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REQUIEM FOR *MYOTRAGUS BALEARICUS* DOMESTICATION

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Resum

La proposta de la domesticació de *Myotragus balearicus* pels primers pobladors humans de Mallorca, una hipòtesi clàssica de la prehistòria balear durant les darreres dècades del segle passat, ha estat recentment qüestionada. Les alteracions en forma de "V" observades a banyes de *Myotragus*, obtingudes a jaciments que contenien restes humanes i de fauna prehumana, varen ser inicialment considerades com a una prova de manipulació humana. Les banyes s'haurien seccionat per tal d'evitar que animals presumptament estabulats dins corrals es fessin mal entre ells. Ramis & Bover (2001) rebutjaren aquesta aproximació, i identificaren les alteracions en "V" observades a les banyes de *Myotragus balearicus* com resultat d'un comportament osteofàgic, una conducta coneguda a diversos bòvids i cèrvids, però no registrada fins a les hores a *Myotragus balearicus*. El comportament osteofàgic no ha estat acceptat per alguns autors en articles recents, que encara proclamen l'autoria humana de les alteracions a les banyes, en base a dades de $\delta^{13}C$. En aquest article, es presenten noves evidències que recolzen inequívocament que la conducta osteofàgica de *Myotragus* és la causa exclusiva del patró d'alteració registrat a les banyes. Recentment s'han recol·lectat nous materials de banyes de *Myotragus* que presenten alteracions en "V" provinents d'un jaciment subaquàtic a 10 m de profunditat en una cavitat submergida (un lloc sense possibilitat de relació entre *Myotragus* i humans) i materials provinents d'un jaciment del Pleistocè Mitjà.

Paraules clau: *Myotragus balearicus*, domesticació, osteofàgia, Mallorca.

Abstract

The proposal of the domestication of *Myotragus balearicus* by the first settlers on Mallorca, a topic in the Balearic prehistory during the last part of the previous century, has been recently disqualified. The "V"-trimmed *Myotragus* horn cores obtained from deposits containing human remains and pre-human fauna were initially considered as a proof of human manipulation in order to avoid damage in animals assumedly gathered in corrals. After Ramis & Bover (2001) this approach has been refused and the "V"-trimmed horn cores of *Myotragus balearicus* were identified as the result of an osteophagic behaviour, a kind of behaviour previously known in some extant bovids and cervids, but as so far unrecorded on *Myotragus balearicus*. Although the osteophagic behaviour has been unaccepted by some recent authors, still claiming for a human-caused trimming of horn cores, new evidence supports our approach. Claims of Davis (2002) are based in $\delta^{13}C$, a methodology recently used to study the diet of fossil and recent mammals. In our presentation we argue again on the osteophagic behavior of *Myotragus* as a exclusive cause for the recorded trimmed horn cores. New materials displaying the same "V"-trimmed horn cores pattern come from recently exhumed materials discovered in a subaquatic deposit at 10 m underwater in a flooded cave (a place with no possibility of relation between *Myotragus* and humans) and from Middle Pleistocene deposits.

Key words: *Myotragus balearicus*, domestication, osteophagy, Mallorca.

INTRODUCTION

The hypothesis of the existence of a domestication process for *M. balearicus* by the first settlers in Mallorca, which was considered a classical approach in Balearic prehistory during the end of the last century, has recently been brought into doubt (Ramis & Bover, 2001). The model under question was based on a set of evidence. In different sites, containing human remains and prehuman fauna, *M. balearicus* skulls with a peculiar horn typology were obtained and were interpreted to be the result of human action. Alterations in different long bones of the species were also documented, supposedly also caused as a result of human manipulations (see Fig. 1, Waldren, 1982). The horns would have been cut to avoid any possible harm that assumedly stabled animals could do among them in reduced spaces during fights. On the other hand, the manipulations of the species' bones were attributed to manipulations to prepare them for eating. The theory of animal retention in stables was supported by the presence of coprolite accumulations in the Balma de Son Matge (Waldren, 1982).

The finding of new skulls with a similar horn typology as that documented in Balma de Son Matge (Fig. 2) made it possible to present an alternative interpretation as to their origin. The importance of these skulls lay in the fact that they all came from exclusively paleontologi-

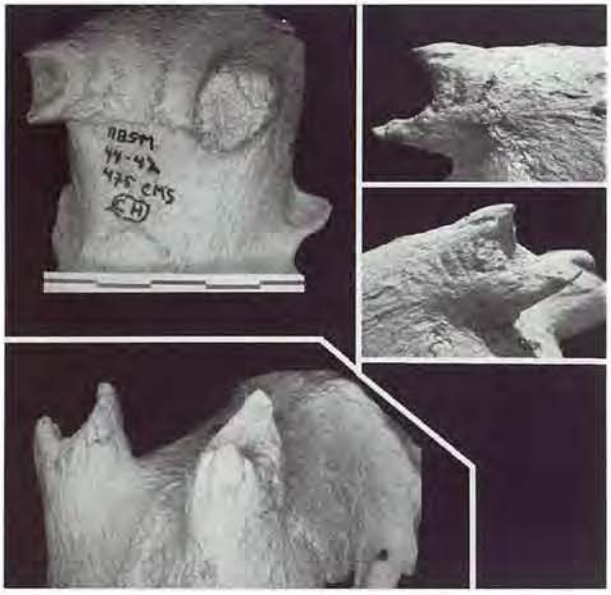

Fig. 1. Photo of one of the *M. balearicus* skulls with "V"-trimmed horn cores from Balma de Son Matge. Left upper side, caudal view. Left lower side, dorso-lateral view. Right upper side, detail of "V"-trimmed horn cores. Photos obtained from Waldren (1982).

Fig. 1. Fotografia d'uns dels exemplars de crani de M. balearicus *amb les banyes alterades trobat al jaciment de la balma de son Matge. Adalt a l'esquerra en norma caudal. Abaix a l'esquerra en norma dorso-lateral. Adalt a la dreta, detall de les alteracions de les banyes. Imatges obtingudes de Waldren (1982).*

cal sites (e.g., Bufador de Son Berenguer, Cova de Son Maiol, Fig. 3) or from levels in archaeological-paleontological sites considered to be prehuman (inferior levels in Cova des Moro). What is more, in some of these sites, bones belonging to the postcranial skeleton were identified with the same alteration pattern as the horns of *M. balearicus* in Balma de Son Matge (Fig. 4).

A review of these materials (e.g., Ramis, 2000; Pérez-Ripoll & Nadal, 2000; Ramis & Bover, 2001) made it possible to reach the conclusion that the "V"-shaped horns of *M. balearicus* were the result of osteophagic behaviour, a type of behaviour previously known in a series of living artiodactyls, but not identified to date in *M. balearicus* (Ramis & Bover, 2001), and also that there was no evidence of species domestication. This osteophagic behaviour is supposedly produced in order to make up for the lack of phosphates in the diet in terrains that are poor in phosphates (e.g., Wika, 1982). On the other hand, the accumulation of coprolites in Balma de Son Matge was interpreted as the result of behaviour natural to the species, both due to the finding of coprolite deposits in a cavern without any type of human remains inside, Cova Estreta (Pollença) (Encinas & Alcover, 1997), and because of what can currently be observed in caves or caverns where goats (*Capra hircus*) normally spend a certain amount of time. Furthermore, modifications registered in different *Myotragus* bones were identified to be the result of osteophagic effects (Ramis & Bover, 2001), while some supposed bone needles found in Cova de Moleta were reinterpreted as non-modified *M. balearicus* fibulas (Ramis & Alcover, 2001a). It was also documented that some supposed traces of flesh removal from a *Myotragus* radius (Waldren, 1974) were actually made on the radius of an introduced caprine (Alcover *et al.*, 2001).

Davis (2002) and Waldren *et al.* (2002) have rejected osteophagic behaviour as a cause of the alterations found in the bones of *M. balearicus*, and continue arguing that the typology observed in the horns of the species found in Balma de Son Matge is the result of human activities. Davis' arguments (2002) are based on the $\delta^{13}C$ and $\delta^{15}N$ study of bones from different species (among them, *M. balearicus*), a methodology used to study the diet of fossil and living mammalian species. This author contends that a habitual consumption of bones by *M. balearicus* which would have represented between 5% and 20% of their diet would be reflected in a rise in the $\delta^{13}C$ values, due to the fact that the value of this parameter is increased over the trophic chain (e.g., Palmqvist *et al.*, 2003). Another of the arguments proposed by Waldren *et al.* (2002) is that the symmetry of the alterations in the two horns could only be possible if they had been made by humans. These authors, also, argue that only domestication could explain the great accumulation of coprolites in Balma de Son Matge. In their opinion, a long coexistence of *M. balearicus* and humans could be demonstrated due to the fact that the isotopic analysis of some very fragmented bones (not taxonomically diagnosable from their morphology) from a relatively modern site, Son Ferrandell-Olesa (Early Bronze Age), supposedly fall within the isotopic profile of *M. balearicus*. These authors also use the basis of the $\delta^{13}C$ and $\delta^{15}N$ comparison of *M. balearicus* bones and the goat currently living in Mallorca (*Capra hircus*). Davis (2002), once the values of these two isotopic parameters were analysed for these two species, reaches the conclusion that they are similar, and therefore, since actually there has been no observed osteophagic behaviour in goats, it would have to be deduced that neither did *M. balearicus* have this behaviour.

The aim of this article consists of assessing the validity of the conclusions we expounded at the time about the supposed domestication process of this species (Ramis & Bover, 2001), by analysing the reliability of the arguments proposed in a sense contrary to Davis (2002) and Waldren *et al.* (2002).

Materials and Methods

The new materials studied are two *Myotragus* skulls from two locations in Mallorca:

1- Avenc Socarrat (Calvià, Mallorca)

2- Cova Genovesa (Manacor, Mallorca)

From the first location (Fig. 5) a fragmented *Myotragus* skull with altered horns was obtained (MNIB 68749, Fig. 6) (Crespí *et al.*, 2001). The only part of the skull left is the top of the neurocranium. It still has the horns, which have the same morphology as that recorded in the examples from Balma de Son Matge described by Waldren (1982). From the same place in the site, a mandible corresponding to *M.* cf. *batei*, a species from Lower Pleistocene, was obtained (Crespí *et al.*, 2001). These materials come from a breccia situated between blocks of one of the halls in the cavern.

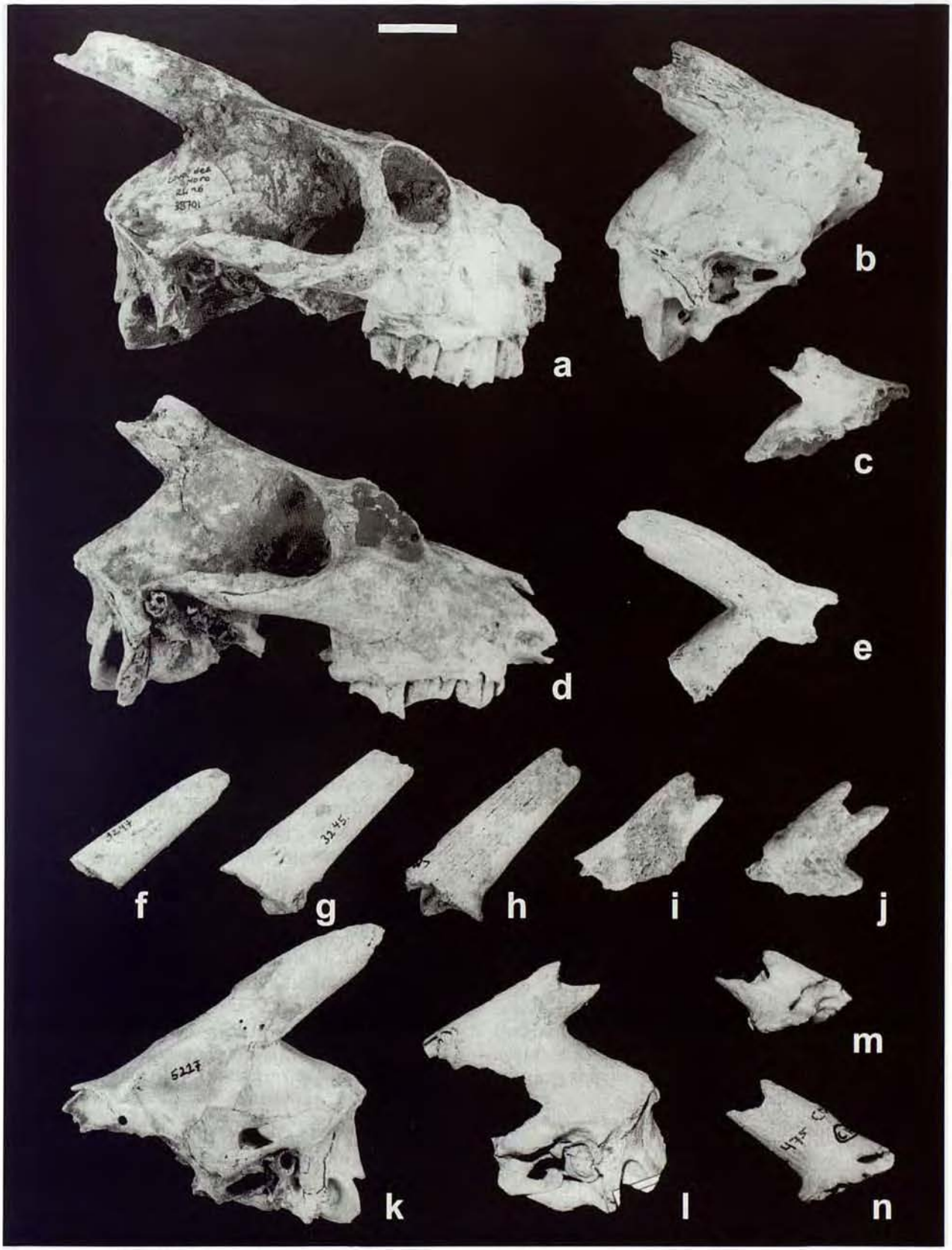

Fig. 2. Holocene skulls of *M. balearicus* with "V"-trimmed horn cores from different deposits. a-k : Cova des Moro and l-n, Balma de Son Matge. a: MNIB 38701; b: MNIB 5226; c: MNIB 3180; d: MNIB 60750; e: MNIB 3181; f: MNIB 3247; g: MNIB 3245; h: MNIB 3249; i: MNIB 8165; j: MNIB 60751; k: MNIB 5227; l: without number (Museu de Mallorca); m: without number (Museu de Mallorca); n: without number (Museu de Mallorca). Bar scale 2 cm. Photo obtained from Ramis & Bover (2001).

Fig. 2. Cranis holocènics de M. balearicus *amb banyes alterades procedents de diversos jaciments. a-k : cova des Moro i l-n, balma de son Matge. a: MNIB 38701; b: MNIB 5226; c: MNIB 3180; d: MNIB 60750; e: MNIB 3181; f: MNIB 3247; g: MNIB 3245; h: MNIB 3249; i: MNIB 8165; j: MNIB 60751; k: MNIB 5227; l: sense número (Museu de Mallorca); m: sense número (Museu de Mallorca); n: sense número (Museu de Mallorca). Escala 2 cm. Imatge obtinguda de Ramis & Bover (2001).*

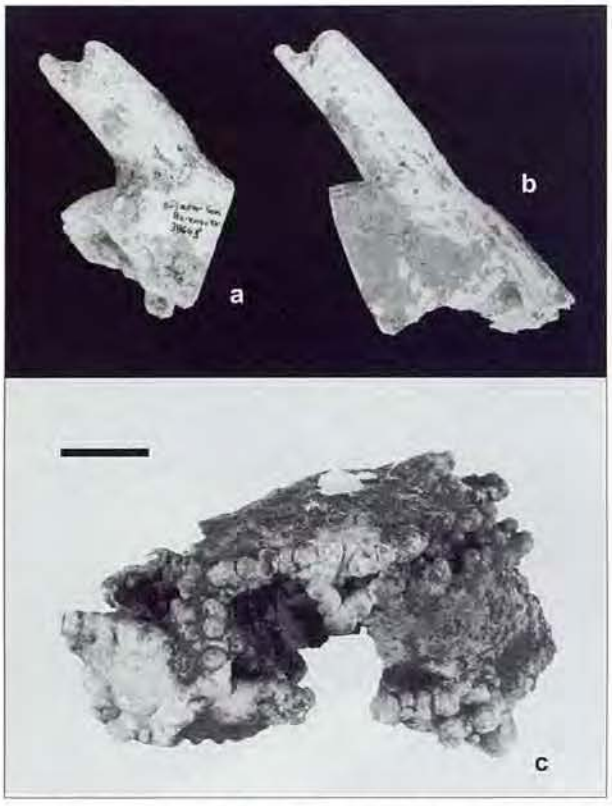

Fig. 3. Pleistocene skulls of *M. balearicus* with "V"-trimmed horn cores. A and B, skulls from Bufador de Son Berenguer; C, skull from Cova de Son Maiol. A: MNIB 38643; B: MNIB 38644; C: MNIB 60805. Bar scale 2 cm. Photo obtained from Ramis & Bover (2001).

Fig. 3. Cranis de M. balearicus *del Pleistocè amb banyes alterades. A i B, cranis del bufador de son Berenguer; C, crani de la cova de Son Maiol. A: MNIB 38643; B: MNIB 38644; C: MNIB 60805. Escala 2 cm. Imatge obtinguda de Ramis & Bover (2001).*

Cova Genovesa is a cavern which is under water for most of its length (Fig. 7) (Gràcia *et al.*, 2003a). In one part of its flooded galleries, an important number of *M. balearicus* bones were found on the floor surface, at a depth of 10 metres (Fig. 8) (Gràcia *et al.*, 2003b). Among them it is worth noting, for the present study, a series of skulls with the same type of aforementioned horn alteration. The bad state of conservation in which the bones were found (Crespí & Bover, en prep.) did not recommend the extraction from the site of all the skulls. The original layout of the *M. balearicus* skulls was recorded on film, with the aim of documenting it for later studies. From the skulls with this type of alteration, which can be seen in the video film recorded in the cavern study project (Consell de Mallorca and Grup Nord de Mallorca) (Fig.9), only one has been extracted, so as to carry out a detailed study.

This skull from Cova Genovesa (MNIB 85105) is a piece made up of the top of the neurocranium, with well conserved frontal bones (Fig. 10) and with alterations in the horns, also "V"-shaped, just like the ones recorded in Balma de Son Matge. On its surface a series of ridges produced by too quick drying during its conservation process can be observed (Crespí & Bover, in prep.).

Additionally, a series of carbon fractioning values have been obtained from the radiocarbon dating carried out on material from archaeological and paleontological excavations which the IMEDEA palaeontology team has carried out or collaborated in. The values available for *Myotragus* and domestic caprine samples have been compared, so as to assess whether it is actually possible to distinguish between the two from the results. Unfortunately there is no particular numerical value for Nitrogen fractioning available for any of the bovid species (fossils or present day) in the Balearics (Bover, 2004) therefore the results obtained from the literature have been analysed (basically Davis, 2002 and van Strydonck *et al.*, 2002). These authors do not present in their works any table with the specific results obtained. Hence, the values of these parameters have been estimated from their graphs. These authors' data come from an analysis of the bones in Cova de Moleta (Sóller) and Balma de Son Matge (Valldemossa) sites for *M. balearicus*, and from three Bronze Age archaeological sites in the municipality of Valldemossa (Mallorca), Son Mas, Son Ferrandell/Son Oleza and Naveta Baduia, for the introduced bovids. All these sites are situated very nearby, in the Serra de Tramuntana.

Results

Direct observation of the horns on the *M.* cf. *batei* skull from Avenc Socarrat (MNIB 68749, Fig. 6) and from the different *M. balearicus* skulls from Cova Genovesa (MNIB 85105, Fig. 9 and 10), indicates that the alteration patterns are identical to those observed in the horns of skulls interpreted to be the result of human manipulation by Waldren (1982), and in the skulls studied by Ramis & Bover (2001) which were interpreted to be the result of natural osteophagic conduct in the species.

In the case of the skull from Avenc Socarrat (MNIB 68749), the chewing effect in *Myotragus* reached the *collum processus cornualis*, leaving the *sinus frontalis caudalis* of the skull uncovered. Ramis & Bover (2001) present a figure in which the wear gradually produced in *M. balearicus* horns can be seen as they are worn down. The case of Avenc Socarrat would be the most extreme case in which the wear has surpassed the spongy tissue of the horn, nearly reaching the external surface of the frontal bone.

The skull from Cova Genovesa (MNIB 85105) also has the typical marks on the horns produced by the osteophagic conduct of *M. balearicus*. It has a different wear on the horns. One of the horns (the left one) is more worn down than the right one. The form of wear, or to put it another way, the orientation of the "V"-shaped cleft in the horns, is really, broadly speaking, symmetrical.

In Tables 1 and 2 the Carbon fractioning data obtained for *M. balearicus* and domestic caprines are related respectively, from the datings carried out by the IMEDEA paleontological team. The $\delta^{13}C$ data for the *M. balearicus* bones studied are between 19.7 and 22.1 ‰ (mean value 20.67 ‰). The values for introduced caprine species for different archaeological sites are 20.4 and 21.3 ‰, which is clearly within the $\delta^{13}C$ interval for *M. balearicus*. The data for *M. balearicus* and introduced caprines in the same site (Cova des Moro, Mallorca) also overlap, as well

as the data of these two species in the same geographical zone, Serra de Tramuntana in Mallorca (Cova Estreta, Coveta des Gorgs and Coval Simó).

The data obtained from the graphs for *M. balearicus* and the domesticated bovids of Davis (2002) and van Strydonck *et al.* (2002) are shown in Table 3.

The $\delta^{15}N$ values obtained from the literature seem to be quite scattered for *M. balearicus* (Bover, 2004). The lowest $\delta^{15}N$ values are found in *M. balearicus* (+1.57 ‰, whereas the highest values are observed in introduced caprines (*Ovis aries*/ *Capra hircus* group, +7.23 ‰) and in *Bos taurus* (+6.85 ‰). Apart from these two extreme values, the rest of the intervals calculated for introduced bovids totally overlap with the intervals obtained for *M. balearicus*.

As can be appreciated in Table 3, the $\delta^{13}C$ data obtained by other authors for *M. balearicus* and for introduced caprines are basically in line with the data obtained by the IMEDEA paleontology team. There are no important differences that can allow us to define a clear differential pattern between *M. balearicus* and the introduced bovids. In some cases (*Capra hircus*), the values appear to be slightly higher than in *M. balearicus*. It can also be observed that another of the higher $\delta^{13}C$ values corresponds to *Bos taurus*. As extreme values, it can be appreciated that the lowest $\delta^{13}C$ values are found in *M. balearicus* (-22.1 ‰).

Discussion

Osteophagic osteologic evidence

The main difference between the two aforementioned skulls and those studied by other authors lies in their inaccessibility, both timewise and spacewise, to human hands. In the first case, the skull from Avenc Socarrat was attributed, with certain reservations, to *M. batei* (Crespí *et al.*, 2001), a species from the lower Pleistocene (Crusafont & Angel, 1966; Alcover *et al.*, 1981). If the alterations observed in the skull were of human origin, the finding in

DEPOSIT	LAB NUMBER	2σ (years calBC)	$\delta^{13}C$ (‰)
Cova Estreta (MA)	UtC-5171	4720-4400	-21,0 (1)
Coveta des Gorgs (MA)	Beta-177239	6010-5830	-20,2
Coveta des Gorgs (MA)	Beta- 143117	7790-7580	-20,1
Cova des Moro (MA)	UtC-6671	9150-8450	-20,8
Cova des Moro (MA)	Beta-155644	11180-10700	-22,1
Pas den Revull (ME)	Beta-177237	3970-3760	-20,9
Cova des Myotragus (ME)	Beta-177238	22000-20400	-20,6
Cova des Penyal Blanc (CAB)	UtC-6517	3650-3380	-19,7

Table 1. $\delta^{13}C$ values from *M. balearicus* bones from different Gymnesic deposits. MA) Mallorca; ME) Menorca; CAB) Cabrera. (1) Estimated value due to small size of sample.

Taula 1. *Valors de $\delta^{13}C$ obtinguts a partir d'ossos de* M. balearicus *de diferents jaciments de les Gimnèsies. MA) Mallorca; ME) Menorca; CAB) Cabrera. (1) Valor estimat degut a que la mostra era molt petita.*

DEPOSIT	LAB NUMBER	2σ (years calBC)	$\delta^{13}C$ (‰)
Coval Simó (MA)	Beta-154196	2300-2030	-21,3
Cova des Moro (MA)	Beta-155645	2290-2030	-20,6
Coval Simó (MA)	Beta-177240	770-400	-20,4

Table 2. $\delta^{13}C$ values from bones of introduced caprine (*Ovis aries* or *Capra hircus*) from two deposits of Mallorca. MA) Mallorca.

Taula 2. *Valors de $\delta^{13}C$ obtinguts a partir d'ossos de capri introduït (*Ovis aries *o* Capra hircus*) a dos jaciments de Mallorca. MA) Mallorca.*

TAXA	n	$\delta^{13}C$ (‰)		$\delta^{15}N$ (‰)	
		Min	Max	Min	Max
Myotragus pre 10000BC	3	-21,7	-19,65	+4	+5,42
Myotragus post 10000 BC	9	-21,85	-19,74	+1,64	+4,64
Myotragus 14000-6000 BC	6	-21.26	-19,98	+1,57	+6,43
Bos taurus	*13*	*-21,12*	*-19,31*	*+4*	*+6,85*
Ovis aries	5	-21	-19,81	+4,85	+5,84
Capra hircus	2	-19,47	-19,30	+4,15	+4,84
Ovis aries/Capra hircus	22	-21,34	-21,18	+2,84	+7,23

Table 3. $\delta^{13}C$ and $\delta^{15}N$ values obtained from Davis (2002) and van Strydonck et al. (2002) for different bovid species.

Taula 3. *Valors de $\delta^{13}C$ i $\delta^{15}N$ obtinguts a partir dels treballs de Davis (2002) i van Strydonck et al. (2002) per a diferents espècies de bòvids.*

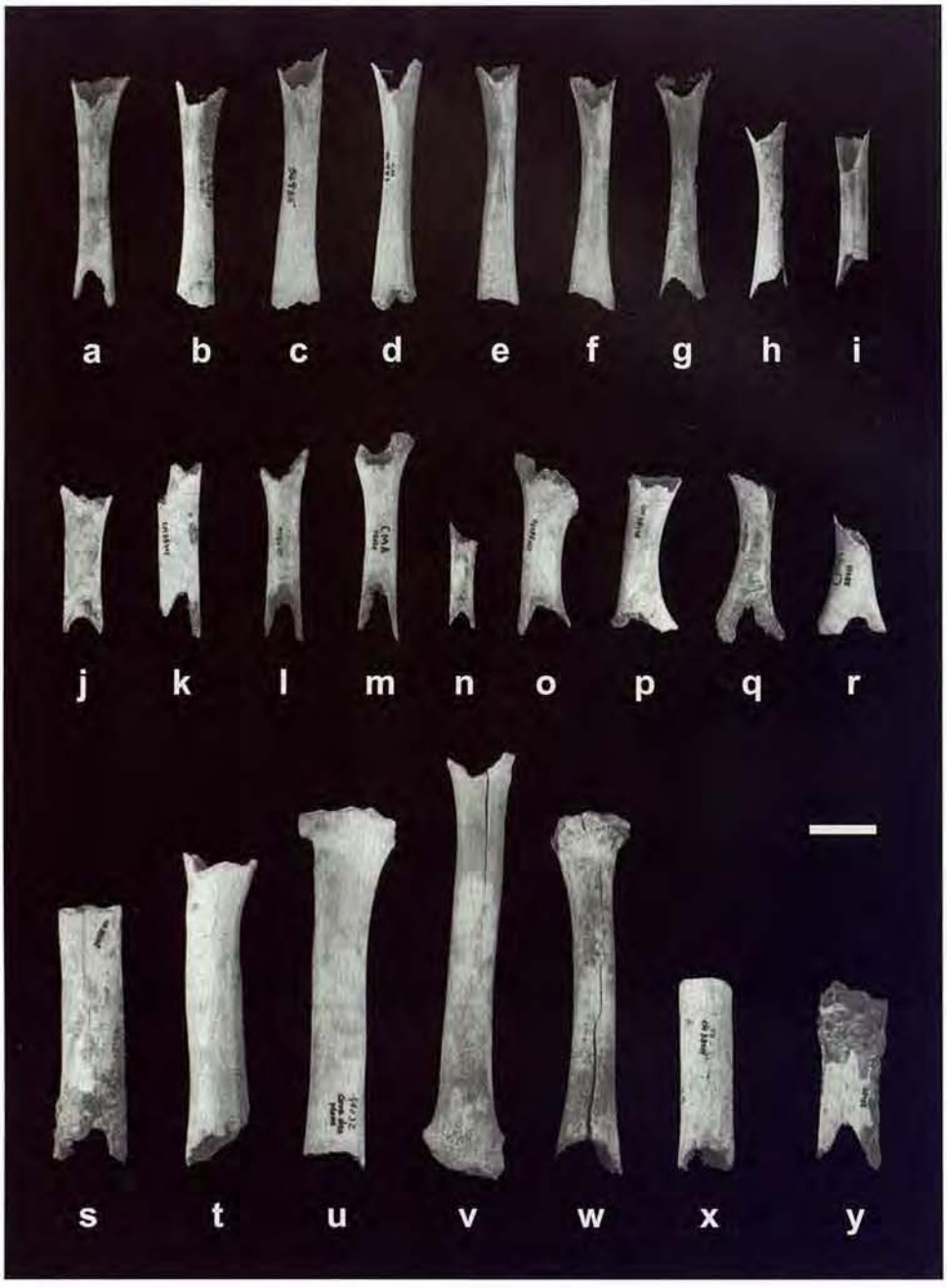

Fig. 4. V-trimmed leg bones of *M. balearicus* from Cova des Moro. All bones from MNIB collection. a: 38463; b: 56983; c: 56935; d: 56984; e: 38468; f: 38465; g: 38466; h: 38464; i: 38469; j: 38442; k: 38441; l: 38444; m: 38446; n: 39440; o: 38470; p: 38448; q: 38450; r: 38451; s: 38443; t: 38439; u: 49032; v: 49088; w: 49096; x: 38447; y: 38453. Bar scale 2 cm. Photo obtained from Ramis & Bover (2001). See this paper for further details of illustrated bones.

Fig. 4. Ossos alterats de les extremitats de M. balearicus *provinents de la cova des Moro. Tots els ossos de la col·lecció MNIB. a: 38463; b: 56983; c: 56935; d: 56984; e: 38468; f: 38465; g: 38466; h: 38464; i: 38469; j: 38442; k: 38441; l: 38444; m: 38446; n: 39440; o: 38470; p: 38448; q: 38450; r: 38451; s: 38443; t: 38439; u: 49032; v: 49088; w: 49096; x: 38447; y: 38453. Escala 2 cm. Imatge obtinguda de Ramis & Bover (2001). Veure aquest treball per a més informació detallada sobre els ossos il·lustrats.*

Avenc Socarrat would indicate that the first human presence in the Balearics would be much earlier than that determined to date by different authors, and that this would even be before the appearance of *Homo sapiens*. The lack of any type of human presence in the Balearics in the paleontological records of this time (lower Pleistocene) and the fact that the archaeological record of the Balearics only dates at the uppermost part of the III millennium cal BC (Alcover *et al.*, 2001; Ramis & Alcover, 2001b; Ramis *et al.*, 2002) allows us to conclusively refute the possibility that the alterations found in the skull in Avenc Socarrat - identical to the skulls from Balma de Son Matge - could be attributed to human activities.

In the second case, that of Cova Genovesa, the remains of different skulls are submerged at an average depth of 10 metres, and in some galleries at least 125 metres from the cave's actual entrance (Gràcia *et al.*, 2003a and b). In fact, there is a great accumulation of *M. balearicus* skeletal remains in a small lateral hall only 50 cm in height, near to where the animals possibly died (see Fig. 11). The layout of the bones and the topography of the cave suggest that the animals entered the cavern at a time when the sea level was at least 10m below the current level (before the Holocene; with a chronology attributable to an undetermined moment in the last glaciation). A step of about 1.5 metres, which can be found at the beginning of the galleries where the bovid remains were found (Francesc Gràcia, pers. comm.), could have impeded the exit of the animals once they had fallen inside the so-called Galeria dels Myotragus. In fact *Myotragus* remains have been found approximately 400 metres from the actual cave's entrance (Fig. 7). The fact that the Cova Genovesa galleries - where remains of the *M. balearicus* species (from the upper Pleistocene – Holocene) can be found - were dry at

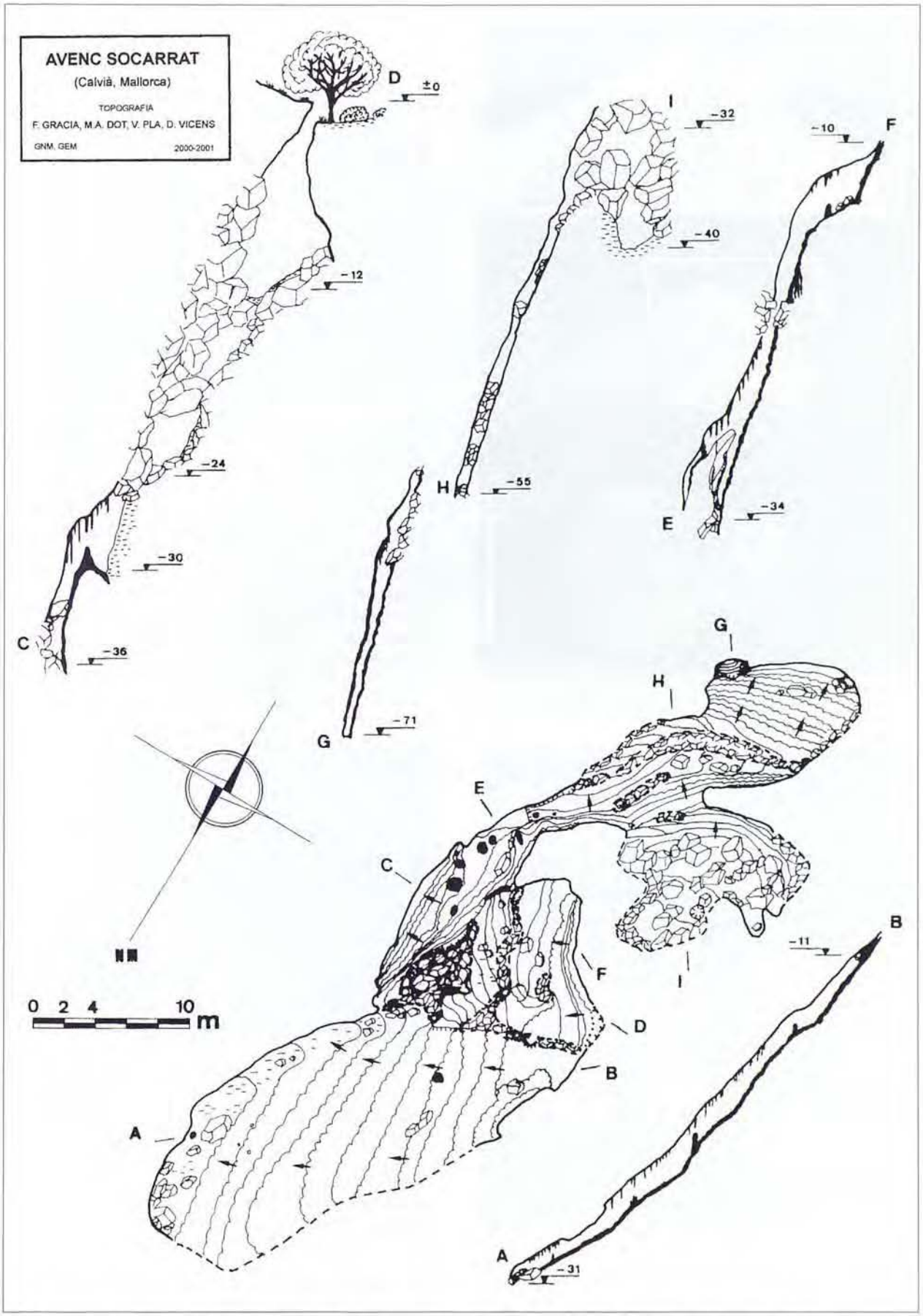

Fig. 5. Topographic survey of Avenc Socarrat (Calvià, Mallorca). Obtained from Crespí *et al.* (2001).

Fig. 5. Topografia de l'avenc Socarrat (Calvià, Mallorca). Obtinguda de Crespí et al. *(2001).*

Fig. 6. *Myotragus* cf. *batei* skull MNIB 68749 from Avenc Socarrat. Lower side, dorsal view; Centre side, lateral view; Upper side, detail of trimmed horn core. Bar scale 4 cm.

Fig. 6. Crani de Myotragus *cf.* batei *MNIB 68749 de l'avenc Socarrat. Abaix, en norma dorsal; enmig, en norma lateral; adalt, detall de la banya alterada. Escala 4 cm.*

the time the bones were deposited, and that these were not very displaced by dragging by mud or water, allows us to assume that the bones were deposited at the time of a glaciation, very possibly the Würm, in any case over 10000 years ago. To date there are no radiocarbon datings available for this site. The fact that all this material has been under water since the end of the Würm allows us to conclusively refute that the alterations found in the skulls from Cova Genovesa could be attributed to human activities. The attribution to human activities would imply a human presence in *Mallorca* at least during the Würm, a fact which can undeniably be excluded.

Apart from the geographical situation, it is worth repeating that the alterations in the horns observed in these skulls have a pattern which is morphologically compatible with the osteophagic patterns observed in other species of present day bovids (Anderson, 1974; Brothwell, 1976; Warrick & Krausman, 1986; Bover *et al.*, in prep), cervids (Sutcliffe, 1973; 1977; Gordon, 1976; Hasegawa, 1977; Krausman & Bisonette, 1977; Wika, 1982; Bowyer, 1983; Kahlke, 1990; Kierdorf, 1993), giraffids, camelids (Johnson & Haynes, 1985) and suids (Greenfield, 1988).

Stable isotopes

The $\delta^{13}C$ and $\delta^{15}N$ data from different *M. balearicus* and present-day bovids have been compared. As can be seen in Tables 1, 2 and 3, there is no important difference between these parameters for *M. balearicus* and for the introduced bovids which have been studied in Mallorca based on prehistoric materials (datings basically made on *Capra hircus* bones). It must be said, firstly, that osteophagic behaviour is a conduct that has irrelevant trophic implications, and that it is not expected to reach an appreciable nutritional value, As a consequence, it is not expected to be reflected in the analysis of the stable isotopes of carbon and nitrogen.

Osteophagic behaviour emerges as the most feasible hypothesis of the origin of the alterations in the horns of *Myotragus*. The great quantity of bones which have actually been extracted from paleontological excavations leads us to believe that this behaviour was of limited extension. It has only been recorded inside the caverns where animals could enter normally and comfortably, and the proportion of chewed bones is always very small. By way of example, this is the case of Cova des Moro (Manacor), Cova de Son Maiol (Palma), Bufador de Son Berenguer (Santa Maria) and Cova Genovesa (Manacor), all of which are caves with an important development in volume, or Balma de Son Matge (Valldemossa), an open cavern. On the other hand, in caves such as Cova Estreta (Pollença), a narrow cavern, where it may not have been comfortable to move about and chew bones, the incidence of osteophagic behaviour in the remains of *Myotragus* is much lower. From Cova des Moro, where nearly 9000 bones have been found, fewer than a hundred have osteophagic marks (this represents close to 1% of the total bones extracted). Logically, not all of the bones are susceptible to being chewed, since small bones (phalanges, sesamoid, tarsal and carpal bones) are difficult to chew.

Recently, a goat (*Capra hircus*) was photographed in the Serra de Tramuntana in Mallorca, chewing the mandible of an individual belonging to its own species (Bover *et al.*, in prep.; Fig. 12). What is more, numerous bones of present day *Capra hircus, Ovis aries* and *Bos taurus* have been collected with the same morphology as that observed in the *M. balearicus* bones. Some specimens of skull chewed in symmetrical "V"-shapes have even been found (Bover *et al.*, in prep.), and actually no type of cut is made in the horns of wild goats in *Mallorca*, neither is it the habitual practice in goats enclosed in stables. In the analyses carried out on individuals of the same species (see Table 2) no type of evidence of osteophagic behaviour has been found using $\delta^{13}C$. Since it is to be expected that in the past in Mallorca *Capra hircus* had a similar behaviour to nowadays, it would seem that osteophagic behaviour is not registered by this parameter. This must be valid both for introduced bovids and for *M. balearicus*.

Davis (2002) considers that different non-morphologically identifiable bone fragments from the Bronze Age site of Son Ferrandell-Oleza (Valldemossa) could be attributed to *Myotragus* due to their isotopic similarity to those belonging to this species. Nevertheless, in the preliminary faunistic study of this site carried out by Clutton-Brock (1984), the presence of *Myotragus* was not identified and this species was considered to have already

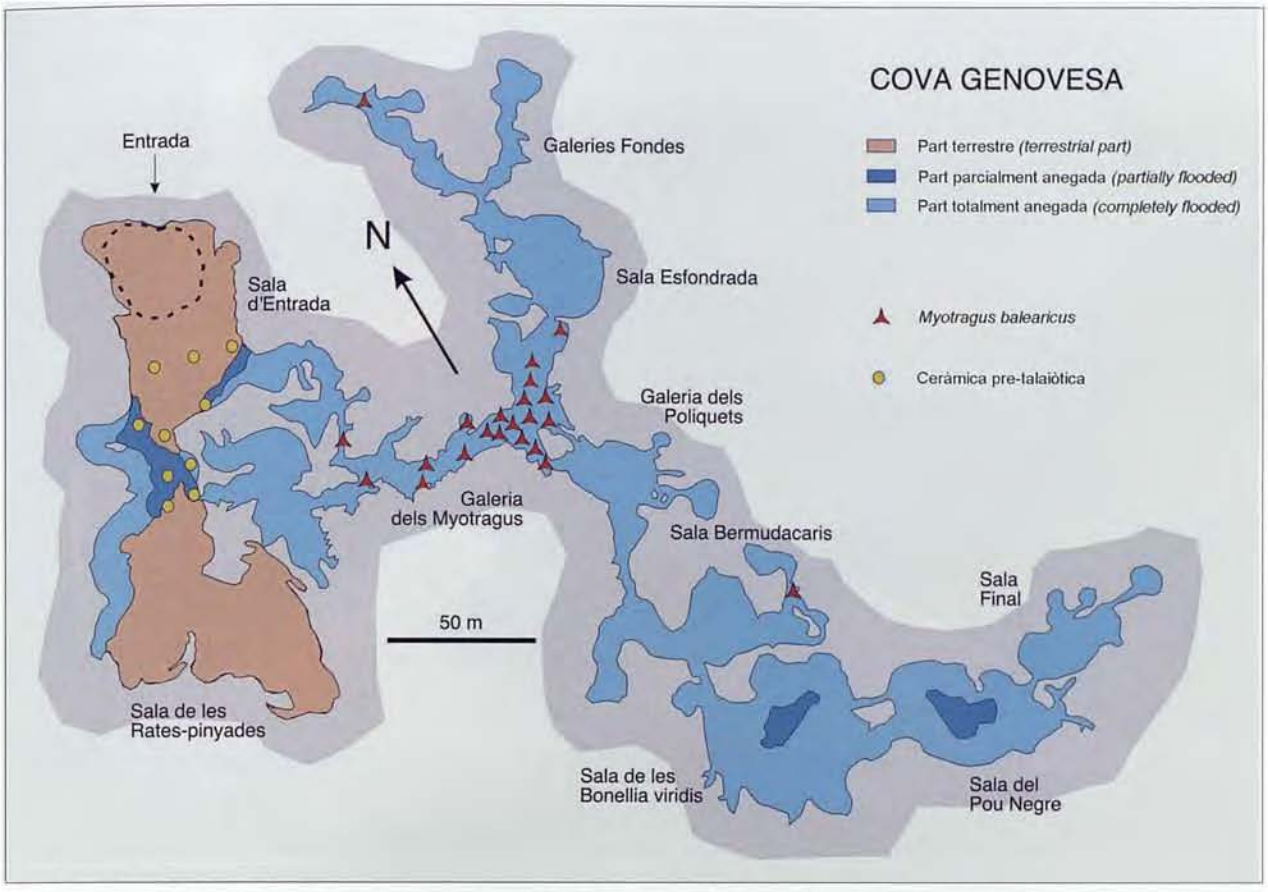

Fig. 7. Sketch of the topographic survey of Cova Genovesa (Manacor, Mallorca) where the *M. balearicus* bones distribution can be observed. Drawing obtained from Gràcia *et al.* (2003b).

Fig. 7. Croquis de la topografia de la cova Genovesa (Manacor, Mallorca) on s'observa la distribució de les restes osteològiques de M. balearicus. *Imatge obtinguda de Gràcia* et al. *(2003b).*

Fig. 8. Bones of *M. balearicus* from Cova Genovesa. These bones are located in a place 10 m underwater. Photo courtesy of F. Gràcia

Fig. 8. Vista de diversos ossos de M. balearicus *de la cova Genovesa. Aquests ossos es troben a 10 m de profunditat. Imatge cortesia de F. Gràcia*

Fig. 9. Detail of *M. balearicus* bones submerged in Cova Genovesa. Arrows show "V"- trimmed horn cores of both skulls. Photo obtained from Gràcia *et al.* (2003b).

Fig. 9. Detall d'ossos de M. balearicus *submergits a la cova Genovesa. Les fletxes indiquen les banyes alterades de dos cranis. Imatge obtinguda de Gràcia* et al. *(2003b).*

disappeared by the time of human occupation of Son Ferrandell-Oleza. Isotopic analyses can be affected by different factors (Bowman, 1990).

In our opinion, there should be no difference due to bone chewing - as far as nitrogen and carbon fractioning is concerned - between living bovids and *Myotragus*. Just as can be observed in Tables 1, 2 and 3, the small differences existing between *M. balearicus* and introduced

Fig. 10. *M. balearicus* skull MNIB 85105 from Cova Genovesa. From upper to lower side and from left to right: dorsal view, caudal view, lateral views. Down, detail of trimmed horn cores. Bar scale 2 cm.

Fig. 10. *Crani de* M. balearicus *MNIB 85105 de la cova Genovesa. D'adalt abaix i d'esquerra a dreta : norma dorsal, norma caudal, normes laterals. Abaix, detall de les banyes alterades. Escala 2 cm.*

bovids can be explained as the result of differences in the diet. The slightly lower values in *M. balearicus* for $\delta^{13}C$ respond to a type of *browser* diet (Bover, 2004) mainly based on shoots from bushes and trees (C3 plants), whereas in the introduced bovids, the presence of herbaceous plants (C4) in their diets would produce not as low $\delta^{13}C$ values.

Very possibly, one of the most important effects of human arrival in the Balearics was in opening up clearings in woods in order to settle, grow crops and move around. The creation of open habitats favours the presence of herbaceous plants (C4 plants) which the different introduced bovids would have fed on. What is more, two of the species studied (*Ovis aries* and *Bos taurus*) have *grazer* types of diet based on herbaceous plants (giving higher $\delta^{13}C$ values).

The interpretation of the small differences as far as $\delta^{15}N$ is concerned is more complicated. This parameter is affected by a factor which is intrinsic to each species, that is, its nitrogen metabolism. We do not know whether *M. balearicus* had a different metabolism for this element to present day bovids. Herbivores living in more arid areas have higher $\delta^{15}N$ values, while those living in more closed habitats have lower $\delta^{15}N$ values (Palmqvist *et al.*, 2003). In

Mallorca and Menorca, a vegetational change has been recorded, mainly expressed by the replacement of *Buxus* by *Olea*, as well as the appearance of plants that are more common in more open, drier environments (Yll *et al.*, 1999; Pérez-Obiol *et al.*, 2000, 2001). Based on palynological data, the accurate chronology of this vegetational change in Mallorca is uncertain (it can only be stated that it was later than 5380 calBC) however in Menorca it has been shown to be later than 2880 cal BC (Bover & Alcover, 2003). The fact of having a more arid climate in the Bronze Age (the time of origin of the introduced bovid bones from which the $\delta^{15}N$ data were obtained) than at much earlier times (times of origin of the *M. balearicus* bones to obtain the $\delta^{15}N$), could contribute to explaining the higher values of this marker for the introduced bovids.

The specific diagnosis of small caprine bone fragments based on the fractioning values of stable isotopes seems, for the time being, not to be very reliable. In the Balearics, these types of studies have only been used to differentiate between human bones and introduced artiodactyl bones (van Strydonck *et al.*, 2002).

Final remarks

Even though the most recent dating in Mallorca (Balma de Son Matge site) made on *Myotragus balearicus* bones, is not reliable (van Strydonck *et al.*, this volume), so far the most recent solid evidence available places the presence of *Myotragus* in the Balearics later than 3650 cal BC, although it is not known how much later (Bover & Alcover, 2003). Current available data allow us to establish that humans and *Myotragus* could have lived together at most for around 960 years in Mallorca and 1070 years in Menorca (Bover & Alcover, 2003; Quintana *et al.*, 2003). However, the most important fact is that this coexistence could have been considerably shorter. The supposed coexistence between humans and *Myotragus* of over 3000 years is not supported by the evidence available (Waldren *et al.*, 2002). The postulated domestication can not be explained either by the presence of coprolite accumulations (already commented on above) or by the supposed long coexistence of *M. balearicus* and humans.

In the sight of the documentation presented it must be concluded that the alteration patterns described by Waldren (1982) and by Ramis & Bover (2001) observed in different *M. balearicus* bones (and an ancient form of the species, *M.* cf. *batei*) are unmistakeably the consequence of osteophagic conduct of the species itself, natural behaviour which has nothing to do with the domestication of the species by the first colonisers of the island, and it must be definitely excluded that there may be proof of the domestication of *M. balearicus* by humans.

Fig. 11. View of Saleta gallery of Cova Genovesa. This small hall is near 50 cm tall. In the deep side of the hall an important number of *M. balearicus* bones can be observed. Photo courtesy of F. Gràcia.

Fig. 11. Vista de la Saleta de la cova Genovesa. L'alçada d'aquesta sala és d'uns 50 cm. Al fons s'observa un nombre important de restes de M. balearicus. *Foto cortesia de F. Gràcia.*

Fig. 12. Individual of feral goat (*Capra hircus*) from Serra de Tramuntana (Mallorca) chewing a jaw of its own species. In this zone of Mallorca the osteophagic behaviour of this species has been widely recorded. Photo courtesy of Josep Solivelles.

Fig. 12. Exemplar de cabra orada (Capra hircus) *de la serra de Tramuntana (Mallorca) rosegant una mandíbula de la seva espècie. A aquesta zona de Mallorca s'ha pogut constatar la conducta osteofàgica d'aquesta espècie. Foto cortesia de Josep Solivelles.*

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