A STUDY OF THE VEGETATION OF THE PONTA DE SÃO LOURENÇO IN MADEIRA, ILHÉU CHÃO AND DESERTA GRANDE

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With 11 figures and 1 table

ABSTRACT. A vegetation transect was made on Madeira eastwards from Machico along the Ponta de São Lourenço. Similar transects were made from north to south on two of the Ilhas Desertas, Ilhéu Chão and Deserta Grande. The results were analysed using a reciprocal averaging algorithm. The results show the vegetation of Deserta Grande and the Ponta de São Lourenço have more in common than either has with Ilhéu Chão. Since the Ilhas Desertas are geologically similar, it seems that the differences between the vegetation on Ilhéu Chão and Deserta Grande are due to attempts at cultivation on the islands. Chi-square analysis of data from the Ponta de São Lourenço reveals two distinct associations of plant species, occurring east and west of Caniçal. The change is probably due to differences in grazing and higher drought tolerance of vegetation east of the village.

RESUMO. Foi analisada a vegetação ao longo de uma linha na parte leste da Madeira, a partir de Machico e ao longo da Ponta de S. Lourenço. Linhas semelhantes foram traçadas de Norte para Sul do Ilhéu Chão e na Deserta Grande. Os resultados foram analisados matematicamente e mostram que as vegetações da Deserta Grande e da Ponta de S. Lourenço têm mais em comum do que qualquer uma delas com a do Ilhéu Chão. Uma vez que as Ilhas Desertas são geologicamente semelhantes, parece que as diferenças entre as vegetações do Ilhéu Chão e da Deserta Grande são devidas a tentativas de cultivo das ilhas. A análise dos dados da Ponta de S. Lourenço pelo teste do Qui-quadrado revela duas associações distintas de espécies de plantas, ocurrendo a leste e a oste do Caniçal. A mudança é devida provavelmente a diferenças no pastoreio e a uma tolerância à secura mais elevada da vegetação a leste da Vila.

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INTRODUCTION

The Madeiran archipelago consists of the main island of Madeira, Porto Santo, and the three Ilhas Desertas (Fig. 1). The islands are of oceanic origin, most rocks being Tertiary. Madeira is roughly rectangular, about 55 km along the main axis from east to west, by 23 km, from north to south at its widest point. The steep topography of the island, which rises to 1860 m at Pico Ruivo, has greatly influenced the abundance of

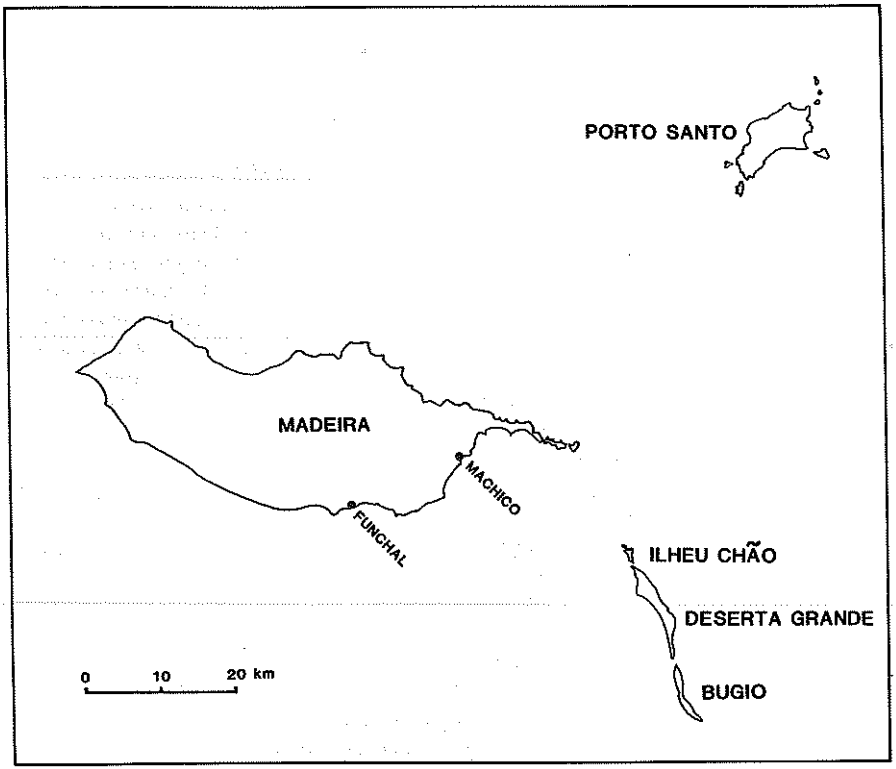

Fig. 1. — Map of the Madeiran archipelago showing the relative positions of the islands.

species. About 1100 vascular plant species occur on the island, of which 11 per cent are endemic. Lowe (1857) described four vegetation zones from Madeira; one tropical, one temperate and two montane zones. Sjögren (1972) divides the vegetation of Madeira into two distinct plant communities (alliances), each of which can be further subdivided. The first vegetation zone, the *Aeonio-Lytanthion,* is mainly coastal, on slopes up to 300 m in the south and 100 m on the north side. The association is

named after the differential species *Aeonium glandulosum* (Ait.) Webb & Berth., *Aeonium glutinosum* (Ait.) Webb & Berth. and *Lytanthus salicinus* (Lam.) Wettst. which frequently dominate the alliance. Sjögren also describes a *Clethro-Laurion* alliance, occurring in the humid cloud zone. The association is named after the two dominant tree species, *Clethra arborea* L. and *Laurus azorica* (Seub.) Franco.

Fieldwork was undertaken during July and August 1981, in conjunction with the Manchester University Expedition to Madeira. The aim was to study molluscs on Madeira, and see whether variation related to differences in vegetation. Vegetation was studied on the easternmost peninsula of Madeira, the Ponta de São Lourenço, and on the two northern Deserta Islands, Ilhéu Chão and Deserta Grande.

The Ponta de São Lourenço lies to the east of the fishing village of Caniçal. It is about 6 km from east to west, by 200 m - 2 km from north to south. In comparison with the remainder of the Island, the Peninsula is low-lying, rising to 180 m. There is a gradual slope from the higher north coast of the Peninsula to the south. The steep, south-facing slopes, above the cliffs between Caniçal and Machico, have been terraced for cultivation. Cattle and goats graze in the area. Riley (1925) thought the Caniçal region offered little of botanical interest since the soil is volcanic and the vegetation consequently scanty. The Ponta de São Lourenço includes the youngest part of Madeira (Mitchell-Thomé, 1979). At the eastern end of the Peninsula are two small islands, Ilhéu da Cevada and Ilhéu São Lourenço.

The uninhabited Deserta Islands lie 16 km southeast of Madeira, and form a chain 20 km long. The islands lack fresh water. The northernmost of the Deserta Islands, Ilhéu Chão, is also called Little Flat Deserta, as it is the smallest. It is 1.5 km by less than 0.5 km and has a flat plateau at about 100 m. The island is surrounded by cliffs. A narrow sea channel, about 500 m wide, separates Ilhéu Chão and Deserta Grande. Deserta Grande is 12 km by 0.5-2 km wide and up to 480 m high. The northern part of the island has two ridges separated by a deep valley. Colonization was attempted circa 1590, when the island was inhabited by nine men. The remains of buildings can be seen, and the remains of a chapel may date back to early 15th century (Hachette, 1956). The island is now home to seabirds, goats, rabbits and feral cats. Shearwaters have been slaughtered for their flesh, oil and feathers. At one time the lichen *Orchilla* was gathered on Deserta Grande, for use as a purple dye.

METHODS

A vegetation transect was made along the Ponta de São Lourenço, eastwards from the village of Machico (Fig. 2). A similar transect was made to study the snail fauna of the Peninsula (Cook, 1984). The vegetation was sampled at 98 sites, approximately 100 m apart (Fig. 2) Five

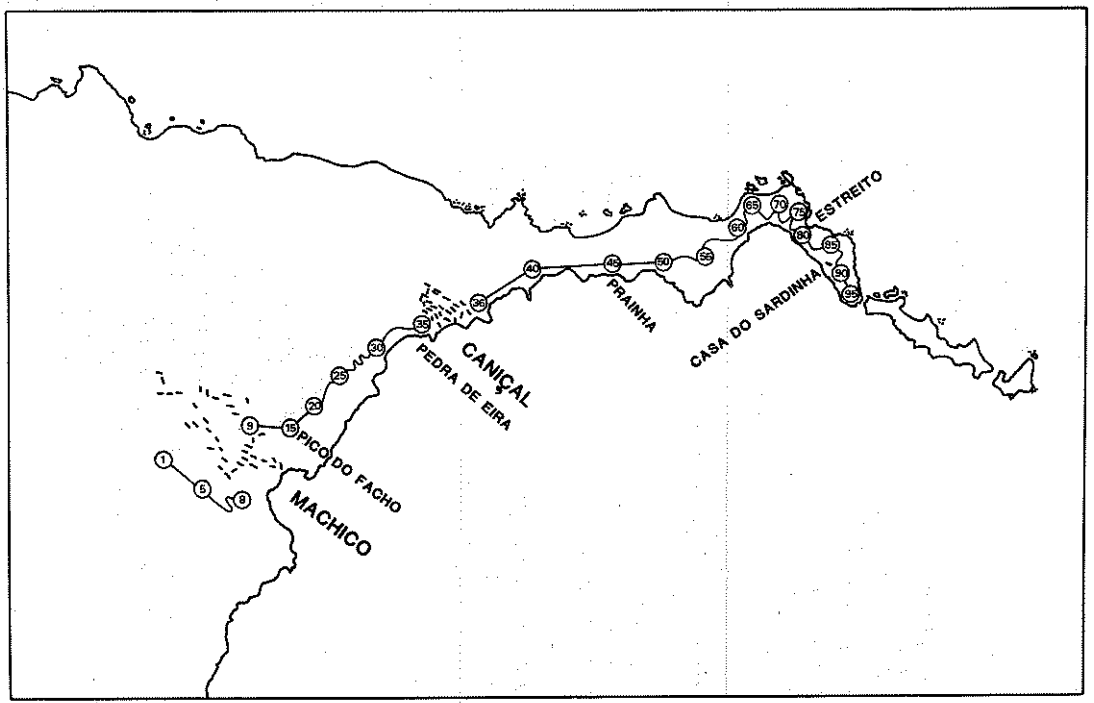

Fig. 2. — Map of the eastern peninsula of Madeira, the Ponta de São Lourenço, showing the transect route and site positions (numbered).

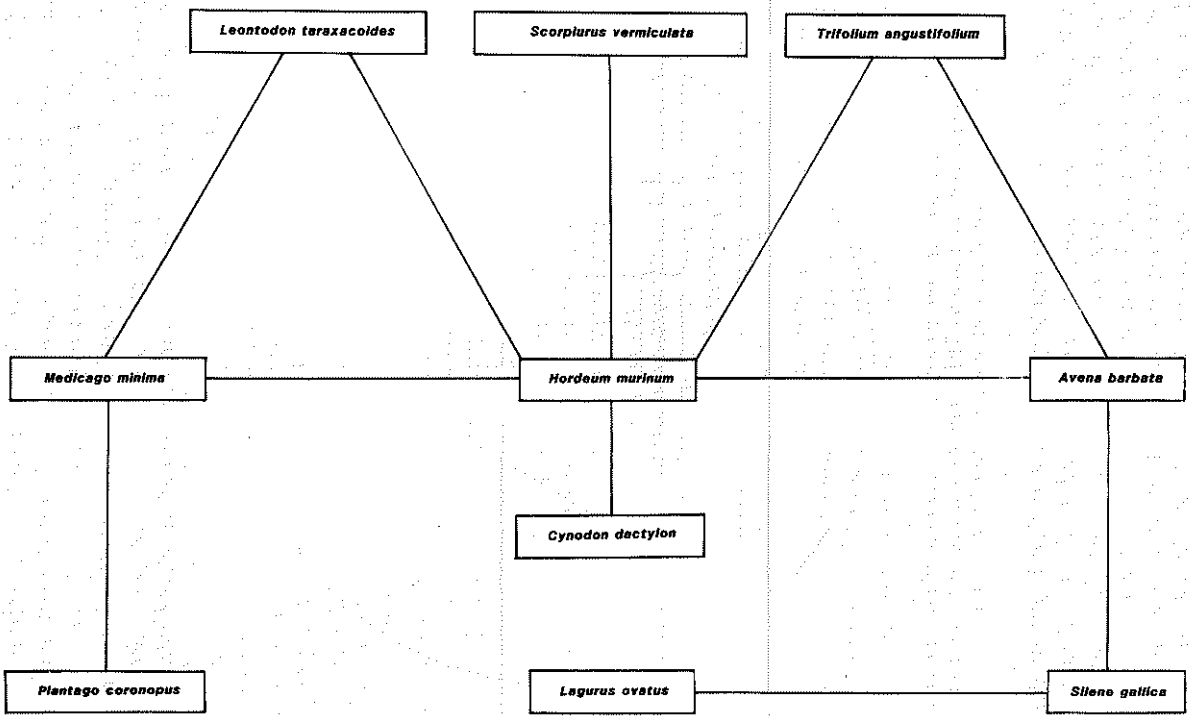

Fig. 3. — Diagram of the associations between plant species for sites east of Canical. The lines joining species represent associations significant at greater than 95 per cent.

25 × 25 cm quadrats were randomly placed at each site, and percentage cover of each plant species was recorded. Voucher specimens of most species were collected and are now in the herbarium of the British Museum (Natural History) (BM). The presence of rabbit droppings in each quadrat was recorded, to see whether there was any relationship between species present and rabbit grazing.

The transect followed a path along the south coast of the Ponta de São Lourenço. Site 1 was at the edge of *Pinus pinaster* woodland on a hill west of Machico. The two shrubby legumes *Sarothamnus scoparius*

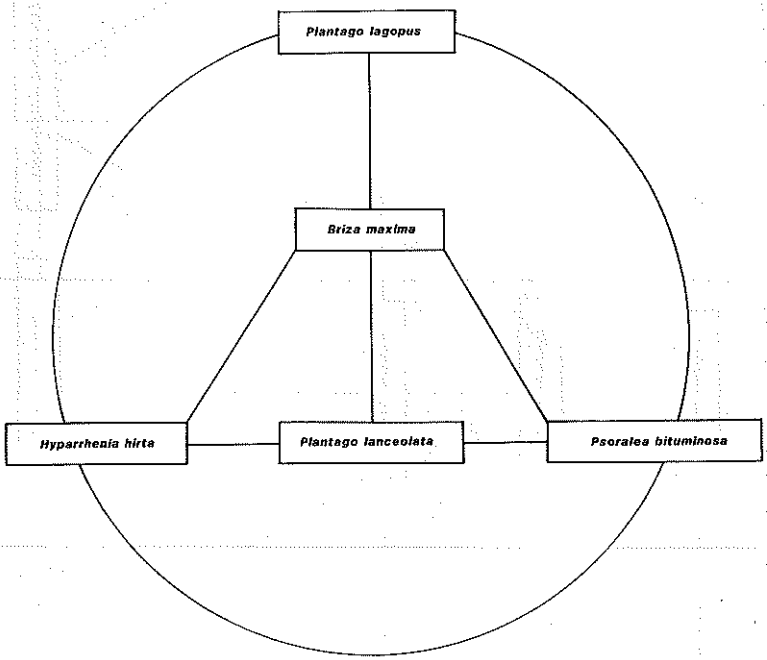

Fig. 4. — Diagram of the associations between plant species for sites west of Caniçal. The lines joining species represent associations significant at greater than 95 per cent.

(L.) Wimm. ex Koch and *Ulex europaeus* L. were dominant in the woodland undergrowth. All three species were introduced to Madeira (Hansen, 1969). From the edge of the wood, sites were sampled along a footpath into the village of Machico. The hillside west of Machico has been terraced for cultivation. Vegetation was not recorded in Machico, but the transect continued from east of the village towards Pico do Facho. From Pico do Facho, sites were sampled along a footpath leading to Caniçal. The path, at

about 300 m above sea level, twists around several valleys with slopes terraced where they were once cultivated. These sites contained *Gomphocarpus fruticosus* (L.) Ait. and *Opuntia tuna* (L.) Mill., both introduced to Madeira (Hansen, 1969). The last site west of Caniçal was at Pedra de Eira. East of Caniçal the transect continued, parallel to the road, initially passing a few scattered houses and Madeira's whaling station. Another introduced species, *Solanum sodomaeum* L., occurred just east of Caniçal. The transect crossed the Serra da Piedade, above the beach at Prainha. The Serra da Piedade, a hillock reaching 108 m, is on a small area of shellsand. The vegetation here consisted of a grassy sward, the two dominant grass species being *Cynodon dactylon* (L.) Pers. and *Hordeum murinum* L. The composite *Cynara cardunculus* L. was abundant on the hillock which is heavily grazed by cattle. The spiny leaves of *Cynara* are presumably unpalatable to cattle. From the Serra da Piedade, the transect ran between the south coast of the Peninsula and the road. At the end of the road it followed a footpath to the eastern end of the Peninsula.

On Deserta Grande, vegetation was sampled from the north of the island, near Ponta da Castanheira southwards to the disused building near Pedregal. Fourteen sites were sampled along the transect, which followed the main valley of the island. On Ilhéu Chão a transect containing thirteen sites was made from north to south across the island plateau.

The data from the transects were reduced to a presence/absence format. Chi-square tests were carried out to detect associations between species pairs (Kershaw, 1973). Those significant at 95 per cent or more were represented diagrammatically (Figs. 3 and 4). The data were also analysed using a reciprocal averaging algorithm (Hill, 1973). The method, although similar to principal components analysis, simultaneously ordinates both sites and species in multi-dimensional space. A good species ordination is used to derive the site ordination and vice versa. The algorithm was used to analyse the data for the three transects collectively, and also the Ponta de São Lourenço data alone. The Ponta de São Lourenço data were analysed separately to see whether the method detected a change in vegetation. Sites 49, 63 and 64 on the Ponta de São Lourenço transect were omitted from the analysis, since no plants were present.

RESULTS

The Ponta de São Lourenço transect contained 62 plant species (64 numbers as two species were recorded twice), while that on Ilhéu Chão had 19 species and the Deserta Grande transect contained eight species.

The results from the reciprocal averaging were plotted graphically. The positions of sites on the Deserta Grande, Ilhéu Chão and Ponta de São Lourenço transects were plotted on the first two axes (Fig. 5) and axes 2 and 3 (Fig. 6). Species were plotted on the first two axes (Fig. 7).

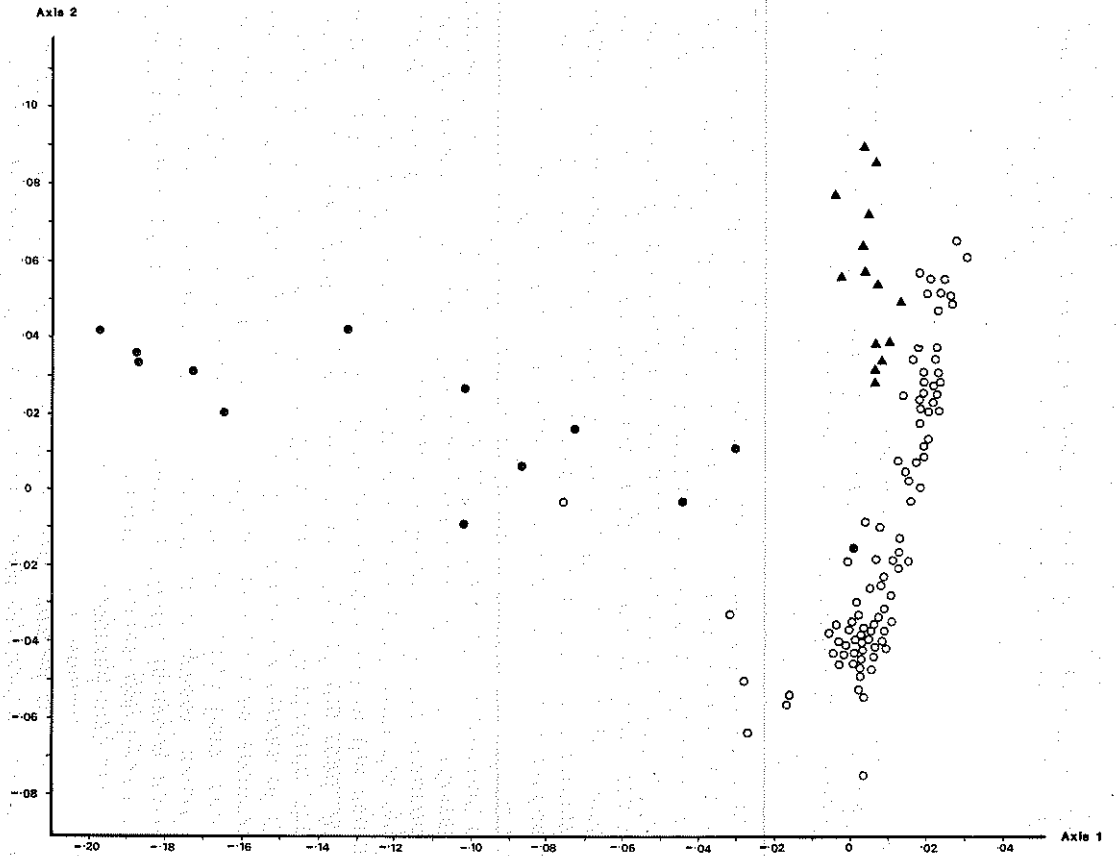

Fig. 5 — Graph obtained by reciprocal averaging of data from the Deserta Grande (▲), Ilhéu Chão (●) and Ponta de São Lourenço (○) transects. Sites are plotted on axes 1 and 2.

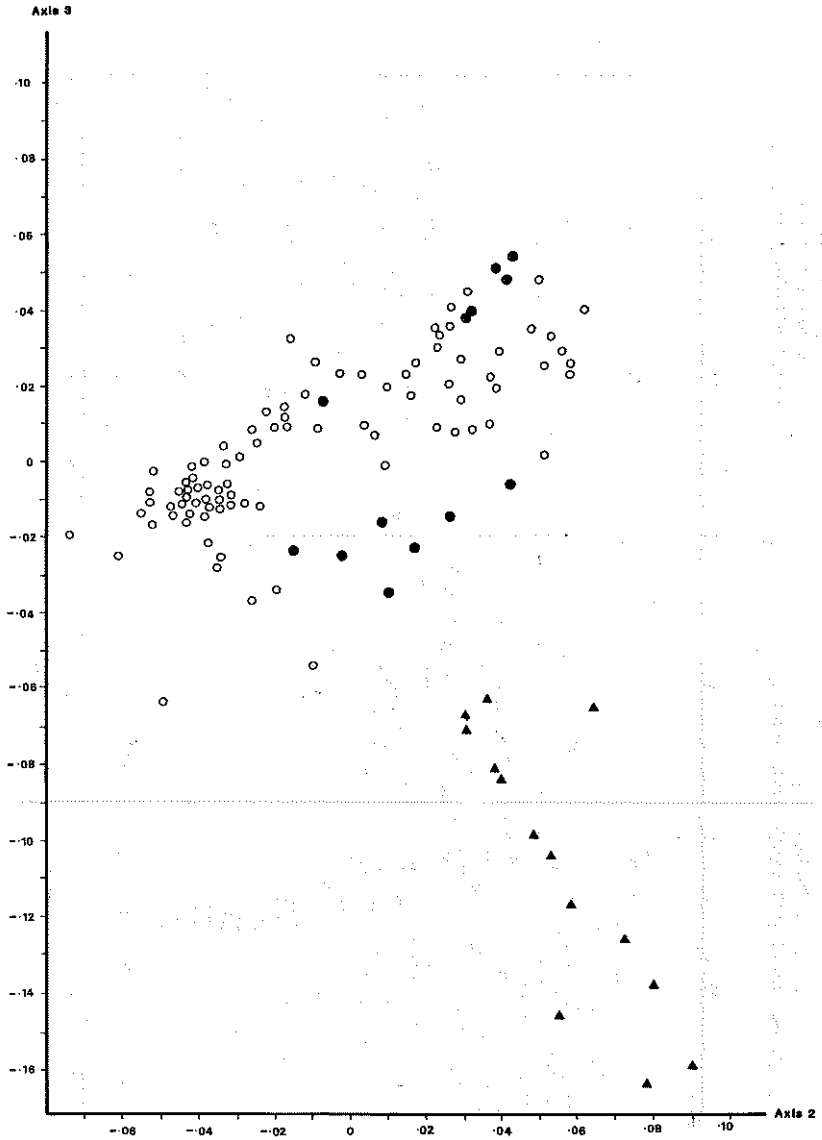

Fig. 6. — Graph obtained by reciprocal averaging of data from the Deserta Grande (▲), Ilhéu Chão (●) and Ponta de São Lourenço (○) transects. Sites are plotted on axes 2 and 3.

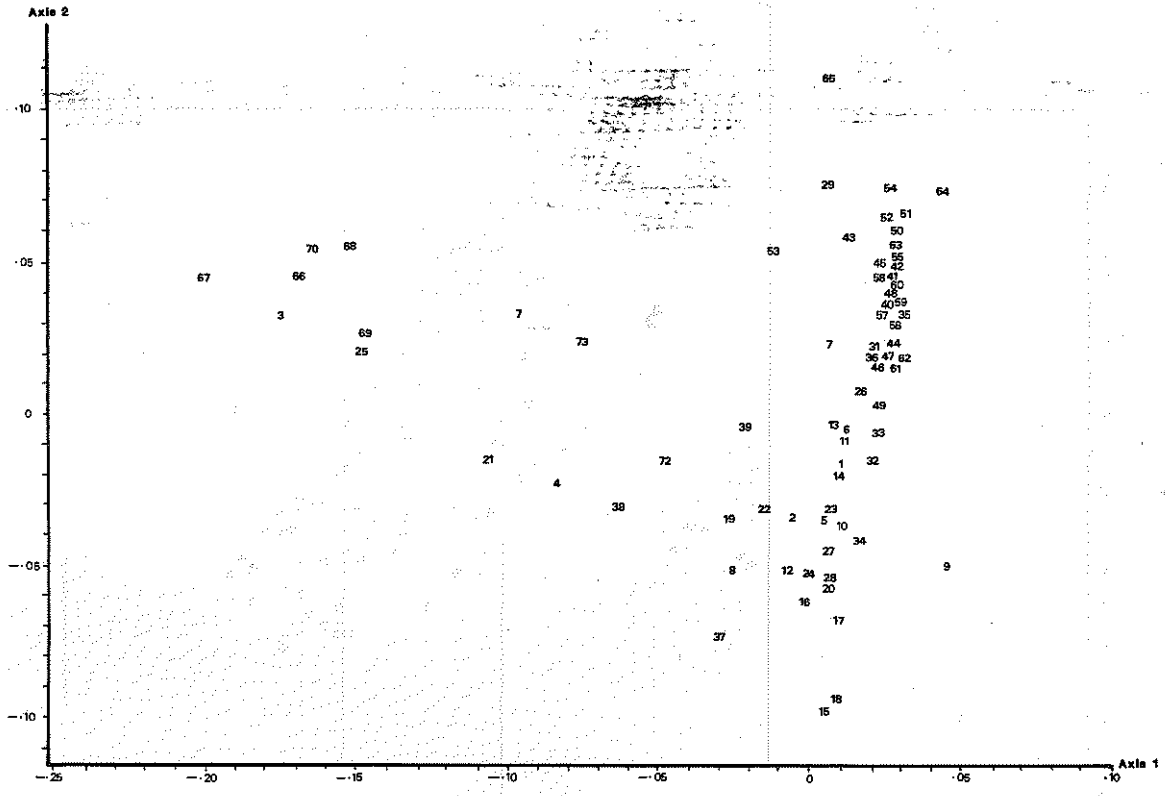

Fig. 7. — Positions of species from the Deserta Grande, Ilhéu Chão and Ponta de São Lourenço transects, plotted on axes 1 and 2 after reciprocal averaging. A key to species is given in Table 1.

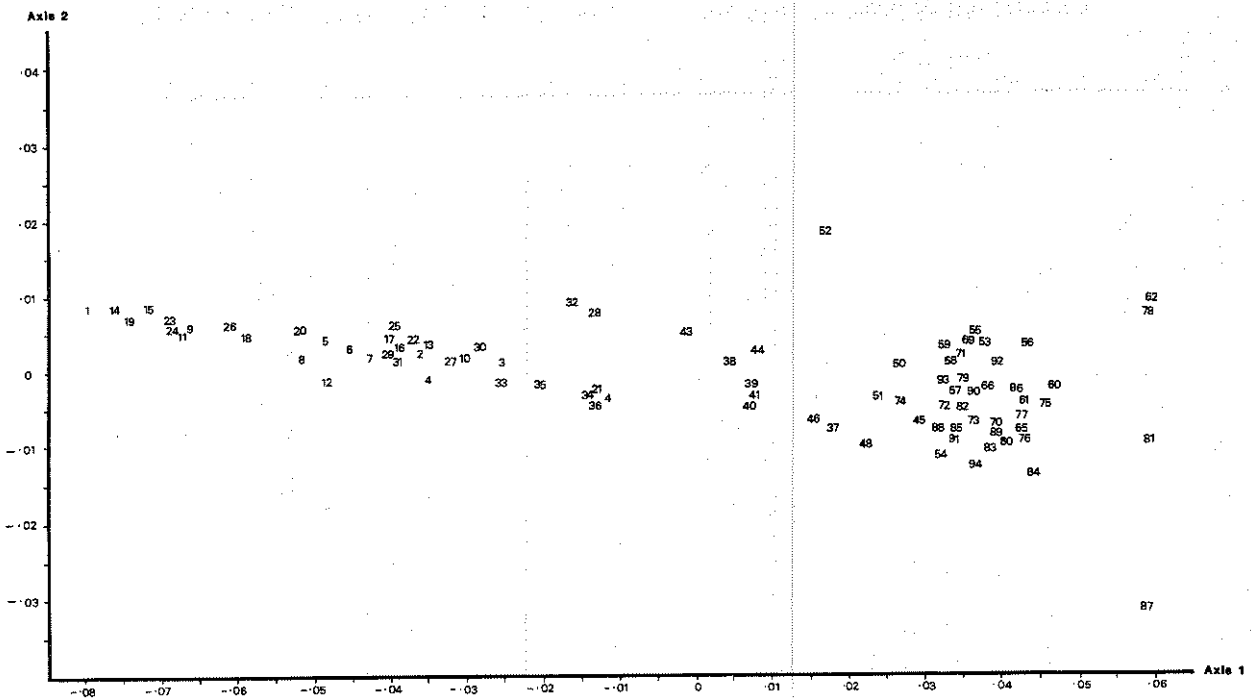

Fig. 8. — Graph obtained by reciprocal averaging of data from the Ponta de São Lourenço transect. Sites are plotted on axes 1 and 2.

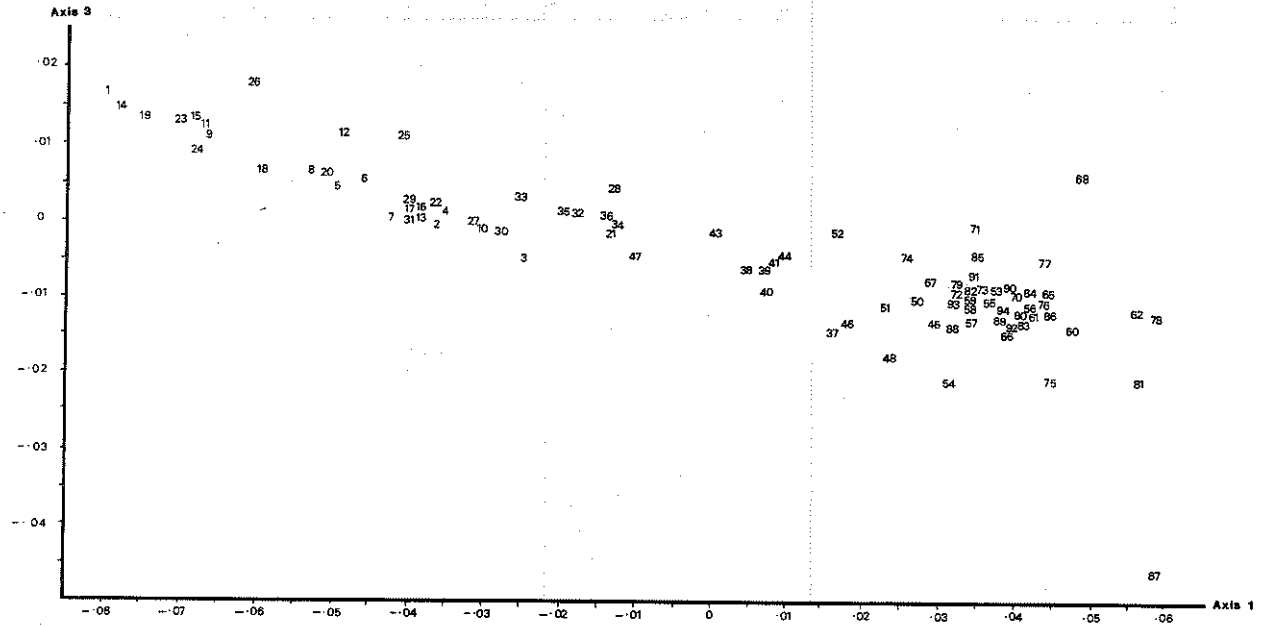

Fig. 9. — Graph obtained by reciprocal averaging of data from the Ponta de São Lourenço transect. Sites are plotted on axes 1 and 3.

The Ponta de São Lourenço sites were plotted on axes 1 and 2 (Fig. 8) and axes 1 and 3 (Fig. 9). Sites 42 and 94 were omitted from Figs. 8 and 9, since they occur off the scale. [The co-ordinates, on axes (1, 2, 3) for site 42 are (0.10, 0.40, 0.27), and those for site 95 are (0.06, -0.29, 0.40)]. Species from the Ponta de São Lourenço were plotted on axes 1 and 2 (Fig. 10). A key to species is given in Table 1. Species 3 and 4, *Mesembryanthemum crystallinum* L. and *Emex spinosa* Campd. occur at identical points (0.08,-0.40) off the scale of Fig. 10. Species 37 and 38, *Polygonum maritimum* L. and *Lotus glaucus* Aiton, also off the scale, have co-ordinates (0.12, 0.55). If these sites and species had been included by plotting points on a smaller scale, the patterns produced by the remaining sites and species would have been obscured.

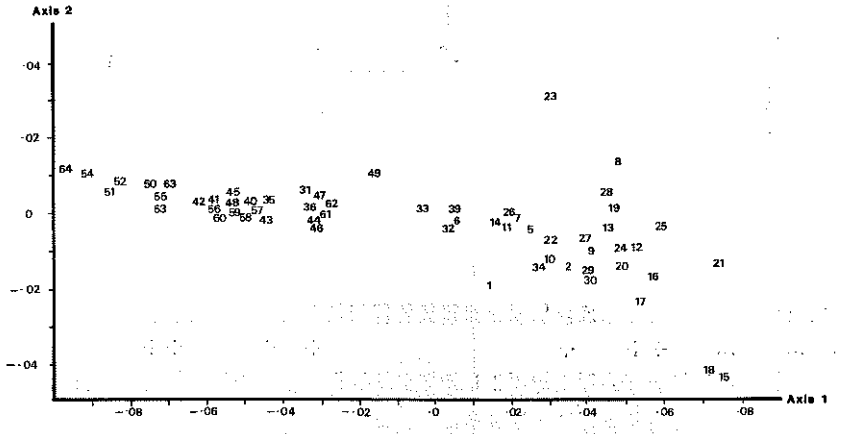

Fig. 10. — Positions of species from the Ponta de São Lourenço transect plotted on axes 1 and 2 after reciprocal averaging. A key to species is given in Table 1.

The plots for the first three axes of the reciprocal averaging results for the Ponta de São Lourenço data (Figs. 8 and 9), split sites 1-36 and site 47 into one group and sites 37-94 (excluding site 47) into another. The change in vegetation thus detected occurs at the village of Caniçal Sites 1-36 are west of Caniçal and sites 37-94 are east of the village. The sites plotted on axes 1 and 3 (Fig. 9) show the same split in vegetation as sites plotted on the first two axes (Fig 8).

60 per cent of sites west of Caniçal showed evidence of rabbits, compared to 47 per cent of sites in the association east of the village. On Deserta Grande all sites contained rabbit droppings, while there were none in the Ilhéu Chão sites. 20.6 per cent of sites west of Caniçal contained plant species not indigenous to the Madeiran archipelago, while the sites east of Caniçal contained 20 per cent introduced species, Deserta Grande contained 12.5 per cent and Ilhéu Chão 10.5 per cent.

TABLE 1. — LIST OF SPECIES FOUND ON DESERTA GRANDE, ILHÉU CHÃO AND PONTA DE SÃO LOURENÇO. INTRODUCED SPECIES (+) AND ENDEMICS (E) ARE INDICATED.

1	+	*Centaurea melitensis* L.
2		*Hordeum murinum* L.
3	+	*Mesembryanthemum crystallinum* L.
4		*Emex spinosa* Campd.
5		*Leontodon taraxacoides* (Vill.) Mérat
6		*Lagurus ovatus* L.
7		*Silene gallica* L.
8		*Medicago minima* Lam.
9		*Reseda luteola* L.
10		*Cynara cardunculus* L.
11		*Avena barbata* Pott. ex Link
12		*Mesembryanthemum nodiflorum* L.
13		*Rapistrum rugosum* (L.) All.
14		*Trifolium angustifolium* L.
15		*Cichorium endivia* L.
16		*Phalaris caerulescens* Desf.
17		*Prunella vulgaris* L.
18		*Galactites tomentosa* (L.) Moench.
19		*Plantago coronopus* L.
20		*Sonchus oleraceus* L.
21		*Trofolium scabrum* L.
22		*Scorpiurus vermiculata* L.
23		*Cynodon dactylon* (L.) Pers.
24		*Biserrula pelecinus* L.
25		*Suaeda vera* J. F. Gmel.
26		*Plantago lagopus* L.
27		*Ammi majus* L.
28		*Anagallis arvensis* L.
29		*Holcus lanatus* L.
30	+	*Phalaris tuberosa* L.
31		*Vicia* sp.
32		*Hainardia cylindricus* (Willd.) W. Greuter
33	+	*Scolymus maculatus* L.
34		*Agropyron repens* (L.) Beauv.
35		*Hyparrhenia hirta* (L.) Stapf.
36		*Linum strictum* L.
37		*Polygonum maritimum* L.
38		*Lotus glaucus* Aiton
39		*Phagnalon saxatile* (L.) DC.
40		*Psoralea bituminosa* L.
41		*Plantago lanceolata* L.
42	+	*Paspalum dilatatum* Poir.
43	+	*Picris echioides* L.
44		*Cynosurus echinatus* L.
45		*Briza maxima* L.
46		*Anchusa azurea* Mill.
47	+	*Opuntia tuna* (L.) Mill.
48		*Centaurium tenuiflorum* (Hoffm. & Link) Fritsch
49	+	*Gomphocarpus fruticosus* (L.) R. Br.
50		*Rubus* sp.
51		*Lytanthus salicinus* (L.) Wettst.
52		*Plantago arborescens* Poir. var.
53		*Gastridium ventriculosum* (Gouan) Sch. & Thell.
54		*Erica scoparia* L.
55		*Poa* sp.
56		= 32
57		= 44
58		*Trifolium repens* L.
59		*Briza minor* L.
60	+	*Ulex europaeus* L.
61		*Trifolium campestre* Schreb.
62		*Ornithopus pinnatus* (Miller) Druce
63	+	*Pinus pinaster* Aiton
64	+	*Sarothamnus scoparius* L.
65		*Pteridium aquilinum* (L.) Kuhn
66		*Lotus argenteus* Webb
67	E	*Artemesia argentea* L.
68		*Silene vulgaris* (Moench) Garcke
69		*Asphodelus fistulosus* L.
70	E	*Calendula maderensis* Lowe
71		*Echium plantagineum* L.
72	E	*Andryala glandulosa* Lam.
73		*Jasminum odoratissimum* L.

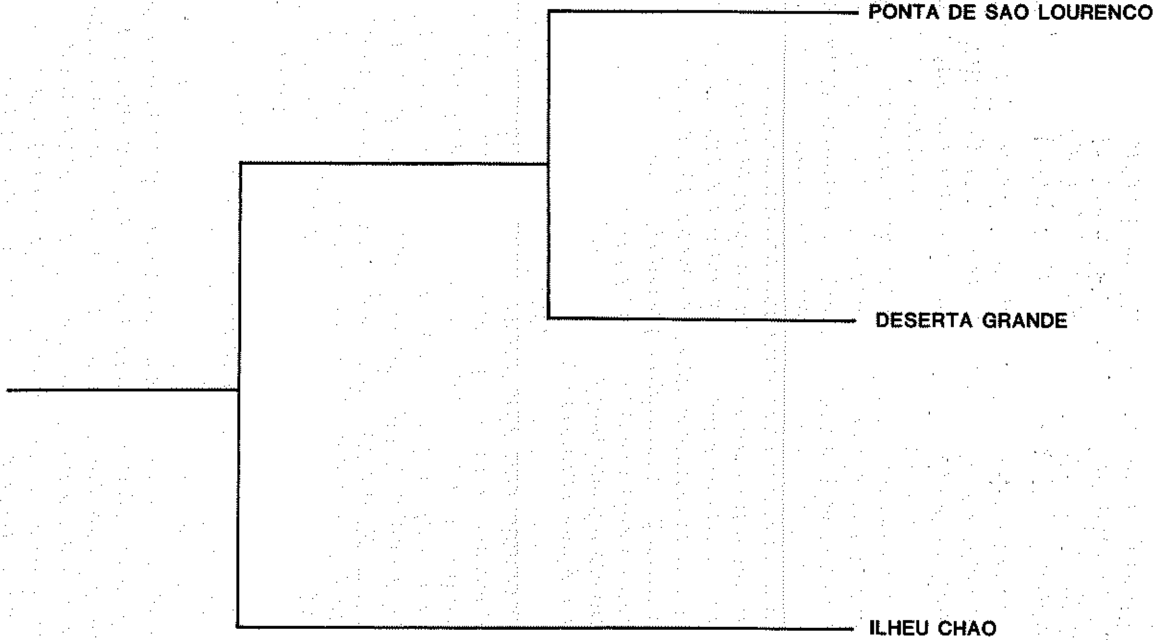

Fig. 11. — Diagram showing the relationships between Deserta Grande, Ilhéu Chão and the Ponta de São Lourenço, as shown by reciprocal averaging analysis of vegetation transects.

The graphs obtained by reciprocal averaging of data for the three transects (Figs. 5 and 6) show the sites from Ilhéu Chão separate from the Deserta Grande and Ponta de São Lourenço sites in the first two axes. The Deserta Grande sites separate when plotted on the second and third axes. With respect to vegetation, Deserta Grande and the Ponta de São Lourenço therefore have more in common than either has with Ilhéu Chão. The relationship thus shown between vegetation of the two Deserta Islands studied and the Ponta de São Lourenço is given schematically in Fig. 11.

DISCUSSION

The results produced by reciprocal averaging (Fig. 11) show a close relationship between the vegetation of Deserta Grande and the Ponta de São Lourenço for the following reasons. The Ilhéu Chão transect contains eight species (42.1 per cent) unique to the transect. Species occur together on the Chão transect which seldom occur in the same sites of the other two transects. For example, *Mesembryanthemum crystallinum* L. and *Suaeda vera* J. F. Gmel. occur together in 30.8 per cent of Chão sites, but are never together in the other transects. The Ilhéu Chão and Deserta Grande transects share only one species, showing little in common between the two islands.

The Deserta Grande transect contained only one species, *Pteridium aquilinum* (L.) Kuhn, found in neither the Ponta de São Lourenço or Chão transects. The Ilhéu Chão transect contained eight unique species: *Lotus argenteus* Webb, *Artemisia argentea* L., *Silene vulgaris* (Moench) Garcke, *Asphodelus fistulosus* L., *Calendula maderensis* Lowe, *Echium plantagineum* L., *Andryala glandulosa* Lam. and *Jasminum odoratissimum* L. The Ponta de São Lourenço transect contained one endemic, 1.6 per cent of the total species in the transect, *Plantago arborescens* Poir. var. *maderensis* (Dcne.) Pilg. The Ilhéu Chão transect contained four species endemic to the Madeiran Archipelago, 21 per cent of the plants found on the transect: *Artemisia argentea* L., *Calendula maderensis* Lowe, *Andryala glandulosa* Lam. and *Jasminum odoratissimum* L. The Deserta Grande transect contained no endemic species.

From the species and site plots for the first three axes (Figs. 5, 6 and 7), the following species are significant in the Ilhas Desertas transects, with endemics (E) and introduced species (+) shown.

Ilhéu Chão; *Artemisia argentea* l'Hérit. (E), *Silene vulgaris* (Moench) Garcke, *Asphodelus fistulosus* L., *Calendula maderensis* Lowe (E), *Echium plantagineum* L., *Andryala glandulosa* Lam. (E) and *Jasminum odoratissimum* L. (E).

Deserta Grande; *Gastridium ventriculosum* (Gouan) Sch. & Thell., *Picris echioides* L. (+), *Holcus lanatus* L. and *Pteridium aquilinum* (L.) Kuhn.

Species shown to occur together at significant levels by the chi-square associations were plotted diagrammatically, producing two distinct web-like patterns (Figs. 3 and 4). The species in the two webs occur mainly in sites east and west of Caniçal respectively. From chi-square associations significant at above 95 per cent, species important in the association east of Caniçal are: *Trifolium angustifolium* L., *Avena barbata* Pott. ex Link, *Silene gallica* L., *Lagurus ovatus* L., *Hordeum murinum* L., *Leontodon taraxacoides* (Vill.) Mérat., *Medicago minima* L., *Scorpiurus vermiculata* L., *Cynodon dactylon* (L.) Pers. and *Plantago coronopus* L. The species in this association are all extremely drought-tolerant. The Ponta de São Lourenço is the driest area of Madeira, with about 400 mm rain per annum. The Peninsula east of Caniçal has a fairly low-lying, undulating topography, averaging about 100 m above sea level and reaching a maximum of 180 m just above the narrow isthmus at Estreito. The plants in this association are all annuals, with the exception of *Leontodon taraxacoides* (Vill.) Mérat., which can be annual or perennial, *Plantago coronopus* L. which is annual, biennial or perennial and *Cynodon dactylon* (L.) Pers. which is perennial.

All species occurring in this portion of the transect are herbaceous; there were no shrubs or trees present. The area east of Caniçal has suffered severe soil erosion in places, partly because heavy grazing has broken the vegetation cover. The association east of Caniçal corresponds with that described by Sjögren (1972), from a site on the Serra da Piedade, at Prainha. He calls the association *Biserrulae-Scorpiuretum,* after two leguminous annuals *Biserrula pelecinus* L. and *Scorpiurus vermiculata* L. Evidence of *Biserrula* was rare in the Ponta de São Lourenço transect, but it may have produced fruits and died back by late July/early August when fieldwork was carried out. In late April, when Sjögren undertook fieldwork on the Peninsula, different species may have been evident. Sjögren (1972) recorded *Hyparrhenia hirta* (L.) Stapf., *Tolpis fruticosa* Schrank, *Crithmum maritimum* L., *Plantago coronopus* L., *Briza maxima* L. and *Echium plantagineum* L. from Serra da Piedade. This was at approximately the same locality as site 45 of the Ponta de São Lourenço transect which contained *Lagurus ovatus* L., *Cynara cardunculus* L., *Avena barbata* Pott. ex Link, *Trifolium angustifolium* L., *Prunella vulgaris* L., *Scorpiurus vermiculata* L., *Cynodon dactylon* (L.) Pers., *Ammi majus* L. and *Linum strictum* L.

From the chi-square associations calculated, species significant in the association west of Caniçal (Fig. 4) are *Hyparrhenia hirta* (L.) Stapf., *Psoralea bituminosa* L., *Plantago lanceolata* L., *Briza maxima* L. and *Plantago lagopus* L. The species in this association are all perennial, with the exception of *Briza maxima* L., which is annual. The association corresponds with that described by Sjögren (1972) as *Hyparrhenietum hirtum.* The land west of Caniçal rises steeply to 332 m at Pico do Facho, and the coastal path, along which vegetation was sampled, averages 300 m above sea level. The rainfall here is slightly higher than in the low-lying eastern

part of the Peninsula, although the soil is porous and water drains rapidly. Consequently, the plants in this association are slightly less drought tolerant than those of the *Biserrulae-Scorpiuretum*. Rocky outcrops are abundant on the slopes.

CONCLUSION

The results produced by the reciprocal averaging algorithm on data from transects on the Ponta de São Lourenço and two Ilhas Desertas show a closer relationship between the vegetation of Deserta Grande and the Ponta de São Lourenço, than between Deserta Grande and Ilhéu Chão (Fig. 11). Ilhéu Chão and Deserta Grande are separated by 500 m, while the eastern end of the Ponta de São Lourenço is 16 km northwest of Ilhéu Chão. One would therefore expect the vegetation of the two islands to be most similar. The Ilhas Desertas are basaltic, of volcanic origin and of similar age. They are connected by a submerged land bridge at 100-140 m below sea level (Morais, 1945 and 1948). The Archipelago was uplifted by about 400 m after the Miocene (Mitchell-Thomé, 1974 and Morais, 1945). The Ilhas Desertas and the Ponta de São Lourenço region of Madeira would then have become exposed. The relationships between vegetation in the three areas, therefore, cannot be explained by geological differences. It seems likely that the differences have been brought about by man's intervention, since the Island's discovery early in the 15th century.

Of the plants found on the Ilhéu Chão transect, *Mesembryanthemum crystallinum* L. and *Suaeda vera* Forssk. were both once cultivated on the Island for burning to yield soda (Lowe, 1857). From the percentage cover data, *Suaeda vera* Forssk. was the most abundant plant on the Chão transect, and *Mesembryanthemum crystallinum* L. ranked fourth of the nineteen species. It seems that following their cultivation on the island, these species have remained dominant and caused the vegetation on Ilhéu Chão to be very different from either Deserta Grande or the Ponta de São Lourenço. It is also significant that there appeared to be no living rabbits on Ilhéu Chão while rabbits are very abundant on Deserta Grande and occur on the Ponta de São Lourenço.

The reciprocal averaging results show a change in the vegetation of the Ponta de São Lourenço region, with different plant associations east and west of Caniçal. The geological map of Madeira produced by Zbyszewski and da Veiga Ferreira (1975) shows no geological change at Caniçal. Sjögren (1972) said that the geology of Madeira is monotonously basaltic and therefore has no influence on the differentiation of vegetation. The change in vegetation at Caniçal cannot therefore be explained geologically. The change is probably brought about by differences in grazing east and west of the village and also the lower rainfall on the low peninsula east of Caniçal, resulting in higher drought tolerance of the vegetation.

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