Mammals from the Azores islands (Portugal) : an updated overview

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Summary. – Nine species of mammals are recorded for the Azores islands : one insectivore *(Erinaceus europaeus)*, two bats *(Myotis myotis, Nyctalus azoreum)*, one lagomorph *(Oryctolagus cuniculus)*, three rodents *(Rattus norvegicus, R. rattus, Mus musculus domesticus)* and two carnivores *(Mustela nivalis, M. furo)*. Here, notes on the origin and known distribution are given for each species, together with taxonomical and ecological comments. Except for bats all the remaining species seem to have been introduced under the influence of man's exploratory and commercial activities.

Résumé. - Neuf espèces de mammifères sont citées de l'Archipel des Açores : un insectivore *(Erinaceus europaeus)*, deux chiroptères *(Myotis myotis, Nyctalus azoreum)*, un lagomorphe *(Oryctolagus cuniculus)*, trois rongeurs *(Rattus norvegicus, R. rattus, Mus musculus domesticus)* et deux carnivores *(Mustela nivalis, M. furo)*. Le présent travail apporte des données sur l'origine et la distribution, ainsi que certains aspects de la taxonomie et l'écologie de chaque espèce. Exception faite des chiroptères, toutes les espèces semblent avoir été introduites, suite à des activités humaines (exploration et commerce).

INTRODUCTION

According to historical records, bats (the Mouse-eared bat *Myotis myotis* and the Azorean noctule *Nyctalus azoreum*) were probably the only wild mammals inhabiting

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the Azores islands by the time of their discovery by Portuguese navigators, five centuries ago (e.g. Fructuoso 1978, 1983). Present mammal fauna was built up under the influence of man's exploratory and commercial activities and includes additionally one insectivore (the hedgehog *Erinaceus europaeus*), one lagomorph (the rabbit *Oryctolagus cuniculus*), three rodents (the brown rat *Rattus norvegicus*, the black rat *Rattus rattus* and the house mouse *Mus musculus domesticus*) and two carnivores (a wild species, the weasel *Mustela nivalis*, and a feral species, the ferret *Mustela furo*).

This paper, dealing with the mammals of the Azores is part of a wider study on the ecology and health importance of these vertebrates (Proj. STRDA 447/92, JNICT). It includes data on the recent distribution of the different species along with some comments on their origin, taxonomic status and ecology.

STUDY AREA

The archipelago of the Azores is located in the mid-North Atlantic, about 1,500 kilometres from the coast of mainland Portugal, 1,900 kilometres from North America and 850 kilometres from the nearest islands of Madeira. The nine islands of the archipelago, all of volcanic origin, are included in three groups, aligned along a NW-SE-axis : the Western Group (Corvo and Flores), the Central Group (Faial, Pico, São Jorge, Graciosa and Terceira) and the Eastern Group (São Miguel and Santa Maria), which is the nearest group from mainland Portugal and Madeira (Table 1). Corvo, in the Western Group, lies approximately at the same distance from Portugal and Newfoundland in North America.

The vegetation on these islands, originally luxuriant, has been strongly modified by man, either by clear cut for pastures, which today, together with agriculture, correspond to about 65 % of the land use, or the introduction of numerous exotic species e.g. the cryptomeria, *Cryptomeria japonica*, nowadays very abundant, the hydrangea, *Hydrangea macrophylla*, so widespread that it has acquired the status of official flower, and *Hedychium gardnerianum*, introduced during the XIXth century and dominating over many natural areas. Remnant species of the original flora can still be found in small and localized spots, mostly at high altitudes, e.g. the laurel, *Laurus azorica*, the green heather *Erica azorica*, the juniper, *Juniperus brevifolia* and the Portuguese laurel, *Prunus lusitanica azorica* (Palhinha 1966 ; Frias Martins 1993).

Table 1. – Physical features of the Azores archipelago.

ISLANDS	LONGITUDE (W)	LATITUDE (N)	DISTANCE TO MAINLAND (km)	AREA (km^2)	MAXIMUM ALTITUDE (m)	AGE (m.y)
Corvo	30.8	39.7	2148	17	718	?
Flores	30.9	39.4	2152	142	915	0.01-1.80
Faial	28.5	38.6	1908	172	1043	0.73-2.60
Pico	28.2	38.5	1860	433	2351	0.03-1.10
Graciosa	27.8	39.1	1844	62	402	0.62-2.50
São Jorge	27.9	38.7	1832	246	1053	0.55-2.00
Terceira	27.2	38.7	1764	402	1023	0.30-2.00
São Miguel	25.5	37.7	1584	757	1103	4.00-4.01
Sta. Maria	25.1	36.9	1588	97	587	8.00-8.12

METHODS

Annual expeditions were conducted within the period May/July to the islands of São Miguel and Terceira (1993-96), Flores (1994-96), Graciosa (1995-96), Pico and São Jorge (1995). Information on the distribution of Azorean mammals was gathered from : i) personal observations ; ii) inquiries ; iii) museum records (Natural History Museum, London) ; and iv) bibliographical data.

Ecological data herein included are mostly based on captures in areas characterized by different altitude, degree of human impact, percentage of soil cover, habitat structure and plant species richness. Measurements and taxonomical data are given for each species whenever relevant.

SPECIES ACCOUNT

Erinaceus europaeus Linnaeus, 1758 - Western hedgehog

Distribution. – The occurrence of this species is known from the Eastern (Santa Maria, São Miguel) and Central Groups (Terceira and Faial) (Table 2).

Historical records. – According to Ulfstrand (1961), *E. europaeus* was first recorded for the archipelago in 1957 at Ponta Delgada (São Miguel), where a specimen was found drowned in a garden pound. There are no references concerning the introduction of this species which certainly arrived under man's influence. The same author considered as probable an European origin for the Azorean populations, a fact which was recently reinforced, at least for São Miguel and Terceira islands, through the study of the helminths of several specimens (Casanova *et al.* 1996).

Measurements. – Average values of 7 males and 4 females : weight 556.1 g and 525.5 g, body length 23.8 cm and 24.5 cm, tail length 2.7 cm and 3.0 cm, hind-foot length 4.1 cm and 4.2 cm, ear length 2.8 cm and 2.7 cm. Azorean hedgehogs are about the same size as Portuguese mainland specimens (Ramalhinho, unpubl. data), although deeper comparative studies are needed.

Ecological data. – Hedgehogs were found in pastures and in cultures, surrounded by woods of *Cryptomeria japonica*, shrubs of *Rubus* sp. and spots of *Pteridium aquilinum.*

Table 2. – Distribution of mammal species in the Azores Islands (suspected occurrence in brackets).

ISLANDS	Hedgehog	Mouse-eared bat	Azorean noctule	Rabbit	Brown Rat	Black rat	House mouse	Weasel	Ferret
Corvo			(X)		(X)	X	X		
Flores			(X)	X	X	X	X		X
Faial	X		(X)	X	X	X	X	(X)	
Pico		(X)	X	X	X	X	X		X
Graciosa		X	(X)	X	(X)	X	X		
São Jorge		(X)	X	X	X	X	X		X
Terceira	X	(X)	X	X	X	X	X	X	X
São Miguel	X	(X)	X	X	X	X	X	X	(X)
Sta. Maria	X		(X)	X	X	X	X		

Myotis myotis (Borkhausen, 1797) - Mouse-eared bat

Distribution. – Confirmed occurrence in Graciosa. Suspected occurrence in other islands of the Central and Eastern Groups. Absence of published information concerning the Western Group (Table 2).

Historical records. – This species was first mentioned in the Azores by Palmeirim (1979), who found three specimens near the entrance of a large cave on the island of Graciosa. These numbers suggest a regular rather than an accidental presence of the species in the archipelago, as stated by Palmeirim (*op. cit.*). In fact, some observations of a large-sized bat on another island, namely S. Miguel (Eastern Group), probably refer to *Myotis myotis*.

Measurements. – Palmeirim (1979) gives the skull measurements of one specimen in Graciosa.

Ecological data. – The use of caves by this species was also reported in mainland Portugal (Palmeirim and Rodrigues 1992). Azorean populations are considered insufficiently known and those on the mainland are threatened with extinction (SNPRCN, 1990).

Nyctalus azoreum (Thomas, 1901) - Azorean bat or Azorean noctule

Distribution. – Probably occurring on all the islands of the archipelago, although known data only concern some islands of the Central and Eastern Groups (Table 2).

Historical records. – The occurrence of this species in the Azores is referred to since the last century (Drouet 1861 ; Godman 1870 ; Chaves 1911 ; Miller 1912 ; Ellerman and Morrison-Scott 1951 ; Ulfstrand 1961 ; Fructuoso 1978 and Palmeirim 1991). *N. azoreum* is probably the only really native mammal species in the Azores and seems to have always been quite common on these islands. In spite of the lack of records concerning the origin of *N. azoreum*, or its ancestor *N. leisleri*, Drouet (1861) mentioned the introduction of a bat from Northern Europe, probably *N. leisleri*, by Flemish immigrants at the time of the colonization. However, this fact seems very unlikely not only due to the migratory character of the species but also because of the degree of differentiation attained which allow us to suspect an earlier arrival in the archipelago.

Taxonomical data. – Although several authors (e.g. Corbet 1978; Stebbings and Griffith 1986) referred to this form as a subspecies of *N. leisleri*, a recent taxonomic analysis agrees with the validity of the species (Palmeirim 1991). *N. azoreum* is quite distinctive from other relatives, such as *N. leisleri verrucosus*, the Madeiran noctule, mainly due to its smaller size and darker colour.

Measurements. – Average values of 14 Azorean specimens from the Natural History Museum (London) : condylobasal length 13.9 mm, zygomathic breadth 9.2 mm and mandible length 10.4 mm. For a more complete description of the species see Drouet (1861), Miller (1912) and Palmeirim (1991).

Ecological data. – Little is known about the Azorean noctules. They roost mainly in buildings and are predominantly diurnal (Stebbings and Griffith 1986 ; pers. obs.) probably due to the lack of raptors (Moore 1975). During the night they can be very numerous in the neighbourhood of towns and gardens, being frequently seen catching insects in flight near light spots (Drouet 1861 ; Godman 1870, pers. obs.). *N. azoreum* is a protected species, classified as rare by SNPRCN (1990).

Oryctolagus cuniculus (Linnaeus, 1758) - Rabbit

Distribution. – Rabbits occur on all the islands of the archipelago, except Corvo in the Western Group (Table 2).

Historical records. – Probably one of the oldest introductions into the archipelago. This species was almost certainly introduced by the first settlers in the 15th century, or even a little earlier, prior to the official discovery, when most of the Azorean islands were already known by the Portuguese navigators (Chaves 1911 ; Fructuoso 1978, 1983). Data on the occurrence of the species in the Azores can be found in Drouet (1861), Godman (1870), Chaves (1911), Miller (1912) and Flux and Fullagar (1992).

Taxonomical data. – Rabbits in the Azores are phenotypically as well as genotypically very similar to the wild rabbits from mainland Portugal (Carvalho *et al.* 1993, 1994). Azorean rabbits have been related to the subspecies *algirus* Locke (= *huxleyi* Haeckel), originally distributed over Iberia and North Africa (Miller 1912 ; Cabrera 1914 ; França 1913 ; Ulfstrand 1961 ; Carvalho *et al.* 1993, 1994).

Measurements. – According to Carvalho (1993), rabbits from S. Miguel are slightly heavier than those from Terceira or mainland Portugal.

Ecological data. – Rabbits are very abundant on all the islands where they were introduced, occurring mainly in the woods, especially when associated with grasslands and bushes (Godman 1870 ; Carvalho 1993 ; pers. obs.). In these suitable habitats, if undisturbed, they can easily be seen by day (pers. obs.). Azorean rabbits live under a marked hierarchy in social groups constituted by 2-7 individuals, such as is usually the case when cover or food have to be shared (Carvalho *et al.* 1993).

Rattus norvegicus (Berkenhout, 1769) - Brown rat

Distribution. – Found on every island of the archipelago, although recent information on its occurrence at Corvo and Graciosa are not available (Table 2).

Historical records. – Data on the introduction of *R. norvegicus* in the archipelago are very scarce, but it must not have occurred before the end of the 18th century. Drouet (1861) states that brown rats colonized the Azores from the island of S. Miguel where they arrived due to the wreck of a ship sailing near the cost of this island, at the beginning of the 19th century. The origin and the course of this ship were unknown.

Measurements. – Average values of 10 males and 4 females : weight 289.2 g and 192.3 g, body length 22.2 cm and 19.8 cm, tail length 20.1 cm and 18.6 cm, hind-foot length 3.9 cm and 3.8 cm, ear length 2.2 cm.

Ecological data. – Azorean brown rats are very successful immigrants, being found mainly in and around farms, urban areas and garbage dumps. Due to the usually high numbers in these areas and to its importance to Public Health (Collares-Pereira *et al.* 1996, 1997), the species has been periodically submitted to pest control policies (unpublished authorithies'reports).

Rattus rattus (Linnaeus, 1758) - Black rat

Distribution. – Common throughout the nine Azorean islands (Table 2).

Historical records. – This species was referred to in the Azores by Drouet (1861), Godman (1870), Chaves (1911) and Fructuoso (1978). Following Drouet (1861) the

introduction of the black rat into the archipelago should have been associated to the arrival of the first colonizers. In fact, Fructuoso (1978) mentioned that this species was already present on some of the islands by the XVIth century. Although its removal and possible replacement by *R. norvegicus*, bigger in size and more competitive, was predicted by Drouet (1861), *R. rattus* is, nowadays, the most common rat species in the archipelago.

Taxonomical data. – Libois *et al.* (1996), discussing the origin of insular black rat populations from Western Europe, conclude that rats from the Azores originated from Europe and, in spite of the differences in size and colour, the reduced genetical divergence does not support a subspecific differentiation. The three coat colour morphotypes known for the species have been identified within Azorean populations although the all black *rattus* morphotype is dominant (Table 3). The other two forms, brown greyish with grey belly (*alexandrinus* morphotype) and brown with whitish belly (*frugivorus* morphotype) are much less frequent.

Measurements. – Average values of 40 males and 31 females : weight 180.5 g and 150.1 g, body length 19.6 cm and 18.0 cm, tail length 20.6 cm and 20.7 cm, hind-foot length 4.3 cm and 3.4 cm, ear length 2.9 cm and 2.4 cm. Black rats from São Miguel and Terceira islands are bigger and have more developed toothrows than the continental ones (Ramalhinho *et al.* 1996).

Ecological data. – According to Godman (1870), previously to the introduction of the brown rat, the black rat inhabited gardens and orange orchards, climbing to the trees and eating the pulp of the fruits. Nowadays, the species is also found in lower human impact areas of higher altitude such as in the Laurisilva forest. Due to its abundance and confirmed role as one of the major *Leptospira* reservoirs (Collares-Pereira *et al.* 1996, 1997), black rats are frequently controlled by poisoning, both in urban and rural areas (unpublished authorithies'reports).

Table 3. – Percentage of melanism in black rat *(Rattus rattus)* and house mouse *(Mus musculus domesticus)* in different Azorean islands (N = number of specimens).

	Rattus rattus		*Mus domesticus*	
ISLANDS	**N**	**% Melanism**	**N**	**% Melanism**
S.Miguel	18	77.8	15	6.7
Terceira	54	31.5	43	48.8
S.Jorge	8	62.5	-	-
Graciosa	5	60.0	45	4.4
Pico	3	100.0	7	14.3
Flores	8	50.0	44	27.3

Mus musculus domesticus Linnaeus, 1758 - House mouse

Distribution. – Cosmopolitan species, occurring on all the islands of the archipelago (Table 2).

Historical records. – The house mouse is referred to in the Azores by Drouet (1861), Godman (1870), Chaves (1911), Miller (1912), Schwarz and Schwarz (1943), Ellerman and Morrison-Scott (1951) and Ulfstrand (1961). This species seems to have been common in the archipelago since the establishment of the first human colonies in the 15th century (Drouet 1861 ; Arruda 1932)

Taxonomical data. – Recent findings of Libois *et al.* (1997) on the fleas of the Azorean house mouse, confirm that this rodent was introduced into the archipelago from the Mediterranean basin. Some individuals, as already mentioned by Ulfstrand (1961), present a darker pigmentation than the continental ones (Table 3). This character was described once as diagnostic of an endemic dark mutant, *M. azoricus* Schinz or *M. domesticus azoricus* Schinz (Miller 1912 ; Schwarz and Schwarz 1943 ; Ellerman and Morrison-Scott 1951).

Measurements. – Average values of 78 males and 55 females : weight 16.1 g and 15.8 g, body length 8.2 cm and 8.4 cm, tail length 8.1 cm and 8.4 cm, hind-foot length 1.7 cm, ear length 1.3 cm and 1.4 cm.

Ecological data. – In the Azores islands, house mice are common indoors and in other man-influenced habitats, as well as in many different kinds of natural habitats (e.g. in forests of *Cryptomeria japonica*, in the indigenous forests of Laurisilva and in shrublands dominated by *Rubus* sp., *Hydrangea macrophylla*, *Pteridium aquilinum*, *Erica azorica*). This species was found up to 700 m in Flores and in Terceira. Considered a pest to agriculture, and a major carrier of *Leptospira* (Collares-Pereira *et al.* 1996, 1997), the numbers of Azorean house mice are periodically controlled through pest management policies (unpublished authorithies' reports).

Mustela nivalis Linnaeus, 1758 - Weasel

Distribution. – Captures of two animals confirmed the presence of the species both in the Eastern (São Miguel) and the Central Groups (Terceira). Present occurrence at Faial (Godman, 1870) was not yet clarified.

Historical records. – The occurrence of the weasel in the Azores archipelago was mentioned by Drouet (1861), Godman (1870), Barrett-Hamilton (1904), Chaves (1911), Ulfstrand (1961) and Fructuoso (1978). Statements concerning its origin and date of introduction are scarce but it seems that weasels may have arrived with the first European colonizers.

Taxonomical data. – Due to its larger size, especially the increased tail length, and some fur peculiarities, some authors considered the Azorean weasel as a different specific (Chaves 1911) or subspecific form (ssp. *africanus* : Barrett-Hamilton, 1904 ; or ssp. *numidica* : Ellerman and Morrison-Scott 1951). These considerations were based on few observations and, so far, no deeper genetical or morphological comparative studies were conducted in order to ascertain the taxonomic status of the Azorean specimens.

Measurements. – São Miguel (1 female) : body weight 179.8 g, body length 24.0 cm, tail length 8.8 cm, hind-foot length 3.8 cm, ear length 1.5 cm. Terceira (1 male) : body weight 128.0 g, body length 22.3 cm, tail length 9.2 cm, hind-foot length 3.5 cm, ear length 1.3 cm. Dimensions of these two specimens are smaller than those reported by Barrett-Hamilton (1904), considering a specimen of unknown sex, originated from Terceira. The values obtained for the male are within the range observed for mainland weasels, except for its longer tail ; for the female, however, all the measurements exceed those found in continental specimens (Santos-Reis 1989)

Ecological data. – *M. nivalis* is the only truly wild carnivore occurring in the Azores archipelago. Captures occurred in an abandoned garden and in a pasture surrounded by a mixed woodland. Features such as the small size and feeding specialisa-

tion in rodents (Santos-Reis 1989), support the hypothesis of an introduction without direct human assistance and are responsible for its successful colonization.

Mustela furo Linnaeus, 1758 - Ferret

Distribution. – The capture of two animals, a road casualty and the observation of a scat confirm the actual presence of the species both in the Central and the Western Groups (Terceira and Flores islands, respectively). Recent inquiries also support its occurrence on Pico and São Jorge islands. The presumable presence of the ferret on São Miguel, as mentioned before by Drouet (1861) and Godman (1870), was not confirmed.

Historical records. – The origin of the ferret in the Azores seems to go back to the time of the archipelago's colonization.

Measurements. – Terceira (1 female): body weight 655.0 g, body length 36.0 cm, tail length 13.5 cm, hind-foot length 6.0 cm, ear length 2.5 cm. Flores (1 male) : body weight 748.0 g, body length 42.4 cm, tail length 15.6 cm, hind-foot length 6.2 cm, ear length 1.7 cm.

Ecological data. – The ferret was intentionally introduced for hunting rabbits. Escaping from the human control, some ferrets have established in natural areas acquiring a feral state. The species seems to be uncommon in the wild, although on Flores the evidence suggests a more abundant feral population. The two captures were made in wetland areas with spots of *Juncus* sp., *Rubus* sp., *Sphagnum* sp. and *Hydrangea macrophylla*, bordered by *Cryptomeria* stands or hedges.

CONCLUSIONS

Although the islands of the Azores stand between Europe and North America (and in the past had been used as harbours by ships coming from e.g. India, Brazil and Guinea) all the mammals seem to have been introduced, probably with the exception of bats, on different occasions exclusively from Europe, under the influence of man.

Indications of a European origin are supported by : i) *morphological data* : recent comparative studies involving black rats (Ramalhinho *et al.* 1996) and rabbits (Carvalho 1993 ; Carvalho *et al.* 1993, 1994) pointed out a similitude with mainland populations ; ii) *genetical data* : DNA analysis of several European populations of *R. rattus*, including insular samples from São Miguel and Terceira, support the conclusion outlined above (Libois *et al.* 1996); iii) *parasitological data* : the Siphonaptera associated with some Azorean mammals, as the house mouse (Libois *et al.* 1997), as well as the specific composition of the helminth fauna of the hedgehog (Casanova *et al.* 1996) confirm their relationship with the European conspecifics.

Concerning the period of introduction, mice, black rats and rabbits probably arrived with the first Portuguese and Flemish settlers, soon after the discovery of the islands of the Oriental and Central Groups, in the XVth century (e.g. Godman 1870). In fact, Fructuoso (1978) mentions that not only rabbits, mice and black rats but also ferrets and weasels were already present on some of the islands in the XVIth century (see also Drouet 1861). Brown rats and hedgehogs are more recent colonizers.

The ecological distribution of *Mus musculus domesticus* and *Rattus rattus* indicates a niche shift which, considering also the high percentage of melanism, is in

accordance with the postulates of an insular syndrome (*sensu* Blondel, 1986). More thorough studies are needed concerning the other mammal species.

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BIBLIOGRAPHY

ARRUDA, M.M., 1932. – *Colecção de documentos relativos ao descobrimento e povoamento dos Açores*, pp. 121-125. Oficina de Artes Gráficas, Ponta Delgada, Açores.

BARRETT-HAMILTON, G.E.H, 1904. – Note on an undescribed weasel from the Atlas Mountains and on the occurrence of a weasel in the Azores. *Ann. and Mag. Nat. Hist.*, sér. 7, 13 : 323-325.

BLONDEL, J., 1986. – *Biogéographie Evolutive*. Masson, Paris, 221 pp.

CABRERA, A., 1914. – *Fauna Ibérica : Mamíferos*. Museo Nacional de Ciencias Naturales, Madrid, 441 pp.

CARVALHO, G., 1993. – Estudo do parâmetro peso no coelho selvagem *(Oryctolagus cuniculus)* na ilha de São Miguel, Açores, *in* : (M.C.Rodrigues, Coord.) *Homenagem a J.R. dos Santos Junior*, pp. 69-88, Vol. II. Instituto de Investigação Científica Tropical, Lisboa, 210 pp.

CARVALHO, G., N. FERRAND, A. FONSECA, M. BRANCO, M. AZEVEDO, R. MENDES, P. BATISTA and P. MÂNTUA, 1993. – Estudo de uma população de coelhos selvagens (*Oryctolagus cuniculus*, L.) na ilha de São Jorge, Açores, *in* : *Expedição Científica São Jorge e Topo / 92*, pp. 8-20. Relatórios e Comunicações do Departamento de Biologia, Ponta Delgada, Açores.

CARVALHO, G., A. FONSECA, A. CRUZ, P. CÉLIO, P. MÂNTUA, C. SIMÕES, S. SILVA and G. ARRUDA, 1994. – Estudo preliminar de alguns parâmetros de uma população de coelho selvagem (*Oryctolagus cuniculus*, L.) da ilha do Faial, Açores, *in* : *Expedição Científica Faial / 93*, pp. 1-10. Relatórios e Comunicações do Departamento de Biologia, Ponta Delgada, Açores.

CASANOVA, J., J. MIQUEL, R. FONS, S. SAQUÉS, C. FELIU, M.L. MATHIAS, J. TORRES, R., LIBOIS, M. SANTOS-REIS, M. COLLARES-PEREIRA and B. MARCHAND, 1996. – On the heminth-fauna of wild mammals (Rodentia, Insectivora and Lagomorpha) in Azores archipelago (Portugal). *Vie et Milieu*, 46 (3/4) : 253-259.

CHAVES, F.A., 1911. – *Introdução de algumas espécies zoológicas na ilha de S.Miguel depois da sua descoberta*. Diário dos Açores, Ponta Delgada, Açores, 22 pp.

COLLARES-PEREIRA, M., M. SANTOS-REIS, M.M. OOM, M.G. RAMALHINHO, M.L. MATHIAS, R. FONS, R. LIBOIS and F. PETRUCCI-FONSECA, 1996. – Bacteriological evidence of *Leptospira* infection in wild mammals from Azores Archipelago, Portugal. *Vie et Milieu*, 46 (3/4) : 380-381.

COLLARES-PEREIRA, M., H. KORVER, H., W.J. TERPSTRA, M. SANTOS-REIS, M.G. RAMALHINHO, M.L. MATHIAS, M.M. OOM, R. FONS, R. LIBOIS and F. PETRUCCI-FONSECA, 1997. – First epidemiological data on pathogenic leptospires isolated on the Azorean islands. *European Journal of Epidemiology*, 13 : 435-441.

CORBET, G.B., 1978. – *The Mammals of the Palaearctic Region, a Taxonomic Review*. British Museum (Natural History) and Cornell University Press, London, 314 pp.

DROUET, H., 1861. – Eléments de la Faune Açoréenne. *Mem. Soc. Agric. Sci. Arts et Belles-Lettres*, 2e sér., n° 59 and 60, pp. 63-110.

ELLERMAN, J.R. and T.C.S. MORRISON-SCOTT, 1951. – *Checklist of Palaearctic and Indian Mammals, 1758 to 1946*. British Museum (Natural History), London, 810 pp.

FLUX, J. and P. FULLAGAR, 1992. – World distribution of the rabbit *Oryctolagus cuniculus* on islands. *Mammal Review*, 22 (3/4) : 151-205.

FRANÇA, C., 1913. – Contribution à l'étude du lapin de Porto Santo (*Oryctolagus cuniculus huxleyi* Hackel). Société Portugaise de Sciences Naturelles : 78-89.

FRIAS MARTINS, A., 1993. – The Azores-Westernmost Europe : where the evolution can be caught red-handed. *Boletim do Museu Municipal do Funchal*, 2 : 181-198.

FRUCTUOSO, G., 1978. – *Livro Sexto das Saudades da Terra* (Edição de um manuscrito do séc. XVI). Instituto Cultural de Ponta Delgada, S. Miguel, Açores, 432 pp.

FRUCTUOSO, G., 1983. – *Livro Terceiro das Saudades da Terra* (Edição de um manuscrito do séc. XVI). Instituto Cultural de Ponta Delgada, S.Miguel, Açores, 300 pp.

GODMAN, F., 1870. – *Natural History of the Azores, or Western Islands*. John van Voorst (Ed.), Paternoster Row., London.

LIBOIS, R., F. FONS, M.L. MATHIAS, M. SANTOS-REIS, F. PETRUCCI-FONSECA, M.G. RAMALHINHO and M.M. OOM, 1997. – Notes on the flea fauna (Insecta, Siphonaptera) of the terrestrial Azorean mammals. *Arquivos do Museu Bocage*, 3 : 1-11.

LIBOIS, R., J. TORRICO, M.G. RAMALHINHO, J. MICHAUX, R. FONS and M.L. MATHIAS, 1996. – Les populations de rats noirs *(Rattus rattus)* insulaires de l'ouest de l'Europe. Essai de caractérisation génétique (caryotype et ADN mitochondrial). *Vie et Milieu*, 46 : 213-218.

MILLER, G., 1912. – *Catalogue of the Mammals of Western Europe (Europe exclusive of Russia)*. British Museum (Natural History), London, 1019 pp.

MOORE, N.W., 1975. – The diurnal flight of the Azorean bat (*Nyctalus azoreum*) and the avifauna of the Azores. *Journal of Zoology*, 177 : 483-506.

PALHINHA, R., 1966. – *Catálogo das Plantas Vasculares dos Açores*. Sociedade Estudos Açorianos Afonso de Chaves, Lisboa, 186 pp.

PALMEIRIM, J., 1979. – First record of *Myotis myotis* on the Azores Islands (Chiroptera : Vespertilionidae). *Arquivos do Museu Bocage*, 46 : 1-2.

PALMEIRIM, J., 1991. – A morphometric assessment of the systematic position of the *Nyctalus* from Azores and Madeira (Mammalia : Chiroptera). *Mammalia*, 5 : 381-388.

PALMEIRIM, J. and L. RODRIGUES, 1992. – *Plano Nacional de Conservação dos Morcegos Cavernícolas*. Estudos de Biologia e Conservação da Natureza, n° 8, Serviço Nacional de Parques Reservas e Conservação da Natureza, Lisboa, 165 pp.

RAMALHINHO, M.G., M.L. MATHIAS, M. SANTOS-REIS, R. LIBOIS, R. FONS, F. PETRUCCI-FONSECA, M.M. OOM and M. COLLARES-PEREIRA, 1996. – First approach on the skull morphology of the black rat *(Rattus rattus)* from Terceira and São Miguel islands (Azores archipelago). *Vie et Milieu*, 46 : 245-251.

SANTOS-REIS, M., 1989. – *As Doninhas Ibéricas (Carnivora : Mustela). Um estudo taxonómico e ecológico*. Tese de Doutoramento. Universidade de Lisboa, 454 pp.

SCHWARZ, E. and H. SCHWARZ, 1943. – The wild and commensal stocks of the house mouse, *Mus domesticus* Linnaeus. *Journal of Mammalogy*, 24 : 59-72.

SNPRCN, 1990. – *Livro Vermelho dos Vertebrados de Portugal*, Vol. I. Mamiferos, Aves, Repteis e Anfibios Serviço de Estado do Ambiente e Defesa do Consumidor, Lisboa, 219 pp.

STEBBINGS, R.E. and F. GRIFFITH, 1986. – *Distribution and status of bats in Europe*. Institute of Terrestrial Ecology, Huntingdon, 142 pp.

ULFSTRAND, S., 1961. – On the Vertebrate fauna of the Azores. *Boletim do Museu Municipal do Funchal*, 49 : 75-86.