

NATURAL AND SEMI-NATURAL BRYOPHYTE FLORA OF THE COASTAL DRY ZONES OF MADEIRA ISLAND

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With 1 table and 34 figures

ABSTRACT. This study provides information about the bryoflora of the coastal and exposed areas of Madeira Island. The dry zone habitats occupied by less known bryophytes occurring in Madeira were also examined. A total of eleven sites were selected and 128 bryophytes (46 hepatics and 82 mosses) were identified and studied.

For each taxon the phytogeographical affinities and the threat status are presented.

Distribution maps of the most characteristic species are given based on the recent studies and herbarium specimens. Species diversity within each locality is presented and the importance of distinct localities is examined. Some measures to ensure protection are outlined.

RESUMO. Neste trabalho são apresentados dados da diversidade da brioflora das zonas costeiras e expostas da Ilha da Madeira. Foram seleccionados onze locais tendo sido identificados 128 taxa (46 hepáticas e 82 musgos). Para cada taxon são referidas as afinidades fitogeográficas e informações sobre o estado de conservação. São apresentados mapas de distribuição de briófitos menos conhecidos na Madeira. É relacionada a riqueza específica para cada localidade com a respectiva área assim como é defenida a importância de cada localidade no que respeita à brioflora, propondo-se medidas de protecção para os habitats dos locais estudados.

INTRODUCTION

Bryophytes exist all over Madeira Island. Their percentage of covering is very high and represents an important role in the establishment and dynamics of different island ecosystems. Comparing to the natural forest-Laurisilva, bryophytes from coastal and dry zones are less abundant, either in number or species diversity.

The knowledge of the actual status of the bryophytes from coastal dry areas (e. g.

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from the extreme E. and SE. to the W. and SW. parts) of Madeira is still not known enough. In addition, factors like tourism pressure, industry development, buildings and dynamic of natural vegetation, enhance the possibilities of endangerment of the coastal bryoflora.

The only way to save, at least something of this interesting bryoflora related with mediterranean or tropical flora, is to know their ecological requirements. Afterwards, in order to prevent its decline and disappearance from Madeira it would be urgent to establish natural conservation areas.

From field research in coastal parts of Madeira it was evident that bryophytes were absent from some potential sites. It was not due to the lack of open land and natural conditions, but to the influence of man for agricultural purposes or urbanisation. In fact, the bryophytes of exposed sites are almost exclusively confined to habitats which have always been strongly influenced by man.

On the other hand some areas with ravines are inaccessible, being impossible to survey. However, these areas seem to be the best relict sites of natural coastal vegetation, either bryophytes or vascular plants.

This study is to provide information concerning the bryophyte species occurring in coastal and exposed areas of Madeira, with a phytogeographical approach, in order to explain the origin of the peculiar bryoflora of this island. It also examines distribution patterns of less known bryophytes occurring in Madeira.

THE STUDY AREAS AND VEGETATION

The Madeira Archipelago is of volcanic origin and dates from the Tertiary. Madeira is the youngest island, also with a Miocene reefintercalation (CARVALHO & BRANDÃO, 1991). The more eastern part consists of not only basaltic rocks, but also fossiliferous calcareous sediments.

The climate of the study areas is under maritime influence and is characterized by relatively mild, wet winters and dry warm summers. The annual precipitation in Funchal is 638 mm, in Santa Catarina is 740 mm and in São Lourenço (east) is less than 500 mm (RIBEIRO, 1985). In the western part, the precipitation range is 750-1000 mm. In Madeira Island the climatic alterations have been gradual since the Tertiary (HUMPHRIES, 1979).

Natural vegetation of the coastal parts of Madeira are generally characterized by reduced shrub and tree cover corresponding to a "Savane littorale" mentioned by DANSEREAU (1966). SJÖGREN (1972) has included in an alliance *Aeonio-Lythantion* with three provisional associations *Hyparrhenietum hirtae*, *Euphorbietum piscatoriae* and *Biserrulae-Scorpiurietum*.

Paúl do Mar, Campanário (Vereda do Calhau), Ponta do Pargo areas, all the valley of Ribeira do Tristão and Ribeira do Calvário, are representative sites of an indigenous

xerophytic vegetation in some places mixed with Laurisilva species. At the SE. part as Pináculo, Garajau, Pico do Facho and the peculiar cape of Ponta de São Lourenço, an interesting natural and semi-natural vegetation still exists, with high tolerance to the extreme xerophytic conditions (HAMPSHIRE, 1984).

On the other hand, due to extensive grazing by sheep, the association *Hyparrhenietum hirtae* is now abundant with other introduced herbs, such as *Oxalis pes-caprae* L., an aggressive plant particularly luxuriant in Ponta do Pargo and Fajã da Ovelha.

It is difficult to define the limits of the natural vascular vegetation in the coastal part of Madeira due to the introduction of a large number of cultivated and exotic species, which became spontaneous and compete with the original vegetation.

Madeira is rich in paleoendemics (TAVARES, 1965) and some bryophytes are apparently extraneous elements in Macaronesia, having their main ranges in either mediterranean, or temperate regions of Europe, Africa or North America (SÉRGIO, 1984).

Bryophyte flora of exposed habitats with steep sloping cliffs was included in *Eucladio-Adiantetum*, refereed by HÜBSCHMANN (1971). It is a strongly hygrophilous community dependent of a continuous water supply. This association is not confined only to coastal areas, being more frequent in the northern part of the Island. Nevertheless we have recognised some small niches in the south coast (e.g. Ribeira das Galinhas and valley between Prazeres and Paúl do Mar).

Cliffs and rocks or volcanic deposits on shaded sites seem to be also rich in bryophyte species, so often mixed with pteridophytes such as: *Adiantum capillus-veneris* L., *A. reniforme* L., *Davallia canariensis* (L.) J. E. SM., *Polypodium macaronesticum* BOBROV. and *Ceterach aureum* (COV.) BUCH.

The epiphytic flora is mainly composed by lichens due to the absence of the tree layer, and the shrub natural vegetation (*Euphorbietum piscatoriae*) occurs in restricted small areas.

THE STUDIED SITES

Samplings were taken from different areas of the Madeira Island, during 1991-1992.

The selected areas (Fig. 2) were chosen using the following criteria:

- Geographically well-delimited sites;

- Localities with natural or semi-natural vegetation (arable fields were not used,

excluding rocks and walls nearby);

- Sites to 400 m a.s.l., particularly of south exposure (Fig. 1);

- Only terricolous and saxicolous habitats were studied.

The selected sites, with the altitudinal range and the UTM square (28S, 1 Km²),

were the following:

- 1- Caniçal, Ponta de São Lourenço, 50-100 m: CB3723, CB3823, CB3824, CB3923, CB3924, CB4023, CB4024, CB4123, CB4124, CB4223, CB4224, CB4322.
- 2 - Machico, Pico do Facho, 300 m: CB3521.
- 3 - Santa Cruz, 100-300 m: CB2915, CB3117, CB3118, CB3217.
- 4 - Caniço, 100-300 m: CB2612, CB2613, CB2712, CB2713.
- 5 - São Gonçalo, 300 m: CB2413.
- 6 - Campanário, 20-400 m: CB0815, CB0915, CB1015, CB1016.
- 7 - Miradouro da Ribeira Brava, 80-150 m: CB0616.
- 8 - Madalena do Mar, 50-400 m: BB9920, CB0019, CB0020, CB0021.
- 9 - Paul do Mar, Ribeira das Galinhas, ±400 m: BB9127; Vereda entre os Prazeres e o Paúl do Mar, 50 a ±400 m: BB9225, BB9226.
- 10 - Ponta do Pargo, pr. do Farol, 300 m: BB8832.
- 11 - Achadas da Cruz, confluência entre a Ribeira do Calvário e a Ribeira do Tristão, 50-300 m: BB9336, BB9337, BB9437.

Collections of all mosses and hepatics species were made at each site in different periods, especially in winter and spring. Vascular species were also recorded.

HERBARIUM MATERIAL

As a complement, we have also studied old records that could correspond to the bryophytes of exposed coastal flora. All herbarium specimens were studied using new taxonomic criteria. New interesting species, some of them not present in our survey, were also considered. (Annex 1).

The herbarium specimens studied are located at MADS, MADJ, LISU, PC and S. [MADS (Herbário do Museu de História Natural do Seminário), MADJ (Herbário do Jardim Botânico da Madeira), LISU (Herbário do Museu, Laboratório e Jardim Botânico, Lisboa), PC (Herbier du Laboratoire de Cryptogamie du Muséum National d'Histoire Naturelle, Paris) and S (Swedish Museum of Natural History, Stockholm)].

RESULTS AND DISCUSSION

The total number of bryophytes taxa is 128, 46 hepatics and 82 mosses. This corresponds more or less to 30% of all Madeira bryoflora.

Nomenclature largely follows CORLEY et al. (1981, 1991), HEDENÅS (1992) and GROLE (1983). Phytogeographical affinities are according to DÜLL (1983, 1984 and 1985) definitions, with some adaptations.

The total number of species of each locality is given in Table 1. This list includes for each taxon, the phytogeographical affinities, the threat status and a symbol for the new elements to the island and/or Macaronesia (after EGGERS, 1982). Species richness varies between 63 (São Lourenço area, locality 1) and 6 (Miradouro da Ribeira Brava, locality 7) (Fig. 3).

The large number of bryophytes in the locality 1 (São Lourenço Cape), is partly due to the more intensive studies, to its greater area (12 square with 1 km²) and to the existence of more habitats.

The relationships between species richness in each locality with the area (square with 1 km²) are shown in figure 3. Based on these data the importance of each locality, for bryophyte flora, can be defined.

The total data of phytogeographic tendency of the bryoflora indicate (Fig. 4):

- The number of endemic elements of macaronesia is higher in the locality 11 and locality 1, which apparently are the less disturbed by man.

- Due to the extremely dry conditions, especially in the eastern part of the island, the mediterranean and the oceanic-mediterranean elements are the most representative in all localities, decreasing in the two western areas .

- The richness of temperate elements is more evident in the localities 7 and 4, areas more influenced by man.

- In general, the Atlantic influence is shown by the presence of 35 to 68% of species with oceanic tendency in the different localities.

- Only one moss has a boreal preference, *Tortella* aff. *tortuosa* (not included in figures).

The graphic, Fig. 5, illustrates the phytogeographical position of each taxonomic group (hepatics and mosses):

- For hepatics, there is a highly significant value of oceanic elements, while for the mosses the temperate species are the most abundant.

- Comparing this results with the total flora, attributed by KOPPE & DÜLL (1986) for Madeira Island, there is a different pattern. This author indicates about 53% and 31% of oceanic elements for hepatics and mosses respectively; 21% and 23% for oceanic-mediterranean; 6% and 18% for mediterranean; 10% and 17% for temperate elements.

- Comparing these values with figure 5, there are: important increasing of mediterranean species in the dry areas of Madeira with $\pm 26\%$ of hepatics to $\pm 24\%$ of mosses; some increasing of oceanic-mediterranean elements compared to a strong decrease of the oceanic bryophytes ($\pm 23\%$ of hepatics and only $\pm 5\%$ of mosses).

The bryophyte taxonomic pattern of dry areas of Madeira, are given in terms of

percentage of species (Fig. 6, A and B):

- They indicate that the *Pleurocarpous* mosses (*Isobryales*, *Hypnobryales*) are less abundant, and the *Pottiales* are the most numerous ($\pm 42\%$). Considering the total bryoflora of Madeira Island this order comprises only 17% of species. However, the *Hookeriales* are not present. The *Bryales* and *Funariales* are well represented and have been considered the most primitive *Bryidae* (VITT 1984).

- On the other hand the *Marchantiales*, have the largest number of species ($\pm 42\%$) however they represent only $\pm 18\%$ of the total hepatic flora of Madeira Island (DÜLL, 1984).

THREAT STATUS

In this study the 128 species were classified according to the threatened categories. The degree of threat was based on the same criteria used by SÉRGIO et al. (1992) for Madeira Island. (Table 1) (Fig. 7 A and B):

- More than 70 species (50% of taxa) are out of danger; 9 are rare; 18 vulnerable and 20 endangered.

- The localities that includes the largest number of endangered species are the locality 1, 5 and 8.

- The species with mediterranean affinities are the most threatened.

- Almost all *Riccia* species are threatened. From a total of 13 species only 1 is out of danger.

DISTRIBUTION MAPS

The distribution maps (Fig. 8 to 33) are based on the recent studies and herbarium specimens, located in different collections. The map scheme presents a grid of 1 km² as used in SÉRGIO et al. (1992). The selection criteria are based in the most characteristic, or frequent species for dry exposed areas. To the establishment of altitudinal gradient and the "Laurion Macaronesian forest" limits, other species with affinities or restricted to the Laurisilva, have been chosen.

PROTECTION MEASURES

Bryophytes, as other lower plants, have often restricted ecological niches and may therefore be very vulnerable to environmental change. It has been shown that some species are extremely sensitive to small microsite differences (SLACK, 1990 and 1992), so they can often be good indicators of a particular type of management.

It is also unfortunate that this group of plants is frequently ignored in conservation programmes. Because of their small size and a lack of common names also contributes to

their neglect, furthermore, non-specialists have difficulty with the identification of taxa. There is an urgent need to provide information about the ecology of the Macaronesian ecosystem in order to develop a sustainable conservation programme. Actually, the easiest and suggest way for the conservation of ephemeral bryophytes and so many with shuttle life strategy, the most frequent in these dry areas, is to protect the localities within the natural habitats. Herewith we propose some measures:

- As the bryophytes from exposed areas have very specialised niches it is necessary to maintain the diversity of the mosaic of vascular plants.

- To favour open ground, and not an intensive agriculture, in order to enhance the development of pioneer bryophyte species, that colonise more rapidly than vascular plants.

- To preserve the typical volcanic rock walls, which support the cultivated fields. Artificial cement walls should be avoided.

- Permanent open systems with water supply are necessary for some species typical of Laurisilva and also a large number of aquatic pioneer and perennial bryophytes.

- Modern agriculture practices, with the increasing use of herbicides and fertilisers, should be avoided because some species are sometimes preferentially restricted to artificial habitats, like *Anthoceros*, *Phaeoceros* and *Pottia* species.

- Some controlled fires must be continued. Bare soils around out-crops also provide an important subtract for bryophytes. The threats to this habitat include the colonisation by too many shrubs and grasses than can shade and modify important situations.

- Some species with nitrophilous tendency are aggressive, such as *Bryum argenteum* HEDW. and *Bryum dunense* A.J. E. SM. & WHITEH. So, all the areas with natural or semi-natural habitats must be preserved of the rubbish and detritus accumulation.

In conclusion, the habitat destruction is the major threat to bryophytes of dry areas in Madeira. The best way to protect the bryophytes flora of these habitats is to provide possibilities or their survival in a landscape where man is also an active component (SÖDERSTRÖM et al. 1992).

Exposed and dry areas in Madeira Island with their rare bryophytes species are fragile environments, easily disturbed. Often they are or may be completely eliminated by uncontrolled human development.

CONCLUSIONS

We can check in the list (Table 1) 23 bryophytes are new elements to the island and/ or Macaronesia (after EGGERS, 1982), including 7 new elements for Macaronesia, and 1 new species for science, *Riccia atlantica* SÉRGIO & PEROLD. However, some of these new bryophytes have been recently published by some authors (SÉRGIO, 1985, SÉRGIO &

NÓBREGA, 1985, BRUGGEMAN-NANNENGA, 1985, SÉRGIO & PEROLD, 1992 and HEDENÄS, 1992).

The discovery of greatest part of new or rare bryophytes in Madeira Island reported as a result of our recent surveys, but various examples can be neophytes. For instance, *Bryum dunense* A. J. E. SM. & WHITEH. is a frequent species nowadays, but was not found in any of the old collections.

Nevertheless, more localities must be investigated such as Cabo Girão, in the vicinity of Funchal. A survey comparison with old records from Funchal area, is obviously impossible, at the moment.

Undoubtedly, subsequent investigations will lead to new interesting discoveries such as *Oedipodiella australis* (WAGER. & DIX.) DIX. which is very rare in Europe and more disseminated in South Africa and can corresponds to an old element that have persisted in Macaronesia or a neophyte.

The importance of herbarium studies can be emphasised by the revision of many previous collections that give new elements to Madeira and do not presently occur in the region. This is the case of *Tortella inflexa* (BRUCH.) BROTH. Other such as *Brachymerium philonotula* BROTH. apparently related with *Bryum dunense* A. J. E. SM. & WHITEH., also with gemmae but with the typical erect capsule, was not found by us.

The causes of rarity and threats of several bryophytes in dry habitats in Madeira can be explained in many ways, but some species are rare because they represent the limit of the range of other phylogeographical areas.

We can summarize the important bryophytes included in the studied area:

- Endemic species of Macaronesia: *Heteroscyphus denticulatus* (MITT.) SCHIFFN.; *Riccia atantica* SÉRGIO & PEROLD; *Andoa berthelotiana* (MONT.) OCHYRA; *Brachymerium notarisii* (MITT.) SCHAW; *Fissidens coacervatus* BRUGG.-NANN.; *Leucodon treleasei* (CARD.) PAR. and *Rhyncostegiella macilenta* (REN. & CARD.) CARD.

- Oceanic or oceanic-mediterranean species threatened or rare in Europe:

Asterella africana (MONT.) Evans; *Exormotheca pustulosa* STEPH.; *Frullania caesatiana* DE NOT. var. *musciicola* (STEPH.) BISANG et al.; *Riccia trabutiana* STEPH.; *Fissidens algarvicus* SOLMS.; *Rhamphidium purpuratum* MITT.; *Tortula solmsii* (SCHIMP.) LIMPR. and *Weissia triumphans* (DE NOT.) M. HILL.

- Mediterranean species threatened or rare in Europe: *Mannia androgyna* (L. emend. LINDB.) EVANS; *Acaulon triquetrum* (SPRUCE) C. MUELL. and *Tortula revolvens* (SCHIMP.) G. ROTH.

- Rare species with their main range distribution in other continents as *Frullania ericoides* (NEES) MONT.; *Lejeunea eckloniana* LINDB and *Oedipodiella australis* (WAGER. & DIX.) DIX.

- Species that can represent new elements (neophyte) on Madeira Island as: *Bryum*

dunense A. J. E. SM. & WHITEH. or *Oedipodiella australis*.

- New species, apparently rare on Madeira Island but indicated to Porto Santo as: *Didymodon luridus* HORNSCH.; *Didymodon rigidulus* HEDW and *Tortula atrovirens* (SM.) LINDB.

- Declining species in Madeira Island: *Brachymenium notaristii* (MITT.) Schaw and *Fissidens coacervatus* BRUGG.-NANN.

- Species not found in this survey, but present in these areas or in the same habitats in the past (list of herbarium specimens in annex 1): *Brachymenium philonotula* BROTH.;

Leptobarbula berica (DE NOT.) SCHIMP. and *Tortella inflexa* (BRUCH) BROTH.

- Species to exclude from Madeira Island (list of herbarium specimens in annex 1): *Cheilothela chloropus* (BRID.) LINDB.; *Crossidium crassinerve* (DE NOT.) JUR.; *Crossidium squamiferum* (VIV.) JUR. and *Pterigoneurum ovatum* (HEDW.) DIX. = *P. cavifolium* (EHRH.) JUR.

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ANNEX 1

Others studied specimens:

1- Species not found in this survey, but present in these areas or in the same habitats, in the past (list of herbarium specimens):

Brachymenium philonotula BROTH.: Madeira, Funchal, caminho do Conde Carvalhal, 11.01.1909, *Armitage*, s. n. (PC HERB. CARDOT); Rocha da Pena, 01.1928, *Barreto* (MADS 289); Porto Moniz, Lamaceiros, 01.1945, *Costa* (MADS 290).

Leptobarbula berica (DE NOT.) SCHIMP.: Funchal, Seminário, s.data. *Johnson* (MADS 4082); Funchal, Seminário da Encarnação, 12.05.1937, *Barreto* (MADS 1742); *ibidem*, 21.04.1940, (MADS 1743); Funchal, Travessa do Vale Formoso, 14.05.1943, *Barreto* (MADS 1744); Porto Moniz, 28.05.1945, *Costa* (MADS 1745).

Tortella inflexa (BRUCH) BROTH.: Funchal, Seminário de Fátima 25.05.1960, *Barreto* (MADS 1526), as *Gymnostomum calcareum*. New species to Madeira.

2- Species referred to Madeira Island in the past, characteristics of this habitats, but misidentified. To exclude of the Madeira bryoflora:

Cheilothela chloropus (Brid.) Lindb.: Ribeira do Porto Novo, 3.08.1950, *Luisier* (MADS 731), is *Philonotis rigida* Brid.

Crossidium crassinerve (De Not.) Jur.: s. loc., 19.07.1943, *Barreto* (MADS 794), is *Aloina rigida* (Hedw.) Limpr.

Crossidium squamiferum (VIV.) JUR.: Faial, no Porto, 17.08.1935, *Luisier* (MADS 795), is *Tortula* aff. *solmsii*; Ponta Delgada, Quebradas, 1.04.1936, s.leg. (MADS 796), is *Tortula* aff. *solmsii*.

Pterigoneurum ovatum (HEDW.) DIX. (= *Pterigoneurum cavifolium* (EHRH.) JUR.): Curral das Freiras, Colmeal, 01.1943, *Nóbrega* (MADS 2173); Fundoa de Cima, 28.04.1955, *Barreto* (MADS 2174), is *Tortula solmsii* (SCHIMP.) LIMPR.

ANNEX 2

Table 1

Nomenclature following mostly CORLEY et al. (1981, 1991) for mosses and GROLLE (1983) for hepatics, and sometimes EGGERS (1982). *- New taxa to Madeira Island; **- New taxa to Macaronesia and ***- New taxa to science. T (taxa of critical taxonomical value). Status in Madeira; E (Endangered) in danger of extinction: survival unlikely if causal factors continue operating. Includes taxa whose population numbers have been reduced to a

critical level or whose habitats or localities have been drastically reduced. Species known from 2 or less localities in the island; **V** (Vulnerable) expected to move into category E in the near future if the causal factors continue operating, 30 to 50% of the localities or known populations have disappeared. Species known from 3 to 5 localities (with small populations) in the island; **R** (Rare) taxa localized within restricted geographical areas or habitats, often with small populations, not at present E or V, but at risk. Species known from 6 to 10 localities (with small populations) in the island. **O** (Out of danger), species known from more than 10 localities (or with large populations) in the island. **K** (Insufficiently known) taxa that are suspected to belong to E, V or R category, but not confirmed, due to lack of information: **Bor**-Boreal; **Oc**-Oceanic (including the euoc, oc, oc-bip,-subtrop, oc-trop, oc-mont, s.oc, n.oc and w.oc); **Oc-med**-Oceanic-mediterranean (including the suboc-med, suboc-submed, oc-submed, -mont); **Med**-Mediterranean (including the med-oc, submed-suboc, c.med, w.submed, w.med); **Temp**-Temperate (including the s.temp, n.temp, wtemp and temp-mont); **Mac**-Macaronesian endemic; **Mad**-Madeira endemic.

TABLE 1

Localities

Status Geogr. 1 2 3 4 5 6 7 8 9 10 11

HEPATICES																					
	<i>Acanthocoleus aberrans</i> (Lindenb. et Gott.) Kujit	O	euoc																	x	
**	<i>Anthoceros agrestis</i> Paton	E	temp																	x	
	<i>Anthoceros punctatus</i> L.	V	oc-med	x																	
	<i>Asterella africana</i> (Mont.) Evans	O	euoc			x															
	<i>Corsinia coriandrina</i> (Spreng.) Lindb.	O	oc-med	x	x	x		x							x	x				x	
	<i>Exormotheca pustulosa</i> Steph.	O	oc-med	x	x	x	x	x	x	x	x	x	x	x							x
	<i>Fossombronia angulosa</i> (Dicks.) Radd	O	med	x		x															
	<i>Fossombronia caespitiformis</i> De Not. ex Rabenh.	O	oc-med	x			x		x	x					x	x				x	
	<i>Fossombronia husnotii</i> Corb.	O	oc-med	x	x				x												
	<i>Fossombronia pusilla</i> (L.) Nees	V	oc-med				x														
**	<i>Frullania caesatiana</i> De Not. var. <i>musciicola</i>	O	euoc																	x	
	<i>Frullania dilatata</i> (L.) Dum.	O	temp	x			x													x	
	<i>Frullania ericoides</i> (Nees) Mont.	O	euoc	x											x					x	
	<i>Frullania tamarisci</i> (L.) Dum.	O	euoc	x																	
	<i>Frullania tamarisci</i> var. <i>nervosa</i> Mont.	O	euoc			x	x														
	<i>Gongylanthus ericetorum</i> (Raddi) Nees	O	oc-med	x																	
	<i>Heteroscyphus denticulatus</i> (Mitt.) Schiffn.	O	mac																		
	<i>Jubula hutchinsiae</i> (Hook.) Dum.	O	euoc																		
	<i>Jungermannia hyalina</i> Lyell	O	temp																	x	
	<i>Lejeunea eckloniana</i> Lindenb.	O	euoc																	x	
	<i>Lejeunea hibernica</i> Bischl. et al. ex Grolle	R	euoc																		
	<i>Lunularia cruciata</i> (L.) Dum. ex Lindb.	O	oc-med	x	x																
	<i>Mannia androgyna</i> (L.) emend. Lindb. Evans	O	med		x										x	x					
	<i>Marchesinia mackaii</i> (Hook.) S. Gray	O	oc-med																		
	<i>Phaeoceros bulbiculosus</i> (Brotero) Prosk.	O	med																		
	<i>Phaeoceros laevis</i> (L.) Prosk.	R	oc-med	x		x															
	<i>Plagiochasma rupestre</i> (Forst.) Steph.	O	med			x	x	x							x	x					
	<i>Porella arboris-vitae</i> (With.) Grolle	O	med			x															
	<i>Porella obtusata</i> (Tayl.) Trev.	O	med																		
	<i>Radula lindenbergiana</i> Gott. ex C. Hartm.	O	euoc			x	x													x	
**	<i>Riccardia incurvata</i> Lindb.	E	euoc																	x	
***	<i>Riccia atlantica</i> Sérgio & Perold	V	mad	x																	
*	<i>Riccia atromarginata</i> Levier var. <i>glabra</i>	E	med	x																	
*	<i>Riccia cavernosa</i> Hoffm.	E	temp					x	x												
	<i>Riccia ciliata</i> Hoffm.	R	med																	x	
	<i>Riccia crozalsii</i> Levier	R	oc-med		x	x														x	
*	<i>Riccia gougetiana</i> Durieu & Mont.	E	med	x																	
	<i>Riccia lamellosa</i> Raddi	V	med	x		x															
	<i>Riccia nigrella</i> DC.	R	oc-med	x	x	x	x	x							x	x					
	<i>Riccia sorocarpa</i> Bisch.	O	temp	x				x		x	x	x	x								

TABLE 1 (Cont.)

Localities

Status Geogr. 1 2 3 4 5 6 7 8 9 10 11

	<i>Tortella nitida</i> (Lindb.) Broth.	O	oc-med	x					x		x	x		
T	<i>Tortula</i> aff. <i>solmsii</i>	K	euoc	x										
*	<i>Tortula atrovirens</i> (Sm.) Lindb.	E	med	x										
*	<i>Tortula laevipila</i> (Brid.) Schwaegr.	E	oc-med								x			
	<i>Tortula muralis</i> Hedw. var. <i>muralis</i>	O	temp	x	x									
*	<i>Tortula revolvens</i> (Schimp.) G. Roth.	E	med	x										
	<i>Tortula solmsii</i> (Schimp.) Limpr.	O	oc-med	x								x		
	<i>Trichostomum brachydontium</i> Bruch	O	med				x					x	x	
	<i>Trichostomum crispulum</i> Bruch	O	temp	x		x			x			x	x	x
	<i>Weissia controversa</i> Hedw.	O	temp	x			x						x	
*	<i>Weissia longifolia</i> Mitt.	E	temp	x										
*	<i>Weissia triumphans</i> (De Not.) M. Hill.	E	oc-med	x								x	x	

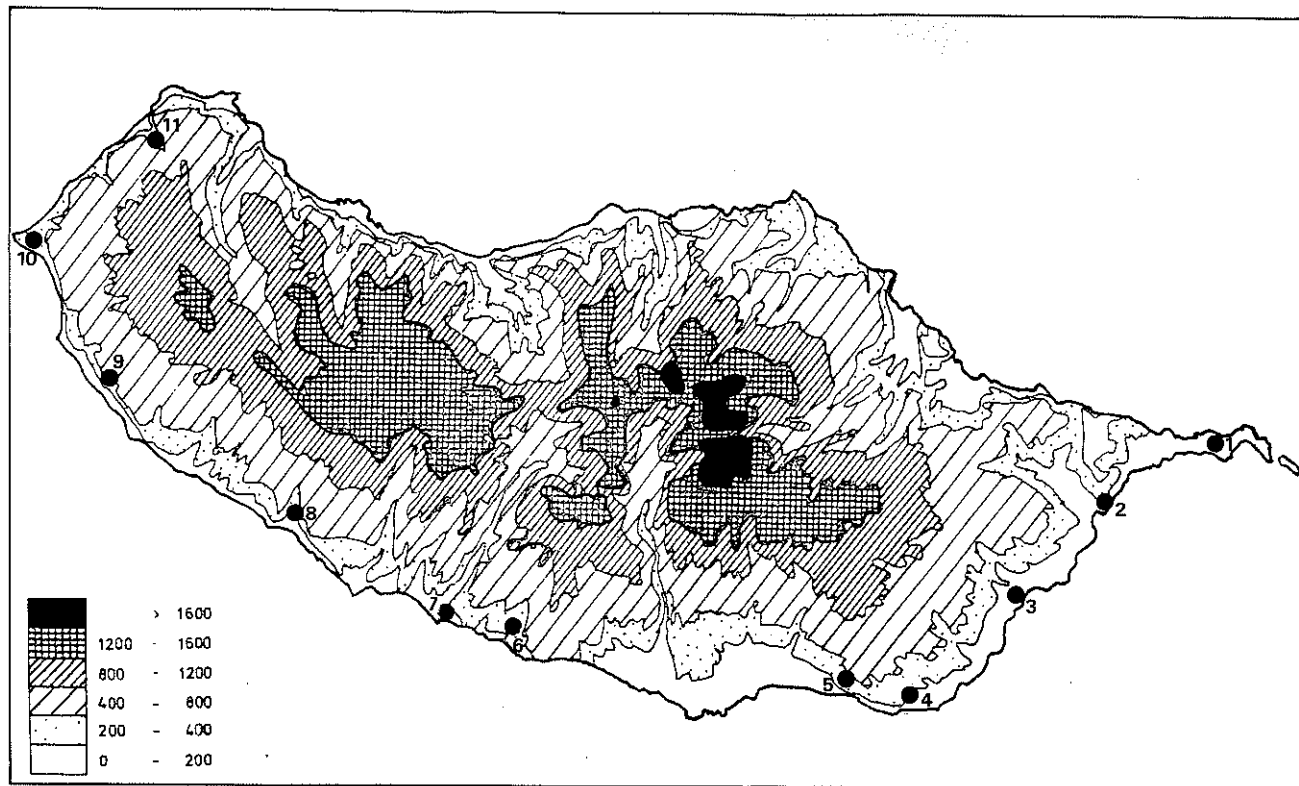


Fig. 1- Madeira Map showing the altitudinal levels (from Centro de Estudos Geográficos, 1984, Lisboa) and the study areas (Loc. 1 to Loc. 11).

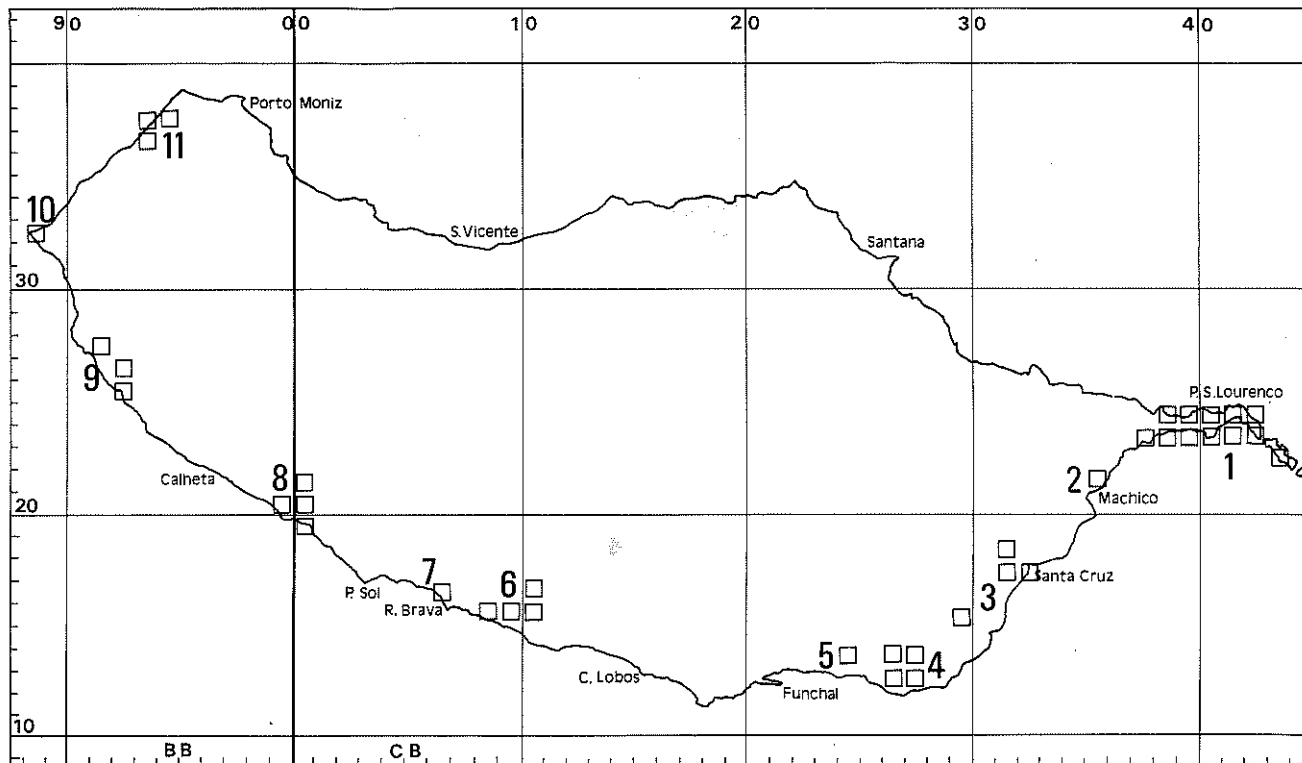


Fig. 2- Study areas (Loc. 1 to Loc. 11) according to 1 x 1 km UTM grid on Madeira.

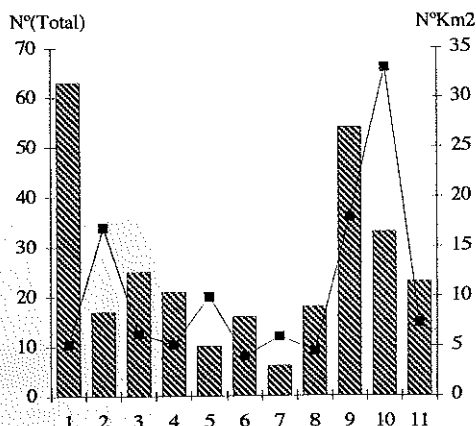


Fig. 3-The relationships between species richness (total number) in each locality with the area (square of 1 km²).

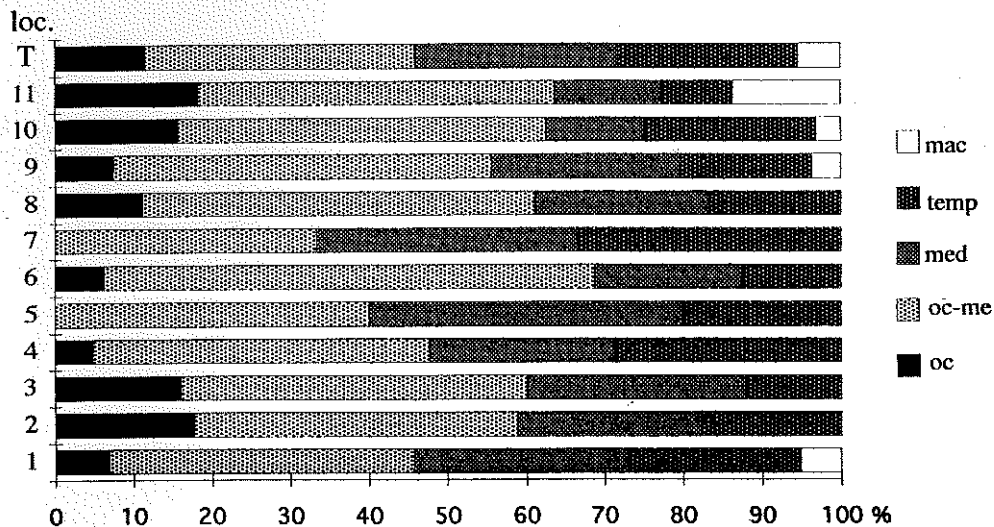


Fig. 4-Total data (T) and for each locality (1 to 11) of the phytogeographic tendency on the selected sites. Abbreviations and definitions:

Bor- Boreal; **Oc-** Oceanic (including the euoc, oc, oc-bip, sub-trop, oc-trop, oc-mont, s.oc, n.oc and w.oc); **Oc-med-** Oceanic-mediterranean (including the suboc-med, suboc-submed, oc-submed, mont); **Med-** Mediterranean (including the med-oc, submed-suboc, c.med, w.submed, w.med); **Temp-** Temperate (including the s.temp, n.temp, w.temp and temp-mont); **Mac-** Macaronesian endemic; **Mad-** Madeira endemic.

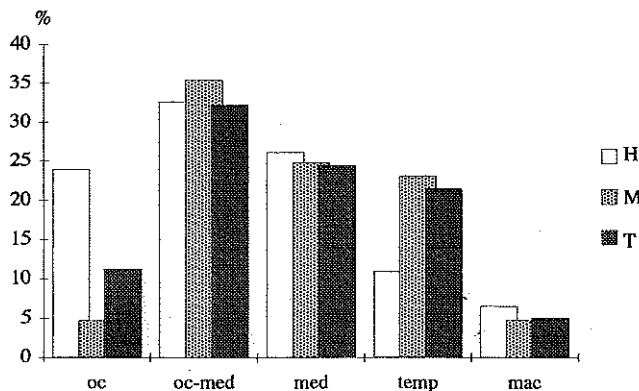


Fig. 5- Phylogeographical position of each taxonomic group (H- Hepatics; M- Mosses). Abbreviations and definitions as Fig.4.

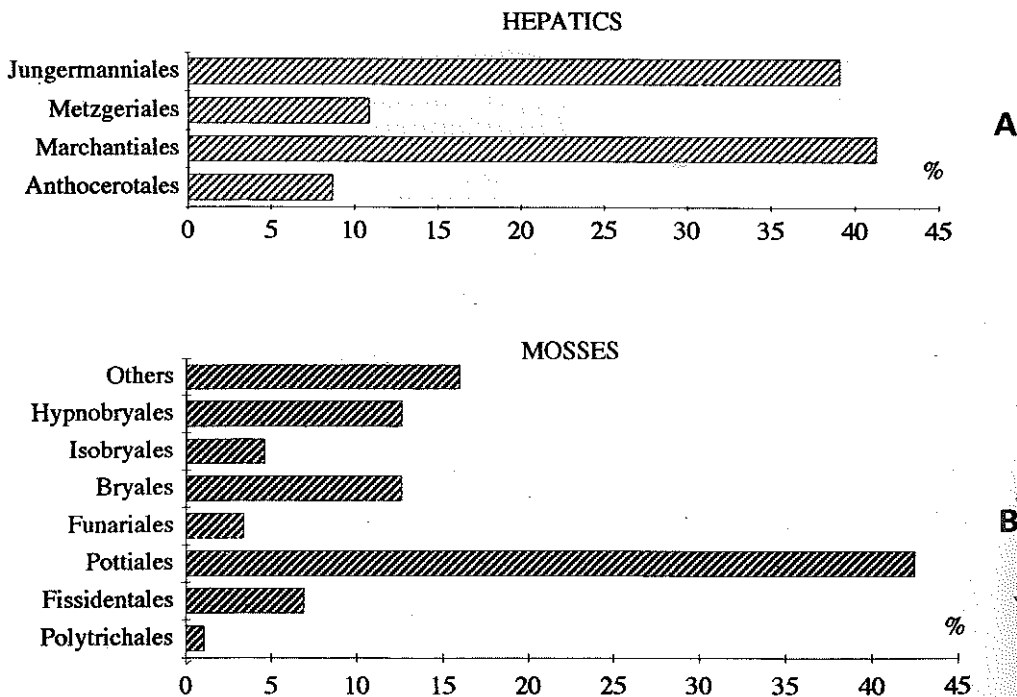


Fig. 6 A, B- Taxonomic pattern of the dry areas in Madeiran bryoflora, in terms of percentage of species.

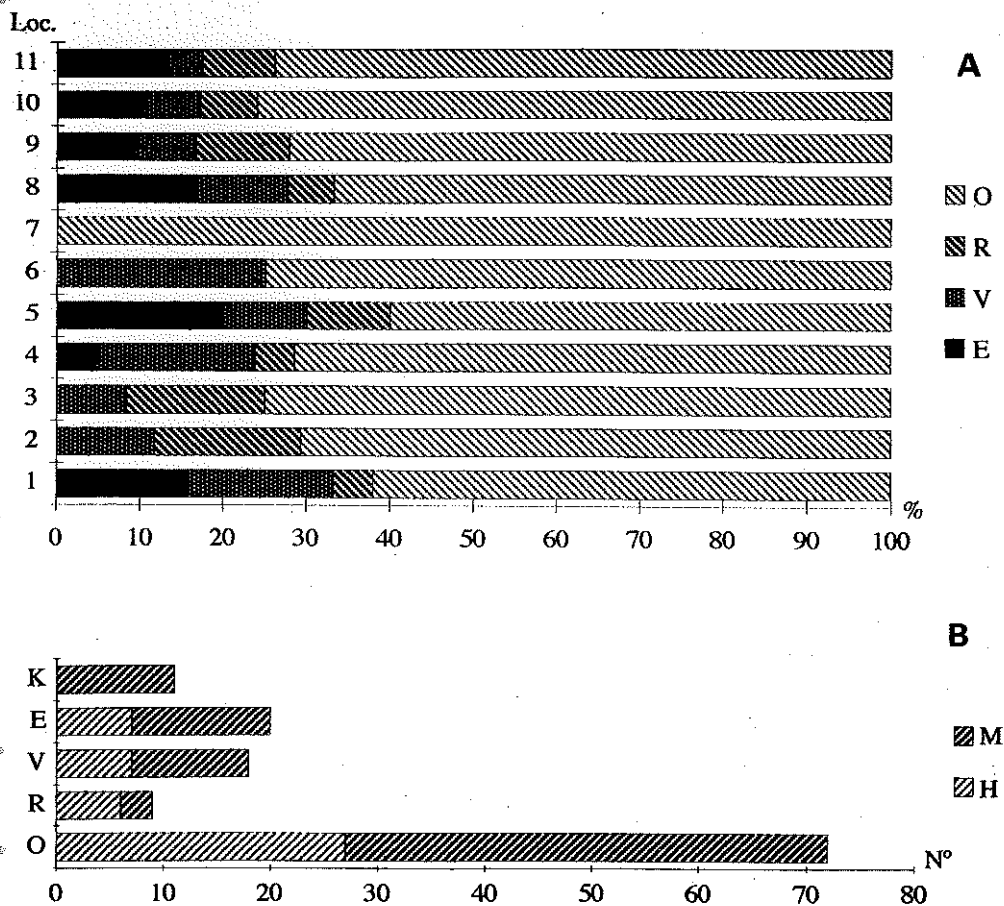


Fig. 7- A. Total data for each locality, according to the threatened categories for the selected sites. B. Threat position of each taxonomic group (H- Hepatics; M- Mosses).

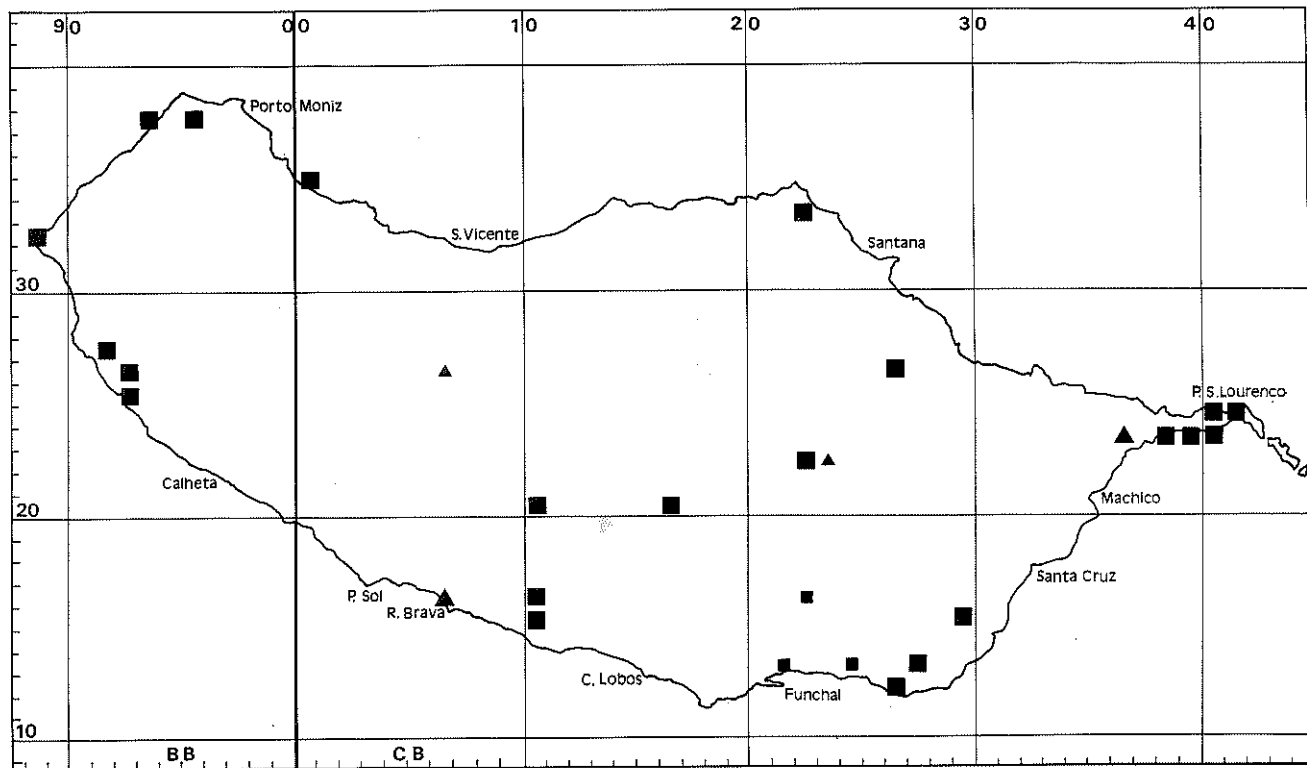


Fig. 8- Map showing the distribution on Madeira of *Corsinia coriandrina* (SPRENG.) LINDB.

▲ Bibliographic references (▲, ▲) herbarium specimens (■, ■), before 1950 and since 1950. ▲

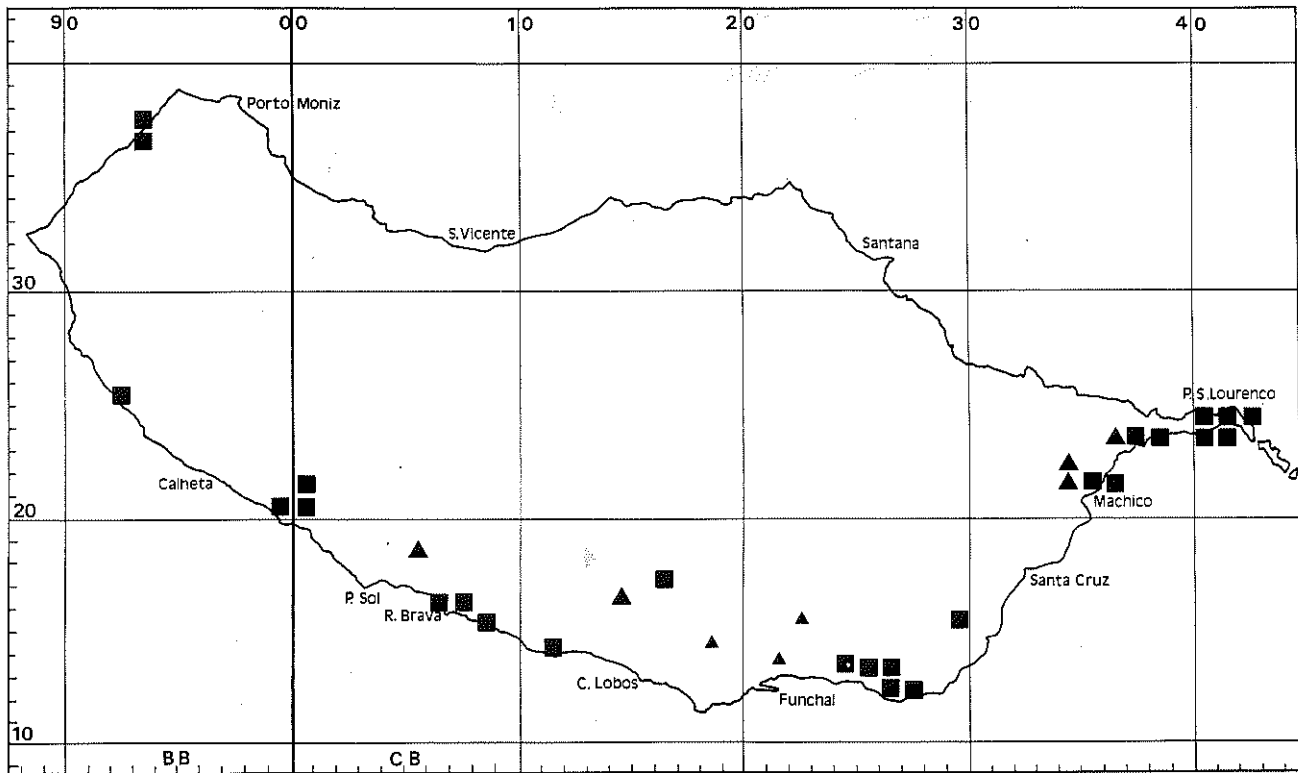


Fig. 9- Map showing the distribution on Madeira Island of *Exormotheca pustulosa* STEPH. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

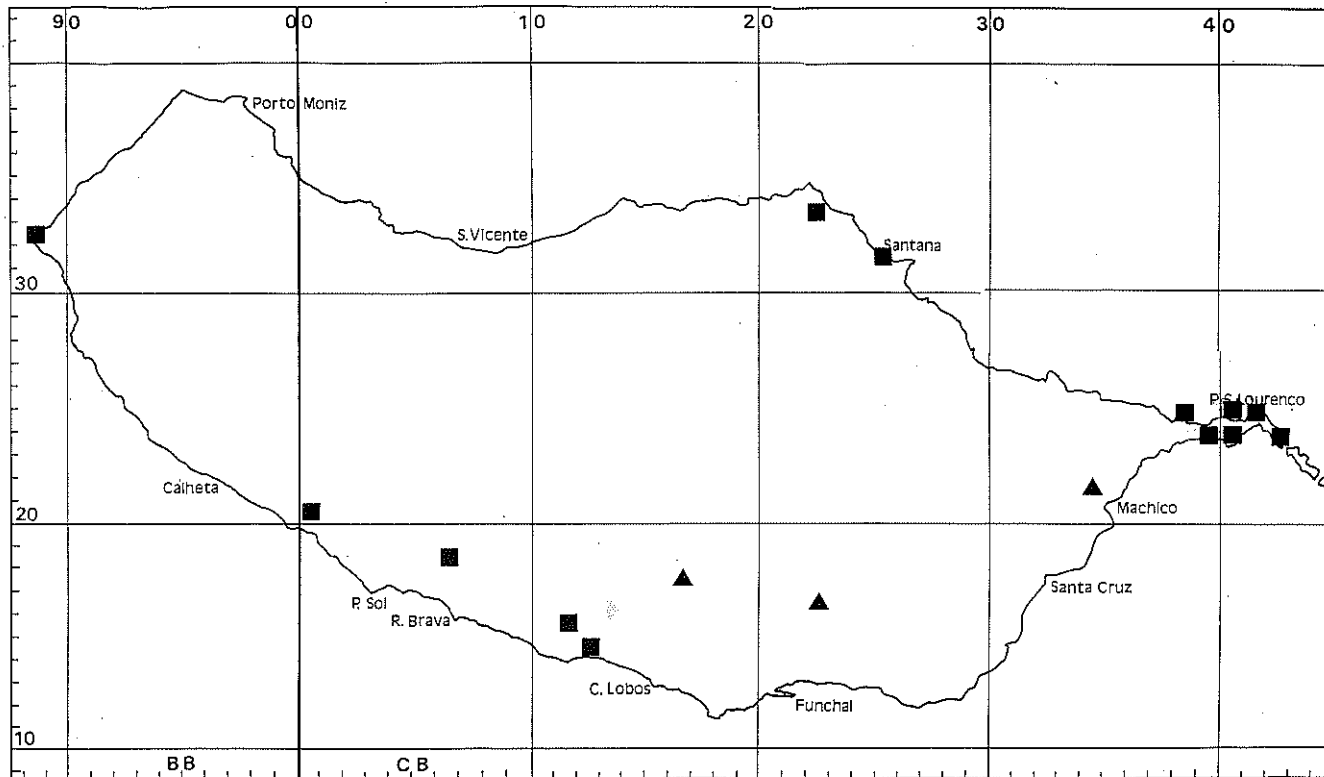


Fig. 10- Map showing the distribution on Madeira Island of *Frullania ericoides* (NEES) MONT. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950. Adapted from SIM-SIM & SÉRGIO, 1992.

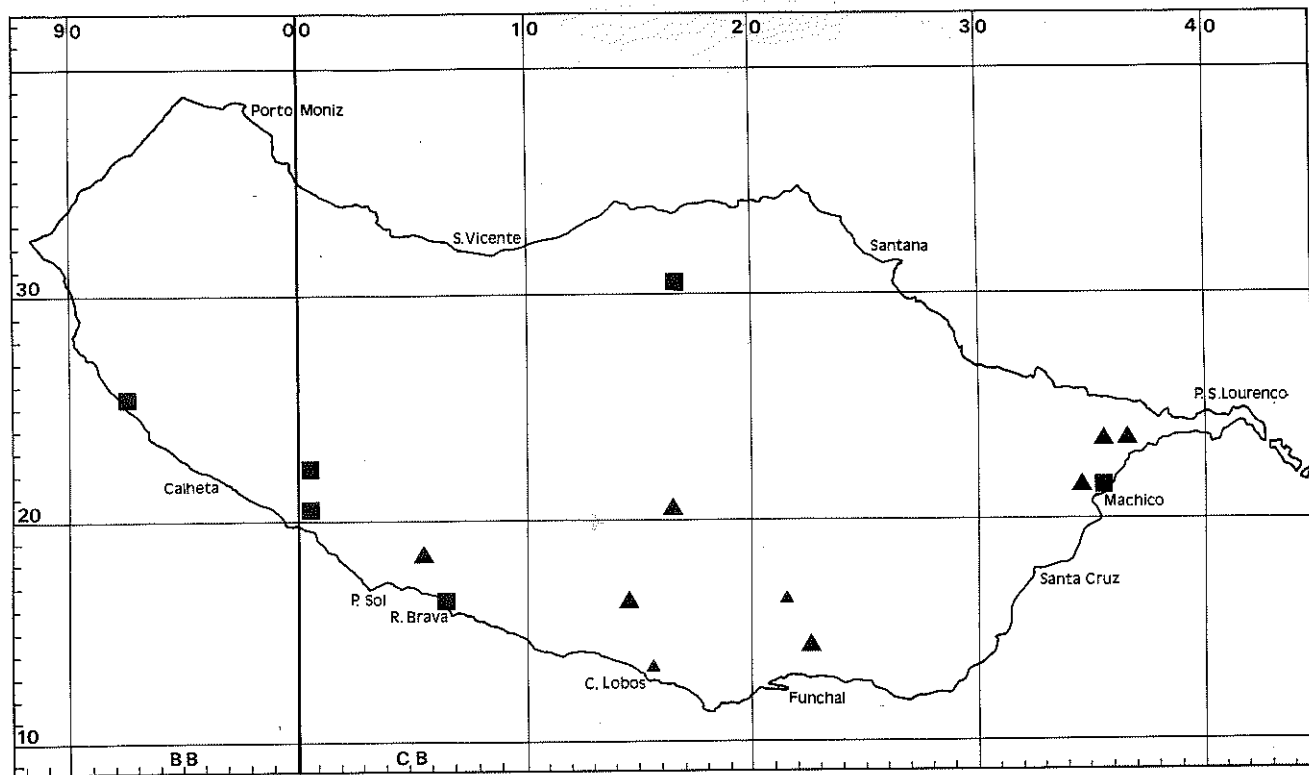


Fig. 11- Map showing the distribution on Madeira Island of *Mannia androgyna* (L.emend.LINDB.) EVANS. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

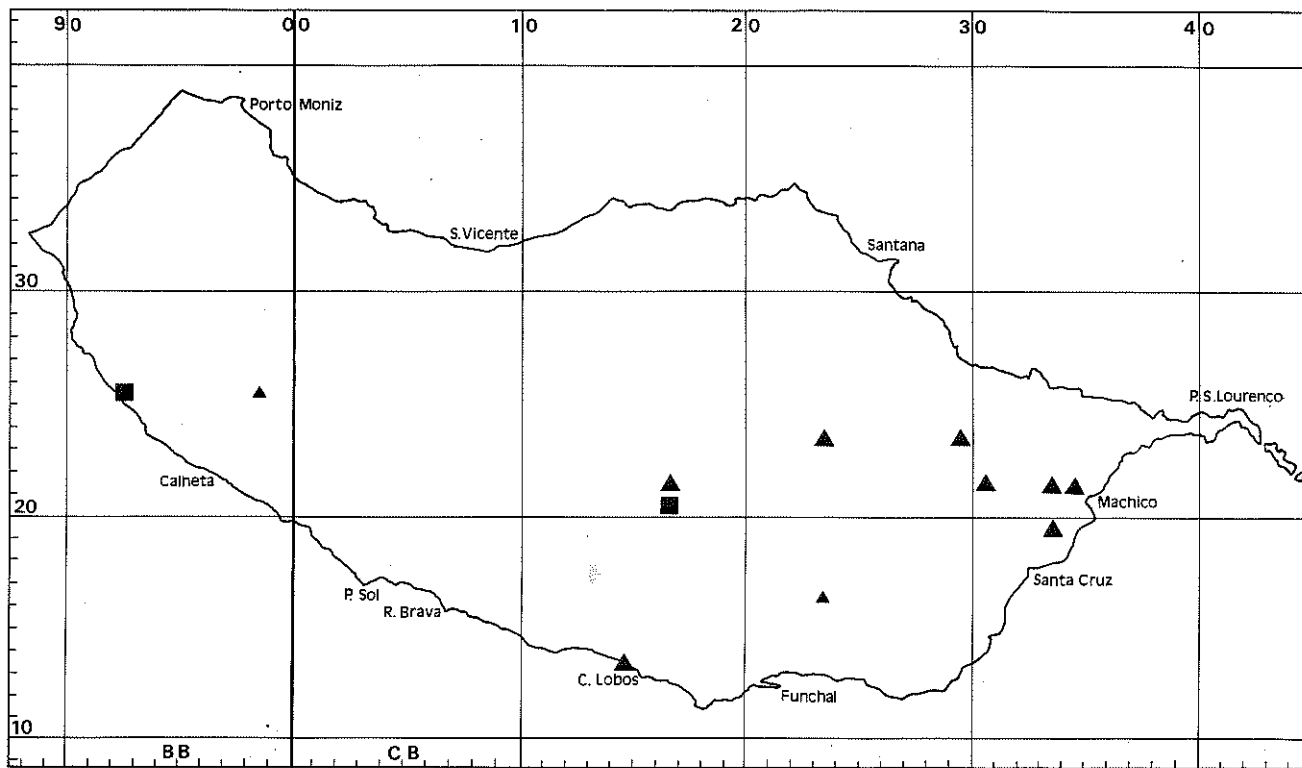


Fig. 12- Map showing the distribution on Madeira Island of *Phaeoceros bulbiculosus* (BROTERO) PROSK. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

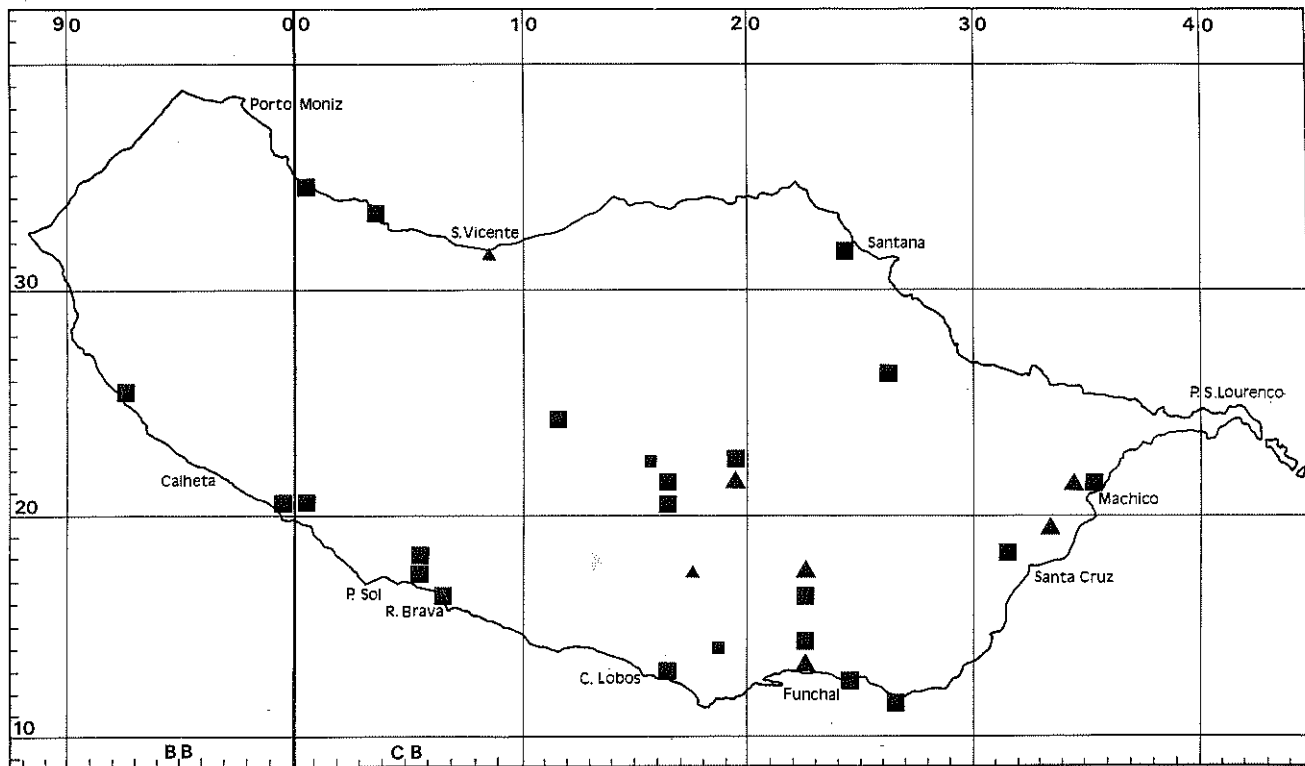


Fig. 13- Map showing the distribution on Madeira Island of *Plagiochasma rupestre* (FORST.)
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

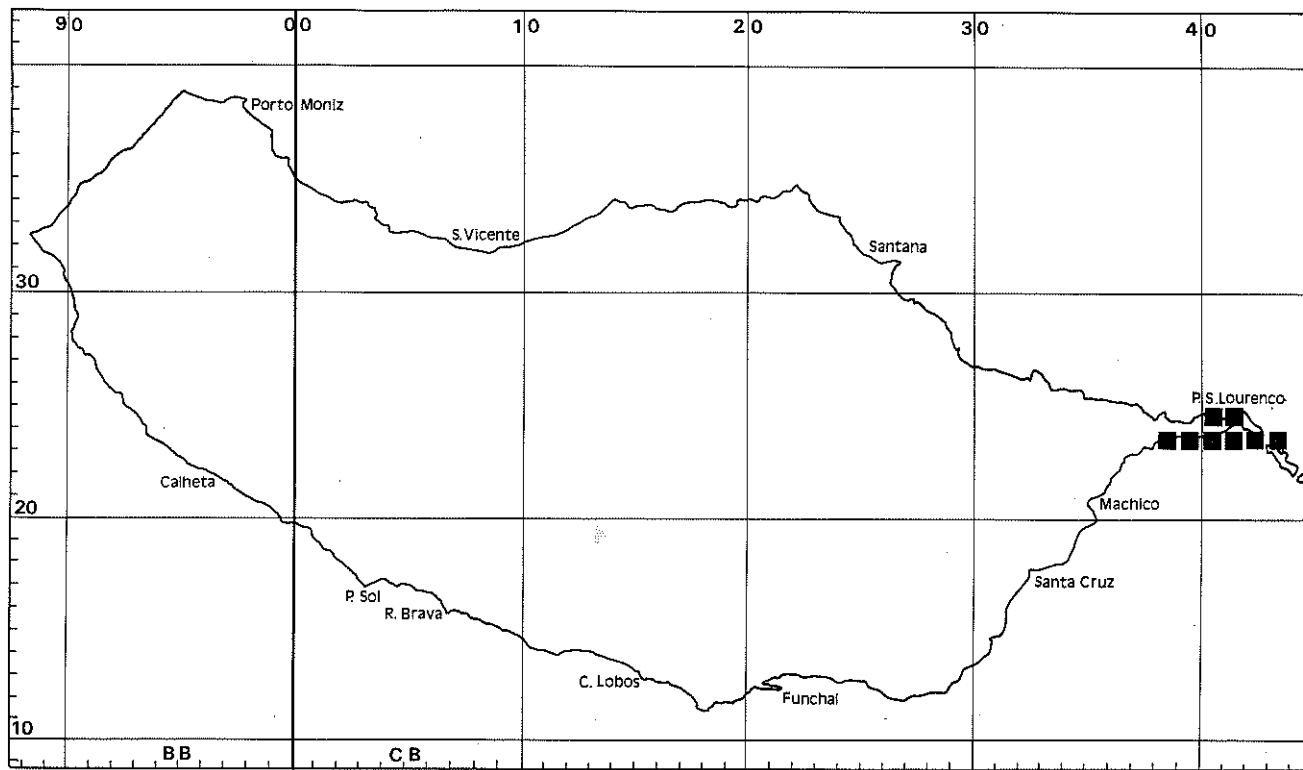


Fig. 14- Map showing the distribution on Madeira Island of *Riccia atlantica* SÉRGIO & PEROLD. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

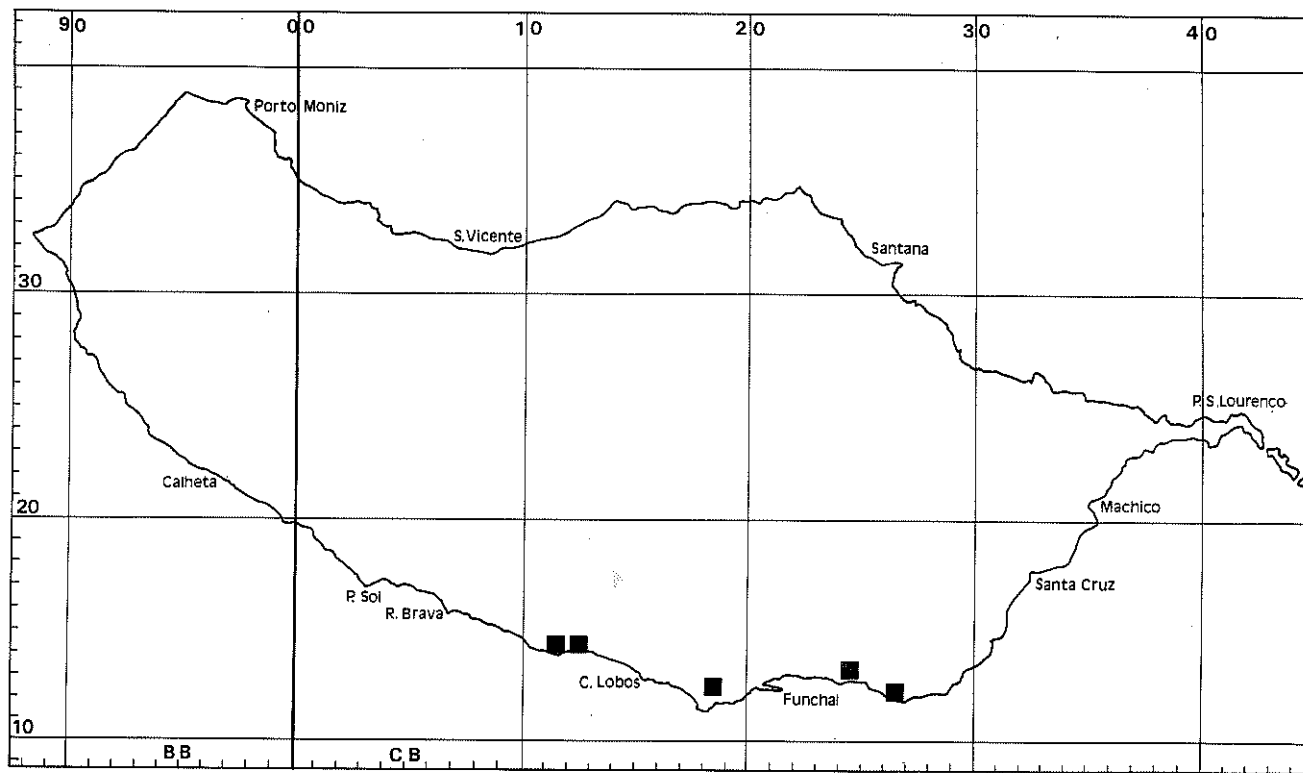


Fig. 15- Map showing the distribution on Madeira Island of *Riccia cavernosa* HOFFM.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

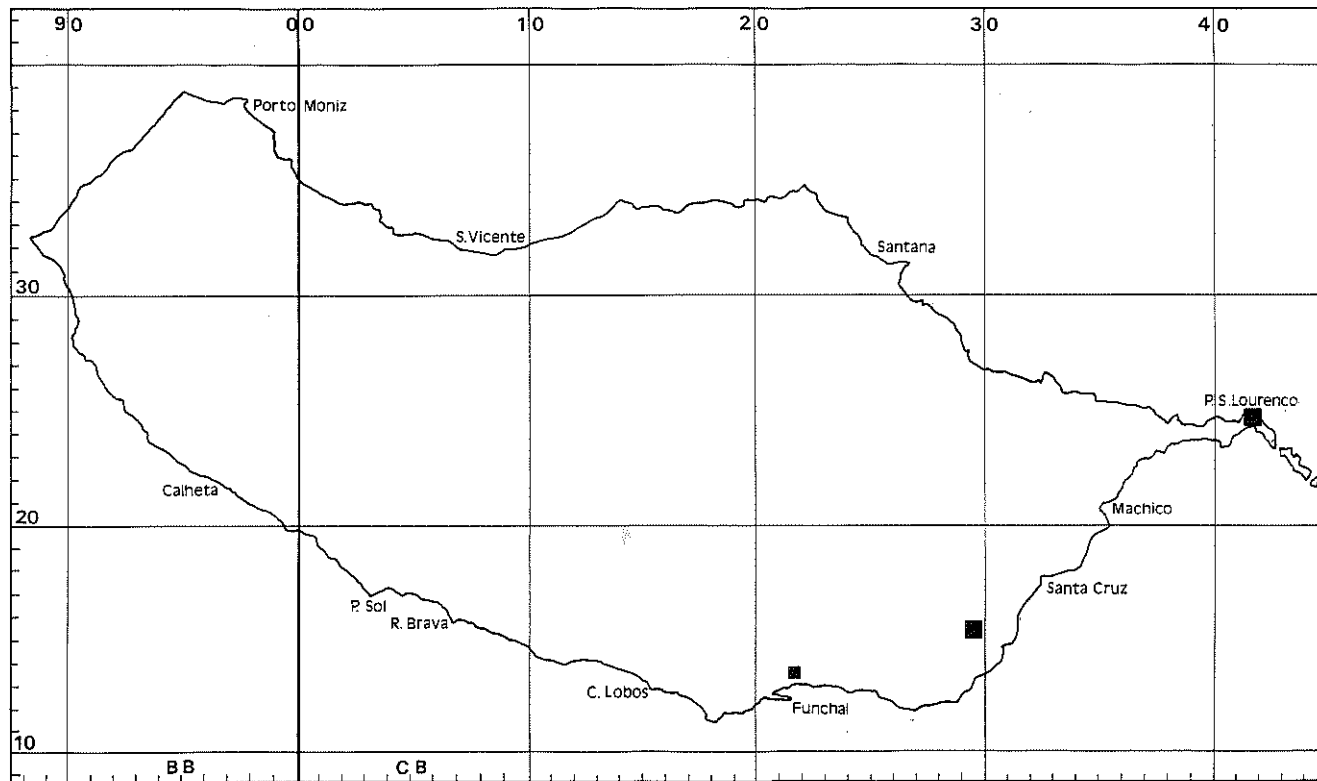


Fig. 16- Map showing the distribution on Madeira Island of *Riccia lamellosa* RADDI.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

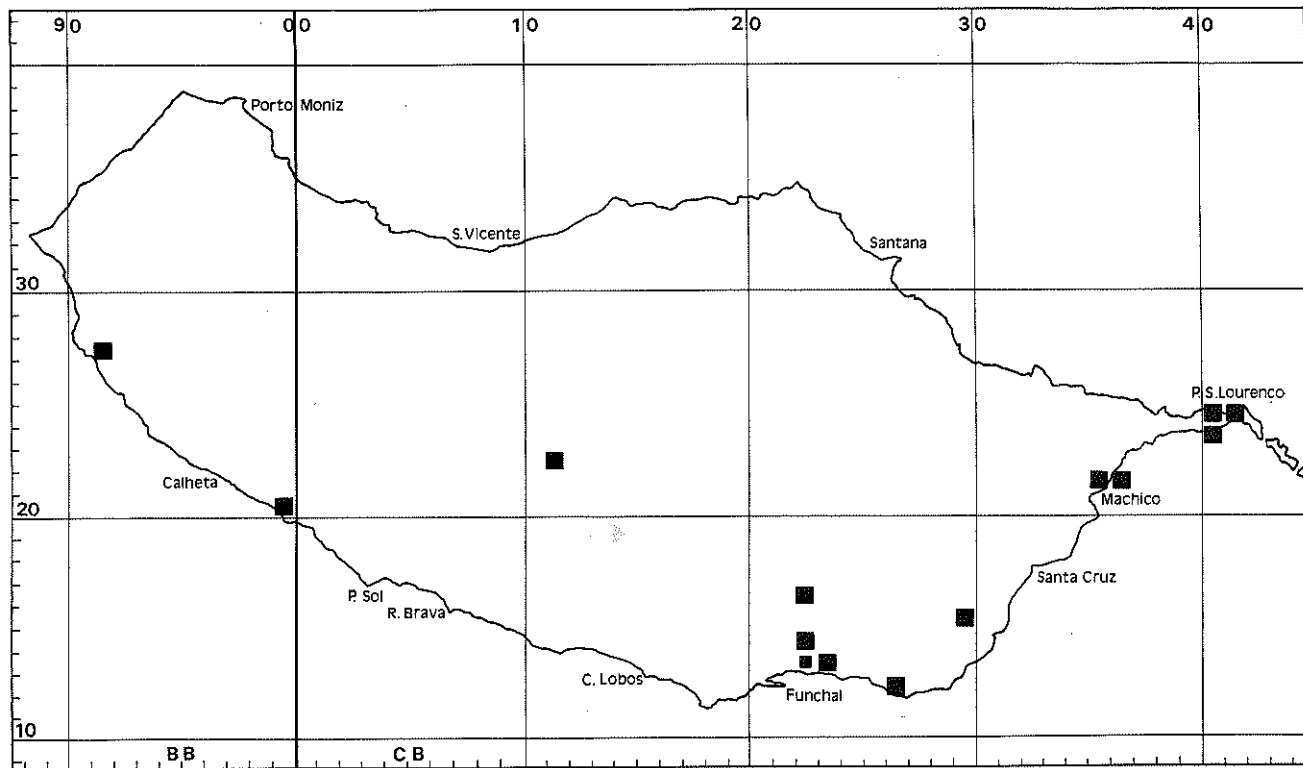


Fig. 17- Map showing the distribution on Madeira Island of *Riccia nigrella* DC.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

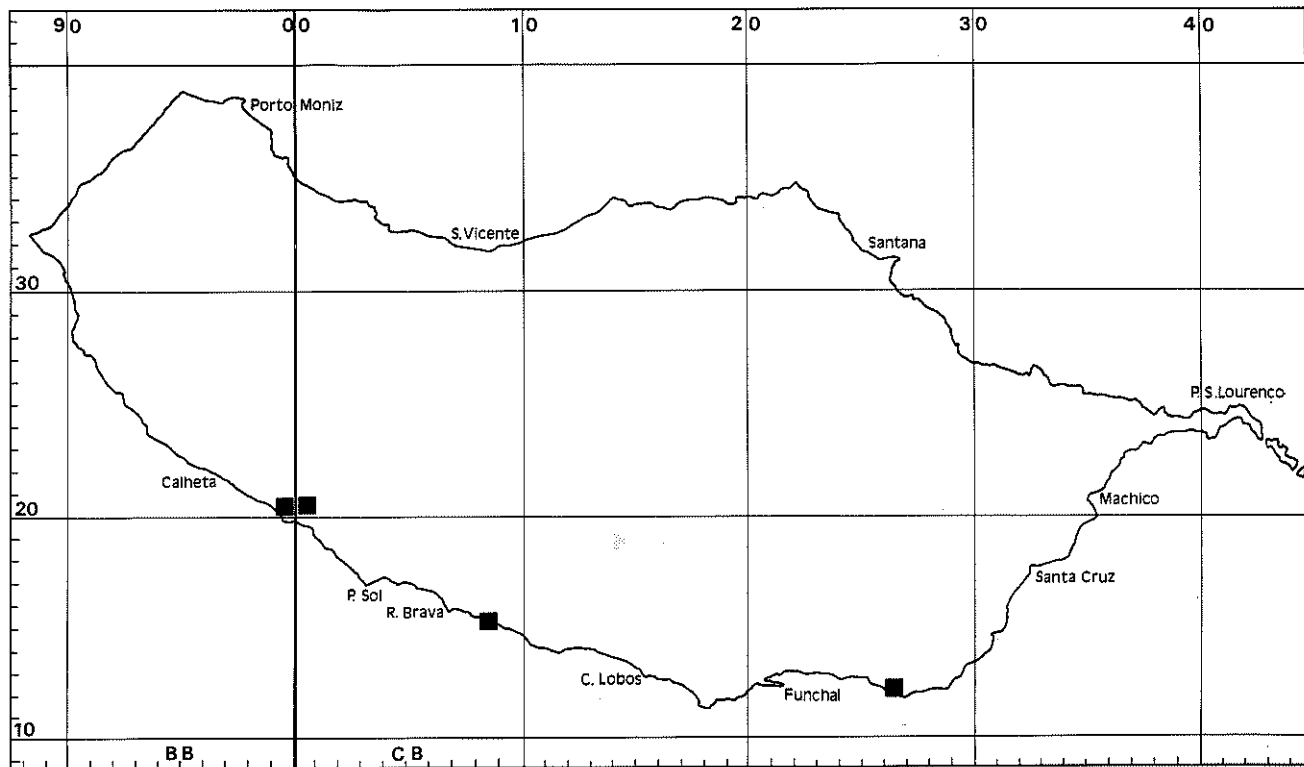


Fig. 18- Map showing the distribution on Madeira Island of *Riccia trabutiana* STEPH.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

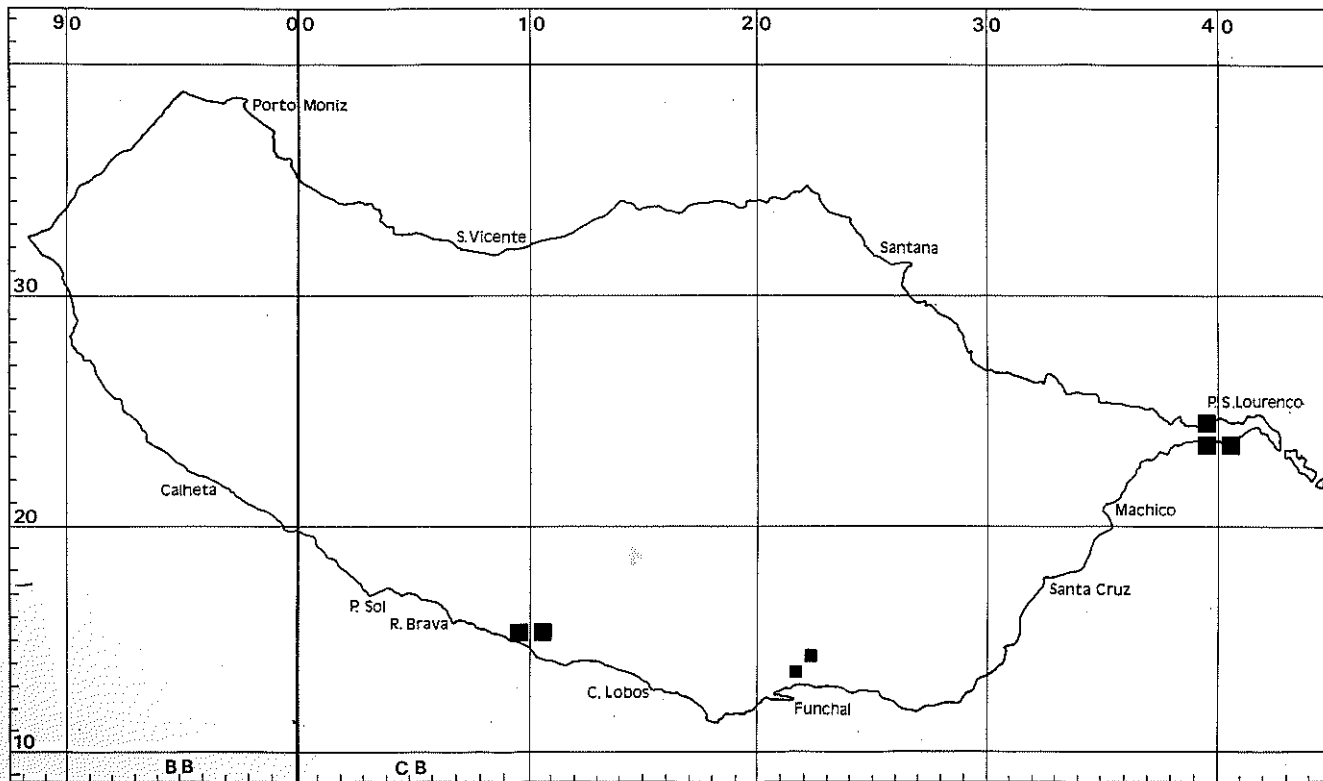


Fig. 19- Map showing the distribution on Madeira Island of *Aloiua ambigua* (BR. & S.) LIMPR. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

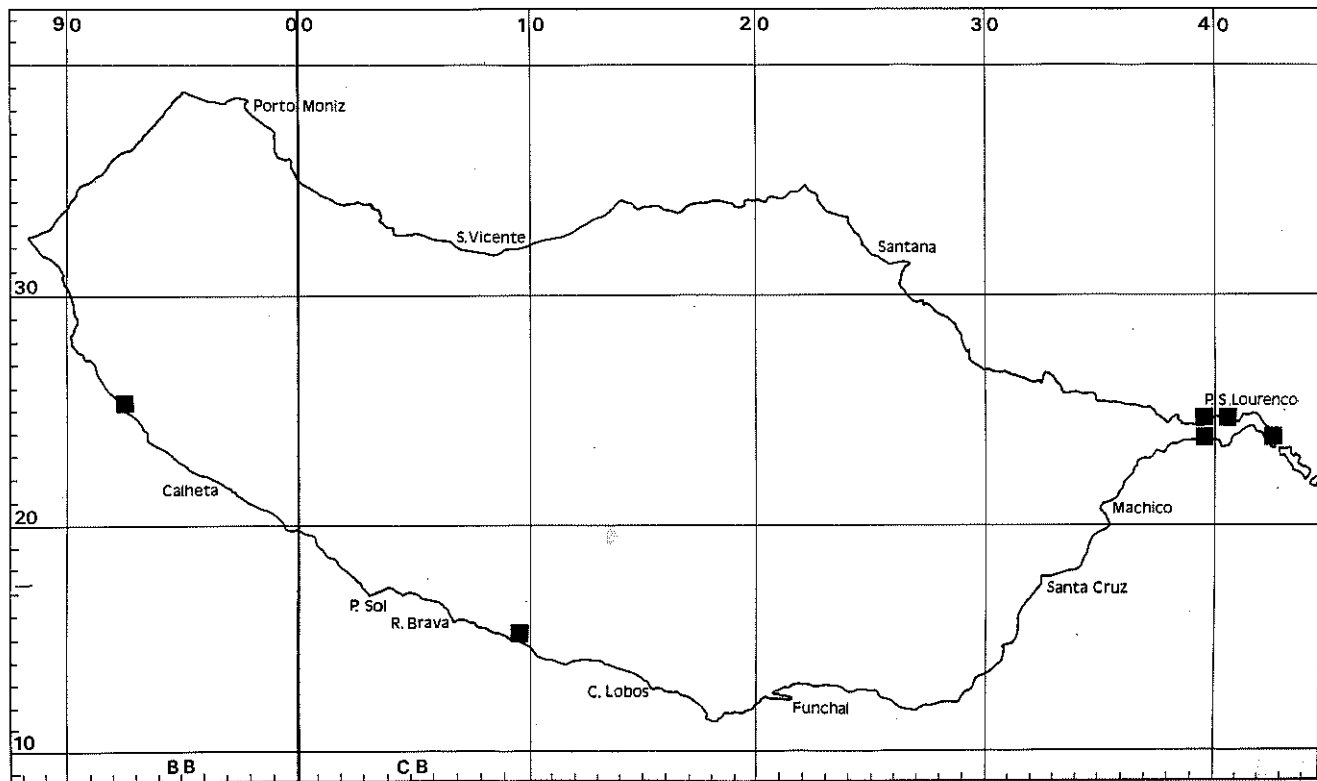


Fig. 20- Map showing the distribution on Madeira Island of *Aloina rigida* (HEDW.) LIMPR.

◀ Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

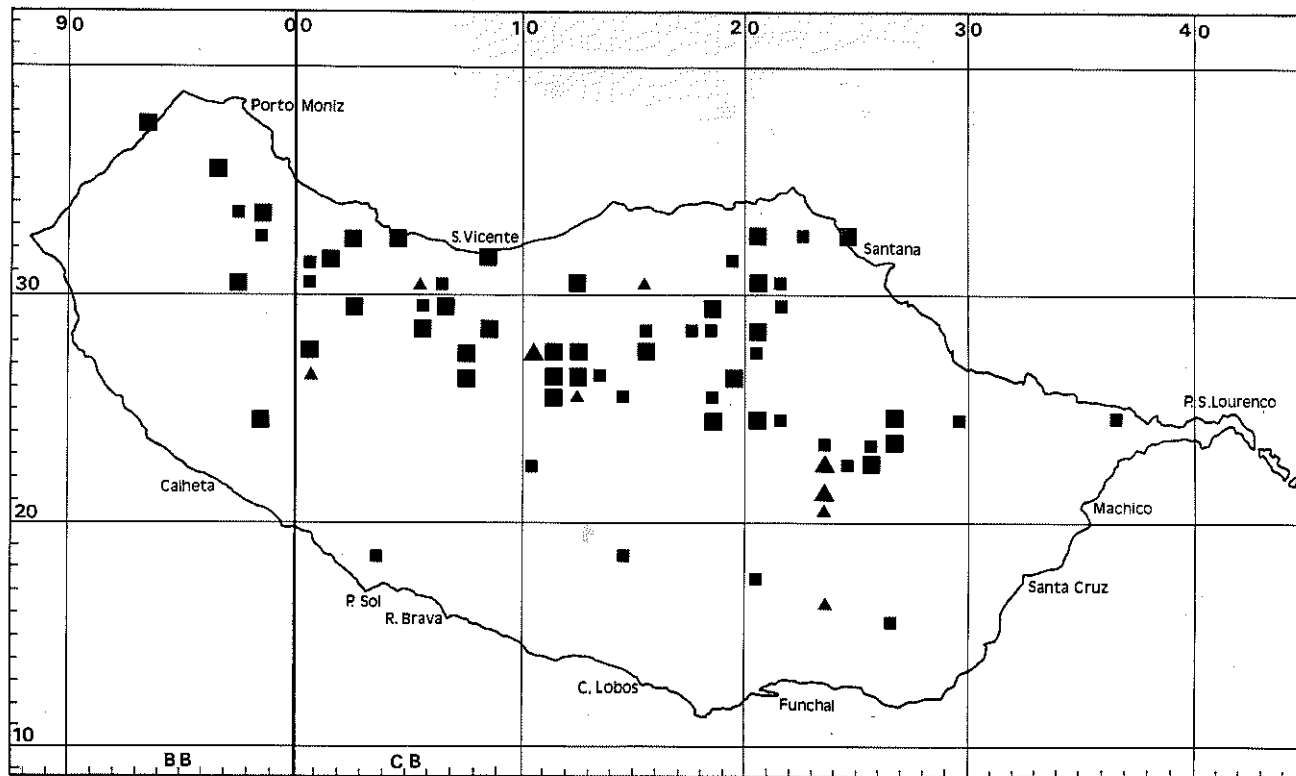


Fig. 21- Map showing the distribution on Madeira Island of *Andoa berthelotiana* (MONT.) OCHYRA. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

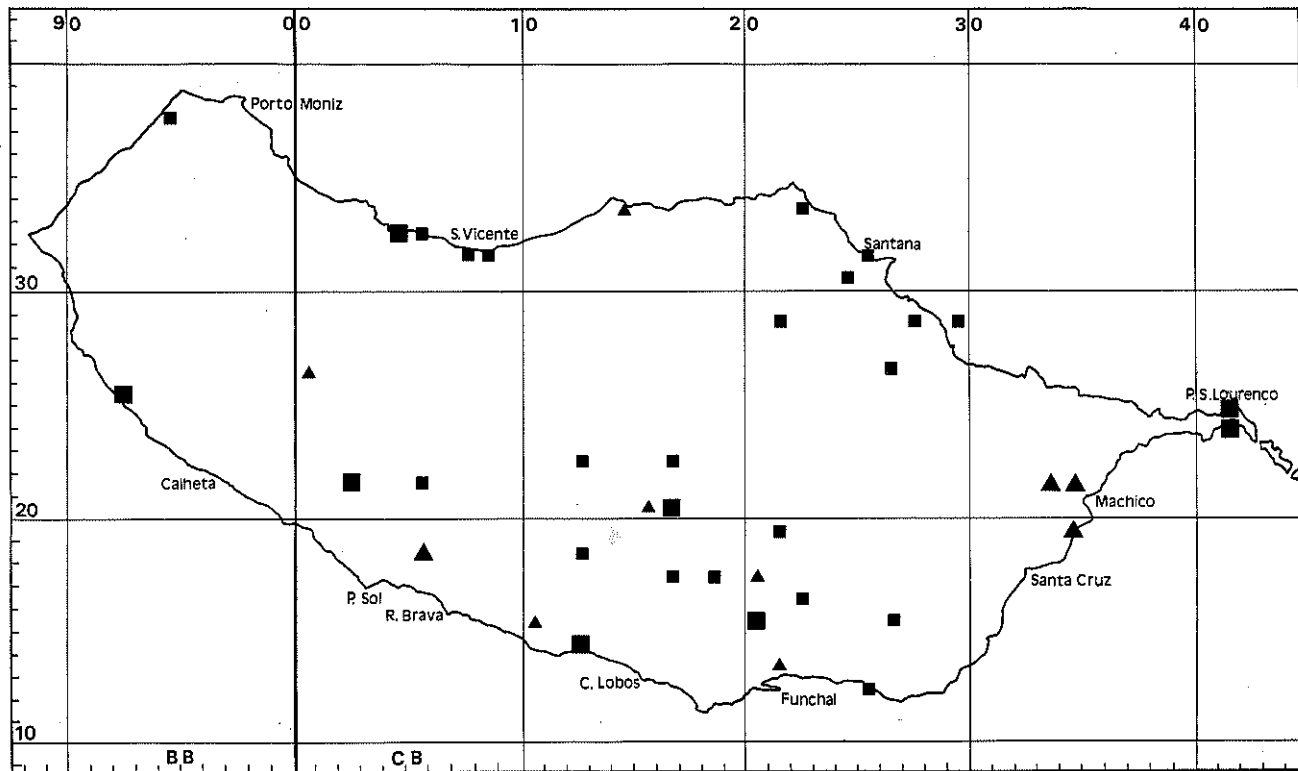


Fig. 22- Map showing the distribution on Madeira Island of *Brachymenium notaristii* (MITT.) SCHAW. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

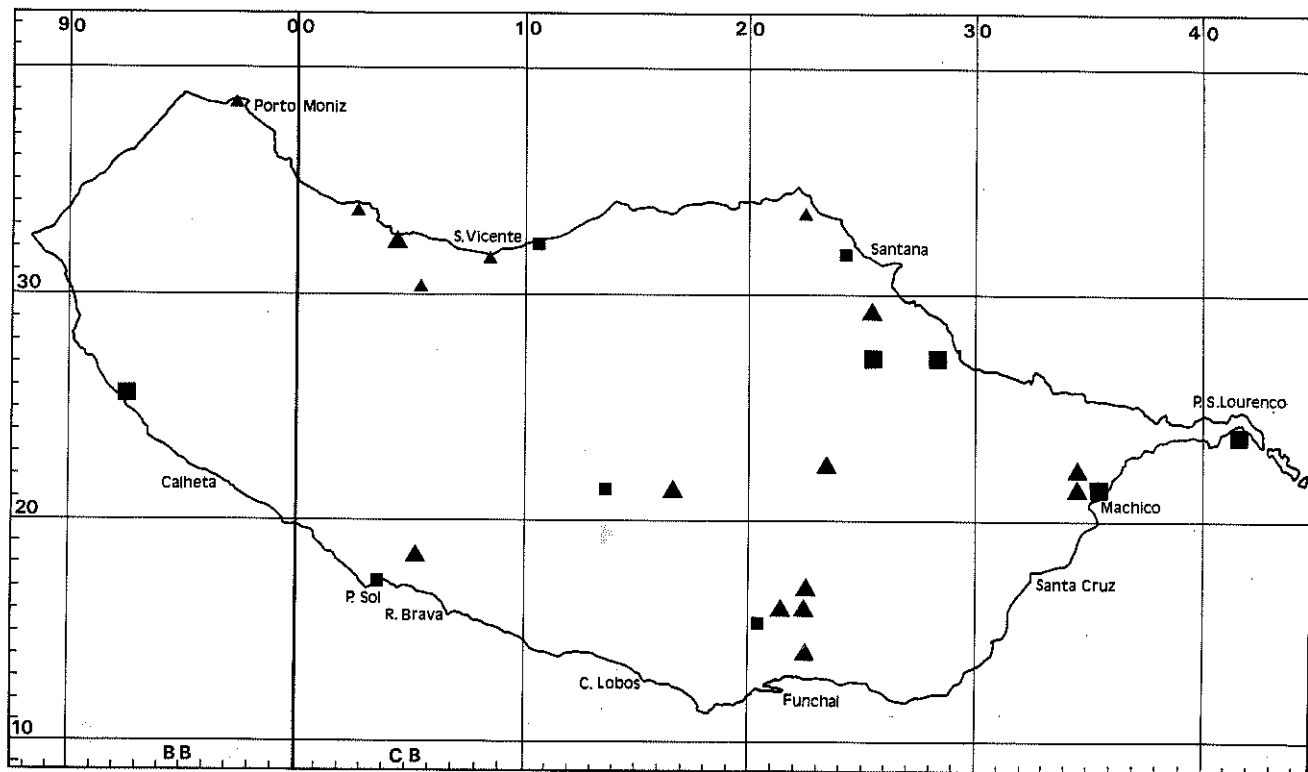


Fig. 23- Map showing the distribution on Madeira Island of *Bryum canariense* BRID.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

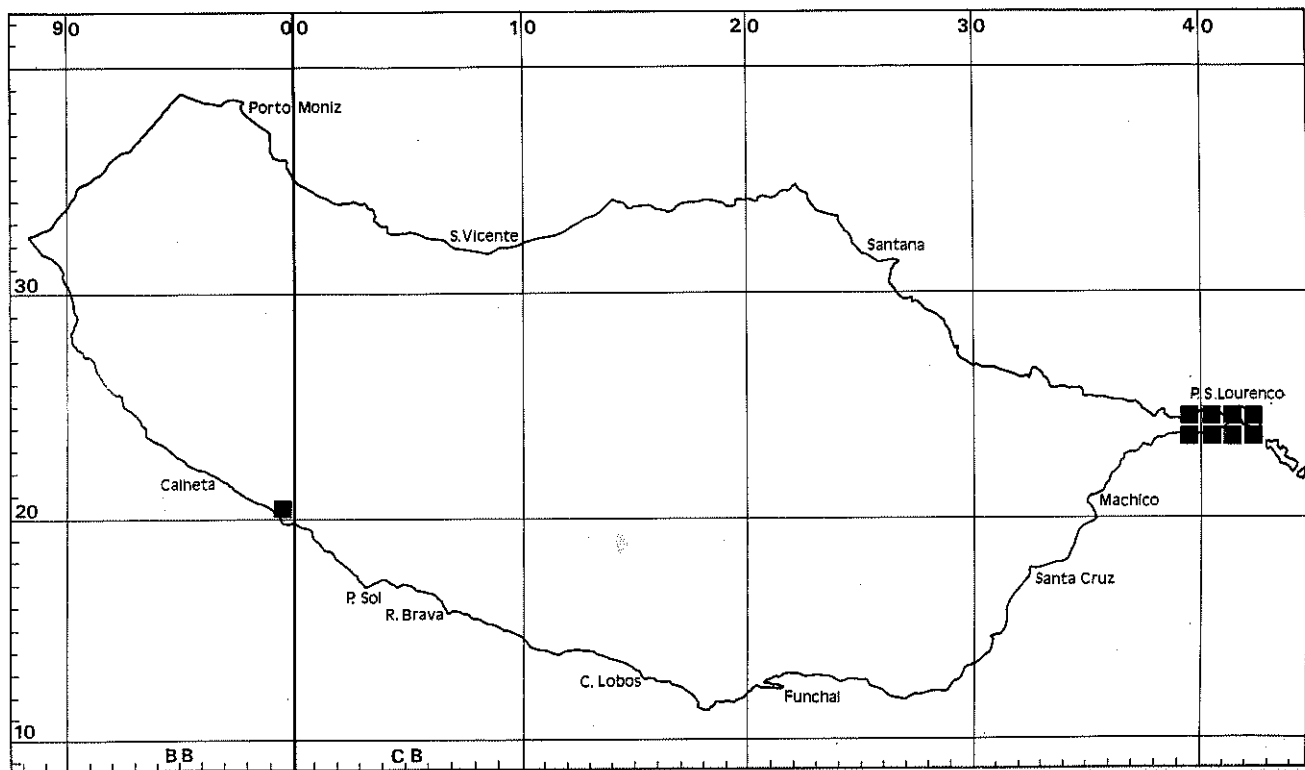


Fig. 24- Map showing the distribution on Madeira Island of *Bryum dunense* A.J.E. SM. & WHITEH.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

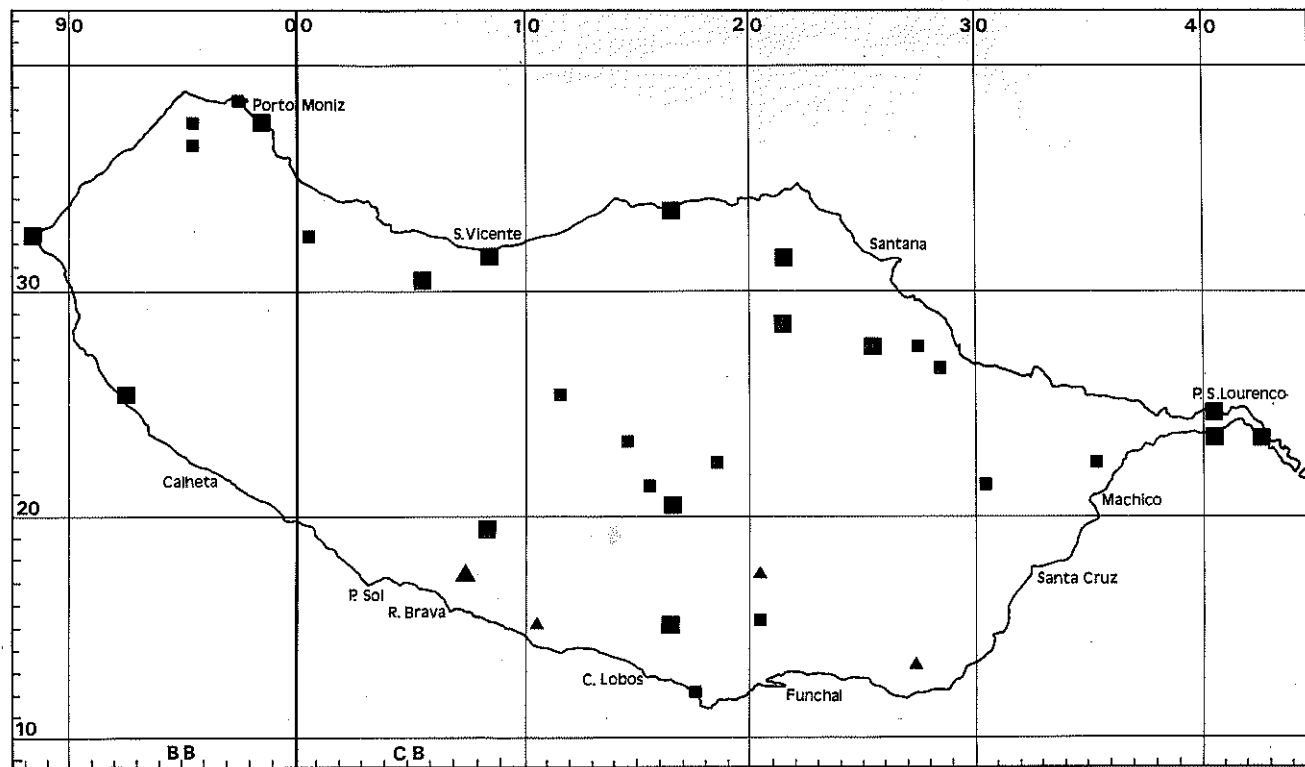


Fig. 25- Map showing the distribution on Madeira Island of *Fissidens algarvicus* SOLMS. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

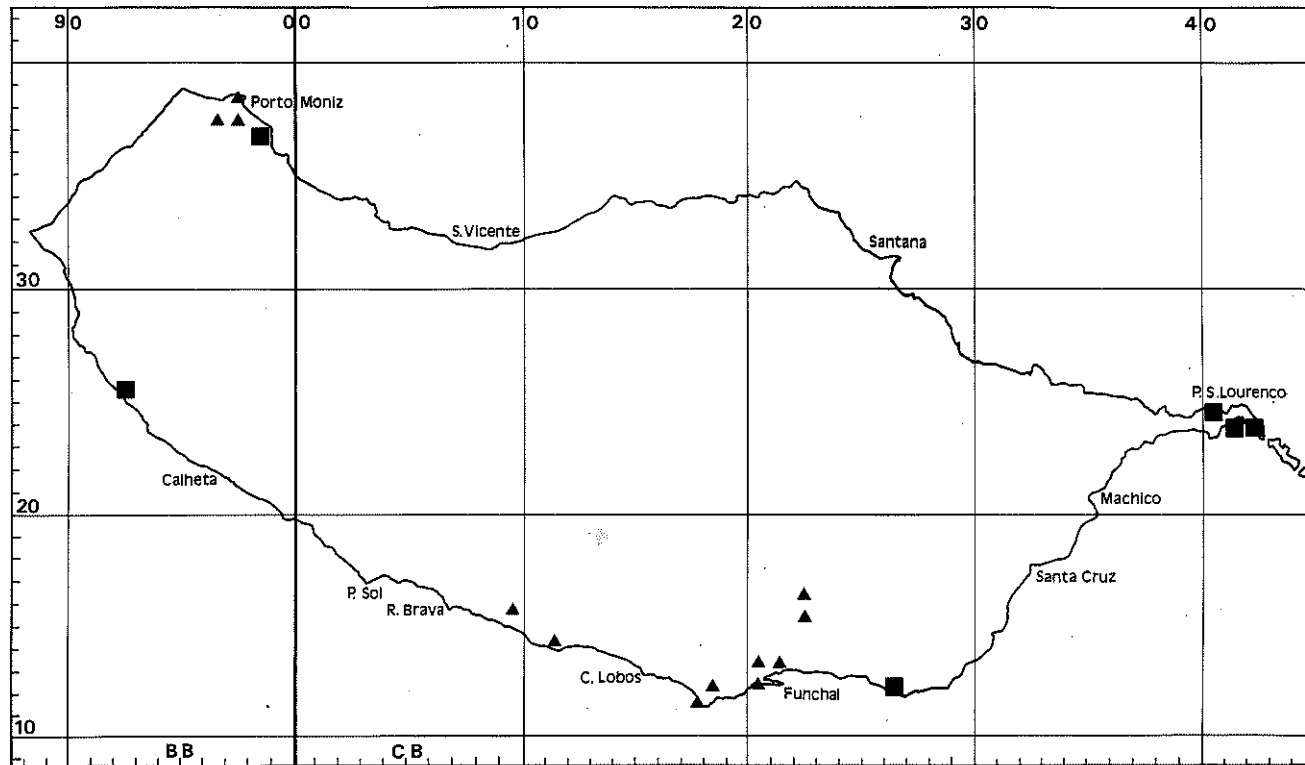


Fig. 26- Map showing the distribution on Madeira Island of *Fissidens coacervatus* BRUGG. - NANN.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

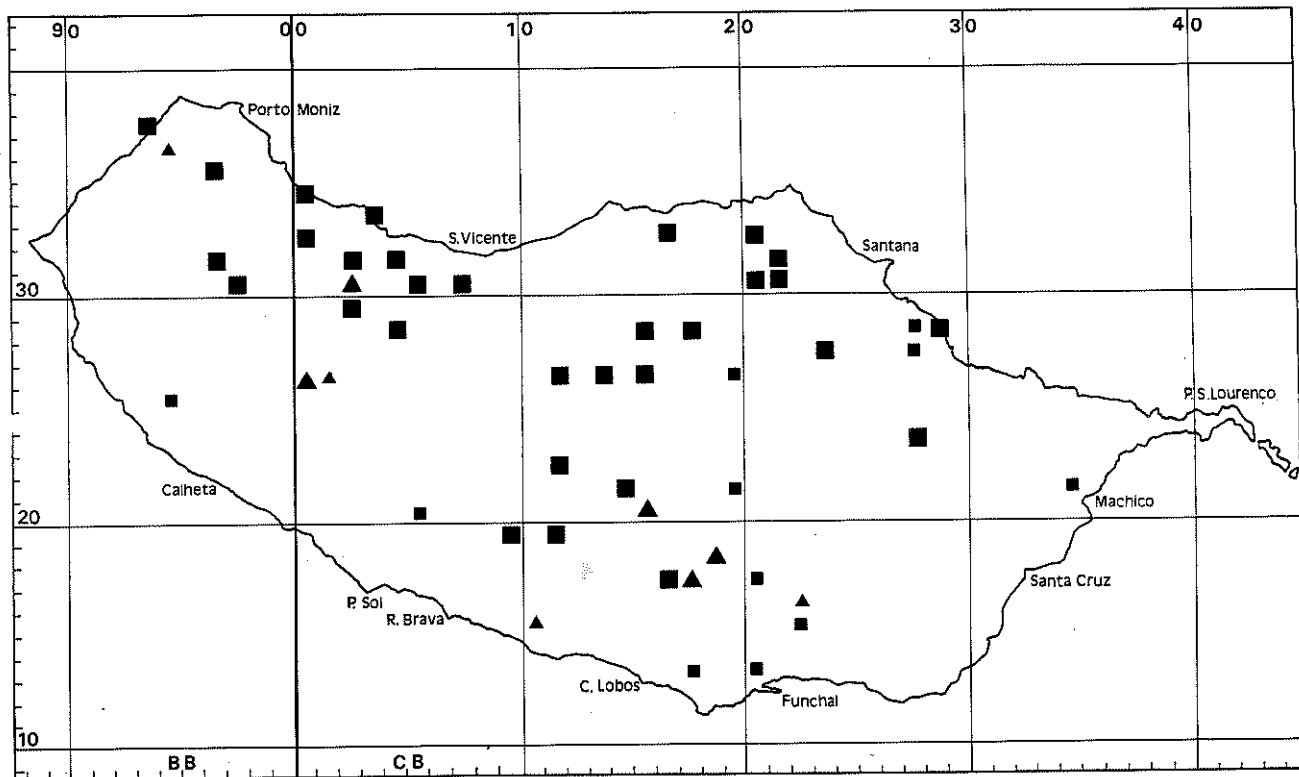


Fig. 27- Map showing the distribution on Madeira Island of *Homalia lusitanica* SCHIMP.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

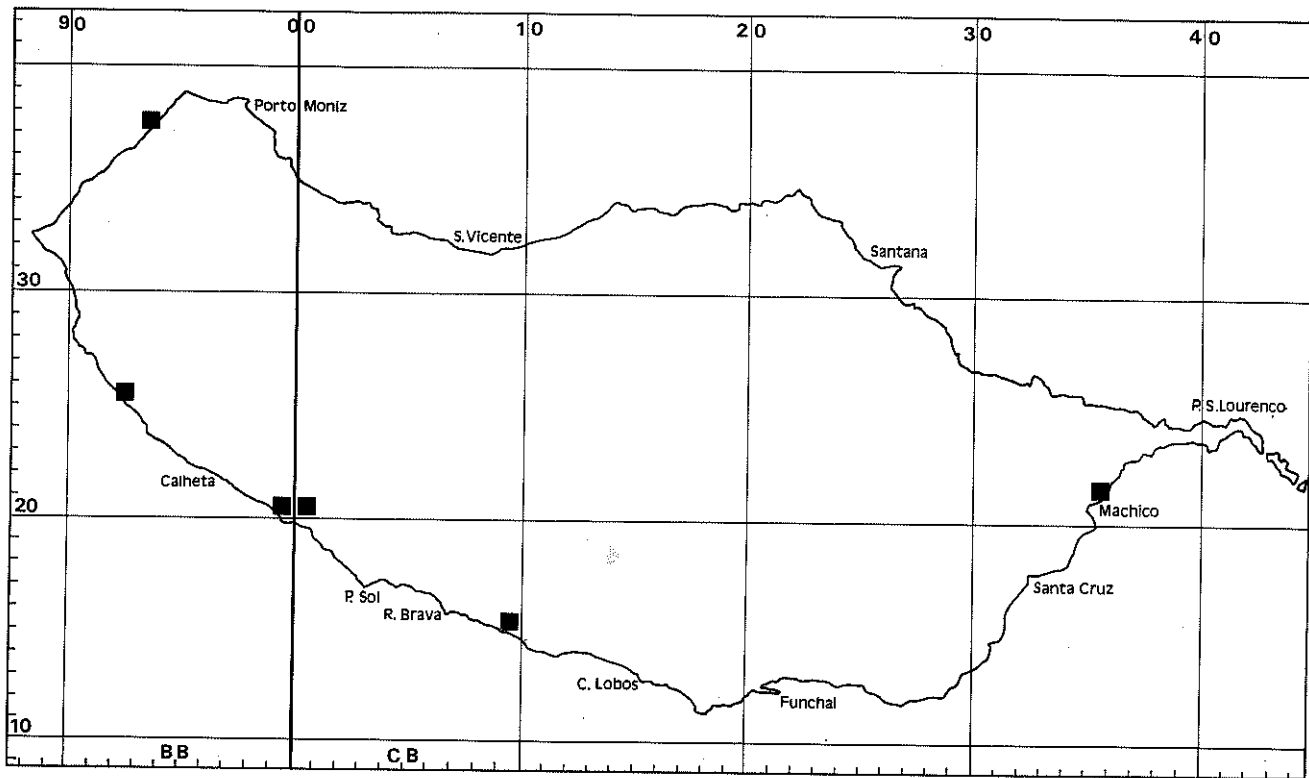


Fig. 28- Map showing the distribution on Madeira Island of *Oedipodiella australis* (WAGER. & DIX.) DIX. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

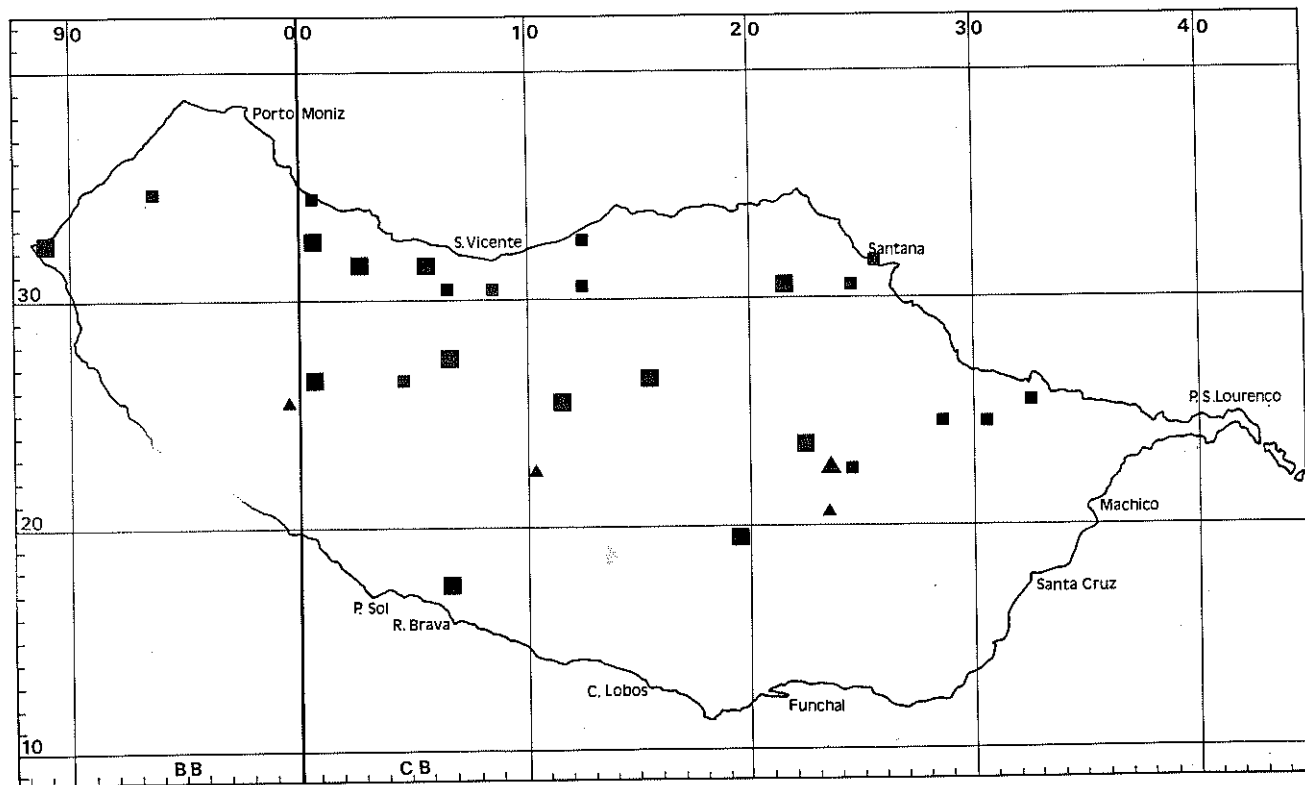


Fig. 29- Map showing the distribution on Madeira Island of *Rhamphidium purpuratum* MITT. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

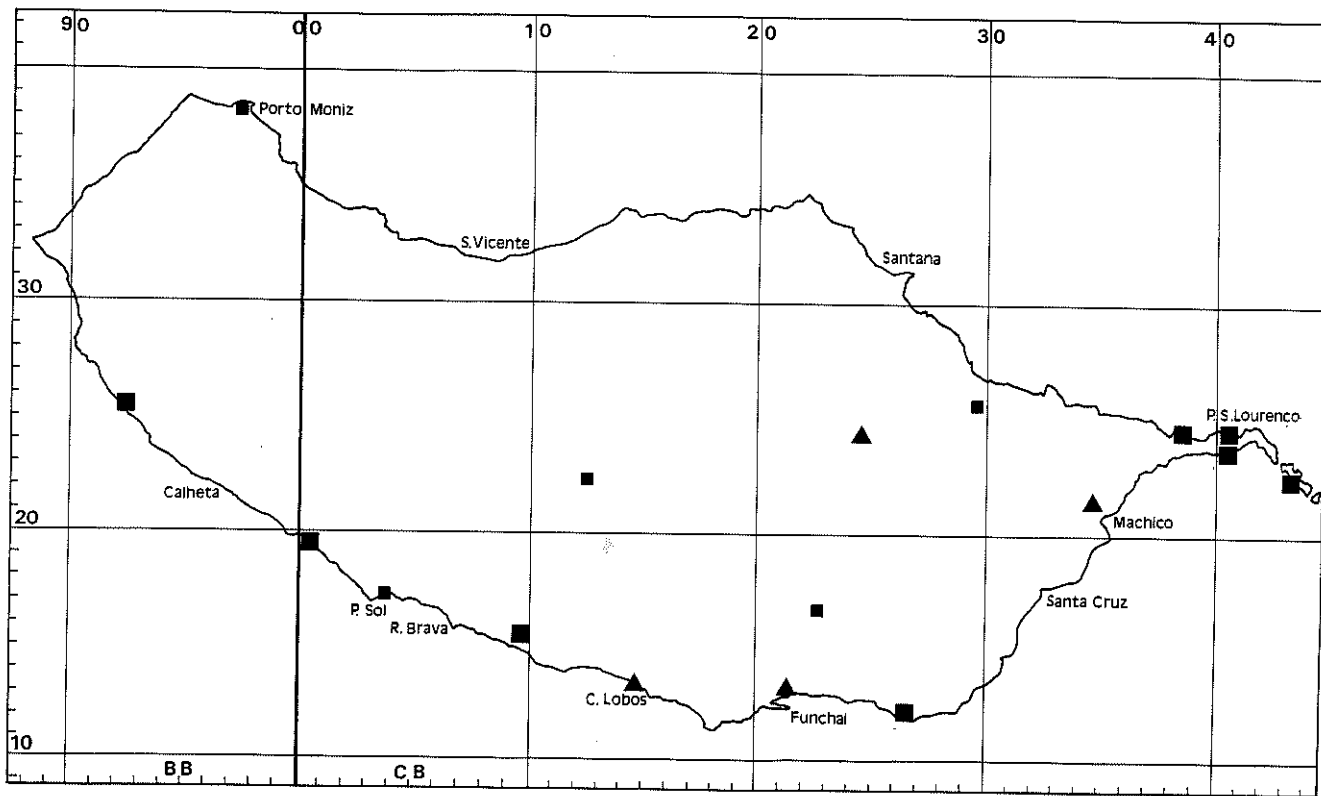


Fig. 30- Map showing the distribution on Madeira Island of *Tortella nitida* (LINDB.) BROTH.
Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

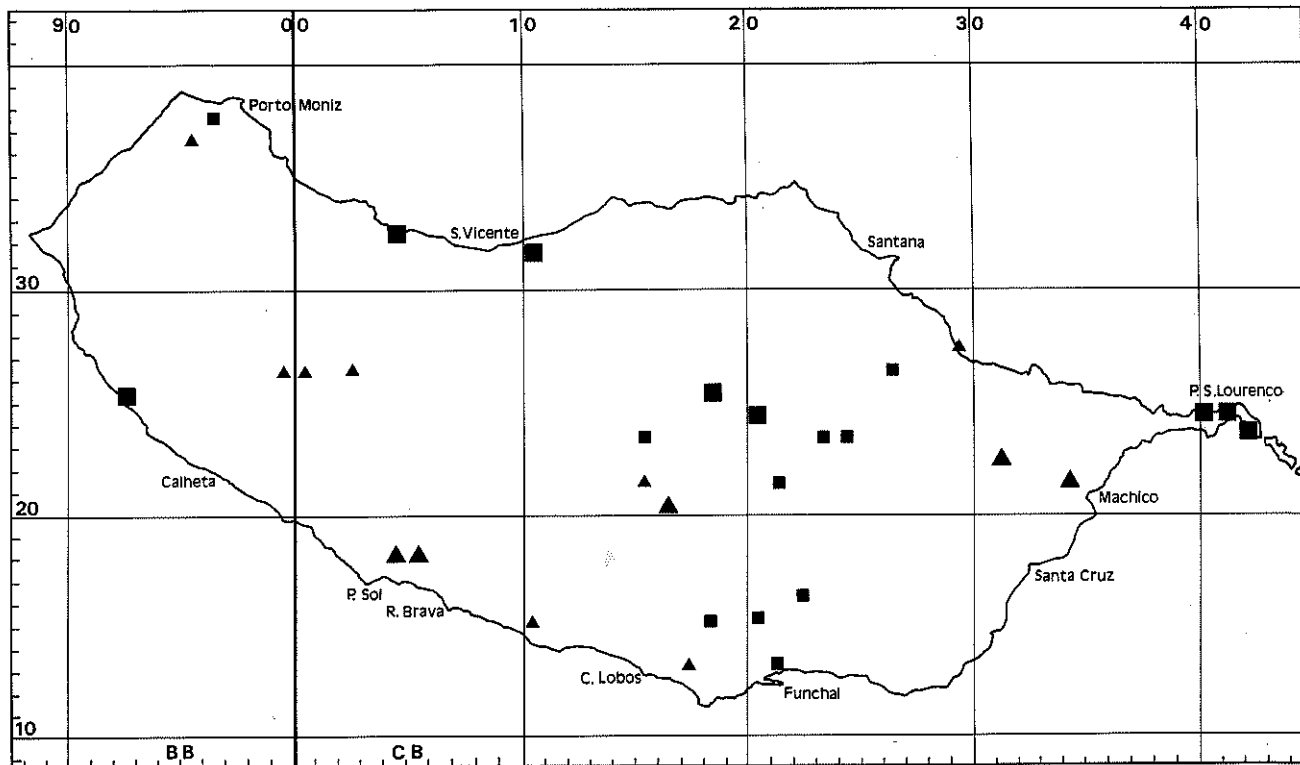


Fig. 31- Map showing the distribution on Madeira Island of *Tortula solmsii* (SCHIMP.) LIMPR. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

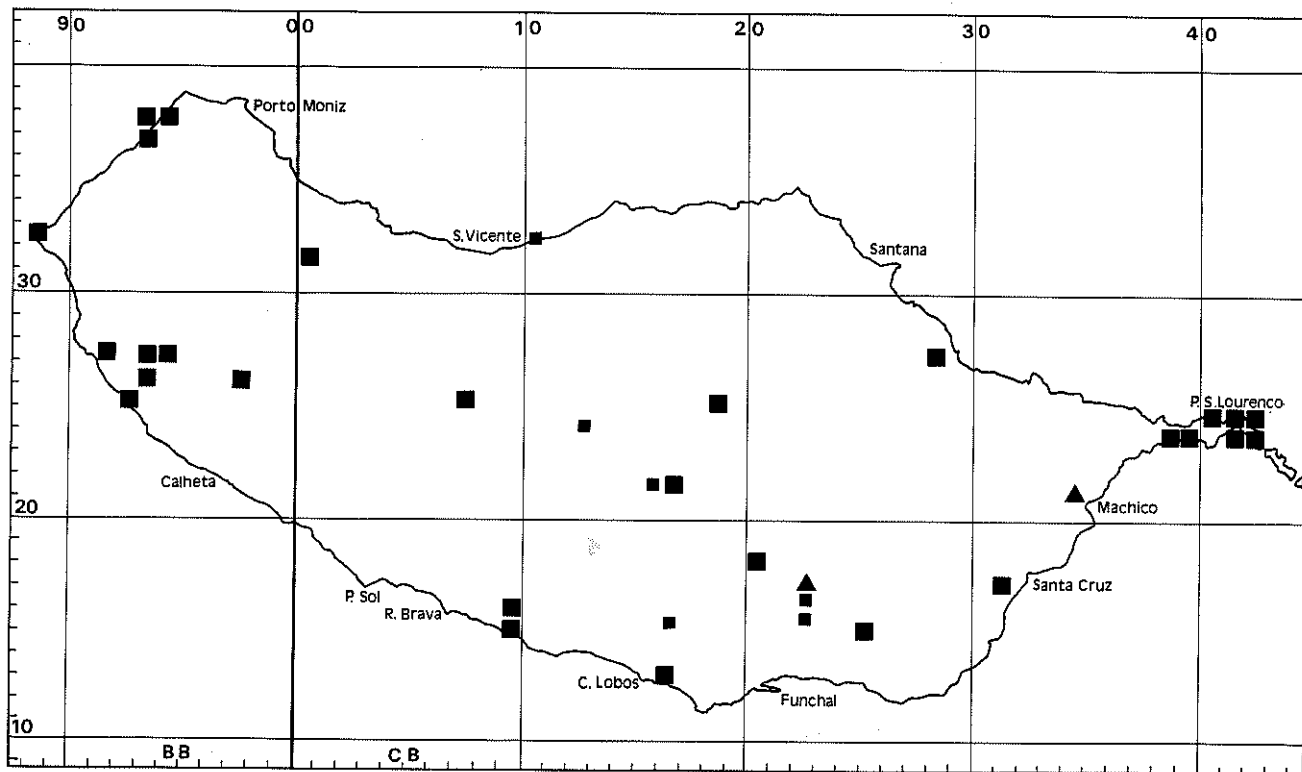


Fig. 32.- Map showing the distribution on Madeira Island of *Trichostomum crispulum* BRUCH. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

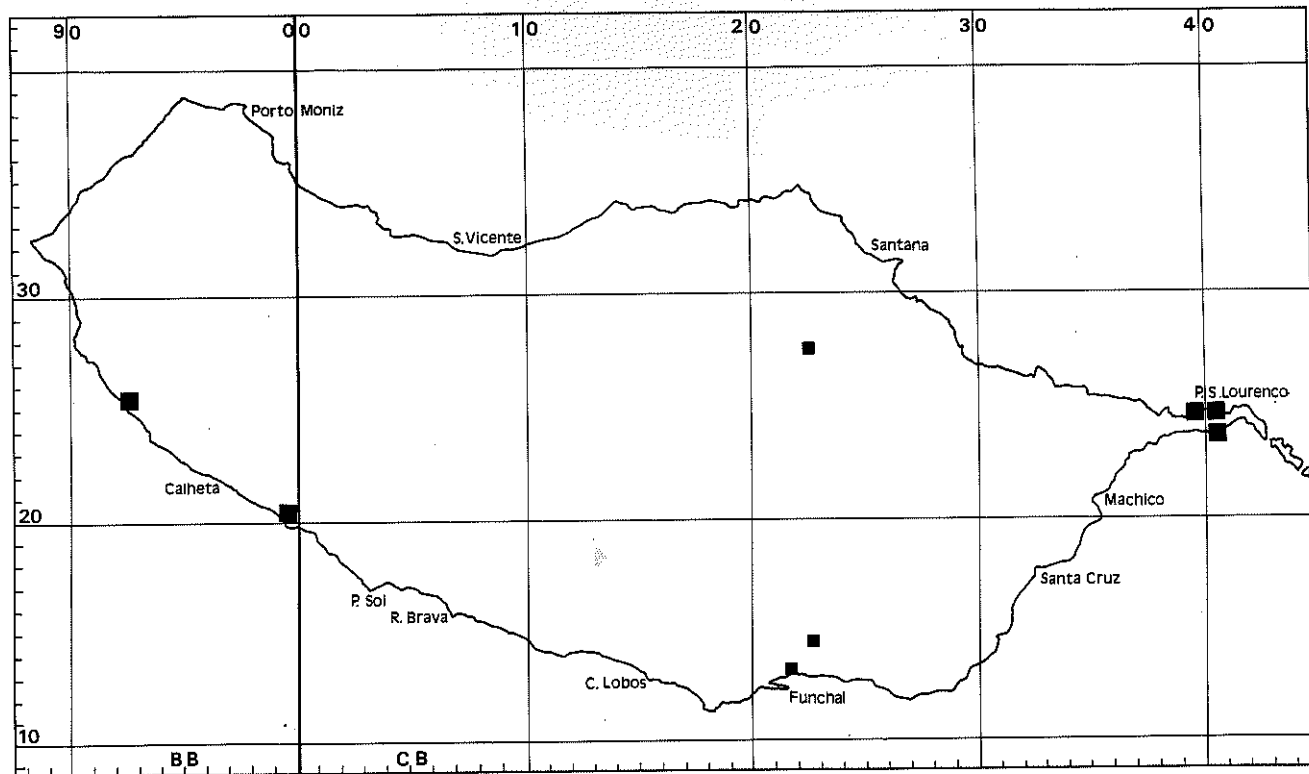


Fig. 33- Map showing the distribution on Madeira Island of *Weissia triumphans* (DE NOT.) M. HILL. Bibliographic references (▲, ▲) and herbarium specimens (■, ■), before 1950 and since 1950.

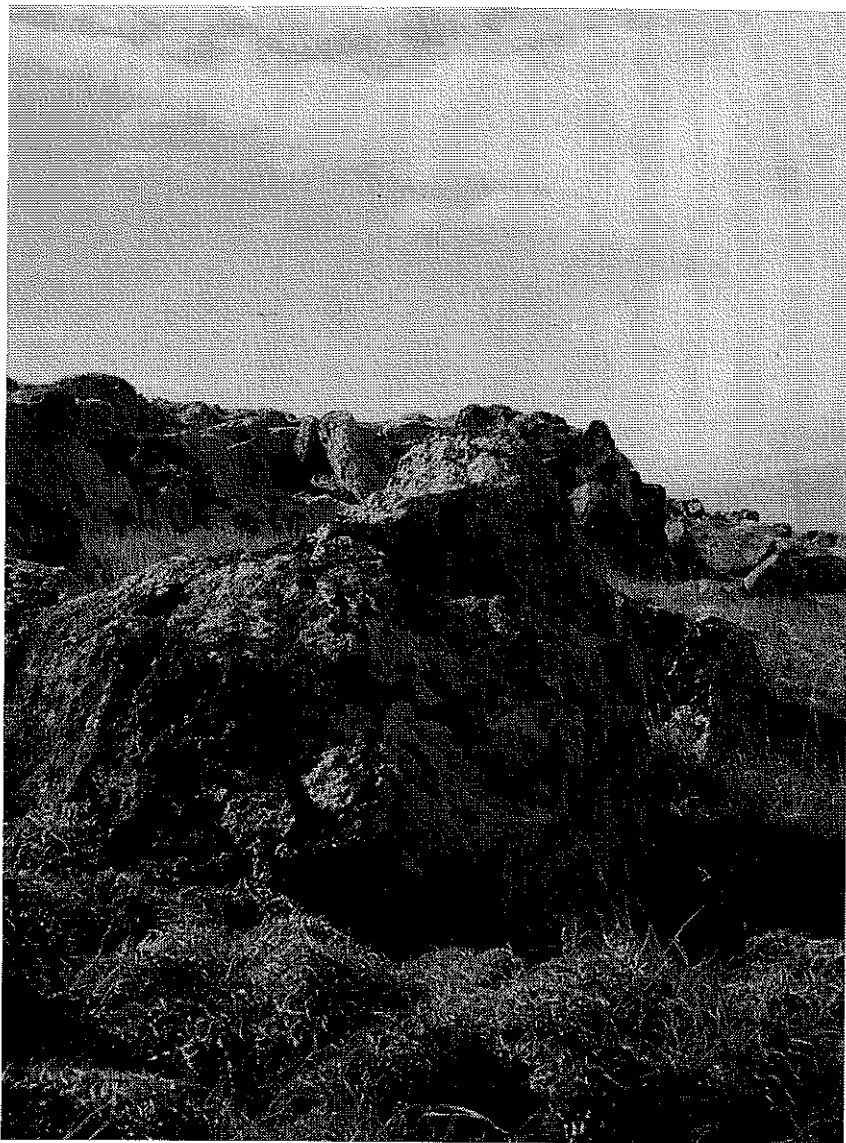


Fig. 34 - Coastal volcanic rocks in São Lourenço Cape, with an elevated cover degree of *Frullania ericoides* (NEES) MONT.