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Insights into neanderthal bird hunting practices during MIS5-3: Taphonomical analysis of avian remains from Valdegoba cave (Burgos, Spain)

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A B S T R A C T

Small-prey exploitation has been considered an important component of socio-economic development of past human groups. Consequently, several studies have set the focus on taphonomical analysis of small animals such as birds or leporids. Nevertheless, human groups are not the only agents that can produce bone accumulations, as archaeological assemblages can also be the result of non-human predators and natural phenomena. For this reason, it is essential to determine the taphonomical pattern of each potential accumulator, with the aim of identifying their inputs. This work presents the first taphonomical analysis of an avian sample from Valdegoba Cave. The assemblage shows a mixed origin of both human and non-human (probably a nocturnal bird of prey) predator contributions. Clear evidence of human processing – such as the presence of cut marks – demonstrates intentional bird processing. Neanderthal groups from Valdegoba therefore show a broad spectrum diet, from large herbivores to small animals. These findings position Valdegoba cave as a unique Mousterian site in the region, thereby expanding the understanding of Neanderthal behaviour and small-prey use.

1. Introduction

The way in which Neanderthals hunted and processed their prey has constituted a focal point in the investigation of their behavioural patterns. The variability of bioclimatic factors is considered a relevant issue to explain variability in human behaviour and subsistence strategies (Carrión et al., 2018; Ochando et al., 2022; Albouy et al., 2024). There is ample proof of big game consumption by neanderthal groups (e.g. Stiner, 1995; Gaudzinski and Roebroeks, 2000; Richards and Trinkaus, 2009; Smith, 2015; Blasco and Peris, 2021; Gaudzinski-Windheuser et al., 2023). In general, large herbivores have been considered to be more profitable, as their return of calories is higher than that of smaller prey (Stiner et al., 2000). Nevertheless, several studies have focused on the analysis of small prey (Speth and Tchernov, 2002; Blasco and Peris, 2009, 2012; Cochard et al., 2012; Hardy et al., 2013; Rufà et al., 2014; Nabais and Zilhão, 2019; Blasco et al., 2016a, 2016b; Morin et al., 2019; Blasco et al., 2022). There is, however, still a need for a well-established corpus of knowledge. The exploitation of avian resources in particular, is a promising field of study to shed light on Neanderthal ecological interactions.

The oldest evidence of bird processing by human groups can be found at TE9 level from the Sima del Elefante site (Atapuerca, Spain), with a dating of 1.2 million years (Ma) (Huguet et al., 2013). Except other Early Pleistocene isolated findings (Güleç et al., 2009), a systematic bird hunting is well-established from the Middle Palaeolithic (Blasco and Peris, 2009; Peresani et al., 2011; Finlayson et al., 2012; Blasco et al., 2013; Fiore et al., 2016; Martínez-Valle et al., 2016; Gómez-Olivencia et al., 2018). However, bird-use by human groups can sometimes be difficult to identify at archaeological sites, as cut-marks are usually rare – although not absent (e.g., Ripoll, 2001) – in small-prey bones. Their small size made it easy to process their bones using teeth or hands, and tools were not always necessary (Romero et al., 2016; Val et al., 2016). For this reason, it is essential to recognise other taphonomic traits such as tooth-marks, burnt bones, or fractures produced by flexion (Finlayson et al., 2012; Fiore et al., 2016) which, together with the presence of cut-marks, would indicate human processing.

Recent neo-taphonomic studies have valued the role of birds in Neanderthal diets (e.g., Nabais et al., 2024). Moreover, birds were hunted not only for nutritional purposes, elements like feathers and claws could also have been utilised (Peresani et al., 2011; Finlayson et al., 2012; Morin and Laroulandie, 2012; Romandini et al., 2014; Radovčić et al., 2015; Blasco and Peresani, 2016; Negro et al., 2016; Majkić et al., 2017; Blasco et al., 2019; Rodríguez-Hidalgo et al., 2019). Although small animal bones in archaeological sites can be attributed to

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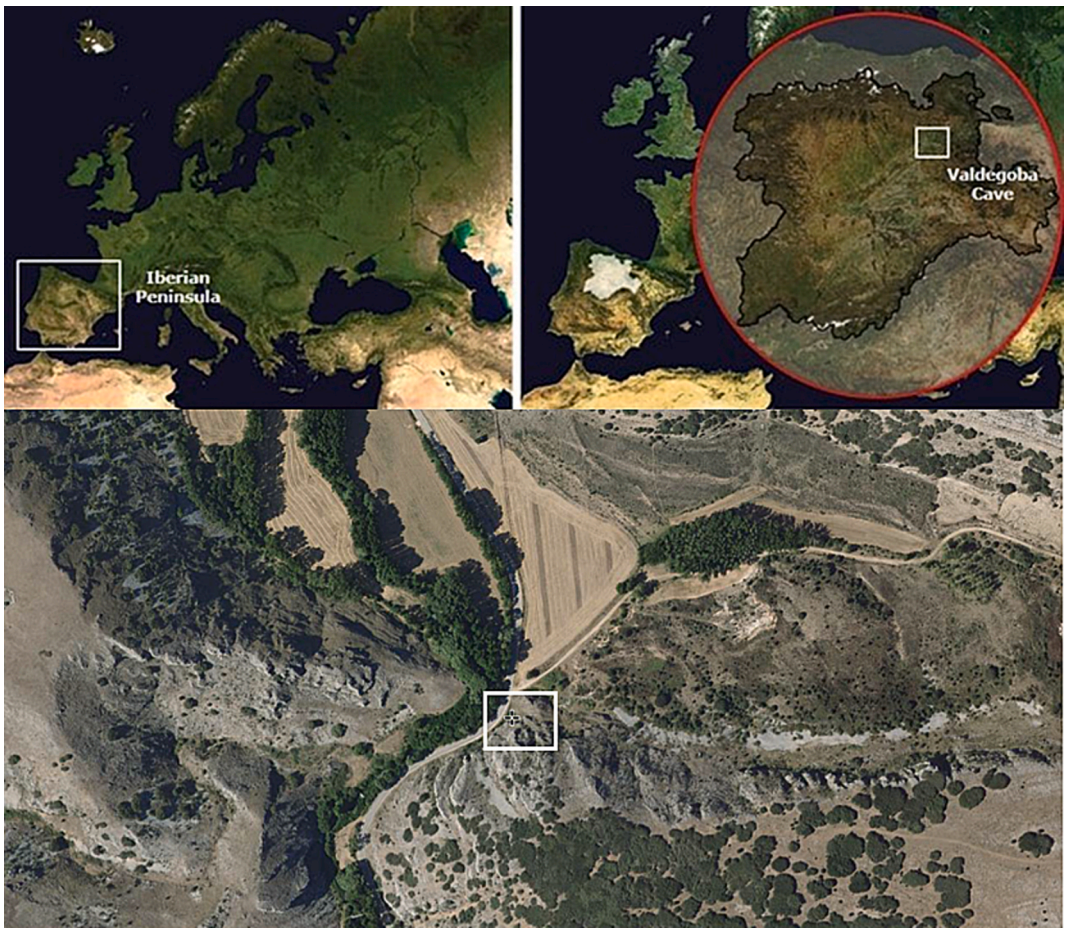

Fig. 1. Location of Valdegoba cave (modified from Rodríguez-Gómez et al., 2022).

human groups, other predators such as birds of prey (Bochenski et al., 1993; Bochenski and Tomek, 1994; Bochenski, 1997; Bochenski et al., 1999; Laroulandie, 2002; Bochenski, 2005; De Cupere et al., 2009; Bochenski et al., 2009; Lloveras et al., 2014a, 2014b; Royer et al., 2019; Rufà and Laroulandie, 2019; Alonso et al., 2020; Marqueta et al., 2023) and mammalian carnivores (Mallye et al., 2008; Rodríguez-Hidalgo et al., 2016; Rufà and Laroulandie, 2020) may have also contributed to the formation of avian assemblages.

Post-depositional processes could alter previous modifications of bones, hindering the correct interpretation of the archaeological assemblage. It is therefore clear that archaeological assemblages show mixed contributions by numerous agents. For this reason, the study of anthropogenic accumulations is sometimes difficult to tackle, as they are usually the result of different overlapping activities and occupation events. The capture of quick-flying game could imply the use of sophisticated technology such as traps or snares (Blanco et al., 2021), which would be an indicator of the complexity of Neanderthal groups. Based on the above, it can be stated that birds played an important role in Neanderthal behaviour and subsistence strategies, as previously proposed by Laroulandie (2010). It is therefore essential to identify

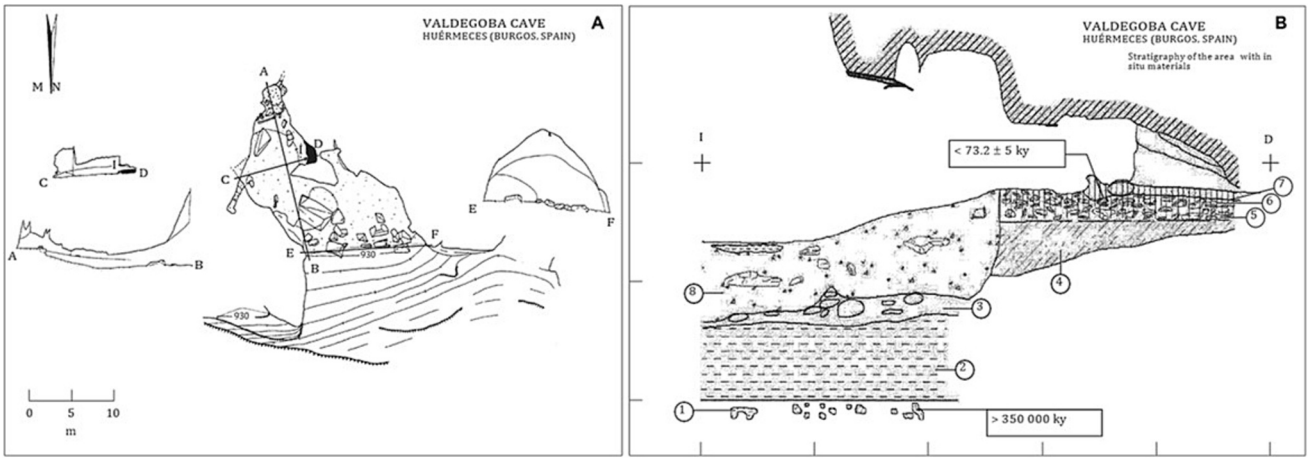

Fig. 2. Cross-sections (A) and the stratigraphic profile of the excavated area (B) of Valdegoba cave (modified from Quam et al., 2001).

characteristic taphonomic patterns that facilitate the recognition of anthropogenic and non-anthropogenic manipulation of small prey bones. In this paper the results of the analysis of an avian assemblage from Valdegoba cave are presented with the aim of shedding light on the interactions between Neanderthals and other predators.

2. Materials and methods

2.1. Study area: Valdegoba

Valdegoba is a set of three cavities located in the north of the Iberian Peninsula (42° 32′ 30 " N, 0° 05′ 10″ W), 28 km northwest of Burgos city (see Fig. 1). It is situated at an altitude of 930 m, 35 m above the current course of the Urbel River (Díez et al., 1989; Terradillos-Bernal and Díez, 2018). The cave and its contents were already known by the local people, but its importance was not recognised until 1980. In 1986, it was decided to apply for an excavation permit in order to avoid repeated looting of the cave (Díez et al., 1989). The archaeological deposit from the central cavity was excavated between 1987 and 1991, and again in 2006 (Díez et al., 1989; Díez et al. 2014). All the sediments were water-screened in the Urbel River using meshes of various sizes (0.1 mm, 0.2 mm and 0.5 mm). The site was occupied by Neanderthal groups between Marine Isotope Stages 5c and 3. The environment was classified as mixed, with rocky areas, mountain and deciduous forests, and open areas (Feranec et al., 2010; Díez et al., 2014).

The Valdegoba karstic system is located on the southern edge of the Cantabrian Mountain range, on top of a Turonian (upper Cretaceous) calcareous outcrop. Of the three caves that form the system, the central cavity is the one containing the archaeological site. This cavity is filled with clay materials and scattered blocks. The stratigraphic sequence (see Fig. 2) was defined from the study of the four archaeological test pits carried out (Díez et al., 1989):

- Unit F (Level 8): is separated from the rest of the sequence by a distinct erosive scar. It contains mixed materials from underlying levels.
- Unit E (Level 7): speleothem throughout the cavity, sealing the sedimentation.
- Unit D (Levels 4–6): clastic deposits containing lithic remains, faunal remains of large mammals, and human remains of *Homo neanderthalensis*, all of them slightly displaced from their original position.
- Unit C (Level 3): fragments of small stalagmite concretions and speleothems without continuity throughout the cavity.
- Unit B (Level 2): red clay accumulation (80 to 90 cm) occupying the entire cavity.
- Unit A (Level 1): speleothems from the base of the sequence.

The dating of the Valdegoba archaeological deposit is based on Uranium series, (Level 7, two dates, 95 ka and 73 ka), C14 (Level 5, 48.400 ± 3.300 years before present (OxA-21970, close to the limit of the 14C technique) and AAR (93.26 ka Level 6, 138.74 ka Level 5 and 121.86 ka Level 4) (Díez et al., 2014). Five specimens of human remains have been attributed to *Homo neanderthalensis* (Quam, et al., 2001). The excavations have yielded numerous faunal remains, with herbivores constituting 87 % of the assemblage. The dominant species (59 %) is the chamois (*Rupicapra rupicapra*). However, carnivores were also represented, with *Vulpes vulpes*, *Crocuta crocuta*, *Canis lupus* and *Ursus arctos* as the most abundant carnivore species. Regarding small mammals, the presence of cold-adapted species such as *Microtus nivalis*, *Marmota marmota*, and *Castor fiber* should be highlighted. Moreover, the remains of *Castor fiber* and *Lutra lutra* suggest the proximity of the cave to a river (Quam et al., 2001; Díez et al., 2014). A large part of animal bones shows evidence of human processing, including cut-marks and percussion-marks (Díez, 2006; Rodríguez-Gómez et al., 2022). However, carnivore damage – gnawing, digested bones, scores and pitting – has also been documented (Díez, 2006). Seasonality studies have revealed intensive resource-use by Neanderthals, with a predominance of adult herbivores over juveniles (Alonso and Díez, 2009). Lithic tools recovered from Unit D reveal a similar proportion of flint and quartzite (Terradillos-Bernal and Díez, 2018), probably from the cave vicinity (Díez et al. 2014). The presence of flakes and flake tools stands out, produced through complex knapping methods (Terradillos-Bernal and Díez, 2018).

2.2. Anatomical and taxonomical analysis

The avian sample was taxonomically classified by one of us (A. S. M) using the reference bird collection from the Universidad Autónoma de Madrid (UAM) archaeozoology laboratory (Sánchez-Marco, 2004; 2005), and the works of Howard (1980) and Livezey and Zusi (2007). In cases where specific assignment to a species category was not possible, the specimens were classified by genus (e.g. Columba) or family (e.g. Anatidae). Most bones were anatomically classified, except those that could not be classified and were categorised as 'indeterminate'. The status of ossification of bones was used to distinguish between adult and juvenile remains (Hargrave, 1970; Lefèvre and Pasquet, 1994). All the remains were quantified to calculate the Number of Identified Specimens (NISP), minimum number of elements (MNE) and minimum number of individuals (MNI) (Lyman 1994). To compare the number of recovered bones in relation to the number of bones expected to be recovered, the relative abundance (RA) index was determined and shown as a percentage (Dodson and Wexlar 1979; Lyman 1994). Other ratios were also calculated to evaluate the proportion of wing elements (humeri, ulnae, carpometacarpi) with respect to leg elements (femora, tibiotarsi, tarsometatarsi) (the total number of wing elements divided by the sum of wing and leg elements) (Ericson 1987), the proportion of core elements (sterna, scapulae, coracoides, pelves) with respect to limb elements (humeri, femora, ulnae, tibiotarsi, tarsometatarsi, carpometacarpi, radii) (total number of core elements divided by the sum of core and limb elements) and the proportion of proximal elements (scapulae, coracoides, humeri, femora, tibiotarsi) with respect to distal elements (ulnae, tarsometatarsi, carpometacarpi, radii) (total number of proximal elements divided by the sum of proximal and distal elements) (Bramwell et al., 1987; Bochenski and Nekrasov 2001). All indexes were calculated based on the MNE and shown as a percentage.

2.3. Taphonomical analysis

2.3.1. Fragmentation

Fragmentation degree was assessed following Bochenski et al. (1993) for long bones, pelvis, sternum, mandible and skull. For scapulae, coracoids, ribs, vertebrae and phalanges the classification proposed by Lloveras et al. (2014b) was applied. The fragmentation degree was calculated based on the NISP and shown as a percentage. Long bone fragmentation was assessed following previous works (Pérez, 2014, 2019, 2023; Real, 2017, Real et al., 2022). The work of Pérez (2014) was based on the breakage patterns proposed by Villa and Mahieu (1991). Thus, bones were classified as complete or fragmented bones. Regarding the latter, it was noted whether they preserved the proximal, distal or diaphyseal part. According to Villa and Mahieu (1991), different parameters such as fracture angle, fracture line and fracture edge are useful to determine the condition of the bone (fresh or dry) at the moment of the breakage. Fracture angle was classified as right, oblique or mixed angle. Fracture lines were categorised as transverse, curved or longitudinal. The fracture edge was classified as smooth or irregular. Fractures produced by flexion, as a consequence of the hyperextension of the bone, were also considered. These fractures were documented by Fiore and colleagues for bird remains (2020). The bones were also analysed searching for the loss of cortical tissue related to disarticulation, which is referred to as *arrachement* (Laroulandie, 2000; Laroulandie et al., 2008; Fiore et al., 2020). Additionally, the completeness of the sample was

Table 1
NISP, (MNE) and MNI of the Valdegoba bird assemblage. Cra: cranium; ste: sternum; fur: furcula; cor: coracoid; ver: vertebra; sca: scapula; syn: synsacrum; hum: humerus; rad: radius; uln: ulna; cmc: carpometacarpus; wph: wing phalanx; fem: femur; tib: tibiotarsus; tmt: tarsometatarsus; pph: posterior phalanx; tal: talon; keel: keel.

	cra	ste	fur	cor	ver	sca	syn	hum	rad	uln	cmc	wph	fem	tib	tmt	pph	tal	keel	TOTAL	MNI
Anatidae				**5(5)**							**2(2)**				**1(1)**			**1(1)**	**9(9)**	**7**
Anas querquedula				1(1)															1(1)	1
Anas crecca											1(1)								1(1)	1
Anas platyrhynchos				2(2)															2(2)	1
Somateria											1(1)								1(1)	1
Anser fabalis				1(1)														1(1)	2(2)	1
Anas acuta/platyrhynchos															1(1)				1(1)	1
Anatidae				1(1)															1(1)	1
Phasianidae				**4(3)**		**2(2)**		**3(2)**		**2(2)**	**3(2)**		**1(1)**		**6(5)**				**21(17)**	**7**
Perdix perdix				3(2)		1(1)		3(2)			3(2)				6(5)				16(12)	3
Gallus				1(1)															1(1)	1
Tetrao tetrix													1(1)						1(1)	1
Lagopus mutus										1(1)									1(1)	1
Coturnix coturnix						1(1)				1(1)									2(2)	1
Columbidae				**3(3)**		**6(6)**	**1(1)**	**5(4)**	**10(6)**	**10(9)**	**8(7)**	**9(9)**	**5(4)**	**5(4)**	**8(7)**	**1(1)**		**1(1)**	**72(62)**	**9**
Columba						1(1)	1(1)	1(1)	2(1)	2(2)	1(1)	1(1)			3(2)	1(1)			13(11)	2
Columba palumbus														1(1)					1(1)	1
Columba livia/oenas				3(3)		5(5)		4(3)	8(5)	8(7)	7(6)	8(8)	5(4)	4(3)	5(5)			1(1)	58(50)	6
Falconiformes																**2(2)**			**2(2)**	**1**
Falconiformes																2(2)			2(2)	1
Falconidae	**1(1)**			**7(7)**		**4(4)**		**4(4)**		**4(4)**	**1(1)**		**5(5)**	**5(5)**	**7(6)**				**38(37)**	**12**
Falco peregrinus				1(1)				1(1)			1(1)		2(2)		1(1)				6(6)	1
Falco tinnunculus						2(2)		2(2)					1(1)	2(2)					7(7)	2
Falco tinnunculus/ columbarius								1(1)						1(1)	2(2)				4(4)	1
Falco tinnunculus/ columbarius/subbuteo										2(2)									2(2)	2
Falco tinnunculus/subbuteo				3(3)															3(3)	2
Falco naumanni	1(1)									1(1)			2(2)	1(1)	3(2)				8(7)	2
Falco				3(3)		2(2)				1(1)				1(1)	1(1)				8(8)	2
Accipitridae				**1(1)**				**1(1)**		**1(1)**	**1(1)**		**4(4)**		**2(2)**		**2(2)**		**12(12)**	**9**
Gyps fulvus											1(1)								1(1)	1
Gypaetus barbatus				1(1)															1(1)	1
Accipiter gentilis/Buteo sp.													1(1)						1(1)	1
Accipiter gentilis										1(1)									1(1)	1
Buteo sp.													1(1)		1(1)				2(2)	1
Buteo lagopus													1(1)						1(1)	1
Buteo buteo								1(1)					1(1)						2(2)	1
Milvus migrans															1(1)				1(1)	1
Aegypius monachus																	2(2)		2(2)	1
Strigidae				**3(3)**		**1(1)**			**1(1)**	**2(2)**	**3(3)**				**2(2)**				**12(12)**	**2**
Athene noctua				3(3)		1(1)			1(1)	2(2)	3(3)				2(2)				12(12)	2
Otididae															**1(1)**				**1(1)**	**1**
Tetrax tetrax															1(1)				1(1)	1
Caprimulgidae											**1(1)**								**1(1)**	**1**
Caprimulgidae											1(1)								1(1)	1
Hirundinidae								**2(2)**											**2(2)**	**2**
Delichon urbicum								1(1)											1(1)	1
Hirundo rustica								1(1)											1(1)	1
Alaudidae		**1 (1)**						**5(5)**											**6(6)**	**4**
Galerida cristata								1(1)											1(1)	1

(*continued on next page*)

Table 1 (*continued*)

	cra	ste	fur	cor	ver	sca	syn	hum	rad	uln	cmc	wph	fem	tib	tmt	pph	tal	keel	TOTAL	MNI
Alauda arvensis		1 (1)						1(1)											2(2)	1
Galerida								2(2)											2(2)	1
Alaudidae								1(1)											1(1)	1
Muscicapidae								**6(6)**											**6(6)**	**5**
Muscicapa striata								2(2)											2(2)	2
Saxicola torquata								3(3)											3(3)	2
Oenanthe oenanthe								1(1)											1(1)	1
Turdidae	**1(1)**							**8(8)**											**9(9)**	**7**
Turdus philomelos								2(2)											2(2)	2
Turdus iliacus								1(1)											1(1)	1
Turdus viscivorus								3(3)											3(3)	2
T.pilarus								1(1)											1(1)	1
Turdus	1(1)							1(1)											2(2)	1
Motacillidae								**4(4)**											**4(4)**	**2**
Anthus spinoletta								4(4)											4(4)	2
Sturnidae								**2(2)**											**2(2)**	**2**
Sturnus								2(2)											2(2)	2
Passeridae	**2(2)**							**1(1)**											**3(3)**	**2**
Petronia petronia	2(2)							1(1)											3(3)	2
Fringillidae	**3(3)**							**18(18)**											**21(21)**	**13**
Pinicola enucleator	2(2)							17(17)											19(19)	11
Chloris chloris	1(1)																		1(1)	1
Acanthis flammea								1(1)											1(1)	1
Emberizidae								**8(8)**											**8(8)**	**4**
Emberiza calandra								2(2)											2(2)	1
Emberiza citrinella								6(6)											6(6)	3
Prunellidae								**6(6)**											**6(6)**	**5**
Prunella modularis								2(2)											2(2)	2
Prunella collaris								4(4)											4(4)	3
Corvidae	**8(8)**	**2 (2)**	**11 (11)**	**131 (104)**	**59 (59)**	**77 (77)**	**30 (30)**	**124 (80)**	**78 (43)**	**145 (89)**	**128 (94)**	**66 (59)**	**103 (68)**	**108 (77)**	**112 (72)**	**56 (56)**	**12 (12)**	**16 (16)**	**1266 (957)**	**65**
Pyrrhocorax graculus	7(7)	2 (2)	11 (11)	120 (94)	59 (59)	74 (74)	30 (30)	113 (70)	75 (41)	130 (76)	113 (80)	63 (56)	96 (61)	98 (70)	97 (61)	55 (55)	12 (12)	13 (13)	1168 (872)	49
Pyrrhocorax pyrrhocorax	1(1)			8(7)		3(3)		9(8)	3(2)	9(7)	14(13)	3(3)	3(3)	7(4)	10(7)	1(1)		3(3)	74(62)	8
Pica pica										1(1)	1(1)		1(1)	2(2)					5(5)	1
Corvus corone														1(1)	2(1)				3(2)	1
Corvus monedula										3(3)			2(2)		1(1)				6(6)	2
corvidae				1(1)				2(2)		1(1)			1(1)		2(2)				7(7)	2
cf. Garrulus glandarius										1(1)									1(1)	1
Corvus corone/frugilegus				2(2)															2(2)	1
Total	**15 (15)**	**3 (3)**	**11 (11)**	**154 (126)**	**59 (59)**	**90 (90)**	**31 (31)**	**197 (151)**	**89 (50)**	**164 (107)**	**147 (111)**	**75 (68)**	**118 (82)**	**118 (86)**	**139 (96)**	**59 (59)**	**14 (14)**	**18 (18)**	**1501 (1177)**	**160**

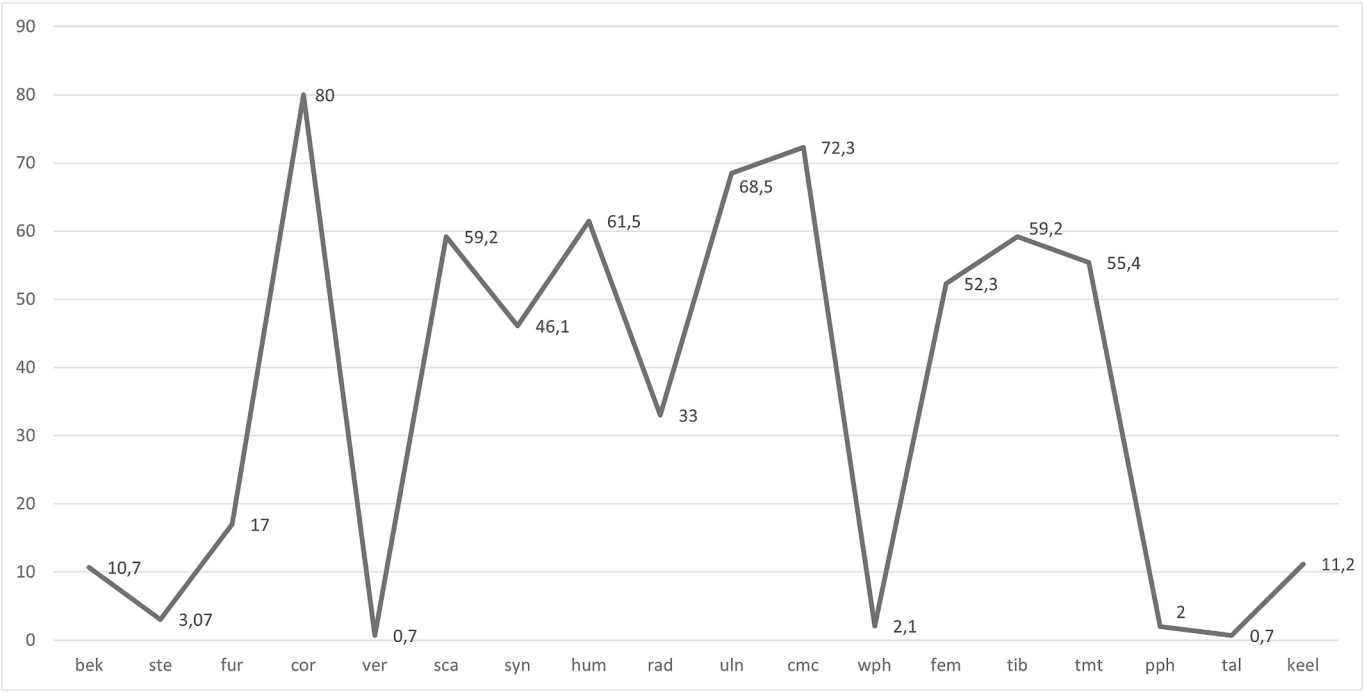

Fig. 3. RA percentage of the different skeletal elements for the Corvidae family (bek = beak; ste = sternum; fur = furcula; cor = coracoid; ver = vertebra; sca = scapula; syn = synsacrum; hum = humerus; rad = radius; uln = ulna; cmc = carpometacarpus; wph = wing phalanx; fem = femur; tib = tibiotarsus; tmt = tarsometatarsus; pph = posterior phalanx; tal = talon; keel = keel).

estimated according to three degrees proposed by Bochenski (2005): high (>60 % complete), moderate (30–60 % complete) and low (<30 % complete). To assess the proportion of complete bones, the following equation modified from Laroulandie (2000) was applied: number of complete bones × 100/total NISP.

2.3.2. *Surface modifications*

The sample was analysed using a Motic SMZ-140 stereomicroscope with 40x magnification. Mechanical modifications produced by carnivores or birds of prey – such as pits, punctures, scores and beak/talon marks – were documented. Alterations produced by the beak or talons can be defined as grooves with a flat or rounded bottom (Cáceres 2002). Nevertheless, punctures are more common modifications (Bochenski and Tornberg 2003; Bochenski et al., 2009). Digestion damage was classified according to Andrews (1990): absent (0), light (1), moderate (2), strong (3) and extreme (4). The sample was also analysed searching for anthropogenic modifications like cut- and tooth-marks, as well as burning damage. In general, cut marks are defined as straight grooves with an V-shaped cross-section (NOE-Nygaard, 1989). Post-depositional modifications were recorded, including fissures, chemical corrosion, root-etching, calcite coating and manganese oxide deposits (Behrensmeyer 1978; Fernández-Jalvo and Andrews 1992; 2016). Location and distribution of surface modifications were always documented.

Table 2
Wing-to-leg (WL), core-to-limb (CL) and proximal-to-distal (PD) ratios based on the MNE. Some families (Muscicapidae, Hirundinidae, Turdidae, Motacillidae, Fringillidae, Passeridae, Sturnidae, Caprimulgidae, Emberizidae and Prunellidae) lacked the skeletal elements necessary to calculate CL and PD (Caprimulgidae) ratios.

	wing	leg	WL ratio	core	limb	CL ratio	proximal	distal	PD ratio
Anatidae	2	1	66.6	5	3	62.5	5	3	62.5
Phasianidae	6	6	50	5	12	29.4	8	9	47
Columbidae	20	15	57.1	9	41	18	21	29	42
Falconidae	9	16	36	13	25	34,2	25	11	69
Accipitridae	3	6	33.3	1	9	10	6	4	60
Strigidae	5	2	71.4	4	8	33.3	4	8	33.3
Caprimulgidae	1	–	100	–	–	–	–	–	–
Hirundinidae	2	–	100	–	–	–	2	–	100
Alaudidae	5	–	100	1	5	16.7	5	–	100
Muscicapidae	6	–	100	–	–	–	6	–	100
Turdidae	8	–	100	–	–	–	8	–	100
Motacillidae	4	–	100	–	–	–	4	–	100
Sturnidae	2	–	100	–	–	–	2	–	100
Passeridae	1	–	100	–	–	–	1	–	100
Fringillidae	18	–	100	–	–	–	18	–	100
Emberizidae	8	–	100	–	–	–	8	–	100
Prunellidae	6	–	100	–	–	–	6	–	100
Corvidae	263	217	55	183	523	26	406	298	57
Total	**369**	**263**	**58.7**	**221**	**626**	**26**	**535**	**362**	**59.6**

Table 3
Bone completeness and percentage (%) for each taxon. Note that those families or species showing no complete bones were excluded from this table.

	Total NISP	Complete %	Limb bones	Crania	Coracoids	Scapulae	Sternum	Vertebrae	Phalanges	Furcula
Anatidae	**4**									
Anas platyrhynchos	2	1(50 %)			1(50 %)					
Anser fabalis	2	1(50 %)			1(50 %)					
Phasianidae	**16**									
Perdix perdix	16	4(25 %)	3(18.75 %)			1(6.25 %)				
Columbidae	**71**									
Columba	13	5(38.4 %)	3(23 %)						2(15.3 %)	
Columba livia/oenas	58	25(43.1 %)	15(25.8 %)		1(1.7 %)	2(3.44 %)			7(12 %)	
Falconidae	**24**									
Falco peregrinus	6	3(50 %)	3(50 %)							
Falco tinnunculus	7	2(28.5 %)	2(28.5 %)							
Falco tinnunculus/subbuteo	3	2(66.7 %)			2(66.7 %)					
Falco	8	2(25 %)			2(25 %)					
Accipitridae	**3**									
Gypaetus barbatus	1	1(100 %)			1(100 %)					
Aegypius monachus	2	2(100 %)							2(100 %)	
Strigidae	**12**									
Athene noctua	12	5(41.7 %)	2(16.7 %)		2(16.7 %)	1(8.3 %)				
Hirundinidae	**2**									
Delichon urbicum	1	1(100 %)	1(100 %)							
Hirundo rustica	1	1(100 %)	1(100 %)							
AlaudidaeGalerida cristataAlauda arvensis	**3**12	1(100 %)1(50 %)	1(100 %)				1(50 %)			
Muscicapidae	**6**									
Muscicapa striata	2	2(100 %)	2(100 %)							
Saxicola torquata	3	2(66.7 %)	2(66.7 %)							
Oenanthe oenanthe	1	1(100 %)	1(100 %)							
TurdidaeTurdus philomelosTurdus iliacusTurdus viscivorus	**9**213	2(100 %)1(100 %)2(66.7 %)	2(100 %)1(100 %)2(66.7 %)							
Turdus pilarus	1	1(100 %)	1(100 %)							
Turdus	2	1(50 %)	1(50 %)							
Motacillidae	**4**									
Anthus spinoletta	4	2(50 %)	2(50 %)							
Sturnidae	**2**									
Sturnus	2	1(50 %)		1(50 %)						
Passeridae	**3**									
Petronia petronia	3	2(66.7 %)	1(33.3 %)	1(33.3 %)						
Fringillidae	**20**									
Pinicola enucleatorChloris chloris	191	6(31.6 %)1(100 %)	6(31.6 %)	1(100 %)						
Emberizidae	**8**									
Emberiza calandra	2	2(100 %)	2(100 %)							
Emberiza citrinella	6	2(33.3 %)	2(33.3 %)							
Prunellidae	**6**									
Prunella modularis	2	2(100 %)	2(100 %)							
Prunella collaris	4	3(75 %)	3(75 %)							
CorvidaePyrrhocorax graculusPyrrhocorax pyrrhocoraxPica picaCorvus monedulaCorvidae	**1260**116874567	370(31.7 %)26(38.8 %)1(20 %)1(16.7 %)1(14.2 %)	123(10.5 %)16(23.8 %)1(20 %)1(16.7 %)		66(5.6 %)5(7.4 %)1(14.2 %)	14(1.2 %)1(1.5 %)		55(4.7 %)	111(9.5 %)4(6 %)	1(0.08 %)
Total	**1455**	**491(32.7 %)**	**203(13.5 %)**	**2(0.1 %)**	**82(5.5 %)**	**19(1.2 %)**	**1(0.06 %)**	**55(3.7 %)**	**128(8.5 %)**	**1(0.06 %)**

3. Results

3.1. Anatomical and taxonomical analysis

The analysed sample involved a total of 1501 avian specimens corresponding to an MNI of 160. Corvidae (84.4 % of the whole sample) was the most abundant family (NISP = 1267). The Corvidae group mainly consisted of Alpine chough (*Pyrrhocorax graculus*) (NISP = 1174), followed by the Red-billed chough (*Pyrrhocorax pyrrhocorax)* (NISP = 69), although other species were also present (see Table 1). Accipitridae, Corvidae, Anatidae and Falconidae were families with a higher variety of species (see Table 1). The assemblage was dominated by adult individuals, as just three remains from Columbidae (*Columba livia/oenas*), Falconidae (Falco sp.) and Corvidae (*Pyrrhocorax graculus*) families corresponded to immature animals. A predominance of post-cranial elements over cranial elements was documented. However, most skeletal elements were represented to a greater or lesser degree. Regarding the RA index, the best-preserved elements were coracoids and carpometacarpi (80 % and 72.3 %, respectively), followed by ulnae (68.5 %) and humeri (61.5 %) (see Fig. 3). On the other hand, cranial elements (including beak, nasal and premaxillary bones, and mandibles) showed very low representation, implying an important loss of these skeletal elements. It should be noted that the RA index was calculated only for Corvidae family, as other taxa showed very few remains that

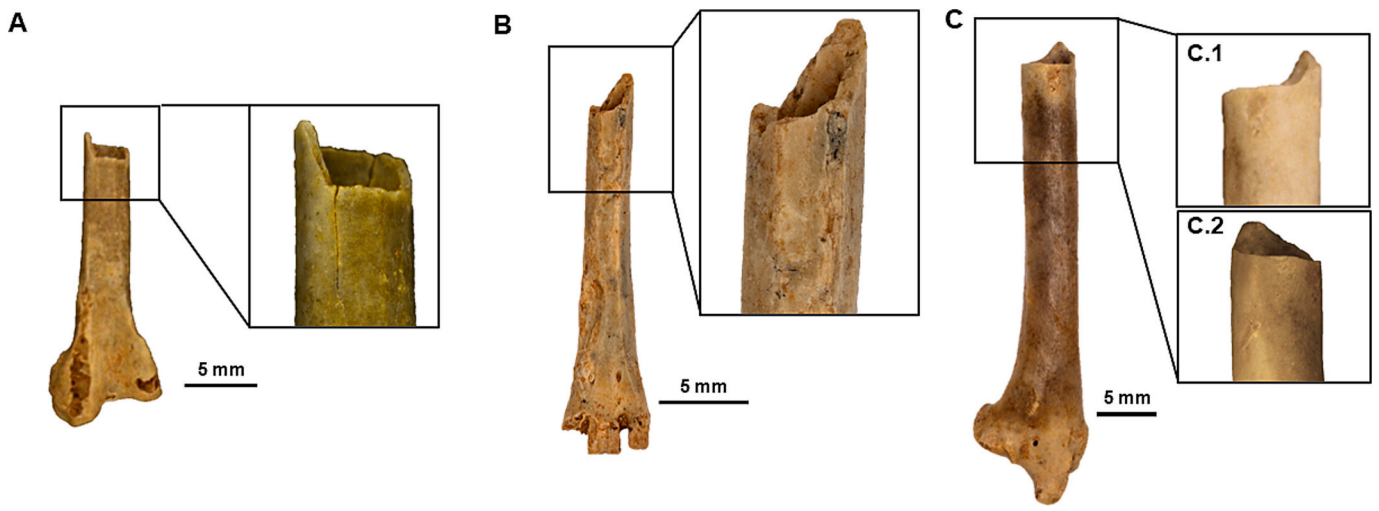

Fig. 4. Fractures produced by flexion on a tibiotarsus from *Pica pica* (A), a tarsometatarsus (B) and ulna (C; C1 = posterior view; C2 = ventral view) from *Pyrrhocorax graculus*.

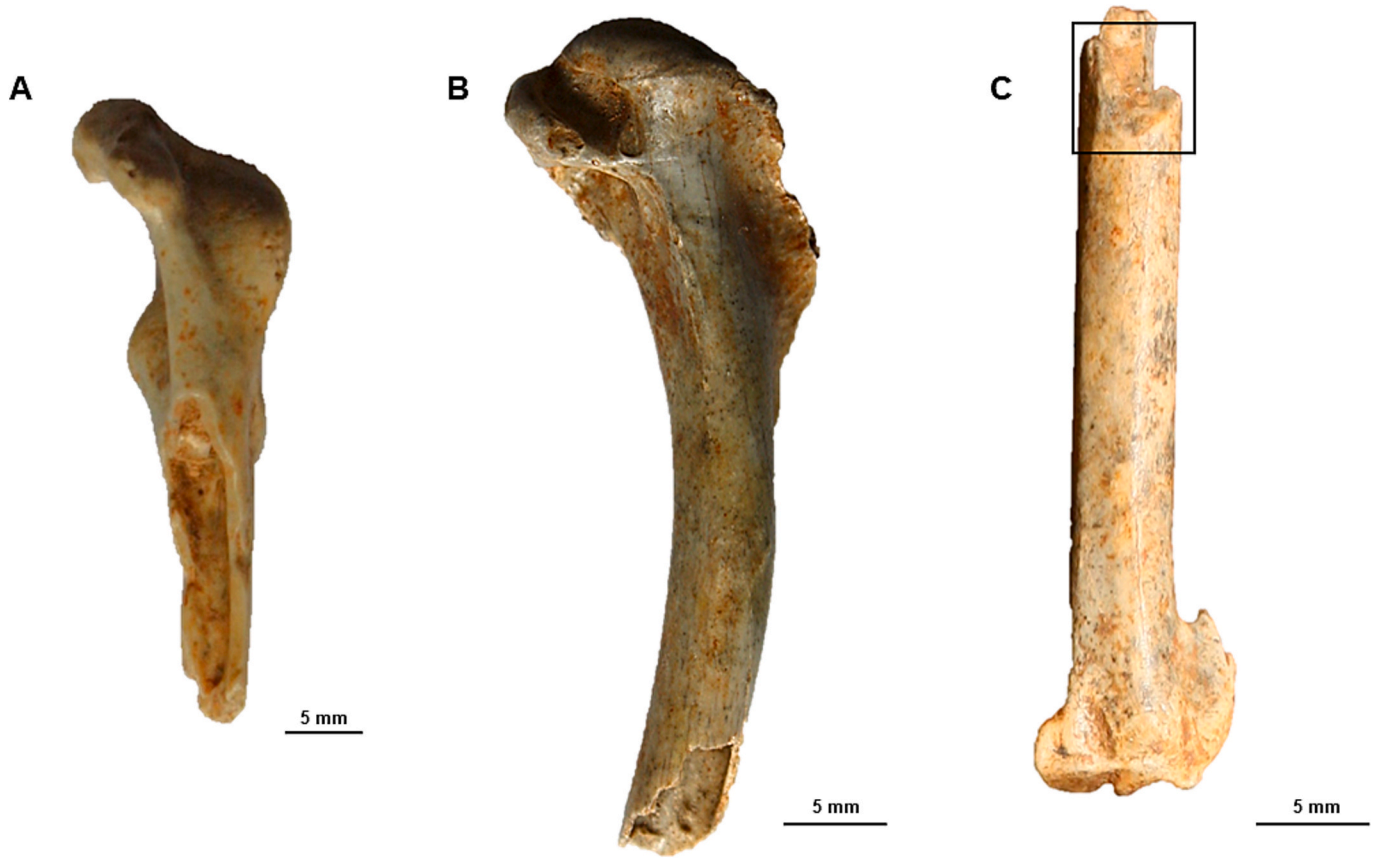

Fig. 5. Fresh fractures on a coracoid from *Perdix perdix* (A) and a humerus from *Falco tinnunculus* (B). Presence of *arrachement* on a carpometacarpus of Somateria (C).

could bias the results. Likewise, a higher proportion of upper limb bones was observed according to the wing-to-leg ratio, as the percentage exceeded 50 % in most cases. Limb elements were more abundant than core elements, except for the Anatidae family. However, the Anatidae family was composed of just 9 bones, so conclusions should be made carefully. Additionally, proximal-to-distal ratio showed a higher proportion of proximal elements for most groups (see Table 2). Note that some families were excluded, as the skeletal elements necessary for calculating the ratios were absent.

3.2. Taphonomical analysis

3.2.1. Fragmentation

The completeness of the sample was moderate, as complete elements comprised 32.9 % of the analysed remains. The bones that were documented as complete more times were coracoids, followed by humeri, wing phalanges, vertebrae and carpometacarpi. Many carpometacarpi (38.7 %) lacked the minor metacarpal. Amongst complete limb bones (NISP = 203), those that were complete were primarily humerus (NISP = 66) and carpometacarpi (NISP = 62), comprising 32.5 % and 30.5 %

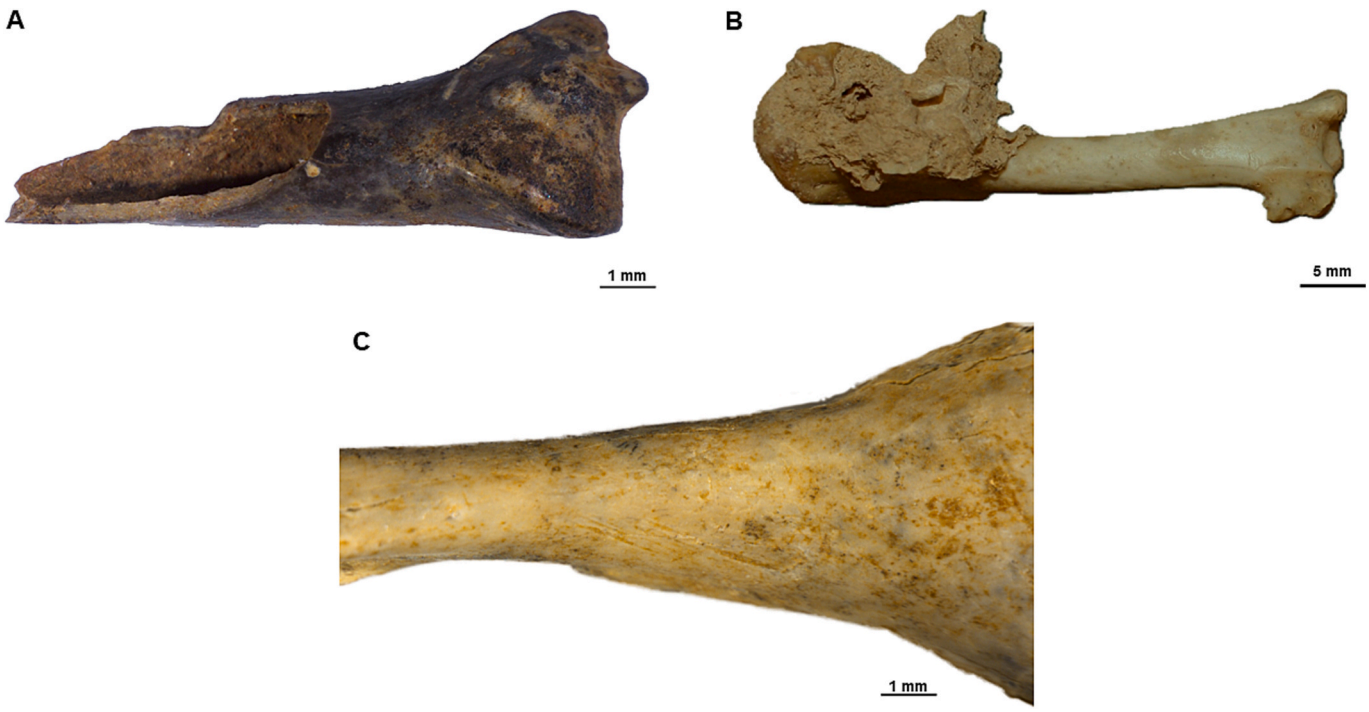

Fig. 6. Post-depositional modifications on avian remains from Valdegoba cave. A = manganese oxides on a distal ulna from *Lagopus mutus*; B = calcite coating on a humerus from *Phyrrocorax phyrrocorax*; C = trampling on a coracoid from the genus Falco.

Table 4
Modifications produced by non-human and human predators. (*) The column "fractures" refers to those fractures produced by flexion, as in Fiore et al., 2020.

	Punctures	Digestive damage				Cut-marks	Fractures*	*Arrachement*
		light	**moderate**	**strong**	**total**			
coracoides	3	1		1	2	2	12	
scapula						1		1
humerus	15	2	2	3	7		29	
radius		2			2			
ulna	7	1		1	2		21	2
carpometacarpus	4						2	
wing phalanx	5							
femur	3	10	3		13		21	
tibiotarsus			1	1	2		24	
tarsometatarsus		1		1	2		8	
TOTAL	**37 (2,4%)**	**17 (1,13 %)**	**6 (0,4%)**	**7 (0,5%)**	**30 (2 %)**	**3 (0.2 %)**	**117 (7,8%)**	**3 (0.2 %)**

Table 5
Post-depositional modifications NISP and percentage (%) by skeletal element.

	Post-depositional modifications					
	fissures	**chemical corrosion**	**root-eching**	**calcite coating**	**manganese**	**total**
rib	1			1	3	5
sternum					1	1
furcula				1		1
coracoides	26		1	8	44	79
vertebra	6			6	3	15
scapula	12				12	24
humerus	24			16	52	92
radius	8			1	11	20
ulna	27		1	4	34	66
carpometacarpus	26		1	12	25	64
wing phalanx	8			10	16	34
femur	17			3	22	42
tibiotarsus	17	1	2	5	18	43
tarsometatarsus	22			6	22	50
posterior phalanx				2	5	7
talon					1	1
keel	2		1	1	2	6
TOTAL	**196 (13 %)**	**1 (0,06 %)**	**6 (0,4%)**	**76 (5 %)**	**271 (18 %)**	**550 (36,64)**

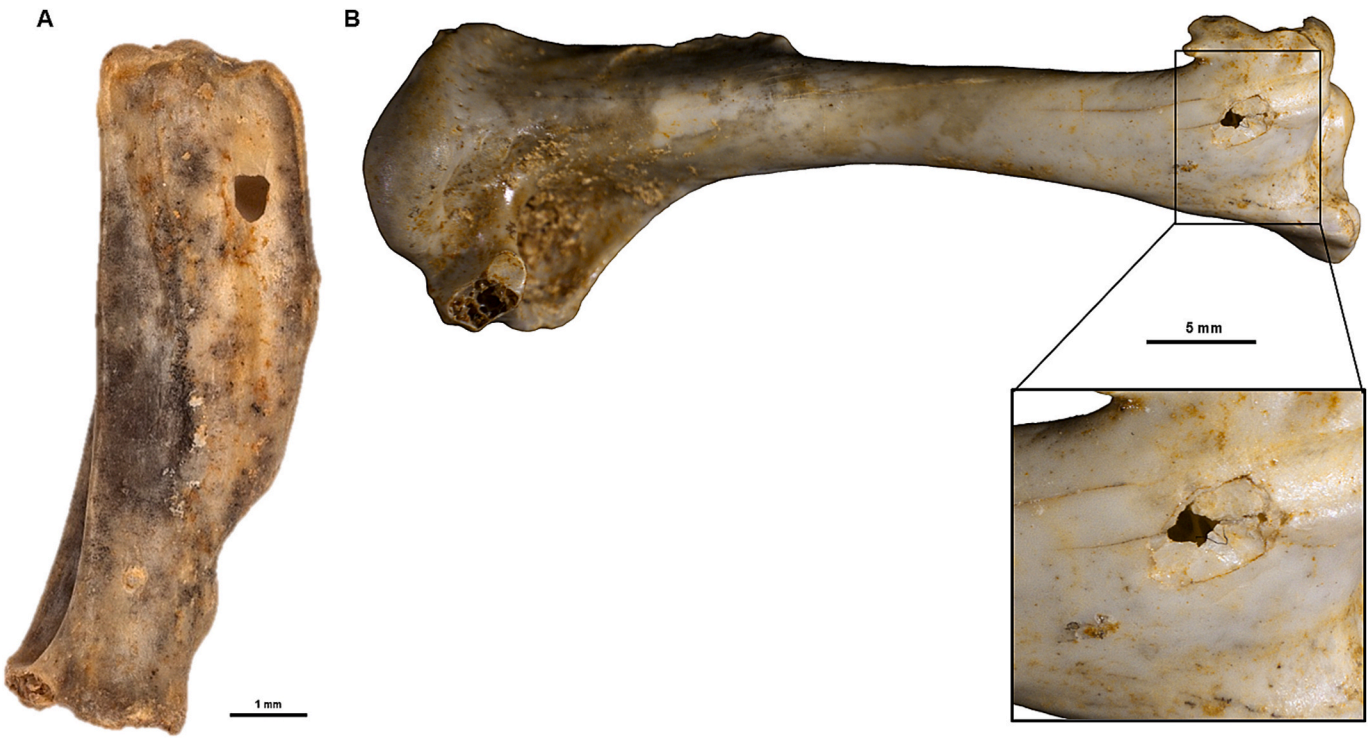

Fig. 7. Punctures on a wing phalanx (A) and a humerus (B) from *Phyrrocorax graculus*.

of complete limb bones respectively. Cranium, sternum and scapulae were rarely complete. However, as the absolute numbers for these skeletal elements were low, results were not highly reliable. It is worth noting that the only species in Table 3, are those with at least one complete bone. The most abundant fracture angle on long bones was oblique angle (NISP = 519; 34.5 %), followed by mixed (NISP = 188; 12.5 %) and right types (NISP = 50; 3.3 %). The dominant fracture line type in the assemblage was curved fracture line (NISP = 696; 46.4 %), and most bones showed smooth edges (NISP = 696; 46.4 %). Fractures related to flexion and *arrachement* (Figs. 4 and 5) were recorded in a total of 117 and 3 bones, representing 7.8 % and 0.2 % of the sample, respectively. They were documented mainly within the Corvidae family, as expected given that it was the most abundant family in the assemblage. Fractures related to flexion were commonly found on humeri (NISP = 29) and tibiotarsi (NISP = 24), followed by ulnae (NISP = 23) and femora (NISP = 21). Additionally, *arrachement* was documented mainly on the ulnae, although the scarcity of this type of modification hindered significant inferences.

3.2.2. *Surface modifications*

Post-depositional modifications (see Fig. 6) were documented in the third (36.6 %) of the analysed bones. Long bones were the most affected bones, among which the humerus stood out, with 16.7 % of bones with post-depositional modifications. The most common alterations were fissures and manganese oxide deposits, comprising 13 % and 18 % of the sample, respectively. Calcite coating was also relatively abundant, while root-etching and chemical corrosion appeared on a small portion of the sample (see Table 5).

Several mechanical modifications (pits and punctures) were documented in the analysed avian sample. Overall, this type of modification was found on the surface of 37 bones, 2.4 % of the sample. In some cases (NISP = 4; 0.3 %), multiple punctures were recorded on the same bone. They appeared mainly on the surface of long bones, mainly the humerus (NISP = 15; 1 %) (see Table 4), concentrated on both proximal and distal epiphysis. The Corvidae family had the largest number of bones with pits or punctures (NISP = 30, 2 %), easily expected, as it is the most represented family in the assemblage (see Fig. 7).

Digestive damage was documented on 30 remains, 2 % of the analysed sample. A predominance of light digestion damage was documented, followed by strong and moderate damage (see Table 4). The most affected bones were the humerus and the femur, although digestion damage was documented on other long bones and coracoids (see Table 4). As occurred with mechanical modifications, the most affected family was Corvidae. The proximal and distal ends of the bones were the most damaged parts (see Fig. 8).

Regarding anthropogenic modifications, unmistakable disarticulation cut marks were documented on 3 remains, 0.2 % of the analysed sample (see Table 4). These marks can be classified as incisions, and they were recorded on the proximal part of a scapula from *Pyrrhocorax graculus* and on the proximal part of two coracoids from the Anatidae family. All were straight and showed an oblique orientation (see Fig. 9). No other anthropogenic modifications such as tooth marks or burn damage were observed.

4. Discussion

Archaeological assemblages are usually a combination of inputs from different agents, leading to the formation of complex palimpsests (Bailey, 2007). Consequently, deciphering the origin of bone remains can be a difficult task. It is therefore necessary to determine the taphonomical pattern of both non-anthropogenic and anthropogenic predators. The results presented in this work from the analysis of the bird assemblage from Valdegoba cave shed some light on this issue. This accumulation points to a mixed contribution by carnivores and humans, reflecting the complex dynamics of the site. The most common post-depositional modifications in the assemblage (fissures and manganese oxides) were documented below 20 % of the sample. Moreover, the relative abundance percentage shows that all skeletal elements were represented to a greater or lesser degree. Therefore, it can be concluded that there is a good preservation of bones. This information is consistent with the fact that the bird remains were identified by species category in most cases.

Fig. 8. Digestion damage on a humerus from *Perdix perdix* (A) and a distal femur from *Buteo* sp. (B).

The analysis of the avian assemblage from Valdegoba reveals a predominance of the Alpine chough (*Pyrrhocorax graculus*). As corvids are habitual inhabitants of caves and shelters (Cramp and Brooks, 1992), their presence in archaeological sites can be expected. However, it is essential to determine the origin of bone accumulations. In the case of natural or catastrophic deaths, a similar representation of all skeletal elements should be expected (Laroulandie, 2000; Rufà and Laroulandie, 2021), which was not documented in the present study. The presence of immature individuals and anatomical connections would also be highly probable (Delestrade and Stoyanov, 1995; Laroulandie, 2000; Rufà and Laroulandie, 2021; Garcia-Fermet et al., 2023). However, in the case of Valdegoba cave, no anatomical connections were documented, and the presence of juvenile individuals was extremely low (0.1 % for both Corvidae and other taxa). It should be noted that, even if the remains were deposited naturally, post depositional processes might have altered their original distribution.

As proposed by Ericson (1987), a predominance of wing bones over leg bones might be an indicator of natural accumulation, as human groups would mostly use bones from posterior extremities, richer in meat. However, a predominance of wing elements, as in the case of Valdegoba, has been also documented on accumulations produced by both diurnal and nocturnal birds of prey and mammalian carnivores (Bochenski et al., 1993, 1997, 1999, 2009; Bochenski and Tomek, 1997; Laroulandie, 2000, 2002; Bochenski and Nekrasov, 2001; Monchot and Gendron, 2009; Lloveras et al., 2014a, 2014b; Alonso et al., 2020). On the other hand, other factors could affect the differential conservation of skeletal elements (Livingston, 1989; Bovy, 2002, 2012; Cruz, 2005; Broughton et al., 2007). According to these authors, it should be expected that the denser bones would be better preserved. Nevertheless, the bone density hypothesis is not always useful (Bovy, 2002).

Therefore, other taphonomic traits should be considered when assessing an avian accumulation. In the present work, mechanical modifications produced by teeth, beak or claws were recorded on 2.4 % of corvid bones (2 % of the whole assemblage), while digestion damage was documented on 2 % within this family (1.6 % of the whole assemblage). Nocturnal birds of prey usually swallow their prey whole. Therefore, those ingested bones commonly show digestion damage to a slight or moderate degree. Bone assemblages of these types of predators commonly show a predominance in both wing-to-leg and proximal-to-distal ratios, while core elements are usually scarce. They could also produce mechanical modifications, although their percentages can vary (Bochenski et al., 1993; Bochenski and Tomek, 1994, 1997; Bochenski and Nekrasov, 2001; Laroulandie, 2000, 2002; Royer et al., 2019; Alonso et al., 2020). Regarding diurnal birds of prey, digested damage and the amount of mechanical modifications varies depending on the processing of the remains. The ratios are also highly variable, as the predominance of specific skeletal elements is different for each predator. For ingested bones, strong and extreme digestion degrees could be expected, as well as a low representation of beak or claw damage, and a major amount of leg bones over wing bones (Bochenski et al., 1997; Lloveras et al., 2014a, 2014b). On the contrary, for non-ingested remains digestive damage is nonexistent, and mechanical modifications

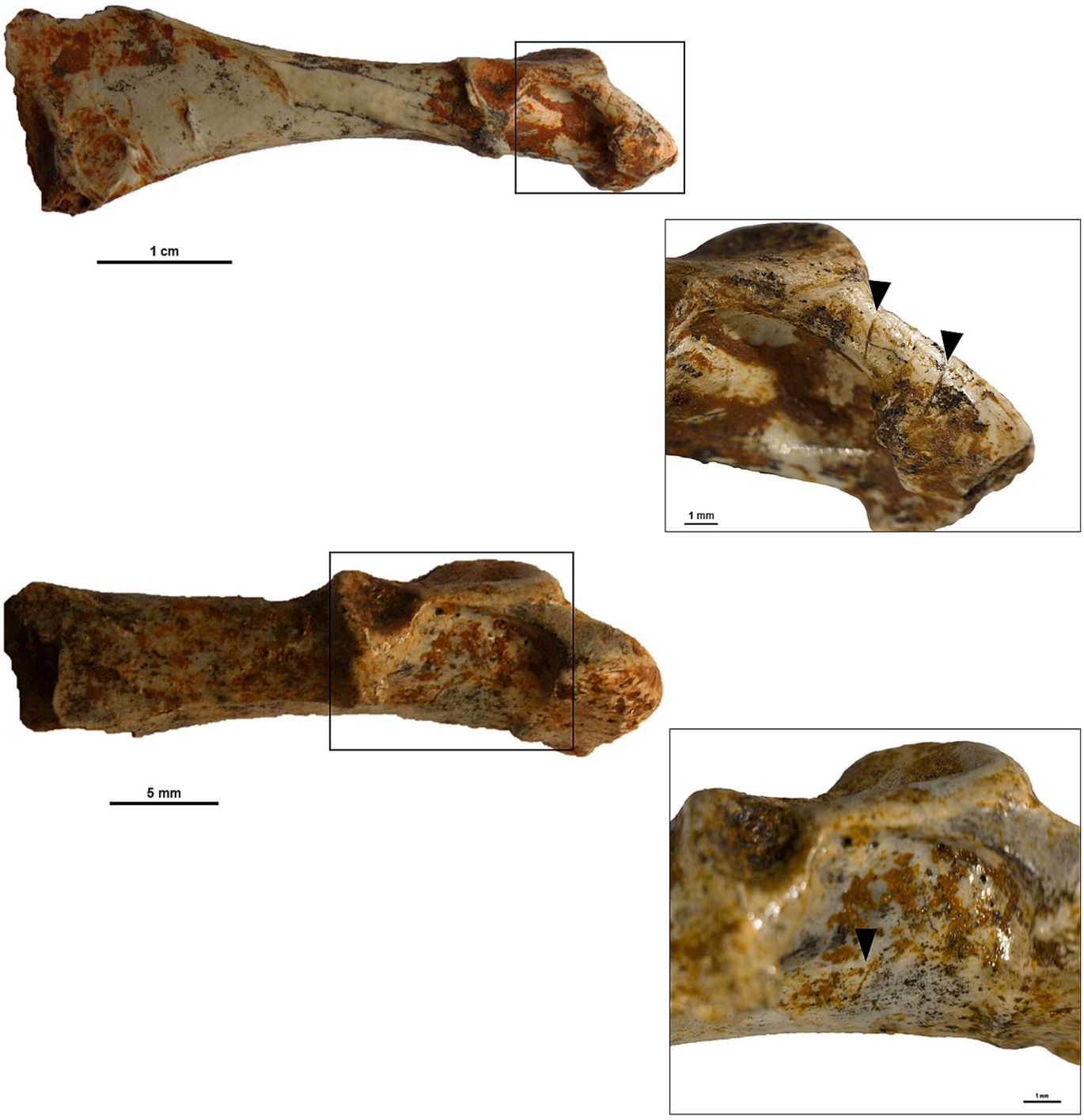

Fig. 9. Cut marks on two coracoids from the Anatidae family (A = *Anas platyrhynchos*; B = Anatidae), and a scapula from *Pyrrhocorax graculus* (C).

appear on a high percentage of the bones. In general terms, wing elements outnumber leg elements (Bochenski et al., 1997; Laroulandie, 2000, 2002; Bochenski and Tornberg, 2003; Bochenski et al., 2009; Lloveras et al., 2014a, 2014b; Wertz et al., 2021). Focusing on mammalian carnivores, mechanical modifications (including pits and punctures) and crenulated edges are extremely common for non-ingested remains. Additionally, digestive damage reaches extreme corrosion degrees, and ratios can be variable (Laroulandie, 2000; Mallye et al., 2008; Monchot and Gendron, 2009; Rodríguez-Hidalgo et al., 2016; Rufà and Laroulandie, 2020).

Among birds exploited by hominins, diverse taxa such as anatids, corvids, phasianids and columbids have been recorded (e.g., Díez et al., 1995; Laroulandie, 2005; Blasco and Peris, 2009; Sánchez-Marco and Quesada, 2010; Romero et al., 2017; Goffette et al., 2020; Lloveras et al., 2020, 2022). Although human presence is widely demonstrated in Valdegoba cave (Terradillos-Bernal and Díez, 2018; Quam et al., 2001), its taphonomic pattern on small prey might be difficult to detect. In fact, cut marks comprised just 0.2 % of the analysed assemblage, and no burnt bones were recorded. The scarcity of cut marks is usual in other bird assemblages, as in the case of Bolomor Cave where the presence of this type of anthropogenic modification was documented on approximately 15 % of the sample (Blasco and Peris, 2012). Overall, cut marks are

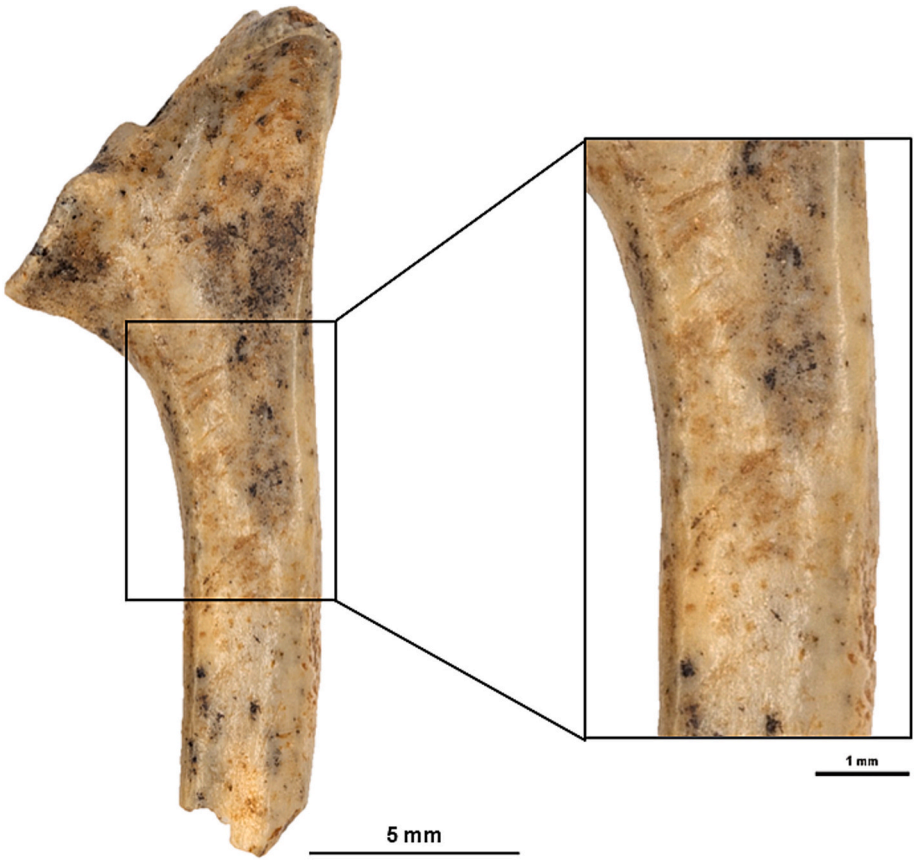

Fig. 9. (*continued*).

usually below 20 % of the avian assemblages of several Middle Palaeolithic sites alongside Europe, and higher percentages are a consequence of small sample size (Steadman et al., 2002; Morin and Laroulandie, 2012; Romero et al., 2017; Lloveras et al., 2018; Blasco et al., 2022). However, in spite of their scarcity, cut marks are clear evidence of human contribution to the avian assemblage of Valdegoba cave. As mentioned in previous paragraphs, cut marks were classified as incisions with oblique orientation. Regarding the location of these three cut marks (two coracoids and one scapula) they might be related to the disarticulation of the wings. As seen in previous experimental works about bird processing by humans, cut marks are common modifications on both scapulae and coracoids (Nabais et al., 2024). Following the work of Steadman et al. (2002), the access through the coracoid and scapular region could be related with meat removal. Some authors (Tagliacozzo and Gala, 2004; Blasco et al., 2016a) have documented cut marks on coracoids, associated with defleshing activities. The anthropogenic processing of birds for nutritional purposes is well documented at both Middle Palaeolithic and Upper Palaeolithic sites (e.g., Laroulandie, 2003; Blasco and Peris, 2009; Bochenski et al., 2009; Laroulandie et al., 2016, 2020; Martínez-Valle et al., 2016; Lloveras et al., 2018). On the Iberian Peninsula, evidence of Middle Palaeolithic anthropogenic exploitation of bird resources is well established for the eastern (Blasco and Peris, 2009; Martínez-Valle et al., 2016; Lloveras et al., 2020, 2022), southern (Finlayson et al., 2016), and northern (Gómez-Olivencia et al., 2018) areas. Nevertheless, on the Spanish plateau, there is still a lack of archaeological sites with evidence of small-prey consumption. In fact, Valdegoba is, so far, the only archaeological site in the interior of the Iberian Peninsula with evidence of Neanderthal activity. In this context, the results of the analysis of avian remains from Valdegoba cave are highly significant as they lay the groundwork for future studies.

On the other hand, there is a possibility that this modification is related to the exploitation of feathers. The exploitation of birds for feather removal is similarly documented in several European Middle Palaeolithic sites such as Gorham's Cave, Vanguard Cave, Cova Negra, Fumane and Ibex Cave (Laroulandie, 2010; Peresani et al., 2011; Finlayson et al., 2012; Blasco et al., 2016a; Fiore et al., 2016; Martínez-Valle et al., 2016). The Upper Pleistocene site of Gran Dolina (Atapuerca, Burgos, Spain) has also yielded avian remains with cut marks, probably associated with feather removal (Blasco et al., 2013; Rodriguez-Hidalgo et al., 2017). It is commonly accepted that the presence of cut marks on wing bones might indicate a particular interest for feathers (Fiore et al., 2020). It should be noted that the disarticulation is a considerably more probable explanation for the presence of cut marks in Valdegoba cave. However, the exploitation of feathers is a possibility that should not be ruled out.

Due to the overall scarcity of cut marks on avian archaeological assemblages, it is essential to search for other taphonomic modifications related to human activity. The analysis of fractures in the present work sheds light on this issue. In fact, oblique fracture angles, curved fracture lines, and smooth edges of bones are usually associated with fresh fractures (Fiore et al., 2020). It can be therefore concluded, in the case of Valdegoba, that most bones were fractured when they still preserved organic material. These fractures resemble those recorded by Ripoll (2001) for leporid bones. Fresh fractures might be the result of several processes, including humans, carnivores, and trampling (e.g., Villa and Mahieu, 1991; Villa et al., 2004; Sala and Arsuaga, 2018; Rufà and Laroulandie, 2021). For this reason, they are not a uniquely anthropogenic modification, and they should be analysed together with other traits. In addition to fresh bone fractures, fractures produced by flexion and the presence of *arrachement* as a consequence of the disarticulation of bones are considered to be characteristic of human processing. These anthropogenic modifications are probably related to the consumption of birds by Neanderthals, as documented in other archaeological sites (e.g., Blasco and Peris, 2009; Blasco et al., 2014; Gómez-Olivencia et al., 2018;

Martínez-Valle et al., 2016; Romero et al., 2017). Moreover, together with the presence of cut marks, they would support the hypothesis of anthropogenic bird processing at Valdegoba Cave.

Based on the results presented in this paper, the taphonomic pattern of corvid bones from Valdegoba fits with that produced by some nocturnal birds of prey, together with anthropogenic input. Natural accumulation can be discarded, as there are no anatomical connections, and the presence of immature individuals is practically non-existent. Consequently, the presence of the Corvidae family might respond to a complex combination of human and non-human action. Mixed accumulation of avian remains has also been documented in other Middle Palaeolithic sites, such as La Crouzade Cave (France) (Garcia-Fermet et al., 2023), Pié Lombard (France) (Romero et al., 2017) or Scladina Cave (Belgium) (Goffette et al., 2024). Among other relatively abundant families in the assemblage, the presence of the Columbidae family indicates the contribution of external agents, as the members of this family are not usual cave inhabitants (SEO BirdLife, 2024). Nevertheless, the Rock dove (*Columba livia*) is known to use rocky hollows and ledges as roost sites (Díaz et al, 1996). Therefore, their bones could be accumulated as a consequence of natural deaths. However, as mentioned above, other agents (including non-anthropogenic and anthropogenic predators and natural processes) might have altered those bones. Mechanical modifications were documented on one bone from the Columbidae family (0.1 % of the whole assemblage), while four bones showed a slight degree of digestion (0.1 % of the assemblage). Although the number of bones is too low to make confident inferences, the results point to some raptor as an external accumulator. On the other hand, it is highly probable that most of the remains of Falconidae respond to natural accumulation, as there are no bones with mechanical modifications or digestive damage. Moreover, bird species within this family usually use caves or shelters for nesting (SEO BirdLife, 2024). Nevertheless, the number of remains from the Falconidae family are scarce. For this reason, conclusions based on the analysis of those bones should be reached carefully.

5. Conclusions

The bird assemblage from Valdegoba cave is the result of different accumulation agents. The mixed contribution of both human and non-human predators seems to be the main explanation for the presence of avian bones. This can be easily established for the Corvidae family, especially the Alpine chough (*Pyrrhocorax graculus)* and the Red-billed chough (*Pyrrhocorax pyrrhocorax*), as they are the most abundant taxa. Other bird species show a lower representation, hindering accurate conclusions. In any case, it can be concluded that, at least for the Corvidae family, the principal agent of the accumulation was probably a nocturnal bird of prey, in addition to anthropogenic input.

Evidence of anthropogenic use of birds in Valdegoba cave is supported not only by the presence of cut marks, but also fractures produced by flexion and *arrachement*, which could confirm the exploitation of birds by neanderthal groups. It can therefore be concluded that the bird assemblage presented in this study responds to a complex taphonomic story in which diverse agents took part. It is important here to emphasise the need for neo-taphonomical studies that characterise the pattern of both human and non-human predators, as well as that of natural events. The data obtained would help the correct interpretation of archaeological palimpsests, and to understand the relationship between human groups and their environment.

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Data availability

No data was used for the research described in the article.

References

Albouy, B., Paquin, S., Riel-Salvatore, J., Kageyama, M., Vrac, M., Burke, A., 2024. Evaluating the impact of climate change and millennial variability on the last Neanderthal populations in Europe (Marine Isotope Stage 3). Quat. Sci. Rev. 338, 108812.

Alonso, D.A., Díez, J.C., 2009. Age of death and seasonality based on ungulate tooth remains from the Upper Pleistocene site of Valdegoba (Burgos, Spain). J. Taphon. 7 (2), 73–89.

Alonso, G., Rufà, A., Arilla, M., Blasco, R., 2020. Taphonomic signature of the Eurasian eagle-owl (Bubo bubo) on the avian accumulation of Cau del Duc (Lleida, Spain). Hist. Biol. 32 (10), 1320–1333.

Andrews, P., 1990. Small mammal taphonomy. In: Lindsay, E.H., Fahlbusch, V., Mein, P. (Eds.), *European Neogene Mammal Chronology*. Springer, US, Boston, MA, pp. 487–494.

Behrensmeyer, A.K., 1978. Taphonomic and ecologic information from bone weathering. Paleobiol. 4 (2), 150–162.

Bailey, G., 2007. Time perspectives, palimpsests and the archaeology of time. J. Anthropol. Archaeol. 26 (2), 198–223.

Blanco, G., Sánchez-Marco, A., Negro, J.J., 2021. Night capture of roosting cave birds by neanderthals: An actualistic approach. Front. Ecol. Evol. 9, 733062.

Blasco, R., Peresani, M., 2016. Humankind and the avian world: zooarchaeological evidence for inferring behavioural evolutionary signatures. Quat. Int. 421, 134–153.

Blasco, R., Peris, J.F., 2009. Middle Pleistocene bird consumption at level XI of Bolomor cave (Valencia, Spain). J. Archaeol. Sci. 36 (10), 2213–2223.

Blasco, R., Peris, J.F., 2012. Small and large game: human use of diverse faunal resources at Level IV of Bolomor Cave (Valencia, Spain). C. r. Palevol 11 (4), 265–282.

Blasco, R., Peris, J.F., 2021. From tortoises to elephants: The impact of elephants in the broad spectrum diet at Bolomor Cave (MIS 9–5 Spain). In: Konidaris, G.E., Barkai, R., Tourloukis, V., Harvati, K. (Eds.), Human-Elephant Interactions: from past to Present. Tübingen University Press, pp. 363–385.

Blasco, R., Rosell, J., Peris, J.F., Arsuaga, J.L., de Castro, J.M.B., Carbonell, E., 2013. Environmental availability, behavioural diversity and diet: a zooarchaeological approach from the TD10-1 sublevel of Gran Dolina (Sierra de Atapuerca, Burgos, Spain) and Bolomor Cave (Valencia, Spain). Quat. Sci. Rev. 70, 124–144.

Blasco, R., Finlayson, C., Rosell, J., Marco, A.S., Finlayson, S., Finlayson, G., Vidal, J.R., 2014. The earliest pigeon fanciers. Sci. Rep. 4 (1), 1–7.

Blasco, R., Rosell, J., Rufà, A., Marco, A.S., Finlayson, C., 2016a. Pigeons and choughs, a usual resource for the Neanderthals in Gibraltar. Quat. Int. 421, 62–77.

Blasco, R., Rosell, J., Smith, K.T., Maul, L.C., Sañudo, P., Barkai, R., Gopher, A., 2016b. Tortoises as a dietary supplement: A view from the Middle Pleistocene site of Qesem Cave, Israel. Quat. Sci. Rev. 133, 165–182.

Blasco, R., Rosell, J., Sánchez-Marco, A., Gopher, A., Barkai, R., 2019. Feathers and food: human-bird interactions at Middle Pleistocene Qesem Cave, Israel. J. Hum. Evol. 136, 102653.

Blasco, R., Cochard, D., Colonese, A.C., Laroulandie, V., Meier, J., Morin, E., Thompson, J.C., 2022. Small animal use by Neanderthals. In: Romagnoli, F., Rivals, F., Benazzi, S. (Eds.), Updating Neanderthals. Academic Press, pp. 123–143.

Bochenski, Z.M., 1997. Preliminary taphonomic studies on damage to bird bones by Snowy Owls Nyctea scandiaca, with comments on the survival of bones in palaeontological sites. Acta Zool. Cracov. 40 (2), 279–292.

Bochenski, Z.M., 2005. Owls, diurnal raptors and humans: signatures on avian bones. In: O'Connor, T. (Ed.), Biosphere to Lithosphere. New Studies in Vertebrate Taphonomy. Oxbow Books, Oxford, pp. 31–45.

Bochenski, Z.M., Tomek, T., 1994. Pattern of bird bone fragmentation in pellets of the Long-eared Owl Asio otus and its taphonomic implications. Acta Zool. Cracov. 37 (1), 177–190.

Bochenski, Z.M., Tomek, T., 1997. Preservation of bird bones: erosion versus digestion by owls. Int. J. Osteoarchaeol. 7 (4), 372–387.

Bochenski, Z.M., Nekrasov, A.E., 2001. The taphonomy of sub-Atlantic bird remains from Bazhukovo III, Ural Mountains, Russia. Acta Zool. Cracov. 44 (2), 93–106.

Bochenski, Z.M., Tornberg, R., 2003. Fragmentation and preservation of bird bones in uneaten food remains of the Gyrfalcon *Falco rusticolus*. J. Archaeol. Sci. 30 (12), 1665–1671.

Bochenski, Z.M., Tomek, T., Boev, Z., Mitev, I., 1993. Patterns of bird bone fragmentation in pellets of the Tawny Owl (Strix aluco) and the Eagle Owl (Bubo bubo) and their taphonomic implications. Acta Zool. Cracov. 36 (2), 313–328.

Bochenski, Z.M., Korovin, V.A., Nekrasov, A.E., Tomek, T., 1997. Fragmentation of bird bones in food remains of Imperial Eagles (Aquila heliaca). Int. J. Osteoarchaeol. 7 (2), 165–171.

Bochenski, Z.M., Huhtala, K., Sulkava, S., Tornberg, R., 1999. Fragmentation and preservation of bird bones in food remains of the Golden Eagle Aquila chrysaetos. Archaeofauna 8 (3), 31–39.
Bochenski, Z.M., Tomek, T., Tornberg, R., Wertz, K., 2009. Distinguishing nonhuman predation on birds: pattern of damage done by the white-tailed eagle Haliaetus albicilla, with comments on the punctures made by the golden eagle Aquila chrysaetos. J. Archaeol. Sci. 36 (1), 122–129.
Bovy, K.M., 2002. Differential avian skeletal part distribution: explaining the abundance of wings. J. Archaeol. Sci. 29 (9), 965–978.
Bovy, K.M., 2012. Why so many wings? A re-examination of avian skeletal part representation in the south-central Northwest Coast, USA. J. Archaeol. Sci. 39 (7), 2049–2059.
Bramwell, D., Yalden, D.W., Yalden, P.E., 1987. Black grouse as the prey of the golden eagle at an archaeological site. J. Archaeol. Sci. 14 (2), 195–200.
Broughton, J.M., Mullins, D., Ekker, T., 2007. Avian resource depression or intertaxonomic variation in bone density? A test with San Francisco Bay avifaunas. J. Archaeol. Sci. 34 (3), 374–391.
Cáceres, I. (2002). *Tafonomía de yacimientos antrópicos en karst. Complejo Galría (Sierra de Atapuerca, Burgos), Vanguard cave (Gibraltar) y Abric Romani (Capellades, Barcelona): tesis doctoral* (Doctoral dissertation, Universitat Rovira i Virgili. Facultat de Lletres. Departament d'Història i Geografia).
Carrión, J.S., Ochando, J., Fernández, S., Blasco, R., Rosell, J., Munuera, M., Finlayson, C., 2018. Last Neanderthals in the warmest refugium of Europe: Palynological data from Vanguard Cave. Rev. Palaeobot. Palynol. 259, 63–80.
Cochard, D., Brugal, J.P., Morin, E., Meignen, L., 2012. Evidence of small fast game exploitation in the Middle Paleolithic of Les Canalettes Aveyron, France. Quat. Int. 264, 32–51.
Cramp, S., & Brooks, D. J. (1992). *Handbook of the birds of Europe, the Middle East and North Africa. The birds of the western Palearctic, vol. VI. Warblers* (pp. 396-405). Oxford university Press, Oxford.
Cruz, I., 2005. La representación de partes esqueléticas de aves.Patrones naturales e interpretación arqueológica. Archaeofauna 14, 69–81.
De Cupere, B., Thys, S., Van Neer, W., Ervynck, A., Corremans, M., Waelkens, M., 2009. Eagle owl (*Bubo bubo*) pellets from Roman Sagalassos (SW Turkey): distinguishing the prey remains from nest and roost sites. Int. J. Osteoarchaeol. 19 (1), 1–22.
Delestrade, A., Stoyanov, G., 1995. Breeding biology and survival of the Alpine Chough Pyrrhocorax graculus. Bird Study 42 (3), 222–231.
Díaz, M., Asensio, B., Tellería, J.L. (1996). *Aves ibéricas* (Vol. 1). JM Reyero Editor.
Díez, C., García, M.A., Gil, E., Jordá, J.F., Ortega, A.I., Sánchez, A., Sánchez, B., 1989. La cueva de Valdegoba (Burgos).Primera campaña de excavaciones. Zephyrus 42, 55–74.
Díez, J.C., 2006. Huellas de descarnado en el Paleolítico Medio: La cueva de Valdegoba (Burgos). Zona Arqueol. 7, 305–318.
Díez, J.C., Jordá Pardo, F.J., Alonso, D.A., 2014. Valdegoba Palaeolithic site: (Huérmeces, Burgos). In: Sala, R. (Ed.), Pleistocene and Holocene Hunter-Gatherers in Iberia and the Gibraltar Strait: the Current Archaeological Record. Fundación Atapuerca, pp. 608–610.
Díez, J.C., Marco, A.S., Lara, V.M., 1995. Grupos avicaptores del Tardiglaciar: las aves de Berroberria. Munibe Antropologia-Arkeologia 47, 3–22.
Dodson, P., Wexlar, D., 1979. Taphonomic investigations of owl pellets. Paleobiology 5 (3), 275–284.
Ericson, P.G., 1987. Interpretations of archaeological bird remains: a taphonomic approach. J. Archaeol. Sci. 14 (1), 65–75.
Feranec, R., García, N., Díez, J.C., Arsuaga, J.L., 2010. Understanding the ecology of mammalian carnivorans and herbivores from Valdegoba cave (Burgos, northern Spain) through stable isotope analysis. Palaeogeogr. Palaeoclimatol. Palaeoecol. 297 (2), 263–272.
Fernández-Jalvo, Y., Andrews, P., 1992. Small mammal taphonomy of Gran Dolina, Atapuerca (burgos), Spain. J. Archaeol. Sci. 19 (4), 407–428.
Fernández-Jalvo, Y., Andrews, P., 2016. Atlas of taphonomic identifications: 1001+ images of fossil and recent mammal bone modification. Springer.
Finlayson, C., Brown, K., Blasco, R., Rosell, J., Negro, J.J., Bortolotti, G.R., Rodríguez Llanes, J.M., 2012. Birds of a feather: Neanderthal exploitation of raptors and corvids. PLoS One 7 (10), 10.1371.
Finlayson, C., Finlayson, S., Guzman, F.G., Marco, A.S., Finlayson, G., Jennings, R., Vidal, J.R., 2016. Using birds as indicators of Neanderthal environmental quality: Gibraltar and Zafarraya compared. Quat. Int. 421, 32–45.
Fiore, I., Gala, M., Romandini, M., Cocca, E., Tagliacozzo, A., Peresani, M., 2016. From feathers to food: Reconstructing the complete exploitation of avifaunal resources by Neanderthals at Fumane cave, unit A9. Quat. Int. 421, 134–153.
Fiore, I., Gala, M., Boschin, F., Crezzini, J., Tagliacozzo, A., Moroni, A., 2020. Archeozoology and taphonomy of bird remains from Grotta di Castelcivita (Salerno, Italy) and clues for human-bird interactions. Quat. Int. 551, 224–242.
Garcia-Fermet, T., Testu, A., Moigne, A.M., Saos, T., Grégoire, S., 2023. The bird remains from La Crouzade Cave (Gruissan, Aude): the mixed origin of a Middle Palaeolithic bone accumulation. Quat. Environ. Hum. 1, 100001.
Gaudzinski, S., Roebroeks, W., 2000. Adults only. Reindeer hunting at the middle palaeolithic site salzgitter lebenstedt, northern Germany. J. Hum. Evol. 38 (4), 497–521.
Gaudzinski-Windheuser, S., Kindler, L., MacDonald, K., Roebroeks, W., 2023. Hunting and processing of straight-tusked elephants 125.000 years ago: Implications for Neanderthal behavior. Sci. Adv. 9 (5), eadd8186.
Goffette, Q., Germonpré, M., Lefèvre, C., Brecko, J., Goemaere, E., Rots, V., 2020. Bird bones from Trou de Chaleux and the human exploitation of birds during the late Magdalenian in Belgium. J. Archaeol. Sci. Rep. 29, 102096.
Goffette, Q., Rots, V., Abrams, G., Pirson, S., Di Modica, K., Bray, F., Amos, L., 2024. Neanderthal exploitation of birds in north-western Europe: Avian remains from Scladina Cave (Belgium). Front. Environ. Archaeol. 3, 1441926.
Gómez-Olivencia, A., Sala, N., Núñez-Lahuerta, C., Sanchis, A., Arlegi, M., Rios-Garaizar, J., 2018. First data of Neandertal bird and carnivore exploitation in the Cantabrian region (Axlor; Barandiaran excavations; Dima, Biscay, Northern Iberian Peninsula). Sci. Rep. 8 (1), 10551.
Güleç, E., White, T., Kuhn, S., Özer, I., Sağır, M., Yılmaz, H., Howell, F.C., 2009. The lower pleistocene lithic assemblage from Dursunlu (Konya), Central Anatolia, Turkey. Antiquity 83 (319), 11–22.
Hardy, B.L., Moncel, M.H., Daujeard, C., Fernandes, P., Béarez, P., Desclaux, E., Gallotti, R., 2013. Impossible Neanderthals? Making string, throwing projectiles and catching small game during Marine Isotope Stage 4 (Abri du Maras, France). Quat. Sci. Rev. 82, 23–40.
Hargrave, L.L., 1970. Mexican macaws: comparative osteology and survey of remains from the southwest. University of Arizona Press, Tucson AZ.
Huguet, R., Saladié, P., Cáceres, I., Díez, C., Rosell, J., Bennàsar, M., Carbonell, E., 2013. Successful subsistence strategies of the first humans in south-western Europe. Quat. Int. 295, 168–182.
Laroulandie, V., 2000. Taphonomie et archéozoologie des Oiseaux en grotte: applications aux sites paléolithiques du Bois-Ragot (Vienne), de Combe Saunière (Dordogne) et de La Vache (Ariège). Université Sciences et Technologies-Bordeaux I). Doctoral dissertation.
Laroulandie, V. (2002). Damage to pigeon long bones in pellets of the eagle owl Bubo bubo and food remains of peregrine falcon (*Falco peregrinus*): zooarchaeological implications. In *ZM Bochenski, Z. Bochenski, JR Stewart (Eds.), Proceedings of the 4th Meeting of the ICAZ Bird Working Group, Krakow, Poland, 11-15 september 2001. Acta Zoologica cracoviensia (V*ol. 45, pp. 331-339). Institute of Systematics and Evolution of Animals, Polish Academy of Sciences.
Laroulandie, V. (2003). Exploitation des Oiseaux au Magdalénien en France: Etat des lieux. In S. Costamagno, V. Laroulandie (Eds.), Mode de vie au Magdalénien: Apports de l'archéozoologie/Zooarchaeological insights into Magdalenian lifeways. Actes du colloque 6.4 du XIVe Congrès du l'UISPP, Liège, Belgique, 2-8 septembre 2001. BAR n° 1144 (Vol. 1144, pp. 129-138). Archaeopress, British Archaeological Reports.
Laroulandie, V. (2005). Bird exploitation pattern: the case of Ptarmigan Lagopus sp. in the Upper Magdalenian site of La Vache (Ariège, France). In G. Grupe, J. Peters (Eds.), Feathers, grit and symbolism. Birds and humans in the ancient Old and New Worlds. Proceedings of the 5th Meeting of the ICAZ Bird Working Group, Munich, 26-28 July 2004.(Documenta Archaeobiologiae 3) (pp. 165-178). Verlag Marie Leidorf.
Laroulandie, V. (2010). Alpine chough *Pyrrhocorax graculus* from Pleistocene sites between Pyrenees and Alps: Natural versus Cultural Assemblages. In 6th Bird Working Meeting (BWG) of ICAZ (pp. 219-232). Barkhuis.
Laroulandie, V., Costamagno, S., Cochard, D., Mallye, J. B., Beauval, C., Castel, J. C., ... & Rendu, W. (2008, October). Quand désarticuler laisse des traces: le cas de l'hyperextension du coude. In Annales de paléontologie (Vol. 94, No. 4, pp. 287-302). Elsevier Masson.
Laroulandie, V., Faivre, J.P., Gerbe, M., Mourre, V., 2016. Who brought the bird remains to the Middle Palaeolithic site of Les Fieux (Southwestern, France)? Direct evidence of a complex taphonomic story. Quat. Int. 421, 116–133.
Laroulandie, V., Morin, E., Soulier, M.C., Castel, J.C., 2020. Bird procurement by humans during the Middle and early Upper Paleolithic of Europe: New data for the Aurignacian of southwestern France. Quat. Int. 543, 16–24.
Lefèvre, C., & Pasquet, E. (1994). Les modifications post-mortem chez les oiseaux: l'exemple de l'avifaune holocène de Patagonie australe. Outillage peu élaboré en os et en bois de Cervidés IV: 6è table ronde Taphonomie/Bone modification, Paris, septembre 1991, 9, 217-229.
Livezey, B.C., Zusi, R.L., 2007. Higher-order phylogeny of modern birds (Theropoda, Aves: Neornithes) based on comparative anatomy. II. Analysis and discussion. Zool. J. Linn. Soc. 149 (1), 1–95.
Livingston, S.D., 1989. The taphonomic interpretation of avian skeletal part frequencies. J. Archaeol. Sci. 16 (5), 537–547.
Lloveras, L., Nadal, J., Moreno-García, M., Thomas, R., Anglada, J., Baucells, J., Vilasís, D., 2014a. The role of the Egyptian Vulture (*Neophron percnopterus*) as a bone accumulator in cliff rock shelters: an analysis of modern bone nest assemblages from North-eastern Iberia. J. Archaeol. Sci. 44, 76–90.
Lloveras, L., Thomas, R., Lourenço, R., Caro, J., Dias, A., 2014b. Understanding the taphonomic signature of Bonelli's Eagle (*Aquila fasciata*). J. Archaeol. Sci. 49, 455–471.
Lloveras, L., Garcia, L., Maroto, J., Soler, J., Soler, N., 2018. The bird assemblage from the Middle Palaeolithic level I of Arbreda Cave: A taphonomic story. J. Archaeol. Sci. Rep. 21, 758–770.
Lloveras, L., Salazar, R., García-Argüelles, P., Nadal, J., 2020. Birds and Epipalaeolithic hunter-gatherers in northeast Iberia. The case of the Balma del Gai site. Quat. Int. 543, 25–33.
Lloveras, L., Garcia, L., Marqueta, M., Maroto, J., Soler, J., Soler, N., 2022. The role of birds in Upper Palaeolithic sites: Zooarchaeological and taphonomic analysis of the avian remains from Arbreda Cave (Serinyà, northeast Iberia). Quat. Int. 626, 22–32.
Lyman, R.L., 1994. Vertebrate taphonomy. Cambridge University Press.
Majkić, A., Evans, S., Stepanchuk, V., Tsvelykh, A., d'Errico, F., 2017. A decorated raven bone from the Zaskalnaya VI (Kolosovskaya) Neanderthal site, Crimea. PLoS One 12 (3), e0173435.
Mallye, J.B., Cochard, D., Laroulandie, V.A., 2008. July). Accumulations osseuses en périphérie de terriers de petits carnivores: les stigmates de prédation et de fréquentation. Paléontol. 94 (3), 187–208.

Marqueta, M., Huguet, R., Núñez-Lahuerta, C., 2023. Accumulation agents and bird assemblages: The case of the TE9d level at Sima del Elefante (Sierra de Atapuerca, Spain). Int. J. Osteoarchaeol. 33 (4), 652–667.
Martínez-Valle, R., Calatayud, P.M.G., Bonilla, V.V., 2016. Bird consumption in the final stage of Cova Negra (Xátiva, Valencia). Quat. Int. 421, 85–102.
Monchot, H., & Gendron, D. (2009). Les restes d'une tanière de renard en milieu périglaciare (Île Digges, rive sud du détroit d'Hudson, Canada). Taphonomie des petits vertébrés: Référentiels et transferts aux fossiles. Actes de la table ronde du RTP Taphonomie, Talence 20-21 octobre 2009, 65-76.
Morin, E., Laroulandie, V., 2012. Presumed symbolic use of diurnal raptors by Neanderthals. PLoS One 7 (3), e32856.
Morin, E., Meier, J., El Guennouni, K., Moigne, A.M., Lebreton, L., Rusch, L., Cochard, D., 2019. New evidence of broader diets for archaic Homo populations in the northwestern Mediterranean. Sci. Adv. 5 (3), eaav9106.
Nabais, M., Zilhão, J., 2019. The consumption of tortoise among last interglacial Iberian Neanderthals. Quat. Sci. Rev. 217, 225–246.
Nabais, M., Rufà, A., Igreja, M., 2024. Experimental replication of early human behaviour in bird preparation: a pilot-study focusing on bone surface modification and breakage patterns. Front. Environ. Archaeol. 3, 1411853.
Negro, J.J., Blasco, R., Rosell, J., Finlayson, C., 2016. Potential exploitation of avian resources by fossil hominins: An overview from ethnographic and historical data. Quat. Int. 421, 6–11.
Noe-Nygaard, N., 1989. Man-made trace fossils on bones. Hum. Evol. 4, 461–491.
Ochando, J., Amorós, G., Carrión, J.S., Fernández, S., Munuera, M., Camuera, J., Finlayson, C., 2022. Iberian Neanderthals in forests and savannahs. J. Quat. Sci. 37 (2), 335–362.
Peresani, M., Fiore, I., Gala, M., Romandini, M., Tagliacozzo, A., 2011. Late Neandertals and the intentional removal of feathers as evidenced from bird bone taphonomy at Fumane Cave 44 ky BP. Italy. Proc. Natl. Acad. Sci. 108 (10), 3888–3893.
Pérez, L., 2014. La gestión de los recursos animales en los Valles de Alcoy durante el Pleistoceno Superior (MIS 3): Estudio zooarqueológico y tafonómico. Universitat Rovira i Virgili, Tarragona. Unpublished Master Dissertation.
Pérez, L. (2019). Estrategias de subsistencia y dinámicas de asentamiento en los Valles de Alcoy durante el Paleolítico medio. Análisis zooarqueológico, tafonómico y paleoecológico de la secuencia arqueológica de El Salt (Alcoy, Alicante). Doctoral dissertation, Universitat Rovira i Virgili. Facultat de Lletres. Departament d'Història i Geografia. http://hdl.handle.net/10803/668396.
Pérez, L., 2023. Subsistencia neandertal en los valles de Alcoi: análisis de los conjuntos faunísticos del yacimiento de El Salt (Alicante). Diputación de València Servicio de Investigación Prehistórica del Museo de Prehistoria de Valencia.
Quam, R.M., Arsuaga, J.L., Bermúdez de Castro, J.M., Díez, J.C., Lorenzo, C., Carretero, M., Ortega, A.I., 2001. Human remains from Valdegoba Cave (Huérmeces, Burgos, Spain). J. Hum. Evol. 41 (5), 385–435.
Radovčić, D., Sršen, A.O., Radovčić, J., Frayer, D.W., 2015. Evidence for Neandertal jewelry: modified white-tailed eagle claws at Krapina. PLoS One 10 (3), e0119802.
Real, C. (2017). Estudio arqueozoológico y tafonómico del magdaleniense de la Cova de les Cendres (Teulada-Moraira, Alicante). Doctoral dissertation, Universitat de Valencia. http://hdl.handle.net/10550/58478.
Real, C., Morales, J.V., Sanchis, A., Pérez, L., Pérez-Ripoll, M., Villaverde, V., 2022. Archaeozoological studies: new database and method based on alphanumeric codes. Archeofauna 31, 133–141.
Richards, M.P., Trinkaus, E., 2009. Isotopic evidence for the diets of European Neanderthals and early modern humans. Proceed. Natl. Acad. Sci. 106 (38), 16034–16039.
Ripoll, M. P. (2001). Marcas antrópicas en los huesos de conejo. In De neandertales a cromañones: el inicio del poblamiento en las tierras valencianas (pp. 119-124). Servicio de Publicaciones= Servei de Publicacions.
Rodríguez-Gómez, G., Pérez-Fernández, E., Fernandez, P., Arsuaga, J.L., Díez, C., Arceredillo, D., 2022. Palaeoecology of the Southern chamois from Valdegoba Cave (Burgos, Spain) and its exploitation by the Neanderthals. Lethaia 55 (4), 1–25.
Rodriguez-Hidalgo, A., Saladie, P., Olle, A., Arsuaga, J.L., de Castro, J.M.B., Carbonell, E., 2017. Human predatory behavior and the social implications of communal hunting based on evidence from the TD10. 2 bison bone bed at Gran Dolina (Atapuerca, Spain). J. Hum. Evol. 105, 89–122.
Rodríguez-Hidalgo, A., Morales, J.I., Cebriá, A., Courtenay, L.A., Fernández-Marchena, J. L., García-Argudo, G.G., Fullola, J.M., 2019. The châtelperronian Neandertals of Cova Foradada (Calafell, Spain) used Iberian imperial eagle phalanges for symbolic purposes. Sci. Adv. 5 (11), e27133v2.
Rodríguez-Hidalgo, A., Saladié, P., Marín, J., Canals, A., 2016. Bird-bone modifications by Iberian lynx: A taphonomic analysis of non-ingested red-legged partridge remains. Quat. Int. 421, 228–238.
Romandini, M., Peresani, M., Laroulandie, V., Metz, L., Pastoors, A., Vaquero, M., Slimak, L., 2014. Convergent evidence of eagle talons used by late Neanderthals in Europe: a further assessment on symbolism. PLoS One 9 (7), e101278.
Romero, A.J., Díez, J.C., Rodríguez, L., Arceredillo, D., 2016. Anthropic fractures and human tooth marks: An experimental approach to non-technological human action on avian long bones. Quat. Int. 421, 219–227.
Romero, A.J., Díez, J.C., Brugal, J.P., 2017. Aves de caza. Estudio tafonómico y zooarqueológico de los restos avianos de los niveles musterienses de Pié Lombard (Alpes-Maritimes, Francia). Munibe 68, 73–84.
Royer, A., Montuire, S., Gilg, O., Laroulandie, V., 2019. A taphonomic investigation of small vertebrate accumulations produced by the snowy owl (Bubo scandiacus) and its implications for fossil studies. Palaeogeogr. Palaeoclimatol. Palaeoecol. 514, 189–205.
Rufà, A., Laroulandie, V., 2019. Prey size as a critical factor for bird bone taphonomy in Eagle Owl (Bubo bubo) pellets. Sci. Rep. 9 (1), 19200.
Rufà, A., Laroulandie, V., 2020. Carnívoros y carroñeros. Una nueva visión sobre la depredación de los lobos sobre las aves carroñeras y su implicación en el registro arqueológico. ArkeoGazte 10, 127–140.
Rufà, A., Laroulandie, V., 2021. Unravelling the Taphonomic stories of bird bones from the middle Pleistocene layer VIII of Grotte Vaufrey, France. Quat. 4 (4), 30.
Rufà, A., Blasco, R., Rivals, F., Rosell, J., 2014. Leporids as a potential resource for predators (hominins, mammalian carnivores, raptors): an example of mixed contribution from level III of Teixoneres Cave (MIS 3, Barcelona, Spain). C. r. Palevol 13 (8), 665–680.
Sala, N., Arsuaga, J.L., 2018. Regarding beasts and humans: a review of taphonomic works with living carnivores. Quat. Int. 466, 131–140.
Sánchez-Marco, A., 2004. Avian zoogeographical patterns during the Quaternary in the Mediterranean region and paleoclimatic interpretation. Ardeola 51 (1), 91–132.
Sánchez-Marco, A. (2005). Avifaunas cuaternarias de la Península Ibérica: sistemática, paleoecología y paleozoogeografía (Doctoral dissertation, Universidad Autónoma de Madrid). http://hdl.handle.net/10486/673842.
Sánchez-Marco, A., Quesada, C.C., 2010. Avian wings as ornaments in the Magdalenian? Archaeofauna 19 (1), 133–139.
SEO BirdLife, 2024. https://seo.org/ (accessed 2024 September 10).
Smith, G.M., 2015. Neanderthal megafaunal exploitation in Western Europe and its dietary implications: A contextual reassessment of La Cotte de St Brelade (Jersey). J. Hum. Evol. 78, 181–201.
Speth, J.D., Tchernov, E., 2002. Middle Paleolithic tortoise use at Kebara cave (Israel). J. Archaeol. Sci. 29 (5), 471–483.
Steadman, D.W., Plourde, A., Burley, D.V., 2002. Prehistoric butchery and consumption of birds in the Kingdom of Tonga, South Pacific. J. Archaeol. Sci. 29 (6), 571–584.
Stiner, M.C., 1995. Neanderthal Carnivory: Honor Among Thieves. A Zooarchaeological Study of Neandertal Ecology. Princeton University Press, Princeton.
Stiner, M.C., Munro, N.D., Surovell, T.A., 2000. The tortoise and the hare: small-game use, the broad-spectrum revolution, and Paleolithic demography. Curr. Anthropol. 41 (1), 39–79.
Tagliacozzo, A., & Gala, M. (2004). L'avifauna dei livelli 24-22 (Aurignaziano e Gravettiano antico) di Grotta Paglicci: l'aspetto ambientale e quello economico. Paglicci. L'Aurignaziano e il Gravettiano antico. Foggia, Claudio Grenzi Editore, 71-89.
Terradillos-Bernal, M., Díez, J.C., 2018. La tecnología lítica neandertal de Valdegoba en el contexto del Paleolítico medio de la Meseta norte. Trab. Prehist. 75 (2), 320–332.
Val, A., de la Peña, P., Wadley, L., 2016. Direct evidence for human exploitation of birds in the Middle Stone Age of South Africa: The example of Sibudu Cave, KwaZulu-Natal. J. Hum. Evol. 99, 107–123.
Villa, P., Mahieu, E., 1991. Breakage patterns of human long bones. J. Hum. Evol. 21 (1), 27–48.
Villa, P., Castel, J.C., Beauval, C., Bourdillat, V., Goldberg, P., 2004. Human and carnivore sites in the European Middle and Upper Paleolithic: similarities and differences in bone modification and fragmentation. Rev. Paléobiol. 23 (2), 705–730.
Wertz, K., Tornberg, R., Bochenski, Z.M., 2021. The taphonomy of medium-sized grouse in food remains of the northern goshawk Accipiter gentilis, compared with damage done by man and other predators. Int. J. Osteoarchaeol. 31 (2), 188–195.