

STUDIES ON THE LICHENS OF THE AZORES. PART 1- CALDEIRA DO FAIAL

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ARQUIPÉLAGO

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This paper is the first in a series treating the lichens of the Azores in relation to their taxonomy, ecology and biogeography. In this paper the lichen flora occurring in the crater of Caldeira do Faial is described. Three distinct lichen zones are recognised within the Caldeira according to an altitudinal zonation from summit to base. (1) An upper, lichen-poor zone dominated by bryophytes, 922-800 m. (2) A middle, relatively species-rich zone with a distinctive facies of the Lobarion, 800-600 m. (3) A lower, relatively species-poor zone on the floor of the crater at 600-562 m. This zonation appears related to different levels of precipitation and periodic persistence of cloud and mist cover.

105 species are reported for the Crater, 31 as new records for the Azores, including *Thelotrema isidioides*, previously known only from the Irish type collection from last century. Three species are newly described: *Peltigera dissecta*, *P. melanorrhiza* and *Ramonia azorica*. *Mycoblastus caesius* is reported fertile for the first time in Europe and *Catinaria albocincta* is considered conspecific with *Catillaria pulvereae*.

The relict lichen flora of the Caldeira is an important element on Faial which was formerly very much more widespread on most of the main islands prior to wide-scale deforestation.

PURVIS, O.W. & P.W. JAMES 1993. Estudo dos líquenes dos Açores. Parte 1- Caldeira do Faial. *Arquipélago*. Ciências Biológicas e Marinhas 11A: 1-15. Angra do Heroísmo. ISSN 0870-6581.

Este trabalho, o primeiro de uma série sobre a taxonomia, ecologia e biogeografia dos líquenes dos Açores, descreve a flora de líquenes que ocorrem na cratera da Caldeira do Faial. Correspondendo a uma zonação em altitude foram reconhecidas três zonas distintas de líquenes na Caldeira. (1) Uma zona superior, entre 922-800 m, pobre em líquenes e dominada por briófitos. (2) Uma zona média, entre 800-600 m, relativamente rica em espécies e com uma fácies distintiva de Lobarion. (3) Uma zona inferior relativamente pobre em espécies no fundo da cratera, entre 600-562 m de altitude. Esta zonação parece estar relacionada com os diferentes níveis de precipitação e com a persistência de nuvens e nevoeiros.

Neste levantamento dos líquenes da Caldeira registaram-se 105 espécies, sendo 31 delas novas ocorrências para os Açores, incluindo *Thelotrema isidioides*, que era anteriormente apenas conhecida através da espécie-tipo Irlandesa do século passado. Três novas espécies foram encontradas: *Peltigera dissecta*, *P. melanorrhiza* e *Ramonia azorica*. *Mycoblastus caesius* foi encontrada em estado fértil pela primeira vez na Europa e *Catinaria albocincta* passa a ser considerada como conspecifica de *Catillaria pulvereae*.

A flora reliquia de líquenes da Caldeira é um elemento importante da flora do Faial, que deveria também existir nas principais ilhas do arquipélago antes da desflorestação em larga escala.

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INTRODUCTION

The Azorean archipelago (Fig. 1) is situated in the Atlantic Ocean 1480 km west of the nearest continental land in Portugal lying between 36° 59' N and 39° 44' N latitude and 24° 41' W and 31° 16' W longitude. There are three separate island groups of which Faial is the westernmost of the is-

lands in the central group being separated from Pico by the 7 km wide Faial channel. Faial (Fig. 1) from north to south is about 14 km, while at its widest the island is 21 km across. The principal physical feature of the island is Cabeço Gordo (1043 m) in the centre of the island. This symmetrical volcanic mountain was last active in 1672 and has a steep-sided crater with a floor more than

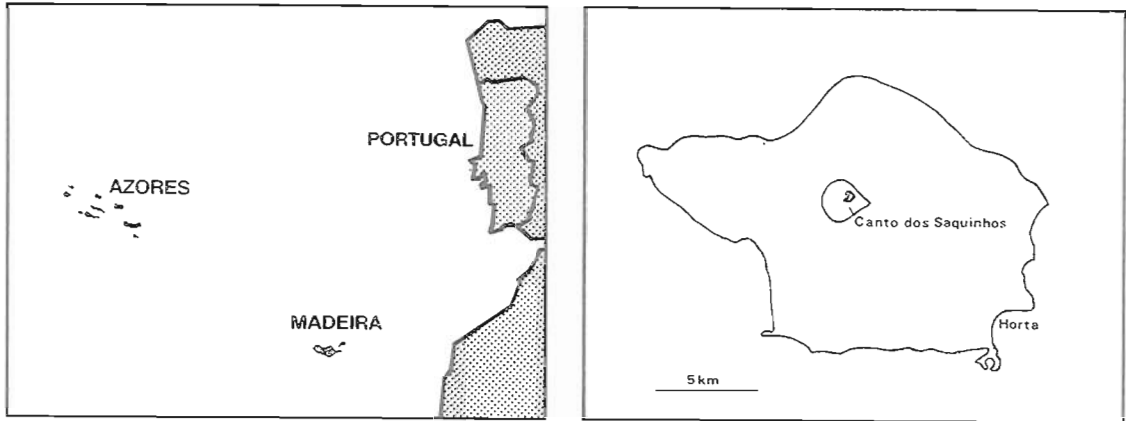


Fig. 1. - a) Map showing location of Azores. b) Faial and Caldeira.

4.5 km in diameter. The crater floor is ca. 350 m below the rim and contains a shallow lake which varies in size according to the rainfall and which is slowly silting up; the drier areas support almost pure stands of *Erica azorica*, with little diversity in shrubs (Fig. 3).

The climate of the Azores is oceanic, with comparatively small seasonal fluctuations in temperature and rainfall at sea level. Precipitation is ca. 1054 mm annually at sea level in Faial, increasing about 16% for every 100 m rise in altitude (SJÖGREN 1978). Cloud descends almost daily to 700 m or lower throughout the year; frosts are rare below 600 m.

All nine principal islands were once covered with characteristic evergreen forest (GODMAN 1870). These, together with those of the Canaries and Madeira, are considered to be relicts of the now largely lost Tertiary forests of southern Europe (HAGGAR 1984, 1988; TUTIN 1953). The special interest of the vegetation is reflected in eight of the eleven native trees being endemic to

the Azores. Now, virtually no natural forests with native trees exist below 500 m, having been replaced almost completely by the exotic *Pittosporum undulatum*, though some stands of *Myrica faya* occur in drier, scattered localities. Native forests now remain only at high altitude above ca. 800 m in the cloud zone of some of the islands (Terceira, São Miguel and Pico), though large-scale clearance of forest for pasture and fire-wood is taking place in these areas. Increasingly, plantations of *Cryptomeria japonica* are becoming a dominant feature of the landscape. This substrate has its own special lichen flora, one especially rich in species of *Micarea*. At moderately high altitudes, from 500 m to 1350 m, the predominant natural vegetation belongs to the Juniperion brevifolii alliance, dominated by *Juniperus brevifolia* and *Erica azorica*, generally with *Laurus azorica*, *Ilex perado* ssp. *azorica*, *Vaccinium cylindraceum*, *Viburnum tinus* ssp. *subcordatum*, *Hypericum foliosum*, *Myrsine africana* and locally *Euphorbia stygiana* (SJÖGREN 1973). The vegeta-



Fig. 2. Mid slopes of Caldeira do Faial with *Juniperus brevifolia* in foreground.



Fig. 3. Bottom of Caldeira do Faial with *Erica azorica*.

tion within Caldeira do Faial belongs entirely to this community.

The lichen flora of the Azores has been relatively poorly studied and except for a few papers published on the discovery of particular species, there has been little attempt to describe the predominant lichen communities, even of the relict woodlands. Apart from a number of recent monographic and other taxonomic studies and floras (e.g. AHTI 1961, HALE 1965, JAMES & WHITE 1987, JØRGENSEN 1974 & 1978, KROG & SWINSCOW 1978, MOBERG 1989, PURVIS et al. 1992) which include reference to Azorean lichens, the majority of the literature was published over 50 years ago, including DES ABBAYES (1946, 1947), CROMBIE (1878), NAVAS (1909), NYLANDER (1895, 1898), SEUBERT (1844) and STIRTON (1875). DEGELIUS (1941) published a catalogue of 157 lichens of the Azores, mainly collected by the bryologist Dr H. Persson. Contributions to the Macaronesian lichens, including some reference to the Azores, have also been prepared (e.g. TAVARES 1952, 1953, 1958, 1964; KALB & HAFELLNER 1992). Recently, two papers were published which deal with modern Azorean collections (APTROOT 1989, ARVIDSSON 1990); both list additions to the lichen flora. Endemism is a characteristic feature of the phanerogams in the Azores. Some indication that the same is true for lichens are reports of two endemic macrolichens - *Nephroma venosum* (DEGELIUS 1941) and *Nephroma hensseniae* (JAMES & WHITE 1987).

There are few published records of lichens collected at the Caldeira, viz. *Cladonia stereoclada* (type locality - DES ABBAYES 1946), *Degelia atlantica*, *Lobaria pulmonaria*, *Parmelia sinuosa* (Sm.) Ach., *Peltigera canina* (L.) Willd., *P. polydactyla* (Necker) Hoffm., *Sticta dufourii* (DEGELIUS 1941), *Megalospora tuberculosa*, *Pannaria pezizoides*, *Parmelinopsis horrescens* (ARVIDSSON 1990) and *Graphis elegans*, *G. scripta* (L.) Ach., *G. triticea*, *Heterodermia japonica*, *Hypotrachyna microblasta*, *Micarea alabastrites* (Nyl.) Coppins, *M. peliocarpa*, *Pannaria leucosticta* (Tuck.) Nyl., *Trapeliopsis flexuosa* (APTROOT 1989). However, in the light of our research and recent revisionary studies, some of these identifications are doubtful and will need confirmation. Furthermore, as Aptroot gives only vague locality details and lists several species as

occurring on *Cryptomeria*, it would appear that most, if not all, his records were made outside the rim of the Caldeira. One of us (PWJ) and Professor Aino Henssen spent a day in the Caldeira in March 1976 and made a number of collections which were deposited in The Natural History Museum (BM) and Marburg (MB). Species recorded at that time which were not seen during the present survey include *Peltigera lactucifolia*, *Placopsis gelida*, *Platismatia glauca*, *Polyblastia gothica*, *Rimelia reticulata*, *Stereocaulon azoreum*, *S. vesuvianum*, *Trapelia involuta* and *T. obtogens*, all near or at the Caldeira rim.

MATERIALS AND METHODS

The authors visited the Caldeira on 14 April 1992, in excellent weather conditions. Descent was via the main path and donkey trail from "Canto dos Saquinhos" (922 m) by the steep interior NW-facing slopes of the Caldeira to the base at 576 m. Lichen epiphytes, and also the very few saxicolous species, were widely collected. However, a more intensive study would undoubtedly reveal further species, but access is difficult in many parts owing to the near vertical sides of the crater and unstable surfaces.

Observations and measurements of lichens were made using a Wild M7 stereomicroscope equipped with a measuring eyepiece. Internal features were investigated with a Leitz Dialux 20 microscope. Most sections were made by hand with a razor blade. A list of lichens recorded is given (Table 1). Author citations generally follow BRUMMIT & POWELL (1992) and are presented in full (Table 1); full author citations are also given for lichens the first time they are mentioned in the text but which are not indicated in Table 1. Higher plant nomenclature follows SJÖGREN (1973, 1984) and that for lichens conforms to recent taxonomic papers. A small number of crustose species remain to be identified which will be referred to in future papers. Material is deposited in BM; some duplicates at University of Hawaii (HAW) and additional specimens and holotypes of new species at the Department of Agrosociences, University of Azores, Terceira.

Chemical analyses were performed using standard methods of thin layer chromatography (CULBERSON 1972, WHITE & JAMES 1985). Two

solvent systems TDA (Toluene : dioxan : acetic acid; 180:60:8) and G (Toluene : ethyl acetate : formic acid; 139:83:8) were routinely used and two dimensional chromatograms were run in the case of *Peltigera*.

RESULTS

Flora of Caldeira do Faial alongside track from Canto dos Saquinhos to base

(1) Alt. 922-800 m

The upper, frequently mist-enshrouded zone is notable for the luxuriance of the bryophytes which hang from tree branches and cover large tracts of the ground, including rock faces. The lichens are neither conspicuous nor numerous; those occurring being typically macrolichens which can compete with or grow over (foliose) or away from (fruticose) mosses. A number, including the few crustose species, occur on decorticated wood and smooth bark of small shrubs of *Vaccinium* and *Ilex*. Amongst the macrolichens, *Heterodermia japonica*, *Hypotrachyna endochlora*, *H. rockii* and *Parmelinopsis horrescens* are particularly frequent; *Parmotrema arnoldii*, *P. robusta* and *Hypotrachyna microblasta* were also observed on *Juniperus*. A range of species of *Cladonia* is frequent, often on partly rotted wood, including *C. azorica*, *C. caespiticia*, *C. coniocraea*, *C. diversa*, *C. merochlorophaea*, *C. squamosa*, *C. squamosa* var. *subsquamosa* and *C. stereoclada*. Crustose species present, on bare bark or \pm overgrowing mosses, include *Catillaria pulvereae*, *Dimerella pineti*, *Gomphillus calycioides*, *Graphis triticea*, *Gyalideopsis* sp., *Megalospora tuberculosa*, *Micarea prasina*, *Mycoblastus caesius*, *Pannaria pezizoides*, *Ramonia azorica*, *Thelotrema lepadinum* and *Trapelia corticola*. Several crustose species also grow directly on wood, particularly *Micarea lignaria*, *M. peliocarpa*, *Trapelia corticola*, and *Trapeliopsis flexuosa*. *Baeomyces rufus* is frequent on the ground and *Thrombium epigaeum* was recorded on disturbed soil by the path. Few species were noted on rocks though *Rhizocarpon hochstetteri* was rather frequent, together with *Leptogium cyanescens* and species of *Trapezia*.

Table 1.
Alphabetical list of lichens of Caldeira do Faial

- * *Arthonia elegans* (Ach.) Almq.
 * *Arthopyrenia antecellans* (Nyl.) Arnold
 * *A. carneobrunneola* Coppins
 * *A. viridescens* Coppins
Baeomyces rufus (Huds.) DC.
Byssoloma subdiscordans (Nyl.) P. James
Catillaria pulvereola (Borrer) Lettau
 * *Celothelium ischnobelum* (Nyl.) Aguirre
Cladonia azorica Ahti
 * *C. caespiticia* (Pers.) Flörke
C. coniocraea (Flörke) Sprengel
 * *C. diversa* Asperges
 * *C. firma* (Nyl.) Nyl.
C. merochlorophaea Asah.
C. ochrochlora Flörke
C. polydactyla (Flörke) Sprengel
C. squamosa (Scop.) Hoffm.
C. squamosa var. *subsquamosa* (Nyl. & Leighton) Vainio
C. stereoclada des Abb.
Coccocarpia palmicola (Spreng.) L. Arvidss. & D. J. Galloway
Dactylospora parasitica (Spreng.) Zopf
Degelia atlantica (Degel.) P.M. Jørg. & P. James
Dictyonema interruptum (Carm. ex Hook.) Parm.
Dimerella pinetii (Schrader) Vézda
Eopyrenula sp.
 * *Fellhanera bouteillei* (Desm.) Vézda
 * *Gomphillus calycioides* (Del.) Nyl.
Graphis elegans (Borrer ex Sm.) Ach.
G. triticea Nyl.
Gyalideopsis sp.
Haematomma elatinum (Ach.) Massal.
Herteliana taylorii (Salwey) P. James
Heterodermia japonica (Sato) Swinscow & Krog
H. obscurata (Nyl.) Trevisan
Hypotrachyna endochlora Leighton Hale
H. microblasta (Vainio) Hale
H. rockii (Zahlbr.) Hale
 * *Lecanora symmicta* (Ach.) Ach.
Lecidea sp.
Lecidella sp.
 * *Lepraria lobificans* Nyl.
 * *L. umbricola* Tønsberg
Leptogium cyanescens (Rabenh.) Körber
Lobaria pulmonaria (L.) Hoffm.
L. virens (With.) Laundon
Loxospora elatina (Ach.) Massal.
Megalospora tuberculosa (Fée) Sipman
Melaspilea sp.
 * *Micarea botryoides* (Nyl.) Coppins
M. lignaria (Ach.) Hedl.
M. peliocarpa (Anzi) Coppins & R. Sant.
 * *M. prasina* Fr.
 * *Mycoblastus caesius* (Coppins & P. James) Tønsberg
Nephroma helveticum Ach.
N. hensseniae P. James & F.J. White
N. laevigatum Ach.
N. venosum Degel.
Normandina pulchella (Borrer) Nyl.
 * *Omphalina pararustica* Clemençon
Opegrapha sp.
Pannaria conoplea (Ach.) Bory
P. pezioides (Web.) Trev.
P. rubiginosa (Ach.) Bory
Parmelinopsis horrescens (Taylor) Elix & Hale
Parmeliella janessii S. Ahlner & P.M. Jørg.
 * *Parmentaria chilensis* Fée
Parmotrema arnoldii (Du Rietz) Hale
P. chinense (Osbeck) Hale
P. robustum (Degel.) Hale
 * *Peltigera dissecta* Purvis, P. James & Vitik.
P. lactucifolia (With.) Laundon
 * *P. melanorrhiza* Purvis, P. James & Vitik.
 * *Pertusaria pulvinata* Erichsen
Phaeographis sp.
Placopsis gelida (L.) Lindsay
Platismatia glauca (L.) Culb. & C. Culb.
 * *Polyblastia gothica* Th. Fr.
Pseudocyphellaria aurata (Ach.) Vainio
P. intricata (Del.) Vainio
P. lacerata Degel.
 * *Pyrenula dermatodes* (Borrer) Schaerer
P. harrisii Hafellner & Kalb
P. macrospora (Degel.) Coppins & P. James
P. sp. (x 3)
 * *Ramonia azorica* P. James & Purvis
 * *Rhizocarpon hochstetteri* (Körber) Vainio
Rimelia reticulata (T. Taylor) Hale & A. Fletcher
R. subsidiosa (Müll. Arg.) Hale & A. Fletcher
Stereocaulon azureum (Schaer.) Nyl.
S. vesuvianum Pers.
Sticta fuliginosa (Hoffm.) Ach.
Tapellaria epiphylla (Müll. Arg.) R. Sant.
 * *Thelotrema isidioides* (Borrer) R. Sant.
T. lepadinum Ach.
T. sp.
Thrombium epigaeum (Pers.) Wallr.
Trapelia coarctata (Sm. & Sow.) M. Choisy
 * *T. corticola* Coppins & P. James
 * *T. involuta* (Taylor) Hertel
 * *T. obtegens* (Th. Fr.) Hertel
Trapeliopsis flexuosa (Wallr.) Coppins & P. James
 * *Usnea cornuta* Körber
 * *U. flammnea* Stürton
U. sp. (x 2)
 * = new record for the Azores.

(2) Alt. 800-600 m

Lichens reach their maximum diversity in this zone (Fig. 2) and are characterised by the dominance of complex associations of foliose species of the Lobarion. These include *Coccocarpia palmicola*, *Degelia atlantica*, *Leptogium cyanescens*, *Loëaria pulmonaria*, *L. virens*, *Nephroma helveticum*, *N. hensseniae*, *N. laevigatum*, *N. venosum*, *Normandina pulchella*, *Pannaria conoplea*, *Pannaria rubiginosa*, *Parmeliella jamesii*, *Pseudocyphellaria aurata*, *P. intricata*, *P. lacerata* and *Sticta fuliginosa*. *Parmelinopsis horrescens* is particularly abundant. The macrolichens do not appear to be host-specific, occurring on a wide range of substrates, often entangled amongst mosses. By contrast, crustose species are also more conspicuous here than in the upper zone, though they are more host-specific. Smooth-barked *Vaccinium cylindraceum* and *Ilex perado* subsp. *azorica* support distinctive communities dominated by a species of *Melaspilea* and several pyrenocarpous lichens including *Arthopyrenia antecellans*, *A. carneobrunneola*, *Parmentaria chilensis*, *Pyrenula dermatodes* and *P. harrisii*, *P. macrospora* as well as *Thelotrema lepadinum*. In contrast, *Erica azorica* and *Juniperus brevifolia* with a more friable, peeling, acidic bark support no pyrenocarpous lichens, but *Micarea prasina*, *Mycoblastus caesius*, *Pertusaria pulvinata*, *Thelotrema isidioides* and a second, distinctive species of *Thelotrema* (see p. 11) are present. *Myrsine africana* is a particularly rich substrate for lichens. The foliicolous *Byssoloma subdiscordans* and *Tapellaria epiphylla* were collected from *Laurus* and *Ilex* leaves; both these phorophytes and also the endemic *Euphorbia stygiana* were rather rare.

(3) Alt. 600-562 m

The floor of the Caldeira is characterised by a mosaic of vegetation defined largely by local hydrology. Here the most abundant shrub is *Erica azorica* and *Hypericum foliosum* is also frequent (Fig. 3). This area is floristically less diverse and members of the Lobarion are correspondingly scarcer here, though *Coccocarpia palmicola*, *Loëaria pulmonaria* and *Sticta fuliginosa* are frequent. Species of the Parmeliaceae including

Usnea are well-represented, particularly *Hypotrachyna microblasta*, *Parmotrema robusta*, *P. subisidioides* and *Usnea flammea*. Crustose species present include *Byssoloma subdiscordans*, *Catillaria pulvereae*, *Pyrenula dermatodes* and unidentified species of *Thelotrema* and *Pyrenula*.

New and Interesting Records

Catillaria albocincta Degel. and *C. pulvereae* (Borrer) Lettau

The former was described as a new species and recorded from both the Azores and North America (DEGELIUS 1941) and was subsequently recorded on several occasions in the Azores (ARVIDSSON 1990, APTROOT 1989). Both were observed within Caldeira do Faial in the present study and were also reported to occur together on the western slopes of the Caldeira by ARVIDSSON (1990). Examination of this and other material, collected principally on Pico, indicates that an intergradation exists between thalli with a thin, frequently non-sorediate, richly fertile, membranous thallus ('*C. albocincta*') and those rarely fertile thalli with a continuously granular, sorediate crust ('*C. pulvereae*'). As apothecial characters are identical, the two species are here regarded as conspecific, the earlier name, *Catillaria pulvereae*, having priority. A similar situation occurs in *Megalospora tuberculosa* within the Caldeira and elsewhere on the islands. In this case the thalli are also variably sorediate and with or without apothecia, although extremes of these entities have never been afforded taxonomic status.

Mycoblastus caesius (Coppins & P. James) Tønsberg

This species is characterised by a blue-grey prothallus with whitish to blue-grey, mainly discrete, efflorescent soralia and the presence of perlatolic acid (UV+ white). Formerly included in *Haematomma* (COPPINS & JAMES 1978) this species was recently transferred to *Mycoblastus* (TØNSBERG 1992). At the same time he also reported that some recently collected, fertile specimens of *Mycoblastus* from the Pacific coast of North America (British Columbia and Washing-

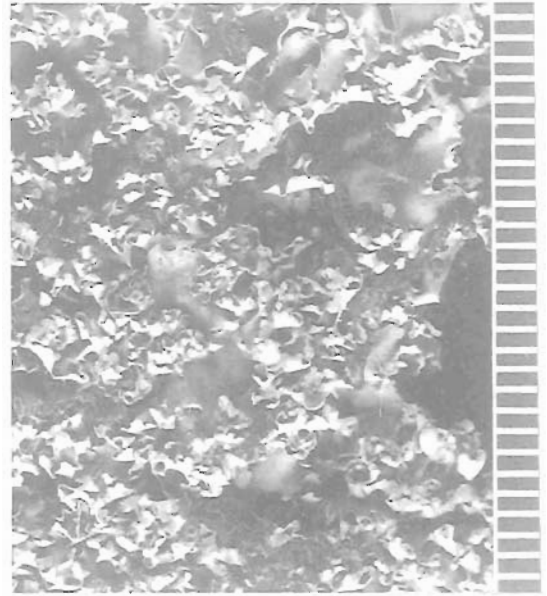
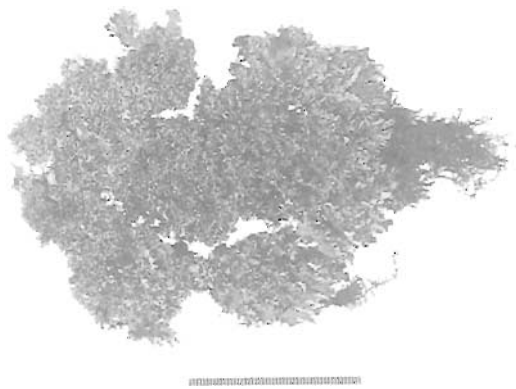


Fig. 4. *Peltigera dissecta* (holotype). a) Upper surface. b) Close-up of lobules. Scales in mm.

ton) were chemically and morphologically similar to the Norwegian specimens and probably represented fertile *Mycoblastus caesius*. Similar fertile material was found during the present and earlier survey on Pico*: apothecia black, scattered, convex; exciple much reduced laterally and merging and \pm concolorous with epithecium; epithecium indigo-blue to greenish, at times with a brownish tinge, K+ intensifying clear green-blue; hymenium colourless, interspersed with globules; paraphyses branched and anastomosing; asci 2-spored; ascospores $50\text{-}57 \times 27\text{-}36 \mu\text{m}$, ellipsoid, thick-walled, wall $4\text{-}7 \mu\text{m}$ thick. Our specimens closely agree with a description of the North American specimens provided by TØNSBERG (in litt.); his material occurring in coastal sites, mainly on *Alnus rubra*. Fertile specimens in the Azores seem principally confined to lignum, although sterile specimens are frequent in smooth bark communities, especially on *Vaccinium*.

Peltigera dissecta Purvis, P. James & Vitik. sp. nov.

Thallus ad 10 cm diam., fragilis; lobis angustis, ca. 0.5(-1.0) cm latis, plus minusve imbricatis, saepe lobulis; marginibus elevatis; superne caesio-cinereus aut fuscus suffusus, glaber; subtus pallidus; venis pallidis vel brunneis. Rhizinae simplicae vel fasciculatae, pallidae vel fuscatae, ad 3-4 mm longae. Apothecia ad 2 mm diam., revoluta disco ca. 5 x 3 mm; sporae $55\text{-}82 \times 3.5\text{-}4.5\text{-}(5.0) \mu\text{m}$, bacillari-aciculares, 3- vel multiseptatae, hyalinae.

Typus Azores: Faial: Caldeira, alongside track from Canto dos Saquinhos, alt. 580-670 m, [site 31], 14 April 1992, O.W. Purvis & P.W. James (Terceira) - holotypus (Fig. 4); (BM) - isotypus.

Thallus to 10 cm diam., but often much less, delicate, forming neat rosettes or as scattered, tangled lobes; lobes to 0.5 (-1.0) cm diam., irregu-

* 9 km E of Madalena, near Redondo, in *Juniperus* and *Ilex* scrub, 17 June 1978, P.W. James; S of Santa Luzia, northern slopes of Pico Mountain, Cerrado das Sonicas, on *Erica* and *Juniperus* on hillside near signal station alt. 900-1000 m. 11 June 1978, P.W. James; 12 km NNE of S. João. Bosque da Junqueira near road EN 2, alt. 700 m. [site 14], 9 April 1992, O.W. Purvis & P.W. James; 4 km NW of Pico summit, alongside road leading to aerial at Cerrado das Sonicas, alt. ca. 900 m, [site 5], 6 April 1992, O.W. Purvis & P.W. James.

larly incised, \pm ascending at apices and margins, ascending lobes often becoming markedly crisped-contorted and centrally with abundant, delicate, \pm erect folioles to 1(-1.5) mm across (Fig. 4); upper surface bluish grey, often tinged brownish, shiny, without pruina, tomentum, soredia, isidia or slash-like cracks; lower surface, white, with narrow, flat, brown veins, becoming ochre-coloured towards margins; rhizines colourless or brown, \pm simple or fasciculate. Apothecia rather rare, small, to 2 mm diam., rounded or elongate, becoming saddle-shaped, held \pm vertically, dark red-brown. Ascospores 45-65 \times 3.5-4.5 μ m, fusiform to acicular, often curved, 3- to 8-septate, colourless.

Chemistry: Tenuiorin, \pm methyl gyrophorate, \pm gyrophoric acid, \pm 7 β -acetoxyhopan-22-ol (peltidactylin) (T1), 15 α -acetoxyhopan-22-ol (dolichorrhizin) (T2), hopane-6 α ,22-ol (zeorin) (T3), and hopane-7 β ,22-ol (T4) (Fig. 5).

On mossy tree trunks and small branches on twigs occurring on a wide range of shrubs including *Erica azorica*, *Juniperus brevifolia*, *Laurus azorica* and *Myrsine africana* in the cloud zone-mist forest associated with the Lobarion.

Characterised by the delicate, marginally radiating, narrow lobes which frequently become lobulate and often partly obscured by numerous, delicate, scale-like, ascending, marginal folioles, particularly towards thallus centre. No other European *Peltigera* has such folioles. *P. dissecta* shares an almost identical terpenoid chemistry with *P. lactucifolia* though an additional accessory substance may occur below 15 α -acetoxyhopan-22-ol (dolichorrhizin) in solvent G (Fig. 5). *P. lactucifolia* further differs in having broader lobes lacking marginal folioles, pale to ochre-coloured veins with paler, simple rhizines which are unbranched, though occasionally splitting towards the ends.

Additional selected specimens of *P. dissecta*

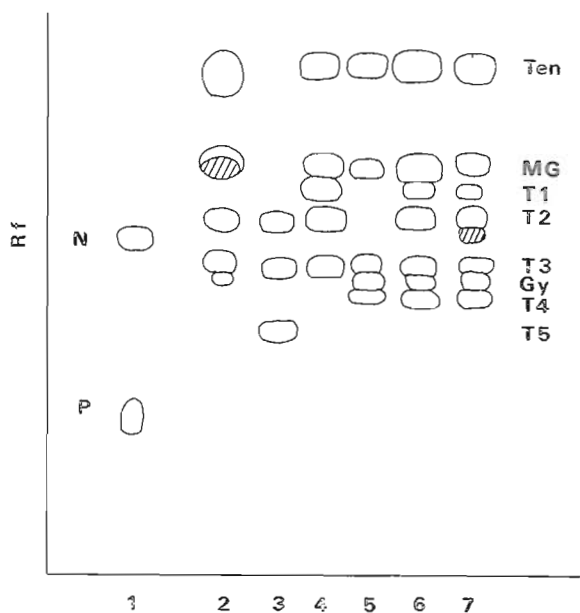


Fig. 5. Chromatogram of species of *Peltigera* and controls in solvent 'G' (WHITE & JAMES 1985). (1) control (N= norstictic acid, P= protocetraric acid). (2) *Peltigera melanorrhiza* (holotype). (3) *Nephroma parile* (4) *Peltigera lactucifolia*. (5) *P. horizontalis*. (6) *P. dissecta* (holotype) and (7) *P. dissecta* (Caldeira do Faial). Ten = tenuiorin. MG = methyl gyrophorate, gy = gyrophoric acid, T1 = 7 β -acetoxyhopan-22-ol (peltidactylin). T2 = 15 α -acetoxyhopan-22-ol (dolichorrhizin). T3 = hopane-6 α ,22-ol. T4 = hopane-7 β ,22-ol and T5 = hopane-15 α ,22-diol.

examined:- Faial: several specimens from same Caldeira from alt. 567-922 m., 14 April 1992, O.W. Purvis & P.W. James; W. slopes of Caldeira, Cabeço dos Trinta, on *Erica azorica*, ca. 650 m alt., 24 June 1986, L. Arvidsson A-108 (hb. L. Arvidsson):- Pico: (no locality) 600-1500 m alt., 7 May 1937, H. Persson (UPS) [*P. polydactyla* det. G. Degelius; as *P. polydactyla* in DEGELIUS 1941]; 10 km SW of Prainha, Cabeço da Rocha, 1 km W of Lagoa do Caiado, by roadside, alt. ca. 780 m, in cloud forest [site 15], 9 April 1992, O.W. Purvis & P.W. James; 12 km NNE of S. João, Bosque da Junqueira near Road EN 2, alt. 700 m, on *Juniperus brevifolia*. [site 14], 19 April 1992, O.W. Purvis & P.W. James; Lagoa do Caiado, ca. 7 km N. of Lajes do Pico, alt. ca. 825 m, on trees in relict natural forest, 13 June 1978, P.W. James; 9 km E. of Madalena, near Redondo, in *Juniperus* and *Ilex* scrub, 17 June 1978, P.W.

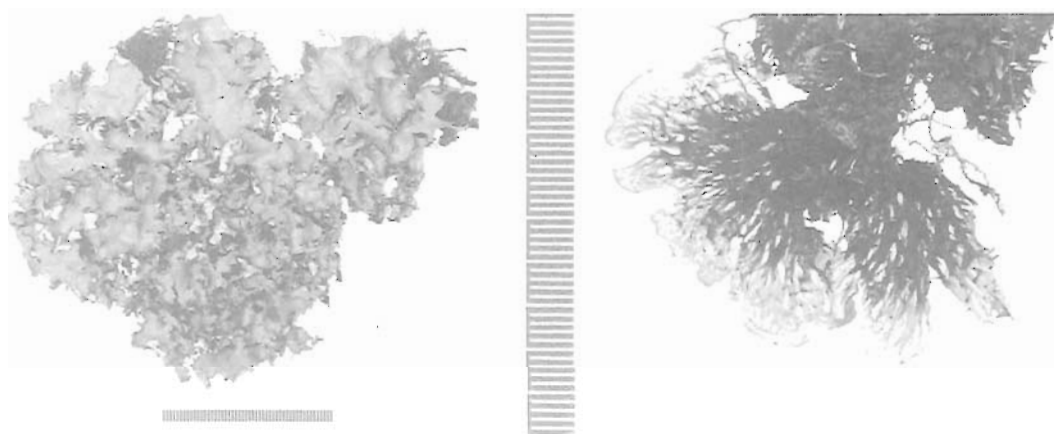


Fig. 6. *Peltigera melanorrhiza* (holotype). a) Upper surface. b) Close-up of lower surface. Scales in mm.

James; Cabeço do Rocha, 7-8 km north of Lajes do Pico, W. of Lagoa do Caiado, alt. ca. 830 m, in natural forest, 11 June 1978, P.W. James; Terceira: S.W. of Agualva, 22 April 1937, H. Persson (UPS) [*P. polydactyla* det. G. Degelius; as *P. polydactyla* in DEGELIUS 1941].

Peltigera melanorrhiza Purvis, P. James & Vitik. sp. nov.

Thallus ad 10(-20) cm diam., robustus; lobis ca. 1.5-2.5 cm latis, marginibus elevatis; superne cinereus aut brunneolus, glaber; subtus in centro atrobrunneus, marginem versus pallidus vel incoloratus; venis atrobrunneis et interstitiis albidis. Rhizinae fasciculatae, squarrositer ramosae, fuscatae, ad 3-4 mm longae. Apothecia revoluta disco ca. 5 x 3 mm; sporae 55-82 x 3.5-4.5(-5.0) μm , bacillari-aciculares, 3-vel multiseptatae, hyalinae.

Typus: Azores: Pico, Cerrado de Sonicas, ca. 200 m along track leading off road EN3 to aerial, alt. 900 m, 11 April 1992, O.W. Purvis & P.W.

James (Terceira) - holotypus (Fig. 6); (BM) - isotypus.

Thallus to 10(-20) cm diam., robust, forming wide-spreading rosettes; lobes to 1.5 (-2.5) cm wide, rounded and \pm ascending at apices and margins, \pm overlapping; margins sparingly indented, not crisped or with folioles; upper surface \pm matt or slightly shiny, grey or slightly brownish, without pruina, tomentum or slash-like cracks; lower surface blackish brown centrally, with poorly-defined, dark brown-black veins with frequent pale interstices especially towards centre of thallus, extending towards margins of lobes or with a 0.5 cm wide naked zone or with pale veins; rhizines 3-4 mm long, fasciculate, tufted, squarrosely branched, dark brown-black. Apothecia to 5 x 3 mm, red-brown, saddle-shaped, mostly on short extensions of lobes. Ascospores 55-82 x 3.3-4.5 (-5.0) μm , 3- to 7-septate, fusiform to acicular, colourless.

Chemistry: Tenuiorin, methyl gyrophorate, \pm gyrophoric acid, unidentified terpenoid with similar rf to methyl gyrophorate in solvent G, 15 α -

* NW slopes of Pico, ca. 3 km off road EN3 through Cerrado das Sonicas, S of track leading to aerial, alt. 1000-1150 m. [site 24], 11 April 1992, O.W. Purvis & P.W. James (BM); 7 km SSE of Prainha, Cabeço do Caveiro by roadside, alt. ca. 950 m, elfin cloudforest dominated by *Frullania* sp. and mosses. [site 17], 9 April 1992, O.W. Purvis & P.W. James.

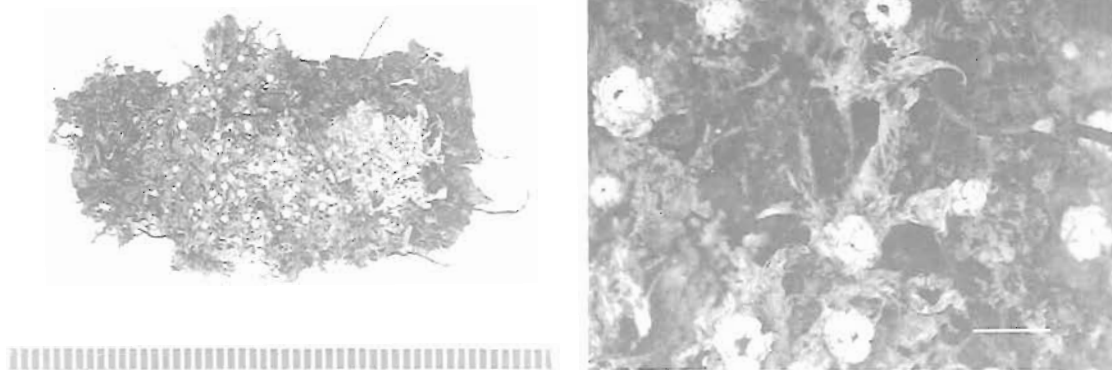


Fig. 7. *Ramonia azorica* (holotype). a) Habit view. b) Close-up of apothecia. Scales = 1 mm.

acetoxyhopan-22-ol (dolichorrhizin) (T2), \pm hopane-6 α ,22-ol (zeorin) (T3) (Fig. 5).

On old decaying logs and amongst mosses on the lower part of tree trunks in cloud forest in the Lobarion.

Characterised by the large lobes lacking tomentum on the upper surface and a lower surface with distinctive, dark brown, radiating, often anastomosing veins bearing long, dark brown-black, fasciculate rhizines; conspicuous, pale interstices occur between the veins (Fig. 6). The new species closely resembles *Peltigera horizontalis* (Huds.) Baumg. which has a similar type of veining and rhizines, but has a very different terpenoid pattern, rounded, not saddle-shaped, apothecia held horizontally, and 3-septate ascospores. *Peltigera lactucifolia* differs in having less distinct, pale to ochre-coloured veins with paler, simple rhizines which are unbranched, though occasionally splitting towards the ends. The terpenoid pattern of *P. melanorrhiza* is similar to that of *P. lactucifolia* but lacks 7- β -acetoxyhopan-22-ol (peltidactylin), and has an additional unidentified terpenoid with a similar *rf* to methyl gyrophorate in solvent G (Fig. 5). *P. lactucifolia*

is said to be by far the most common species of *Peltigera* on the Azores (APTROOT 1989). From our observations *P. lactucifolia* appears to be much less frequent than either *P. dissecta* or *P. melanorrhiza* and was recorded by us at above 950 m during our survey of Pico in 1992*. It was also recorded by PWJ near the rim of Caldeira do Faial, March 1976 at 920 m.

Additional selected specimens of *P. melanorrhiza* examined:- Pico: Cerrado de Sonicas, ca. 200 m along track leading off road EN 3 to aerial, alt. 900 m, [site 23], 11 April 1992, O.W. Purvis & P.W. James; 9 km E. of Madalena, near Redondo, in *Juniperus* and *Ilex* scrub, 16 June 1978, P.W. James:- Faial: Caldeira, bottom of the Caldeira and slopes to Canto dos Saquinhos, alt. 920-600 m, on slopes, amongst wet, shaded, rocks with *Juniperus brevifolia*, *Ilex* and *Erica azorica* and soil, 10 March 1976, P.W. James; inside the Caldeira, below view-point, alt. ca. 900 m, on base of *Juniperus brevifolia*, 29 June 1986, L. Arvidsson A-229 (hb. L. Arvidsson): São Miguel: Lagoa do Campo, 1 April 1937, H. Persson (UPS) [*P. polydactyla* det. G. Degelius; as *P. pol.* in DEGELIUS 1941]; 4.5 km SW Nordeste, on road-

side bank by EN 1-2a, alt. 550 m, 10 April 1977, P.W. James.

Ramonia azorica P. James & Purvis sp. nov.

Thallus hypophloedes aut in musci, subgelatinosus, cinereo-virens; prothallo nullo. Algae ad *Trentepohliam* pertinens. Apothecia 0.3-0.7 mm lata, dispersa vel partim aggregata, vertice apertura punctiformi demum gylactoidea. Excipulum thallinum fissuris radiatis. Asci 1-spori. Ascospores (100-)120-135(-140) x (27-)35-45 μm , oblongae vel elongatae, muriformes, hyalinae. Sine materia chemica.

Typus: Azores: Faial: Caldeira, alongside track from Canto dos Saquinhos, alt. ca. 800 m, [site 31], 14 April 1992, O.W. Purvis & P.W. James (Terceira) - holotypus (Fig. 7); (BM) - isotypus.

Thallus \pm immersed in bark or encrusting mosses, very thin, membranous to subgelatinous, \pm continuous, pale green-grey, smooth, \pm shiny; prothallus absent. Photobiont *Trentepohlia*, cells 9-12 μm , in short filaments or \pm compacted. Hyphae thin, much branched, penetrating moss leaf cells. Apothecia 0.3-0.7 mm diam., \pm globose, \pm elevated when on bark, gyalectoid, numerous, mostly discrete, rarely 1-3 contiguous, often rather evenly spaced, adnate; disc deeply concave, partly to almost completely occluded and then poriform. True exciple of small, elongate, compacted, rather ill-defined cells, pale straw-coloured, surface very irregular, of necrotic cells intermixed with small crystal clusters (? calcium oxalate). Thalline exciple pure white in upper half, flesh-coloured below, scabrid, indistinctly radiately fissured or pleated; Hymenium 150-180 μm tall, paraphyses thin, ca. 2 μm thick, not swollen at apices, numerous, simple, conglutinated. Epithecium colourless, non-granular. Hypothecium thin, ca. 20 μm tall, \pm opaque, blackish. Asci 1-spored, narrowly cylindrical becoming ellipsoid. Ascospores (100)120-135(-140) x (27-)35-45 μm , oblong-ellipsoid with rounded apices, densely muriform, colourless; perispore absent.

Thallus Pd-, K-, KC-, C- (lichen products absent).

Confined to *Juniperus brevifolia* in cloud forest, mainly on the sides or lower part of \pm horizontal branches, on bark or spreading over mosses.

Characterised by the conspicuous, white, roughened, dot-like apothecia with a small pore surrounded by a fissured thalline exciple, the 1-spored asci and large, muriform spores, a combination of which is unknown amongst other members of this genus. The fungus *Xerotrema megalospora* Sherw. & Coppins has also 1-spored asci and very large, richly muriform spores but grows directly on wood and is non-lichenized (PURVIS et al. 1992).

Additional selected specimens of *Ramonia azorica* examined:- Pico: 6.5 km N of Pico summit, Testadas dos Baldios do Concelho, by roadside, 890 m alt., [site 4], 6 April 1992, O.W. Purvis & P.W. James; Between Lajes do Pico and S. Roque do Pico, ca. 100 m from beginning of road to Lagoa do Caiado, 1 km SE of Cabeço da Cruz, 700 m alt., [site 2], 6 April 1992, O.W. Purvis & P.W. James.

Thelotrema isidioides (Borrer) R. Sant.

Collected within Caldeira at ca. 670 m alt. Thallus whitish brown or yellowish fawn, forming thin, wide-spreading patches. Apothecia 0.2-0.3 mm diam., perithecioid, \pm completely immersed in scattered hemispherical warts or warts becoming confluent and flatter and appearing areolate; disc black, conspicuous. Ascospores 34-45 x 13-18 μm , elongate-ellipsoid, muriform, colourless or brownish. Thallus Pd+ orange, K+ orange, C- (hypostictic, stictic, cryptostictic and constictic acids). On *Juniperus brevifolia* and *Erica azorica* in cloud-zone forest within the Lobarion. This species was only previously known from the type collection from last century on hard, siliceous rocks, S.W. Ireland (W. Cork, Glengariff) (PURVIS et al. 1992).

The name is almost certainly derived from the \pm isidiate appearance of the warts bearing immersed apothecia. However, these are not always so well developed as in the type and the thallus may appear more areolate with slightly raised areoles.

Thelotrema sp.

A distinctive species of this genus was collected at the base of the Caldeira: thallus pale grey-white to

steel grey, occasionally yellowish brown-tinged, very smooth, even, \pm shining, forming wide-spreading patches to 10 cm diam; apothecia black, \pm totally immersed, with a whitish ostiole surrounded by a poorly-developed not or little elevated thalline exciple. True exciple well-developed, carbonaceous; ascospores broadly fusiform with rounded ends, muriform, colourless; stictic acid, hypostictic acid and additional accessories present. Widely distributed on bark, especially of *Erica* and *Juniperus* in cloud forest, also occurring at many localities on Pico. This material bears no resemblance to any European species of the genus or apparently to the tropical species from either Sri Lanka (HALE 1981) or Central America (HALE 1978) and might represent a new taxon. However, a critical examination of this and other relevant material from elsewhere on the Azores and particularly that from N. America will be necessary.

DISCUSSION

The lichen flora of Caldeira do Faial comprises 105 species, 31 being newly recorded for the Azores, and 3 of which are new to science. The rich and varied lichen communities differ with respect to altitude and essentially, three altitudinal zones, an upper, middle and lower, are recognised.

The upper zone (922-800 m), dominated by luxuriant growth of bryophytes, has many lichens which are also frequent in hyperoceanic areas of W. Britain, S.W. Ireland and other parts of W. Europe including W. Brittany. The distinctive alliance, Parmelion laevigatae, was described from these areas, all of which are characterised by high rainfall (129-229 cm year⁻¹) and a tendency for bark to become leached and more acidic with a pH for this community of between 3.75 - 4.60 (JAMES et al. 1977). Several species occurring in this alliance in Britain are also found in Caldeira do Faial, including *Hypotrachyna endochlora* which is best developed in this zone. On the other hand, the newly described *Ramonia azorica* is unknown outside the Azores and appears to be restricted to this very wet and humid zone. Also in this zone, the basidiolichen *Dictyonema interruptum* is abundantly fertile and is a species recorded only elsewhere in Europe from S.W. Ireland.

The mid zone (800-600 m) is characterised by

a more diverse flora where lichens become more conspicuous. The distinctive Lobarion alliance occurring within this zone is generally accepted as being the major climax community of lichen epiphytes on the trunks of mature trees in the forests of the post-glacial in Europe (JAMES et al. 1977, ROSE 1988). The Lobarion includes not only large foliose lichens of the genera *Lobaria*, *Sticta* and *Pseudocyphellaria*, smaller foliose species of such genera as *Nephroma*, *Pannaria*, *Parmelia*, *Parmeliella* and *Peltigera* but also many crustose lichens and a number of bryophytes. The Lobarion is oceanic-montane in distribution and comprises a complex of associations. That occurring within the Caldeira do Faial below 800 m clearly most closely resembles the western Nephromaetum lusitanicae described by BARKMAN (1958), which has as faithful species, *Degelia plumbea*, *Lobaria virens*, *Nephroma laevigatum*, and species of *Pseudocyphellaria* and *Sticta*. All species, with the exception of *Degelia plumbea*, were found in Caldeira do Faial, although fertile material of *Degelia atlantica* is frequent. This oceanic community is also well-represented in W. Scotland, W. and S. England, W. Wales, S.W. Ireland, S.W. Norway, W. and N.W. France and the Western Pyrénées (JAMES et al. 1977, ROSE 1988). Although there are several macrolichens within the Caldeira which also occur in W. Europe within the Lobarion, it is interesting to note that only one crustose species listed (ROSE 1988), *Megalospora tuberculosa* (fertile), is common to the Lobarion in both W. Scotland and Caldeira do Faial. However, additional species are present in the Caldeira, e.g. *Nephroma hensseniae*, *Peltigera dissecta* and *P. melanorrhiza* which are important endemic components of the Lobarion in the Azores. Furthermore, the local *Erioderma leylandii* (Taylor) Müll. Arg. and the more frequent *E. mollissimum* (Sampaio) Du Rietz, unknown in Caldeira, but which occur in cloud forest vegetation on Pico, are also important components of this alliance in the Azores.

The specialised communities occurring on the smooth-barked *Ilex perado* and *Vaccinium cylindraceum* include species which are extremely local in Europe, e.g. *Parmentaria chilensis* and *Pyrenula dermatodes*, both of which occur locally abundantly in S.W. Ireland and rarely in N.W. Scotland. The absence of *Leptogium hibernicum*

Mitchell ex P.M Jørg. and *L. juressianum* C. Tav. in the Caldeira is noteworthy, as these are occasionally dominant in comparable conditions with similar associated species in S.W. Ireland.

The base of the Caldeira, which appears to experience less misting and is more exposed to drought and strong sunlight, in contrast, has significantly fewer lichens, and probably represents a species-poor Lobarion. The lack of diversity of phorophytes is a contributory factor though more detailed phytosociological studies are required to investigate this aspect more fully.

A notable feature of the Caldeira is the scarcity of lichens growing on rocks, *Baeomyces rufus*, *Herteliana taylorii*, *Leptogium cyanescens*, *Rhizocarpon hochstetteri* and species of *Trapelia* being most frequent. In W. Scotland, e.g. on the island of Mull, a similarly poor saxicolous lichen flora on basalt was noted (BANGERTER et al. 1978). As lichens usually need environments subject to greater fluctuations in humidity and light than is usual for many mosses and algae, in the more sheltered, damp habitats, lichens tend to come into direct competition with blue-green algae and mosses, which often overgrow or make initial colonisation difficult by the crustose and smaller foliose species.

Since the species abundance and composition of the lichen communities were observed to differ markedly according to altitude, it appears likely that the distribution of species is related to precipitation and the persistence of mist. Evidence in support is found in bryophytes: SJÖGREN (1978) considers annual rainfall largely responsible for the zonation of plant communities as well as individual species in the Azores. Thus he distinguishes three bryophyte communities occurring within the Juniperion viz. the epiphyllous *Cololejeuneetum azoricae* as growing optimally at altitudes between 600-900 m, rarely occurring where rainfall is less than 2000 mm, but only occurring frequently at more than 2400 (2500) mm or else in sheltered situations where air humidity is almost continuously very high (> 80 %). He also observes that a direct additional water supply to phorophyte surfaces, such as spray from waterfalls, will not compensate for a lack of shelter or low annual rainfall (< 2000 mm). A second bryophyte community, the *Lepidozietum azoricae* is an epiphytic association and the third, the epiphytic

Echinodio-Lepidozietum cupressinae (mainly on rotting stems and branches of trees and shrubs) were identified as occurring at an altitudinal range from 500-900 m. It is interesting to note that the three bryophyte communities he describes occur on different substrates within a broadly similar altitudinal range. The lichen communities in the Caldeira do Faial, in contrast, appear to be more sensitive to a climatic gradient, involving humidity, temperature and illumination, but a more detailed survey will be necessary to confirm this. This observation is not unexpected in view of the very different physiologies exhibited by bryophytes and lichens.

SJÖGREN (1978) points out that there are considerable differences in substrate preferences of certain bryophytes in the Azores as compared for example with W. Europe. Thus a number of species are epilithic in Skye, Shetland and the Faeroes, whereas the same species are mostly epiphytic in the Azores. An analogous situation in lichens is that of *Thelotrema isidioides* which is saxicolous in S.W. Ireland but is epiphytic in the Azores. These observed differences in substrate preferences may relate to variations in humidity, but also to substrate availability, nature of surface and competition. Alternatively, lichens growing under particularly favourable conditions seem to be less substrate-selective and those at the extremes of their range may be highly restricted to a particular substrate, e.g. as in the case of several species of *Pannaria* (JØRGENSEN 1978).

Macaronesia was regarded as a separate, biogeographical region more than a century ago. However, this concept has recently been criticized due to the floristic heterogeneity of the region (NICOLAS et al. 1989). The more traditional approach emphasises the historical spatial or temporal discontinuity to explain the actual pattern of the vegetation. However, the Azores are of relatively young volcanic activity (< 8 million years old) and the African, European and American continents were already separated by the time these islands were formed. Problems associated with long-distance dispersal may be less than is generally assumed in other areas owing to the influence of the trade winds which might act as an agency for the transport of spores and propagules. The Azores is not on a major bird-migratory route (Professor C.W. Smith, pers. comm.) which can

be significant agents of long distance dispersal (BAILEY & JAMES 1979). The majority of the lichens recorded in Caldeira do Faial, apart from those newly described, also occur in W. Europe, though others are pan-tropical or cosmopolitan (*Coccocarpia palmicola*, *Hypotrachyna microblasta*, *H. rockii*, *Rimelia subsidiosa*). A fuller analysis of the biogeographical affinities of the Azorean lichen flora will be presented in a future paper.

Further work is required to assess fully the lichenological interest of the natural vegetation. However, it is already apparent, particularly from unpublished observations of the authors on Pico, that several lichens are undoubtedly restricted to the natural cloud zone vegetation. JAMES & WHITE (1987) report that the Azorean endemic, *Nephroma hensseniae*, apart from a single record from Terceira, was confined to the middle slopes of Pico between 500 and 900 m, occurring with *Erioderma soledatum* D. J. Galloway & P.M. Jørg. *Leptogium brebissonii*, *L. burgessii* and *Sticta canariensis*. In the present study this species was also found for the first time in a similar habitat on Faial. The other endemic species of the *Nephroma* genus, *N. venosum*, by contrast, was recorded from the islands of Faial, Pico, São Jorge and São Miguel, occurring both in relict forest, and also on *Platanus*, *Populus*, twigs of *Escallonia* and church walls between 270 and 1000 m. JAMES & WHITE (1987) suggested that *N. hensseniae*, in common with several other species from native scrub, was more widespread throughout the Azores in the last century, but unlike *N. venosum* they seem unable to colonise cleared relict forest areas and are therefore endangered species as the relict forest is destroyed. The sensitivity of this climax community to habitat destruction has been well documented in Europe where the *Lobarion* was formerly widespread throughout much of lowland north and north-west Europe on the bark of most broad-leaved species. It has declined significantly in many regions owing to pronounced changes in forest management and deforestation and the additional effect of atmospheric air pollution, including both sulphur dioxide and acid rain (HAWKSWORTH et al. 1973, JAMES et al. 1977, ROSE 1988).

The Caldeira do Faial has a rich and varied lichen flora which must be regarded as an important

remnant which was formerly more widespread prior to wide-scale deforestation. Further phytosociological studies are needed to define the communities more precisely and studies of other areas of both relict and secondary scrub on both Faial and other areas will enable the importance of this site to be more fully assessed.

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