THE INVERTEBRATE FAUNA OF EARLY SUCCESSIONAL VOLCANIC HABITATS IN THE AZORES

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With 2 figures and 1 table

ABSTRACT. Standardized trapping and searching was used to investigate the arthropod fauna of recent lavas in four different islands of the Azores (S. Miguel, Terceira, Pico and Faial). Seventeen sites were chosen for the study, from seashore up to 2,400 m a.s.l., and varying from absolutely barren lava and tephra to vegetated lava flows. Results are presented graphically and in the form of an annotated systematic account.

The mild, humid climate of the islands is responsible for rapid primary succession, so that there are few barren lavas with animal communities supported by biological fallout. The sites at Capelinhos volcano, on land formed in 1957-58, were the only ones containing true lavicolous species. High altitude sites also have significant fallout of windborne debris, but resident arthropods there are similar to those in the surrounding vegetated areas. All sites in general produced a substantial number of animals, but the variety of species was substantially higher in vegetated lavas.

RESUMO. O presente trabalho relata o estudo dos artrópodes em áreas constituídas por substratos vulcânicos recentes em algumas ilhas do arquipélago dos Açores (S. Miguel, Terceira, Pico e Faial). Os resultados são apresentados sob a forma de uma listagem sistemática e indiciam a ocorrência de sucessões ecológicas na maioria dos locais estudados, os quais indiciam a ocorrência de sucessões ecológicas na maioria dos locais estudados, os quais apresentam composições faunísticas semelhantes a outros de natureza diferente.

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INTRODUCTION

The Azores lie in the same general part of the Atlantic as Madeira and the Canary Islands, and have closely related biota. These archipelagos (plus the Cape Verde Islands) are often considered to form a biogeographic unit called Macaronesia. However, the flora and fauna of the Azores are much less diverse than those of the other archipelagos, and various factors are probably responsible for this. First, the Azores are nearly in the centre of the Atlantic, between 1400 and 2100 km to the west of the Iberian Peninsula and more than 1900 km from the nearest part of North America (Newfoundland); the two western islands, Flores and Corvo, are west of the mid-atlantic ridge. Second, the winds and ocean currents are predominantly from the west, and thus not favourable for colonization of the islands from Europe or Africa. Third, the relatively high latitude position of the Azores (between 37 and 40°N) probably resulted in strong climatic fluctuations during the Pleistocene (RUDDIMAN & McINTYRE, 1977). Finally, the rocks so far dated indicate that the islands of Santa Maria and São Miguel, forming the eastern group, have (minimum) ages of only about 5 and 4 Ma respectively, while the central and western groups are respectively less than 3 Ma and less than 1 Ma (FERAUD *et al.*, 1980; V. H. FORJAZ, pers. comm.).

During previous work in the Canaries (MARTÍN *et al.*, 1987, ASHMOLE *et al.*, 1992) we have demonstrated that the fauna of the surface of recent lava flows shows interesting relationships with that of the caves within the flows. For this reason, although the primary purpose of our expeditions to the Azores was the investigation of the cavernicolous fauna, we also planned sampling in recent surface volcanic habitats. Barren lava flows and pyroclastic deposits form aeolian ecosystems in which predatory and scavenging invertebrates feed on biological fallout: plant and animal material (especially dispersing insects) brought by the wind from areas where significant primary production occurs.

Primary succession, however, is evidently much faster in the Azores - which are extremely humid - than in the relatively dry Canary Islands. On the Azores it was hard to find lava without dense vegetation, and in fact it was noticeable that much of the best development of indigenous forest was on relatively recent lava flows. The surface fauna of such flows, at a relatively late stage of plant succession, has little in common with the fauna of the associated caves, and we spent little time working on them. There are, however, some historic lava flows that do not yet have significant numbers of higher plants. Some coastal and high altitude sites, though older, also have sparse vegetation and show some similarity to the younger flows. In all, we sampled surface volcanic substrates at about 14 sites where vegetation was sparse or lacking, as well as 3 with more developed vegetation cover. These sites are briefly described in the next section.

TABLE I - Epigean volcanic substrates in the Azores sampled in 1987 and 1989. Lava flows from historic eruptions are indicated by dates in brackets. Quotation marks indicate informal names used to identify sites.

Recent barren volcanic substrates (1957-58)		
Faial	Vulcão dos Capelinhos «Crater»	(UTM 0340 4274, ca. 120 m a.s.l.)
	Vulcão dos Capelinhos «Lava»	(UTM 0340 4274, ca. 65 m a.s.l.)
	Vulcão dos Capelinhos «Cliff» [1]	(UTM 0341 4274, 130 & 30 m a.s.l.)
	Vulcão dos Capelinhos «Shore» [2]	(UTM 0340 4273, < 5 m a.s.l.)
Recent volcanic ash (1957-58) on older rock, with some vegetation		
Faial	Costa da Nau	(UTM 0341 4274, 100 m a.s.l.)
Coastal pahoehoe lava, largely lacking vegetation because of proximity to sea		
Terceira	Porto Judeu «Agulhas»	(UTM 0490 4277, < 20m a.s.l.)
Pico	Baía Cachorro [3]	(UTM 0372 4268, < 20m a.s.l.)
Recent coastal aa lava flows, with lichens but few higher plants		
Pico	Porto Cachorro (1718)	(UTM 0374 4268, < 20m a.s.l.)
	Mistério da Silveira (1720)	(UTM 0385 4252, 30m a.s.l.)
São Miguel	Mistério de Rabo de Peixe	(UTM 0626 4186, < 30m a.s.l.)
Inland recent aa lava flow, with lichens and some higher plants		
Terceira	Pico do Fogo «Cantera» (1761)	(UTM 0477 4289, 480 m a.s.l.)
Inland extruded lava dome, lacking vegetation		
Terceira	Mistério Negro «Lava» (1761)	(UTM 0475 4287, 580 m a.s.l.)
Inland lava with semi-natural scrub or forest		
Terceira	Mistério Negro «Kipuka»	(UTM 0475 4287, 580 m a.s.l.)
	Mistério Negro «Domo» [4]	(UTM 0475 4287, 560 m a.s.l.)
Faial	Cabeço do Fogo (1762)	(UTM 0346 4272, 500 m a.s.l.)
Montane pahoehoe lava, with sparse subalpine vegetation		
Pico	Caldeira do Pico [3]	(UTM 0377 4258, 2230m a.s.l.)
	Ponta do Pico «Piquinho»	(UTM 0377 4258, 2350m a.s.l.)

[1] The traps here were split evenly between the top of the old sea cliffs and the base of the cliffs from which the new isthmus leads across to the Vulcão dos Capelinhos; no searching was carried out at this site.
[2] Searching here was split between two sites close to the sea. A storm while the traps were set washed away many of them; only a little searching was carried out.
[3] At these two sites some of the traps were disturbed by people.
[4] No searching was carried out at this site.

SITE DESCRIPTIONS

A summary of the sites sampled is provided in Table I, which also indicates the ecological groupings that determine the sequence. Names of higher plants follow HANSEN & SUNDING (1985).

Vulcão dos Capelinhos «Crater», Faial (SAMPLED 1987)

This is the crater of a recent volcano which appeared in the sea in 1957 but later became attached to the westernmost point of the island. At the end of the eruption 2.4 km² of new land had been formed, but the peninsula, consisting mainly of tephra, has now been reduced by wind and wave erosion to less than 1 km². The main crater is at the western end of the complex and the sea cliff is now cutting back into it. The sampling site was just inside the north rim and within 30 m of the cliff edge. No living plants were seen near the traps, but dead grass and feathers were present in several old nests of Herring Gulls *Larus argentatus*, and there was evidence of rats. On the crater rim and on the northeast slope outside there were some clumps of the grass *Festuca petraea* and the plantain *Plantago coronopus*, together with small amounts of the lichen *Stereocaulon vesuvianum* and occasional patches of moss.

Vulcão dos Capelinhos «Lava», Faial (SAMPLED 1987)

This is a small and rather steep flow of aa lava (about 300 x 50 m) located on the NE slope of the crater. A few higher plants (including *Festuca petraea*) were present, and the more stable substrate and exposure to northerly winds has led to substantial growth of *Stereocaulon vesuvianum*, with small patches of moss in places where silt has accumulated. Herring Gulls *Larus argentatus atlantis* were numerous and rabbit droppings were found.

Vulcão dos Capelinhos «Cliff», Faial (SAMPLED 1989)

The traps at this site were divided equally between the top and the bottom of the northern end of the west-facing cliff more than 100 m high, which was at the end of the peninsula before the eruption of 1957. The higher area is exposed and eroded, with no soil and very little vegetation. The lower traps were set in crevices at the base of the cliff and in the accumulation of loose material where the old shoreline is concealed by the cinders forming the base of the new peninsula.

Vulcão dos Capelinhos «Shore», Faial (SAMPLED 1989)

Traps were set on the southwest shore of the Capelinhos peninsula, in the spray zone devoid of vegetation. One group were in rubble below the cliffs at the west end of the beach running out towards Ponta dos Capelinhos; the others were just beyond the south end of the same beach, west of Cais, among blocks of basaltic lava suffering active erosion by the waves.

Costa da Nau, Faial (SAMPLED 1987)

This is an old lava field subsequently covered by shallow and now eroded layers of fine ash from the 1957-58 eruption of the neighbouring Capelinhos volcano. The site is a few metres inland from the cliff-top on the northwest coast of Faial. Vegetation is sparse, the commonest plants being tall clumps of the grass *Festuca petraea*.

Baía Cachorro, Pico (SAMPLED 1987)

This is a non-historic pahoehoe lava flow on the northwest coast of the island, comprising mainly massive basalt but with some domes, and fissures several metres deep. Vegetation is scarce but varied, including *Asplenium marinum, Carex* sp., *Crithmum maritimum, Spergularia azorica, Cyrtomium falcatum, Polygonum maritimum, Euphorbia azorica* and *Festuca petraea*.

Porto Judeu, «Agulhas lava», Terceira (SAMPLED 1987)

This is a relatively recent pahoehoe lava flow on the south east coast, close to Gruta das Agulhas. There is hardly any plant cover because of the influence of spray, but a few specimens of *Asplenium marinum*, *Silene vulgare* ssp. *maritima*, *Solidago sempervirens* and *Euphorbia azorica* were noted.

Porto Cachorro, Pico (SAMPLED 1987)

This is a historic aa lava flow (1718) on the northwest coast of the island, used as a nest site by a colony of terns *Sterna* sp. Although there are trees and bushes nearby, the lava itself has only lichens, especially *Stereocaulon vesuvianum*, and in sheltered places *Cladonia subcervicornis*; *Xanthoria aureola* occurred near bird perching sites.

Mistério da Silveira, «Soldão Lava», Pico (SAMPLED 1987)

Much of this aa lava flow, derived from an eruption in 1720, is now covered with plantations of *Pinus pinaster* and associated flora (together with the invasive tree *Pittosporum undulatum*) but immediately before it reaches the coast there are some strips several metres wide that have only abundant lichens *Stereocaulon vesuvianum* and *Cladonia subcervicornis*, and a few other plants (*Plantago coronopus, Polypogon maritimus* and *Tolpis fruticosa*).

Mistério de Rabo de Peixe, São Miguel (SAMPLED 1989).

A recent aa lava flow (but more than 500 years old) reached the northern coast. The traps were set in a transect from the shore to a point about 250 m inland. Lichens (especially *Stereocaulon vesuvianum*) were fairly abundant away from the shore, and there were scattered ferns and higher plants.

Pico do Fogo, «Cantera», Terceira (SAMPLED 1987)

The lava from the eruption of 1761 in the centre of the island flowed to the north.

Our sampling area was quite close to the vent and near a quarry. It was in the most barren part of the flow, but with substantial growth of the lichen *Stereocaulon vesuvianum* and incipient colonization by a variety of indigenous plants, especially *Erica azorica*, together with *Vaccinium cylindraceum, Juniperus brevifolia, Myrica faya, Laurus azorica* and ferns such as *Pteridium aquilinum*; the introduced *Pittosporum undulatum* was also present.

Mistério Negro «Lava», Terceira (SAMPLED 1987)

This site is on one of a group of black volcanic domes that rise about 100 m above the older central plateau. This zone has an annual mean temperature of 12.7°C and a precipitation of over 2,200 mm. The domes were formed by an eruption in 1761; they are partly surrounded by *Sphagnum* bog and have been colonized mainly by native plants such as *Erica azorica* and *Juniperus brevifolia*. However, our sampling site near the top of one of the most barren domes was in an area of very fragile and rough aa lava where there were no higher plants; there was only a very sparse growth of lichens, while the numerous deep cracks contained an occasional small clump of moss or alga.

Mistério Negro «Kipuka», Terceira (SAMPLED 1987)

This area is about 200 m from the «Lava» site, and appears to consist of an older lava surface tilted up by the most recent eruption. It is also formed of rough aa lava but this is weathered and quite well vegetated, with pockets of soil and well grown individuals of *Juniperus brevifolia, Ilex perado* ssp. *azorica* and *Myrsine africana*.

Mistério Negro «Domo», Terceira (SAMPLED 1987)

This dome lies about 1 km from Mistério Negro and is covered by very dense, low brush (mainly *Erica azorica*) and small planted *Cryptomeria japonica* trees.

Cabeço do Fogo, Faial (SAMPLED 1987)

This site is the blocked vent of a parasitic cone of the volcano Cabeço do Fogo; both were built in the eruption of 1672. There are abundant lichens and mosses on the exposed lava surfaces, and the deep cracks in the lava are filled with bushes and even small trees such as *Juniperus brevifolia*, *Erica azorica* and accompanying species.

Caldeira do Pico, Pico (SAMPLED 1987)

This is a caldera near the top of the peak that dominates the whole island, mainly filled with fresh-looking pahoehoe lavas containing many small cavities. There are sparse clumps of low vegetation, especially *Thymus caespitius*, with some *Daboecia azorica* and mosses.

Ponta do Pico «Piquinho», Pico (SAMPLED in 1987)

This is the summit of the highest mountain of the Azores. The final steep cone of

pahoehoe lava rises from inside the northeast rim of the caldera; it culminates in a small crater about 10 m across, which has a little fumarolic activity. The vegetation is very sparse, similar in character to that in the caldera, but with scattered clumps of moss in the final crater.

METHODS

Previous work has shown that a combination of techniques can provide a more balanced view of an arthropod community on lava than the use of a single sampling method (ASHMOLE & ASHMOLE, 1987). We therefore made our collections by means of two types of traps together with standardized visual searching. Except where specified, the same sampling regime was used at all the surface sites; it was also used in the dark zones of the caves, and the cave thresholds, that were studied at the same time (OROMÍ *et al.*, 1990 and in prep.)

At each site we used 16 traps, placed in pairs with the members of each pair 15 m apart and each pair normally at least 10 m from the next. Within each pair, one trap was a pitfall (Barber) trap consisting of a straight-sided white polypropylene jar of 110 ml capacity, 82 mm high, internal diameter 42 mm. Pitfalls were dug in flush with the substrate where possible (Fig. 1A), or small rock fragments were used to build up an artificial surface round the trap. Rocks were placed nearby to shade the trap from direct sunlight and so reduce evaporation. Each pitfall contained ca. 50 ml of modified Turquin's liquid (TURQUIN 1973). The form that we used consisted of 10 g chloral hydrate, 5 ml formalin, 5 ml glacial acetic acid, 1 ml liquid detergent and beer to 1 litre.

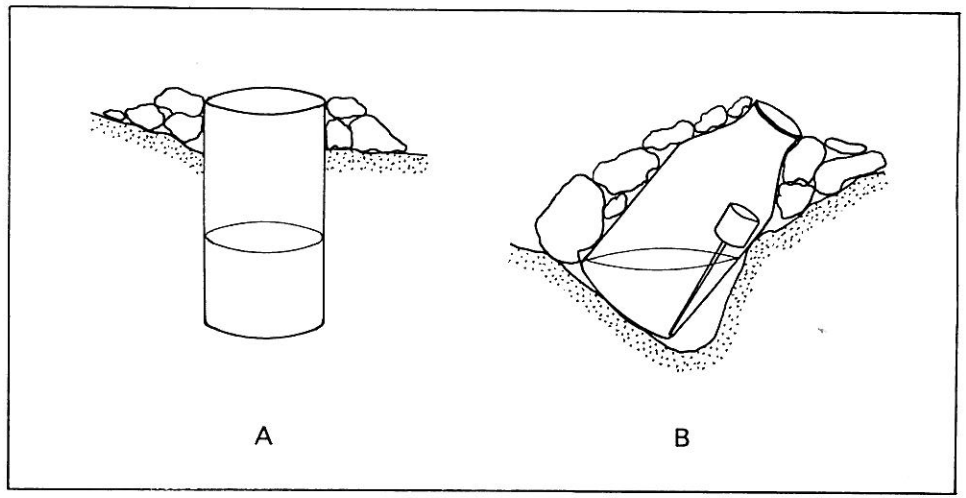

Fig. 1 - Methods of setting of the two types of traps.

The second trap in each pair was a 250 ml clear pvc bottle with internal neck diameter 21.5 mm; it was set at an angle of 45-60 degrees from the horizontal and small rocks were placed around it to facilitate the entry of animals. Each bottle contained 25 ml of Turquin's liquid (as above) but also ca. 2 g of «Danish Blue» cheese in a small plastic cup impaled on a galvanized nail that supported it above the level of the liquid (Fig. 1B). All traps were left set for four days, and were then closed with screw caps and taken back to the field laboratory for immediate sorting and preservation of their contents.

In addition, three hours of visual searching was carried out in the vicinity of the traps at each site; this was always done by two or more people to minimize the effect of individual differences in collecting technique.

RESULTS

General composition of the samples

The composition of the samples is summarised in Fig. 2 (a and b), and details at the family level are given in the Systematic Account. The sites will be discussed mainly in terms of succession, following the sequence used in Table I and Figure 2; some sites where the sampling regime was seriously deficient are omitted from the figure.

The most striking feature of Figure 2 is the relatively similar numbers of animals caught at the different sites. This is consistent with parallel studies done on the Canary Islands (ASHMOLE *et al.* 1990). The samples with fewest animals had more than one third of those with the largest number (apart from Costa da Nau). Even the almost totally barren volcanic habitats, where there was naked lava or tephra almost entirely lacking plants, nonetheless produced substantial numbers of animals.

The most recent substrates, resulting from the series of eruptions of the Vulcão dos Capelinhos in 1957-58, have very few plants and are largely aeolian ecosystems. They support abundant microarthropods (entomobryid collembolans and mites) but also many porcellionid isopods, reflecting the ecological importance of the scavenger niche in such a system. The isopods, together with the surprisingly abundant ants, are probably exploiting feathers, excreta and detritus left by the nesting gulls as well as biological material brought by the wind; they presumably also benefit, together with the few acridid Orthoptera, from the small amounts of local primary production. The melyrid beetle *Gietella faialensis* (see taxonomic section) which was discovered at the crater site is probably a predator on collembolans. The ecological role of the phorid flies is not clear, but they may be associated with decaying organic matter brought in by the gulls. At both these sites there were a number of clearly predatory species, especially spiders. At the crater site there were lycosids hunting on the surface, and theridiids with webs under rocks, while on the lava there were theridiids and linyphiids; the latter site also had scutigerid chilopods.

The samples from the Capelinhos «Cliff» site, which had virtually no vegetation

and where the traps were split between the foot and the top of the original sea cliff, showed a fauna generally similar to the main Capelinhos sites, with collembolans, mites, isopods and ants all important. Phorid flies and elaterid beetles were more numerous, while julid diplopods and several additional families of beetles were represented.

The Capelinhos «Shore» sampling, in which traps were split between two parts of the southwest shore with different orientation, was largely abortive because of a storm during the trapping period. The few remaining traps showed that as well as collembolans and isopods, carcinophorid dermapterans were numerous in this habitat.

An interesting comparison can be made between the main Capelinhos samples and that from Costa de Nau, a cliff-top site on the north coast of Faial just east of Capelinhos. Although some groups (e.g. entomobryids, mites and phorids) had similar representation, there were also contrasts. Ants were extremely abundant at Costa da Nau, and there were also many noctuid lepidopterans, carabid beetles, and calliphorid and muscid flies; acridids also appeared more abundant, although few were caught. Predators were represented by a wider variety of spiders and by numerous chilopods, especially scutigerids. Isopods were much less abundant.

Of the other habitats sampled, perhaps the most comparable to those on Capelinhos are the coastal pahoehoe lava sites of Baía Cachorro on Pico (where some traps were vandalized) and Porto Judeu «Agulhas» on Terceira. At both of these sites the rock is somewhat monolithic, although crevasse-like cracks at Baía Cachorro provide some additional habitat structure. Acari were abundant, but Collembola were obtained in relatively small numbers. Ants were abundant at Porto Judeu but more diverse at Baía Cachorro, while isopods and phorid Diptera were important at both, though other flies were relatively scarce. Significant taxa at these sites that were not found at Capelinhos include Pseudoscorpiones and polyxenid Diplopoda at Baía Cachorro, and gryllid Orthoptera at Porto Judeu.

Historic or subhistoric flows of aa lava were sampled near the coast at Porto Cachorro (3 km east of the Baía site), at the Mistério da Silveira on Pico, and at the Mistério de Rabo de Peixe on São Miguel; a flow further inland was sampled at the Pico do Fogo «Cantera» site on Terceira. These flows, unlike the pahoehoe sites, have rich growths of lichens, especially of the genus *Stereocaulon*, but the establishment of higher plants takes a long time except in very humid situations, and productivity is evidently low. The piles of loose scoria at these sites provide a maze of cavities at the surface and deep underground, so that refuges are abundant.

These aa flows typically have abundant mites and ants, with many entomobryid and sminthurid Collembola. Apart from groups typical of the shore (carcinophorid Dermaptera and Amphipoda in the traps closest to the sea at Rabo de Peixe) few other taxa are common, although spiders are often reasonably diverse. The talitrid amphipods at Mistério da Silveira are probably representative of the forest habitat that surrounds this flow, which is very narrow. The same may be true of the drosophilid Diptera (and the eucoilid Hymenoptera that may be parasitic on them) at this site.

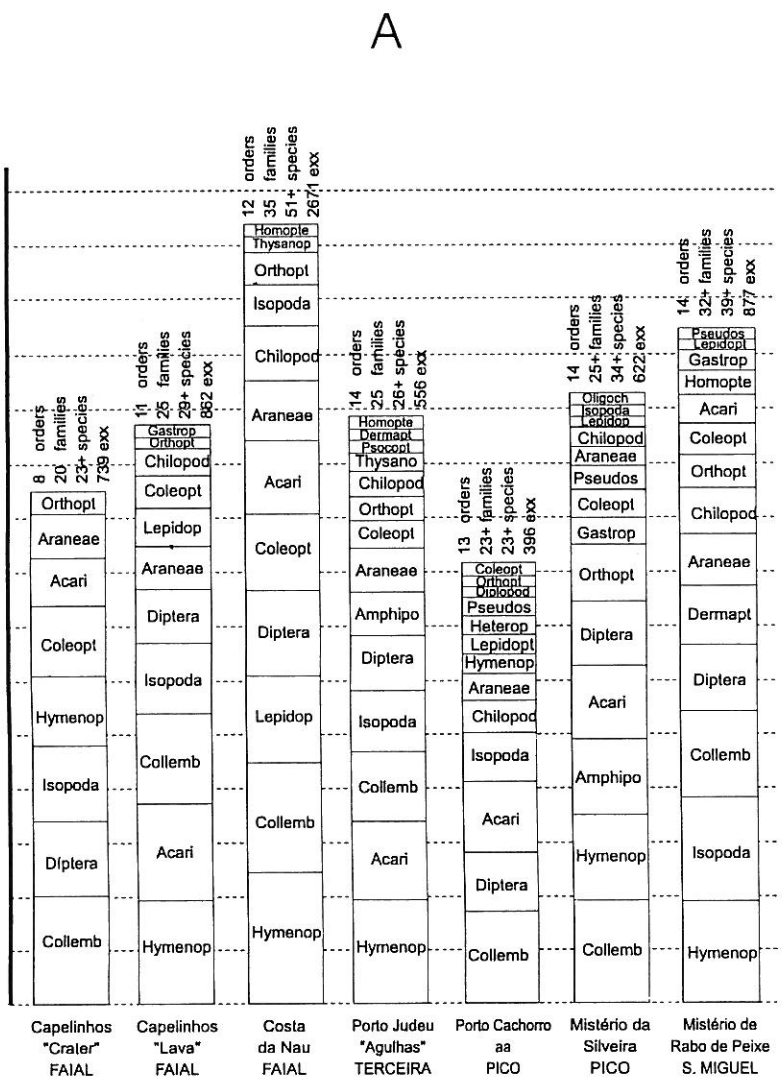

Fig. 2 (A and B) - Dominance-diversity diagrams for invertebrates at the main lava sites. All orders represented are ranked, starting with the most abundant order at the bottom. The height of the segment shown for each order shows the number of individuals ($\log_{10} n + 1$) caught. Also included are total sample sizes, and numbers of species (minima), families and orders represented in the samples. No searching was carried out at Mistério Negro "Domo", and several traps were disturbed by humans at Caldeira do Pico.

The lava at Mistério Negro on Terceira is a special case: it derives from an eruption in 1761, when semi-solid lava pushed up to form a dome, and on cooling produced extremely jagged rock and very deep cracks; the part we sampled had no vegetation apart from a very few lichens. The fauna of this site is very limited, consisting mainly of

scavengers and predators. Microarthropods are represented by fair numbers of Acari but few - though fairly diverse - Collembola. The absence of ants differentiates this site from all the other aa and pahoehoe lava sites, and the most numerous arthropods in the traps were calliphorid and phorid Diptera. The former probably immigrated from more productive sites, but the latter may be local residents. Spiders are fairly numerous, both web-building and wandering groups being present. Other taxa are represented only in small numbers. The finding of remains of noctuid moths on the lava demonstrates a significant input of biomass from elsewhere.

However, the most striking feature of this site was the capture of 13 individuals of a lavicolous form of lithobiid centipede, described as an endemic subspecies of *Lithobius obscurus* Meinert by EASON & ASHMOLE, 1992. Another endemic subspecies of the same species, adapted to cavernicolous life, was discovered in Balcoes cave a few kilometres away and was also found on Faial and Pico (see Systematic Account).

Only about 200 m away from the barren lava just discussed, and at the same level, was the habitat that we called «Kipuka». This word is used in Hawai'i for islands of forest surrounded by recent lava flows: it was not quite appropriate in the present case, since the area concerned appeared to consist of older rock physically pushed aside, rather than surrounded, by the semi-solid lava bulging up beside it in 1761. It had well developed though low-growing native trees, especially *Juniperus brevifolia*, which presumably quickly reestablished in preexisting pockets of soil after the nearby eruption, although the survival of a few individuals cannot be ruled out. The greater availability of organic matter on the kipuka was indicated by the presence of oligochaetes, oribatid mites, juliform Diplopoda, many ants and numerous Isopoda in three families (only 2 specimens of one family were found on the lava site). Collembola were also more numerous, and included the family Tomoceridae, while a single machilid thysanuran was found (the only one that we encountered during our work). There were various Diptera, including phorids and calliphorids, but also many anisopodids. There were also a few cixiid Homoptera, but phytophagous insects are probably under-represented since our sampling procedure was geared to the ground fauna.

Also in the area of the Mistério Negro we set traps (but did not undertake searching) on a more vegetated and apparently older volcanic dome a few hundred metres to the north, which we called «Domo». This had a luxuriant growth of *Erica azorica* and other native plants, though with young *Cryptomeria japonica* recently planted nearby. The microarthropods here included many entomobryid but also sminthurid Collembola, and small numbers of Acari. The absence of ants was striking, and there were very few beetles. However, there was a great variety of Diptera and some Lepidoptera and auchenorrhynchan Homoptera. Predators included large numbers of lycosid spiders and of lithobiid centipedes.

The most similar site elsewhere to those on the Mistério Negro (and especially to the «Kipuka») was Cabeço do Fogo on Faial, close to the vent of a volcano that erupted in 1672. Most of the lava flow has been colonized by bushes and small trees,

but there is some exposed aa lava at the summit, though with pockets of soil in cracks. Oligochaetes and a variety of gastropod molluscs were present, as well as several families of isopods and also talitrid amphipods. Predators included dysderid and linyphiid spiders. Lepidoptera (especially Noctuidae) were well represented, and a wide variety of Diptera including numerous anisopodids. Ants were also fairly numerous. The lithobiid Chilopoda were of special interest, with 3 individuals of *Lithobius pilicornis* but also one *L. obscurus azoreae*, a form found otherwise only in caves (EASON & ASHMOLE, 1992).

The final two sites were at high altitude on Pico, one in the Caldeira and one at the extreme summit of the peak. These sites showed obvious faunal resemblance to high altitude habitats in western Europe. They were the only sites at which isotomid Collembola outnumbered entomobryids. Braconid Hymenoptera were abundant, the Diptera were mainly sphaerocerids, tipulids and sciarids, and the spiders were mainly lycosids and linyphiids. Both Homoptera and Heteroptera were present, though collected only in small numbers, and a tenthredinid Hymenopteran was also found. Beetles were represented mainly by chrysomelids, carabids and staphylinids. Ants and isopods were conspicuous by their absence.

Systematic account

OLIGOCHAETA

Earthworms were identified by J. A. TALAVERA.

Lumbricidae

Eisenia eiseni Levinsen. Cabeço do Fogo, Faial; Mistério da Silveira, Baía Cachorro and Caldeira do Pico, Pico; Pico do Fogo «Cantera» and Mistério Negro «Kipuka», Terceira.

Allolobophora caliginosa (SAVIGNY). Cabeço do Fogo, Faial.

GASTROPODA

The work of the 1987 and 1989 expeditions was focused primarily on arthropods, but some gastropods were obtained, mainly while searching. These have been identified by M. IBÁÑEZ and R. ALONSO. Those found in epigean habitats are listed below; species represented only by remains of dead specimens are included, but are indicated with the symbol (r).

Arionidae

Arion aff. *lusitanicus* Mabille. Mistério Negro «Kipuka», Terceira.

Clausiliidae

Balea perversa (LINNAEUS). Capelinhos «Lava» and Cabeço do Fogo, Faial; Mistério Negro «Kipuka», Terceira (r).

Ellobidae

Ovatella sp. Baía Cachorro, Pico; Porto Judeu «Agulhas», Terceira (r); Mistério de Rabo de Peixe, São Miguel.

Endodontidae

Discus rotundatus (O. F. MULLER). Cabeço do Fogo, Faial.

Enidae

Napaeus sp.. Cabeço do Fogo, Faial; Mistério da Silveira, Pico.

Helicidae

Oestophora barbula (ROSSMASSLER). Pico do Fogo «Cantera» (r) and Mistério Negro «Lava», Terceira.

Vertiginidae

Lauria cylindracea anconostoma (LOWE). Mistério da Silveira, Pico.

Leiostyla sp. Cabeço do Fogo, Faial; Porto Cachorro, Pico (r).

Zonitidae

Oxychilus sp. Pico do Fogo «Cantera» (r) and Mistério Negro «Lava» and «Kipuka», Terceira.

PSEUDOSCORPIONES

The pseudoscorpions from both the 1987 and 1989 expeditions have been identified by Dr. V. MAHNERT. Two cave syarinids proved to be of special interest and are discussed by MAHNERT (1990) and OROMÍ *et al.* (1990). Those found at surface sites were as follows:

Chthoniidae

Chthonius (C.) ischnocheles (HERMANN). Cabeço do Fogo, Faial; Mistério da Silveira and Porto Cachorro, Pico; Mistério Negro «Kipuka», Terceira; also found in caves.

Chthonius (E.) tetrachelatus (PREYSSLER). Mistério da Silveira and Baía Cachorro, Pico.

Chthonius (E.) aff. *kewi* Gabbutt. Mistério de Rabo de Peixe, São Miguel; also found in caves.

Cheliferidae

Rhacochelifer sp. (*?peculiaris*). Baía Cachorro, Pico.

ARANEAE

The spiders were mainly identified by Dr. J. WUNDERLICH, but some by C. RIBERA and N. P. ASHMOLE.

Dysderidae

Dysdera crocata C. L. KOCH. Cabeço do Fogo, Faial; Pico do Fogo «Cantera» lava and Mistério Negro «Kipuka» and «Domo», and Porto Judeu «Agulhas», Terceira; also found in several caves (mainly thresholds).

Dysdera sp. Mistério de Rabo de Peixe, São Miguel.

Segestriidae

Segestria florentina (ROSSI). Mistério de Rabo de Peixe, São Miguel.

Pholcidae

Pholcus phalangioides (FUESSLIN). Baía Cachorro, Pico; also found in caves.

Araneae

Argiope bruennichi (SCOPOLI). Costa da Nau, Faial; also collected on coastal lava at Lajes, Pico.

Mangora acalypha (WALCKENAER). Mistério Negro «Kipuka», Terceira.

Tetragnathidae

Meta merianae (SCOPOLI). Mistério Negro «Lava», Terceira; also found in several cave thresholds.

Linyphiidae

Eperigone sp. Ponta do Pico "Piquinho", Pico (WUNDERLICH 1991).

Agyneta sp. Mistério Negro «Lava» and «Kipuka», Terceira.

Lepthyphantes acoreensis WUNDERLICH. The holotype of this species, described by WUNDERLICH (1991), was a male collected at the Mistério Negro «Kipuka» on Terceira. This species was also found in the Caldeira of Pico and in a cave on Faial.

Lepthyphantes tenuis (BLACKWALL). Caldeira do Pico, Pico.

Lepthyphantes sp. Mistério Negro «Lava», «Kipuka» and «Domo», Terceira.

Theridiidae

Teutana grossa (C. L. KOCH). Abundant on barren volcanic substrates near the coast. Capelinhos «Crater», «Lava», «Cliff» and «Shore», and Costa da Nau, Faial; Mistério de Rabo de Peixe, São Miguel; also found in several caves, mainly thresholds.

Agelenidae

Textrix coarctata (DUFOUR). Mistério da Silveira, Pico.

Tegenaria domestica (CLERCK). Pico do Fogo «Cantera», Terceira; Mistério de Rabo de Peixe, São Miguel.

Pisauridae

Pisaura acoreensis WUNDERLICH. Five individuals were obtained at Mistério Negro «Domo», Terceira.

Lycosidae

Arctosa perita (LATREILLE). Fairly common on Capelinhos peninsula. Capelinhos «Crater» and Costa da Nau, Faial.

Pardosa acoreensis SIMON. An abundant and widespread species, in rocky and vegetated habitats up to high altitudes, as well as occasionally in caves. Caldeira and Ponta do Pico, Pico; Pico do Fogo «Cantera» and Mistério Negro «Lava», «Kipuka» and «Domo», Terceira.

Zodariidae

Zodarion machadoi DENIS. Costa da Nau, Faial.

Gnaphosidae

Drassodes sp. (*lapidosus* group). Pico do Fogo «Cantera», Terceira.

Thomisidae

Xysticus cribratus SIMON. Mistério Negro «Domo», Terceira.

Xysticus cor Canestrini. Mistério Negro «Kipuka», Terceira.

Salticidae

Chalcoscirtus infimus (SIMON). Porto Cachorro, Pico; Porto Judeu «Agulhas», Terceira.

Euophrys vafra (BLACKWALL). Porto Judeu «Agulhas», Terceira; Mistério de Rabo de Peixe, São Miguel.

Heliophanus kochi SIMON. Coastal lava at Lajes, Pico.

Neon ?convolutus DENIS. Mistério Negro «Lava», Terceira.

ACARI

The oribatid mites from both expeditions have been identified by Dr. L. S. SUBÍAS. Large numbers of mites in other groups have not been studied for the moment. Most of the oribatids were obtained in caves, and only those found on the surface are listed here.

Phthiracaridae

Phthiracarus anonymus Grandjean. Pico do Fogo «Cantera», Terceira.

Camisiidae

Camisia horrida (HERMANN). Porto Cachorro and Ponta do Pico «Piquinho», Pico.

Heminothrus oromii MORELL & SUBÍAS. Mistério Negro «Kipuka», Terceira.

Heminothus peltifer (C. L. KOCH). Mistério Negro «Domo», Terceira.

Hermanniidae

Hermannia nodosa MICHAEL. Mistério Negro «Domo», Terceira.

Hermanniellidae

Hermanniella incondita C. PÉREZ-IÑIGO. Cabeço do Fogo, Faial.

Cepheidae

Cepheidae indet. Cabeço do Fogo, Faial.

Xenillidae

Xenillus discrepans azorensis C. PÉREZ-IÑIGO. Mistério Negro «Domo», Terceira.

Scutoverticidae

Scutovertex sp. Capelinhos «Crater» and Capelinhos «Lava» (many), Faial.

Hypovertex sp. Porto Cachorro, Pico.

Ceratozetidae

Melanozetes azoricus WEIGMANN. Mistério Negro «Kipuka», Terceira.

Latilamellobates incisellus KRAMER. Capelinhos «Cliff», Faial.

Galumnidae

Galumna gibbula GRANDJEAN. Porto Cachorro, Pico.

Galumna sp. Mistério Negro «Kipuka», Terceira.

Oribatulidae

Oribatula propinqua (OUDEMANS). Mistério de Rabo de Peixe, São Miguel.

Protoribatidae

Liebstadia gallardoi (MORELL). Mistério da Silveira, Pico.

Scheloribatidae

Scheloribates laevigatus (C. L. KOCH). Baía Cachorro, Pico.

Scheloribates latipes (C. L. KOCH). Mistério Negro «Domo», Terceira.

Dometorina plantivaga (BERLESE). Mistério da Silveira and Porto Cachorro, Pico.

ISOPODA

The isopods from the 1987 expedition were examined in a preliminary way by Dr. H. SCHMALFUSS, and proved to include several taxa of interest; it has not yet been possible, however, to study them in depth. The 1989 specimens have been identified to family level by Dr. R. RODRÍGUEZ SANTANA, who hopes to make a more intensive study of the material soon.

Isopods were important community members in some of the lava habitats, porcellionids being the most successful group on the most recent substrates.

Ligiidae

Ligia italica FABRICIUS. Capelinhos «Shore», Faial; coast at Lajes, Pico; coast at Água de Pau, São Miguel.

Trichoniscidae

Trichoniscus pusillus BRANDT. Costa da Nau and Cabeço do Fogo (many), Faial; Mistério Negro «Kipuka», Terceira; also found in caves.

Halophilosciidae

Halophiloscia sp. Baía Cachorro lava, Pico.

Indet. Capelinhos «Shore», Faial; coast at Lajes, Pico; Mistério de Rabo de Peixe and coast at Água de Pau, São Miguel.

Philosciidae

Chaetophiloscia sp. Baía Cachorro and Porto Cachorro, females only, but probably referable to *C. guernei* (DOLLFUS), which occurs in a cave nearby.

Oniscidae

Oniscus asellus (LINNAEUS). Cabeço do Fogo, Faial; Mistério Negro «Lava», «Kipuka» (many), and «Domo», Terceira; also found in caves.

Porcellionidae

Porcellio lamellatus Budde-Lund. Capelinhos «Crater» and «Lava», Faial (many at both sites, presumably feeding on detritus brought by the wind and by seabirds); Porto Cachorro, Pico. According to VANDEL (1968) this is a species of the upper shore.

Porcellionides pruinosus (BRANDT). Costa da Nau, Faial; Mistério da Silveira and Porto Cachorro (many) and Baía Cachorro, Pico.

P. sexfasciatus (BUDDE-LUND). Costa da Nau, Faial.

Indet. Capelinhos «Cliff» and Capelinhos «Shore», Faial; Mistério de Rabo de Peixe, São Miguel.

Armadillidiidae

Armadillidium sp. aff. *album*. Baía Cachorro lava, Pico; Agulhas lava, Terceira (many). A probable new species.

Eluma purpurascens BUDDE-LUND. This species seems typical of native vegetation in the moist uplands. Mistério Negro «Kipuka» (many) and «Domo», Terceira.

Armadillidium amicorum RODRÍGUEZ & VICENTE. Mistério de Rabo de Peixe, São Miguel (296). A new species discovered in our sampling (RODRÍGUEZ & VICENTE, 1993).

Isopoda indet. Lajes coast, Pico (3); Água de Pau coast (26), São Miguel.

AMPHIPODA

The amphipods collected were identified by Dr. J. H. STOCK. A new genus and species of microphthalmous talitrid, *Macarorchestia martini* STOCK, was present in the samples from the threshold of Agulhas cave on Terceira; this is discussed by STOCK (1989) and OROMÍ *et al.* (1990). Talitrids were also obtained at some surface sites.

Talitridae

Orchestia chevreuxi DE GUERNE. Porto Judeu «Agulhas», Terceira; also found in the cave thresholds here and in Furna Ruim on Faial. This species is endemic to the Azores.

Talitroides topitorum (BURT). Cabeço do Fogo, Faial; Mistério da Silveira, Pico (many); also found in several caves. Introduced to the Azores from SE Asia.

DIPLOPODA: PSELAPHOGNATHA

Identification of this material was by M. NGUYEN-DUY.

Polyxenidae

Polyxenus lagurus LINNAEUS. Baía Cachorro, Pico.

DIPLOPODA: CHILOGNATHA

The chilognath diplopods collected during the 1989 expedition have been studied by C. VICENTE; the 1987 material is currently under study. Most millipedes were collected in caves, and are discussed by OROMÍ *et al.* (in prep.); only those from the surface are considered here.

Ommatoiulidae

Ommatoiulus moreleti (LUCAS). Capelinhos «Cliff».

Indet. Porto Cachorro, Pico, 1 individual.; Mistério Negro, Terceira: «Kipuka», 16 individuals; «Domo» 1 individual.

CHILOPODA: SCOLOPENDROMORPHA

Cryptopidae

Cryptops hortensis LEACH. Cabeço do Fogo, Faial; Mistério Negro «Kipuka», Terceira; also found in Agulhas cave on Terceira. This is a common European species that has also been recorded from the USA and Caribbean. Our specimens, which were identified by Dr. J. G. E. LEWIS, are referable to *C. hortensis* var. *hortensis*, which has previously been recorded from São Miguel, while *C. hortensis* var. *atlantis* Pocock has been recorded from the Canaries, Madeira and «Azores».

CHILOPODA: LITHOBIOMORPHA

The lithobiomorphs obtained both in caves and in lava flows during our expeditions are the subject of a separate paper by EASON & ASHMOLE (1992) so only a brief account of the material from lava flows will be given here. Only one species of henicopid and two species of lithobiid had previously been found in the archipelago, and all were considered by EASON (1985) to be introduced. We collected two additional species, both probably indigenous. *Lithobius obscurus* Meinert is represented on Faial, Pico and Terceira by an endemic cavernicolous subspecies, and on the Mistério Negro «Lava» site on Terceira also by a distinct lavicolous subspecies. *Lithobius melanops* Newport is represented by an endemic subspecies, which we found on coastal lava flows on Pico, Terceira and São Miguel. A third species not previously recorded from the archipelago, *Lithobius subtilis* Latzel, is provisionally recorded by EASON & ASHMOLE on the basis of a specimen collected by Dr. PAULO BORGES in Terceira.

Henicopidae

Lamyctes fulvicornis (MEINERT). Caldeira do Pico (many) and Ponta do Pico "Piquinho", Pico.

Lithobiidae

Lithobius pilicornis NEWPORT. Costa da Nau and Cabeço do Fogo, Faial; Caldeira do Pico, Pico; Pico do Fogo «Cantera», Mistério Negro «Lava», «Kipuka» (many) and «Domo» (many), Terceira; Mistério de Rabo de Peixe, São Miguel.

Lithobius lusitanus VERHOEFF. Costa da Nau, Faial.

Lithobius obscurus azoreae EASON & ASHMOLE. Cabeço do Fogo, Faial; also found in caves.

Lithobius obscurus mediocris EASON & ASHMOLE. Mistério Negro «Lava», Terceira (many).

Lithobius melanops borgei EASON & ASHMOLE. Baía Cachorro, and Porto Cachorro, Pico; Porto Judeu «Agulhas», Terceira; Mistério de Rabo de Peixe, São Miguel.

CHILOPODA: SCUTIGEROMORPHA

Scutigeridae

Scutigera coleoptrata (LINNAEUS). Capelinhos «Lava» and Costa da Nau (many), Faial; Mistério da Silveira and Porto Cachorro, Pico; Porto Judeu «Agulhas», Terceira; Mistério de Rabo de Peixe, São Miguel (many). This species is a regular component of lava faunas, and its abundance at Costa da Nau suggests that it may be important at many open vegetated sites. It also occurs occasionally in caves, mainly in the thresholds.

COLLEMBOLA

Study of the Collembola collected on our two expeditions by Prof. MARIA MANUELA da GAMA has led to a major addition to knowledge of the collembolan fauna of the Azores, including the discovery of at least four new species and 18 new records for the archipelago, of which 7 are also new for Macaronesia (GAMA 1988a, 1988b). Only a brief summary of the results is appropriate here. The treatment follows the sequence of sites used in «Site descriptions» above.

In Capelinhos crater itself entomobryid Collembola were extraordinarily abundant, the dominant species being the cosmopolitan *Entomobrya marginata* (TULLBERG), not previously recorded from the archipelago. The lava habitat had a greater variety of Collembola, including abundant *E. marginata* but also many of the hypogastrurid *Xenylla maritima* TULLBERG, another cosmopolitan species, and of the sminthurid *Sminthurinus niger* (LUBBOCK), a holarctic species new to the Azores.

The Collembola of the Costa da Nau site were of special interest, since the 13

species included 6 not previously recorded from the Azores. Although the sample was numerically dominated (as in all the Capelinhos sites) by *Entomobrya marginata*, there were also abundant *E. multifasciata/nivalis* and a number of the cyphoderid *Cyphoderus albinusa* NICOLET and the sminthurids *Jeannenotia stachia* (JEANNENOT) and *Prorastriopes quinquefasciatus* (KRAUSBAUER), two palaearctic species respectively new to the Azores and to Macaronesia.

Intriguingly, the *Entomobrya* niche on the Agulhas pahoehoe lava was occupied not by *E. marginata* (which has not been recorded from Terceira) but by *E. dollfusi* DENIS, a palaearctic species not previously found in Macaronesia. This species was also more numerous than *E. marginata* in the small sample from the Baía Cachorro site on Pico, and it is evidently well adapted to coastal lava since it was also found in more casual sampling at two other sites of this type.

Passing to the aa lava sites, *Entomobrya marginata* is dominant at Porto Cachorro on Pico and common at Rabo de Peixe on São Miguel, but at the latter the niche is shared with abundant *E. dollfusi* and small numbers of two other species of the genus. Furthermore, *Lepidocyrtus curvicollis* BOURLET (another entomobryid) is also present in small numbers. At the Mistério da Silveira on Pico the situation is even more complex, with an additional species, *E. albocincta* (TEMPLETON) dominant, but *E. multifasciata/nivalis* (previously mentioned from Costa da Nau) and *Lepidocyrtus curvicollis* both abundant, and three other entomobryids present. At all three of these aa lava sites the sminthurid *Disparrhopalites patrizii* (CASSAGNAU/DELAMARE), not previously found in the Azores, is also abundant. At the inland historic aa lava flow on Terceira that we called «Cantera» *Lepidocyrtus curvicollis* is the dominant entombobryid, but with both *Entomobrya albocincta* and *E. multifasciata/nivalis* also present in significant numbers; we also found one individual of a second *Lepidocyrtus*, apparently a new and endemic species (GAMA 1988b).

Hypogastruridae

Most species of this family were found mainly in caves; only the records from lava sites are listed here.

Hypogastrura vernalis (CARL). Costa da Nau, Faial, one individual. New for Macaronesia (Palaearctic).

Xenylla maritima TULLBERG. Common at Capelinhos «Lava» and 1 or 2 at Costa da Nau, Faial; 1 or 2 at Mistério da Silveira, Pico.

Paraxenylla affiniformis (STACH). A few at Mistério de Rabo de Peixe, São Miguel.

Isotomidae

Anurophorus laricis NICOLET. Found only, and in large numbers, at Caldeira do Pico and Ponta do Pico «Piquinho», Pico. New for Macaronesia (Palaearctic).

Folsomia norvegica ALTNER. Large numbers at Caldeira do Pico and Ponta do Pico «Piquinho», Pico; 1 at Capelinhos «Lava», Faial. New for Macaronesia (Palaearctic).

Folsomides parvulus Stach. One individual in Capelinhos «Lava», Faial.

Pseudisotoma sensibilis (TULLBERG) (=Isotoma s.) One in Cabeço do Fogo, Faial.

Isotoma maritima meridionalis Altner. 1 on Ponta do Pico «Piquinho», Pico; 1 in the threshold of a cave in Terceira. New for Macaronesia (Atlantic-Mediterranean).

Isotoma viridis BOURLET. 4 in Caldeira do Pico, Pico.

Isotomurus palustris (MULLER). 2 in Mistério Negro «Lava», Terceira.

Proctostephanus madeirensis GAMA. 6 in Mistério da Silveira, Pico; 1 each in Capelinhos «Crater» and «Lava», Faial.

Entomobryidae

Entomobrya albocincta (TEMPLETON). One of the main species on coladas. Many on Mistério da Silveira, few on Pico do Fogo «Cantera», Pico; few on Mistério Negro «Lava», Terceira; few on Costa da Nau, Faial.

Entomobrya atrocincta SCHOTT. 3 on Mistério da Silveira, Pico. New for Azores (Cosmopolitan).

Entomobrya marginata (TULLBERG). This is an abundant species of coastal barren lava, with large numbers on Capelinhos «Crater», «Lava», «Cliff» and «Shore», and Costa da Nau, Faial; also abundant at Porto Cachorro aa (1 on pahoehoe), Pico; abundant on Mistério de Rabo de Peixe, São Miguel. New for Azores (Cosmopolitan).

Entomobrya multifasciata/nivalis. This species was normally absent or rare on barren lava sites. It was abundant at Costa da Nau and absent from Capelinhos except a few on «Cliff», Faial; abundant at Mistério da Silveira, small numbers at Ponta do Pico «Piquinho», 1 at Baía Cachorro, Pico; small numbers at Mistério Negro «Domo» and «Cantera», Terceira; 1 at Mistério de Rabo de Peixe, São Miguel.

Entomobrya pazaristei DENIS. 1 on Mistério de Rabo de Peixe, São Miguel. New for Azores.

Mesentotoma dollfusi (DENIS) (= *Entomobrya d.*) A coastal lava species, abundant on Porto Judeu «Agulhas», Terceira; Mistério de Rabo de Peixe. São Miguel and Baía Cachorro pahoehoe, Pico; a few on the coast near Lajes, Pico; in the threshold of a cave in Terceira. New for Macaronesia (Palaearctic).

Heteromurus major (MONIEZ). A species typical of inland vegetated sites. Common at Mistério Negro «Domo», and small numbers «Kipuka» and Cabeço do Fogo, Terceira; small numbers at Mistério da Silveira and Ponta do Pico «Piquinho», Pico; 1 at Costa da Nau, Faial. The species was also sometimes found in thresholds of caves.

Lepidocyrtus curvicollis BOURLET. An abundant and widespread species, typical of inland lava sites, and cave thresholds and pits. Abundant at Pico do Fogo «Cantera» and Cabeço do Fogo, fewer on Mistério Negro «Lava» and «Kipuka», Terceira; abundant

at Mistério da Silveira, Pico; a few on Mistério de Rabo de Peixe, São Miguel; 1 at Costa da Nau, Faial.

Lepidocyrtus sp. indet. GAMA (1988b) considers this as representing a new record for Macaronesia and as endemic. Scarce but widespread, perhaps mainly in native vegetation, but occasional on lava near the coast. Mistério Negro «Domo», Faial; Ponta do Pico «Piquinho», Pico; 1 on Capelinhos «Lava».

Pseudosinella octopunctata BORNER. A few, at Capelinhos «Lava» and Costa da Nau, Pico. New for Azores.

Tomoceridae

Tomocerus minor (LUBBOCK). Numerous in several caves (mainly thresholds) on Terceira, São Jorge and one on São Miguel. Numerous at Mistério Negro «Kipuka» and 1 at «Domo», Terceira. No records from Pico/Faial, but has been found there.

Cyphoderidae

Cyphoderus albinus NICOLET. Numerous at Costa da Nau, Faial, but not found at any other site.

Sminthuridae

Bourletiella hortensis (FITCH). Only 1, at Costa da Nau, Faial. New for Azores (Cosmopolitan).

Bourletiella viridescens STACH. Abundant at Mistério Negro «Domo», Terceira; the species was also found in a cave on São Jorge.

Dicyrtomina minuta (O. FABRICIUS) (= *Dicyrtoma m.*). 1 each at Mistério Negro «Domo» and «Kipuka», Terceira.

Disparrhopalites patrizii (CASSAGNAU/DELAMARE). Abundant on coastal aa lava. Porto Cachorro and Mistério da Silveira, Pico; Mistério de Rabo de Peixe, São Miguel. Also found in semi-dark cave environments. New for Azores (Atlantic-Mediterranean).

Jeannenotia stachi (JEANNENOT). Numerous at Costa da Nau (only), Faial. New for Azores (West Palaearctic).

Prorastriopes quinquefasciatus (KRAUSBAUER). Numerous at Costa da Nau only. New for Macaronesia (Palaearctic).

Lipothrix lubbocki (TULLBERG) (= *Sphyrotheca* = *Sminthurus l.*). 1 at Mistério Negro «Domo», Terceira.

Sminthurinus niger (LUBBOCK). A lavicolous species, found at Capelinhos «Crater» and «Lava» and Cabeço do Fogo, Faial; Mistério Negro «Lava» and «Kipuka», Cabeço do Fogo and probably one at Pico do Fogo «Cantera», Terceira; Mistério de Rabo de Peixe, São Miguel. New for Azores (Holarctic).

THYSANURA

Thysanura were identified by C. BACH.

Machilidae

Parapetrobius cf. *azoricus*. On coastal lava at Lajes, Pico.

Machilinus sp. On coastal lava at Lajes, Pico. This is a new record of this genus in the Azores.

Machilidae indet. (*Petrobius* or *Parapetrobius*). An unidentifiable juvenile was found at Mistério Negro «Kipuka», Terceira.

BLATTARIA

Ectobiidae

Phyllodromica chavesi (BOLIVAR). Mistério Negro «Lava» and «Domo», Terceira.

ORTHOPTERA

Gryllidae

Gryllus bimaculatus de GEER. Costa da Nau, Faial; Mistério da Silveira (many) and Porto Cachorro, Pico; Agulhas lava, Terceira; Mistério de Rabo de Peixe, São Miguel.

Acrididae

Acrididae indet. Capelinhos Crater and Lava, and Costa da Nau, Faial; Mistério da Silveira, Pico.

DERMAPTERA

Carcinophoridae

Anisolabis maritima GENE. Capelinhos Shore, Faial (abundant); on coast lava at Lajes, Pico; Mistério de Rabo de Peixe (many), and on the coast at Água de Pau, São Miguel and Agulhas lava, Terceira (Porto Judeu).

PSOCOPTERA

Psocoptera indet. Capelinhos Cliff, Faial; Caldeira and Ponta do Pico "Piquinho".

Pico; Mistério Negro «Lava» and Agulhas lava, Terceira.

THYSANOPTERA

The thrips were indentified by R. ZUR STRASSEN.

Thripidae
Ceratothrips ericae (HALIDAY). Mistério Negro «Domo», Terceira.
Thrips tabaci LINDEMAN. «Cantera» lava and Agulhas lava, Terceira.

HOMOPTERA

The homopterans were identified by M. ASCHE, except for the Psyllidae, which were studied by I. HODKINSON.

Delphacidae
Muellerianella fairmairei Perris. Ponta do Pico "Piquinho", Pico.
Sogatella kolophon ssp. *atlantica* FENNAH. Ponta do Pico "Piquinho", Pico.
Toya propinqua (FIEB). Agulhas lava, Terceira.

Cixiidae
Cixius azopifajo REMANE & ASCHE. Cabeço do Fogo, Faial.
Cixius azoterceirae REMANE & ASCHE. Mistério Negro «Kipuka», Terceira.

Psyllidae
Acizzia uncatoides (FERRIS & KLYVER). Caldeira do Pico, Pico. This is an introduced Australian species that typically feeds on Acacia.
Trioza laurisilvae HODKINSON. This Macaronesian species was described by HODKINSON (1990) on the basis of material from the Canary Islands and Madeira, together with a single Azorean specimen collected by us at Porto Cachorro, Pico, in a water trap.

Homoptera indet. Capelinhos "Cliff" and "Shore", Faial; Mistério Negro «Domo», Terceira; Mistério de Rabo de Peixe, São Miguel.

HETEROPTERA

Identifications in this order were by J. RIBES.

Miridae
Orthops insularis (REUTER). Ponta do Pico "Piquinho", Pico.
Heterotoma planicorne (PALL.). Cabeço do Fogo, Faial.

Tingidae
Acalypta parvula (FALLEN). Caldeira do Pico, Pico.

Lygaeidae
Nysius ericae (SCHILLING). Capelinhos "Cliff", Faial; Baía Cachorro lava and Caldeira do Pico, Pico. An unidentified *Nysius* was also found at Porto Cachorro lava, Pico.

COLEOPTERA

Beetle identifications were made by P. OROMÍ, P. A. V. BORGES, G. ISRAELSON, G. GILLERFORS and J. C. OTERO.

Carabidae
Ocys harpaloides (Audinet-Serville). Porto Cachorro, Pico; Porto Judeu «Agulhas», Terceira.
Bembidion sp. Caldeira and Ponta do Pico «Piquinho», Pico.
Laemosthenes complanatus (DEJEAN). Costa da Nau, Faial.
Harpalus distinguendus (DUFTSCHMIDT). Costa da Nau, Faial (many).

Hydrophilidae
Cercyon haemorrhoidalis (FABRICIUS). Caldeira do Pico, Pico.

Ptiliidae
Ptenidium pusillum (GYLLENHAL). Porto Judeu «Agulhas», Terceira.

Staphylinidae
Phloeonomus punctipennis THOMSON. Mistério Negro «Lava» and «Kipuka», Terceira.
Gabrius nigritulus (GRAVENHORST). Ponta do Pico «Piquinho», Pico.
Pseudocypus aethiops WALTL. Mistério Negro «Kipuka», Terceira.
Myrmedoniini indet. Mistério Negro «Lava», Terceira.
Atheta dilutipennis MOTSCHULSKY. Capelinhos «Crater» and «Lava», Faial; Mistério de Rabo de Peixe, São Miguel.
Atheta laticollis (STEPHENS). Capelinhos «Crater», Faial; Baía Cachorro, Pico.

Elateridae
Heteroderes azoricus TARNIER. Costa da Nau, Faial (many).
Heteroderes melliculus reletii TARNIER. Capelinhos «Crater» and «Lava», and Costa da Nau, Faial.
Melanotus dichrous ERICHSON. Capelinhos «Crater», Faial.

Melyridae
Gietella faialensis MENIER & CONSTANTIN. Capelinhos «Crater» (many) and «Lava», Faial. The outstanding result of the sampling on the Capelinhos peninsula was the discovery of a population of this new species, which has been described by MENIER & CONSTANTIN (1988, 1989; CONSTANTIN & MENIER, 1990). This is the second known species of a new subfamily, Gietellinae, recently discovered in the Canaries (CONSTANTIN & MENIER, 1987; MARTIN *et al.*, 1987; ASHMOLE *et al.*, 1990). One of the objectives of our 1987 lava work was to determine whether this group was represented in the Azores. *G. faialensis* was obtained in considerable numbers in traps at Capelinhos «Crater» and a single individual at «Lava»; none were seen during the visual searching at these sites. In 1989 an attempt was made to learn more of the distribution of the species. Trapping was undertaken at Capelinhos «Cliff» and «Shore», and on rocky coasts at Lajes (Pico) and near Agua de Pau and Rabo de Peixe (Terceira): all attempts yielded negative results. We therefore still do not know where *Gietella* lives in the Azores, apart from the 30 year-old deserts of Capelinhos volcano. The Canarian species *G. fortunata* CONSTANTIN & MENIER, 1987, occurs on many islands (La Palma, Hierro, Tenerife, Lanzarote, Alegranza) always in recent or sub-recent coastal lavas, as well as in gravel beaches surrounded by lavas.

Nitidulidae
Epuraea unicolor OLIVER. Mistério Negro «Domo», Terceira.

Anthicidae
Hirticomus quadriguttatus (ROSSI). Costa da Nau, Faial.

Tenebrionidae
Blaps lethifera MARSHAM. Porto Judeu «Agulhas», Terceira.

Scraptiidae
Anaspis proteus WOLLASTON. Mistério Negro «Domo», Terceira.

Chrysomelidae
Epitrix cucumeris HARRIS. Caldeira (many) and Ponta do Pico «Piquinho», Pico.

Scolytidae
Coccotrypes carpophagus (HORNUNG). Mistério de Rabo de Peixe, São Miguel.
Xyleborus saxeseni (RATZENBURG). Mistério da Silveira, Pico; Pico do Fogo «Cantera», Terceira.

LEPIDOPTERA

A preliminary study of the material has been made by K. P. BLAND. Larvae and pupae identified only to family are ignored, but all adults are listed, except for some additional specimens obtained in water traps.

Tineidae
Monopis sp. Costa da Nau, Faial.

Epermeniidae
Indet. Costa da Nau, Faial.

Yponomeutidae
Argyresthia sp. Cabeço do Fogo, Faial.

Lycaenidae
Indet. Costa da Nau, Faial.

Noctuidae
Indet. Capelinhos «Lava», Costa da Nau (many) and Cabeço do Fogo (many), Faial.

DIPTERA

The flies have been examined briefly by M. BÁEZ (mainly), and NPA and MJA; Phoridae are being studied by R. H. L. DISNEY. Although few specific identifications are available it seems worthwhile to list the material, which is available for further study by specialists. Additional unlisted specimens were obtained in water traps.

Tipulidae
Indet. Cabeço do Fogo, Faial; Caldeira and Ponta do Pico «Piquinho», Pico.

Chironomidae
Indet. Ponta do Pico «Piquinho», and coast at Lajes, Pico.

Anisopodidae
Indet. Cabeço do Fogo, Faial; Baía Cachorro, Pico; Mistério de Rabo de Peixe, São Miguel.

Sciaridae
Indet. Capelinhos «Lava», Faial; Caldeira and Ponta do Pico «Piquinho», Pico.

Cecidomyiidae
Lestremiinae indet. Costa da Nau, Faial; Ponta do Pico «Piquinho», Pico.

Dolichopodidae
Indet. Mistério da Silveira, Caldeira and Ponta do Pico «Piquinho», Pico.

Phoridae
Indet. Capelinhos «Crater» and «Lava», Costa da Nau, and Cabeço do Fogo, Faial; Mistério da Silveira, Baía and Porto Cachorro, Caldeira and Ponta do Pico «Piquinho», Pico; Mistério de Rabo de Peixe, São Miguel.

Sepsidae
Indet. Cabeço do Fogo, Faial; Caldeira do Pico, Pico.

Sphaeroceridae
Indet. Capelinhos «Crater» and «Lava», Faial; Caldeira and Ponta do Pico «Piquinho», Pico; also in some caves.

Drosophilidae
Indet. Cabeço do Fogo, Faial; Mistério da Silveira (many) and Baía Cachorro, Pico; Mistério de Rabo de Peixe, São Miguel.

Chloropidae
Indet. Capelinhos «Lava». Faial.

Agromyzidae
Indet. Costa da Nau, Faial.

Heleomyzidae
Indet. Capelinhos «Lava» and Cabeço do Fogo, Faial; Baía Cachorro, Pico.

Trixoscelidae
Indet. Capelinhos «Crater», Faial.

Scatophagidae
Scathophaga stercoraria LINNAEUS. Cabeço do Fogo, Faial; Caldeira and Ponta do Pico «Piquinho», Pico.

Anthomyiidae
Indet. Capelinhos «Crater» and «Lava», and Cabeço do Fogo, Faial; Mistério da Silveira and Ponta do Pico «Piquinho», Pico; Mistério de Rabo de Peixe, São Miguel.

Sarcophagidae
Indet. Capelinhos «Crater» and Costa da Nau, Faial ; Mistério da Silveira, Pico.

Muscidae
Helina clara (HOFFMANNSEGG). Costa da Nau, Faial.
Muscidae indet. Costa da Nau and Cabeço do Fogo, Faial; Mistério de Rabo de Peixe and coast at Água de Pau, São Miguel.

Fannidae
Indet. Capelinhos «Crater», Faial.

Calliphoridae
Calliphora vicina ROBINEAU-DESVOIDY. Capelinhos Crater, Costa da Nau, and Cabeço do Fogo, Faial.
?*Pollenia rudis* (FABRICIUS). Capelinhos «Crater», Costa da Nau, and Cabeço do Fogo, Faial; Porto Cachorro, Pico.
Calliphoridae indet. Capelinhos «Crater», Costa da Nau, and Cabeço do Fogo, Faial; Porto Cachorro, Pico; Mistério de Rabo de Peixe, São Miguel.

HYMENOPTERA

The Hymenoptera were studied by G. ORTEGA, K. VAN ACHTERBERG (Braconidae), R. R. ASKEW (Chalcidoidea) and X. ESPADALER (Formicidae). Some additional unlisted specimens were obtained in water traps.

Tenthredinidae
Nematinus sp. Caldeira do Pico, Pico.

Braconidae
Dinotrema sp. Ponta do Pico «Piquinho», Pico.
Aphaereta minuta (NEES) s.l. Cabeço do Fogo, Faial; Caldeira and Ponta do Pico

«Piquinho», Pico; Mistério Negro «Domo», Terceira.
Chremylus elaphus HALIDAY. Capelinhos «Crater», Faial.

Eulophidae
Diglyphus isaea group. Mistério Negro «Domo», Terceira.
Tetrastichinae nr. *Melittobia* sp. Porto Judeu «Agulhas», Terceira.
Tetrastichus sp. Caldeira and Ponta do Pico «Piquinho», Pico.
Pediobius sp. Caldeira do Pico, Pico.

Aphelinidae
Indet. Caldeira do Pico, Pico.

Encyrtidae
Indet. Mistério da Silveira, Pico.

Torymidae
Monodontomerus sp. Porto Cachorro, Pico.

Pteromalidae
Mesipolobus sp. Mistério Negro «Kipuka», Terceira.

Eucoilidae
Indet. Mistério da Silveira and Caldeira do Pico, Pico.

Diapriidae
Indet. Capelinhos «Cliff», Faial; Mistério de Rabo de Peixe, São Miguel.

Scelionidae
Indet. Caldeira do Pico, Pico.

Sphecidae
Psen sp. Ponta do Pico «Piquinho», Pico.

Melittidae
Macropis sp. Costa da Nau, Faial.

Formicidae
Our data on the distribution of ant species on the lava habitats of the Azores shows some clear differences among the islands.
Hypoponera eduardi (FOREL). Recorded only from the islands of Faial and Pico:

Capelinhos «Lava», Costa da Nau and Cabeço do Fogo, Faial; Baía Cachorro, Pico.
Leptothorax unifasciatus (LATREILLE). Cabeço do Fogo, Faial; Pico do Fogo «Cantera», Terceira; Mistério de Rabo de Peixe, São Miguel.
Tetramorium caespitum (LINNAEUS). This species was very abundant at some sites on Faial and Terceira and was present on Pico, but was not recorded from São Miguel. Records are from: Capelinhos «Crater», «Lava», «Shore» and base and top of «Cliff», Cabeço do Fogo and Costa da Nau, Faial; Mistério da Silveira, Baía and Porto Cachorro, and on the coast at Lajes, Pico; Pico do Fogo «Cantera» and Porto Judeu «Agulhas», Terceira.
Monomorium carbonarium FOREL. This species was not found at lava sites, but was present in the thresholds of two caves on Santa Maria.
Iridomyrmex humilis MAYR. Found at Baía Cachorro, Pico; and on the shore and in the cave threshold at Agua da Pau, São Miguel.
Lasius niger (LINNAEUS). This species was abundant on Faial, Pico, Terceira and São Miguel. Records are from: Cabeço do Fogo, Costa da Nau and the base of Capelinhos «Cliff», Faial; Mistério da Silveira and Baía Cachorro, Pico; Pico do Fogo «Cantera» and Mistério Negro «Kipuka», Terceira; and Mistério de Rabo de Peixe, São Miguel. The species was also found in some caves and thresholds.

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