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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To cite this version:
J Michaux, N López-Martínez, J J Hernández-Pacheco. 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. Vie et Milieu / Life & Environment, 1996, pp.261-266. hal-03100694

HAL Id: hal-03100694
https://hal.sorbonne-universite.fr/hal-03100694
Submitted on 6 Jan 2021

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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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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-
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: $12,230 \pm 140$ 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 preceded 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 \(^{14}\)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., 1993) 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 incidentally 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.

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

Mammals 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 reproductive 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 littersature are indicated in brackets. Asterisk indicates that males are heavier than females. Cross asterisks indicate species very recently introduced which did not play any role in the extinction of Canariomys.

<table>
<thead>
<tr>
<th>Species</th>
<th>Island</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>pig (Sus scrofa)</td>
<td>All</td>
<td>60 - 100 kg according to the race</td>
</tr>
<tr>
<td>goat (Capra hircus)</td>
<td>All</td>
<td>45 - 60 kg *</td>
</tr>
<tr>
<td>dog (Canis familiaris)</td>
<td>All</td>
<td>20-25 kg (middle-sized race)</td>
</tr>
<tr>
<td>giant rat Canariomys bravoi *</td>
<td>Tenerife</td>
<td>1900 - 2300 g</td>
</tr>
<tr>
<td>giant rat Canariomys tamarani *</td>
<td>G.Canaria</td>
<td>1350 g (range 750 - 1200 g in López Martínez et al., 1987)</td>
</tr>
<tr>
<td>rabbit (Oryctolagus cuniculus)</td>
<td>All</td>
<td>1000 g</td>
</tr>
<tr>
<td>hedgehog** (Atelerix algirus)</td>
<td>Tenerife</td>
<td>740 g</td>
</tr>
<tr>
<td>rat (Rattus rattus)</td>
<td>G.Canaria</td>
<td>Lanzarote</td>
</tr>
<tr>
<td>ground squirrel** (Atlantoxerus getulus)</td>
<td>Fuenteventura</td>
<td>250 g</td>
</tr>
<tr>
<td>lava mouse (Molphisomys insularis)*</td>
<td>Eastern islands</td>
<td>90 g (see Boye et al., 1992 for another estimation)</td>
</tr>
<tr>
<td>mouse (Mus musculus)</td>
<td>All</td>
<td>15 g</td>
</tr>
<tr>
<td>shrew (Crocidura canariensis)</td>
<td>Eastern islands</td>
<td>7.5 g (in Molina et al., 1989)</td>
</tr>
<tr>
<td>shrew (Crocidura osorio)</td>
<td>Gran Canaria</td>
<td>5.7 g (in Molina et al., 1989)</td>
</tr>
</tbody>
</table>

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 14C 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 Reventón, Icod; Cuesta de la Villa, Orotava; Cueva Chajaña, Arico (altitude: 1 000 m); Cueva de Chiguerque, Guía de Isora; Cueva de Arafo, valle de Guimar; (?) 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 Martínez, 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). Thyrenian. Middle marine Pleistocene (?): Jover, Tejina.

ACKNOWLEDGMENTS — F. García-Talavera (Museum of Natural Sciences, Santa Cruz de Tenerife), L. F. López-Jurado (Las Palmas de Gran Canaria University), C. Castillo-Ruiz (La Laguna University) and T. Bravo (Puerto de la Cruz, Tenerife), are thanked for giving information and interesting discussion. We also thank S. Montuire and S. Legendre for providing information about the weight of recent mammals, as well as E. Marzin for extracting bone collagen. CNRS (France) and Action Intégrée franco-espagnole, Programme Picasso 1993 n° 91128 gave financial support. Publication n° 96-030 de l’Institut des Sciences de l’Evolution de Montpellier (France). The present paper is dedicated to the memory of Dr Hernandez Pacheco.

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Reçu le 20 février 1996 ; received February 20, 1996
Accepté le 4 mars 1996 ; accepted March 4, 1996