THE AZORES - WESTERNMOST EUROPE: WHERE EVOLUTION CAN BE CAUGHT RED-HANDED

By Antonío M. de Frias MARTINS[1]

INTRODUCTION

Very often we see the "wheels of Progress" as treacherous hopes that, under the golden promises of improving the standard of life, roll over life itself and leave behind them a path of destruction and impoverishment. Apparently, there is no return in the process, for every time a correction is made it catches the river farther downstream, where the scenario is different, the challenges are different, the ways of thinking are different and, consequently, the hopes, dreams and values may not be the same. It is a dynamic process, one that has at its heart the pulsating force of the future. Yet a similar environment surrounds Evolution. In the name of life itself, Evolution personifies the continuous change, the ever-present adaptation, the merciless struggle for life. The consequences, however, set both realities apart. The "wheels of Progress", alias, the "wings of Progress" proceed at a rate to which Nature is not accustomed, hence the impoverishment resulting thereafter. Time is what Evolution needs; time is what Progress cuts short. For that reason, if in the prosecution of the latter we disrespect the former, although we may succeed in a short term, in the long run we will be the main losers, for time is on Nature's side and we will not be playing by Nature's rules.

This paper is about Nature and Man, isolation and invasion, Evolution and Progress, the struggle of life and the struggle for life. It happens everywhere and all the time, but I will be concerned at this moment with tiny specks of land, in the middle of the North Atlantic: The Azores.

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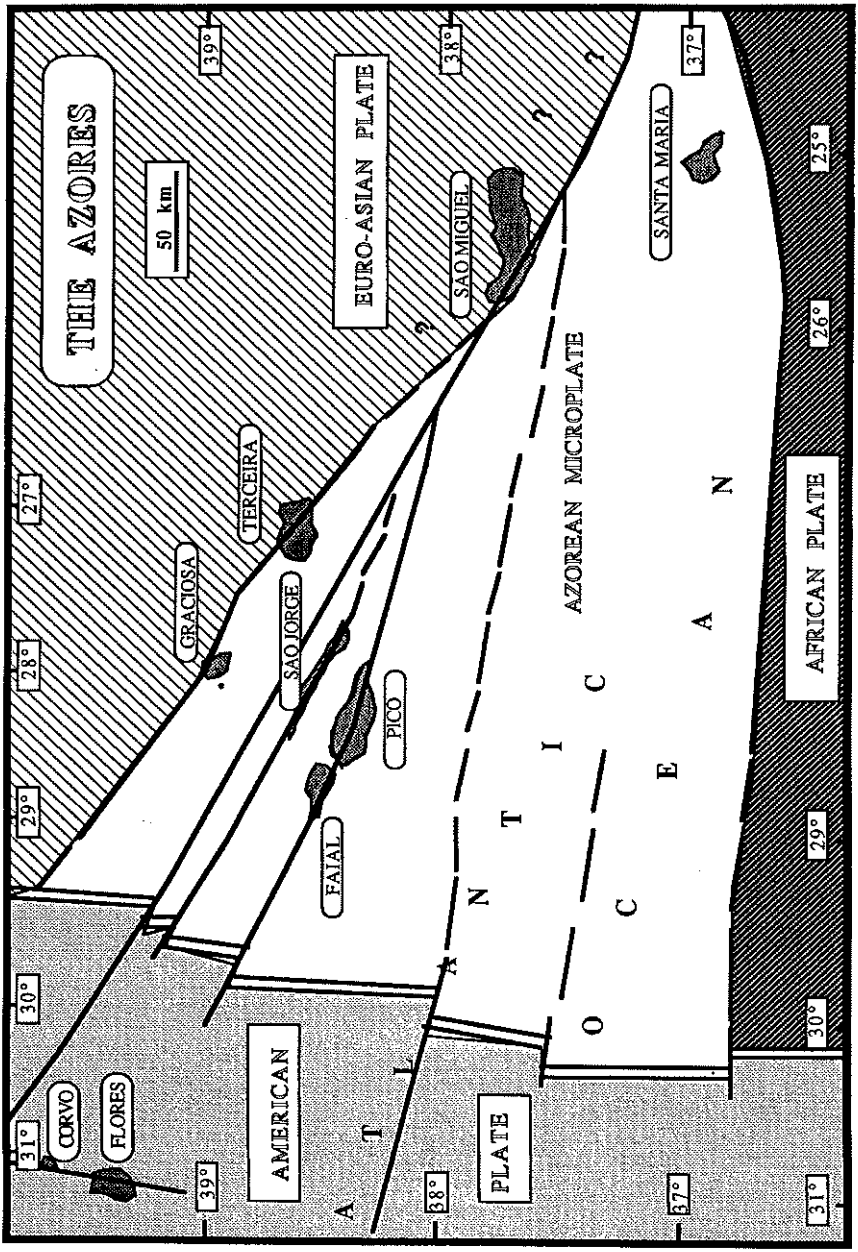

Figure 1. Geotectonic framing of the Azores (Adapted from Forjaz, 1986).

THE ORIGINS

Situated roughly between the coordinates 37° to 40° N and 25° to 31° W, the nine islands of the Azores stand isolated in the middle of the North Atlantic Ocean. The Azores we know today arose from the depths of the ocean at different times, essentially through volcanic activity due to tectonic movements. The Archipelago lies over two tectonic plates (Figure 1). Except for Flores and Corvo, all the islands are located on the Azorean microplate, a small, triangular enclave at the site of the junction of the Euro-Asian, African and American plates (Forjaz, 1986).

Santa Maria (97km²), the easternmost and oldest island, is volcanically the most stable; the highest mountain, Pico Alto, rises to 587 m; its oldest basalts are pre-vindobonian and there are scattered calcareous deposits of marine biological origin that have been dated also to the Miocene (Zbyszewski & Ferreira 1961).

São Miguel is the largest island (750 km²); the oldest portion (4 M yrs old) is located at the eastern tip, Nordeste, where the highest mountain stands (Pico da Vara, 1103m); the island was progressively formed due west (Povoação, 2 M yrs; Furnas, 750,000 yrs); a second island appeared (Sete Cidades, 500,000 yrs), latter connected to Serra de Água de Pau (250,000) through Região dos Picos (50,000 yrs); throughout the island, as in many places throughout the archipelago, several historical eruptions have been recorded (Zbyszewski *et al.*, 1958; Zbyszewski and Ferreira, 1959; Forjaz, personal communication).

São Miguel and Santa Maria form the Oriental Group; the next five islands belong to the Central Group and cluster relatively close to each other. The roundish Terceira (400 km²), 150 km NW of São Miguel, had its origins about 2 million years ago (Forjaz, personal communication); the highest mountain is Serra de Santa Bárbara (1020 m) and its caldeira is the youngest of the major island's complexes (25,000 yrs), with the last eruption dating from 2000 years ago (Fernandes, 1986).

Graciosa (62km²) is the lowest island, with the highest point at Pico Timão (398 m); the existence of a series of ancient quaternary beaches lead one to think that the island's formation goes back at least to the early Quaternary (Zbyszewski *et al.*, 1972).

The long and thin São Jorge (246 km²) is nevertheless elevated, the central platform averaging 700 m, the highest point reaching 1067 m; the oldest

formation (Topo) dates to the Pliocene (Forjaz and Fernandes, 1975).

Pico bears the highest azorean elevation (2351 m) and is the second largest island (436 km²); its oldest formation dates also to the Pliocene (Forjaz and Fernandes, 1975).

Faial was once connected to Pico, from which it is now separated by a shallow and 5 km wide channel; the borders of the central caldeira rise to 1043 m and the recent (1957) Capelinhos eruption has slightly increased the island due NW (173 km²).

Flores and Corvo, the islands of the Occidental Group, lie isolated on the American plate, 234 km from the nearest one, Faial. The westernmost island, Flores (143 km²), with its highest point at Morro Alto (913 m), had its origin probably during the Pliocene, and the last major volcanic activity goes back to the Tirrenian (Zbyszewski *et al.*, 1968); abundant fresh-water lakes are scattered throughout the island, some unusually deep (Lagoa Negra, 100 m deep). The smallest (17 km²) and northernmost island, Corvo, is but a big volcano 718 m high, with high cliffs all around except at the southern coast and a large central crater with a small lake within; the oldest formations appeared around the Pleistocene (Zbyszewski *et al.*, 1967).

THE FLORA

Gaspar Frutuoso (1522-1591), the historian of the early days of the colonization of the Azores, wrote about the first encounter of Conçalo Velho with Santa Maria (1432): "[he] found [the island] covered with many and thick forests of juniper [*Juniperus brevifolia* (Seub.) Antoine], Portugal laurel [*Prunus lusitanica* L. ssp. *azorica* (Moillef.) Franco], pau-branco [*Picconia azorica* (Tutin) Knobl.], faya [*Myrica faya* Aiton], laurel [*Laurus azorica* (Seub.) Franco], green heather [*Erica azorica* Hochst.] and other plants ..." (Frutuoso, III:11). In spite of the intense clearing of land by the colonizers, the same landscape was recorded by Frutuoso, at his time, for the remaining islands. Of Terceira that historian wrote (VI:51): "... there are enormous forests of all kinds of wood, juniper, pau-branco, sanguinho [*Frangula azorica* Tutin], Portugal laurel, laurel, laurustinus [*Viburnum tinus* L. ssp. *subcordatum* (Trel.) P. Silva] and other trees so dense that sometimes people get lost in them ...".

On Pico Island the now extinct yew [*Taxus baccata* L] was one of the main income sources and there were tight regulations controlling the cutting

down of the trees. However, as so many times has happened, the power of the law was not enough to protect people from their own greed and, in the words of Morelet (1860: 35), referring to the disappearance of the magnificent yews from Flores, "... far from grubbing up the land according to their needs, the first colonizers walked their axes everywhere, abandoned the ground to the futile pasture, and ended up exhausting a source of richness which their successors lament bitterly today".

Monoculture is as old as agriculture for profit and, naturally, it sat firmly on the Azores from the very beginning. Frutuoso often mentioned the fertility of the land. However, be it the exhaustion of the soil, as with the wheat in the late 1500's, the appearance of a better substitute, as in the case of pastel in the second half of the seventeenth century, the introduction of diseases, as happened in the orange period after 1830, market competition, as with the pineapple in the early years of this century and, in a foreseeable future, with pasture or eucalyptus, these monocultures that ruled the azorean economy have faded away, always leaving deep scars on the islands' landscape.

Since the very beginning, indiscriminate clearing up of land has led to disaster. Frutuoso (V1: 232) mentioned the case of Guilherme Silveira, who searched for good soil and found it at Topo, the eastern tip of the high-cliffed São Jorge. After some years of extremely good harvest, the rain washed the good soil away to the sea, the land became sterile and that place ended up being the worst of São Jorge and of all the islands, such that not even rabbits would survive there. The abundant rainfall, responsible for the evergreen azorean landscape, and the steep slope of the hill-sides led him to bankruptcy.

History has repeated itself time and time again, and even nowadays the vegetation coverage of the azorean land is heatedly disputed. The remnants of the original vegetation have been balancing between "unproductive wasteland" and "prime relic laurisilva", with consequent one-sided values attached to it. At the same time, hopeful conservationist trends can be seen in some official actions, leading to believe that an equilibrium can be reached between usage and conservation. The effort toward reforestation can be taken as an example.

The XIX century witnessed a great enthusiasm for reforestation and gardening, mostly in São Miguel. Numerous exotic species were introduced and many botanical gardens were created. The now common cryptomeria [*Cryptomeria japonica* (L.f.)D. Don], from Japan, was introduced around 1860 (Palhinha, 1966); the imponent New Caledonian araucaria (*Araucaria excelsa* R. Br.) and the acacias [*Robina pseudoacacia* L, *Acacia dealbata* Link and

Acacia melanoxylon R. Br. from Australia] also made their entrance to the azorean botanical community by that time. The Australian *Pittosporum undulatum* Vent. made its conquering way to the Azores, through England, to fence orange-groves and orchards, taking over the abandoned orchards and infiltrating everywhere. The beautiful Japanese hydrangeas [*Hydrangea macrophylia* (Thumb) Sér.], introduced in the early 1800's, consummated their victory by acquiring the status of "official flower", and the aggressive himalayan *Hedychium gardneranum* Rosco dominates now over disturbed natural forest and as undergrowth on secondary forest.

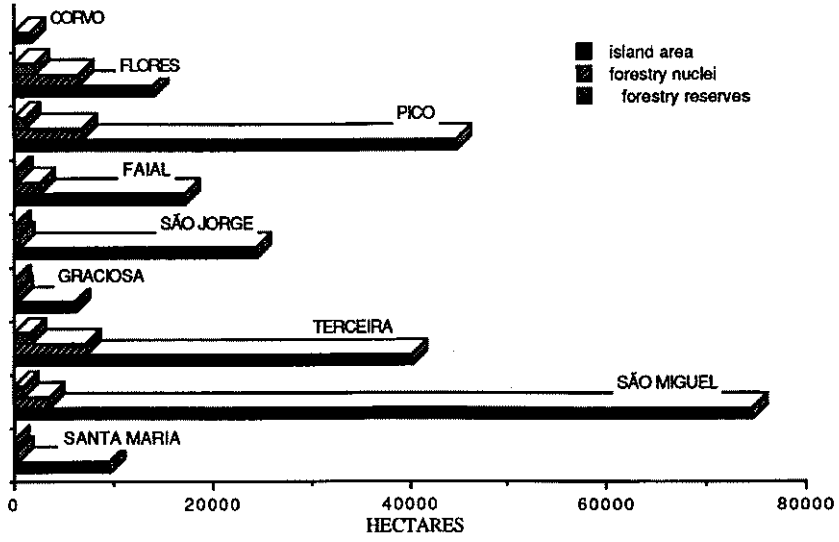

Figure 2. Distribution of Forestry services in the Azores. (Data from DRRF, 1988)

No control existed for the introduction of species nor was there any visible concern about the indigenous vegetation. However, the alarm had already been given in 1844 for the need of strong legislation toward the protection of forests (Loureiro, 1844). The demand for wood became acute due to the industrial revolution and during the Second World War. In 1943 the real condition of forest cover was revealed: only 4780 hectares in São Miguel, the equivalent to 7% of the island's area. Five years later a Forestry Department was created in São Miguel, soon after branching to other islands (Figure 2) and old and new laws were enforced. Presently 21% of the island is covered with replanted forest, to which one might add 9% of more or less original shrubland (DRRF, 1988).

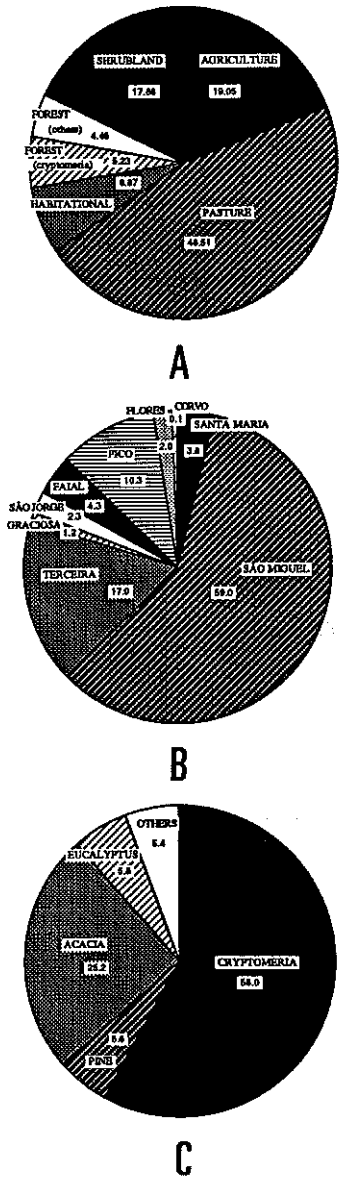

Figure 3. Relative distribution (%) of land utilization in the Azores. A, main components; B, forest cover; C, species constituting forest cover (Data from DRRF, 1988).

Although the scenario for the Archipelago as a whole is not as rich as for São Miguel (Figure 3), overall improvement has been observed and the plans for a near future are promising (Figure 4). The choice of species can be a matter of opinion; however, the fact that the projected growth will happen at the expense of shrubland is of great concern. One only hopes that high altitude pasture, already proven to be of reduced value, should be the one to reconvert into the forest. Also, taking into account the vulnerability of extensive monocultures to ravaging diseases, economical demands and ecological factors, the dominance of cryptomeria should be reconsidered.

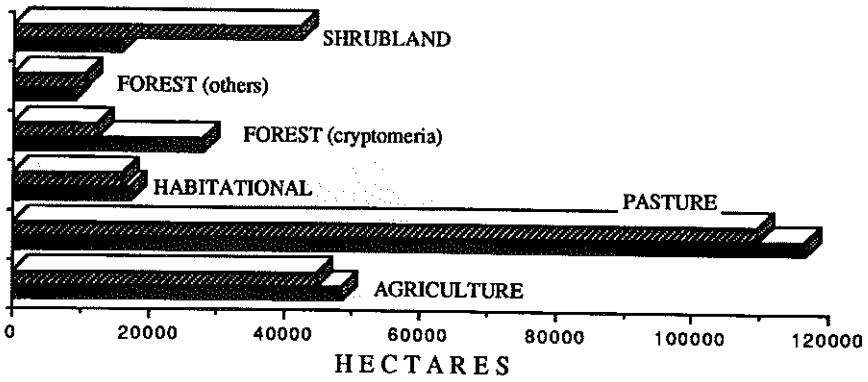

Figure 4. Land utilization as in 1988 (hatched) and perspectives for a near future (solid). (Data from DRRF, 1988).

The fertility of the soil, the permanent humidity and the mild temperature all year round created tempting conditions for cattle raising, and from the early days of colonization great amounts of land were cleared for pasture. From the late 1960's to the middle 1970's the Government reinforced the development of cattle-raising through important financial assistance, and great amounts of land, from sea level to the top of the mountains, were transformed into pasture. The imminent (1992) disappearance of trade frontiers within the EEC countries and the latest evolution of economic policies in Europe have led the Government of the Azores to favour high production of dairy products, thus continuing previous policies. Another dangerous monoculture is, then, installed in the Azores. The mechanical and chemical treatments of the soil may rapidly depauperate the still productive azorean land, unless a swift revision of policies toward an integrated allotment for agriculture/pasture/forest/shrubland is achieved.

THE FAUNA

The poverty of the Azorean fauna, when compared to that of Madeira and the Canary Islands, has been noticed in almost every work dealing with the subject. Besides the commonly accepted incomplete knowledge due to lack of major systematic research, distance from mainland, youth of the islands and destructive volcanic activity have been the most plausible explanations for that fact (Lindroth, 1960; Backhuys, 1975; Waldén, 1984).

The introduced fauna, evidently, shares the same country of origin as human colonization. Also, the autochthonous and even the endemic groups of azoreans animals, similarly to the already mentioned flora, exhibit a strongly dominating European influence.

More or less adapted European birds (among them the now rare azorean bullfinch *Pyrrhula murina* Godman) and a bat [*Nictalus leisleri* (Kuhl)] were the only land vertebrates originally living in the Azores. Rats [*Rattus norvegicus* (Berkenhout) and *Rattus rattus* (L.)], mice (*Mus musculus* L.) and rabbits [*Oryctolagus cuniculus* (L.)] came with the first colonizers, as well as, probably, weasels (*Mustella nivalis* L.) and ferrets (*Mustella putorius* L.). The appearance, in 1990, of an oriental virus has wiped out 90% of the rabbit population on most islands and the ecological consequences of that reduction are understandably serious. Frogs [*Rana esculenta* (L.)] and lizards (*Lacerta dugesi* Milne-Edwards) were brought in by middle 1800's, and the hedgehog (*Erinaceus europaeus* L.) and the crested newt (*Triturus cristatus*) escaped from cages or aquaria by the end of last century. The recently (1957) introduced house sparrow (*Passer domesticus* L.), now spread all over the Azores, is causing expected disturbance among the native birds. Several accidental introductions of snakes, tarantulas and scorpions in cargo ships fortunately were not successful (Chaves, 1911).

Except for the freshwater eel [*Anguilla anguilla* (L.)] no other freshwater fish lived in the Azores. Now a dozen species can be found in the azorean interior waters, all but the gold fish [*Carasius auratus* (L.)] introduced after 1876 (Vicente, 1956; Forestry Services, personal communication).

The invertebrate fauna is known mostly through the research of visitors, demonstrated particularly in the works of Morelet (1860), Drouët (1861), the many studies resulting from the 1957 Lundt University Azores Expedition, published in the Boletim do Museum Municipal do Funchal, and Backhuys' (1975) doctoral dissertation. Recent works of residing researchers (Serrano and

Borges, 1987; Martins, 1989) are adding important new occurrences or even new species, thus creating a slightly different scenario for zoogeographical discussions.

GUESTS OR INVADERS?

Reference has been made to unfortunate introductions (*Hedychium gardneranum*, *Pittosporum undulatum*, house sparrow) and, much to our dismay, we have learned to cope with those species as part of the azorean landscape. Other invaders, however, pose no lesser threat and are likely either to dislodge the endemic flora and take over the azorean land or to cause economically important devastation. So far they are restricted to São Miguel or Terceira, and one only hopes that a short term solution will be found to control or to eradicate them.

Clethra arborea Ait. is endemic to Madeira and was introduced in São Miguel in the early 1960's (Sjögren, 1984). It has spread over Graminhais and the residue of laurisilva of Pico da Vara, and the consequences are yet to be guessed.

Another aggressive intruder, perhaps of greater concern, is *Gunnera tinctoria* (Molina) Mirb. Escaped recently from the botanical gardens of Furnas, it has spread deadly through Graminhais and is found creeping its way towards Lagoa do Fogo, 50 km W.

Of the numerous invertebrate introductions, two are of great economical concern: *Fasciola hepatica* L. and *Popillia japonica* Newman, the Japanese beetle. Of the former you will hear next in this Conference (Cunha, 1993). The Japanese beetle, arrived from the United States by the early 1970's, is so far restricted to Terceira Island, where it has been declared a major pest. Research is in progress at the Department of Biology of the University of the Azores to develop a biological control program, mostly with nematodes, fungi and bacteria.

The development of cattle-raising has brought with it the burst of the pasture army caterpillar [*Mythimna unipuncta* (Haworth)]. The annual damage caused by this lepidopteran in the Azores can reach the alarming figures of 1,000,000,000$00, Portuguese currency (U.S. $6.9 million) and the Department of Biology of the University of the Azores is leading a biological control program with the utilization of the parasitic hymenopterans *Trichogramma* and *Apantheles*.

PILLAGE AND OTHER THREATS

Without pretending to champion a short-sighted crusade against progress and economic self-sufficiency, I have expressed my concerns about the dangers of monocultures. Cattle-raising has received a big increment in the 1960's and also now, at the doorstep of the free trading era of the EEC and pressed by the necessary production quota definitions. Although apparently a good decision to boost the economy of the islands, for it intended to take full advantage of careful breeding experiments to find the most adapted cattle to the Azorean climate, the plan failed partially when it pretended to turn every Azorean into a cowboy. Lured by substantial financial aid, good agricultural soil and less productive high altitude land were converted to green pasture. Among other things, isolation took its toll on marketing. Small cattle farmers now see the one time subsidies begin to subside in favour of well organized, profitable corporations, but they do not have the incentive nor the means to reconvert. On the other hand, those better prepared now treat the land mechanically, deep cultivating the ground and, due to high rain-fall, rapidly washing the good soil down to the sea. This I call pillage, for it selfishly and lavishly squanders the richness of generations past and the well being of generations to come. At the moment, pasture is probably the major problem of the azorean land.

Another extensive monoculture, that of the eucalyptus, has made its way into the Azores recently. If not tightly controlled, it will pass through and, unlike business of old times, not even mansions will be left to testify its past prosperity.

One more threat I will mention here, and that one, too, I call pillage. Since the middle of last century good pineapple has been cultivated in hot houses in São Miguel. As in all arts, secrets of the trade have been developed and jealously kept, and those normally do not evolve with time. Any innovation is seen as a deviation from the original and thus firmly rejected. Such is the case with pineapple cultivation. In order to prepare the "bed" for the young plants, a mixture of moss and other small plants, *leiva*, is laid on the ground of the hot-houses; the heat emanating from the decaying process creates the proper environment for the growth of the pineapple. The only way to get the moss mixture is to scrape the sphagnum layer of primitive shrubland, thus destroying the associated complex plant community and the top layer of the rich soil; the remaining soil, unprotected, is quickly washed away. Experiments with cut up plant material, mostly the abundant *Pittosporum*, have achieved similarly good results and are slowly being used; however, some pineapple farmers cling to the old method and every year pay good money for load of *leiva*, thus unnecessarily inciting a few to pillage the amazingly undisturbed legacy of many centuries.

THE AZORES: A "WORLD RESERVE"?

With all these vicissitudes, after all the abuse and violence the islands have been subjected to since man set foot ashore, there is still something special in the Azores worth mentioning and preserving.

a. *Remnants of ages past*

In some of the islands there are important pockets of laurisilva, or whatever one calls that primitive environment; Pico da Vara, in São Miguel, besides harbouring the endemic and endangered bullfinch, the priôlo, is still relatively intact; Lagoa do Fogo, where an eruption in the 1500's probably has wiped out all life in the surroundings, is a good example of primitive shrubland; the out-of-place cryptomeria plantations inside the crater, should be readily destroyed and their owners properly reimbursed and the stripping-off of *leiva* should be stopped and deterred at all costs. The spectacular Caldeira de Santa Bárbara Terceira, probably has the best juniper forest in the Azores. The slopes of Pico are a clear cut example of altitude zonation of vegetation coverage.

b. *A natural laboratory*

The very geographical position of the Azores, far away from everything, poses important dispersal questions and makes these islands as a natural laboratory. Midway between the European and the North American continents and born out of the attrition of three tectonic plates, the Azores are biologically truly westernmost Europe. With a maximum inter-island distance of about 600 km, at the same time clustering differently into three groups, the indigenous fauna and flora associations of the various islands, when better known, are expected to improve our understanding of colonization strategies.

The conspicuous variability of external morphology or the concealed divergence in molecular structures from population to population witness the complex and tortuous pathway we call Evolution. Forced by natural selection, made up of trials on multiple fronts, its failures are often immortalized in rock, but its victories live to carry the burden of transmitting to the future the secret of their success. Evolution is a permanent event and can be seen everywhere. By stating that it can be caught red-handed in the Azores, I only want to stress the systematic problems arising from an in-depth research on some groups of land molluscs and, by extrapolation, present probably in other groups.

Although poor in the amount of endemisms, when compared to the geologically much older Madeira and Canary Islands, the Azores hide some surprises of their own. Exploring the field of Malacology, we find some well represented groups, either typically azorean, as *Plutonia*, *Drouetia* and other *Oxychilus* subgenera, the enids, or macaronesian, as *Phenacolimax*, *Leptaxis*, *Actinella*.

Variability in the endemic subgenus *Drouetia* was noted by Riedel (1964), who added two new species to that once monotypic taxon. Four new species were added (Martins, 1981, 1989b; de Winter, 1989) and three more are in the process of description (Martins, in preparation). An holistic approach has been adopted, integrating morphological, anatomical and molecular parameters, in order to search for an understanding of the existing inter- and intra-specific variability (Brito, 1992).

Backhuys (1975) has rightly pointed to the azorean enids as belonging to a new taxon, an opinion shared by other researchers (Martins, 1989a; Alonso, personal communication). Early in 1990, for a paper presented at ICSEB VI, U.S.A., I made an anatomical survey of the group in order to assess the reliability of the reproductive system as a major taxonomic character, and came up with startling results. Although only qualitative data are available, shell and anatomical morphology are seen to vary independently, and major anatomical differences were found in otherwise conchologically similar taxa. Once again surfaces the problem of how much variety can a species withstand. Also, how does one interpret intra-island differences and inter-island similarities. I had promised my Canarian colleagues that a paper on the new enid genus was bound to appear soon, but, in view of the exciting preliminary results obtained, their kindness and patience will bear with me for a while longer.

Other endemic molluscan taxa are presently under study, mostly as a result of joint projects with specialists who visit us regularly, and it is our purpose to engage in further commitments with as many researchers as possible. Isolation is the prime spice for evolution, but it may be the worst handicap for its study. Our policy has been to assure that most of this study is carried out *in situ*, thus minimizing our isolation and maximising the chances of an in-depth and long term research. Hence, we will welcome the exchange of graduate students eager to work with us on the Azores.

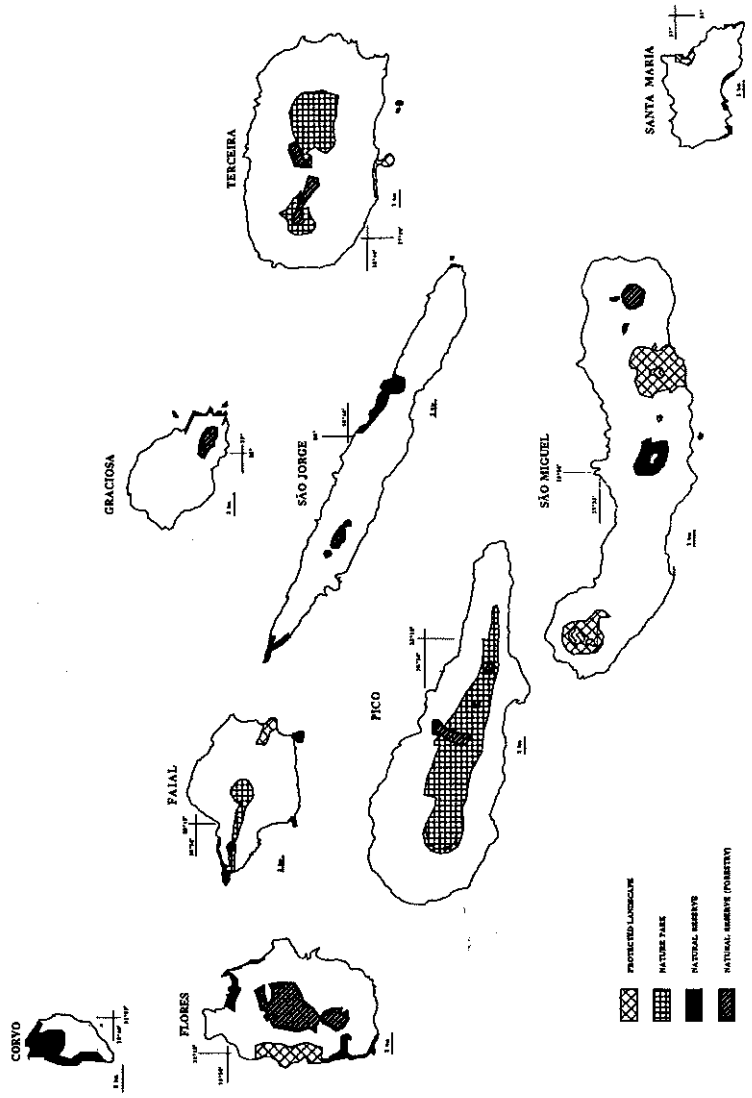

Figure 5. Classified areas of the azorean land. Nature reserve (Forestry) is under the administration of the Direcção Regional dos Recursos Florestais (DRRF); all others, proposed for legislation, will be under the administration of the Direcção Regional do Ambiente (DRA).

TOWARDS A SOUND CONSERVATION POLICY

Much is known about the Azores, but we know that much more waits to be discovered. Any conservation policy should be based on a fundamental knowledge of what is there to be conserved. Hence the urgent need for inventories. Much more than preliminary lists, mostly mentioning common occurrences, I mean systematically elaborated inventories. An effort in that direction is being made by the Department of Biology of the University of the Azores through the creation of a nucleus of Systematics and Evolution; however, aware of the diversity and vast magnitude of the many fields to cover, we welcome joint projects, preferably to be developed in the Azores.

Large areas are being proposed by the appropriate Government agency to be classified, most intelligently bordering the ones already existing under the competence of the Forestry Department, thus joining efforts in a common cause (Figure 5). The new Government policy towards conservation, now in preparation, allied to the most valuable work of the Forestry Department in the Azores and backed up by the scientific research of the University, constitute a reassuring hope that a proper and convenient allotment of land to the various activities, from housing to recreation, from agriculture to pasture, from forest to wilderness, will respect not only the needs of progress but also our natural patrimony.

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