Biol Invasions
DOI 10.1007/s10530-012-0321-y

INVASION NOTE

Radiocarbon evidence for a prehistoric deliberate translocation: the weasel (*Mustela nivalis*) of Mallorca

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Received: 7 December 2011 / Accepted: 21 August 2012

Abstract We present radiocarbon evidence for the presence of the weasel (*Mustela nivalis*) on Mallorca prior to the Roman colonization of the Balearics. Bone collagen from a single specimen recovered at Cova del Ninot, Mallorca rendered two radiocarbon ages, independently obtained at two laboratories (2σ interval: 386–206 cal BC). These dates indicate that the translocation of the weasel to Mallorca occurred in Late Prehistory. The inhabitants of Mallorca at that time were the Talaiotic people (Iron Age settlers of the Balearics). The weasel appears to have been introduced by Talaiotic mercenaries returning to the island on Carthaginian ships. This is the first documented case of the translocation of a wild carnivorous mammal to the Gymnesic Islands (i.e., Mallorca and Menorca) in prehistoric times. Some ecological consequences of this invasion are outlined.

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Keywords *Mustela nivalis* · Mustelidae · Mallorca · Western Mediterranean · Faunal translocation

Introduction

All the extant terrestrial mammals of the Balearic Islands were introduced by humans (e.g., Alcover 1979; Bover and Alcover 2008). The first human settlement of these islands took place in the third millennium BC (Alcover et al. 2001; Ramis et al. 2002), most probably between c. 2,350 and c. 2,150 BC (Alcover 2008). The extinction of the endemic, autochthonous terrestrial mammals of Mallorca and Menorca (*Myotragus*, *Hypnomys*, *Nesiotites*) was coeval with the initial phase of human presence (Bover and Alcover 2003, 2008). The first human settlers introduced a domestic stock composed of five species (cattle, goats, sheep, pigs and dogs) as well as two small rodents (the garden dormouse *Eliomys quercinus* and the wood mouse *Apodemus sylvaticus*).

The introduction of predators is one of the most critical events affecting the ecology of islands (e.g., Worthy and Holdaway 2002; Johnson 2006: 197–206). The establishment of an accurate date for the first arrival of an alien predator is therefore important for understanding subsequent ecological changes. It is a key date not only for understanding extinction events, but also for establishing the time-span between the arrival of the predator and its

Published online: 01 September 2012

ultimate consequences (such as the chronologies of prey extinctions or of body size changes in the surviving prey species). Until now, there was no conclusive evidence for the presence of wild carnivorous mammals in the Balearic Islands in prehistoric times. Currently, five species of carnivores are present in Mallorca, the common genet (*Genetta genetta*), the pine marten (*Martes martes*), the weasel (*Mustela nivalis*), the recently established coati (*Nasua nasua*; see Álvarez and Mayol 2007) and the still questionably incorporated raccoon (*Procyon lotor*; see Pinya et al. 2009). The precise timing of the introduction of the first three species has not yet been established. It is assumed that the genet was introduced during the Islamic occupation (Alcover 1979), as appears to have occurred in the Iberian Peninsula (Morales 1994). No data are available on the chronology of the introduction of the pine marten on Mallorca and Menorca, although its absence from the entire archaeological record would suggest that it was incorporated in Modern times Alcover (2010).

The introduction of the weasel to the Gymnesic Islands (Mallorca and Menorca) has traditionally been associated with the arrival of the Romans (e.g., Alcover 1979; Sanders and Reumer 1984), although Morales (2007) claims an earlier presence of the species on Menorca based on pottery-dated assemblages. The available isotopic information on the first presence of the weasel on Menorca (Sanders and Reumer 1984) derives from assumed associations with ^{14}C dated charcoal (eight ages) and herbivore bones (two ^{14}C ages derived from collagen). Nevertheless, the assumed associations of weasel bones to the aforementioned pottery-dated assemblages and to ^{14}C ages are actually inconclusive: charcoal-based ages have some intrinsic uncertainties (Anderson 1991), the stratigraphy proposed by Sanders and Reumer (1984) was presented only as a proxy, and the pottery—associated assemblages are considered to be insufficient indicators for establishing accurate chronologies (e.g., Bruins and van der Plicht 2001; Micó 2006).

Thus, the total absence of directly-dated weasel remains means that until now the presence of wild carnivores in Balearic Prehistory was speculative. Here we present direct ^{14}C dates obtained from Mallorcan weasel bones that suggest a change in the traditional view on the introduction of carnivores, their cultural framework, and their ecological consequences.

Materials and methods

Remains of *M. nivalis* were retrieved from the excavation of Cova del Ninot (Pollença, Mallorca). The stratigraphic sequence of this cave consists of flat-lying and unconsolidated sediments deposited as a result of natural and anthropic agents. The intervention of humans in the cave took place during brief periods irregularly scattered throughout the Bronze and Iron Ages. During the uninhabited periods, barn owls inhabited the cave and produced layers of pellets containing remains of small mammals.

The bones studied here come from the stratigraphic unit UE 300. It is one of the upper levels of the sedimentary sequence, and it overlaps the stratigraphic unit UE 3 (the most recent archaeological unit). It comprises a small package composed mainly of fine grained and non-compacted gray clay. Other items were recovered in association with the weasel remains. They include prehistoric pottery, attributed to the Late Iron Age, and bones of goat (*Capra hircus*), wood mouse (*A. sylvaticus*) and garden dormouse (*E. quercinus*).

The bones of *M. nivalis* were identified at the Institut Mediterrani d'Estudis Avançats (IMEDEA). Most probably, they all belong to the same adult male individual, as they come from a very small sedimentary package and no repeated skeletal elements were noted.

Two AMS radiocarbon dates were obtained (see Fig. 1). The first one, from the Royal Institute for Cultural Heritage (Belgium), derives from the collagen of a fragment of skull, an atlas and a humerus. This sample was processed by the Longin method (Longin 1971) with an extra NaOH cleaning step. Collagen quality was checked by C/N and % collagen. As it furnished a ^{14}C age older than expected, a second date (on a complete left mandible, presumably of the same individual) was obtained in the radiocarbon accelerator unit of the Research Laboratory for Archaeology and the History of Art, University of Oxford, UK. This mandible was initially analysed for collagen remains, with a small test for measuring % Nitrogen. It was acceptably well preserved. No difficulties in obtaining the ^{14}C date were reported. The two dates (Table 1) were initially analysed separately. Calibration of the results was obtained using OxCal 4.1.7 (Bronk Ramsey 1995, 2010) and the INTCAL09 calibration curve (Reimer et al. 2009). Later, both ages were

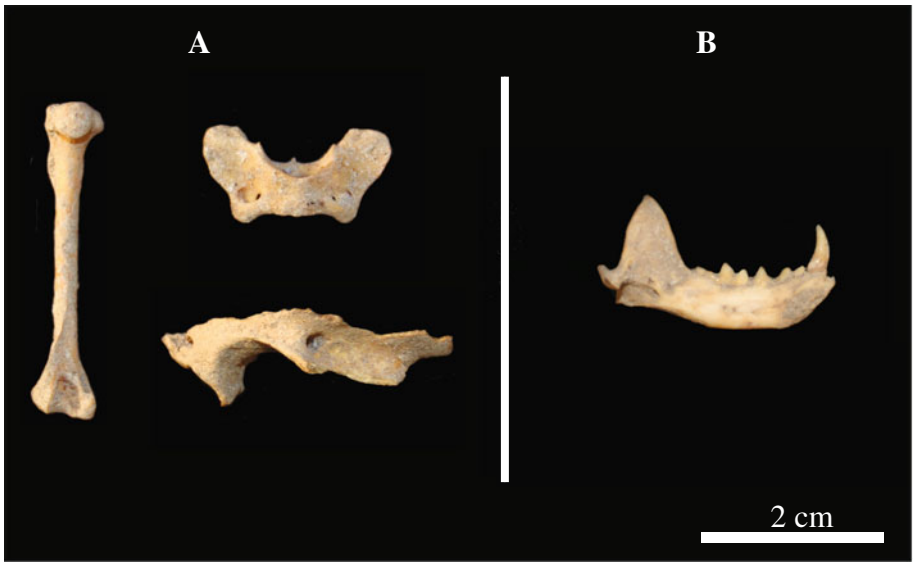

Fig. 1 Weasel bones dated from Cova del Ninot. **a** fragment of skull, atlas and humerus (KIA-41154); **b** complete mandible (OxA-23737)

Table 1 AMS radiocarbon ages of *M. nivalis* from Cova del Ninot

Lab. number	Sample	^{14}C age BP	2σ (cal BC)	δ^{13}C (‰)
KIA-41154	Skull, atlas, humerus	2,195 ± 40	390–160 BC	−19.43
OxA-23737	Complete left jaw	2,246 ± 24	390–208 BC	−18.29

combined to narrow down the chronological range of the calibrated date.

Results

The ^{14}C dates obtained are presented, individually and combined, in Table 1 and Fig. 2. Assuming the weasel has a totally terrestrial diet, these data point to its presence on the island prior to 206 cal BC. The Balearic Islands were integrated into the Roman Republic in 123 BC. According to these ages, the translocation of the weasel to Mallorca was the result of a pre-Roman introduction.

This result must be carefully scrutinized. Radiocarbon ages may be distorted by diet, due to the 'reservoir effect' produced by the consumption of marine food (e.g., Chisholm et al. 1982; Hobson and Collier 1984). Although there are no specific studies on the diet of the weasel in the Balearic Islands, it is known that it preys mainly on small mammals, especially microtines and

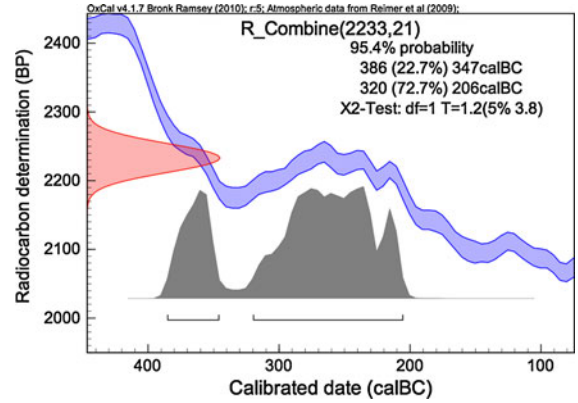

Fig. 2 Combined radiocarbon dates of the weasel from Cova del Ninot

murines (e.g. Day 1968; Tapper 1979; King 1980; 1991; Erlinge 1975). In addition, the occasional consumption of birds—both meat and eggs—(Tapper 1979) and of lagomorphs (Day 1968; Tapper 1979; McDonald et al. 2004) has been recorded. Other small terrestrial vertebrates, insects (mostly beetles), fish,

worms, and carrion are taken only very occasionally. Thus, a terrestrial diet can be assumed for the Cova del Ninot weasel. In order to confirm this assumption, the available stable ^{13}C isotopes from the dated material were analyzed. Although the two samples correspond to the same individual, the $\delta^{13}C$ values obtained are slightly different: -19.43 ± 0.3 ‰ and -18.29 ± 0.25 ‰ (average: -18.86 ‰). We compared them with the $\delta^{13}C$ values of the main putative prey using 4 samples of rodents (*A. sylvaticus* and *E. quercinus*) coming from the same Cova del Ninot (2 samples) and from the nearby Cova Estreta (2 samples), average: -19.52 ‰ (extreme values: -19.0 to -20.2 ‰). Given that the average difference in the bone collagen $\delta^{13}C$ values between terrestrial herbivores and carnivores is <1 ‰ (Schoeninger and De Niro 1984; Schoeninger 1985), the values obtained for the isotopic signature of the weasel from Cova del Ninot widely agree with such a diet. The possible effects of the improbable incorporation of some food items of marine origin have been checked, following the methodology used by Barrett et al. (2000), and using the average value for rodents here presented (i.e., -19.52 ‰) as the extreme endpoint for a completely terrestrial diet. All the ^{14}C dates obtained fall prior to 200 BC. Consequently, it can be established that both radiocarbon ages unquestionably document that the introduction of the weasel took place before this date.

Discussion

According to the radiocarbon age obtained, two possible scenarios arise for the introduction of the weasel to Mallorca. A first scenario considers the Carthaginians as the direct agents for the translocation. They traded with the prehistoric Talaiotic people of Mallorca during the centuries previous to the Roman occupation (e.g. Ramon 1991; Gómez Bellard 1993; Guerrero 1999). A second scenario considers the Talaiotic people themselves as the agents. They repeatedly acted as mercenaries in the Punic Wars (268–146 BC), primarily as slingers.

The absence of the weasel on Eivissa (Ibiza), an important Carthaginian colony since 654 BC, precludes the possibility that this island acted as the source region for the populations of Mallorca and Menorca. If the Eivissan Carthaginians had been the translocation agents, especially considering the relevant role of Eivissa in the trade with Mallorcan prehistoric societies starting in the 4th century BC (e.g. Ramon 1991; Gómez Bellard 1993; Guerrero, 1999), we would expect weasels to be present on this island, but no evidence to this effect has ever been found. Besides, there is no conclusive evidence of direct trade between the remaining Punic colonies (e.g. Carthage, Caralis or Gadir) and Mallorca.

The second scenario points to the Talaiotic people as the most probable agents for the weasel's translocation. There is no evidence of any Talaiotic naval technology, and in fact the available evidence suggests that the Talaiotics lived mainly with their backs turned to the sea (Hernández-Gasch et al. 2002; Rihuete 2003; Van Strydonck et al. 2002, 2005). In spite of this, those that enrolled as mercenaries with the Carthaginians travelled widely throughout the Central and Western Mediterranean during the Punic Wars. Although there is no direct information concerning the ultimate fate of these Talaiotic slingers, it can be inferred from some classical authors such as Diodorus Siculus (*Bibliotheca Historica* V, 16–18), that at least some of them returned to the Balearics.

Punic Wars were fought in Sardinia, Sicily, mainland Italy, the Iberian Peninsula and North Africa. Thus, the Talaiotic slingers could have brought the weasel from any of these territories. In this regard, the genetics of extant weasels could be used to establish the source region. Although the biomolecular evidence is still limited, the DNA of a Menorcan weasel agrees with the assignment of the individual to the same sub-clade as the Sardinian weasels and differs from those of the Western European mainland (Lebarbenchon et al. 2010). Thus, Sardinia emerges as a possible source region for the Balearic weasel. Unfortunately, there is insufficient information on the DNA of weasels from northern Africa, leaving open the possibility that both island populations originated directly from North Africa. In any event, the return of the Talaiotic slingers with their accompanying weasels was necessarily linked to Carthaginian shipping.

The ultimate causes for the translocation are unknown. Weasels have been introduced in recent times to isolated territories to control pests (e.g. Terschelling Island, Netherlands, de Vos et al. 1956; Australia, New Zealand, Azores and Sao Tomé, Corbet 1978). It may have been introduced deliberately on Mallorca and Menorca during Late Prehistory in order to control crop pests.

The Late Iron Age of the Balearics seems to have been characterised by an increasing importance of agriculture (e.g., Hernández-Gasch et al. 2002). One of the main problems of agriculture is the loss of crops to rodent and lagomorph pests. Some Greek and Roman writers (e.g. Strabo, *Geographica* III, 2, 6; Pliny the Elder, *Naturalis Historia*, VIII, 217) refer to the problems produced by lagomorphs on the crops of Gymnesic farmers. Likewise, the occurrence of a remarkable abundance of small mammals during Prehistory has been suggested on the basis of high concentrations of small mammals in the Prehistoric sites and their later absence (Bover and Alcover 2008).

Alternatively, the Talaiotic warriors might have brought the weasel with them as a pet. Nevertheless, the non-domestication of the weasel makes this option unlikely.

The introduction of the weasel on the Gymnesic Islands had relevant ecosystemic implications. When weasels were imported to Mallorca and Menorca, they found an unexpected amount of food available, as has also been pointed out on other islands when the first alien predator was incorporated (e.g., Worthy and Holdaway 2002). After the arrival of the weasel, the endemic Balearic lizard (*Podarcis lilfordi*) disappeared from the main islands (Mallorca and Menorca) and the endemic midwife toad (*Alytes muletensis*) became extinct on Menorca and lost more than 95 % of its former distribution on Mallorca (Alcover et al. 1981; Sanders and Reumer 1984; Tonge 1986; Moore et al. 2004). Currently the Balearic lizard survives only on the small islets where weasels are not present, while the midwife toad only survives in narrow canyons that are inaccessible to weasels and other predatory mammals. Furthermore, the recorded reduction in body size between prehistoric and extant populations of wood mice and garden dormice has also been attributed to the introduction of the weasel (e.g. Sanders 1980; Sanders and Reumer 1984). Additionally, a decline in the population density of rodents (and of barn owls as a rebound effect) has also been attributed to the introduction of the weasel (Bover and Alcover 2008). The combined effect on the vegetation of the body size reduction and the density decline of rodents after the weasel's arrival is unknown, but some effect is to be expected. All these ecological changes evidence a huge transformation of Mallorcan ecosystems as a consequence of the introduction of the weasel.

Conclusion

The radiocarbon ages obtained from bone collagen present in material recovered from Cova del Ninot document the translocation of the weasel in the Late Prehistory of Mallorca. These dates are earlier than those previously documented and exclude the Romans as potential agents of the translocation. Talaiotic slingers were the most probable agents for this introduction, although its ultimate cause remains unresolved. At the current state of knowledge, the weasel, which we clearly show to be a Prehistoric introduction, stands as the first wild carnivore to reach the Gymnesic Islands. Its arrival affected the structure of the existing ecological communities, and it became a keystone species in the reconfigured ecosystems.

Acknowledgments This paper is included in the Research Project CGL2010-17889 of the Dirección General de Investigación, Ministerio de Ciencia y Tecnología (Madrid). We acknowledge the help of Dr. Christopher Bronk Ramsey and Dr. Thomas Higham (Oxford) as well as Mr. Mathieu Boudin and Dr. Mark van Strydonck (Brussels) who provided valuable supplementary information on different radiocarbon ages. We also thank Maria Soledad Gogorza for her assistance with the manuscript review. Hannah Bonner revised the English text. One of the authors (A.V.) has a JAE-Predoc fellowship from the Consejo Superior de Investigaciones Científicas of the Ministerio de Educación y Ciencia of Spain.

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