Title

The Châtelperronian Neandertals of Cova Foradada (Calafell, Spain) used Iberian Imperial Eagle phalanges for symbolic purposes

The necklace of the last Neandertal

Authors

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Abstract

The use of personal ornaments by Neandertals is one of the scarce evidence of their symbolic behaviour. Among them stand up the eagle talons used presumably as pendants, in an analogous way than anatomically Modern Humans (*Homo sapiens*) did. Considering the broad range and time scale of Neandertals distribution across Eurasia, this phenomenon seems to be concentrated in a very specific area of Southwestern-Mediterranean Europe during a span of *ca.* 80 ka. Here we present the analysis of one pedal phalange of a large eagle recovered in Foradada cave site, Spain. Our research confirms the use of eagle talons as symbolic elements in Iberia, expanding geographically and temporally one of the most common evidence of symbolic behaviour among western European Neandertals. The convergence in use of large raptor talons as symbolic elements by one of the last Neandertal populations raises the survival of some cultural elements of the Middle Paleolithic into beginnings of the Upper Paleolithic.

Introduction

Personal ornaments (PO) such as beads and pendants have traditionally been recognized such as a direct evidence of symbolic behavior and their confection and use have been related with the emergence of "behavioural modernity" (*1-3*). By analogy, the projection of its current ethnographic meaning, has led specialists to interpret Paleolithic PO as conveyors of social identity (*4-6*). The current paradigm indicates long-lasting and widespread bead working tradition (of marine shells, although other materials are used too) emerged in Africa and the Levant among anatomically Modern Humans (AMH) (100-75 ka) well before their arrival in Europe (*7*). Probably later (50-37 ka) this expression appear among western European Neandertals independently or by acculturation (*2, 8, 9*), being particularly relevant for the historiography the ensembles from the Châtelperronian (CP) layers in Grotte du Renne (Arcy-sur-Cure) and La Grande Roche de la Plématrie (Quinçay) (*10-13*). On this paradigm, a recent investigation in Cueva de los Aviones (Spain) proposes the use of marine shells such as beads and pigment containers by Iberian Neandertals as early as 115 ka, predating any AMH expression of symbolism in Eurasia (*14*). This finding together with the new dates for some rock art motives in three Spanish caves (*15*) have generated a profound shake regarding to the origin of symbolic behavior and cultural modernity.

Focusing on the Neandertal techno-cultural traditions (Middle Paleolithic, MP or "Transitional", TA Middle to Upper Paleolithic, UP, techno-complexes,), other more controversial evidences of symbolism such as abstract engraving, body-painting, use of feathers, funerary practices and grave goods have been claimed historically as evidences of their symbolic complexity, but the debate continues (*3, 16-23*). Apart from these, the use of raptor talons as bead-like objects seems to be the most widespread evidence of symbolism among the European context. At least 23 large raptor phalanges from 10 sites dated between ~130 to 44.5 ka, shows traces of manipulation in the form of cut marks (table S1). The main arguments supporting the symbolic nature of this elements are: 1) the anatomical distribution of cut marks, positively contrasted by actualistic experiments, 2) the scant or null attractive of bird feet as food, 3) the rarity of large raptors in ecosystems (namely their anthropogenic selection), 4) the established analogy with other cut-marked phalanges and claws from UP contexts, and 5) the ethnographic analogy (*24-32*).

The lack of formal criticism on the interpretation indicates that the hypothesis of large raptor's pedal phalanges modified by Neandertals to be used as body ornaments is plausible. Considering the large range and time scale of Neandertals distribution across Eurasia, this phenomenon seems to be concentrated in a very specific area of Western Europe (fig.1). Nevertheless, the relative novelty of the discovery of this symbolic expression among pre-AMH makes necessary more investigation. With this aim, here we present a new case of large raptor pedal phalange associated to a Neandertal CP context contributing to expand our knowledge about the significance and limits of this kind of evidence in the emergence of behavioural modernity.

Results

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Site stratigraphy, chronology and archeological record

Cova Foradada is a small karstic corridor 1.8 km far from the actual shoreline in the Mediterranean coastline of NE Spain (Fig. 1 and Fig. 2A). The morphology of the cave is defined by a circular entrance yielding direct access to the "excavation room" of *ca*. 14 m^2.The stratigraphy uncovered consisting in a 2.5 m section provided eight archaeological horizons with evidences of cave's human frequentation from the mid-Holocene to the Upper Pleistocene. Units II & II corresponds to the Holocene. The middle part of the sequence corresponds to the litho-stratigraphic Unit III, formed by three different archaeological layers. Layer III-n formed during the Early Gravettian, the almost sterile layer III-g and the layer III-c corresponding to the Early Aurignacian. The basal part of the stratigraphy corresponds to the Unit IV with layers IV, IV.1 and IV.2 providing Châtelperronian occupational evidences. Underneath these layers an almost archeologically sterile Layer V has been also documented in contact with a thick basal flowstone supposing now the base of the cave's stratigraphy (Fig. 2B).

The archaeological pattern shared by layers III-n, III-c and IV suggest that the cave was only occasionally occupied by human groups, leaving back a very scarce archaeological record formed mainly by shell ornaments in Layer III-n, and hunting-related tools in both Layer III-c and Layer IV. Fortunately, the lithics remains recovered from layers III-c and IV are typologically diagnostic and, besides chronology, useful indicators to attribute occupations to cultural complexes (Fig. 2B, 2C and Supplementary Materials Text1).

Layer IV provided a small lithic assemblage highlighting the almost exclusive presence of Châtelperronian points (Fig. 2C). This represents the southernmost European expression of this tool class exclusively related with the Châtelperronian culture (*33*), definitely associated with the Neandertals (*13*, *34*). Currently, the radiocarbon evidence place the occupations of Unit IV sometime before 39 kyr cal BP. The faunal assemblage of this layer is composed by 795 identified specimens (NISP), dominated by leporids, Iberian lynx remains and small birds (table S2). Twelve elements correspond to medium and large-sized raptors, mainly Spanish imperial eagle (cf. *Aquila adalberti*) (table 1). Bone surface modification (BSM) analysis indicate virtually non- anthropogenic intervention except for 35 burned bones (0.2% of the number of specimens, NSP) and the Spanish imperial eagle cut-marked phalange object of this study.

The specimen FO15/IV.2/E6/1339

The specimen FO15/IV.2/E6/1339 (Fig. 3) corresponds to a phalanx II of the toe 1 (the thumb) from the left foot of a large eagle. The general morphology of the phalanx is stylized and svelte as in the genus *Aquila* and different to the more robust morphology of Aegypiinae (sub-family of vultures) and *Haliaeetus* (genus including white-tailed eagle). The dorsal surface of the body is deeper than in vultures and present well-marked attachment to fibrous sheaths of flexor tendons. The distal condyles and the groove between them are very marked as in the genus *Aquila*. General morphology, proportions, PCA results as well as the past and extant Pleistocene distribution of large eagles in the Mediterranean Basin (*35-37*), makes *Aquila adalberti* the most plausible taxon (Fig. 4).

The phalange presents 12 cut marks in the dorsal side of diaphysis along of the two-thirds of the total length of the phalanx (Figs. 3 and 5). Most of the cuts (n=11) are oriented obliquely to the principal axis of the bone, from the proximal epiphysis to distal extreme and the striae are parallel among them. All these oblique cuts are deep and show composed striae, where shoulder effect, as deep as the principal groove and double groove, similar to those produced by retouched stone tools (*38*), can be recognized. One more cut mark is obliquely orientated with the longitudinal tendency. This last mark is more superficial than the previous ones and is superimposed on them. The 12 incisions observed present an average length of 3.678mm and width of 0.234mm. As can be seen in Table S3, a general increase in the opening angle of each groove can be observed while a similar pattern is

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observed through a decrease in depth of each profile along the groove. This variation, however, is relatively subtle and gradual, most likely explained by the physical properties and pressure exerted when making an incision (*39*). The homogeneity of the groove's shape, however, is clearly represented by the cross-section morphology and its development along the course of the incision. Procrustes analysis, indicates that all these marks present an asymmetrical V shaped cross section (Fig. 5A). This particular feature is one of the key characteristics described by multiple authors when diagnosing a taphonomic trace as a cut mark (*38, 40, 41*). Considering only the shape profile, these taphonomic traces are clearly comparable with cut mark samples studied by a great deal of taphonomist (*42-47*) as opposed to the morphology of other linear traces such as tooth scores (*48*). 3-Dimensional analysis (Fig. 5B), indicates that depth and shape of the linear marks are clearly more pronounced than what would be expected of a trampling mark, for example. Combined with a clear lack of a rounded base, as well as other features, this also rules out the possibility that these marks can be confused as a product of other natural agents (*49*), carnivores (*50, 51*), humans (*52, 53*) or even herbivores (*54, 55*). While these marks are associated to some other taphonomic alterations such as biochemical BSM, they do not prevent the morphological study of these traces to a degree where equifinality is overly present (*56*). Mark location and depth agree with experimental works of Romandini et al. (*30*) relating the striae with the disarticulation of the claw and the entire digit from the tarsometatarsus (*30*). Apart from FO15/IV.2/E6/1339, no specimens of the eagle nor other raptor remains show anthropic modifications, although it should be noted that all the remains of *A. adalberti* are from the legs, and only one talon has been recovered, while these are abundant among small birds skeletal representation (Supplementary Materials Text 2).

Discussion

The exploitation of birds as alimentary and non-alimentary resource has been proven through several zooarcheological investigations suggesting that bird trapping was part of the behavioural variability of the Neandertals (*18, 57-60*). Although not usual, the consumption of raptors among hunter-gatherers is confirmed by data from the ethnographic literature (*61*) and from archeological record, including Neandertal sites (*26, 62, 63*). Non-alimentary use is exclusively related to the symbolic sphere (*18*) and never the use of bird parts as raw material for performing domestic tools has been proved. In the case of talons, its non-edibility has been exhibited as a negative evidence of their alimentary character and, in consequence as a positive indication of their symbolic use by Neandertals (*26, 30*). Nevertheless, although it's obvious that eat talons don't seem a good idea, the edibility of the raptor's feet understood as the skin and cartilaginous tissues, it's just a matter of cooking and taste as a lot of current Spanish, Latin-American and Oriental recipes demonstrates. Cut marks only reflect anthropogenic manipulation, so the butcher can leave traces in the phalanges precisely during the removal of the non- inedible parts (*64*). The present study demonstrates how a combination of traditional and fresh methodological approaches in cut mark analysis can be a powerful tool when classifying BSM. Our results lean strongly towards the classification of the marks on FO15/IV.2/E6/1339 as cut marks. Their presence is fundamental and usually the unique evidence on which the hypothesis of manipulation of these elements by ancient humans is constructed. For this reason, the combination of old and new methods and tools in BSM analysis is unavoidable when the existence or marks leads to relevant evolutionary hypothesis. Besides, we strongly agree with the interpretation of that cut-marks as the result of the talon extraction or claw sheath removal, independently of the phalanx in which traces are (*26, 29-31, 65-67*), especially because these interpretations are fully supported by neo-taphonomical experiments (*30, 68*). The additional arguments leading us to discard the alimentary nature of this phenomenon in Foradada are: 1) the scarcity of raptor remains in the assemblage, namely the selection of the species for anthropogenic handling, 2) the high anatomical bias in favor of phalanges, namely selection of anatomical parts, and 3) the absence of other BSM related with anthropogenic consumption such as

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human chewing, green breakage, burning or cooking signals in raptor bones and in the whole faunal assemblage.

Cut marks never was found in pedal phalanges of other birds than raptors except for the case of Baume Gigny (*28*), neither in claws of large carnivores which could be common if they were used as tools. This exceptionality reinforces their use as symbolic elements and suggest that Neandertals conferred similar symbolic connotations to large raptors than current traditional societies (*59*). Thus, the symbolic meaning of majestic eagles as large predators could be transmitted to some parts of their bodies as talons and feathers. However, although most of the archeological cases have been identified as large eagle's talons, other species are also represented, including vultures and eagle owl. Following the same logic, the talons of other species should convey other meanings due to, for both traditional and current societies, vulture and eagle can even represent opposing concepts. The same can be said for the swan from Baume Gigny due to the modest claw of a duck can hardly express the same symbolic message than a white-tailed eagle talon. Foradada increases the occurrence of the selection of large eagles to exploit their talons but increases the number of represented species too. Consequently, while some authors have proposed a symbolic meaning of the "ornamental talons" related to large eagles (*26*), or large diurnal raptors associated with scavenging habits (*59*, *67*), the increase in the variety of taxa documented suggests greater complexity in terms of the symbolic nature of these elements.

Finally, the archaeological parallels documented specially among hunter-gatherers of the late Pleistocene and Holocene, support the symbolic character of this type of elements (*32*, *67*, *69-71*). Faced with the same type of zooarcheological and taphonomic evidence, the interpretation of specimens as fully symbolic in context associated to AMH leaves little space for speculation when the same elements and evidences are found within Neandertals context, which applies to Foradada case. Curiously, manipulated talons are not very abundant among the UP assemblages until the end of UP (17/12 ka), being the cases documented during the early UP less frequent than in Neandertal contexts (*24*, *25*, *69*, *72*). Again it is applicable to Foradada, where no UP layer has provided anthropogenically modified raptor phalanges but abundant seashell beads, nor have they been recovered for the rest of the UP sites in the Iberian Mediterranean region or the entire Iberia, except for one snowy owl (*Bubo scandiacus*) talon from a Magdalenian context in Santa Catalina site, in Biscay (*25*). In addition to archeological parallels, the ethnographic data proves that different cultural groups of all continents have used the claws/talon of raptors for the elaboration of a great variety of elements associated with rituals, dances, personal adornment, grave goods, etc. (*73-76*). Only the National Eagle Repository (NER) (Colorado, USA), provides more than 600 eagle carcasses to American Nations each year for religious and cultural purposes. The most used parts are the feathers and legs (of the latter a good estimate is between 1200 and 1500 delivered every year) (Dennis Wiist, NER, Personal Communication). All carcasses belong to two species, Bald eagle (*Haliaeetus leucocephalus*) and Golden Eagle (*Aquila chrysaetos*), since they are the species that contain a high symbolic meaning for most of the Native American People.

Although researchers agree in the symbolic nature of talons, their definition as PO has been explored with prudence. Most have advocated defining the talons as "supposedly ornaments" while others after the accumulation of evidence opted to refer them directly as an example of Neandertal jewelry (*29*). Accepting the use of talons as PO, that tradition predates any other manifestation of symbolism among Neandertals or MN, especially those in which seashells play a central role (*14*). If not, this manifestation also entails important implications for the emergence of symbolism and behavioral modernity, although further investigation is necessary to establish what these objects might have been. Regardless of whether the talons were hanging "beads", part of necklaces, earrings or others for which there are no current parallels, Foradada case indicates that the use of talons as symbolic objects was a well-rooted tradition among the Neanderthals of Western Europe for more than 80 millennia, suggesting the presence of a common cultural territory. The case presented in this paper evidences the last occurrence of the use of talons among Neanderthals, immersed in a cultural

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moment in which other jewelry traditions, developed independently or not, are documented (*2*). This practice emerging in the early MP appears from time to time but recurrently in the Neandertal world surviving on one of the last expressions of their material culture, the Châtelperronian and probably extinguishing with them forever.

Materials and Methods

Excavation methods

The sediments of Cova Foradada were systematically excavated in extension according to an artificial subdivision of 1x1m squares and following the natural inclination of the geological layers. Regarding the faunal remains all ≥ 2 cm and all identifiable specimens regardless of size have been recovered and 3D positioned. Additionally, all the sediment previously recovered by square, layer, and relative depth (5 cm ranges), were water-sieved using superimposed 1, 0.5 and 0.05 mm mesh screens and bagged. Then, microfossils were sorted and classified.

Zooarcheological and Taphonomical methods

Anatomical and taxonomic determination of mammalian and bird remains has been done in the Zooarchaeology and Taphonomy Laboratory of the IPHES. Avian reference collection at Nat-Museu de Ciències Naturals de Barcelona in Barcelona, Muséum National d´Histoire Naturelle in Paris, Laboratório de Arqueociências - LARC-DGPC in Lisbon and Estación Biológica de Doñana in Sevilla were used for comparative purpose. The osteological measurements have been taken by digital caliper with two decimal places in the anatomical points specified in the Figure 4.
Bone surfaces of all faunal remains were inspected macroscopically and microscopically with a stereomicroscope OPTHEC 120 Hz model, using magnifications from 15x to 45x.
Cut marks and its relationship with specific butchering activities were identified based on the criteria of Potts and Shipman (*77*), Shipman and Rose (*78*), Domínguez-Rodrigo et al. (*38*) and Romandini et al. (*30*). Additionally, each of the marks was digitalized using a HIROX KH-8700 3D Digital Microscope with a MXG-5000REZ triple objective revolving lens. Firstly, cross-sections of each mark were produced using the mid-range lens at a 600x magnification. A fixed high intensity LED light source was placed above each sample, combining the use of coaxial and ring illumination. 3D digital reconstructions were produced using a combination of quick auto focus and depth synthesis functions that are provided by the HIROX's system, generating a 3D display of each mark where measurements could be taken and cross-section profiles extracted. In order to construct each digital image, between 110 and 130 photos were taken for each profile. The capturing and assessment of the morphology of each mark's profile was carried out using a total of three cross sections, taken at 30, 50 and 70 percent of the total length of each mark. As described by Maté-González et al. (*45*), this particular range along the groove is suggested to be the most representative for cut mark morphological analysis.
These profiles were then exported to the free tpsDig2 (v.2.1.7) software where the allocation of seven homologous landmarks was carried out following the geometric morphometric models described by Maté-González et al. (*45*). The resulting files produced through landmark allocation were then edited and imported into the free software R (www.rproject.org, (*79*)) where a full Procrustes fit was performed using the Geomorph library (*80, 81*). This package can be used to prepare the sample for multivariate statistical analysis and is commonly referred to as a generalized Procrustes analysis (GPA). Through GPA each individual is standardized through a series of superimposition procedures involving the translation, rotation and scaling of each shape. Any differences in structure can thus be studied through patterns of variation and covariation which can then be statistically assessed (*82, 83*). The library Shapes (*84*) is then used to calculate and plot the mean shape of each cross section. Additional measurements concerning the depth and opening angle of each of the profiles were later taken. In order to capture the entire shape of these incisions, a

further digital reconstruction was carried out on the entire mark using the low-range lens at 100x or 150x magnification, depending on the necessities of the analyst with regards to resolution. In order to capture the entire length of each mark, the HIROX's tiling function was used to create a mosaic and complete digital reconstruction of each groove. 30 photos were taken for each tile while any number between 15 and 32 tiles were used to create the final image. With the use of a high pixel resolution as well as the consequential stacking of photos produced by the microscope, the entire shape of the taphonomic trace could be reproduced digitally. A 13 landmark model, as developed by Courtenay et al. (*85*), was then used to capture the entire shape of the groove. The position of each landmark was recorded through a series of measurements. This was done first using the 'XY-width' function to measure and plot the location of each landmark across a 2-Dimensional graph, followed by the measurement of depth using the 'point height' function in order to establish each landmarks position along the Z-axis of a 3-Dimensonal plot. Landmark coordinates were recorded and processed in the same manner as the 2D profiles.

H2: Supplementary Materials

Introduction

Table S.1. Neandertal sites and layers with cut-marked raptor phalanges interpreted as symbolic elements. CP: Châtelperronian; CM: Classic Mousterian; L: Levallois; MP: Middle Paleolithic; M: Mousterian; MTA: Mousterian of Acheulean Tradition; N: Neronian; N/A: Not applicable/ Unknown.*The case of Baume de Gigny correspond to a swan

Results

Table S2. NISP, % and Minimal Number of Individuals (NMI) for the Unit IV faunal assemblage at Cova Foradada

Table S3. Average measurements of the opening angle and depth of incision profiles at 30%, 50% and 70% of the grooves total length

Data S1. 3D microCT model of the **FO15/IV.2/E6/1339**

Text S.1. Stratigraphy, chronology and archeology of Cova Foradada

Text S.2. Taphonomic analysis of avian remains

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Figures and Tables

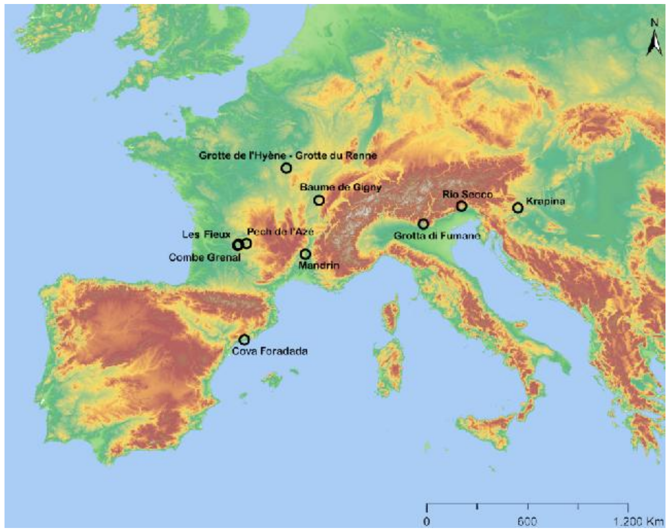

Fig. 1. Neandertal sites with cut-marked raptor phalanges. The figure legend should begin with a title (an overall description of the figure, in boldface) followed by additional text. Each legend should be placed immediately after its corresponding figure.

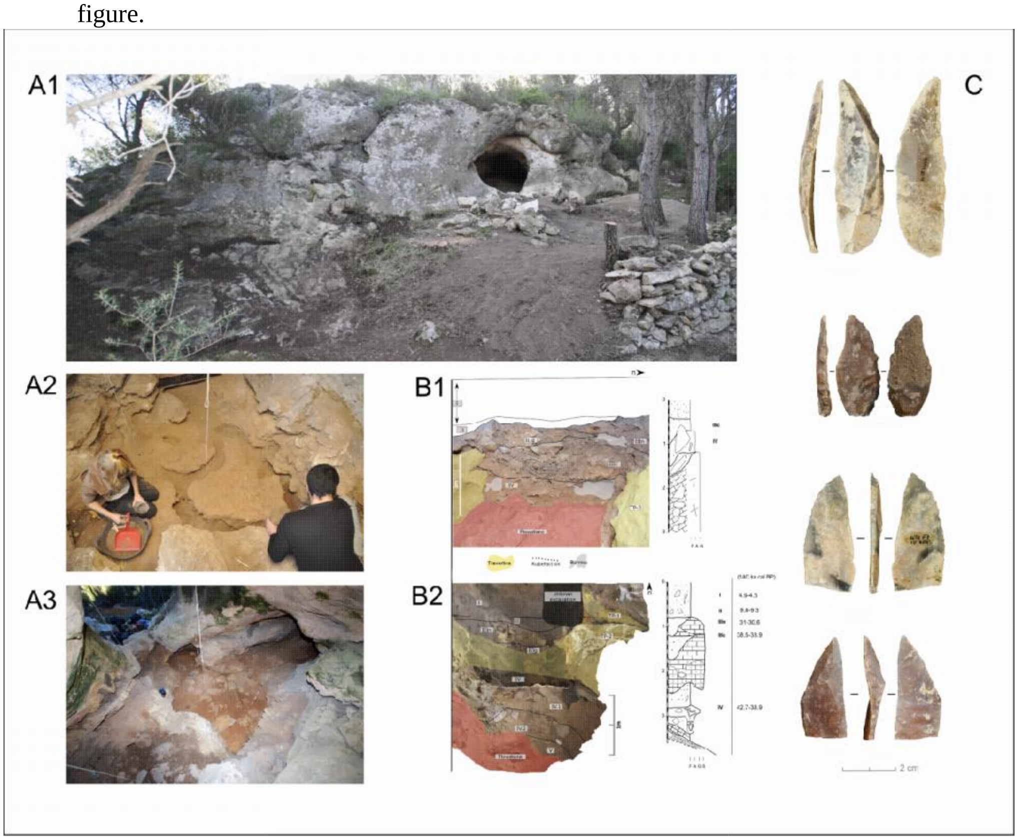

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Fig. 2. Cova Foradada site location and context. Diverse views of Cova Foradada site (**A**), from the exterior of the cave (A1), and in different moments of the excavation in the main room (A2, A3). Stratigraphic profiles and synthetic stratigraphic lithological column with archeological layers and chronology in 14C ka cal BP (**B**), West profile (B1), and North Profile (B2), Legend of the Lithology of the vertical profile: F, mud; A, sand; G, fine gravels; S, flowstone. Symbols of the column: 1, mud; 2, sand; 3, fine gravels; 4, plain gravels (desquamations); 5 blocks; 6, calcarenite (cemented calcite sands); 7, calcilutite and marl (carbonated mud); 8, black impregnations; 9, lamination; 10, traces of bioturbation (roots casts); 11, organic-mineral mud; 12, massive. Examples of Châtelperronian Points **(C)**.

Fig. 3. FO15/IV.2/E6/1339 specimen. Four anatomical views of the phalange from left to right, dorsal, medial, plantar and lateral (**A**), detail of the cut marks in the plantar view and doted-line squares with the area amplified in the pictures C and D (**B**), Detail of cut marks (**C**), Detail of cut marks (**D**).

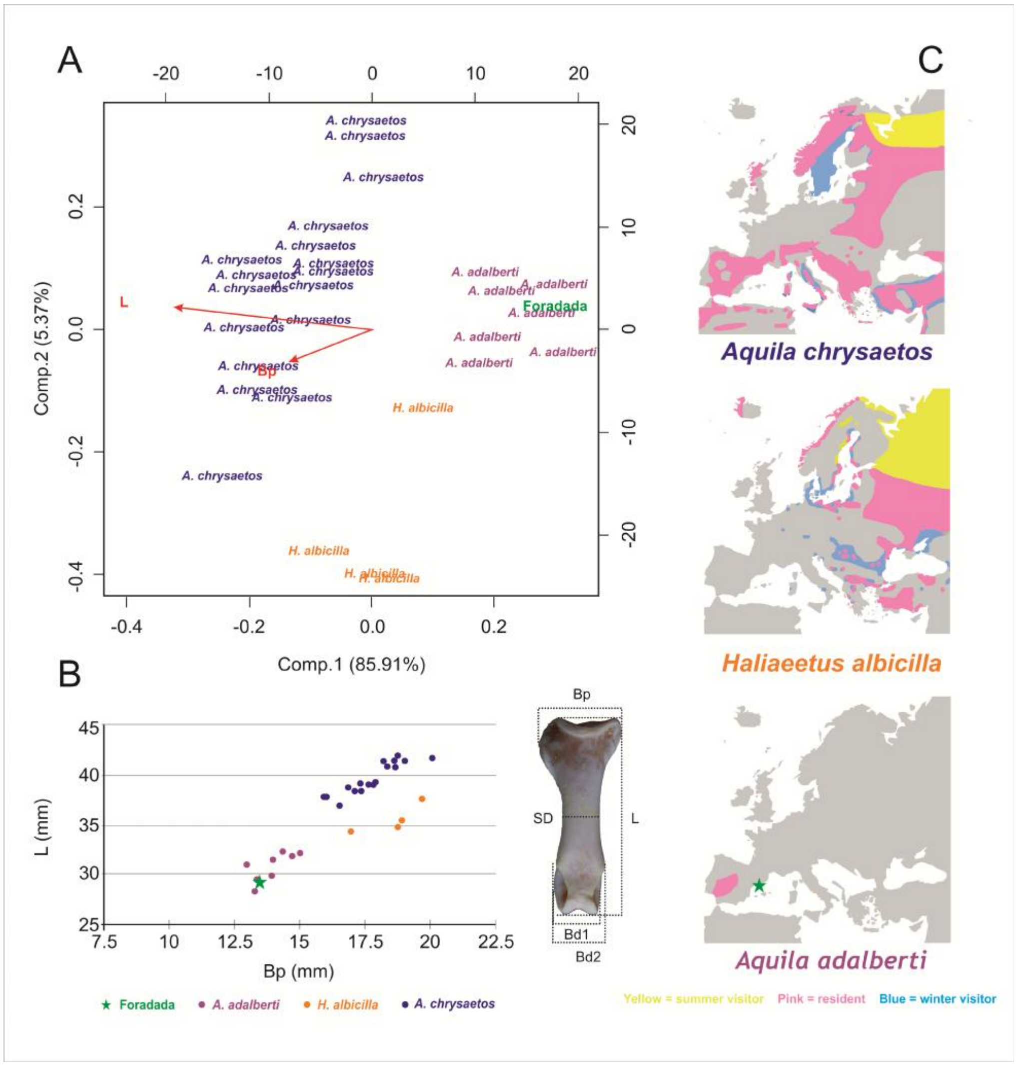

Fig. 4. Data supporting species identification. PCA comparative analysis of six measurements of 1st phalanges of the toe II from different species of large eagles documented in the Iberian Pleistocene Fossil Record (**A**), Diagram with comparative measurements of the two measurements of 1st phalanges of the toe II from different species of large eagles documented in the Iberian Pleistocene Fossil Record (**B**), Current distribution of the three large eagles documented in the iberian fossil record.

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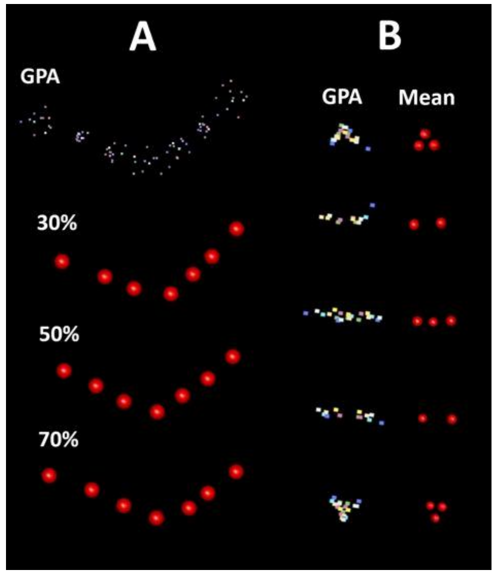

Fig. 5. Analysis of Cut Mark Morphology through the HIROX KH-8700 3D Digital Microscope. (A) 2D GPA and Mean Shape of cut mark cross-section profiles across 30%, 50% and 70% of each incision. (B) 3D GPA and Mean Shape of entire incision.

ID	Layer	Element	Side	Taxon	Common Name	BSM
fo14/IV.1/F8/2864	IV.1	Phalange II Toe 2	R	cf. *Aquila adalberti*	Spanish Imperial eagle	-
fo14/IV.1/F8/2862	IV.1	Phalange II Toe 2	L	cf. *Aquila adalberti*	Spanish Imperial eagle	-
fo14/IV.1cau/F8/3129	IV.1	Phalange II Toe 1	-	Accipitridae cf. *Aquila* sp.	-	Broken
fo15/IV.2/E6/1339	IV.2	Phalange II Toe 1	L	cf. *Aquila adalberti*	Spanish Imperial eagle	CM
fo15/IV.2inf/D7/sn	IV.2	Ulna	R	Accipitridae cf. *Milvus milvus*	cf. Red kite	Broken
fo14/IV/F8/2848+3453	IV	Tarsometatarsus	R	cf. *Aquila adalberti*	Spanish Imperial eagle	Broken-Dg
fo15/IV/G8/sn	IV	Phalange II Toe 2	L	cf. *Aquila adalberti*	Spanish Imperial eagle	-
fo14/IV/F9/1971	IV	Talon	-	Accipitridae sp.	-	-
fo14/Ib-IV/F6/306+307	IV	Tibiotarsus	R	cf. *Aquila adalberti*	Spanish Imperial eagle	Broken-Dg
fo15/IVcau/D7/sn	IV	Humerus	L	Accipitridae cf. *Milvus milvus*	cf. Red kite	Broken-Dg
fo14/IV/D8/1018	IV	Phalange II Toe 3	R	*Gyps fulvus*	Griffon vulture	-
fo15/IV/E6/Criba/	IV	Phalange	-	Accipitridae cf. *Accipiter* sp.	-	-

Table 1. Raptor remains from the Unit IV of Cova Foradada. ID is the unique identification number of each specimen, bone surface modifications (BMS). Cut marks (CM), diagenetic (Dg).

Supplementary Materials

Table S1
Table S2
Table S3
Data files S1 to S#
Text S1
Text S2

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