A 14 C DATING OF CANARIOMYS BRAVOI (MAMMALIA RODENTIA), THE EXTINCT GIANT RAT FROM TENERIFE (CANARY ISLANDS, SPAIN), AND THE RECENT HISTORY OF THE ENDEMIC MAMMALS IN THE ARCHIPELAGO

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J. MICHAUX*, N. LÓPEZ-MARTÍNEZ**, J.J. HERNÁNDEZ-PACHECO***

**Laboratoire de Paléontologie des Vertébrés EPHE et URA 327 du CNRS, Université Montpellier II, Case courrier 064, place E.-Bataillon, 34095 Montpellier cedex 05, France*
***Departamento y UEI Paleontologia, Instituto de Geología Economica CSIC, Facultad de C. Geologicas, Universidad Complutense, 28040 Madrid, Spain*
****In memorian 1994, Museo de Ciencias Naturales de Tenerife, Apdo. Correos 853 38080 Santa Cruz de Tenerife, Islas Canarias, Spain*

EXTINCTION
GIGANTISM
RODENTS
INSECTIVORES
ENDEMISM
CANARY ISLANDS

ABSTRACT. – The endemic land mammals of the Canarian archipelago include five species : three rodents now extinct and two living shrews. We discuss their chronological distribution, the date, and the causes of their extinction. For the first time a ^{14}C date is obtained for *Canariomys bravoi*, the giant rat of Tenerife : 12,230 ± 140 years BP. It confirms the presence of the endemic rat before man settled in Tenerife. It is not definitively established that *Canariomys bravoi* was contemporaneous with man. The two other endemic rodents, *Canariomys tamarani* from Gran Canaria and *Malpaisomys insularis* from Fuerteventura, got extinct after man settled on the islands. Weight estimations of the extinct rodents have been used in order to test the hypothesis of a possible competition with the introduced mammals. If competition is difficult to support, the size of the giant rats makes them good prey for hunting either by man or by feral dogs.

EXTINCTION
GIGANTISME
RONGEURS
INSECTIVORES
ENDEMISME
CANARIES

RÉSUMÉ. – Les Mammifères endémiques des Canaries incluent trois Rongeurs maintenant éteints et deux Insectivores toujours présents. Trois points relatifs à ces espèces endémiques sont discutés : leur répartition chronologique, la date et les causes des extinctions qui les ont affectées. Pour la première fois, une datation ^{14}C a été obtenue pour le Rat géant *Canariomys bravoi* : 12 230 ± 140 B.P. Ceci confirme sa présence sur l'île avant l'arrivée de l'Homme mais il n'est pas encore établi que *Canariomys bravoi* et l'Homme aient été contemporains alors que les Rongeurs endémiques sur la Gran Canaria (*Canariomys tamarani*), et sur Fuerteventura et Lanzarote (*Malpaisomys insularis*), se sont éteints après l'installation de l'Homme. Enfin, le poids des Rongeurs éteints a été calculé afin de discuter la validité de l'hypothèse d'une compétition possible entre les espèces endémiques et les Mammifères introduits. Si la compétition est difficile a étayer, la taille des Rongeurs géants en faisait des proies idéales pour l'Homme chasseur ou les chiens divaguants.

INTRODUCTION

The aboriginal fauna of terrestrial vertebrates of the Canary Islands includes lizards, tortoises, and mammals. Some of them now extinct were of a larger size than their closer relatives from the continent (Mertens, 1942 ; Bravo, 1953 ; Crusafont and Petter, 1964 ; Zeuner, 1966 ; López-Martínez, *et al.*, 1987). Endemic mammals belong to the orders Rodentia and Insectivora. Rodents belong to the Murinae and were giant rats on the central islands (Fig. 1A), *Canariomys bravoi* Crusafont and Petter, 1964 on Tenerife, *C. tamarani* López-Martínez and López-Jurado, 1987 on Gran Canaria, and a large mouse on the eastern ones, the lava mouse *Malpaisomys insularis* Hutterer, López-Martínez and Michaux, 1988, from Fuerteventura and Lanzarote. Insectivores are shrews : *Crocidura osorio* Molina and Hutterer, 1989 on Gran Canaria and *C. canariensis* Hutterer, López-Jurado and Vogel, 1987 on Fuerteventura and Lanzarote. The three endemic rodents became extinct together with some species of the giant endemic li-

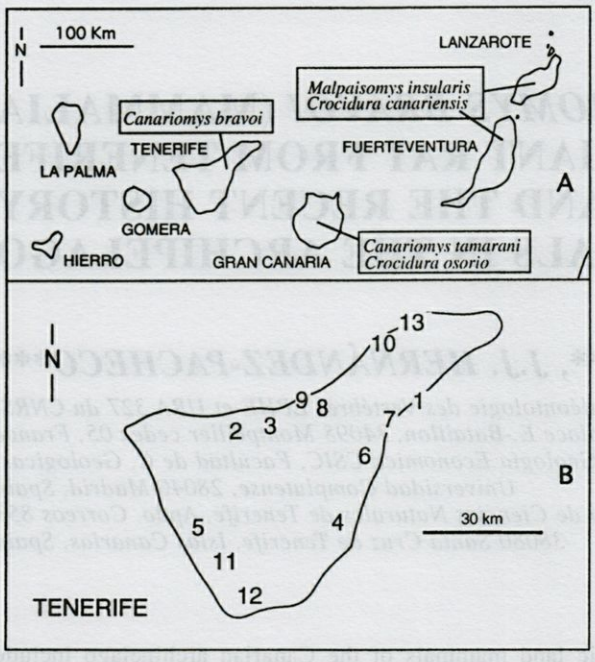

Fig. 1. – A, Canary Islands with indication of the occurrence of past and extant endemic mammals. B, Fossil sites of Tenerife with *Canariomys bravoi*. 1 Cueva del Barranco de Santos (with human remains), Santa Cruz; 2 Cueva del Viento, Cueva de S.Marcos, Cueva de Felipe Reventòn, Icod; 3 Cuesta de la Villa, Orotava; 4 Cueva Chajaña, Arico (at 1.000 m altitude); 5 Cueva de Chiguergue, Guía de Isora; 6 Cueva de Arafo, valle de Güimar; 7 (?) Cueva del Barranco de la Arena, Barranco Hondo (the entrance of the cave with human occupation, dated at 500 BC (Acosta y Pellicer, 1976). 8 Santa Ursula, Montaña de las Ovejas (Bravo, 1954); 9 Acantilado Martinez, Puerto de la Cruz (Bravo, 1953); 10 Bajamar; 11 Callao de Fañabé, Adeje (pyroclastic flow, with *Geochelone burchardi*); 12 Montaña de Guasa, Arona (mixed with ceramic and aborigen remains) (Bravo, 1966; García Cruz & Marrero, 1979); 13 Jover, Tejina, Costa de Anaga.

zards contrary to the shrews, which are still extant. As we know now that some of the endemic species have coexisted with man, a correlation may be established between the extinction of most of the endemic species and the arrival of man on the islands.

The extinction of endemic land vertebrates in islands is a well known fact in western Pacific islands (Cassels, 1984), the Galápagos archipelago (Hutterer and Oromi, 1993), the Caribbean region (Morgan and Woods, 1986), the Mediterranean (Vigne, 1987; Caloi *et al.*, 1986), or the Canary Islands. Most extinctions occurred recently and post-date any climatic change or sea-level rise as direct or indirect dating indicate that they happened after first human settlements or after the arrival of the Europeans (*op. cit.*). Very recent extinctions are not uncommon as for some Caribbean species, for example the Sigmodontinae *Megalomys* which was still living on Martinique and St. Lucia at the very beginning of this century (Woods, 1989). Very recent extinctions are also highly probable in the Galápagos (Hutterer and Oromi, 1993).

For many extinct endemic species, chronological data are scanty. There are few direct ^{14}C datings as well as relative datings, and many of the latter are unreliable. Precise and accurate datings are also scanty for the first settlement of man on islands and so for the introduction of exotic species (domesticated or commensal ones). If it is probable that some non-volant endemic mammals from islands got extinct prior to human settlement, as for some Caribbean rodents (Morgan and Woods, 1986), however most of the extinctions had an anthropic origin and occurred during the last thousand years.

One of the main causes invoked to explain recent extinction is hunting (Ehrlich and Ehrlich, 1981), large as well as small-sized species being over-killed by aboriginal peoples. Other causes are habitat alteration and introduction of exotic species. Since the arrival of Europeans these causes of extinction are more intensively at work. The present paper considers three problems in relation with the endemic mammals of the Canary Islands : their chronological distribution, the dating and the causes of their extinction.

^{14}C DATING OF *CANARIOMYS BRAVOI*

The Tenerife island yields abundant remains of *Canariomys bravoi* particularly in the north (see map, Fig. 1B and the list of the localities). Fossils were found in coastal dunes as well as in caves and in lava tubes (García-Cruz *et al.*, 1979). Up to now the age of fossil remains of *C. bravoi* was estimated as Pliocene and Pleistocene (García-Talavera *et al.*, 1989). As it has not been definitively proved that *Canariomys bravoi* is associated with human artefacts in archaeological sites, its age was effectively difficult to assess. For the first time a numerical age of *C. bravoi* from Tenerife is available : 12,230 ± 140 BP.

Bones used for the datation were taken from an assemblage found at the Cueva del Viento (Icod, Tenerife) near one of the entrances of the cave. The findings inside this cave, the longest lava tube recorded in the Canary Islands, were known a long-time ago. They consist of mixed assemblages of giant lizard and *Canariomys* bones, which are included either in the sediment near the entrance of the cave or directly upon the floor of the lava tube. Exceptionally, nearly undisturbed skeletons of young individuals were discovered in one of the galleries. They belong to very young individuals. These specimens are still

under study. Neither archaeological remains nor bones of other mammals were associated with *Canariomys* bones.

The extraction of the bone collagen from *C. bravoi* was proceeded by E. Marzin from whom details of the treatment can be obtained (Lab. de Géologie du Quaternaire, CNRS, Luminy, case courrier 907, 13288 Marseille cedex 9 – France). 580 mg of collagen have been extracted from 3 g of bone. The preservation of the protein fraction (19,3 % of the total weight) was rather very good. The ^{14}C dating was performed in the Radiocarbon Accelerator unit of the Research Laboratory for Archaeology and the history of Art, Oxford University, and yields 12,230 ± 140 years BP (reference of the dating OxA-5450). According to the $d^{13}C$ value, the collagen was in a good state and the AMS date should be reasonably reliable (Hedges *et al.*, 1993).

The date of 12,230 BP confirms that *Canariomys bravoi* was present before man arrived on the island. Though dating is not definitely established, the few available data indicate that man settled only recently in the Canary Islands (radiocarbon dates give 500 BC, Martín de Guzmán, 1978; Onrubia-Pintado, 1987). The only site with *C. bravoi* and archaeological human remains (Barranco de Santos, Tenerife, García-Talavera *et al.*, 1989) does not present evidence for coexistence of rodents and man, since the cave was used as a burial place, and probably fossil bones were already there in the sediment (F. García-Talavera, pers. com.).

Two out of three endemic rodents from the Canary Islands are clearly contemporaneous with man, *Canariomys tamarani* in Gran Canaria and *Malpaisomys insularis* on the eastern islands Fuerteventura and Lanzarote. In the case of *C. bravoi*, no direct evidence of its contemporaneity with man is known up to now.

CHRONOLOGICAL DISTRIBUTION AND EXTINCTION OF ENDEMIC MAMMALS

Table I gives the chronology of the palaeontological and archaeological sites in the Canary Islands from which endemic mammals have been reported. Fossils of the giant rat of Gran Canaria, *C. tamarani*, are found associated with remains of domestic animals (goat, dog and mouse) and dated at 130 years BC (López-Martínez *et al.* 1987). It may be also present in a slightly earlier deposit. The oldest fossils of *M. insularis* on the eastern islands are Late Pleistocene (Michaux *et al.*, 1991) and the youngest fossils are found associated with remains of domesticated animals and dated a little earlier than the arrival of Spaniards, ca 1000 AD (Boye *et al.*, 1992).

The extinction of the endemic rodents on Gran Canaria (*C. tamarani*), and Fuerteventura and Lanzarote (*M. insularis*) occurred posteriorly to the presence of man on these islands (Table I). This observation favours the inference that the environmental change introduced by agriculture and increasing human settlement is the factor of the final extinction of the endemic rodents in the natural shelters of the islands. Man brought with him domestic animals such as goats (sheep?), dogs and pigs (Zeuner, 1958; Meco-Cabrera, 1992) and also introduced accidentally the house mouse (Carrascosa *et al.*, 1988). Later on, Europeans introduced more species such as the rabbit and the black rat (Boye *et al.*, 1992). The most recently introduced mammals are the hedgehog in Tenerife, Gran Canaria, and Lanzarote and the Barbary ground squirrel (Fuerteventura). The introduced species may have played a more direct role in the extinction. Commensal mammals such as mice and rats may have behaved as competitors, and the latter even as a predator. The dog can also be a predation pressure causing the final extinction of endemic rodents. The return to the wild of some domestic mammals such as dogs and cats is advocated for the extinction of endemic species in the Caribbean region (Morgan and Woods, 1986).

Among the proposed hypotheses we test the competition either for food or space between endemic and domestic-commensal mammals. In order to estimate the conditions of a possible competition, the weights of the involved species (Table II) are an indication for niche overlap. In the case of the extinct species, their weights have been estimated according to a method based on the strong correlation found in mammals between the size of the teeth and the mean weight of individuals. In the present case, we use the coefficients given for rodents according to Legendre (1987). The calculation shows that only rabbits among invader mammals have a weight similar to the one of both *Canariomys* species (Table II and Fig. 2). Rabbits have a herbivorous diet, as that inferred for *C. tamarani* (López-Martínez *et al.* 1987), contrary to the omnivorous diet inferred for *C. bravoi*. Nevertheless, there exists no evidence for a coexistence between rabbits and *Canariomys*.

Another hypothesis accounting for the extinction of aboriginal rodents of the Canary Islands is predation by dogs. The size of *C. tamarani* as well as *C. bravoi* (Table II and Fig. 2) was adequate for these species to become an easy prey for middle-sized dogs, just as for the giant lizards. Since there were no terrestrial predators in the endemic fauna, species probably lacked any defensive behaviour. Gigantism is related to other traits that define the insular syndrome, among which a lowered reproduction rate (Adler and Levins, 1994; Rollo, 1994). Therefore, large ani-

Table I. – Chronology of the palaeontological and archaeological sites with endemic mammals in the Canary Islands. Question marks in brackets indicate datings still uncertain.

	Tenerife	Gran Canaria	Fuerteventura & Lanzarote
Present	Extinct *Canariomys bravoi*	Living *Crocidura osorio*	Living *Crocidura canariensis*
state		Extinct *Canariomys tamarani*	Extinct *Malpaisomys insularis*
1420			
Europeans			
1000			Malpais de Arena
220 AD		(?) El Hormiguero	Cueva Villaverde
			El Belvedero
0			
130 BC		La Aldea *Canariomys tamarani*	
400-500	Cueva del Barranco de la Arena, Barranco Hondo (human occupation ca 500 BC) Association with man ?	(?) Oldest man in Canary Islands	
		(?) Galdar volcano	
10,000	Cueva del Viento (12,230 BP)		
Upper Pleistocene	(?) Bajamar		Costa Calma, Cofete
> 20,000	*Canariomys bravoi*		ca 25,000 BP
			Malpaisomys, Crocidura

mals are less resistant to predation pressure than small ones. *Malpaisomys* may have been also a prey for dogs, but it probably supported heavier predation pressure because it had the size of a large field-mouse, and consequently more reproductive effort. The insular rodent populations show higher densities than those of the continents, even with lower reproductory rates (Gliwick, 1984), which has been related to higher survival rates of younger individuals.

Another possible predator in the islands is the cat. Cats are now known by feral populations in some islands but their history is still largely unknown even if it is possible that cat was present in Tenerife more than 1,000 years ago (see Hutterer, 1990). Birds are also common predators in islands (Alcover and McMinn, 1994), but large predatory birds are unknown in Canary Islands. Owls are unable to prey upon large, rabbit-sized rodents although they could feed on young *Canariomys*.

The hypothesis of a disease introduced by the invader mice was proposed to explain the extinction of *Malpaisomys* (Boye *et al.*, 1992). Until now no remains of *Canariomys* associated with either mice or rats have been found in Tenerife contrary to the fossils of *C. tamarani* in Gran Canaria found together with remains of mice.

By contrast with the rodents, one shrew species from Gran Canaria, and another from Fuerteventura and Lanzarote, survive. In the latter islands both *Crocidura* and *Malpaisomys* have undergone predation by owls (Boye *et al.*, 1992; Rando and Castillo, 1993) before and after the settlement of the Canarian human population, but contrary to *Malpaisomys* the insectivorous *Crocidura* resists better the impact of anthropic action (Boye *et al.*, 1992). Assuming that dogs may be involved in the extinction of *Canariomys tamarani* as well as of *C. bravoi*, the survival of *Crocidura* may be explained by the fact that dogs are reluctant to eat them because of their disgusting taste.

Table II. – Weight of extant and extinct mammals from the Canary Islands. Weight of the giant rats are calculated with Legendre's method (Legendre, 1987). References on estimated weights for endemic species given in the litterature are indicated in brackets. Asterisk indicates that males are heavier than females. Cross mean that the species is extinct. Double asterisks indicate species very recently introduced which did not play any role in the extinction of *Canariomys*.

Species	Island	Weight
pig (*Sus scrofa*)	All	60 - 100 kg according to the race
goat (*Capra hircus*)	All	45 - 60 kg *
dog (*Canis familaris*)	All	20-25 kg (middle-sized race)
giant rat *Canariomys bravoi* *	Tenerife	1900 - 2300 g
giant rat *Canariomys tamarani* *	Gran Canaria	1350 g (range 750 - 1200 g *in* López Martínez *et al.*, 1987)
rabbit (*Oryctolagus cuniculus*)	All	1000 g
hedgehog** (*Atelerix algirus*)	Tenerife G.Canaria Lanzarote Fuerteventura	740 g
ground squirrel** (*Atlantoxerus getulus*)	Fuerteventura	250 g
rat (*Rattus rattus*)	All	165 g
lava mouse (*Malpaisomys insularis*)*	Eastern islands	90 g (see Boye *et al.*, 1992 for another estimation)
mouse (*Mus musculus*)	All	15 g
shrew (*Crocidura canariensis*)	Eastern islands	7,5 g (*in* Molina *et al.* 1989)
shrew (*Crocidura osorio*)	Gran Canaria	5,7 g (*in* Molina *et al.* 1989)

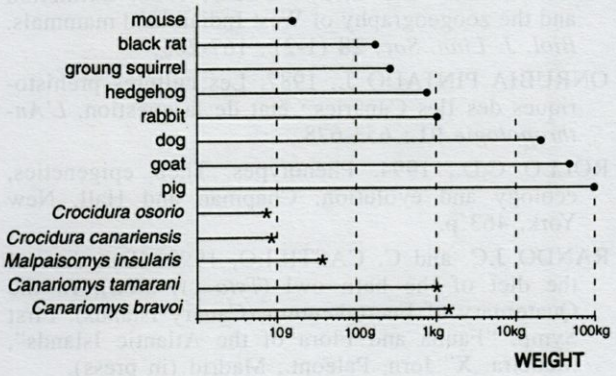

Fig. 2. – Comparison between weights of endemic extinct and extant species (stars) and introduced ones (circles) from the Canary Islands. Species are ordered according to increasing weight.

CONCLUSION

Canariomys bravoi was present before man settled in the Canary Islands as demonstrated by the first ^{14}C dating of bones of the giant rat of Tenerife : 12,230 ± 140 years BP. However this age does not provide any information about the date of its extinction in this island. Neither archaeological remains nor bones of other mammals were clearly associated with *Canariomys* bones on Tenerife. More datings are necessary to answer the question of its chronological distribution and an exhaustive survey of archeological data is urged. Among the many explanations given for the extinction of endemic species, two have been partially tested here, the competition and the predation by exotic species. Predation by dogs may be worth of interest.

List of fossil sites of Tenerife containing *Canariomys* :

Holocene (?) : Cueva del Barranco de Santos (with human remains); Santa Cruz; Cueva del Viento; Cueva de S.Marcos; Cueva de Felipe Reventòn, Icod; Cuesta de la Villa, Orotava; Cueva Chajaña, Arico (altitude : 1 000 m); Cueva de Chiguergue, Gu¡a de Isora; Cueva de Arafo, valle de Güímar; (?) Cueva del Barranco de la Arena, Barranco Hondo (entrance of a cave with human occupation, 500 BC, Acosta y Pellicer, 1976). Santa Ursula, Montaña de las Ovejas (Bravo, 1954). **Late Pleistocene (?)** : Acantilado Martinez, Puerto de la Cruz (Bravo, 1953); Bajamar; costa de Anaga; Callao de Fañadé Adeje (pyroclastic flow, with *Geochelone burchardi*); Montaña de Guasa, Arona (mixed with ceramic and aborigen remains) (Bravo, 1966; García Cruz & Marrero, 1979). Thyrrenian. **Middle marine Pleistocene** (?) : Jover, Tejina.

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REFERENCES

ACOSTA MARTINEZ P. and M. PELLICER CATALAN, 1976. Excavaciones arqueológicas en la Cueva de la Arena (Barranco Hondo, Tenerife). *An. Est. Atlant.* **22** : 125-184.

ALCOVER J.A. and M. McMINN, 1994. Predators of vertebrates on islands. *BioScience* **44** : 12-18.

ANCHOCHEA E., J.M. FUSTER, E. IBARROLA, A. CENRERO, J. COELLO, F. HERNAN, J.M. CANTAGREL and C. JAMOND, 1990. Volcanic evolution of the island of Tenerife (Canary Islands) in the light of new K-Ar data. *J. Volcan. Geoth. Res.* **44 :** 231-249.

BOYE P., R. HUTTERER, N. LOPEZ-MARTINEZ and J. MICHAUX, 1992. A reconstruction of the Lava

mouse (*Malpaisomys insularis*), an extinct rodent of the Canary Islands. *Z. Säugetierk.* **57** : 29-38.

BRAVO T., 1954. *Lacerta maxima*, nueva especie de la fauna continental extinguida del Pleistoceno de Las Canarias. *Estudios Geol.* **17** : 7-34.

BRAVO T., 1966. The beds of fossil rats in the Canary Islands. Acta V° Congr. panafr. Prehist. y Est. Cuatern. **2** : 294.

CALOI L., T. KOTSAKIS and M.R. PALOMBO, 1986. La fauna a vertebrati terrestri del Pleistocene delle isole del Mediterraneo. *Geol. Rom.* **25** : 235-256.

CARRASCOSA M.C. and N. LOPEZ-MARTINEZ, 1988. The house mouse from a prehistoric site in Fuerteventura (Canary Islands). *Bonn. Zool. Beitr.* **39** (2/3) : 237-256.

CASSELS R., 1984. Faunal Extinction and Prehistoric man in New Zeland and the Pacific Islands. Quaternary Extinction. Tucson, Arizona, The University of Arizona press, 767.

CRUSAFONT M. and F. PETTER, 1964. Un muridé géant fossile des Iles canaries *Canariomys bravoi* gen. nov., sp. nov. (Rongeurs, Muridés). *Mammalia* **28** : 608-611.

EHRLICH P.R. and A.H. EHRLICH, 1981. Extinction : the causes and consequences of the disappearence of species. Random House, New York, 305 p.

GARCÍA CRUZ M.C. and A. MARRERO RODRIGUEZ, 1979. Sobre la distribuciòn geogràfica de los yacimientos de vertebrados fòsiles de las Islas Canarias. *Vieraea* **8** (1) : 95-106.

GARCÍA-TALAVERA F., R. PAREDES GIL and M. MARTÍN OVAL, 1989. Catalogo-inventario yacimientos paleontològicos. Prov. de Sta. Cruz de Tenerife. Instit. Est. Canarios C.E.C.E.L., La Laguna : 76 p.

GLIWICK J., 1984. Rodents on islands : living in a crowd. *Acta Zool. Fennica* **172** : 95-98.

HEDGES R.E.M., R.A. HOUSLEY, C. BRONK and G.J. VAN KLINKEN, 1993. Radiocarbon dates from the oxford AMS system : *Archaeometry* date list 17. *Archeometry* **35** (2) : 305-326.

HUTTERER R., 1990. Remarks on a presumed record of *Felis margarita* from Tenerife, Canary Islands. *Vierae* **19 :** 169-174.

HUTTERER R., L.F. LOPEZ-JURADO and P. VOGEL, 1987. The shrews of the eastern Canary Islands : a new species (Mammalia : Soricidae). *J. Nat. Hist.* **21 :** 1347-1357.

HUTTERER R., N. LÓPEZ-MARTÍNEZ and J. MICHAUX, 1988. A new rodent from Quaternary deposits of the Canary Islands and its relationships with Neogene and recent Murids of Europe and Africa. *Palaeovertebrata*, Montpellier **18** (4) : 241-262.

HUTTERER R., T. MADDALENA and O. MOLINA, 1992. Origin and evolution of the endemic Canary Island shrews (Mammalia : Soricidae). *Biol. J. Linn. Soc.* **46 :** 49-58.

HUTTERER R. and P. OROMI, 1993. La rata gigante de la Isla Santa Cruz, Galápagos : algunos datos y problemas. Resultados cientificos del proyecto Galápagos : Patrimonio de la humanidad. Res. Cient. Proy. Galápagos TFMC, **4 :** 63-76.

LEGENDRE S., 1987. Les communautés de mammifères d'Europe occidentale de l'Eocène supérieur et Oligocène : structure et milieux. *Münchner Geowiss Abh.* **10 :** 301-312.

LOPEZ MARTINEZ N. and L.F. LOPEZ JURADO, 1987. Un nuevo murido gigante del Cuartenario de Gran Canaria *Canariomys tamarani* nov. sp. (Rodentia, Mammalia). *Doñana, Publ. ocas.* **2 :** 1-66.

MARTÍN DE GUZMÁN C., 1978. Dataciones ^{14}C para la prehistoria de las Islas Canarias. Fundación J. March, Serie Universitaria, 77, Madrid.

MECO CABRERA J., 1992. Los ovicaprinos de Villaverde. Diseño paleontológico y marco paleoambiental. Est. Prehist., Dir. G. P. Hist., 167 p., Las Palmas.

MERTENS R., 1942. *Lacerta goliath* n. sp. eine ausgestorbene Rieseneidechse von den Kanaren. *Senck. Biol.* **25 :** 330-339.

MICHAUX J., R. HUTTERER and N. LOPEZ-MARTINEZ, 1991. New fossil faunas from Fuerteventura, Canary Islands : evidence for a Pleistocene age of endemic rodents and shrews. *C. R. Acad. Sc. Paris.* **312,** série II **:** 801-806.

MOLINA O. and R. HUTTERER, 1989. A cryptic new species of *Crocidura* from Gran Canaria and Tenerife, Canary Islands (Mammalia : Soricidae). *Bonn. Zool. Beitr.* **40** (2) : 85-97.

MORGAN G.S. and C.A. WOODS, 1986. Extinction and the zoogeography of West Indian land mammals. *Biol. J. Linn. Soc.* **28** (1-2) : 167-203.

ONRUBIA PINTADO J., 1987. Les cultures préhistoriques des Iles Canaries : état de la question. *L'Anthropologie* **91** : 653-678.

ROLLO C.D., 1994. Phenotypes. Their epigenetics, ecology and evolution. Chapman and Hall, New York, 463 p.

RANDO J.C. and C. CASTILLO, 1993. First data of the diet of the barn owl (*Tyto* cf. *alba*). *In* the Quaternary of Fuerteventura (Canary Islands). First Symp. "Fauna and Flora of the Atlantic Islands", Madeira. X° Jorn. Paleont., Madrid (in press).

VIGNE J.-D., 1987. L'extinction holocène du fond de peuplement mammalien indigène des îles de la Méditerranée occidentale. *Mém. Soc. géol. Fr.* **150** : 167-177.

WOODS C.A. Ed., 1989. The biogeography of West Indian rodents. Biogeography of the West Indies; Past, present and future. Gainsville, Sandhill Crane Press.

ZEUNER F.E., 1966. The first fossil mammal from the Canary Islands. Actas V Congreso Panafricano Prehist. y Est. Cuat. **2** : 289-298.

ZEUNER F.E., 1958-59. Some domesticated animals from the prehistoric site of Guayadeque. *E.M.C.*, 19-20 : 40 p.

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