In RDB noted for 6 islands and less than 20 localities. The correct information should have been: on 8 of the Azorean islands (at least 30 localities), on Madeira less than 10 localities. *C. a.* has recently been recorded by the author on Santa Maria (1996).

Cololejeunea minutissima (Sm.) Schiffn.
(Lejeuneaceae)

ECOLOGY: Preferentially epiphyllous, rarely as epilithic. Between 200-1100 m. Mostly as epiphytic where present below 500 m. Recorded on several phorophyte species, especially above 500 m (Table 4). The largest numbers of associated preferentially epiphyllous species also



Fig. 2. *Cololejeunea minutissima* (Sm.) Schiffn., characteristically growing at the margin of a hole, on an old leaf of *Laurus azorica*, where the substrate surface is less glossy and diaspores of the tiny epiphyllous hepatics get more easily attached. - Magnification $\pm \times 14$. Sample locality at 900 m a.s.l. on the island of Pico.

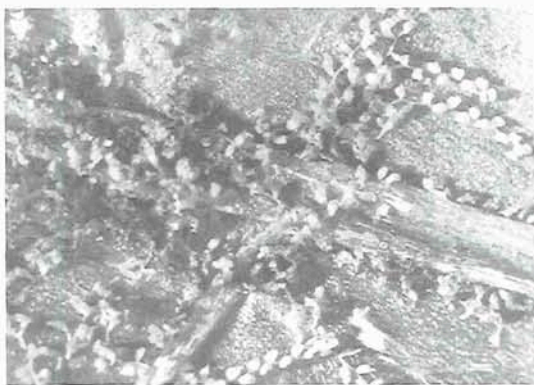


Fig. 3. *Cololejeunea minutissima* (Sm.) Schiffn. on frond of *Woodwardia radicans*; colonization originating from diaspores growing in the groove and at the margins of the midrib. - Magnification $\pm \times 14$. Sample locality at 700 m a.s.l. on the island of S. Jorge.

occur above 500 m, on average the largest numbers between 700-900 m (Table 3).

SOCIOLOGY. Diff. sp. of the *Cololejeuneo-Colurion* both in the Azores and on Madeira (Fig. 2 and 3). Common in many localities forming large populations. Large numbers of associated preferentially epiphyllous species below 500 m have only been recorded on the island of Corvo. - High frequency of this small hepatic is generally a good indicator (if growing as epiphyllous) of habitat conditions suitable for development of a mature *Juniperion brevifoliae*. Size of populations also has indicator value. Possible application for suggestion of forest areas to become preserved.

Colura calyptrifolia (Hook.) Dum.
(Lejeuneaceae)

ECOLOGY: Recorded between 300-1000 m. Most samples are taken above 500 m (Fig. 4). Strongly preferentially epiphyllous, rarely as epixylic and epiphytic. The largest numbers of phorophyte species and of associated preferentially epiphyllous species above 500-600 m (Tables 3 and 4).

SOCIOLOGY: Diff. sp. of the *Cololejeuneo-Colurion*. Rare non-epiphyllous presence of *C. c.* almost only in the cloud-zone forest. Only few records on *Cryptomeria*-trunks.

COMMENTS: Clear-felling or thinning of mature stands of the cloud-zone forest will rapidly accentuate the rarity of *C. c.*, providing motivation to give the species a status at least as regionally threatened (RT). *C. c.* is one of the very few hepatics which have epiphyllous occurrence also on the European continent. In Brittany on *Blechnum* and *Pteris* (CORBIÈRE 1889), in Britain and Ireland on bryophytes such as *Frullania tamarisci* (SMITH 1990). Epilithic presence on Corsica (MACVICAR 1910).

Cyclodictyon laetevirens (Hook. et Tayl.) Mitt.
(Hookeriaceae)

ECOLOGY: Preferentially epixylic, on all types of substrates except as epigeic. Highly shelter-demanding species (cf. SJÖGREN 1978). The epiphyllous presence is accidental.

SOCIOLOGY: No. diff. val.

COMMENTS: This peculiar double-nerved species of a tropical genus is treated in RDB as rare (R) in Portugal (Azores + Madeira). The narrow ecological range and the few localities (only on three of the Azorean islands) makes it more appropriate to treat *C. l.* as vulnerable (V). Cutting of tree/shrub layer in river-ravines and explosion craters, where a maintained high air humidity is required by the species, may rapidly give *C. l.* the status as vulnerable or even endangered.

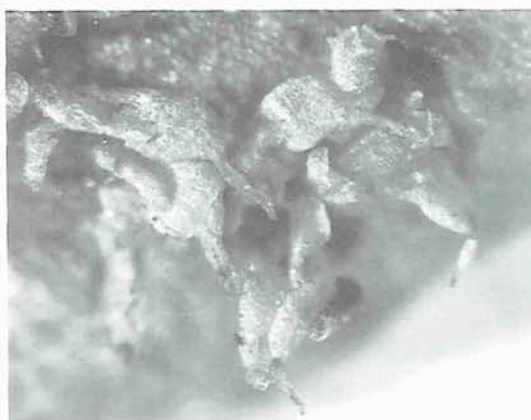


Fig. 4. *Colura calyptrifolia* (Hook.) Dum., on old frond of *Blechnum spicant*. - Magnification $\pm \times 28$. Sample locality at 800 m a.s.l. on the island of Pico.

Daltonia splachnoides (Sm.) Hook. et Tayl.
(Daltoniaceae)

ECOLOGY: Preferentially epiphytic/epixylic, few accidental epiphyllous records. Generally above 700 m. Highly shelter-demanding, like *Cyclodictyon*. Restricted to mature types of the *Juniperion brevifoliae* forest, preferentially in craters and explosion holes.

SOCIOLOGY: No. diff. val.

COMMENTS: In RDB treated as vulnerable (V) in Europe and as endangered (E) in the Azores, which is correct, although the known altitude range is 750-1400 m (SjÖGREN 1978) and not the mentioned 900-1400 m, important in this case in order to stress the presence of the species within the cloud-zone forest. Few localities and small populations. *D. s.* is the only species of this genus in Europe.

Dicranolejeunea johnsoniana (Mitt.) Grolle
(Lejeuneaceae)

ECOLOGY: No clearly defined substratum preference. Recorded by the author as epiphyllous on *Trichomanes* and *Blechnum*. Probably a cloud-zone species. On Madeira between 600-1300 m, being more common than in the Azores. The altitude range of its close relative *Marchesia mackaii* is much wider, including also numerous localities below the cloud-zone.

SOCIOLOGY: Probably under-recorded. *D. j.* may possibly be treated as a diff. sp. of the mature *Juniperion brevifoliae*.

COMMENTS: Species unfortunately not mentioned in RDB. Should be treated as insufficiently known (K) until distribution and ecological range become better known. Azorean records are few, only on 3 islands and populations are small. Eventually probably to become assessed as vulnerable (V). Taxonomy and illustration by GROLLE (1966).

Dicranum scottianum Turn. s.l.
(Dicranaceae)

ECOLOGY: Preferentially epiphytic and epixylic, with rare presence as epiphyllous, in late stages of development of the moss-cover. Few recorded phorophytes, mostly on senescent specimens of

Trichomanes and *Elaphoglossum*. The epiphyllous presence is restricted to the native cloud-zone forest.

SOCIOLOGY: Only weak diff. val. towards epigeic and epilithic bryo-communities.

COMMENTS: The var. *scottianum* and var. *canariense* need further investigation of taxonomy and distribution.

Diplophyllum albicans (L.) Dum.
(Scapaniaceae)

ECOLOGY: Preferentially above 500 m. On all types of substrates, rarely as epiphyllous and epiphytic. Only senescent specimens of a few fern species get colonized, in very late stages of development of the epiphyllous moss-cover.

SOCIOLOGY: Diff. val. only towards epiphytic and epiphyllous communities within the cloud-zone. Locally highly frequent in the epigeic *Andoa-Nardion*, both in sheltered and strongly exposed habitats; in many localities up to 95 % cover, if sample plots of ¼ m² are used.

Drepanolejeunea hamatifolia (Hook.) Schiffn.
(Lejeuneaceae)

ECOLOGY: On all types of substrates. Preferentially epiphyllous; many samples where the species is epiphytic and epixylic. Large number of phorophyte species (Table 4), especially above 600 m. Recorded between 300-1300 m, most records above 600 m where *D. h.* also grows together with the largest number of preferentially epiphyllous species (Table 3).

SOCIOLOGY: Together with *Cololejeunea minutissima* the most frequent of the preferentially epiphyllous species. In the Azores, even growing on the comparatively dry island of Graciosa (epigeic on litter). Diff. val. towards epigeic and epilithic bryo-communities of the *Juniperion brevifoliae*. Mostly in early stages of development of the *Cololejeuneetum azoricae* as well as the Madeiran *Cololejeuneetum microphyllae* (Fig. 5).

COMMENTS: High frequency, large populations and large number of phorophyte species indicate a mature *Juniperion brevifoliae*, worthy of attention as an object for preservation.



Fig. 5. *Drepanolejeunea hamatifolia* (Hook.) Schiffn. Growth of diaspores probably supported by presence of scattered fimbriate scales on fronds of the fern *Elaphoglossum semicylindraceum*, here growing on the stem of *Juniperus brevifolia*. - Magnification $\pm \times 14$. Sample locality at 900 m a.s.l. on the island of Pico.

Dumortiera hirsuta (Sw.) Nees
(Wiesnerellaceae)

ECOLOGY: Preferentially epigeic and epilithic. Almost from the coast - 1000 m. Epiphyllous records are few and the presence is restricted to wilted fern specimens with a moss-cover in transition towards epixylic.

SOCIOLOGY: Diff. val. of associations of the epilithic *Heterocladion hutchinsiae*.

Echinodium prolixum (Mitt.) Broth.
(Echinodiaceae)

ECOLOGY: Preferentially epiphytic, preferentially at altitudes above 600 m. Recorded on all types of substrates. The rare epiphyllous presence in late stages of development of the moss-cover is occasional and the specimens only get poorly developed.

SOCIOLOGY: Diff. sp. of the epiphytic *Echinodiolopidozietum cupressinae*, ass. of the endemic *Echinodion*.

COMMENTS: This valued cloud-zone species, endemic to Macaronesia, has been treated as rare (R) in Portugal. Fortunately in the Azores as well as on Madeira to be looked upon as not threatened (NT), even present at high altitudes in non-mature *Juniperion brevifoliae*.

Echinodium renauldii (Card.) Broth.
(Echinodiaceae)

ECOLOGY: Not recorded as epiphyllous, but known as a phorophyte for preferentially epiphyllous hepatics. Preferentially above 500 m, only in very much sheltered habitats, as epilithic. Preferentially in the cloud-zone forest but on Corvo (Fig. 6) found in a deep ravine (SJÖGREN 1993) with no trees or shrubs and on Terceira in a dense *Erica-Laurus* - dominated forest at altitude below the mature *Juniperion brevifoliae* (see GABRIEL 1994), on Flores at 200 m in a dense *Eucalyptus-Acacia* forest.

COMMENTS: This remarkable species, endemic to the Azores, needs a few comments. In RDB listed as vulnerable (V). The correct status is endangered (E). Few localities found during my 30 years of excursions on all the Azorean islands. Totally 7 localities on 5 islands, although the species is of large size and easily recognized (one locality on Pico not found again in 1995, first recorded in 1982). All known localities need protection from management leading to changes of shelter and consequently of the humidity regime.

Eurhynchium praelongum (Hedw.) B.S.G. s.l.
(Brachytheciaceae)

ECOLOGY: On all types of substrates. As epiphyllous only represented by very small specimens, colonizing in very late stages of development of the epiphyllous bryo-community, on old specimens of ferns and bryophytes.

Fissidens serrulatus Brid.
(Fissidentaceae)

ECOLOGY: Preferentially epigeic and epilithic, very rare as epiphyllous. Mostly on large bryophytes (*Thamnobryum*), as small underdeveloped specimens.

SOCIOLOGY: Diff. sp. of the epilithic *Heterocladion hutchinsiae* on the level of association, generally u.c. *Thamnobryum*, *Conocephalum* and *Dumortiera*.

Frullania microphylla (Gott.) Pears. incl. var. *deciduifolia* Grolle
(Frullaniaceae)

ECOLOGY: Preferentially epiphyllous, although in several localities as epiphytic, rarely as epilithic. Between 200-1100 m, preferentially above 500 m where growing as epiphyllous, and with highest frequency within the cloud-zone forest. Mostly as epiphytic below 500 m. The largest numbers of phorophytes between 500-1000 m (Table 4) as well as the largest numbers of associated preferentially epiphyllous species (Table 3). Where epiphyllous, mostly a member of secondary stages of development of the *Cololejeuneetum azoricae*.

SOCIOLOGY: Diff. sp. of the *Cololejeuneetum azoricae*. On Graciosa and on Santa Maria highly frequent member of an epiphytic miniassociation, the *Frullanietum microphyllae*, at low altitude levels (cf. v. HÜBSCHMANN 1971; SJÖGREN 1990). COMMENTS: The differences in frequency of var. *microphylla* and var. *deciduifolia* (cf. GROLLE 1970) in the Azores are still insufficiently investigated, but the var. *deciduifolia* may be more frequent, at least as epiphyllous, than stated before (SJÖGREN 1978). Recently collected material from Santa Maria (1996) consists almost totally of specimens of small size, with single line of ocelli, rarely enlarged with additional cells in the apex, thus of the var. *deciduifolia* - type. For taxonomy see BISANG et al. (1989).

Frullania tamarisci (L.) Dum.
(Frullaniaceae)

ECOLOGY: On all types of substrates. However, frequently as epiphyllous in secondary stages of development of the moss-cover, where Lejeuneaceae-species start to disappear. Very wide altitude range and in sheltered as well as in strongly exposed habitats. Several phorophyte species, especially above 600 m.

Frullania teneriffae (F. Web.) Nees
(Frullaniaceae)

ECOLOGY: Like the similar species *F. tamarisci*, growing on all types of substrates but less

frequent than that species in strongly exposed habitats.

SOCIOLOGY: More closely confined to the native *Juniperion brevifoliae* forest types than *F. tamarisci*.

Harpalejeunea ovata (Hook.) Schiffn.
(Lejeuneaceae)

ECOLOGY: Recorded on all types of substrates, although preferentially epiphyllous. From 200-1100 m, most records as epiphyllous from altitudes above 500 m; between 200-500 m several epiphytic samples.

SOCIOLOGY: Diff. val. only towards epigeic and epilithic bryo-communities.

COMMENTS: On the European continent mostly epiphytic and epilithic. Several Azorean bryophytes, like *H. o.*, have less pronounced substrate preference than on the continent (cf. ALLORGE, P. 1947; ALLORGE, V. 1974; JOVET-AST & BISCHLER 1976; SMITH 1990). *H. o.* on Madeira, as in the Azores, is not restricted to the cloud-zone.

Herbertus azoricus (Steph.) Richards
(Herbertaceae)

ECOLOGY: Recorded on all types of substrates, preferentially as epiphytic, epilithic and epixylic. Only juvenile specimens occur as epiphyllous, accidentally in postmature stages of the moss-cover. Altitude range 600-1500 m, but clearly preferentially within the range 700-1000 m.

SOCIOLOGY: No diff. val. of any bryo-community but probably to become treated as a diff. sp. of the *Juniperion brevifoliae*, both in sheltered and in strongly exposed habitats.

COMMENTS: This attractive large hepatic, endemic to the Azores, has been treated in RDB as rare (R). It is not threatened (NT) and in some localities on some islands frequently present at high altitudes, with fairly large populations.

Heterocladium heteropterum B.S.G. s.l.
(Thuidiaceae)

ECOLOGY: Preferentially epilithic, rarely and accidentally as epiphyllous on large bryophytes

such as *Thamnobryum*, in river ravines where *H. h.* is abundant as epilithic.

SOCIOLOGY: Diff. sp. of the epilithic *Heterocladion hutchinsiae*.

COMMENTS: Recently Macaronesian records of *H. h.* have been treated as *H. wulfsbergii* I. Hag. (cf. HEDENÄS 1992). The taxonomic status of *H. w.* as a species has not been accepted, e.g. by DÜLL (1992). The var. *macounii* (Best.) Dix. shows intermediate forms towards typical *H. h.*

Heteroscyphus denticulatus (Mitt.) Schiffn.
(Lophocoleaceae)

ECOLOGY: Recorded as epigeic and epilithic, only once as epiphyllous, on *Trichomanes*. Altitude range undefined due to rarity of the species.

COMMENTS: In RDB listed as rare (R). It is true that *H. d.* is a rare species in the Azores (cf. SÉRGIO 1985). On six islands only scattered small populations, within the cloud-zone forest. Better treated as insufficiently known (K), as probably still under-recorded.

Hylocomium splendens (Hedw.) B.S.G.
(Hypnaceae)

ECOLOGY: Preferentially epigeic, only recorded once as epiphyllous on *Huperzia*.

COMMENTS: Only on 4 islands. Recently recorded also on Madeira (HEDENÄS 1992). *H. s.* occurs u. c. *Thuidium tamariscinum*, which seems to have, at least in the Azores, a stronger competitive ability.

Hylocomium armoricum (Brid.) Wijk et Marg.
(Hypnaceae)

ECOLOGY: Grows in a few localities, between 600-700 m, on the island of S. Jorge. Recorded on all types of substrates, with very large populations. The epiphyllous presence on old fronds of ferns is accidental.

COMMENTS: One of the most peculiar, very local presences of bryophytes in the Azores. Never seen by the author on other islands although similar habitats in efficiently sheltered river ravines are richly present, e.g. on the nearby island of Pico. Another highly frequent species on the European

continent, but in the Azores present on only one island and very locally, is *Aulacomnium palustre*.

Hypnum uncinulatum Jur.
(Hypnaceae)

ECOLOGY: Preferentially epiphytic and epixylic but present on all types of substrates. The epiphyllous presence is confined to late or very late stages of development of the moss-cover and most records are on ferns. Altitude range from the coast to about 1500 m.

SOCIOLOGY: No diff. val. The highest frequency is in the epiphytic *Echinodion* of the cloud-zone forest but the species is also highly frequent in *Cryptomeria* plantations and in dense forests of *Pittosporum*.

COMMENTS: For taxonomy see HEDENÄS (1992). Recent record in Hb (ANDO & TOWNSEND 1980).

Jubula hutchinsiae (Hook.) Dum.
(Jubulaceae)

ECOLOGY: On all types of substrates but preferentially epiphyllous and epilithic. The only epiphyllous species with such a preference. Recorded between 200 - 1000 m. Most records from above 600 m, within the cloud-zone.

SOCIOLOGY: Diff. sp. of the epilithic river ravine community *Heterocladion hutchinsiae*. The most frequently associated species are *Heterocladium heteropterum* and *Tetrastichium fontanum*.

COMMENTS: Specimens with densely denticulate leaves or with generally only one apical tooth (var. *integrifolia* Lindb.; f. *integrifolia* Grolle) occur. This var. seems to be more frequent in fairly dry habitats (cf. v. HÜBSCHMANN 1971). *J. h.* is epiphytic and epilithic in Br and Hb (SMITH 1990) and in Hs (ALLORGE, P. 1947).

Lejeunea cavifolia (Ehrh.) Lindb.
(Lejeuneaceae)

ECOLOGY: Few records, only one as epiphyllous, on *Trichomanes*. Rare and local, on 2 islands. In the Azores this species, fairly common in continental Europe, is substituted by other *Lejeunea* species, which are present on all types of substrates. Presence in Az and Cn uncertain.

Lejeunea eckloniana Lindenb.
(Lejeuneaceae)

ECOLOGY: Preferences undefined as still only a few records, on Terceira and S. Miguel. The new record of the species, on S. Miguel, is as epiphyllous on *Thamnobryum* at 400 m.

COMMENTS: This African/Macaronesian species is probably still under-recorded in the Azores. It looks superficially like a senescent specimen of *L. lamacerina*. Its presence in the Canary Islands is epiphytic and epigeic, as in S. Africa (ARNELL 1961, 1963). Taxonomy and illustrations, see JONES (1974) and SÉRGIO (1978).

Lejeunea flava ssp. *moorei* (Lindb.) Schust.
(Lejeuneaceae)

ECOLOGY: Recorded on all types of substrates. Preferentially epiphytic, very rare as epiphyllous. On *Trichomanes* in late stages of development of the epiphyllous community. From the coast (Flores) - about 1300 m, preferentially between 500 - 900 m.

SOCIOLOGY: Diff. sp. of the *Echinodio-Lepidozietum cupressinae*, epiphytic ass. of the *Juniperion brevifoliae*.

COMMENTS: In RDB treated as rare (R). The species is characteristically absent from the two small "dry" islands of Santa Maria and Graciosa, but is not rare on the islands of the central group in the Azores. *L. f.* is one of the regionally threatened species (RT), which may rapidly become rare or even vulnerable as a consequence of cutting or thinning of the mature cloud-zone forest. On Madeira preferentially in the *Clethro-Laurion* forest. For taxonomy see SCHUSTER (1980).

Lejeunea holtii Spruce
(Lejeuneaceae)

ECOLOGY: On all types of substrates but only one record as epigeic and a few as epiphyllous (also on large bryophytes such as *Thamnobryum*). From the coast - 700 m.

COMMENTS: In Hb as epilithic (SMITH 1990).

Lejeunea lamacerina (Steph.) Schiffn.
(Lejeuneaceae)

ECOLOGY: Recorded on all types of substrates but comparatively rare as epilithic and epigeic (Fig. 6).

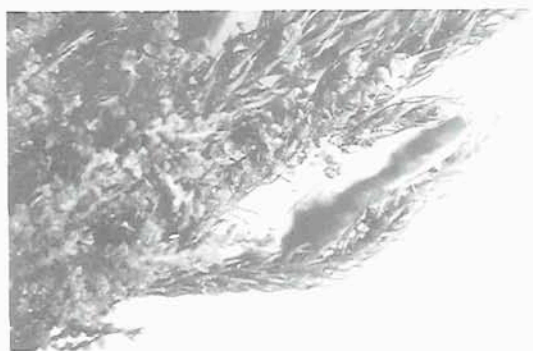


Fig. 6. *Lejeunea lamacerina* (Steph.) Schiffn. on old specimens of *Echinodium renauldii* (bryophyte endemic to the Azores). Magnification $\pm \times 7$. Sample locality at 350 m a.s.l. on the island of Corvo.

Wide altitude range, from the coast - 1100 m at least. *L. l.* is one of the most frequent epiphyllous species in the Azores, present in both primary and secondary stages of development of the *Cololejeuneetum azoricae* as a successful competitor to small epiphyllous hepatics of the genera *Cololejeunea* and *Aphanolejeunea*. The largest numbers of associated preferentially epiphyllous species occur at altitudes above 500 m (Table 3) as well as the largest numbers of phorophyte species (Table 4).

COMMENTS: *L. l.* is a very variable species as to size and colour. It is a diff. sp. of the *Cololejeuneetum microphyllae* on Madeira.

Lejeunea patens Lindb.
(Lejeuneaceae)

ECOLOGY: On all types of substrates but rarely as epigeic and epilithic. From coast-near localities - 1500 m, preferentially between 600 - 1000 m. Largest numbers of associated preferentially epiphyllous species above 500 m as well as the largest numbers of phorophyte species.

SOCIOLOGY: Diff. val. towards epilithic and epigeic bryo-communities. Present in primary and secondary stages of development of the *Cololejeuneetum azoricae*, being a successful competitor to small species of the family Lejeuneaceae.

COMMENTS: *L. p.* is almost restricted to the *Juniperion brevifoliae*, like several epiphyllous

species. All sorts of management for various purposes of the cloud-zone forest may rapidly transfer the species to a status as vulnerable. Epilithic and epiphytic in England (SMITH 1990).

Lejeunea ulicina (Tayl.) Gott. et al.
(Lejeuneaceae)

ECOLOGY: Recorded as epilithic and epiphytic but preferentially epiphyllous. A primary stage colonizer. Wide altitude range.

SOCIOLOGY: No diff. val. A rise of the number of records may eventually motivate that the species becomes treated as a diff. sp. of the *Cololejeuneetum azoricae*.

COMMENTS: Still few records, probably under-recorded as frequently mistaken for *Cololejeunea minutissima*, if the presence of underleaves is not checked. The species is more common on Madeira, where it has been treated as diff. sp. of the *Cololejeuneetum microphyllae* (SJÖGREN 1975). Recorded in continental Portugal as epiphytic and as epiphyllous on lichens and on *Frullania tamarisci* (ALLORGE, V. 1974). As epiphytic in Spain on *Quercus suber* (JOVET-AST & BISCHLER 1976).

Lepidozia azorica Buch et H. Perss.
(Lepidoziaceae)

ECOLOGY: On all types of substrates but rarely as epigeic (GABRIEL 1994). Occasionally between 250 - 500 m, preferentially between 600 - 900 m. A few epiphyllous records.

SOCIOLOGY: Diff. sp. of the epixylic *Lepidozietum azoricae*.

COMMENTS: In RDB treated as vulnerable (V) in Europe. The status is correct, but there is an evident risk that *L. a.* turns to become endangered (E) in the Azores if more areas of the *Juniperion brevifoliae* become cut or thinned. The present status in the Azores is rare (R). Characteristic absence of the species on Corvo, Graciosa and Santa Maria, where the cloud-zone forest is absent or impoverished. Description and illustration by BUCH & PERSSON (1941).

Lepidozia cupressina (Sw.) Lindenb. in Gott.
(Lepidoziaceae)

ECOLOGY: On all types of substrates but preferentially epiphytic. From 500 - 1200 m, preferentially between 600 - 900 m. Absent on the "dry" islands of Graciosa and Santa Maria; not recorded on Corvo. Very rare as epiphyllous. Only two samples, on senescent fronds of *Trichomanes* and *Blechnum*.

COMMENTS: Abundant and frequent member of the mature *Juniperion brevifoliae*. Boreal/Tropical element in the Macaronesian bryo-flora (GREIG-SMITH 1950).

Lepidozia reptans (L.) Dum.
(Lepidoziaceae)

ECOLOGY: On all types of substrates, preferentially as epixylic, rarely as epiphyllous on old fronds of ferns. Wide altitude range.

SOCIOLOGY: Diff. sp. of the epiphytic and epixylic communities in the cloud-zone forest (cf. SJÖGREN 1975).

Leptosecyphus azoricus (Buch. et H. Perss.) Grolle
(Lophocoleaceae)

ECOLOGY: Recorded as epiphytic and epiphyllous. Very few records. Probably only in mature *Juniperion brevifoliae* forest. Only one record as epiphyllous, on *Elaphoglossum* at 1050 m in an explosion crater within a lava field; very sheltered habitat.

COMMENTS: In RDB as vulnerable (V). Few, very scattered and small populations. Should be treated as endangered (E) as habitat conditions in the few localities may become easily changed in negative directions. For distinguishing features of *L. a.*, see GROLLE (1962).

Leucobryum juniperoideum (Brid.) C. Müll.
(Leucobryaceae)

ECOLOGY: On all types of substrates. Rarely as epiphyllous. Only one record, on old frond of *Trichomanes*. Wide altitude range. Rapidly colonizing wilted ferns and the litter carpet in the

Juniperion brevifoliae; also rapidly disappearing, as *L. j.* is preferentially epiphytic and epixylic.

Lophocolea bidentata (L.) Dum.
(Lophocoleaceae)

ECOLOGY: On all types of substrates except as epilithic. Rarely as epiphyllous, on old fronds of ferns. Wide altitude range. However, much more rare in the Azores as epiphyllous than *L. fragrans*.

Lophocolea fragrans (Moris et De Not.) Gott. et al.
(Lophocoleaceae)

ECOLOGY: Recorded on all types of substrates; rarely as epigeic and epilithic. Wide altitude range but mostly above 500 m. On several phorophyte species, especially between 600 - 900 m.

SOCIOLOGY: Weak diff. val. towards epilithic and epigeic bryo-communities within the mature cloud-zone forest.

COMMENTS: Young specimens with only one extra marginal tooth below the two apical ones of the leaves may be mistaken for *L. bidentata*. More frequent as epigeic, e.g. in England and continental Portugal (cf. SMITH 1990; JOVET-AST & BISCHLER 1976).

Lophocolea heterophylla (Schrad.) Dum.
(Lophocoleaceae)

ECOLOGY: Recorded as epiphytic, epixylic and epigeic. Only one record as epiphyllous, on old frond of *Blechnum*. Wide altitude range.

COMMENTS: Still few localities in the Azores of this almost cosmopolite species. Apparently *L. h.* belongs to the group of species, common on the European continent but with maintained more or less extreme rarity in the Azores (e.g. *Lejeunea cavifolia*, *Aulacomnium androgynum*, *Rhytidadelphus loreus*).

Lophozia ventricosa (Dicks.) Dum.
(Lophoziaaceae)

ECOLOGY: On all types of substrates. Only one epiphyllous record, on *Trichomanes*. Wide altitude range. Few scattered localities on five

islands (wide world distrib., cf. *Lophocolea heterophylla*).

Marchesinia mackaii (Hook.) S. Gray
(Lejeuneaceae)

ECOLOGY: On all types of substrates but rarely as epigeic and epilithic. Frequently as epiphyllous and epiphytic, on several phorophyte species. From 200 - 800 m. Most epiphytic, epixylic and epilithic records are from localities below 600 m.

SOCIOLOGY: No diff. val. (cf. SJÖGREN 1975).

COMMENTS: The treatment of *M. m.* as a coastal species (ALLORGE, V. & ALLORGE, P. 1938; ALLORGE, P. & PERSSON 1938), associated mainly with Mediterranean species such as *Exormothesa* and *Gongylanthus*, is not correct. However, *M. m.* has an unusually wide ecological range and consequently the number of associated species is very high.

Metzgeria conjugata Lindb.
(Metzgeriaceae)

ECOLOGY: Recorded as epiphytic, epixylic and epiphyllous. Altitude range 500 - 1100 m. Preferentially in strongly sheltered habitats.

SOCIOLOGY: Diff. val. towards epigeic and epilithic bryo-communities within the cloud-zone forest.

COMMENTS: Different substrate preference in continental Europe (SMITH 1990; ALLORGE, V. 1974). Probably under-recorded in the Azores.

Metzgeria furcata (L.) Dum.
(Metzgeriaceae)

ECOLOGY: On all types of substrates, rarely as epigeic and epilithic. Very wide altitude range. Epiphyllous records mostly above 600 m. Numerous phorophyte species (Table 4) and large number of associated preferentially epiphyllous species, especially above 700 m (Table 3).

SOCIOLOGY: No diff. val. The first stage of development of the epiphyllous *Cololejeuneetum azoricae* is frequently formed by very small specimens of *M. f.*, which may eventually become a serious competitor to the small species of the Lejeuneaceae family.

Metzgeria leptoneura Spruce
(Metzgeriaceae)

ECOLOGY: No distinct substratum preference, but rarely as epilithic and epigeic. Preferentially between 500 - 900 m. Most epiphyllous records from fronds of ferns.

SOCIOLOGY: The diff. val. is restricted to epiphyllous, epiphytic and epixylic bryo-communities of the cloud-zone forest. The epiphyllous presence of *M. l.* is most frequent in secondary stages of the *Cololejeuneetum azoricae*. The presence on Madeira is also in postmature stages of the epiphyllous *Cololejeuneetum microphyllae*.

Myurium hochstetteri (Schimp.) Kindb.
(Myuriaceae)

ECOLOGY: On all types of substrates but distinctly preferentially epigeic. Very few epiphyllous records, mostly on senescent fronds of ferns.

SOCIOLOGY: Diff. sp. of the *Andoe-Nardion*. Where *M. h.* has invaded the *Cololejeuneetum azoricae*, this ass. has always left its typical stage of development.

Nardia scalaris S.F.Gray
(Jungermanniaceae)

ECOLOGY: Preferentially epigeic. Only one epiphyllous record.

SOCIOLOGY: Diff. sp. of the endemic, epigeic *Andoe-Nardion*.

Nowellia curvifolia (Dicks.) Mitt.
(Cephaloziaceae)

ECOLOGY: Recorded as epixylic, epiphyllous and epiphytic. Preferentially epixylic, only one epiphyllous record, on senescent frond and stem of *Culcita*.

SOCIOLOGY: Diff. val. of the epiphytic *Echinodio-Lepidozietum cupressinae* and the epixylic *Lepidozietum azoricae*.

Odontoschisma denudatum (Nees in Mart.) Dum.
(Cephaloziaceae)

ECOLOGY: Recorded on all types of substrates; preferentially epigeic. Only a few epiphyllous

samples, on old specimens of *Trichomanes* and *Elaphoglossum*.

SOCIOLOGY: Diff. val. at the level of association of the epigeic *Andoe-Nardion*.

Odontoschisma sphagni (Dicks.) Dum.
(Cephaloziaceae)

ECOLOGY: Recorded on all types of substrates. Preferentially epixylic and epigeic. Only four epiphyllous records, on old fronds of *Trichomanes* and *Elaphoglossum*.

SOCIOLOGY: Diff. sp. of the *Andoe-Nardion*.

Plagiochila allorgei Herz. et H. Perss.
(Plagiochilaceae)

ECOLOGY: Recorded on all types of substrates but still only one record as epiphyllous, on *Trichomanes*. Wide altitude range but few records below 500 m.

SOCIOLOGY: No distinct diff. val. for one or some bryo-communities, but strictly confined to the *Juniperion brevifoliae*. Thus, not present on Graciosa and Corvo and only one recent (1996) record by the author on Santa Maria (epilithic; new to the island).

COMMENTS: In RDB treated as vulnerable (V), which is correct, as habitat conditions within the mature cloud-zone forest are preferred. Populations of *P. a.* are always small and the localities are few. Thinning of the *Juniperion brevifoliae* may easily endanger the survival in the Azores of this beautiful endemic hepatic.

Plagiochila exigua (Tayl.) Tayl.
(Plagiochilaceae)

ECOLOGY: Not found as epilithic, otherwise on all types of substrates. Wide altitude range, 500 - 1100 m, preferentially above 600 m. Most records within the cloud-zone forest. On several phorophyte species, mostly on ferns.

SOCIOLOGY: Weak diff. val. of epiphytic and epiphyllous bryo-communities of the *Juniperion brevifoliae*.

COMMENTS: On Madeira diff. sp. of the epiphyllous *Cololejeuneetum microphyllae* and of epiphytic and epixylic bryo-communities within the *Clethro-Laurion* forest.

Plagiochila spinulosa (Dicks.) Dum. s.l.
(Plagiochilaceae)

ECOLOGY: Recorded on all types of substrates. Frequently met with as epiphyllous, on several phorophyte species. Almost always a member of the secondary and postmature stages of development of the epiphyllous moss-cover, mostly on senescent fronds of ferns and on leaves, e.g. of *Ilex* and *Hedera*. Very wide altitude range but epiphyllous records are from altitudes above 400 m. Large populations develop only where the species occurs as epixylic or epiphytic.

SOCIOLOGY: No diff. val. although the frequency of *P. s.* is significantly highest within the *Juniperion brevifoliae*.

COMMENTS: For taxonomic differentiation of *P. spinulosa*, *P. punctata* and *P. killarniensis*, see GROLLE (1983) and SMITH (1990). In fact, *P. spinulosa* is a most variable species in the Azores as to size, colour and dentation of the leaves (cf. ALLORGE, P. & ALLORGE, V. 1950).

Plagiomnium undulatum (Hedw.) T. Kop.
(Mniaceae)

ECOLOGY: Not recorded as epiphytic, otherwise on all types of substrates. Only one record as epiphyllous, with one young specimen found on the large bryophyte *Thamnobryum*; accidental presence of this preferentially epigeic and epilithic species.

Plagiothecium nemorale (Mitt.) Jaeg.
(Plagiotheciaceae)

ECOLOGY: Recorded on all types of substrates except as epigeic. Few epiphyllous samples. Wide altitude range. Probably overlooked.

Pseudotaxiphyllum elegans (Brid.) Iwats.
(Plagiotheciaceae)

ECOLOGY: Recorded on all types of substrates but rare as epigeic and epilithic. Wide altitude range. As epiphyllous on wilted fronds of ferns.

COMMENTS: Young specimens may be difficult to separate from *P. laetevirens* (cf. HEDENÄS 1992).

Pseudotaxiphyllum laetevirens (Koppe et Düll)
Hedenäs
(Plagiotheciaceae)

ECOLOGY: Recorded on all types of substrates except as epiphytic. Epiphyllous records from three islands, mostly on fronds of ferns. Altitude range 300 - 900 m, probably preferentially above 600 m. COMMENTS: Underrecorded. In some records maybe confused with *P. elegans*. On the continent only in Spain.

Radula aquilegia (Hook. f. et Tayl.) Gott. et al.
(Radulaceae)

ECOLOGY: Recorded on all types of substrates but preferentially epiphyllous. Wide altitude range, 200 - 1100 m. Distinct preference to occur above 600 m. On several phorophyte species. The largest numbers of associated preferentially epiphyllous species as well as the largest numbers of phorophyte species occur above 600/700 m (Tables 3 and 4).

SOCIOLOGY: Diff. sp. of the epiphyllous *Cololejeuneetum azoricae* and mostly within the native *Juniperion brevifoliae*. Generally a member of secondary stages of development of the epiphyllous association.

COMMENTS: One of several Azorean bryophytes with different substratum preference in localities on the European continent (cf. SMITH 1990). *R. a.* has no distinct substratum preference on Madeira (SJÖGREN 1975).

Radula carringtonii Jack.
(Radulaceae)

ECOLOGY: On all types of substrates. Few epiphyllous records. Very wide altitude range, from the coast - 1500 m. Epiphyllous presence preferentially above 600 m.

COMMENTS: Recent record in AM 2 (YAMADA 1995), formerly restricted to W. Europe and Macaronesia. In RDB treated as rare (R) in Portugal; in the Azores fortunately not threatened (NT), being the most common *Radula* species and a frequent member of several bryo-communities even at low altitude levels.

Radula holtii Spruce
(Radulaceae)

ECOLOGY: Mostly epiphyllous and epiphytic. Altitude range 100 - 1000 m, however generally above 500 m.

COMMENTS: *R. h.* needs further investigation in the Azores as confusions with other *Radula* species are numerous. Unfortunately, Azorean specimens are frequently not fertile with the characteristic long, narrow perianths. The degree of lobe-overlapping of the stem is not always a distinct and sufficiently distinguishing feature in Azorean specimens. The brown, thick-walled cortical cells of the stem should always be checked (cf. BOUMAN & DIRKSE 1990). In RDB treated as rare in Portugal. The status in the Azores should still be listed as insufficiently known (K). Apparently localities are few and populations small. *R. h.* may eventually become listed as vulnerable (V) in the Azores as most records are within the *Juniperion brevifoliae*, where optimal habitat features for the species may easily become changed in a negative way.

Radula lindenberghiana Gott. - ex Hartm. f.
(Radulaceae)

ECOLOGY: No epigeic records, otherwise recorded on all types of substrates. The epiphyllous presence is rare, only two records, on fronds of *Elaphoglossum* and *Blechnum*. Wide altitude range, from coast - 800 m. Probably preferentially below 500 m (cf. SJÖGREN 1975).

COMMENTS: Former records of *R. complanata* (L.) Dum. in Macaronesia should generally become referred to *R. l.* (cf. BOUMAN & DIRKSE 1990).

Radula nudicaulis Steph.
(Radulaceae)

ECOLOGY: Preferentially epiphytic, rarely on other substrates. Only two epiphyllous records, on ferns, in a locality where *R. n.* was also unusually frequent as epiphytic (Pico). Probably only above 500 m, in the cloud-zone forest.

COMMENTS: In RDB treated as rare (R) in Portugal. The European presence is restricted to

Madeira and the Azores (on three islands). *R. n.* being a South American element in the European bryo-flora, is certainly one of the most remarkable bryophytes in Macaronesia. Its Azorean presence is extremely scarce. One important population on Pico at 600 m has recently become extinguished due to felling of a mature stand of the *Juniperion brevifoliae*, in order to create new grazingland. One population at 900 m is epigeic in *Erica*-scrub close to a road and is consequently easily extinguishable. I have not found the populations on Faial and S. Miguel. The S. Miguel - record of 1937 (ALLORGE, P. & ALLORGE, V. 1950) was made at a time of much larger remaining areas of the *Juniperion brevifoliae* in that island. In RDB *R. n.* is worthy of becoming treated as endangered (E) in the Azores, and is much more endangered than *R. wichurae*, which has been chosen for a comprehensive description.

Radula wichurae Steph.
(Radulaceae)

ECOLOGY: Not epixylic, otherwise on all types of substrates. From coast - 800 m. Most records below 500 m. Wide ecological range (cf. SJÖGREN 1978). Substrates may be dry provided that a shelter of a shrub/tree layer is present. Three probably accidental epiphyllous records on Pico at 800 m. Illustration and description by ALLORGE, P. & ALLORGE, V. (1950).

COMMENTS: In RDB treated as vulnerable (V). In the Azores more appropriate to be treated as rare (R). Habitat, status and suggested conservation measures need revision.

Rhynchostegiella tenella (Dicks.) Limpr.
(Brachytheciaceae)

ECOLOGY: Insufficiently known. Still recorded on only two islands. One epiphyllous record on *Elaphoglossum* (S. Miguel).

Riccardia multifida (L.) S.F. Gray
(Aneuraceae)

ECOLOGY: On all types of substrates but preferentially epixylic. From 200 - 1000 m. Epiphyllous presence is accidental and occurs

only on wilted phorophytes, where the epiphyllous moss-cover is in its final stage of development.

SOCIOLOGY: Diff. sp. of the epixylic *Lepidozietum azoricae*.

Saccogyna viticulosa (L.) Dum.
(Geocalyceae)

ECOLOGY: On all types of substrates. One of the most frequent bryophytes in the Azorean bryoflora. Accidental presence as epiphyllous at altitudes above 500 m, on several phorophyte species. Like *Riccardia multifida* and other large bryophytes, only in late stages of development of the *Cololejeuneetum azoricae*, where the association has got a nontypical constitution.

Scapania gracilis Lindb.
(Scapaniaceae)

ECOLOGY: On all types of substrates but preferentially epiphytic and epixylic. Only one epiphyllous record, on *Huperzia*.

Sematophyllum substrumulosum (Hampe) Britt.
(Sematophyllaceae)

ECOLOGY: Recorded on all types of substrates. Preferentially epiphytic and epixylic. Few epiphyllous records on wilted ferns (*Blechnum*, *Trichomanes*). Known altitude range 500 - 900 m. Late-colonizer in the *Cololejeuneetum azoricae*.

SOCIOLOGY: Only weak diff. val. towards epigeic and epilithic bryo-communities in the *Juniperion brevifoliae*.

Telaranea nematodes (Gott. et Aust.) Howe
(Lepidoziaceae)

ECOLOGY: On all types of substrates; only one record as epigeic; preferentially epixylic and epiphytic. Wide altitude range, preferentially above 600 m. Few epiphyllous records.

SOCIOLOGY: Diff. sp. of the epixylic *Lepidozietum azoricae*. Present but rarely in early stages of development of the epiphyllous *Cololejeuneetum azoricae*.

COMMENTS: In RDB treated as rare (R) in Portugal, which is a correct status for the species in the Azores.

Tetrastichium fontanum (Mitt.) Card.
(Hookeriaceae)

ECOLOGY: Recorded on all types of substrates but distinctly preferentially epigeic and epilithic. Accidentally as epiphyllous, on *Trichomanes* and *Thamnobryum*. Very wide altitude range but preferentially between 600 - 900 m. Preferentially in river ravines and explosion craters, in hollows in rough lava-streams within the cloud-zone.

SOCIOLOGY: Diff. sp. of the epilithic *Heterocladium hutchinsiae* (cf. also SJÖGREN 1990), although with weak diff. val. Only small under-developed specimens in late stages of development of the epiphyllous moss-cover.

COMMENTS: In RDB treated as rare (R) in Portugal. *T. f.* being endemic to Macaronesia, is fortunately not threatened (NT) at least not in the Azores. Localities are numerous and the species exists on all nine islands, in several localities with very large populations.

Tetrastichium virens (Card.) Churchill
(Hookeriaceae)

ECOLOGY: Recorded on all types of substrates. Preference not clearly distinguished. Only one epiphyllous record, on wilted specimen of *Trichomanes*.

COMMENTS: In RDB treated as rare (R) in Portugal, which is true considering the presence of the species in the Azores, where *T. v.* is less frequent than *T. fontanum*. However, on Santa Maria recent records (1996) of *T. v.* as epixylic, whereas *T. fontanum* was not possible to record (LIFE-project; Sjögren in report).

Thamnobryum alopecurum (Hedw.) Nieuwl.
(Thamniaceae)

ECOLOGY: Recorded on all types of substrates, preferentially epiphytic and epilithic. The only epiphyllous record is on a wilted specimen of *Trichomanes*, with one juvenile stem.

Thuidium tamariscinum (Hedw.) B.S.G.
(Thuidiaceae)

ECOLOGY: On all types of substrates but distinctly preferentially epigeic. Accidental presence of young specimens on wilted fronds of ferns.

THREATENED BRYOPHYTES IN THE AZORES

The main threats towards the Azorean bryo-flora of today are almost the same as they have been since the beginning of this century, namely a progressive diminishing of the native cloud-zone forest for creation of grazing land and for plantation of introduced tree species, mostly *Cryptomeria* and *Eucalyptus*. During the last 10 years, construction of numerous new roads also represents a threat towards the native forests in their very different kinds of constitution. In many cases these new roads have been important for management of grazing land on the islands, in quite a few cases, however, their future economic value is most uncertain. Strip cutting of the *Juniperion brevifoliae* has locally meant an impoverishment of the bryo-flora within the narrow strips of native forest left between the clear-cut strips. A progressive invasion of *Hedychium*, introduced long ago, has meant at least locally a hinder to the development or recolonization of the native shrub and tree species.

The epiphyllous bryo-vegetation, rich in species and typically developed, is restricted to efficiently sheltered habitats, generally above 500 m a.s.l. and mostly confined to the native cloud-zone forest, where it is also accompanied by a large number of rare, endemic vascular plant species.

The group of species treated in this paper, found as epiphyllous, includes a fairly large number of bryophyte species that are red-listed for Europe, many with presence in the Azores only, in Macaronesia only, or with also scattered presence on the European continent (see Red Data Book of European Bryophytes 1995; in the following as RDB).

This paper includes a treatment of the individual species, where suggestions have been made to the status given the threatened species in the RDB. The comments are founded upon the authors experiences since 1965, from excursions and recordings with sampling on all the islands in the Azorean archipelago (cf. SJÖGREN 1978, 1990, 1993, 1995). A short summary of these comments is given below, where some species are recommended to be treated as distinctly more rare and endangered than in RDB, whereas other species are fortunately hardly threatened in the archipelago. The suggestions are naturally linked to presence on few or many islands, to number of known localities and size of populations (E- endangered, V- vulnerable, R- rare, NT- not threatened, K- insufficiently known).

A. SPECIES RECORDED AS EPIPHYLLOUS

(1) species treated as vulnerable in Europe (RDB), correct status: *Acrobolbus wilsonii*, *Aphanolejeunea teotonii*, *Cephalozia crassifolia*, *Cololejeunea azorica*, *Lepidozia azorica*, *Plagiochila allorgei*, *Radula wichurae*, *Daltonia splachnoides*.

(2) species treated as vulnerable in Europe (RDB) but clearly endangered: *Leptoscyphus azoricus*, *Echinodium renauldii*.

(3) species with status in the Azores accepted (RDB): *Acrobolbus wilsonii* (E), *Cololejeunea azorica* (R), *Plagiochila allorgei* (V), *Telaranea nematodes* (R), *Campylopus cygneus* (K), *Daltonia splachnoides* (E), *Tetrastichium virens* (R).

(4) species with status in the Azores given in RDB (within brackets), suggested lower status: *Bazzania azorica* (R)NT, *Herbertus azoricus* (R)NT, *Heteroscyphus denticulatus* (R)K, *Radula wichurae* (R)NT, *Andoa berthelotiana* (R)NT, *Echinodium prolixum* (R)NT, *Tetrastichium fontanum* (R)NT.

(5) species with status in the Azores given in RDB (within brackets), with clearly higher status: *Aphanolejeunea madeirensis* (R)V, *Aphanolejeunea teotonii* (R)V, *Cephalozia crassifolia* (NT)R, *Cheilolejeunea cedercreutzii*

(V)E, *Lepidozia azorica* (R)V, *Leptoscyphus azoricus* (V)E, *Radula holtii* (R)V.

As a complement the species in the RDB, which have not been recorded as epiphyllous being mostly preferentially epilithic or epigeic, have been added here. Among these species are several species endemic to the Azores or to Macaronesia. A large number of these endemic species are restricted to the *Juniperion brevifoliae*, or at least to cloud-zone habitats. They add in an important way to the protection values of the Azorean native forests.

B. SPECIES NOT RECORDED AS EPIPHYLLOUS

(1) species with status for Europe (RDB) accepted: *Asterella africana* (V), *Pallavicinia lyellii* (V), *Tylimanthus azoricus* (V), *Fissidens azoricus* (K), *Fissidens luisieri* (K), *Isopterygium tenerum* (E), *Rhamphidium purpuratum* (V).

(2) species with status in Portugal (RDB) accepted here also as valid for the Azores: *Asterella africana* (R), *Exormotheca pustulosa* (R), *Lejeunea hibernica* (R), *Marchantia paleacea* (K), *Marsupella adusta* (K), *Tylimanthus azoricus* (V), - *Campylopus shawii* (R), *Fissidens luisieri* (K), *Microcampylopus laevigatus* (R), *Philonotis hastata* (K), *Pseudotaxiphyllum laetevirens* (R).

(3) species with status in Portugal (RDB), with suggested lower status in the Azores: *Calypogeia azorica* (R)K, *Dumortiera hirsuta* (R)NT, *Radula carringtonii* (R)NT, *Alophosia azorica* (R)NT, *Breutelia azorica* (R)NT, *Fissidens azoricus* (E)K, *Fissidens asplenoides* (R)NT, *Fissidens monguillonii* (R)K, *Fissidens ovatifolius* (R)K, *Isopterygium tenerum* (E)K, *Leucodon treleasii* (K)NT, *Rhamphidium purpuratum* (V)NT, *Rhynchostegiella durieui* (R)K.

(4) species with status in Portugal (RDB), with definitively higher status in the Azores: *Jamesoniella rubricaulis* (K)E, *Pallavicinia lyellii* (R)V, *Radula nudicaulis* (R)E, *Glyphomitrium daviesii* (R)E, *Trematodon perssoniorum* (R)V.

Among the species recorded as epiphyllous in the Azores and not treated in the RDB are: *Adelanthus decipiens* (Hook.) Mitt, now known

from 5 islands, from few localities and with small populations. Restricted to the *Juniperion brevifoliae*. This species should at least be given the status vulnerable (V) in the Azores. *Dicranolejeunea johnsoniana* (Mitt.) Grolle is only recorded on 3 islands; few localities at altitudes within the cloud-zone forest. The present appropriate status in the Azores is insufficiently known (K), a status which, after further recordings, will probably become changed for vulnerable (V).

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APPENDIX

A complete list of epiphyllous bryophytes sampled by the author in 1965-1995 in the Azores. For species with weak or no preference at all to grow as epiphyllous, only the epiphyllous samples have been listed. - For all samples have been given substrate, phorophyte, name of island, altitude of the localities and number of samples (abbreviations and information on nomenclature in "Introduction"; complete names of the phorophytes in "Phorophytes").

eph (p)	epiphyllous
ef (f)	epiphytic
ex (x)	epixylic
el (l)	epilithic
eg (g)	epigeic

Acrobolbus wilsonii Nees (all records)

eph: *Trichomanes* P 900 (2). - ef: *Erica* P 800 m (1 spl.) 1000 (1). - ex: *Culcita* P 900 (4). - el: P 800 (1) - eg: J 600 (1).

Adelanthus decipiens (Hook.) Mitt. (all records)

eph: *Trichomanes* P 900 m (2 spl.); *Elaphoglossum* P 800 (1); *Hymenophyllum* M 700 (1). - ef: *Juniperus* P 800 (2); *Ilex* P 800 (2); *Erica* P 800 (1) 1000 (2);

Cryptomeria M 800 (1). - ex: *Culcita* P 800 (1) 900 (1). - el: L 500, P 1000 (1). - eg: P 900 (1).

Andoa berthelotiana (Mont.) Ochyra (epiphyllous records)

eph: *Trichomanes* F 700 m (1 spl.), J 700 (1), T 600 (4); *Thamnobryum* F 700 (1), *Blechnum* F 700 (1); *Ilex* M 700 (1).

Aphanolejeunea madeirensis (Schiffn.) Grolle (all records)

eph: *Trichomanes* F 700 m (1 spl.), P 600 (2) 700 (3) 800 (3), J 600 (8) 900 (1), T 500 (6) *Blechnum* J 600 (3); *Hedychium* J 600 (1); *Hymenophyllum* J 600 (1). - ex: *Erica* with *Hymenophyllum* P 700 (1).

Aphanolejeunea microscopica (Tayl.) Evans (all records)

eph: *Blechnum* F 500 m (2 spl.) 700 (13) 800 (1), P 600 (1) 800 (7) 900 (2), 1100 (2), J 500 (5) 600 (2) 700 (4), T 600 (1) 900 (6), M 600 (2); *Ilex* F 700 (1), P 600 (2) 700 (1) 800 (8) 1000 (1) 1100 (2), J 500 (1) 900 (2), T 800 (1) 900 (5), M 700 (1) 800 (2); *Elaphoglossum* P 700 (8) 800 (18) 900 (2) 1000 (1) 1100 (1), J 600 (3), T 500 (1) 600 (1) 900 (2); M 1000 (2); *Trichomanes* F 600 (5) 700 (7), P 700 (9) 800 (7) 900 (7), J 500 (2) 600 (5) 700 (1) 900 (1), M 800 (1) 900 (1); *Laurus* P 600 (2) 800 (6) 1000 (1), J 600 (1), T 900 (2), M 600 (4) 700 (2) 800 (1) 1000 (9); *Hedera* F 800 (2), P 700 (2) 800 (13), J 600 (2) 700 (1) 900 (1), M 1000 (1); *Hedychium* F 500 (1), J 700 (2), 900 (1), T 500 (2); *Stenogramma* J 600 (1); *Woodwardia* F 700 (1), J 700 (2), M 500 (1) 1000 (4); *Polytrichum* J 500 (1); *Peltigera* J 500 (1); *Thamnobryum* J 500 (2); *Diplazium* P 600 (1), T 500 (2) 900 (1); *Culcita* P 800 (1); *Hymenophyllum* P 800 (2); *Huperzia* F 700 (1), P 1100 (1), J 900 (2); *Diplazium* P 800 (1); *Viburnum* P 800 (2), M 1000 (1); *Luzula* P 800 (1); *Pteris* P 600 (2); *Persea* M 600 (7); *Christella* M 1000 (2). - ef: *Cryptomeria* C 200 (1), J 600 (1) 700 (4), M 800 (6); *Platanus* F 500 (1); *Laurus* P 1000 (2), T 900 (2); *Juniperus* P 800 (1), J 600 (1), T 600 (1); *Erica* F 500 (1) 800 (1), P 1000 (1), T 700 (3); *Ilex* P 800 (1); *Rubus* P 600 (1); *Hypericum* J 500 (1) 700 (1). - ex: *Ilex* F 800 (1); *Eucalyptus* F 200 (1); *Juniperus* P 1000 (1); *Trichomanes* T 600 (1); *Culcita* P 700 (3) 800 (19) 900 (4), J 900 (2), M 800 (1) 1000 (1); *Erica* P 800 (1); *Luzula* P 800 (1); *Blechnum* P 800 (2); *Hedera* P 800 (3); *Hydrangea* F 700 (1).

Aphanolejeunea teotonii Jov.-Ast. et V. All. (all records)

eph: *Hymenophyllum* C 400 (1); *Trichomanes* C 300 (5) 400 (2), F 500 (3) 700 (4), J 600 (2) 700 (1), G 300 (1), T 500 (2), M 400 (1) 500 (1); *Diplazium* C 400 (2), J 700 (1); *Persea* M 400 (5) 600 (8); *Blechnum* F

500 (1) 700 (8), T 600 (1), M 500 (2); *Hedychium* F 500 (2), J 700 (4), T 500 (1); *Ilex* J 600 (1), M 700 (1) 800 (1); *Stenogramma* J 600 (1); *Woodwardia* J 700 (1), M 500 (4) 1000 (3); *Pteris* J 700 (2); *Laurus* J 700 (1), M 500 (1) 700 (1) 800 (3) 1000 (9); *Hedera* P 700 (1), J 700 (1), M 1000 (1); *Thamnobryum* M 400 (1); *Christella* M 500 (1) 700 (4) 800 (3) 1000 (1); *Viburnum* M 1000 (1). - ef: *Juniperus* C 300 (2); *Pittosporum* G 300 (1); *Laurus* J 700 (1); *Cryptomeria* J 500 (1), M 500 (3); *Acacia* F 400 (1). - ex: *Culcita* M 800 (2) 1000 (3). - el: C 400 (1), G 200 (1) 300 (3).

Bazzania azorica Buch et H. Perss. (all records)

eph: *Trichomanes* P 800 (1), T 900 (2); *Elaphoglossum* P 700 (1), T 900 (1); *Hymenophyllum* P 800 (1); *Huperzia* T 900 (1). - ef: *Juniperus* J 600 (5) 900 (1) P 800 (2); *Erica* P 800 (5), T 900 (1); *Ilex* P 800 (1). - ex: *Culcita* P 800 (2) 900 (1); *Juniperus* J 600 (2); litter T 900 (1); *Hymenophyllum* T 900 (1). - el: P 800 (1) 900 (1). - eg: P 300 (1), J 600 (1).

Brachythecium populeum (Hedw.) B.S.G. (epiphyllous records)

eph: *Stenogramma* P 600 (1); *Trichomanes* P 700 (1); *Blechnum* J 900 (1).

Brachythecium velutinum (Hedw.) B.S.G. (epiphyllous records)

eph: *Trichomanes* F 700 (1).

Calypogeia fissa (L.) Raddi (epiphyllous records)

eph: *Polytrichum* J 500 (1); *Hymenophyllum* J 600 (1).

Calypogeia fusca (Lehm.) Steph. (all records)

eph: *Elaphoglossum* P 800 (1) 900 (1). - ex: *Culcita* P 900 (1).

Calypogeia muelleriana (Schiffn.) K. Müll. (epiphyllous records)

eph: *Elaphoglossum* P 800 (1); *Hymenophyllum* J 600 (1); *Trichomanes* T 500 (2) 900 (1).

Calypogeia neesiana (Mass. et Carest.) K. Müll. (epiphyllous records)

eph: *Trichomanes* T 500 (1).

Campylopus cygneus (Hedw.) Brid. (epiphyllous records)

eph: *Trichomanes* T 400 (1); *Blechnum* T 900 (1).

Cephalozia crassifolia (Lindenb. et Gott.) Fulf. (epiphyllous records)

eph: *Elaphoglossum* P 800 (1); *Trichomanes* T 500 (3).

Cheilolejeunea cedercreutzii (Buch et H. Perss.) Grolle (all records)

eph: *Elaphoglossum* P 700 (1). ef: *Juniperus* F 700 (1).

Chiloscyphus polyanthos v. *pallens* (Ehrh.) Hartm. (epiphyllous records)

eph: *Stenogramma* J 600 (1); *Blechnum* T 900 (2).

Cololejeunea azorica V. All. et Jov.-Ast. (all records)
eph: *Trichomanes* C 300 (2) 400 (2) 600 (2), J 600 (7);
Ilex P 600 (1) 700 (1) 800 (2), J 600 (1); *Persea* M 400
(1) 600 (1); *Elaphoglossum* P 700 (1) J 600 (4);
Diplazium P 600 (2); *Laurus* P 600 (2), J 600 (1) 700
(1); *Blechnum* F 500 (1) 700 (1), P 600 (2); *Hedychium*
J 600 (1) 900 (1); *Hedera* J 600 (2); *Woodwardia* F
700 (1). ef: *Juniperus* C 300 (1); *Cryptomeria* C 200
(1) J 400 (1) M 500 (1); *Eucalyptus* G 200 (1);
Pittosporum G 200 (1); *Persea* G 200 (1). - ex: *Culcita*
P 700 (2) 800 (1); *Hymenophyllum* T 900 (1).

Cololejeunea minutissima (Sm.) Schiffn. (all records)
eph: *Trichomanes* C 300 (4) 400 (1) 600 (2), F 500 (1)
600 (1) 700 (2), P 700 (5), J 600 (5) 900 (1), T 400 (2)
500 (10) 600 (6), M 400 (1) 800 (1); *Blechnum* F 700
(4) 800 (1), P 800 (6) 900 (2) 1100 (2), J 500 (1) 600
(1) 700 (3) 900 (3), T 900 (4), M 500 (1) 600 (1) 1000
(1); *Ilex* F 500 (1) 700 (2) 800 (2), P 600 (2) 700 (2)
800 (6) 1000 (1) 1100 (2), J 900 (1), T 900 (2), M 800
(1); *Elaphoglossum* P 700 (6) 800 (9) 900 (2) 1000 (1)
1100 (1), J 600 (2) 900 (2) 900 T 500 (1), M 1000 (1);
Hedera F 800 (2), P 600 (1) 700 (3) 800 (19), J 600 (1)
900 (1), M 1000 (1); *Laurus* P 600 (3) 800 (3) 100 (1),
J 600 (1) 700 (1), T 600 (1) 900 (1), M 500 (4) 700 (3)
800 (1) 1000 (11); *Persea* M 400 (4) 600 (1);
Hymenophyllum P 800 (1); *Huperzia* J 900 (1) P 1100
(1); *Pteris* P 600 (4), J 700 (2); *Carex* P 600 (1);
Diplazium P 600 (4), T 500 (3) 900 (1); *Hedychium* F
700 (1), J 700 (2) 900 (1), T 500 (2); *Woodwardia* J
700 (2), M 500 (3) 1000 (2); *Christella* M 700 (4) 800
(3); *Culcita* P 800 (1). - ef: *Juniperus* C 300 (7), P 800
(1), J 600 (1), T 600 (1); *Erica* C 200 (2), F 600 (2), P
600 (1) 1000 (1), T 700 (2); *Cryptomeria* C 200 (10), F
400 (3), P 400 (1), J 500 (1) 600 (3) 700 (4);
Pittosporum G 100 (1) 200 (2), F 200 (1); *Acacia* G
200 (1); *Persea* G 200 (3); *Eucalyptus* G 200 (1);
Platanus F 500 (2); *Laurus* J 700 (2). - ex: *Erica* P 700
(1); *Trichomanes* T 600 (1); *Rubus* P 600 (1); *Culcita*
P 800 (5) 900 (2); *Woodwardia* F 800 (1). - el: G 200
(3).

Colura calyptrifolia (Hook.) Dum. (all records)
eph: *Trichomanes* C 300 (3), J 600 (1), T 500 (2) 600
(2), M 900 (1); *Ilex* F 500 (1) 700 (1), P 600 (1) 700
(2) 800 (5) 1100 (3), J 500 (1) 600 (1) 900 (2), T 900
(5), M 800 (3); *Laurus* P 800 (2), T 600 (2) 900 (3), M
500 (1) 600 (3) 700 (3) 800 (3) 1000 (12); *Blechnum* F
700 (8), P 800 (2) 1100 (2), J 500 (1) 600 (1), T 900
(3), M 500 (1) 600 (2); *Elaphoglossum* F 800 (1), P
800 (4) 900 (1), J 600 (1) 900 (3), T 900 (1), M 1000
(1); *Hedera* P 800 (3), J 600 (1) 700 (1) 900 (1), M
1000 (1); *Culcita* P 800 (1); *Viburnum* P 800 (1), M
1000 (1); *Diplazium* T 500 (3) 900 (1); *Stenogramma* J

600 (1); *Hedychium* J 600 (1), *Woodwardia* M 500 (2)
1000 (4); *Christella* M 800 (2) 1000 (2). ef: *Laurus* T
900 (1); *Cryptomeria* J 700 (3). - ex: *Culcita* P 800 (4),
M 800 (1); *Hedera* P 800 (1).

Cyclodictyon laetevirens (Hook. et Tayl.) Mltt.
(epiphyllous records)
eph: *Elaphoglossum* P 800 (1).

Daltonia splachnoides (Sm.) Hook. et Tayl. (epiphyllous
records)
eph: *Blechnum* T 900 (1); *Woodwardia* M 1000 (1);
Laurus M 1000 (1).

Dicranolejeunea johnsoniana (Mitt.) Grolle (epiphyllous
records)
eph: *Trichomanes* P 800 (1); *Blechnum* T 900 (1).

Dicranum scottianum Turn. (epiphyllous records)
eph: *Trichomanes* C 300 (1) 600 (2), P 700 (1), J 600
(1), T 600 (1); *Hedera* P 700 (1) 800 (2),
Elaphoglossum P 800 (6) 1000 (1), J 900 (1);
Blechnum P 800 (1).

Diplophyllum albicans (L.) Dum. (epiphyllous records)
eph: *Trichomanes* T 500 (2); *Huperzia* J 900 (2);
Hymenophyllum J 600 (1); *Blechnum* M 600 (1).

Drepanolejeunea hamatifolia (Hook.) Schiffn. (all
records)
eph: *Ilex* F 500 (1) 700 (3) 800 (3), P 600 (1) 700 (3)
800 (9) 1000 (1) 1100 (4), J 500 (1) 600 (1) 900 (3), T
900 (6), M 700 (1) 800 (3); *Blechnum* F 500 (3) 700
(8) 800 (1), P 800 (5) 900 (1) 1100 (3), J 500 (1) 700
(1), T 600 (1) 900 (6), M 500 (1) 600 (1) 1000 (1);
Elaphoglossum F 700 (1) 800 (1), P 700 (9) 800 (21)
900 (2) 1000 (1) 1100 (1), J 600 (4) 900 (3), T 600 (1)
900 (4), M 800 (2) 1000 (2); *Trichomanes* F 500 (2)
700 (1), P 700 (5) 800 (1) 900 (2), J 600 (2), T 500 (4)
600 (3), M 500 (1) 800 (1); *Laurus* P 600 (1) 800 (6)
1000 (1), J 700 (1), T 600 (2) 900 (3), M 500 (4) 600
(4) 700 (3) 800 (4) 900 (3) 1000 (12); *Hedera* F 800
(2), P 700 (2) 800 (13) 1000 (1), J 600 (1) 700 (1) 900
(1); *Culcita* P 800 (1); *Viburnum* P 800 (2), M 1000
(1); *Persea* M 600 (1); *Diplazium* P 800 (1); *Christella*
M 700 (1) 800 (1) 1000 (3); *Hymenophyllum* P 800
(1); *Huperzia* P 1100 (1), J 900 (1), T 900 (2); *Luzula*
P 600 (1) 800 (1); *Pteris* P 600 (3), J 700 (2); *Phyllitis*
P 600 (1); *Carex* P 600 (1); *Diplazium* P 600 (1), T
500 (2) 900 (1); *Hedychium* J 600 (1) 700 (3) 900 (1),
T 500 (2); *Stenogramma* J 600 (1), *Woodwardia* J 700
(1), M 500 (4) 1000 (2). - ef: *Juniperus* C 300 (1), F
700 (1), P 600 (1) 800 (1) 1000 (2), J 600 (2); *Erica* C
500 (1), F 500 (1) 600 (2) 800 (1), P 400 (1) 600 (1)
1000 (3) 1100 (1), J 700 (1), T 700 (2); *Hydrangea* C
500 (1); *Cryptomeria* F 400 (2), P 400 (1), J 600 (1)
700 (6), T 400 (2), M 500 (1) 800 (6); *Ilex* F 800 (1), T
900 (1); *Laurus* P 1000 (4), T 900 (2); *Daphne* P 1000

(1); *Platanus* F 400 (1); *Myrsine* P 1000 (1), J 500 (1); *Rubus* P 600 (1). - ex: *Prunus* P 700 (1); *Ilex* F 800 (1); *Juniperus* F 500 (1), P 1000 (1); *Culcita* P 700 (2) 800 (17) 900 (2), J 600 (1) 900 (1), T 900 (2), M 500 (2) 800 (3) 1000 (2); *Hydrangea* F 700 (2); *Woodwardia* P 800 (1). - el: C 600 (1). - eg: C 200 (1), L 500 (1), F 700 (1).

Dumortiera hirsuta (Sw.) Nees (epiphyllous records)

eph: *Trichomanes* T 600 (1); *Thamnobryum* P 1000 (1); *Elaphoglossum* P 800 (1); *Hymenophyllum* J 600 (1).

Echinodium prolixum (Mitt.) Broth. (epiphyllous records)

eph: *Laurus* P 1000 (1); *Blechnum* P 800 (1) 1100 (1); *Elaphoglossum* P 800 (2) 900 (1) 1100 (1); *Ilex* F 500 (1); *Huperzia* T 900 (1); *Trichomanes* P 900 (1), J 600 (1).

Eurhynchium praelongum (Hedw.) B.S.G.

eph: *Pteridium* C 400 (1); *Trichomanes* C 300 (1) 400 (1) 500 (1), F 500 (1) 600 (1), P 600 (1) 700 (1) 800 (2), J 500 (2) 600 (2) 700 (1), T 600 (3); *Thamnobryum* F 700 (1) 800 (1), P 600 (1) 800 (1) 1000 (1), J 500 (1); *Huperzia* P 1100 (1); *Ilex* P 600 (1); *Blechnum* P 600 (1), J 500 (1) 900, T 900 (1); *Stenogramma* J 600; *Peltigera* J 500 (1).

Fissidens serrulatus Brid. (epiphyllous records)

eph: *Trichomanes* J 500 (2), T 600 (4); *Thamnobryum* F 700 (1), P 600 (1), J 500 (1).

Frullania microphylla (Gott.) Pears.

eph: *Trichomanes* C 300 (1) 400 (1), F 500 (4) 600 (2) 700 (2), P 800 (1), T 500 (2) 600 (1); *Ilex* P 600 (4) 700 (1) 800 (6) 1100 (1), J 600 (1) 900 (2), T 900 (3), M 800 (3); *Persea* M 400 (5) 600 (3); *Blechnum* F 500 (2) 700 (5), P 600 (1) 800 (2) 1100 (1), J 500 (2) 600 (1) 700 (2) 900 (1), T 900 (4), M 500 (1) 600 (1) 1000 (1); *Laurus* P 600 (2) 800 (1), J 700 (1), T 600 (2) 900 (2), M 500 (3) 600 (3) 700 (3) 800 (2) 1000 (5); *Elaphoglossum* F 700 (1), P 700 (1) 800 (7), J 600 (1) 900 (1); *Hedera* F 700 (1), P 700 (1) 800 (3), J 600 (1) 700 (1) 900 (1); *Myrsine* P 700 (1); *Culcita* P 800 (1); *Hymenophyllum* P 800 (2); *Viburnum* P 800 (1), M 1000 (1); *Diplazium* P 800 (1); *Pteris* P 600 (5), J 700 (2); *Diplazium* P 600 (2), T 500 (2) 900 (1); *Hedychium* J 700 (1) 900 (1), T 500 (2); *Stenogramma* J 600 (1); *Christella* M 700 (2) 800 (1); *Woodwardia* J 700 (1); *Peltigera* G 200 (2), M 500 (2) 1000 (1). ef: *Pittosporum* F 200 (1), P 100 (1), G 100 (1) 200 (1); *Platanus* F 500 (2); *Cryptomeria* C 200 (5), F 400 (1), J 400 (1) 500 (2) 700 (2), G 200 (2), T 400 (2), M 500 (2); *Ilex* J 300 (1); *Eucalyptus* F 500 (1), T 200 (2); *Erica* C 400 (1) 500 (1); *Juniperus* C 300 (4); *Laurus* J 700 (1); *Buxus* J 400 (1); *Acacia* G 200 (2); *Persea* G

200 (2); *Picconia* F 200 (1). - ex: *Culcita* P 700 (2) 800 (8) 900 (1), M 800 (2); *Rubus* P 600 (1); *Hydrangea* F 700 (4).

Frullania tamarisci (L.) Dum. (epiphyllous records)

eph: *Trichomanes* C 300 (3) 600 (2), F 500 (2) 600 (3) 700 (3), P 700 (4) 800 (2) 900 (3), J 500 (1) 600 (1) 700 (1) 900 (1), T 500 (9) 900 (1); *Ilex* F 700 (1) 800 (1), P 800 (6), J 900 (2), T 900 (1), M 800 (2); *Thamnobryum* F 800 (1), P 800 (1), J 400 (1); *Elaphoglossum* F 800 (1), P 700 (3) 800 (9) 900 (1) 1100 (1), J 900 (1); *Laurus* P 800 (2) 1000 (1), T 900 (1), M 600 (2) 700 (2); *Blechnum* F 500 (2) 700 (2), P 800 (9) 900 (2), J 700 (1) 900 (1), T 900 (2), M 600 (2); *Hedera* F 800 (1), P 700 (2) 800 (7); *Viburnum* P 800 (1); *Huperzia* P 1100 (1), J 900 (3), T 900 (4); *Diplazium* T 900 (1); *Hedychium* J 700 (1); *Polytrichum* J 500 (1); *Pteridium* C 400 (1); *Hymenophyllum* M 700 (1) *Woodwardia* F 700 (1).

Frullania teneriffae (F. Web.) Nees (epiphyllous records)

eph: *Trichomanes* C 400 (2) 600 (2), F 500 (1) 600 (2) 700 (2), P 800 (2) 900 (5), T 400 (1) 500 (2) 600 (4) 900 (2), M 500 (1) 800 (2); *Ilex* F 500 (1) 800 (4), P 800 (3) 1000 (1) 1100 (2), J 500 (1) 900 (1), T 900 (1), M 700 (1) 800 (3); *Elaphoglossum* P 700 (6) 800 (8) 900 (1) 1000 (1), T 900 (2), M 800 (1) 1000 (1); *Thamnobryum* P 700 (1) 1000 (1); *Blechnum* F 700 (4), P 800 (1) 1100 (3), J 500 (1) 700 (2), T 900 (1), M 500 (1); *Laurus* P 800 (4), T 600 (1) 900 (2), M 500 (4) 600 (2) 800 (3); *Hedera* P 700 (1) 800 (6), M 1000 (2); *Viburnum* P 800 (1); *Huperzia* P 1100 (1); *Pteris* P 600 (1), J 700 (2); *Hedychium* J 500 (1) 700 (1), T 500 (1); *Diplazium* T 500 (2); *Woodwardia* J 700 (1), M 500 (2) 1000 (2); *Christella* M 1000 (1), *Persea* M 600 (2).

Harpalejeunea ovata (Hook.) Schiffn. (all records)

eph: *Ilex* M 800 (3); *Elaphoglossum* P 800 (4) 900 (1) 1000 (1); *Woodwardia* M 500 (1); *Laurus* M 1000 (1). ef: *Juniperus* C 300 (4), P 1000 (1); *Erica* G 100 (1), P 400 (1) 1000 (1); *Cryptomeria* G 200 (1), T 400 (7); *Persea* G 200 (2); *Pittosporum* G 200 (2); *Platanus* F 500 (1); *Acacia* F 400 (1); *Ulmus* F 200. - ex: *Ilex* F 800 (1); *Culcita* P 800 (2). - el: C 500 (2), F 200 (1) 500 (1), G 200 (7) 300. (3). - eg: G 100 (1) 200 (3).

Herbertus azoricus (Steph.) Richards (epiphyllous records)

eph: *Hymenophyllum* P 800 (1); *Huperzia* J 900 (1); *Trichomanes* P 900 (3).

Heterocladium heteropterum B.S.G.

eph: *Thamnobryum* P 1000 (1).

Heteroscyphus denticulatus (Mitt.) Schiffn.

eph: *Trichomanes* J 600 (1).

Hylocomium splendens (Hedw.) B.S.G. (epiphyllous records)

eph: *Huperzia* T 900 (1).

Hylocomium armoricum (Brid.) Wijk et Marg. (epiphyllous records)

eph: *Hymenophyllum* J 600 (1).

Hypnum uncinulatum Jur. (epiphyllous records)

eph: *Trichomanes* C 300 (3) 400 (1) 600 (1), F 500 (1) 600 (1) 700 (3), P 700 (7) 800 (1) 900 (6), J 600 (3) 700 (1) 900 (1), T 400 (1) 500 (10) 600 (3) 900 (1), M 800 (2); *Diplazium* C 400 (1); *Ilex* P 700 (2) 800 (4) 1000 (1) 1100 (2), J 500 (1), T 900 (2), M 800 (3); *Elaphoglossum* F 800 (1), P 700 (7) 800 (10) 900 (2), J 600 (2) 900 (2), T 500 (1) 900 (1), M 800 (2); *Blechnum* P 800 (2) 900 (1) 1100 (1), J 600 (1), T 900 (2); *Hedera* P 700 (1) 800 (1); *Viburnum* P 800 (1); *Huperzia* J 900 (1), T 900 (2); *Hymenophyllum* M 700 (1); *Persea* M 600 (4); *Laurus* M 600 (1); *Woodwardia* F 700 (1).

Jubula hutchinsiae (Hook.) Dum. (all records)

eph: *Trichomanes* F 500 (4) 700 (6), P 600 (1) 700 (1), J 500 (1) 600 (1), T 600 (2), M 800 (3); *Thamnobryum* F 700 (1) 800 (1), P 700 (1), J 500 (1), M 400 (1); *Elaphoglossum* P 700 (1) 800 (1); *Ilex* P 700 (1); *Hymenophyllum* J 600 (1); *Blechnum* F 700 (1), M 600 (1). - ef: *Cryptomeria* J 600 (1); *Frangula* P 600 (1). - ex: *Cryptomeria* F 600 (1); *Calcita* M 800 (1); *Erica* P 700 (1); *Ilex* P 700 (1); litter L 500 (1), P 1000 (2); *Hymenophyllum* T 900 (1). - el: C 400 (1), L 200 (1), 300 (1), F 500 (2) 600 (7), P 500 (7) 600 (1) 800 (5), J 200 (1) 800 (1). - eg: J 800 (1).

Lejeunea cavifolia (Ehrh.) Lindb. (epiphyllous records)

eph: *Trichomanes* T 500 (1).

Lejeunea eckloniana Lindenb. (epiphyllous records)

eph: *Thamnobryum* M 400 (1).

Lejeunea flava (Sw.) Nees (epiphyllous records)

eph: *Trichomanes* C 300 (1) 600 (1), T 500 (1).

Lejeunea holtii Spruce (all records)

eph: *Thamnobryum* M 500 (1); *Trichomanes* M 500 (1); *Blechnum* F 500 (1). ef: *Cryptomeria* M 500 (1).

Lejeunea lamacerina (Steph.) Schiffn. (epiphyllous records)

eph: *Trichomanes* C 300 (3) 400 (2) 500 (1) 600 (2), F 500 (6) 600 (4) 700 (12), P 600 (2) 700 (13) 800 (5) 900 (8), J 500 (1) 600 (14) 700 (1) 900 (1), G 300 (1), T 400 (2) 500 (16) 600 (8) 900 (3), M 400 (1) 500 (1) 800 (3) 900 (2); *Diplazium* C 400 (2), P 600 (2), J 700 (1), T 500 (3) 900 (1); *Ilex* F 800 (1), P 600 (2) 700 (1)

800 (2) 1100 (1), J 500 (1), M 700 (1) 800 (2); *Blechnum* F 500 (2) 700 (14) 800 (1), P 600 (1) 800 (4) 900 (1) 1100 (1), J 500 (3) 600 (1) 900 (2), T 500 (1) 600 (1) 900 (8), M 500 (1) 600 (1) 1000 (1); *Thamnobryum* F 700 (2) 800 (1), P 700 (1) 800 (1) 1000 (1), J 400 (1) 500 (1) 900 (1), T 500 (1), M 400 (1); *Hedera* F 700 (1) 800 (1), P 700 (3) 800 (7), J 600 (1) 700 (1) 900 (1); *Elaphoglossum* P 700 (4) 800 (14) 900 (2) 1100 (1), J 600 (2), T 500 (1) 600 (1) 900 (3); M 800 (1) 100 (2); *Laurus* P 600 (3) 800 (2) 1000 (1), M 600 (3) 700 (2) 800 (2) 1000 (10); *Pteridium* C 400 (1); *Persea* M 400 (2) 1000 (2); *Viburnum* P 800 (2); *Woodwardia* F 700 (1), J 700 (2), M 500 (4) 1000 (4); *Diplazium* P 800 (1); *Hymenophyllum* P 800 (1), J 600 (1), M 700 (1); *Huperzia* P 1100 (1), J 900 (1), T 900 (4); *Pteris* P 600 (4), J 700 (2); *Phyllitis* P 600 (2); *Luzula* P 600 (1); *Calcita* T 900 (1); *Stenogramma* J 600 (2); *Hedychium* F 500 (1), J 700 (2) 900 (1); *Polytrichum* J 500 (1); *Christella* M 700 (3) 800 (3) 1000 (2); lichen J 500 (1) (add. *Persea* M 600 (4)).

Lejeunea patens Lindb. (all records)

eph: *Trichomanes* C 400 (1) 600 (1), P 800 (1); *Diplazium* C 400 (2); *Ilex* P 800 (1); *Hymenophyllum* P 800 (1); *Thamnobryum* J 500 (1); *Hedera* P 700 (1), J 900 (1), M 1000 (1); *Huperzia* J 900 (2); *Laurus* M 500 (1) 600 (1) 1000 (3); *Elaphoglossum* P 800 (1) 1100 (1); *Blechnum* P 900 (1). - ef: *Cryptomeria* M 800 (3); *Hypericum* J 500 (1); *Erica* P 800 (1) 1000 (2), J 700 (1), T 700 (2); *Platanus* F 400 (2); *Luzula* P 800 (1). - ex: *Calcita* P 700 (1) 900 (2), J 900 (1), M 500 (1) 1000 (4); litter M 1000 (1). - el: P 800 (1).

Lejeunea ulicina (Tayl.) Tott et al. (all records)

eph: *Trichomanes* M 800 (1). - ef: *Cryptomeria* J 600 (1), G 200 (2); *Pittosporum* G 100 (1).

Lepidozia azorica Buch et H. Perss. (all records)

eph: *Blechnum* P 800 (1); *Hymenophyllum* P 800 (1); *Hedera* P 800 (1); *Elaphoglossum* P 800 (1) 900 (1); *Trichomanes* T 500 (3) 900 (1); *Huperzia* J 900 (1). - ef: *Juniperus* P 1000 (1); *Erica* P 400 (1), T 900 (1). - ex: *Erica* P 700 (1) 800 (1), J 600 (1); *Juniperus* P 1000 (4), T 900 (1); *Calcita* P 800 (6), J 600 (1) 900 (1).

Lepidozia cupressina (Sw.) Lindenb. in Gott. et al. (epiphyllous records)

eph: *Trichomanes* P 800 (1); *Blechnum* P 900 (1).

Lepidozia reptans (L.) Dum. (epiphyllous records)

eph: *Christella* M 1000 (1); *Trichomanes* P 900 (2).

Leptoscyphus azoricus (Buch et H. Perss.) Grolle (epiphyllous records)

eph: *Elaphoglossum* P 1050 (1).

Leucobryum juniperoideum (Brid.) C. Müll. (epiphyllous records)

eph: *Trichomanes* T 500 (1).

Lophocolea bidentata (L.) Dum. (epiphyllous records)

eph: *Stenogramma* J 600 (1); *Trichomanes* P 900 (1).

Lophocolea fragrans (Moris et De Not.) Gott. et al. (all records)

eph: *Elaphoglossum* P 700 (4) 800 (6) 900 (2), J 600 (2); *Trichomanes* P 600 (1) 700 (9) 800 (3), J 500 (1) 600 (1) 900 (1), T 500 (2) *Hedera* P 700 (1); *Thamnobryum* P 800 (1) 1000 (1), J 500 (1); *Hymenophyllum* P 800 (1); *Blechnum* F 700 (1), J 500 (1); *Stenogramma* J 600 (1). ef: *Pittosporum* T 200 (1); *Platanus* F 500 (1); *Juniperus* P 600 (1) 1000 (1); *Erica* P 600 (1) 800 (1) 1000 (1); *Cryptomeria* F 400 (1), J 500 (1), G 200 (1), M 500 (3). - ex: litter P 700 (1), G 200 (1), T 900 (2); *Cryptomeria* F 500 (1); *Prunus* P 700 (1); *Ilex* P 700 (1); *Culcita* P 700 (2) 800 (8) 900 (3), M 1000 (1); *Erica* P 800 (1). - el: J 200 (1), G 200 (1) 300 (1). - eg: G 300 (1).

Lophocolea heterophylla (Schrad.) Dum. (epiphyllous records)

eph: *Blechnum* T 900 (1).

Lophozia ventricosa (Dicks.) Dum. (epiphyllous records)

eph: *Trichomanes* T 900 (1).

Marchesinia mackaii (Hook.) S. Grey (all records)

eph: *Trichomanes* F 600 (1) 700 (1), P 600 (3) 800 (1), J 700 (1); *Persea* M 600 (1) 700 (5); *Elaphoglossum* P 700 (1); *Hedera* P 800 (1); *Ilex* P 600 (3), *Pteris* P 600 (4); *Blechnum* F 500, P 600 (1); *Diplazium* P 600 (2); *Laurus* P 600 (1); *Stenogramma* J 600 (2); *Thamnobryum* J 600 (1). - ef: *Populus* L 200 (1); *Cryptomeria* J 400 (1), T 400 (1); *Erica* J 500 (1); *Pittosporum* F 400 (2), T 200 (1); *Eucalyptus* F 200 (1), T 200 (2); *Hydrangea* C 300 (2), J 600 (1); *Laurus* P 500 (1), J 700 (1); *Platanus* L 300 (1), F 500 (1), T 300 (1); *Juniperus* J 600 (1); *Ilex* J 300 (1); *Buxus* J 300 (1) 400 (1); *Rubus* P 600 (4). - ex: *Erica* T 300 (1); *Pittosporum* C 200 (1), F 200 (1), *Ilex* P 700 (1); *Culcita* P 800 (1). - el: C 200 (1), L 200 (1) 300 (1), F 200 (3) 300 (2), P 300 (1), J 200 (3) 400 (1). - eg: L 400 (1), P 300 (1).

Metzgeria conjugata Lindb. (epiphyllous records)

eph: *Laurus* P 800 (1); *Hedera* F 800 (1), P 800 (2); *Elaphoglossum* P 800 (2) 900 (1) 1100 (1); *Pteris* J

700 (1); *Trichomanes* F 500 (1) 700 (1); *Ilex* F 700 (1), P 1100 (1); *Blechnum* F 700 (1).

Metzgeria furcata (L.) Dum. (epiphyllous records)

eph: *Ilex* F 700 (1) 800 (3), P 800 (3) 1000 (1) 1100 (3), T 900 (3), M 700 (1) 800 (3); *Trichomanes* F 500 (1) 600 (2) 700 (4), P 700 (5) 800 (1) 900 (1), J 700 (1), T 400 (1) 900 (1); *Persea* M 400 (4) 600 (4); *Blechnum* F 700 (2), P 900 (1) 1100 (2), T 900 (3); *Elaphoglossum* F 700 (1) 800 (1), P 800 (4) 1000 (1), T 900 (2), M 800 (1) 1000 (1); *Laurus* P 800 (2), T 600 (1) 900 (1), M 500 (2) 600 (2) 800 (2) 1000 (3); *Diplazium* T 900 (1); *Culcita* T 900 (1); *Woodwardia* J 700 (1), M 500 (2) 1000 (1); *Hedychium* F 500 (1), J 700 (1); *Thamnobryum* M 400 (1); *Christella* M 800 (3); *Hedera* F 800 (1), M 1000 (1).

Metzgeria leptoneura Spruce (epiphyllous records)

eph: *Thamnobryum* F 800 (1), J 500 (1); *Elaphoglossum* P 800 (3), T 900 (1); *Culcita* P 800 (1); *Trichomanes* P 800 (1) 900 (2); *Blechnum* F 700 (1), J 500 (1)

Myurium hochstetteri (Schimp.) Kindb. (epiphyllous records)

eph: *Trichomanes* C 600 (1), F 600 (1) 700 (2), T 600 (1); *Huperzia* T 900 (1); *Hymenophyllum* M 700 (1).

Nardia scalaris S.F. Gray (epiphyllous records)

eph: *Huperzia* J 900 (1).

Nowellia curvifolia (Dicks.) Mitt. (epiphyllous records)

eph: *Culcita* P 800 (2).

Odontoschisma denudatum (Nees in Mart.) Dum. (epiphyllous records)

eph: *Trichomanes* T 500 (1) 600 (1) 900 (1); *Elaphoglossum* P 800 (3), J 900 (1).

Odontoschisma sphagni (Dicks.) Dum. (epiphyllous records)

eph: *Elaphoglossum* P 700 (1) 900 (1); *Trichomanes* P 900 (2).

Plagiochila allorgei Herz. et H. Perss. (epiphyllous records)

eph: *Trichomanes* P 800 (1).

Plagiochila exigua (Tayl.) Tayl. (epiphyllous records)

eph: *Trichomanes* P 700 (3) 800 (2) 900 (4), J 500 (1), M 900 (1); *Elaphoglossum* P 700 (3) 800 (5) 900 (2) 1000 (1) 1100 (1), J 600 (1) 900 (1); *Blechnum* F 700 (1), P 800 (1), J 500 (2); *Hymenophyllum* P 800 (1), M 700 (1); *Polytrichum* J 500 (1); *Thamnobryum* J 500 (1); *Huperzia* J 900 (1).

Plagiochila spinulosa (Dicks.) Dum. (epiphyllous records)

eph: *Trichomanes* C 400 (2) 600 (2), F 500 (1), P 700 (5) 800 (2) 900 (2), J 600 (1), T 400 (2) 500 (7) 600 (4); *Elaphoglossum* P 700 (1) 800 (5) 900 (4) 1100 (1), T 500 (1) 600 (1) 900 (1); *Blechnum* P 800 (2) 900 (1), T 900 (1); *Thamnobryum* P 600 (1) 1000 (1); *Ilex* 800 (1); *Hedera* P 700 (1) 800 (2) *Hymenophyllum* P 800 (2), M 700 (1); *Diplazium* P 800 (1); *Huperzia* P 1100 (1), J 900 (3); *Woodwardia* M 1000 (1); *Pteridium* C 400 (1).

Plagiomnium undulatum (Hedw.) T. Kop. (epiphyllous records)

eph: *Thamnobryum* P 1000 (1).

Plagiothecium nemorale (Mitt.) Jaeg. (epiphyllous records)

eph: *Trichomanes* F 500 (1), T 500 (1) 600 (1); *Thamnobryum* J 400 (1); *Elaphoglossum* P 800 (2) J 600 (2).

Pseudotaxiphyllum elegans (Brid.) Iwats. (epiphyllous records)

eph: *Ilex* F 800 (1); *Trichomanes* P 700 (1) J 500 (1) 900 (1), T 700 (1) 900 (1); *Elaphoglossum* T 900 (1); *Blechnum* J 600 (1); *Thamnobryum* F 700 (1).

Pseudotaxiphyllum laetevirens (Koppe et Düll) Hedenäs (all records)

eph: *Elaphoglossum* P 800 (7); *Ilex* P 800 (2); *Hedera* P 800 (1); *Trichomanes* F 500 (1) 700 (1), P 800 (1) 900 (1), T 500 (1); *Blechnum* F 700 (3), P 800 (1); *Hymenophyllum* P 800 (1). - ex: *Culcita* P 800 (4). - el: P 800 (1). - eg: L 600 (1), P 300 (1).

Radula aquilegia (Hook. f. et Tayl.) Gott. et al. (all records)

eph: *Trichomanes* C 600 (1), F 700 (3), P 700 (3) 900 (1); *Ilex* F 700 (1) 800 (3), P 700 (1) 1100 (1), J 500 (1), T 900 (2), M 800 (3); *Thamnobryum* F 800 (1), P 1000 (1); *Elaphoglossum* F 800 (1), P 800 (3) 1100 (1); *Hedera* P 700 (1) 800 (4), M 1000 (1); *Huperzia* J 900 (1); *Blechnum* F 500 (2) 700 (1), P 700 (1) 900 (1) 1100 (1), M 500 (1) 600 (2); *Laurus* T 900 (1), M 500 (2) 600 (3) 700 (1) 800 (2) 1000 (8); *Hymenophyllum* M 700 (1); *Woodwardia* M 500 (2); *Christella* M 800 (1); *Persea* M 600 (2); *Hedychium* F 500 (1). ef: *Acacia* F 400 (1); *Eucalyptus* F 200 (1); *Cryptomeria* F 400 (1), M 800 (1); *Ilex* P 800 (1) 1100 (1), T 900 (1); *Laurus* P 1000 (4), T 900 (1); *Juniperus* F 700 (1), P 600 (1); *Vaccinium* J 700 (1); *Erica* F 500 (1) 600 (2),

P 800 (2), J 700 (1); *Pittosporum* J 200 (1); *Daphne* P 1000 (1); *Rubus* P 600 (2). - ex: *Ilex* P 700 (1); *Prunus* P 700 (1); *Erica* P 700 (1); *Juniperus* F 500 (1), P 1000 (1); *Culcita* P 800 (3), M 500 (1) 700 (1); *Hydrangea* F 700 (1); *Blechnum* P 800 (1); litter P 1000 (1). - el: C 400 (1). - eg: L 400 (1).

Radula carringtonii Jack. (epiphyllous records)

eph: *Trichomanes* C 500 (1), F 500 (1), P 700 (2); *Elaphoglossum* P 700 (1) 800 (3), M 800 (1) 1000 (1); *Laurus* P 600 (1) 1000 (1); *Hedera* P 700 (1) 800 (1); *Huperzia* P 1100 (1); *Diplazium* T 900 (1); *Blechnum* J 600 (1); *Ilex* F 700 (1), M 700 (1) 800 (1); *Persea* M 600 (4).

Radula holzii Spruce (epiphyllous records)

eph: *Trichomanes* F 600 (1) 700 (1), P 700 (3) 800 (3); *Thamnobryum* P 600 (1); *Elaphoglossum* P 700 (1) 800 (2); *Hedera* P 800 (1) J 600 (1). - ef: *Pittosporum* P 100 (1); *Juniperus* P 800 (1); *Erica* P 800 (1) 1000 (1); *Ilex* P 800 (1); *Laurus* P 1000 (1). - ex: *Ilex* F 800 (1); *Cryptomeria* F 500 (1); *Culcita* P 800 (2); litter J 700 (1). - eg: L 100 (1).

Radula lindenberghiana Gott. - ex Hartm. (epiphyllous records)

eph: *Elaphoglossum* P 800 (1); *Blechnum* P 800 (1).

Radula nudicaulis Steph. (epiphyllous records)

eph: *Hymenophyllum* P 800 (1); *Elaphoglossum* P 800 (1).

Radula wichurae Steph. (epiphyllous records)

eph: *Laurus* P 800 (1); *Ilex* P 800 (1); *Elaphoglossum* P 800 (1).

Rhynchostegiella tenella (Dicks.) Limpr. (epiphyllous records)

eph: *Elaphoglossum* M 1000 (1).

Riccardia multifida (L.) S.F. Gray (epiphyllous records)

eph: *Trichomanes* F 700 (1), P 700 (1) 900 (1), M 900 (2); *Thamnobryum* P 1000; *Stenogramma* J 600 (1).

Saccogyna viticulosa (L.) Dum. (epiphyllous records)

eph: *Trichomanes* C 300 (1) 400 (1), P 700 (4) 800 (2), J 500 (2), T 400 (1) 500 (3) 600 (1), M 800 (2); *Thamnobryum* P 600 (1), M 500 (1); *Blechnum* F 700 (1), P 800 (1) 900 (1); *Polytrichum* J 500 (1); *Hymenophyllum* J 600 (1); *Christella* M 500 (1).

Scapania gracilis Lindb. (epiphyllous records)

eph: *Huperzia* J 900 (1).

Sematophyllum substrumulosum (Hampe) Britt. (epiphyllous records)

eph:-*Trichomanes* F 700 (1), J 500 (1), T 500 (1); *Blechnum* T 900 (1).

Telaranea nematodes (Gott. et Aust.) Howe (epiphyllous records)

eph: *Trichomanes* T 400 (1) 500 (2), M 800 (1); *Ilex* P 700 (1); *Blechnum* T 900 (1).

Tetrastichium fontanum (Mitt.) Card. (epiphyllous records)

eph: *Thamnobryum* F 700 (1), P 700 (1), J 400 (1); *Trichomanes* P 700 (3).

Tetrastichium virens (Card.) Churchill (epiphyllous records)

eph: *Trichomanes* C 300 (1).

Thamnobryum alopecurum (Hedw.) Nieuwl. (epiphyllous records)

eph: *Trichomanes* J 700 (1).

Thuidium tamariscinum (Hedw.) B.S.G. (epiphyllous records)

eph:-*Trichomanes* F 500 (1), P 800 (1) 900 (2), J 900 (1), T 500 (1); *Huperzia* P 1100 (1); *Blechnum* F 700 (1); *Stenogramma* J 600 (1).

