

**Taphonomic data from the Transitional Aurignacian of El Castillo cave (Spain)
reveals the role of carnivores at the Aurignacian Delta level
Supplementary Information**

Alicia Sanz-Royo*, Gabriele Terlato, Ana B. Marín-Arroyo**

Taxonomic analysis

The faunal assemblage of the Aurignacian Delta level of El Castillo is dominated by carnivores, where dental remains are the most abundant elements. For this reason, their taxonomic assessment is based mainly on dentition. On the contrary, ungulates are scarce, and the representation of appendicular skeleton is higher.

1. Order Carnivora Bowdich, 1821

1.1. Family Ursidae Fischer, 1817

Ursus spelaeus Rosenmuller, 1794

A minimum of 34 individuals have been identified as *Ursus spelaeus*, based on diagnostic morphological characters of teeth (**Supplementary Table 1 and 2**), as well as the metric comparison with other brown and cave bears from European Late Pleistocene sites.

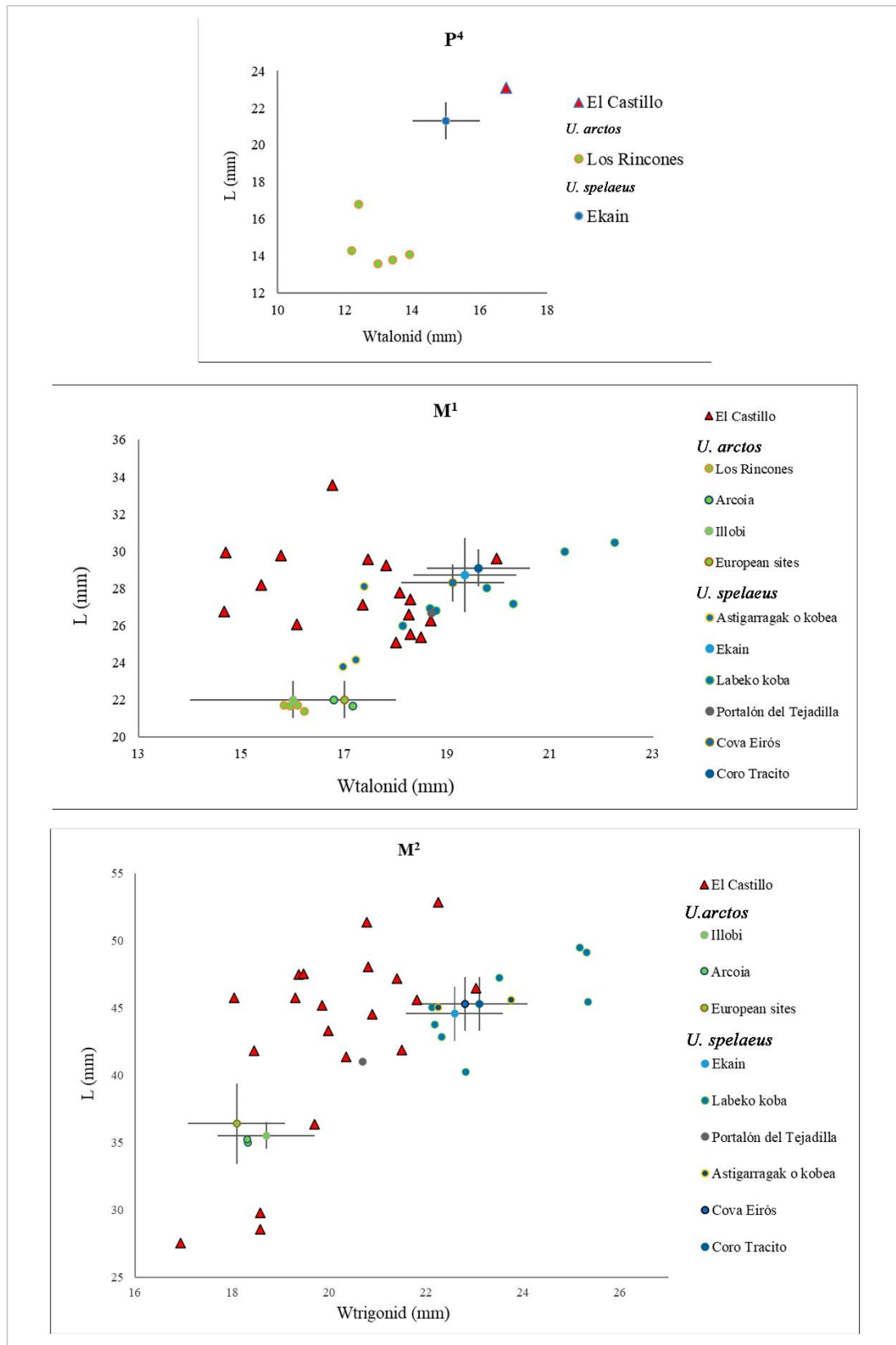
<i>Ursus spelaeus</i>	<i>Ursus arctos</i>	El Castillo
M¹		
Posterior part wider than the anterior part (3)		Posterior part wider than the anterior
Well-developed metastyle and parastyle, generally oriented outwards (3, 5, 6)	Small metastyle and parastyle, generally vertical (1, 2, 3, 4, 5, 6)	Well-developed metastyle and parastyle, generally oriented outwards
Presence of parastyle (1)	Absent or smaller parastyle than <i>U. spelaeus</i> (1)	Parastyle always present: small but well-differentiated
Abundant cusps in the metacone and metaconule area (1)	Absent or scarce cusps in the metacone and metaconule area (1)	Abundant cusps in the metacone and metaconule area
Metaconule always present (1)	Metaconule normally present, sometimes absent (1)	Presence of metaconule
Lingual cingulum generally well-developed (1, 6)	No cingulum (1, 6)	Lingual cingulum well developed
Subtriangular lingual cusps and wide transversely (1)	Subtriangular lingual cusps and narrower than <i>U. spelaeus</i> (1)	Wide and subtriangular lingual cusps
M²		
Metacone generally double, sometimes simple (1, 6)	Metacone generally simple (1)	Simple metacone and sometimes double
Marked separation between metaconule and hypocone (1)	Absent or slight separation between metaconule and hypocone (1)	Marked separation between metaconule and hypocone
Generally, complex hypocone (1, 7)	Generally, simple hypocone (1)	Complex hypocone

Supplementary Table 1. Morphological characters for the upper molars of *Ursus spelaeus*, *Ursus arctos* and the teeth from El Castillo analyzed in this work. References: 1) Torres Pérez-Hidalgo (1988); 2) Kurtén (1955); 3) García (2003); 4) Crégut-Bonnouire et al. (2011); 5) Argant (1989); 6) Grandal-d'Anglade (1993); 7) Rabal-Garcés (2013).

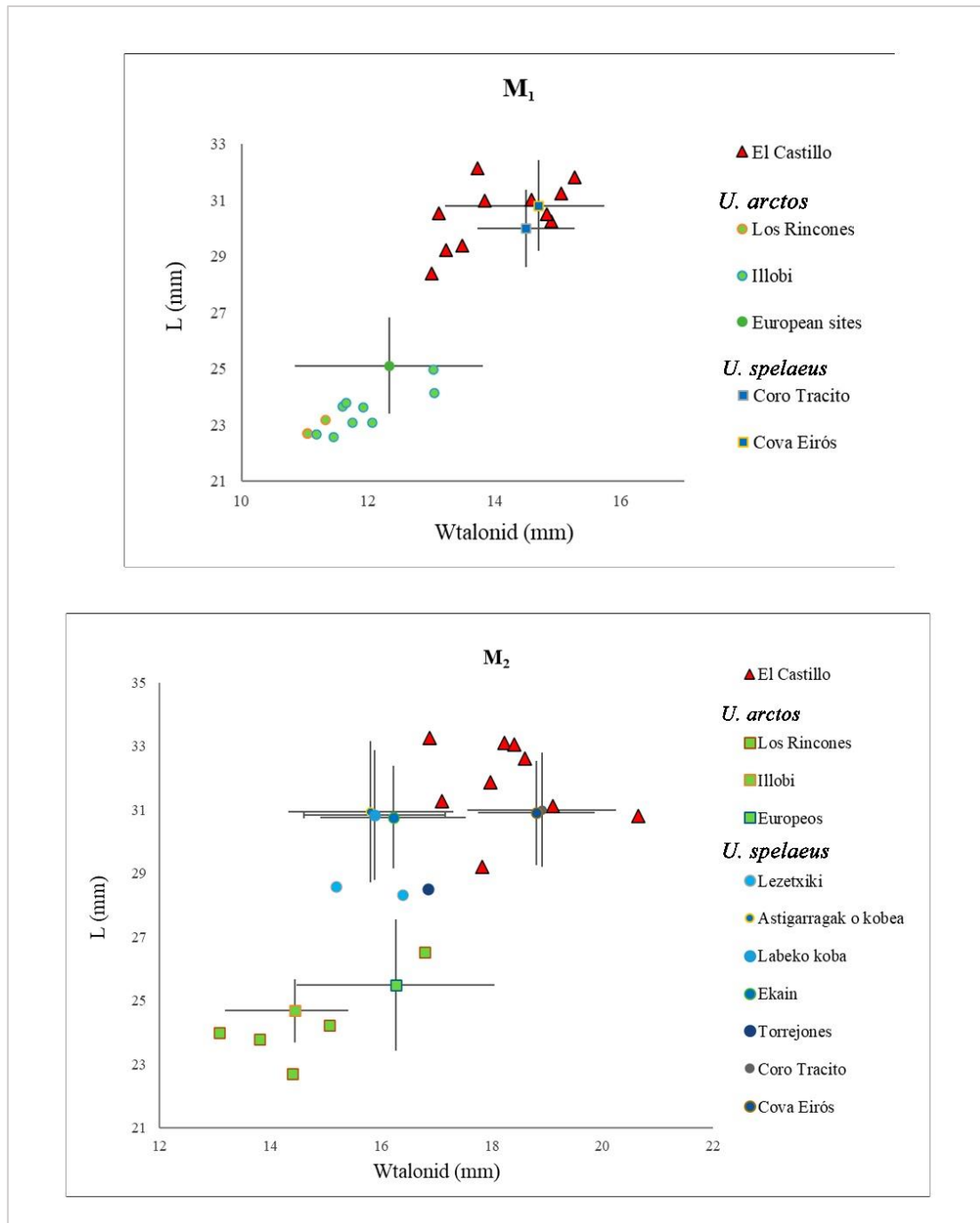
<i>Ursus spelaeus</i>	<i>Ursus arctos</i>	El Castillo
M₁		
Large protoconid (1)	Small and wide protoconid (1)	Protoconid similar to <i>U. spelaeus</i>
Complex metaconid (1)	Normally, simple metaconid (1)	Complex metaconid (2-3 cusps)
Complex entoconid (≥ 2 cusps) (1, 6, 7)	Simple entoconid or with a small cusp associated (1)	Complex entoconid
Presence of hypoconulid (1, 6, 7)	Longitudinal groove of the talonid does not reach the posterior edge of the tooth (1)	Presence of hypoconulid
Longitudinal groove of the talonid reaches the posterior edge of the tooth (1)	Without or almost non-existent cingulum (1)	Longitudinal groove of the talonid similar to <i>U. arctos</i>
Normally, presence of cingulum (1, 6)		Small cingulum
M₂		
Short and robust protoconid, sometimes complex (1, 6)	Simple protoconid (1)	Short and robust protoconid, divided into ≥ 2 cusps
Complex metaconid, divided into several cusps (1, 6, 7)	Simple metaconid, sometimes double (1)	Complex metaconid, with several cusps
Marked narrowing between trigonid and talonid (1, 2, 6)	Narrowing between trigonid and talonid less marked than in <i>U. spelaeus</i> (1, 2)	Marked narrowing between trigonid and talonid
Small cusp in the paracone (1)	No cusps in paracone area (1)	Sometimes cusp in the paracone, sometimes flat
Complex entoconid (≥ 2 cusps) (1, 3, 4, 6, 7)	Normally, doubled entoconid (3, 5)	Entoconid with 2 or more cusps
Hypoconulid developed with an internal cusp (1,6)	Simple hypoconid: no hypoconulid or accessory cusps (1)	Complex hypoconid, with hypoconulid and internal cusp

Supplementary Table 2. Diagnostic morphological characters described for the lower molars of *Ursus spelaeus*, *Ursus arctos* and the teeth from El Castillo analyzed in this work. References: 1) Torres Perez-Hidalgo (1988); 2) Kurtén (1959); 3) García (2003); 4) Torres et al. (2005); 5) Crégut-Bonnouire et al. (2011); 6) Grandal-d'Anglade (1993); 7) Rabal-Garcés (2013).

The advanced wear of an upper P⁴ has not allowed its morphological description within the upper dentition. Although there are not abundant metric data about this tooth of *U. arctos* and *U. spelaeus* in the Iberian Late Pleistocene, the available measurements suggest that the El Castillo specimen is close to *U. spelaeus* (**Supplementary Figure 1**). In general, upper molars from El Castillo show a morphology like *U. spelaeus* (**Supplementary Table 1**). The M¹ have a prominent cusp in the paracone, with a developed parastyle and metaconule, as cave bears. The cingulum is generally well-developed, sometimes even along the whole lingual surface. Towards the posterior part, there are abundant small cusps, typical of cave bears (Torres Pérez-Hidalgo, 1984), although this is only observed in teeth without marked wear. In the M² we have observed simple metacones. Although this character is more typical of brown bears, this morphology has also been documented in other close cave bear populations, such as those recovered from Ekain (Guipúzcoa) (Torres Pérez-Hidalgo, 1984). Metrically, upper molars are comparable to other Late Pleistocene European cave bears (**Supplementary Figure 1**). However, three M² of senile individuals show a smaller size, more similar to the brown bear size, probably because of its advanced wear.

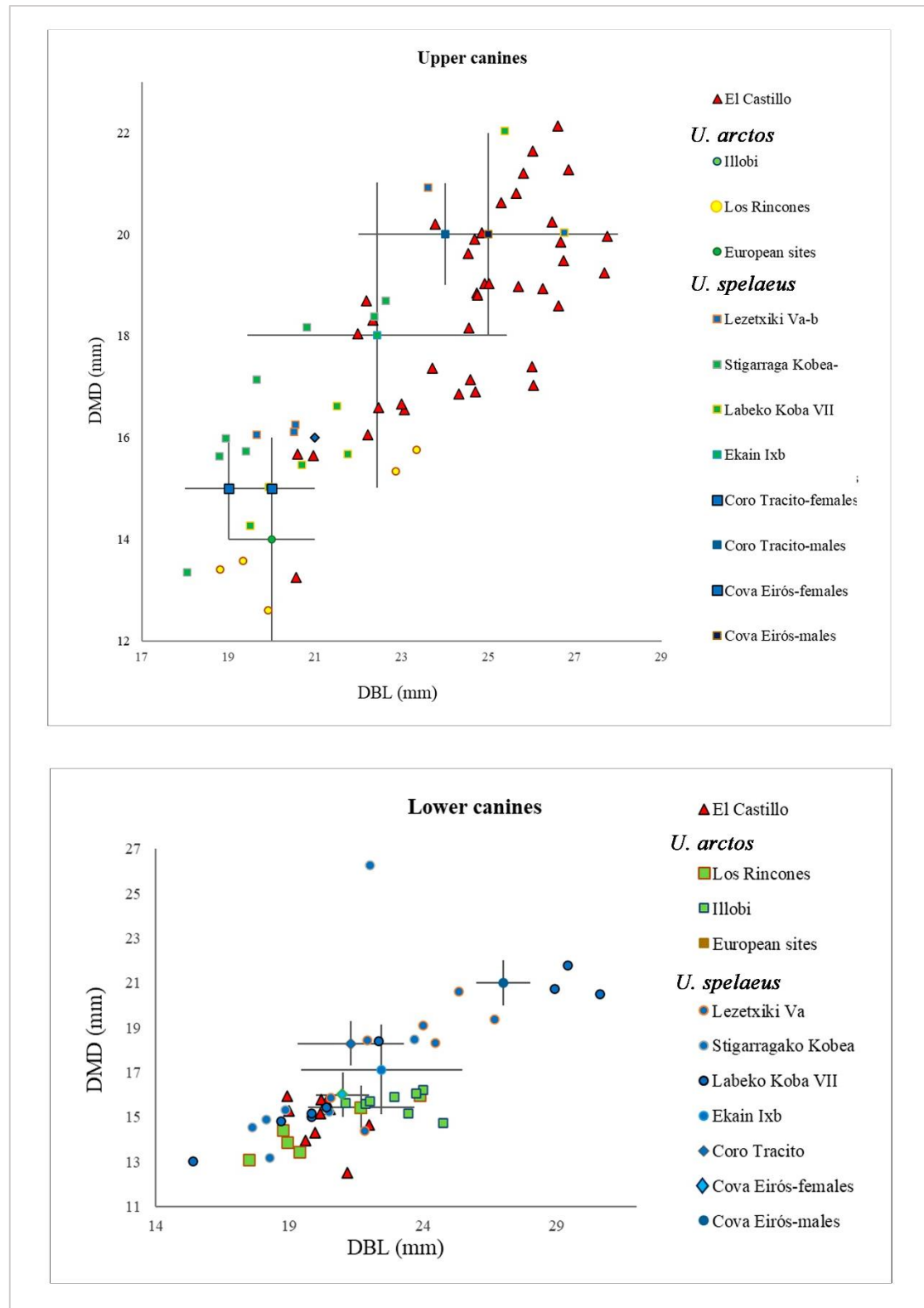


Supplementary Figure 1. Bivariate plots with the length (L) and width (W) of upper ursid teeth from El Castillo compared with European *Ursus spelaeus* and *Ursus arctos* from Late Pleistocene (Grandal-d'Anglade, 1993; Rabal-Garcés, 2013; Villaluenga, 2013; Sauqué et al., 2014; García Vázquez, 2015; Sala et al., 2020; Villalba et al., 2021) (metric raw data in SI3).



Supplementary Figure 2. Bivariate plots with the length (L) and width (W) of lower ursid molars from El Castillo compared with European *Ursus spelaeus* and *Ursus arctos* from Late Pleistocene (Grandal-d'Anglade, 1993; Rabal-Garcés, 2013; Villaluenga, 2013; Sauqué et al., 2014; Sala et al., 2020; Villalba et al., 2021) (metric raw data in SI3).

In general, the morphology of the lower molars resembles *U. spelaeus* (**Supplementary Table 2**). In lower M₁, the protoconid is large, and in teeth without advanced wear stage a cingulum is observed, which has an important development in some specimens, even presenting a small cusp (typical of cave bears). However, in El Castillo, we have not observed that the longitudinal groove of the talonid reaches the posterior edge of the tooth, a common characteristic in this species. In those lower M₂ without marked wear, a small



Supplementary Figure 3. Bivariate plots with the mesio-distal diameter (DMD) and bucco-lingual diameter (DBL) of ursid canines from El Castillo compared with European *Ursus spelaeus* and *Ursus arctos* from Late Pleistocene (Grandal-d'Anglade, 1993; Rabal-Garcés, 2013; Villaluenga, 2013; Sauqué et al., 2014; Villalba et al., 2021) (metric raw data in SI3).

cuspid has been observed in the paracone area, while in *U. arctos* this area is flatter (Torres Pérez-Hidalgo, 1984). As in *U. spelaeus*, the protoconid is a robust and triangular cusp, and (except in specimens with marked wear) two or more cusps are frequently observed. Metrically, these teeth are well-differentiated from other European brown bear populations and are included within the group of *U. spelaeus* (**Supplementary Figure 2**).

The morphology of the canines is not commonly used to differentiate between these two species since they hardly show differences. However, metric data can contribute to this differentiation (**Supplementary Figure 3**). Metrically, upper canines from El Castillo are comparable with the size of *U. spelaeus*, except for a tooth displaced towards *U. arctos* size. Nevertheless, this tooth shows an advanced wear that could influence to this fact. Lower canines are also metrically similar to *U. spelaeus* (Figure 5.4.12). Nevertheless, some specimens appear between the metric ranges of both species. These teeth showed anomalous wear, which could influence these results. This abnormal wear in the bear canines has also been observed in other European sites and is related to the search for some nutritious parts of plants located underground, such as roots and tubers (Ramírez-Pedraza et al., 2022). It must be taken into account that bear canines have significant sexual dimorphism, being larger in males than in females (Koby, 1949; Kurtén, 1955; 1969), so it is also possible that these smaller teeth belong to females.

Regarding the postcranial skeleton, which is notably less represented, the size of the remains also suggests their belonging to the species *U. spelaeus*.

1.2. Family Hyaenidae Gray, 1821

Crocota spelaea Goldfuss, 1823

Although some postcranial elements have been recovered, the presence of this species in El Castillo is based on dental remains, with a minimum of eight individuals. These remains display the typical morphology and size of *C. spelaea*.

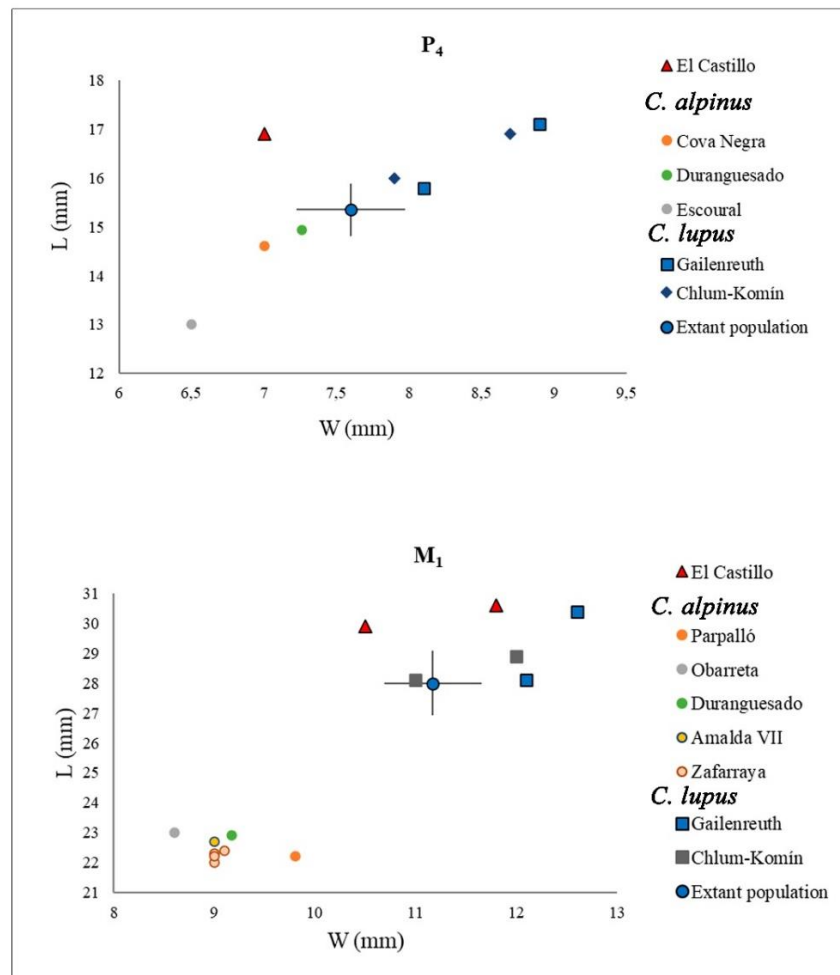
1.3. Family Canidae Fischer, 1817

Canis lupus Linnaeus, 1758

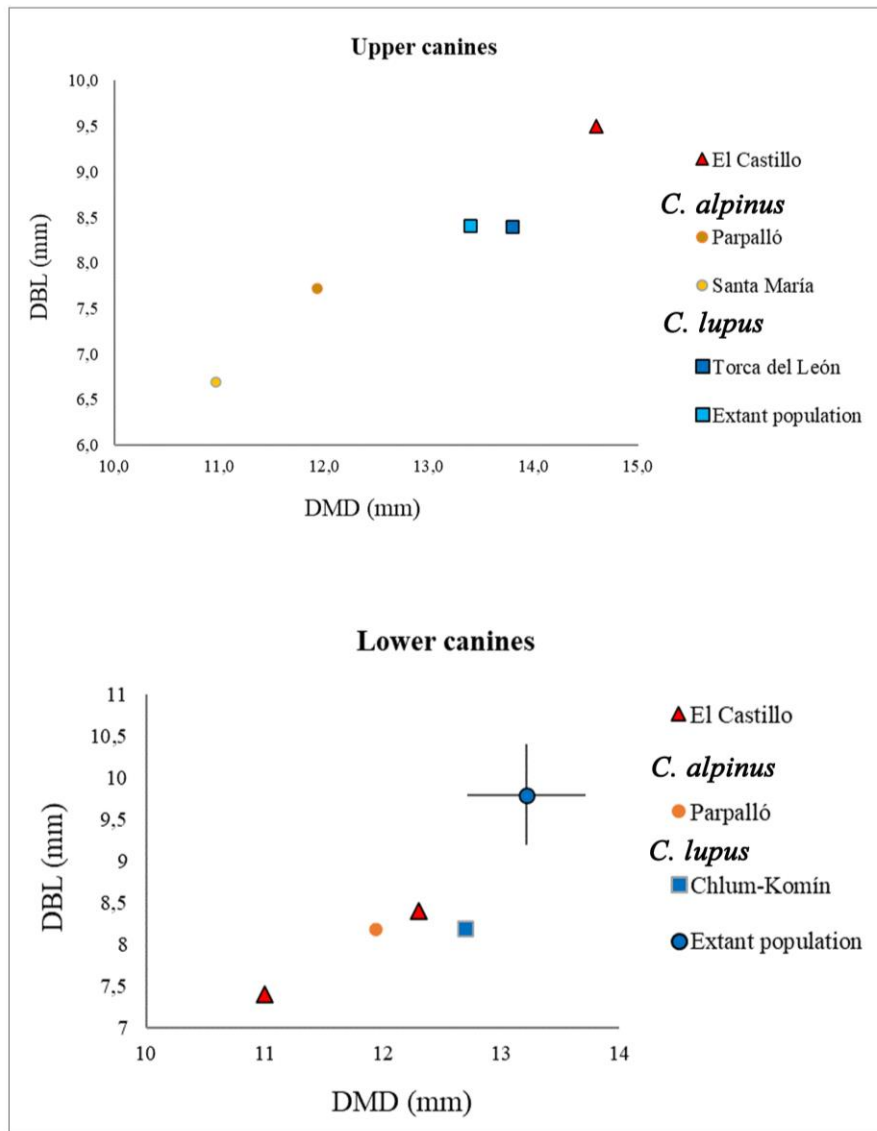
Three individuals have been identified as wolves based on dental elements. Morphological (**Supplementary Table 3**) and metrical features (**SI4**) allow us to assign these dental remains to *Canis lupus*. The size of lower P₄ and M₁, and one upper canine are well-differentiated to *C. alpinus*. However, one lower canine is between wolf and cuon, and a second one is closer to *C. alpinus* size, although this tooth showed advanced wear that could influence its smallest size (**Supplementary Figure 4 and 5**).

Element	<i>Cuon alpinus</i>	<i>Canis lupus</i>	El Castillo
Lower P ₄	Presence of paraconid (1)	No paraconid (1)	No paraconid
Lower M ₁	Underdeveloped metaconid and narrow talonid (1)	Well-developed metaconid and wide talonid, with hypoconulid (1)	Well-developed metaconid and wide talonid
Mandibule	Small diasteme between P ₂₋₃ (2)	Normally, large diasteme between P ₂₋₃ (2)	Large diasteme
	Middle mental foramen below P ₂ (2)	Middle mental foramen below the diasteme of P ₁₋₂ (2)	Position of middle mental foramen as <i>C. lupus</i>
	Posterior mental foramen below the posterior part of P ₃ (2)	Posterior mental foramen below the anterior part of P ₃ (2)	Position of posterior mental foramen as <i>C. lupus</i>
Humerus	Oblique trochlea towards its medial side (3)	Upper edge of trochlea kept straight towards its medial end (3)	Trochlea similar to <i>C. lupus</i>

Supplementary Table 3. Morphological characters described to differentiate between *Canis lupus* and *Cuon alpinus*. References: 1) Sanchis et al. (2020); 2) Pérez-Ripoll et al. (2010); 3) Pionnier-Capitan et al. (2011).



Supplementary Figure 4. Bivariate plots with the length (L) and width (W) of lower P₄ and M₁ of wolves from El Castillo compared with European *Canis lupus* and *Cuon alpinus* from Late Pleistocene (Castaños, 1988; Altuna, 1990; Cardoso, 1992; Martínez Valle, 1996; Barroso et al., 2006; Pérez-Ripoll et al., 2010; Baryshnikov, 2015; Sanchis and Villaverde, 2020) (metric raw data in SI4).



Supplementary Figure 5. Bivariate plots with the mesio-distal diameter (DMD) and bucco-lingual diameter (DBL) of wolf canines from El Castillo compared with European *Canis lupus* and *Cuon alpinus* from Late Pleistocene (Pérez-Ripoll et al., 2010; Baryshnikov, 2015; Alvarez-Lao et al., 2020; Sanchis and Villaverde, 2020) (metric raw data in SI4).

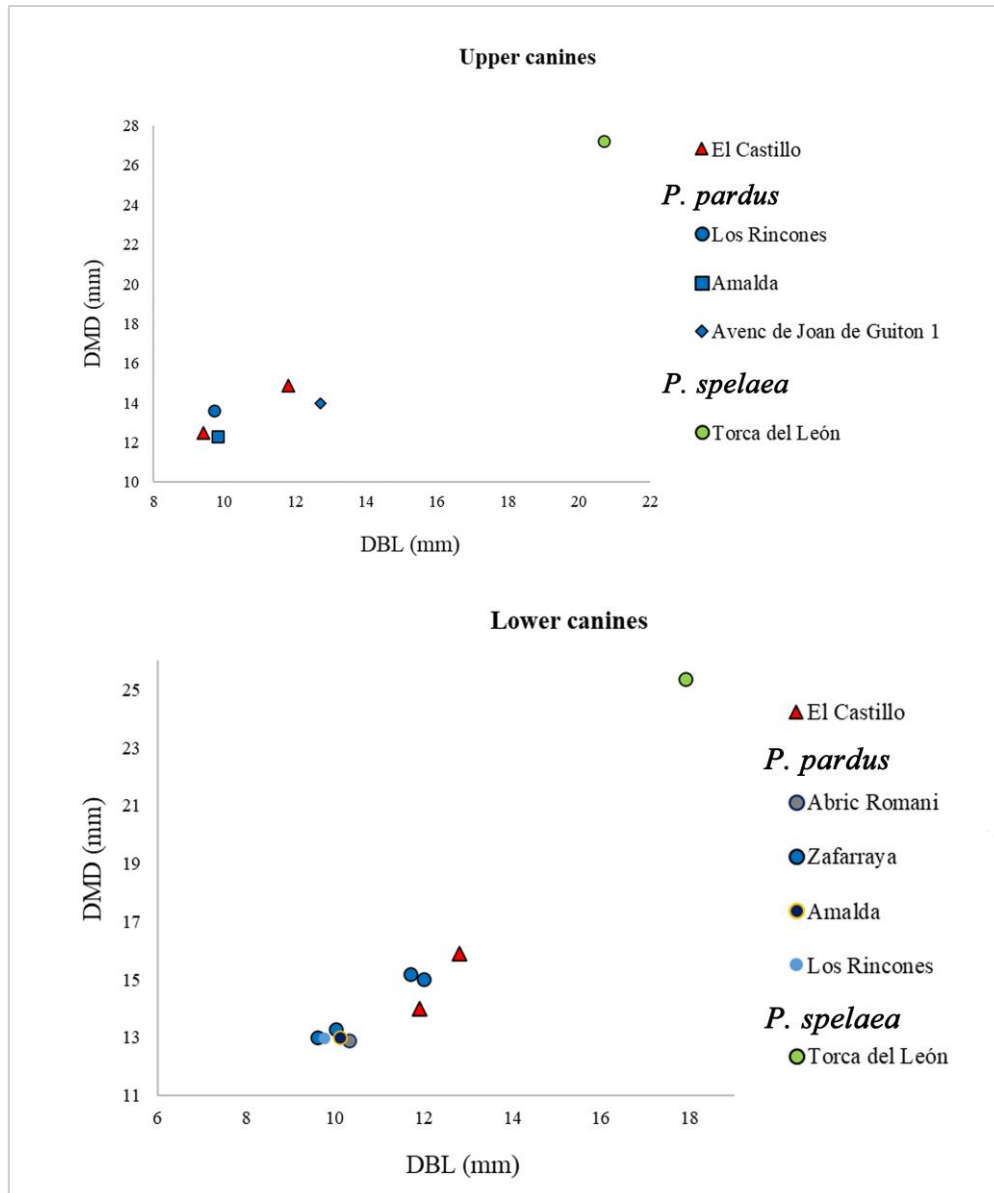
Vulpes vulpes Linnaeus, 1758

A minimum of three individuals have been identified as *Vulpes vulpes*. The morphology and size of remains are more compatible with this species than with *Vulpes lagopus*, which is generally smaller (Boessneck and von der Driesch, 1973; Altuna, 2004;).

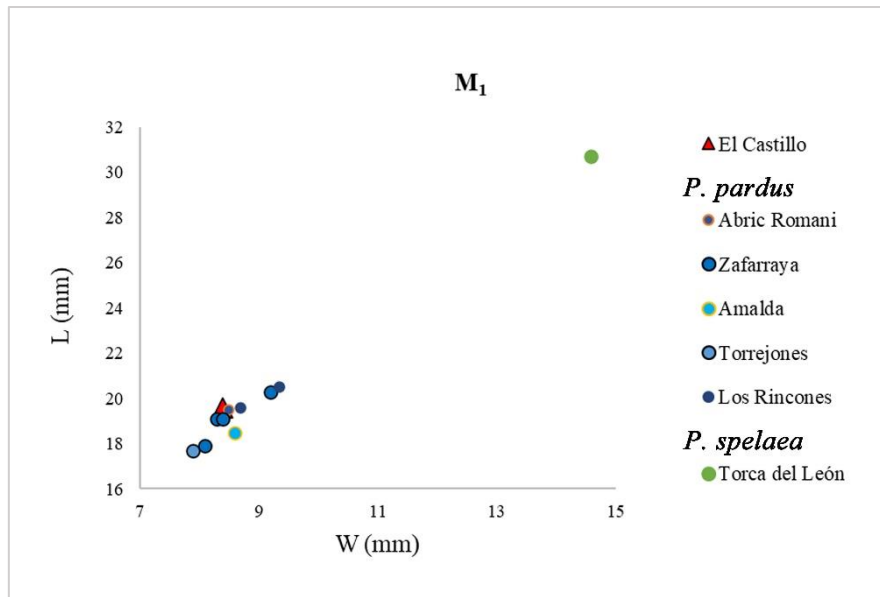
1.4.Family Felidae Fischer, 1817

Panthera pardus Linnaeus, 1758

A minimum of three individuals have been calculated based on dental elements, which show the typical morphology of leopards (Ghezzo and Rook, 2015), similar to those recovered at Los Rincones site (Zaragoza) (Sauqué and Cuenca-Bescós, 2013). Furthermore, metrically, the teeth are within the group of leopards, clearly separated from the larger cave lion (**Supplementary Figure 6 and 7**).



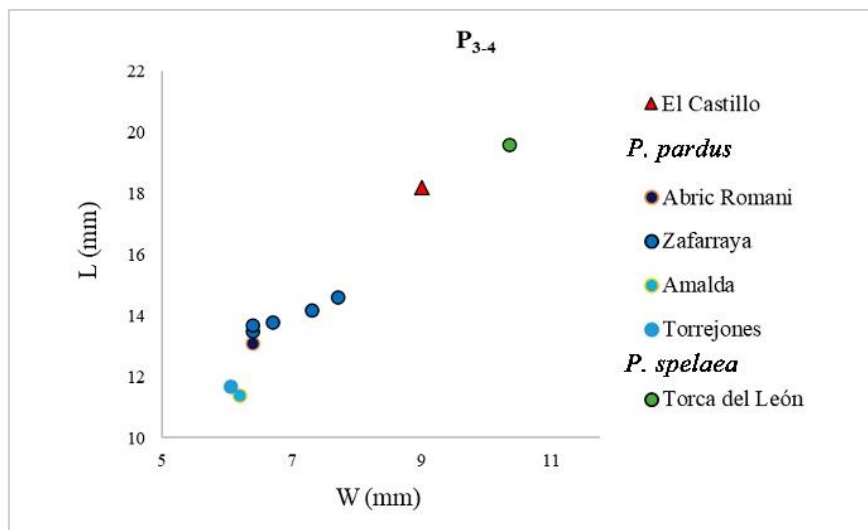
Supplementary Figure 6. Bivariate plots with the mesio-distal diameter (DMD), and bucco-lingual diameter (DBL) of leopard canines from El Castillo compared with Iberian *Panthera pardus* and *Panthera spelaea* from Late Pleistocene (Cáceres et al., 1993; Barroso et al., 2006; Sauqué and Cuenca-Bescós, 2013; Sanchis et al., 2015; Alvarez-Lao et al., 2020) (metric raw data in **SI5**).



Supplementary Figure 7. Bivariate plot with the length (L) and width (W) of lower M₁ of leopard from El Castillo compared with Iberian *Panthera pardus* and *Panthera spelaea* from Late Pleistocene (Cáceres et al., 1993; Barroso et al., 2006; Sauqué and Cuenca-Bescós, 2013; Sauqué et al., 2014; Sanchis et al., 2015; Alvarez-Lao et al., 2020; Sala et al., 2021) (metric raw data in SI5).

Panthera cf. spelaea Goldfuss, 1810

A lower P₃₋₄ shows the typical morphology of a large felid and has a large size, clearly separated from leopards and close to a cave lion from a close paleontological site (Supplementary Figure 8). Therefore, this specimen has been proposed as *Panthera cf. spelaea*, a species not previously identified at this level by Castaños (2018)



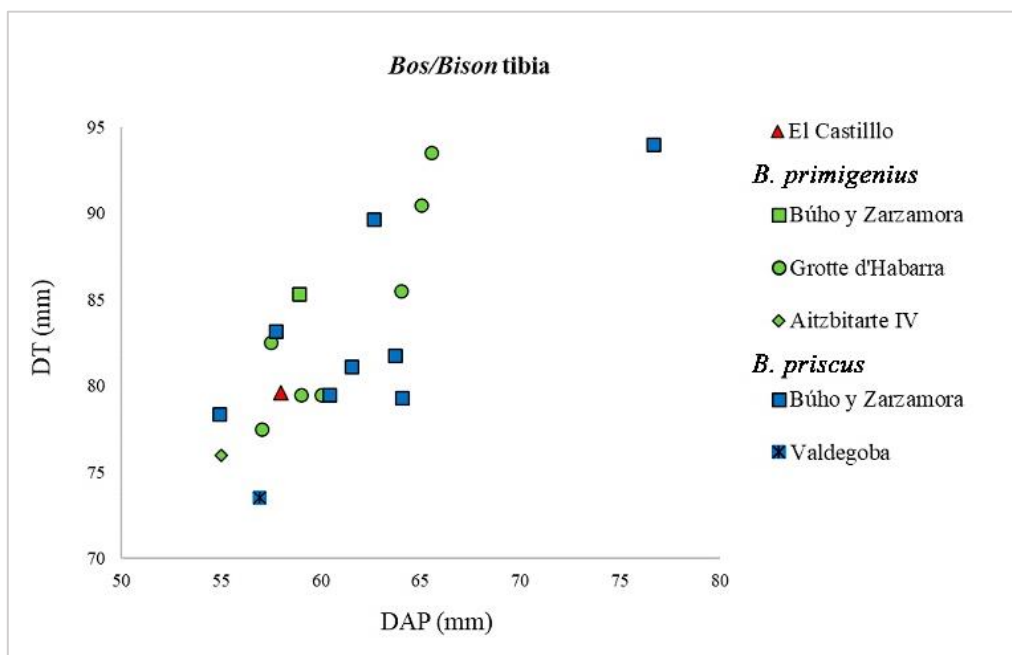
Supplementary Figure 8. Bivariate plot with the length (L) and width (W) of lower P₃₋₄ of *Panthera cf. spelaea* from El Castillo compared with Iberian *Panthera pardus* and *Panthera spelaea* from Late Pleistocene (Cáceres et al., 1993; Barroso et al., 2006; Sanchis et al., 2015; Alvarez-Lao et al., 2020; Sala et al., 2021) (metric raw data in SI6).

2. Order Artiodactyla Owen, 1848

2.1. Family Bovidae Gray, 1821

Bos primigenius Bojanus, 1825 and *Bison priscus* Bojanus, 1825

Distinguishing between the genus *Bos* and *Bison* is sometimes not easy because the anatomical differences among bovines are limited and the metric data usually might have a substantial overlap. In this work, it has been possible to identify the species *Bos primigenius* from the distal epiphysis of a tibia. Although the measurements taken in the epiphysis do not contribute to the differentiation between *Bos* and *Bison* (**Supplementary Figure 9**), the morphology is diagnostic. This specimen has the two articular facets for the malleolus together, typical of *Bos primigenius*, while in *Bison priscus*, they appear separated and isolated (Buitrago, 1992; Gee, 1993; Sala et al., 2010). The remains recovered in El Castillo could not be identified to species level, being grouped as *Bos/Bison* sp.



Supplementary Figure 9. Bivariate plot with the transversal diameter (DT) and antero-posterior diameter (DAP) of the distal epiphysis of *Bos primigenius* tibia from El Castillo compared with Spanish and European *Bos primigenius* and *Bison priscus* from Late Pleistocene (Prat et al., 2003; Sala et al., 2010; Arceredillo et al., 2016) (metric raw data in SI7).

Rupicapra rupicapra Linnaeus, 1758

One individual of *R. rupicapra* has been identified at El Castillo, which is only represented by the postcranial skeleton.

2.2. Family Cervidae Goldfuss, 1820

Cervus elaphus Linnaeus, 1758

A minimum of four individuals of *C. elaphus* have been identified. Following the morphological criteria for distinguishing between *Cervus* and *Dama* (Lister, 1996) and considering that fallow deer has not been documented in the Cantabrian region during this period, the presence of *Dama dama* in El Castillo has been ruled out. Although the presence of reindeer has been documented in some sites in Northern Iberia, neither the morphology nor the size of the specimens studied suggest their presence in El Castillo.

2.3. Family Suidae Gray, 1821

Sus scrofa Linnaeus, 1758

The sample comprises only two teeth, which show a typical morphology and size of *S. scrofa*.

3. Order Perissodactyla Owen, 1848

3.1. Family Equidae Gray, 1821

Equus ferus Linnaeus, 1758

Generally, the differentiation between *Equus ferus* and *Equus hydruntinus* is defined by a combination of metric (typically, *E. hydruntinus* is smaller than *E. ferus*) and morphological criteria. However, this differentiation is complicated and controversial due to the high morphometric variability between species and an overlap in the measurements. The equid remains of El Castillo are large in size and show a morphology associated with the caballine line (Eisenmann et al., 1988; Sanz-Royo et al., 2020). In addition, a third phalanx has been compared with the one recovered at Los Rincones sites, belonging to an *E. hydruntinus*, and it has been concluded that the El Castillo specimen is more similar to *E. ferus*. This, together with the absence (to date) of *E. hydruntinus* in the Cantabrian region, suggests that the equid remains from El Castillo correspond to *E. ferus*.

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