



Distinguishing between *Bos* and *Bison* petrous bones. A case study: bovines from the Des-Cubierta Cave (Pinilla del Valle, Madrid)

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ABSTRACT

The taxonomic identification of large bovine remains in archaeological and palaeontological sites is important in order to infer the palaeoenvironment of these sites and to know if their inhabitants were hunters of *Bos* or *Bison*. Their presence may also have biostratigraphic or archaeozoological implications. Although the petrous bone is one of the elements of the skeleton with the greatest preservation potential in prehistoric sites, due to its hardness and compactness, it is not frequently used by the palaeontologists to distinguish between *Bos* and *Bison*, the two genera commonly present

RESUMEN

La identificación de grandes bovinos en yacimientos arqueológicos es primordial para inferir el paleoambiente de estos yacimientos y para conocer si los seres humanos que los habitaron cazaban *Bos* o *Bison*. Su presencia puede tener, además, implicaciones bioestratigráficas y zooarqueológicas. A pesar de que el hueso petroso es uno de los restos con mayor potencial de conservación en los yacimientos por su dureza y compactidad, los paleontólogos no suelen utilizarlo para discriminar entre *Bos* y *Bison*, los dos géneros de bovinos que más habitualmente se encuentran en los yacimientos

at the sites during the Pleistocene. Due to the abundance of petrous bones at the Late Pleistocene layers of the Des-Cubierta cave, the aim of this work is to identify *Bos* and *Bison* in this site through the morphological features defined by Guadelli (1999) for this bone and using morphometric geometrics with material of *Bos taurus*, *Bos primigenius*, and *Bison priscus* in order to identify the differences among petrous bones of these species.

Keywords: Taxonomy, bovines, Pleistocene, petrous bone, Pinilla del Valle.

pleistocenos. Debido a la abundancia de huesos petrosos que se encuentran en los niveles del Pleistoceno Superior de la cueva Des-Cubierta, el objetivo de este trabajo es diferenciar *Bos* y *Bison* en este yacimiento a partir de los criterios morfológicos definidos por Guadelli (1999) para este hueso y utilizar la morfometría geométrica con material de *Bos taurus*, *Bos primigenius* y *Bison priscus* para precisar las diferencias entre los petrosos de estas especies.

Palabras clave: Taxonomía, bovinos, Pleistoceno, petrosos, Pinilla del Valle.

1. INTRODUCTION

Bison priscus (Bojanus, 1825) (the steppe bison) and *Bos primigenius* Bojanus, 1825 (the modern cattle's - *Bos taurus* - ancestor) are two different species of bovines that coexisted in Europe during the Middle and the Late Pleistocene (Kurtén, 1968).

The steppe bison was one of the most abundant large mammals in the north of the Iberian Peninsula during the Late Pleistocene. It was frequently represented in this region in Upper Palaeolithic engravings and paintings (González Echegaray & González Sáinz, 1994; Altuna & Mariezkurrena, 2014). The steppe bison, together with the mammoth and the woolly rhinoceros, is one of the main taxa represented in typical tundra-steppe wildlife associations, which feed on pastures in open landscapes (Guthrie, 1990; Sher, 1971; Brugal, 1985).

The aurochs (*Bos primigenius* Bojanus, 1825) is the unique ancestor of cattle livestock (*Bos taurus* Linnaeus, 1758) (Zeuner, 1963; Clutton-Brock, 1999). It inhabited the Iberian Peninsula from the Middle Pleistocene (*Bos primigenius* was found for the first time in Torralba and Ambrona sites, dated around 500 ka: Soto *et al.*, 2001) to the Holocene. The latest bone remains of this species have been found at the Roman sites from the Basque Country (Altuna & Mariezkurrena, 2002). The aurochs probably inhabited in wet habitats, such as river valleys, lake fringes, marshy forests (Van Vuure, 2005) and open woodlands (Kurtén, 1968).

Although *Bos* and *Bison* did not have the same ecological preferences, they have been found together at some Iberian sites, in some cases in the form of engravings and paintings (e.g., Ekain, Altxerri; Altuna & Mariezkurrena, 2014), and in other cases as associations of bone remains of both species (e.g., at the Lezetxki site and the Morín site; Altuna, 1972, and at the Búho and Zarzamora caves; Sala *et al.*, 2010).

Assigning the large bovine remains from the Middle and Late Pleistocene sites to one of these species is complex because both species have a similar size and bone morphology. There is an extensive literature devoted to

the distinction of *Bos* and *Bison* (Schertz, 1936; Bibikova, 1958; Stampfli, 1963; Sala, 1986; Altuna, 1972; Brugal, 1985; Gee, 1993; Buitrago-Villaplana, 1992; Prat *et al.*, 2003; Sala *et al.*, 2010; among others). The skeletal elements that allow us to better distinguish between the two species are the metacarpals and the skull (especially the horn cores, the frontals, parietals and occipitals) (Lavocat & Piveteau, 1966). Nevertheless, these diagnostic bones are not represented at most sites or they are not well preserved enough to allow for an unequivocal identification. In these cases, the fossil remains are often grouped without distinction into the category "*Bos/Bison*".

In this context, the purpose of this contribution is to highlight the importance of the petrous bone as an element that can serve to identify the large bovines found at Iberian sites. The petrous bone is, along with the teeth, one of the skeletal elements with the greatest preservation potential in archaeo-palaeontological sites, due to their hardness and compactness (Lam *et al.*, 1999; Bar-Oz & Dayan, 2007) and constitutes one of the best anatomical elements for extracting DNA (Gamba *et al.*, 2014). Some previous works have demonstrated the existence of morphological differences between the petrous bones of aurochs and steppe bison (Guadelli, 1999). In this work, these diagnostic criteria are applied to the identification of a relatively large sample of large bovine petrous bones from the Late Pleistocene levels of the Des-Cubierta cave site (Pinilla del Valle, Madrid) in order to confirm their validity by crossing the identifications obtained from the study of petrous bones with that of the identification of the partial skulls to which they belong.

The GM (geometric morphometrics) is applied for the analysis of shape of the internal auditory canal, which is considered a diagnostic element to distinguish *Bos* and *Bison*, according to Guadelli (1999).

1.1. The site

The Des-Cubierta site is one of the sites located at the Calvero de la Higuera in Pinilla del Valle (Community of

Madrid) (Fig.1). It was discovered in 2009 and since then it has been the subject of annual excavations. It has a long stratigraphy that includes Middle and Late Pleistocene sediments.

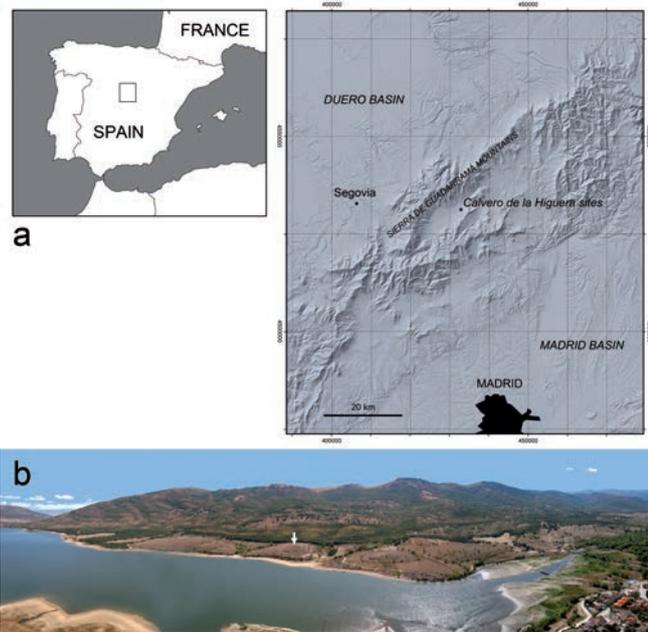


Figure 1. Location map of the Calvero de la Higuera archaeological sites, among which Des-Cubierta cave is included.

The recovered bovine bones that have been studied in this work were found in the Late Pleistocene levels. A *Homo neanderthalensis* mandible and some teeth have been discovered in these levels (Rodríguez *et al.*, 2016). Nevertheless, the most outstanding feature of these levels is the vast amount of partial crania of *Bison priscus*, *Bos primigenius*, *Cervus elaphus*, and *Stephanorinus hemitoechus* (Baquedano *et al.*, 2016). At least 20 individuals of bovines have been identified using horn cores (the most abundant element). Most of the horn cores belong to *Bison priscus* (15 individuals) and only 2 horn cores belong to *Bos primigenius* (2 individuals), although the number of identified individuals is growing up as new excavation campaigns take place. In some cases in which the apexes are the only preserved part of the horn cores, the generic adscription of some individuals has not been possible. In order to determine the abundance of both taxa in this site, some cranial bones other than the horn cores can be used in the identification of bovine remains. The petrous bone is one of the best candidates. This element constitutes the auricular or tuberous portion of the temporal bone, and includes its tympanic part. Due to its preferential preservation with respect to other parts of the skeleton and the skull in particular for the reasons indicated above, numerous well-preserved petrous bones

have been recovered at the site. Therefore, in this work, this bone is going to be used to identify these bovines.

2. MATERIAL AND METHODS

2.1. The material

The studied material is composed of 27 petrous bones: 16 petrous bones from Bovinae of the Pleistocene levels 1, 2, 5 and 101 from the Des-Cubierta cave site (Pinilla del Valle, Madrid) and 11 that belong to modern individuals of *Bos taurus* (Table 1). One petrous bone from Des-Cubierta cave, associated with its corresponding *Bison priscus* skull, and 11 that belong to modern *Bos taurus* have been used for comparison. *Bos primigenius* is the ancestor of modern cattle, *Bos taurus*, and, because petrous bones of aurochs are so difficult to find, the petrous bones of modern cattle have been used for the analysis. Seven of these come from the osteology collection of the Veterinary School's Anatomy and Embryology Department at the UCM (University Complutense of Madrid), two from the animal bone comparative collections of the UCM-ISCIIC Center on Human Evolution and Behaviour (Madrid) and two from the animal bone comparative collection of the Regional Archaeological Museum in Alcalá de Henares.

In order to distinguish between *Bos taurus*, *Bos primigenius* and *Bison priscus*, 33 photos of medial faces of the petrous bone were used, according to the list included in Table 1. Different cameras were used in the taking of the images of the material from the Des-Cubierta cave: Sony DSC-H50; Nikon D500 and Nikon D810 (Mario Torquemada, Regional Archaeological Museum at Alcalá de Henares).

2.2. Methodology

In order to appreciate the morphology of petrosal bone in the skulls of present-day bovines, two skulls belonging to the collections of Anatomy and Embryology Department's laboratory at UCM's Veterinary School were cut longitudinally and prepared for study.

A complete morphological description, as well as metrical analyses, have been carried out from the different faces whenever possible, following the criteria defined by Guadelli (1999). The terminology used in the description of the different parts of the medial face from a bovine petrous bone is shown in Figure 2.

2.2.1. Metrical analysis

The metrical data have been taken using a Sylvac digital caliper (03.02/SYL-235-F, D, E/681.046-100) to the nearest

Table 1. Petrous bones of bovines used for the study. * Bone remains used for the geometric morphometrics study.

	Petrous bone	SIDE	Belonging to	Taxa	Come from
1*	CDC10/I'41/1/29d	Right	Refitting to CDC10/G'41/1/16b	X	CDC level1
2*	CDC10/G'41/1/16b	Left	Refitting to CDC10/I'41/1/29d	X	CDC level 1
3*	CDC10/H'49/2/86	Right		X	CDC level 2
5*	CDC10/I'41/1/29 ^a	Left	Possible same individual of CDC10/I'41/1/29e	X	CDC level 1
4*	CDC10/I'41/1/29e	Right	Possible same individual of CDC10/I'41/1/29a	X	CDC level 1
7	CDC10/H'49/2/158 ^a	Right		X	CDC level 2
8*	CDC12/I40/101/36 ^a	Right		X	CDC level 101
9*	CDC12/I'39/101/11	Left		X	CDC level 101
10*	CDC12/J'38/101/68	Right		X	CDC level 101
11*	CDC13/J'37/101/20b	Right		X	CDC level 101
12*	CDC13/I'39/101/6	Right		X	CDC level 101
13*	CDC14/I'36/251/18	Right		X	CDC level 251
14*	CDC15/K'39/101/87	Left		X	CDC level 101
15*	CDC15/J'39/101/185d	Right		X	CDC15 level 101
16*	CDC17/K'38/101/19	Right	Cranium 2'17	<i>Bison priscus</i>	CDC level 101
17*	BtA	Left		<i>Bos taurus</i>	UCM's Veterinary School
18*	BtA2	Right		<i>Bos taurus</i>	UCM's Veterinary School
19*	BtB	Left		<i>Bos taurus</i>	UCM's Veterinary School
20*	BtB2	Right		<i>Bos taurus</i>	UCM's Veterinary School
21*	BtC	Right		<i>Bos taurus</i>	UCM's Veterinary School
22*	BtD	Left		<i>Bos taurus</i>	UCM's Veterinary School
23*	BtD2	Right		<i>Bos taurus</i>	UCM's Veterinary School
24*	ISCHIII comparative	Left		<i>Bos taurus</i>	ISCHIII
25*	ISCHIII comparative	Right		<i>Bos taurus</i>	ISCHIII
26*	MAR comparative	Left		<i>Bos taurus</i>	MAR
27*	MAR comparative	Right		<i>Bos taurus</i>	MAR
28*	C-G.cb2	Right		<i>Bos primigenius</i>	Guadelli (1999)
29*	Artenac	Right		<i>Bos primigenius</i>	Guadelli (1999)
30*	Livernon	Left		<i>Bos primigenius</i>	Guadelli (1999)
31*	C-G.cE	Left		<i>Bison</i> sp.	Guadelli (1999)
32*	C-G.c.R	Left		<i>Bison</i> sp.	Guadelli (1999)
33*	Unikote	Left		<i>Bison</i> sp.	Guadelli (1999)
34*	Actuel <i>B.bison</i>	Right		<i>Bison bison</i>	Guadelli (1999)

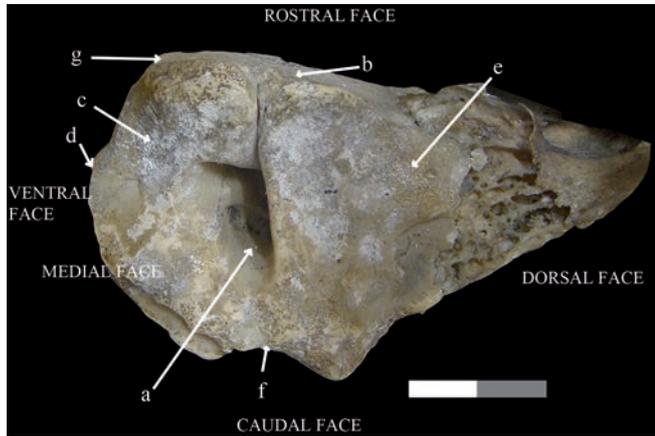


Figure 2. *Bos taurus* (comparative bovine from the UCM, Faculty of Veterinary). Medial view: a: internal acoustic meatus; b: petrosal crest; c: trigeminal nerve print; d: antero-inferior apex; e: cerebellar fossa; f: caudal crest; g: petrosal nerve hiatus.

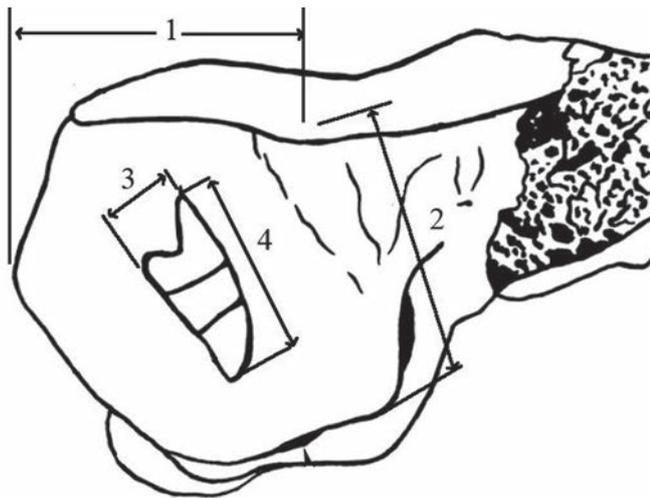


Figure 3. Metrical data of petrous bone: 1: dorso ventral diameter (Dvd); 2: rostro caudal diameter (Rcd); 3: dorso ventral diameter of internal acoustic meatus (DvdIAM); 4: rostro caudal diameter of internal acoustic meatus (RcdIAM), according to Mallet & Guadelli (2013). Image modified from Guadelli (1999).

0.01 mm, following Mallet & Guadelli (2013: Fig. 2) criteria, for the medial view (see Fig. 2 for nomenclature and Fig. 3 for measurements):

1) Dorso-ventral diameter (Dvd) (1): length between the antero-inferior apex and the ventral edge of the cerebellar fossa (measured on the rostral part of the fossa).

2) Rostro-caudal diameter (Rcd) (2): length between the edge of the petrosal crest and the edge of the caudal crest (measured along the cerebellar fossa).

3) Dorso-ventral diameter of the internal auditory meatus (DvdIAM) (3): length of the meatus from one extremity to the other in the dorso-ventral direction.

4) Rostro-caudal diameter of the internal auditory meatus (RcdIAM) (4): length of the meatus from one extremity to the other in the rostro-caudal direction.

For each petrous bone, an attempt has been made to characterize its morphology according to the criteria that distinguish *Bos primigenius* from *Bison priscus* according to Guadelli (1999), which are the following:

1) On the medial face (Fig. 4), the internal acoustic meatus of *Bison* is more elongated than in *Bos*. In order to test this feature we have used an index: the ratio rostro-caudal diameter (4) with the dorso-ventral diameter (3) of the internal auditory meatus (*Meatus acusticus internus*). According to the internal canal description by Guadelli (1999), this index should be close to 1 for *Bos* and, further away from 1 and greater than 1 for *Bison*. The imprint of the trigeminal nerve (located between the antero-inferior apex and the petrosal crest) is clearly concave in *Bison*, as opposed to *Bos* in which it is weakly concave or even almost rectilinear. The ventral part under the imprint of the trigeminal nerve does not protrude downwards in *Bison* (no salient towards the basis), whereas it clearly protrudes downwards in *Bos* (salient towards the basis).

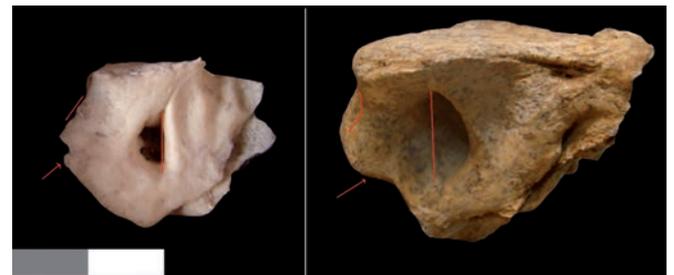


Figure 4. a) The medial face of petrous bone from *Bos taurus* (comparative bovine from UCM University, Faculty of Veterinary). b) The medial face of petrous bone from *Bison priscus*. The red arrow indicates the distinctive features from *Bos* and *Bison*.

2) The extent of the rostral face is very developed in Bovinae. In the case of *Bison*, the Fallopian hiatus hole (*Canaliculus nervi petrosi majoris*) is wide and a groove duct on the rostral surface of petrous bone is observed towards the ventral face. In *Bos*, the Fallopian hiatus opens directly downwards because it is not traversed by a groove (Fig. 5). Moreover, the rostral face is relatively more extensive in modern cattle than in aurochs.

3) The caudal face supports the basioccipital bone. In *Bison* the caudal face is regular. From back to front, a flat surface, a triangular depression, often wide and deep, and a small hole where a bone spine protruding from the occipital

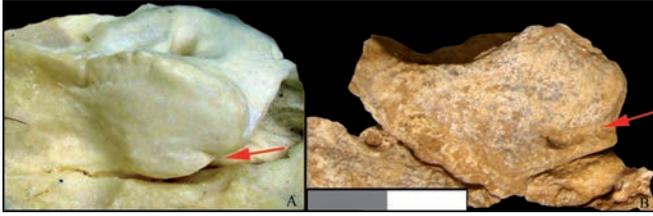


Figure 5. a) The rostral face of petrous bone from *Bos taurus* (comparative bovine from UCM University, Faculty of Veterinary). b) The rostral face of petrous bone from *Bison priscus*. The red arrow indicates no groove on *Bos taurus* and the groove on *Bison priscus*.

bone are observed. In *Bos*, it is irregular and undulating and there is no triangular depression like in *Bison*.

In all descriptions, the petrosal bone is considered to be in anatomical position, with the orientation relative to the Frankfort plane. This means that the cerebral face corresponds to the rostral face and the caudal face to the occipital face (according to the methodology from Mallet & Guadelli, 2013).

2.2.2. Geometric morphometrics

For the taxonomical identification of *Bos taurus*, *Bos primigenius*, and *Bison priscus*, the 32 photos were used (the medial face of one petrous bone, CDC10/H'49/2/158a, was broken so it wasn't included for this analysis). Using geometric morphometrics, the internal auditory canal was analysed and 6 landmarks were defined (Fig. 6): *Landmark 1*: the rostro-ventral apex of the internal auditory canal; *Landmark 2*: the most rostral apex of the internal auditory canal; *Landmark 3*: the rostro dorsal apex of the internal auditory canal; *Landmark 4*: the caudo-dorsal apex of the internal auditory canal; *Landmark 5*: the most caudal apex



Figure 6. Landmarks defined in internal auditory canal. Photo taken by Alfonso Dávila.

of the internal auditory canal; *Landmark 6*: the caudo-ventral apex of the internal auditory canal. The landmarks were digitalized using TpsDig v.2.17 (Rohlf, 2015). After digitizing all landmarks using TpsDig, the PCA analyses were performed using the MorphoJ v. 1.06d (Klingenberg, 2011).

3. RESULTS

3.1. Osteological description

3.1.1. The medial or cerebellar face

In *Bos taurus*, the trigeminal nerve imprint (*Impressio nervi trigemini*) is only very slightly concave and even completely flat. The index (4/3) that shows the shape of the internal auditory meatus (*Meatus acusticus internus*) is less than 1.6 (Table 3), which indicates the internal auditory meatus is not very elongated. In all cases of the *Bos taurus* petrous bones, a salient ventral-caudally is observed below the antero-inferior apex (*Apex antero inferior partis petrosae*).

In the bovines from Des-cubierta cave, the imprint of the trigeminal nerve (*Impressio nervi trigemini*) is concave in most cases of the fossil bone remains from the Des-Cubierta cave, except in CDC10/I'41/1/29a and CDC12/I'40/101/36a, where the concavity is not so clear (Table 2). The index (4/3) of the internal auditory meatus is far from 1, which indicates that the shape is elongated, according to the criteria observed by Guadelli (1999). The index (4/3) is closer to 1 in three cases of the bone material from Des-Cubierta cave: CDC10/H'49/2/86, CDC10/I'41/1/29a, CDC10/I'41/1/29e (see Table 3). This means that the internal auditory canal is not as elongated as in other fossil remains. No salient is observed below the antero-inferior apex in most of the cases.

3.1.2. Osteometry

In all cases of the petrous bones for the comparative modern cattle, the index 4/3 is less than 1.6 (from 1.18 to 1.56) (Table 3). This indicates an internal auditory canal that is a bit elongated, according to the Guadelli (1999) criteria.

3.1.3. Geometric morphometrics analysis of the internal auditory canal

The PCA was performed on *Bos taurus*, *Bos primigenius*, and *Bison priscus* and the bovine petrous bones from Des-Cubierta cave (Fig. 7). The PC1 and PC2 explain respectively 56.88% and 18.39% of the total variance, thus explaining 75.27% of the shape variation within the sample.

Table 2. Morphological characteristics of the petrous bone in medial face, according to Guadelli (1999).

	Medial face			
	Rostro-caudal diameter (4) of the internal auditory canal	Dorso-ventral diameter (3) of the internal auditory canal	trigeminal nerve print	Ventral part of the antero-inferior apex
CDC10/I'41/1/29d	Elongated	Narrow	Concave	
CDC10/G'41/1/16b	Elongated	Narrow	Concave	
CDC10/H'49/2/86	Triangular shape	Narrow	Concave	No salient
CDC10/I'41/1/29 ^a	Little elongated		Little concave	Broken
CDC10/I'41/1/29e	Little Elongated	Narrow	Concave	Broken
CDC10/H'49/2/158 ^a	Broken		Concave	
CDC12/I'40/101/36a	Little elongated		Little concave	Salient
CDC12/I'39/101/11			No visible	No salient
CDC12/J'38/101/68	Elongated	Narrow	Concave	No salient
CDC13/J'37/101/20b	Elongated	Narrow	Concave	No salient
CDC13/I'39/101/6	Elongated	Narrow	Concave	No salient
CDC14/I'36/251/18	Elongated	Narrow	Concave	No salient
CDC15/K'39/101/87	Elongated	Narrow	Concave	
CDC15/J'39/101/185d	Elongated	Narrow	Concave	No salient
CDC17/K'38/101/19 (Fig.8A)	Elongated	Narrow	Concave	
BtA	Little elongated	Wide	Straight	Salient
BtA2	Little elongated	Wide	Straight	Salient
BtB	Little elongated	Wide	Straight	Salient
BtB2	Little elongated	Wide	Straight	Salient
BtC	Little elongated	Wide	Straight	Salient
BtD	Little elongated	Wide	Straight	Salient
BtD2	Little elongated	Wide	Straight	Salient
ISCIII comparative	Little elongated	Wide	Straight	Salient
ISCIII comparative	Little elongated	Wide	Straight	Salient
MAR comparative	Little elongated	Wide	Straight	Salient
MAR comparative	Little elongated	Wide	Straight	Salient

Table 3. Metrical data of the current petrous bones of *Bos taurus* (from UCM Veterinary Faculty): BtA; BtA2; BtB; BtB2; BtC; BtD; BtD2; BtISCIII; BtMAR and the petrous bone of Des-cubierta cave. The measurements have been taken according to Mallet and Guadelli (2013). CDC10/I'41/1/29^a and CDC10/I'41/1/29e seem to belong to the same individual.

Taxonomical identification	Medial view	1	2	3	4	4/3
<i>Bos taurus</i>	BtA	27.55	24.22	7.7	9.1	1.18
<i>Bos taurus</i>	BtA2	28	26.5	6.4	9.9	1.54
<i>Bos taurus</i>	BtB	28.07	24.03	5.6	8.4	1.5
<i>Bos taurus</i>	BtB2	28.3	24.6	5.8	9.08	1.56
<i>Bos taurus</i>	BtC	25.23	22.2	5.7	8.7	1.52
<i>Bos taurus</i>	BtD	25.4	26.6	7.2	11.3	1.56
<i>Bos taurus</i>	BtD2	24.21	26.13	8.29	10.67	1.28
<i>Bos taurus</i> RIGHT	ISCIII comparative	23.8	27.4	5.7	8.6	1.51
<i>Bos taurus</i> LEFT	ISCIII comparative	26.5	27.4	5.7	6.9	1.21
<i>Bos taurus</i> RIGHT	MAR comparative	28.2	26.8	5.9	8.21	1.39
<i>Bos taurus</i> LEFT	MAR comparative	27.15	25.11	7.4	8.11	1.09
<i>Bison prisus</i>	CDC15/K'39/101/87	30.4	26.4	6.25	11.35	1.82
-	CDC15/J'39/101/185d	29.8	28	5.9	11.5	1.95
-	CDC17/K'38/101/19	25.04	23.86	6.28	10.18	1.62
-	CDC10/I'41/1/29d	21.97	26.25	7.2	11.8	1.64
-	CDC10/G'41/1/16b	23.26	24.6	7.2	11.67	1.62
-	CDC10/H'49/2/86	20.06	19.7	6.7	10.06	1.50
-	CDC10/I'41/1/29 ^a	27.1	23.8	8.26	11.4	1.38
-	CDC10/I'41/1/29e	24.45	19.9	7.17	10.8	1.51
-	CDC10/H'49/2/158 ^a	Broken				
-	CDC12/I'40/101/36 ^a	25.17	26.09	5.34	8.7	1.63
-	CDC12/I'39/101/11	28.22	21.95	6.2	10.19	1.64
-	CDC12/J'38/101/68	24.8	22.7	6.8	11.7	1.72
-	CDC13/J'37/101/20b	19.09	22.33	5.93	11.29	1.90
-	CDC13/I'39/101/6	23.86	21.81	4.2	9.78	2.33
-	CDC14/I'36/251/18	19.21	19.18	6.7	11.22	1.67

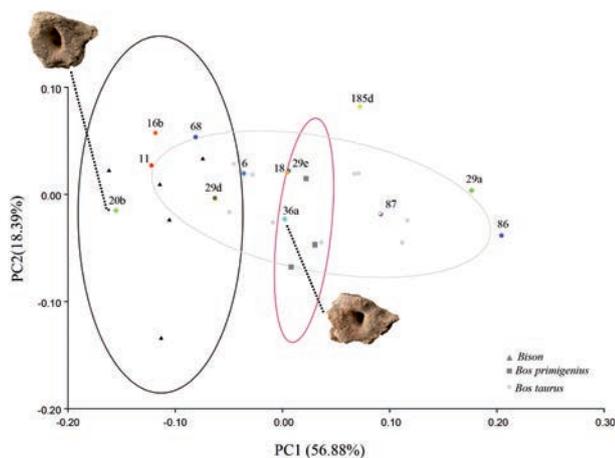


Figure 7. Results of PCA, where data from landmarks of petrous bones from Des-Cubierta cave are included. 11: CDC12/I'39/101/11; 16b: CDC10/G'41/1/16b; 18: CDC14/I'36/251/18; 185d: CDC15/J'39/101/185d; 20b: CDC13/J'37/101/20b; 29a: CDC10/I'41/1/29a; 29d: CDC10/I'41/1/29d; 29e: CDC10/I'41/1/29e; 36a: CDC12/I'40/101/36a; 6: CDC13/I'39/101/6; 68: CDC12/J'38/101/68; 86: CDC10/H'49/2/86; 87: CDC15/K'39/101/87. Photos taken by Mario Torquemada (M.A.R.).

The variation expressed by the PC1 showed differences in the width of the internal auditory canal between *Bos taurus*, *Bison priscus*, and *Bos primigenius*. These differences are illustrated in the Figure 7. In general, the internal auditory canal in *Bos taurus* is wider than in *Bison priscus*. The internal auditory canal of *Bos primigenius* is wider than *Bison* and included within the range of variability of *Bos taurus*. Nevertheless, the width of the internal auditory canal for *Bison priscus* does not overlap with the width for *Bos primigenius* (Table 3).

Accordingly (Fig. 7) seven of the 15 petrous bone remains from Des-Cubierta cave fall within the ellipse of *Bison priscus*. Three samples fall within the ellipse of *Bos primigenius* and four samples are closer to the ellipse of *Bos taurus* and *Bos primigenius* than *Bison priscus*.

3.1.4. The rostral face (Table 4)

In *Bos taurus*, on the rostral face, the Fallopian hiatus opens directly downwards. No groove from the Fallopian hiatus is observed.

Table 4. Morphological characteristics of the petrous bone in the rostral face, according to Guadelli (1999).

	Fallopian hiatus canal	Groove
CDC10/I'41/1/29d	Wide	To ventral face
CDC10/G'41/1/16b	Wide	To ventral face
CDC10/I'41/1/29 ^a	Relatively wide	It is not clear
CDC10/I'41/1/29e	Relatively wide	It is not clear
CDC10/H'49/2/158 ^a	Wide	To ventral face
CDC12/I'40/101/36 ^a		To ventral face
CDC10/H'49/2/86	Wide	To ventral face
CDC12/J'38/101/68	Wide	To ventral face
CDC13/I'39/101/6		To ventral face
CDC13/J'37/101/20b		To ventral face
CDC14/I'36/251/18		To ventral face
CDC15/K'39/101/87		To ventral face
CDC15/J'39/101/185d		To ventral face
CDC17/K'38/101/19	Wide	To ventral face (Fig. 8b)
BtA	Opens directly to ventral face: no groove	
BtA2	Opens directly to ventral face: no groove	
BtB	Opens directly to ventral face: no groove	
BtB2	Opens directly to ventral face: no groove	
BtC	Opens directly to ventral face: no groove	
BtD	Opens directly to ventral face: no groove	
BtD2	Opens directly to ventral face: no groove	
ISCIII comparative	Opens directly to ventral face: no groove	
ISCIII comparative	Opens directly to ventral face: no groove	
MAR comparative	Opens directly to ventral face: no groove	
MAR comparative	Opens directly to ventral face: no groove	

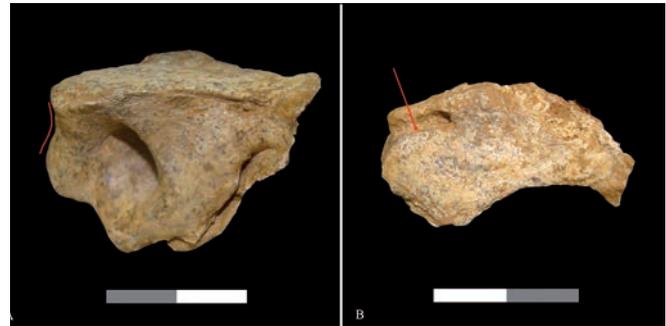


Figure 8. CDC17/K'38/101/19. This petrous bone belongs to an individual of *Bison priscus*. Medial (a) and rostral (b) faces are observed. In red, some diagnostic features are remarked: the concavity of the trigeminal nerve print (in picture a) and petrosal nerve hiatus (Fallopian hiatus canal) is wide and arrives to the ventral face.

The Fallopian hiatus hole is wide and there is a groove opening towards the ventral face in most petrous bones from the bovines of Des-Cubierta cave. This is a typical characteristic of *Bison*, according to Guadelli (1999).

3.1.5. The caudal face (Table 5)

In *Bos taurus*, the caudal face has not been morphologically described due to the lack of visibility of this face because all cattle petrous bones were connected to their skulls. In most cases of the bovines from the Des-Cubierta cave, a flat surface following a triangular depression is observed. A small hole is present in almost all of the petrous bones.

Table 5. Morphological characteristics of the petrous bone in the caudal face, according to Guadelli (1999).

Caudal face	Surface	Depression
CDC10/I'41/1/29d	This face isn't visible	
CDC10/G'41/1/16b	Regular	Triangular and deep
CDC10/H'49/2/86	Regular	A bone spine is observed in basioccipital bone
CDC10/I'41/1/29 ^a	Irregular and mountainous	No depression
CDC10/I'41/1/29e	Irregular and mountainous	No depression
CDC10/H'49/2/158 ^a	No visible: is broken	
CDC12/I'40/101/36 ^a	Regular	Triangular and deep
CDC12/I'39/101/11		
CDC12/J'38/101/68	No visible	
CDC13/J'37/101/20b	Regular	Triangular and deep
CDC13/I'39/101/6	Regular	Triangular and deep
CDC14/I'36/251/18	Regular	Triangular and deep
CDC15/K'39/101/87	No visible	
CDC15/J'39/101/185d	Regular	Triangular and deep
CDC17/K'38/101/19	Regular	Triangular and deep

4. DISCUSSION AND CONCLUSIONS

In the medial face, the index (4/3) for the internal auditory canal is less than 1.6 in all cases for *Bos taurus* and larger than 1.6 in most cases of the petrous bone remains from Des-Cubierta cave (Table 3).

Using geometric morphometrics for the medial face, we can see that, in general, the internal auditory canal in *Bos taurus* is wider than in *Bison priscus*, in agreement with the criteria proposed by Guadelli (1999). The internal auditory canal width for *Bos primigenius* is included within the metrical range for *Bos taurus*. There is no overlap between the internal auditory canal width for *Bos primigenius* and *Bison priscus*. According to the analysis, there are no other shape differences, since the most determining variables are width and length.

In seven of the 15 petrous bone remains from Des-Cubierta cave, both the morphological features and the geometric morphometrics analysis indicate that these belong to *Bison priscus* (Table 6). In 2 cases, CDC10/I'41/1/29a and CDC10/I'41/1/29e (possible same individual), both the morphological features and the GM analysis indicate that they belong to *Bos primigenius*. In five cases, the morphological features do not concur with the MG analysis and, thus, these petrous bones are classified as *Bos/Bison*. The morphological features of CDC10/H'49/2/158a suggests that it belongs to *Bison priscus* but the MG analysis could not be carried out because the bone is broken.

Table 6. Taxonomical classification according to the results obtained in this study.

Level	Label	Morphological features	MG	Taxonomical identification
1	CDC10/I'41/1/29d	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC10/G'41/1/16b	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC10/I'41/1/29a	<i>Bos prim</i>	<i>Bos prim</i>	<i>Bos prim</i>
	CDC10/I'41/1/29e	<i>Bos prim</i>	<i>Bos prim</i>	<i>Bos prim</i>
2	CDC10/H'49/2/86	<i>Bos/Bison</i>	<i>Bos</i>	<i>Bos</i>
	CDC10/H'49/2/158a	<i>Bison</i>	-	<i>Bison</i>
101	CDC12/I'40/101/36a	<i>Bos/Bison</i>	<i>Bos</i>	<i>Bos/Bison</i>
	CDC12/I'39/101/11	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC12/J'38/101/68	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC13/J'37/101/20b	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC13/I'39/101/6	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
	CDC15/K'39/101/87	<i>Bison</i>	<i>Bos</i>	<i>Bos/Bison</i>
	CDC15/J'39/101/185d	<i>Bison</i>	<i>Bos</i>	<i>Bos/Bison</i>
	CDC17/K'38/101/19	<i>Bison</i>	<i>Bison</i>	<i>Bison</i>
251	CDC14/I'36/251/18	<i>Bison</i>	<i>Bos/Bison</i>	<i>Bos/Bison</i>

Therefore, the morphological characteristics established by Guadelli (1999) for the distinction of the petrous bones between *Bos primigenius* and *Bison priscus* agree in most of the analysed cases the results of the geometric morphometric analysis of the internal auditory canal. The petrous bones that correspond with the *Bison* features according to Guadelli (1999) support the previous taxonomical identification through horn cores and crania of bovines from the Des-Cubierta cave.

The different features seem to clearly separate the petrosa in different groups. The internal auditory canal analysis with geometric morphometrics for *Bos taurus*, *Bos primigenius*, and *Bison priscus* suggests that this structure tends to be wider in *Bos primigenius* than in *Bison priscus*, in agreement with the criteria defined by Guadelli (1999). We can see there is no overlap between them; nevertheless, the data must be taken with caution, due to the scarcity of the sample.

Finally, this study demonstrates the possibility of taxonomically identifying *Bos* and *Bison* from one of the bones with the greatest preservation potential in the archaeo-palaeontological sites, and which until now is rarely taken into consideration.

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