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Archeozoology and taphonomy of bird remains from Grotta di Castelcivita (Salerno, Italy) and clues for human-bird interactions

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ABSTRACT

Grotta di Castelcivita (Campania, Southern Italy) is a cave-site containing a key archaeological sequence for the study of the Middle to Upper Palaeolithic transition in Southern Italy. A Late Mousterian occupation, whose modelled dates span from 47.6 to 41.1 ka cal BP, is followed by layers bearing evidence of the Uluzzian techno-complex, which underlie an articulated Protoaurignacian sequence. The prehistoric deposit is sealed by volcanic sediments attributed to the Campanian Ignimbrite (dated to 39.85 ± 0.14 ka BP), which represent a *terminus ante quem* for the Palaeolithic occupation of the cave. We present here the study of the avifauna collected during the excavations carried out at Castelcivita by the University of Siena in the years 1975–88. The examined sample is composed of 631 specimens, out of which 486 have been identified according to species, genus, family or order. Bird remains belong to 36 species and at least to 175 individuals. In the Late Mousterian the abundance of species adapted to open environments indicates a cool-temperate climate; water birds, and wood and forest birds are present as well. During the Uluzzian a shift towards colder climatic conditions is testified by the increase in steppe grassland species. In the Protoaurignacian the presence of birds of open and dry environments is more marked, even if climate seems to shift toward milder conditions at the end of this phase. Taphonomic analyses have provided significant evidence for the exploitation of birds by humans across the whole sequence. Clues of human activity on bird remains are attested both in the Mousterian and, more rarely, in the Protoaurignacian by traces, possibly indicating the intentional removal of feathers (in the Mousterian) and other kinds of carcass manipulation. The Uluzzian sample is the richest in human modifications. Some of them are related to an interest for feathers (on *Pyrrhocorax graculus, Falco subbuteo* and an Accipitriformes of large size). Other modifications (fresh bone fractures, burntbones, peeling, *arrachement*) testifytocarcasstreatmentsof Galliformes, Anseriformes, Columbiformes, Charadriiformes and Passeriformes. In the Protoaurignacian traces due to anthropogenic activity are rare and there is an increase in bone modifications caused by carnivores. Results allow us to assume that at Castelcivita humans consistently hunted birds for several purposes and exploited (especially during the Uluzzian) some species to acquire an exclusive and ethnographically well-documented resource such as feathers.

1. Introduction

Bird bones are an important category of archaeological remains as they provide crucial information for reconstructing palaeoenvironments and human behaviour in prehistoric sites. Taphonomic analyses play a crucial role in palaeontological and zooarchaeological studies, not only for understanding the origin of the accumulation of bone remains, but also for verifying their actual exploitation by humans. The systematic capture of birds for subsistence has always been considered an activity specific to modern humans. Ethnographic data on hunter-gatherer populations suggest that advanced technologies (traps, nets, bows and arrows) are needed to systematically capture large quantities of birds. These technologies have been archaeologically attested almost exclusively for *Homo sapiens* and, up to now, evidence for the capture of thousands of birds belonging to hundreds of different species, has been found only among final Palaeolithic hunter-gatherers, like, for example, in Italy, at Grotta Romanelli (Apulia) (Cassoli and Tagliacozzo, 1997a; Tagliacozzo and Gala, 2000; Cassoli et al., 2003; Gala et al., 2009; Gala and Tagliacozzo, 2010) and Grotta della Madonna (Calabria) (Tagliacozzo and Gala, 2002; Gala and Tagliacozzo, 2004; Gala et al., 2016). Considering in general the spectrum of birds exploited by Palaeolithic groups, even if a clear-cut separation among species involved does not transpire, studies ((Blasco and Peresani, 2016 and references therein)) consistently support the idea

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that some birds, especially corvids and raptors, were often exploited not only for meat but also to obtain other resources such as feathers and bones to make ornaments. Other birds, such as, for instance, Anseriformes, were, instead, preferred as food.

In Lower Palaeolithic sites there is only sporadic evidence of bird exploitation, mostly for food procurement, with the exception of Cova Bolomor in Spain (MIS 9-5e) whose bird consumption pattern, mainly including food but also other resources such as feathers, recalls that observed during the Upper Palaeolithic (Blasco et al., 2013).

Taphonomic analyses carried out on several European sites point to the fact that late Pleistocene Neanderthals exploited a variety of species for their meat contents, but were focused on corvids and raptors of different sizes for the specific selection of feathers and claws (Fiore et al., 2004, 2016; Blasco, 2009; Peresani et al., 2011; Morin and Laroulandie, 2012; Radovcic et al., 2015; Laroulandie et al., 2016). At the onset of the Upper Paleolithic (Protoaurignacian/Early Aurignacian), while in the rest of Europe the exploitation of birds as food becomes progressively more common (Bochenski et al., 2009; Laroulandie et al., 2016; Romandini et al., 2016, Table 1; Rodríguez-Hidalgo et al., 2018), in Italy the use of birds for food purposes does not show a real increase. Conversely a remarkable change attesting a spread of this practice appears during the late Upper Paleolithic, both in Italy and in the rest of Europe (Laroulandie, 2003; Gala et al., 2018).

Over the last 10 years the available data demonstrating the systematic hunting of birds by Neanderthals and human groups living in Europe during the Middle to Upper Palaeolithic transition, are the subject of an open debate within the international scientific community (Blasco, 2009; Peresani et al., 2011; Blasco and Peresani, 2016 and references therein). To date the presence of birds in Mousterian and Early Upper Paleolithic sites is commonly referred to as being due to sporadic and opportunistic catches, with very low estimates of meat yield. What can we say, then, about when true bird hunting began? Were humans only interested in meat? Or could birds also offer exclusive materials not provided by other animals, such as feathers?

In our study we wish to take part in this discussion by presenting taphonomic data on bird specimens from Castelcivita. Our analysis confirms what emerged from the studies cited above suggesting that bird exploitation was not limited to food procurement only, but also involved the removal of feathers. At Castelcivita this is especially true for the Uluzzian phase.

Therefore the aim of this paper is to make available new data on these intriguing and debated questions; thus contributing to shedding new light on what the true interest in birds was for Palaeolithic people.

2. Site presentation and environmental background

Grotta di Castelcivita is a cave site opening at the foot of the Alburni massif (municipality of Castelcivita, Salerno, Campania, Southern Italy), close to the right bank of the Calore River, at an altitude of about 94 m a.s.l. (40.48° Lat., 15.23° Long.). The hypogean system extends for more than 5 km and consists of a network of tunnels and rooms developing inside the carbonatic rocks. The archaeological deposit is located at the cave mouth, where first systematic excavations were undertaken by Prof. P. Gambassini (University of Siena) between 1975 and 1988 (Gambassini, 1997a). From 2015 onwards fieldwork was resumed by the same University, under the direction of Prof. A. Ronchitelli and in collaboration with the local archaeological office (Fig. 1).

The 3.4 m deep stratigraphy (excavated on an area of 12 square meters) preserves evidence of an important cultural sequence,

Table 1
NISP of mammal *taxa* at Castelcivita, according to the different techno-complexes. Data from Masini and Abbazzi (1997).

Taxa	Mousterian		Uluzzian		Protoaurigı acian	
	NISP	%	NISP	%	NISP	%
Stephanorhinus sp.	1	0.2	0	0.0	0	0.0
Equus ferus	3	0.6	73	25.5	11	11.2
Sus scrofa	7	1.5	8	2.8	11	11.2
Cervus elaphus	107	22.2	49	17.1	32	32.7
Capreolus capreolus	29	6.0	34	11.9	10	10.2
Dama dama	137	28.5	20	7.0	2	2.0
Cervidae indet.	17	3.5	5	1.7	3	3.1
Bison priscus	10	2.1	9	3.1	7	7.1
Bos/Bison	4	0.8	8	2.8	0	0.0
Capra ibex	53	11.0	12	4.2	4	4.1
Rupicapra sp.	85	17.7	25	8.7	13	13.3
Canis lupus	0	0.0	1	0.3	2	2.0
Vulpes vulpes	0	0.0	4	1.4	0	0.0
Ursus spelaeus	1	0.2	1	0.3	0	0.0
Ursus arctos	0	0.0	4	1.4	0	0.0
Mustela nivalis	1	0.2	3	1.0	0	0.0
Martes sp.	0	0.0	0	0.0	0	0.0
Meles meles	0	0.0	2	0.7	0	0.0
Mustelidae	0	0.0	2	0.7	0	0.0
Crocuta crocuta spelaea	11	2.3	7	2.4	1	1.0
Felis silvestris	0	0.0	5	1.7	0	0.0
Panthera pardus	4	0.8	5	1.7	0	0.0
Panthera leo spel.	0	0.0	0	0.0	0	0.0
Carnivora indet.	11	2.3	9	3.1	2	2.0
Total Ungulata	**453**	**94.2**	**243**	**85.0**	**93**	**94.9**
Total Carnivora	**28**	**5.8**	**43**	**15.0**	**5**	**5.1**
Total Mammal bones	**481**	**100**	**286**	**100**	**98**	**100**
Total Bird bones	62	11.4180478821363	295	50.7745266781411	129	56.83

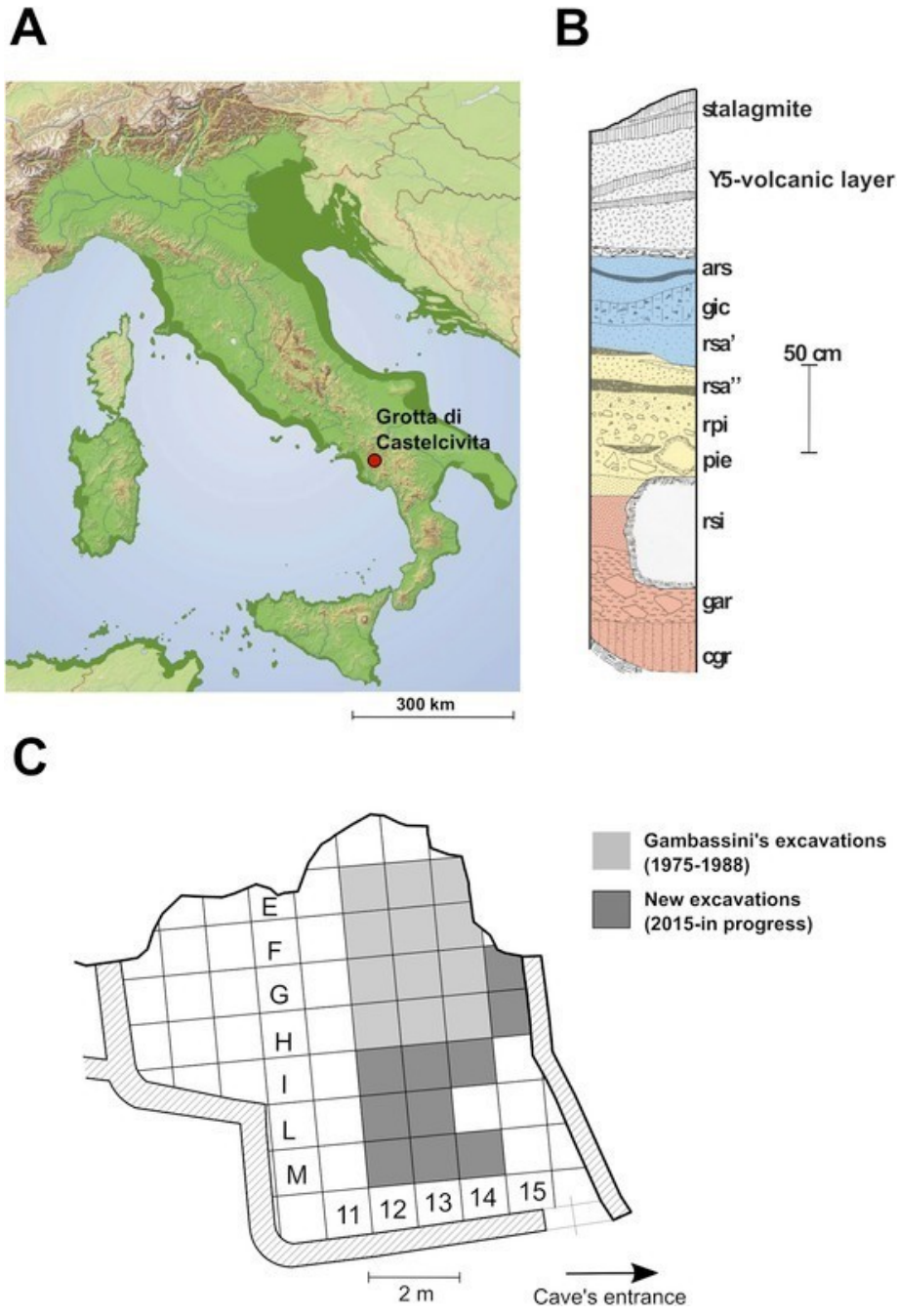

Fig. 1. (A) Location of Grotta di Castelcivita (modified from Moroni et al. (2018), sea level 70 m below the present-day coastline (Benjamin et al., 2017); (B) schematic stratigraphic sequence of Grotta di Castecivita; (C) excavated area (F. Boschin).

spanning from the Late Mousterian to the Protoaurignacian, i.e. the period of transition from Neanderthals to modern humans (Gambassini, 1997b; Wood et al., 2012; Douka et al., 2014; Higham et al., 2014). The three lowermost layers (cgr, gar and lower-rsi) yielded a late Mousterian assemblage characterized by the predominant use of the Levallois concept. The modelled date range of layer cgr spans from 47.6 to 41.1 ka cal BP (95.4% prob.), with an end boundary of 45.7–41.3 ka cal BP(Higham et al., 2014). Levels upper-rsi, pie, rpi and rsa" are related to the Uluzzian technocomplex, whose uppermost phase (layer rsa") was radiocarbon dated to 41.9–40.6 ka cal BP (95.4% prob.) (Wood et al., 2012). Overlying layers rsa', gic and ars contain the Protoaurignacian occupation which probably started soon after 41–42 ka cal. BP (Douka et al., 2014). The early phase of the Protoaurignacian (layer rsa') is marked by the occurrence of marginally backed bladelets, also of the Dufour type. Afterwards (layers gic-ars) a new tool, the so-called micro-point of Castelcivita, becomes the most characteristic implement in the lithic assemblage (Gambassini, 1997b). The Protoaurignacian deposit is sealed by volcanic sediments attributed to the Y5 event (Campanian Ignimbrite) dated to 39.85 ± 0.14 ka BP (Giaccio et al., 2017).

Mammal remains were first identified by Masini and Abbazzi (1997) with the aim of reconstructing palaeoenvironments and past climatic fluctuations. More in-depth taphonomic and zooarchaeological studies are in progress (Table 1). Macrofaunal data attest the occurrence of a first phase (Mousterian layer gar, spits 32–24) characterized by temperate and humid climate: cervid taxa (especially the

fallow deer, *Dama dama*) are abundant, and *Apodemus* sp. and *Microtus* (*Terricola*) sp. are the dominant taxa among small mammals. Other species, related to woody environments, like *Glis glis*, are also present.

In the ensuing phase (Mousterian layers gar and rsi, spits 23–18) there is a reduction in fallow deer, an increase in chamois (*Rupicapra pyrenaica*) and, among small mammals, a substitution of *Microtus* (*Terricola*) sp. with *Microtus agrestis*/*arvalis*. This pattern indicates the spread of more open environments but still in quite humid climatic conditions. In the early Uluzzian (layers rsi and pie, spits 17–15) a climatic shift toward colder and drier conditions has been detected, as testified by the increase in horse (*Equus ferus*) and *Microtus arvalis*. Subsequently (Uluzzian layers pie, rpi and rsa", spits 14–10) cold and arid conditions were well established, as indicated by the quasi absence of fallow deer, the dominance of horse and the abundance of *Microtus arvalis/agrestis*. This climatic setting persists also during the early phase of the Protoaurignacian (layer rsa'), whilst a new climatic shift characterizes the uppermost part of the sequence (Protoaurignancian layers gic and ars), when the almost complete disappearance of horse is counterbalanced by a new increase in red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and chamois (Masini and Abbazzi, 1997).

3. Materials and methods

Most of the avifauna remains presented in this study were the subject of a former paleontological analysis (Cassoli and Tagliacozzo, 1997b) carried out on the materials yielded by Gambassini's excavations (1975–88). A sample of more than 100 bones from the same excavations, found during a recent revision of animal bone fragments previously considered as "unidentifiable", has been added to the study.

The taxonomic determination of the species was carried out using the comparative collections of the Bioarchaeology Laboratory at the Museo delle Civiltà - museo preistorico etnografico "Luigi Pigorini", of the Istituto Italiano di Paleontologia Umana in Anagni, and of the Laboratorio di Paleoantropologia - Dipartimento di Biologia of the Università di Firenze (Borzatti Von Löwenstern's collection). For some specimens no specific attribution was possible. They were determined by genus, family or order. The indeterminate remains mainly consist of phalanges, vertebrae and fragments of small long bones.

The taxonomic sequence and the related nomenclature follow the indications of Clements et al. (2018), and the adopted anatomical nomenclature is according to Baumel and Witmer (1993). The measurements of the main findings were taken following the indications proposed by von den Driesch (1976). Data on the geographical distribution and ecology of the various bird species are derived from Spina and Volponi (2008).

The number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) were calculated.

For taphonomic analyses, surface alterations produced by humans were observed both macroscopically and microscopically. The analyses were carried out with the aid of stereomicroscopes and Nikon SMZ 1000, 8e80 (Bioarchaeology laboratory at the Museo delle Civiltà-museo preistorico etnografico. Luigi Pigorini), with the metallographic microscope and with SEM (Dipartimento di Scienze dell'Antichità, La Sapienza Università di Roma). The aim was to identify and localize the different types of traces as well as to reconstruct the actions at their origin. Araldite casts of bone surfaces with marks were prepared. For molding, we used silicon elastomers (Provil Novo) and high-resolution positive casts were made with epoxy resin (Araldite LY-554 and hardener Hy 956). The casts have a high precision as they reproduce details below 1μ. The observation of the positive casts made of transparent resin, under both the Stereo and the Metallographic with transmitted light Microscopes, allowed us to obtain detailed images with evidence of the microscopic characteristics of the traces even at low magnification. Furthermore, the small size of the casts facilitated positioning and focusing for analysis as well as taking photographs; performing such actions on the original fragments would have been difficult because of the convexity of the bone and the position of the striae or other modifications.

Damages observed on bird remains included cut-marks made by stone tools, fresh bone breakages, over-extension (peeling and *arrachement*), burning, human and carnivore tooth-marks, and digestion. Fresh bone breaks cannot be considered to be of anthropogenic origin but only when they are associated with other modifications (burns, impacts, cuts etc.). Therefore, as in other studies (Villa and Mahieu, 1991; Romero et al., 2016), particular attention was given to the fragment preservation state, the presence of crushing, the degree of fracturing, the regularity and inclination of the fractured edge, and the length of the fractured edge with respect to bone thickness.

Digested Bones are difficult to identify as they bear evidence of rounding and polishing similar to those due to the abrasion of sediment and water action (Fernández-Jalvo and Andrews, 2016). In our case erosion traces are weak and do not allow a certain attribution; therefore we treated them as being "eroded probably digested".

Descriptive terminology of damages and suggestions for analysis and interpretation are derived from the works of several researchers (Cassoli and Tagliacozzo, 1997a; Laroulandie, 2000, 2005; Fiore et al., 2004; Bochenski, 2005; Laroulandie et al., 2008; Peresani et al., 2011; Finlayson et al., 2012; Fernández-Jalvo and Andrews, 2016 and references therein; Fiore et al., 2016; Romandini et al., 2016; Rufa et al., 2016; Pedergnana and Blasco, 2016; Gala et al., 2018).

Experimental tests have been carried out (Fiore, 2018) on a sample of present day bird bones six individuals of Helmeted Guinea fowl (*Numida meleagris)* and several individuals of chicken (*Gallus gallus*). These were of help in distinguishing traces due to cutting tools, human chewing and fracturing by flexion (Figs. 4, 8 and 9).

4. Results

4.1. Taxonomic and anatomical profile

The study of the avifauna from Castelcivita (Cassoli and Tagliacozzo, 1997b) allowed the identification of 631 bird remains; out of which 145 remained unidentified, and 486 were determined by species, genus, family or order (Table 2); they belong to at least 175 individuals of 36 distinct species, plus one large raptor which was absent in the previous study. These remains mainly cluster in the Uluzzian levels (295 remains corresponding to 89 individuals), show a reasonably high frequency in the Protoaurignacian levels (129 remains of 55 individuals), and are scantier in the Mousterian levels (62 remains of 31 individuals).

The determined remains largely belong to Galliformes with over 200 remains and 50 individuals of 3 species, mainly represented by the Gray and the Rock Partridge (*Perdix perdix* and *Alectoris graeca*) as well as by the Common Quail (*Coturnix coturnix)*. The remains of Passeriformes (over 100) are less abundant with 51 individuals of 8 species and 3 families (Corvidae, Hirundinidae and Turdidae). Among the Corvidae the Yellow-billed Chough (*Pyrrhocorax graculus)* dominates (54 remains and 18 individuals). The Columbiformes (34 remains and 11 individuals) are well represented in all the levels of the cave. The other orders are represented by a number of remains ranging from 34 (Anseriformes) to one (Caprimulgiformes), and exclusively in the case of the Anseriformes, Charadriiformes and Strigiformes the number of species is relevant.

Few remains provide important information on sex and age. Among these a proximal femur of *Perdix perdix* from the Uluzzian levels presents an evident medullary bone, while two other fragments, a distal femur of *Coturnix coturnix* and a proximal tarsometarsus of

Table 2
Bird remains from Grotta di Castelcivita: NISP, no. of identified specimens; MNI, minimum no. of individuals; MNE, minimum no. of elements.

Taxa	Mousterian				Uluzzian				Protoaurignacian				Total			
	NISP	%	MNI	MNE	NISP	%	MNI	MNE	NISP	%	MNI	MNE	NISP	%	MNI	%
Spatula querquedula	2	3.2	1	1	13	4.4	4	13					15	3.1	5	2.9
Marecastrepera	5	8.1	2	5					1	0.8	1	1	6	1.2	3	1.7
Marecapenelope	2	3.2	1	1									2	0.4	1	0.6
Mareca cf. penelope									1	0.8			1	0.2		
Anasplatyrhynchos					1	0.3	1	1					1	0.2	1	0.6
Anas crecca									3	2.3	3	3	3	0.6	3	1.7
Aythyanyroca					4	1.4	2	4					4	0.8	2	1.1
Anatidae indet.	1	1.6			1	0.3							2	0.4		
Coturnix coturnix	1	1.6	1	1	7	2.4	3	6	2	1.6	1	2	10	2.1	5	2.9
Alectorisgraeca	10	16.1	4	7	51	17.3	11	42	32	24.8	7	28	93	19.1	22	12.6
Perdix perdix	3	4.8	4	3	95	32.2	13	69	21	16.3	6	16	119	24.5	23	13.1
Galliformes indet.	1	1.6			2	0.7			2	1.6			5	1.0		
Columba oenas	2	3.2	1	2	21	7.1	8	17	10	7.8	5	8	33	6.8	14	8.0
Columba livia/oenas					4	1.4							4	0.8		
Caprimulgus europaeus									1	0.8	1	1	1	0.2	1	0.6
Crexcrex					6	2.0	3	4	4	3.1	3	4	10	2.1	6	3.4
Burhinus oedicnemus					1	0.3	1	1					1	0.2	1	0.6
Pluvialis squatarola									4	3.1	2	4	4	0.8	2	1.1
Numenius phaeopus									1	0.8	1	1	1	0.2	1	0.6
Limosa limosa	2	3.2	2	2									2	0.4	2	1.1
Arenaria interpres					2	0.7	2	2					2	0.4	2	1.1
Calidris pugnax					1	0.3	1	1					1	0.2	1	0.6
Gallinago media					1	0.3	1	1					1	0.2	1	0.6
Chroicocephalus ridibundus					1	0.3	1	1	2	1.6	2	2	3	0.6	3	1.7
Charadriiformesindet.	1	1.6			3	1.0			2	1.6			6	1.2		
Buteo buteo									1	0.8	1	1	1	0.2	1	0.6
Accipitriformesindet.					1	0.3	1	1					1	0.2	1	0.6
Otusscops					1	0.3	1	1					1	0.2	1	0.6
Athene noctua					1	0.3	1	1					1	0.2	1	0.6
Strix aluco					1	0.3	1	1	6	4.7	5	6	7	1.4	6	3.4
Asio otus	5	8.1	2	5	7	2.4	5	6					12	2.5	7	4.0
Coraciasgarrulus					4	1.4	2	4					4	0.8	2	1.1
Falco naumanni					1	0.3	1	1					1	0.2	1	0.6
Falco cf. naumanni									1	0.8			1	0.2		
Falco subbuteo					6	2.0	5	6					6	1.2	5	2.9
Falco sp.					1	0.3							1	0.2		
Nucifraga caryocatactes					6	2.0	4	6	1	0.8	1	1	7	1.4	5	2.9
Pyrrhocoraxpyrrhocorax	5	8.1	2	5	4	1.4	3	4	4	3.1	3	4	13	2.7	8	4.6
Pyrrhocorax graculus	11	17.7	5	10	28	9.5	7	23	15	11.6	6	12	54	11.1	18	10.3
Pyrrhocorax sp.					1	0.3							1	0.2		
Corvidae indet.	1	1.6			3	1.0			3	2.3			7	1.4		
Ptyonoprogne rupestris	1	1.6	1	1	2	0.7	2	2	3	2.3	2	3	6	1.2	5	2.9
Delichonurbicum	1	1.6	1	1					5	3.9	3	4	6	1.2	4	2.3
Turdusviscivorus	6	9.7	3	6	10	3.4	4	9	3	2.3	2	2	19	3.9	9	5.1
Turdus iliacus					2	0.7	1	2					2	0.4	1	0.6

Table 2 (*Continued*)

Taxa	Mousterian				Uluzzian				Protoaurignacian				Total			
	NISP	%	MNI	MNE	NISP	%	MNI	MNE	NISP	%	MNI	MNE	NISP	%	MNI	%
Turdus merula	2	3.2	1	2									2	0.4	1	0.6
Passeriformes indet.					2	0.7			1	0.8			3	0.6		
Total Identified Bird	**62**	**67.3913043478261**	**31**	**52**	**295**	**86.0058309037901**	**89**	**229**	**129**	**66**	**55**	**103**	**486**	**100**	**175**	**100**
Unidentified Bird	**30**	**32.6**			**48**	**14.0**			**67**	**34.2**			**145**			
Total Bird bones	**92**	**100**	**31**	**52**	**343**	**100**	**89**	**229**	**196**	**100**	**55**	**103**	**631**			

Alectoris graeca from the Protoaurignacian levels, show some loose traces of medullary bone. This evidence suggests the presence of female birds prior to and during egg-laying. Two juvenile individuals of *Alectoris graeca* and *Perdix perdix* were found in the Uluzzian levels. Other remains with very porous ends belong to 3 indeterminate individuals from the Mousterian, Uluzzian and Protoaurignacian levels.

Regarding the anatomical representation, the long bones of the wings (especially humerus, ulna and carpometacarpus) are the most frequent in the whole assemblage as they represent 42% of the total with the addition of 1% of wing phalanxes. The long bones of the legs (30%), among which the tarsometatarsus predominates (12%), are less abundant but the posterior phalanges are much more numerous (9%). Most of the posterior phalanxes have been attributed to Galliformes and Passeriformes, but they belong also to orders embodied by fewer remains, such as Strigiformes and Accipitriformes.

The bones of the pectoral girdle (sternum, furcula, coracoid and scapula), are less represented (14%) as they are bones of the axial skeleton and vertebrae (2%), pelvic girdle (1%) and skull (1%).

Over 17% of the determined remains are intact. The posterior phalanxes are the anatomical elements that present the lowest degree of fragmentation. Among the long bones, the carpometacarpus presents the greatest number of complete bones, followed by the humerus, exclusively of Passeriformes, and by the tarsometatarsus.

4.2. Ecological context

The species of open environment and temperate climate are dominant and are mainly embodied by Galliformes: Rock Partridge (*Alectoris graeca),* Gray Partridge (*Perdix perdix)* and Common Quail (*Coturnix coturnix*).

Open and rocky environments are indicated by the Red-billed Chough (*Pyrrhocorax pyrrhocorax)* and the Yellow-billed Chough (*P. graculus*), which are among the most represented species. The Red-billed Chough frequents rocky walls, ravines and caves, mainly along the Apennine ridge, while the Yellow-billed Chough is currently located only in the highest massifs of the Alps, where it nests. The Stock Dove (*Columba oenas*), which frequents open plains, is present in the whole sequence.

There are numerous species of Anatidae, among which the Garganey (*Spatula querquedula)* of cold climate and northern environment. Other waterfowl that mainly frequent the marine coasts and the swampy areas are the waders, among which worth mentioning is the Black-bellied Plover (*Pluvialis squatarola)*, the Ruff (*Calidris pugnax),* and the Whimbrel (*Numenius phaeopus)* that nest in the extreme northern regions, in the Arctic tundra. Also the Redwing (*Turdus iliacus)* nests in the extreme northern European regions, but it migrates to the Mediterranean area during winter periods. Among the diurnal raptors, species of temperate climate but of different habitats are present, such as: the Common Buzzard (*Buteo buteo*) of rocky environments, the Eurasian Hobby (*Falco subbuteo*) of wooded areas, and the Lesser Kestrel (*Falco naumanni*) of open areas with grasslands. The presence of forest environments with temperate climate are attested by the occurrence of some nocturnal birds of prey, such as the Eurasian Nightjar (*Caprimulgus europaeus),* the European Roller (*Coracias garrulus)* and the Turdidae. Also the Eurasian Nutcracker (*Nucifraga caryocatactes*) frequents cold climate copses and coniferous woods.

In the Mousterian levels of Castelcivita, there is a higher presence of rocky habitat birds (choughs) and species of open environments (partridges). Water birds (ducks) as well as wood and forest birds (Long-eared Owl *Asio otus* and thrushes) are also abundant, evidencing a humid, cool-temperate climate.

During the Uluzzian there is a climate cooling and an increase in the steppe grassland species (partridges and stock doves) accompanied by an equivalent decrease in rock and aquatic species.

In the Protoaurignacian levels, steppe grassland species are the majority. It is also interesting to note the fluctuations within this latter period: in a first phase, corresponding to level rsa', the prevalence of steppe grassland species becomes more marked, rock species increase, water and wood species diminish, thus testifying a colder and drier climate, which is also highlighted by the presence of two species nesting in the arctic tundra, the Blach-bellied Plover(*Pluvialis squatarola)* and the Whimbrel (*Numenius phoeopus*). In a later phase (layers gic and ars) a slight increase in wood and water birds may reflect a shift to more humid conditions.

4.3. Taphonomy

Taphonomic analysis required particular attention, both macroscopically and microscopically. Actually, the small size and thinness of bird bones make butchering diagnostic features (impact points, fracture margins, etc.) less evident. Furthermore, the small sizes of most of the birds allow treatments of the carcasses which included the use of manipulation instead of cutting tools, during disarticulation and consumption (Tables 3–4). The analysis was conducted on 631 bird remains. Surface modifications of anthropogenic and non anthropogenic origin (cuts, peeling and localized combustion) or those whose origins are difficult to assign (striations of indeterminate agent, crush and notch, fresh bone fracture, total combustion of the specimen, bites) are present on 194 remains, equal to 30% of the total number. Some elements display more than one type of modification. The greatest number of modified remains comes from the Uluzzian levels (NISP MOD

Table 3
Distribution of bird remains according to the chrono-cultural phases with categories of modifications. CM, Cut-marks; PL, Peeling; AR, Arrachement; LB, localized Burns; B, Burns; N/PM, Notch/Percussion Marks; CR, Crashing; FBFr, Fresh Bone Fracture; TM, Tooth Marks; S, Striae; ER, Erosion; * specimens can present one or more modifications that were separately accounted for.

Traces of modification	TOTAL NISP	TOTAL NISP-MOD	Total clues of Human modifcations	Human/Others	Others	Human Modifications				Human/Others						Others
						CM	PL	AR	BL	B	N/PM	CR	FBRr	S	TM	ER
Mousterian	**92**	23	**8**	**14**	**1**	1	5	1	2	3		2	17		3	1
Uluzzian	**343**	127	**23**	**92**	**12**	3	13	6	8	18	2	8	94	5	12	12
Protoaurignacian	**196**	44	**5**	**31**	**8**		4		1	8	3	1	27	2	8	8
Total NISP	**631**	**194**	**36**	**137**	**21**	**4**	**22**	**7**	**11**	**29**	**5**	**11**	**138**	**7**	**23**	**21**
Mousterian	***14.6***	*25.0*	*34.8*	*60.9*	*4.3*	*1.1*	*5.4*	*1.1*	*2.2*	*3.3*		*2.2*	*18.5*		*3.3*	*1.1*
Uluzzian	***54.4***	*37.0*	*18.1*	*72.4*	*9.4*	*0.9*	*3.8*	*1.7*	*2.3*	*5.2*	*0.6*	*2.3*	*27.4*	*1.5*	*3.5*	*3.5*
Protoaurignacian	***31.1***	*22.4*	*11.4*	*70.5*	*18.2*		*2.0*	*0.0*	*0.5*	*4.1*	*1.5*	*0.5*	*13.8*	*1.0*	*4.1*	*4.1*
Total NISP %	***100.0***	***30.7***	***18.6***	***70.6***	***10.8***	***0.6***	***3.5***	***1.1***	***1.7***	***4.6***	***0.8***	***1.7***	***21.9***	***1.1***	***3.6***	***3.3***

Table 4

Relationships between the species with traces of modification (species without modification have been excluded); distribution of the different species with categories of anthropogenic and non anthropogenic modifications. CM, Cut-marks; PL, Peeling; AR, Arrachement; LB, Localized Burns; B, burns; N/PM, Notch/Percussion Marks; CR, Crashing; FBFr, Fresh Bone Fracture; TM, Tooth Marks; S, Striae; ER, Erosion; * specimens can present one or more modifications that were separately accounted for.

Taxa	Mousterian													Uluzzian												Protoaurignacian		
	NR	NR MOD	Human Modif.				Human/Others						Others	NR	NR MOD	Human Modif.				Human/Others						Others	NISP	NR MOD	Human
			CM	PL	AR	BL	B	N/PM	Cr	FBRr	S	TM	ER			CM	PL	AR	BL	B	N/PM	Cr	FBRr	S	TM	ER			CM
Spatula querquedula	**2**													**13**	**7**		**1**		**1**			**1**	**6**		**1**				
Mareca strepera	**5**	**2**		**1**		**1**				**2**		**1**															**1**		
Mareca penelope	**2**	**1**								**1**																			
Mareca cf. penelope																											**1**	**1**	
Anas platyrhynchos														**1**	**1**								**1**						
Anas crecca																											**3**	**2**	
Aythya nyroca														**4**	**3**					**1**			**3**			**1**			
Coturnix coturnix	**1**													**7**	**4**					**1**			**3**				**2**		
Alectoris graeca	**10**	**4**		**1**					**1**	**4**			**1**	**51**	**23**		**1**	**1**	**3**	**2**	**1**		**20**	**2**	**2**	**1**	**32**	**10**	
Perdix perdix	**3**													**95**	**34**		**4**	**4**	**2**	**8**		**3**	**19**	**1**	**3**	**4**	**21**	**1**	
Galliformes indet.	**1**													**2**	**1**										**1**		**2**	**1**	
Columba oenas	**2**	**2**		**1**						**2**				**21**	**12**		**1**			**2**		**1**	**9**	**1**	**1**		**10**	**3**	
Columba livia/ oenas														**4**	**1**								**1**						
Crex crex														**6**													**4**	**1**	
Burhinus oedicnemus														**1**	**1**				**1**				**1**						
Pluvialis squatarola																											**4**	**2**	
Limosa limosa	**2**	**2**		**1**						**1**																			
Arenaria interpres														**2**	**2**		**1**						**1**			**1**			
Calidris pugnax														**1**	**1**		**1**		**1**			**1**							
Chroicocephalus ridibundus														**1**	**1**								**1**				**2**	**2**	
Charadriiformes indet.	**1**													**3**	**1**								**1**				**2**	**1**	
Accipitriformes indet.														**1**	**1**	**1**					**1**		**1**						
Athene noctua														**1**	**1**									**1**					
Strix aluco														**1**													**6**	**2**	
Asio otus	**5**													**7**	**1**					**1**			**1**						
Coracias garruus														**4**	**2**							**1**	**2**						
Falco subbuteo														**6**	**5**	**1**	**2**					**1**	**4**		**1**				

Table 4 (*Continued*)

Taxa	Mousterian													Uluzzian												Protoaurignacian		
	NR	NR MOD	Human Modif.				Human/Others						Others	NR	NR MOD	Human Modif.				Human/Others						Others	NISP	NR MOD	Human
			CM	PL	AR	BL	B	N/PM	Cr	FBRr	S	TM	ER			CM	PL	AR	BL	B	N/PM	Cr	FBRr	S	TM	ER			CM
Nucifraga caryocatactes														**6**	**4**					**1**			**3**				**1**		
Pyrrhocorax pyrrhocorax	**5**	**4**	**1**			**1**				**3**				**4**	**1**								**1**		**2**		**4**	**2**	
Pyrrhocorax graculus	**11**													**28**	**12**	**1**	**1**	**1**		**1**			**10**		**1**		**15**	**5**	
Corvidae indet.	**1**													**3**													**3**	**2**	
Ptyonoprogne rupestris	**1**	**1**										**1**		**2**													**3**	**2**	
Delichon urbicum	**1**	**1**			**1**							**1**															**5**	**5**	
Turdus viscivorus	**6**	**4**		**1**					**1**	**3**				**10**	**5**		**1**						**4**				**3**		
Turdus iliacus														**2**	**2**								**2**						
Turdus merula	**2**	**1**								**1**																			
Total Identified Bird	**61**													**287**													**124**		
Unidentified Bird	**30**	**1**					**1**							**48**	**1**					**1**						**1**	**67**	**2**	
Total Bird bones	**91**	**23**	**1**	**5**	**1**	**2**	**1**	**0**	**2**	**17**	**0**	**3**	**1**	**335**	**127**	**3**	**13**	**6**	**8**	**18**	**2**	**8**	**94**	**5**	**12**	**8**	**191**	**44**	**0**

127). Modifications are less frequent in the Protoaurignacian (NISP MOD 44) and rare in the Mousterian (NISP MOD 23, Tables 3–4).

Overall, the most frequent modifications are fresh bone fractures (NR 138 equal to 21.9% of the total). In 52 cases they are associated with other traces, such as complete or partial combustion, peeling and *arrachement* (loss of cortical bone tissue related to disarticulation), notch and crushing, bites and pits, and cut traces. Some fragments show fracture types and margins produced by flexion, considered to be typical of human manipulation. The burnt remains represent about 6% of the total. Signs of peeling (roughened surface with parallel grooves and fibrous texture) and *arrachement* have been recognized on 3.5% of the remains. These damages are produced because of the disarticulation performed manually and are almost always associated with fresh bone breakage. Signs of bites are present on 3.6% of the remains; but it is difficult to distinguish between human and other animal teeth.

Notches and cracks were found on 2.5% of the remains, often also associated with fresh bone fractures. The elements with thinning of the walls and traces of corrosion possibly referable to digestion amount to 3.3%. Short, superficial striae and traces of uncertain attribution are present on 1.1% of the remains. Very rare remains show cut-marks due to lithic tools (0.6%). Post-depositional modifications, specifically root-etching and trampling, are poorly represented, while the presence of tenacious concretion, often found on different specimens, has sometimes made the analysis difficult.

4.3.1. Distribution of traces of modification on skeletal elements

The analysis of the anatomical representation in relation to the exploitation of carcasses was complicated by both the scarcity of remains and the sizes of the animals involved. Their weight varies from few tens of grams of some Passeriformes, to 10 kg of large-size Accipitriformes. On average the weight of the 175 individuals ranges from 300 to 500 g per specimen (Brichetti, 2002), with a total meat supply of about 50–70 kg, equivalent to that of a medium-sizedherbivore.

At least 39 taxonomic categories are represented by less than 10 NISPs (Table 2). Numbers are even more reduced when the different cultural phases are taken into account. The examination of the anatomical representation relating to traces of modification was carried out, therefore, per chronological phase, without distinction of species. The analysis of particularly well-represented species does not reveal different trends compared to the general pattern, due to the low consistency of the statistical data obtained from few samples.

Various portions of the carcass are well represented with minor variations. The bones of the wing prevail in general and especially in the Mousterian (Table 5). The rarity of skull and vertebra remains could be due to problems connected to their conservation and identification.

Traces considered as evidence of human activity (cut-marks, peeling, localized burns and *arrachement*) frequently occur on the bones of the wing and are well represented on those of the axial skeleton (Vertebrae - Pectoral/Pelvic girdle), among which the coracoid (a bone of the pectoral belt) is the most frequent (NISP 3 for the Mousterian, 21 for the Uluzzian and 11 for the Protoaurignacian) and upon which a greater number of modifications is preserved. Traces detected on the coracoids are of anthropogenic origin (1 for the Mousterian and 3 for the Uluzzian) or of difficult attribution (Mousterian 1, Uluzzian 9, and Protoaurignacian 3 - in this case indicated as Human/Others). Coracoid is very often involved in the detachment of the wing, thus increasing the interest for this anatomical portion (Table 6). Overall, modifications are more evident on fragments from long appendicular bones among which those of the wing play a clearly prevalent role (Table 7).

The interest in birds is attested from the Mousterian with an increase in the Uluzzian and a depletion in the Protoaurignacian.

4.3.2. Mousterian

In the Mousterian there are 23 remains with modifications representing 25% of the remains recovered in these levels (Tables 3–4). The anthropogenic activity is not easily detectable on bone surfaces, but there are traces that can be considered to be valid clues (NISP With Human MOD 8-NISP 92) such as: the probable cut-marks on an ulna diaphysis of *Pyrrhocorax pyrrhocorax* (the striae are superficial and poorly preserved) and the traces of peeling often associated with fresh bone fractures, which are present on some remains of *Mareca strepera, Alectoris graeca, Limosa limosa, Columba oenas, Turdus viscivorus*. These modifications could indicate carcass manipulation during reduction into smaller portions. Localized combustion is present on a distal coracoid of *Mareca strepera*, where it is associated with fresh bone fracture. Diffused combustion, is present on an ulna of *Pyrrhocorax pyrrhocorax.* Remains with gnawing marks are scarce and could be referred to human mastication, at least in the case of the already described

Table 5
Distribution of traces of modification according to skeletal portions.

Mousterian	NISP	%	Human	Human/Others	Others	Tot. Mod.	NISP/NISP MOD
Skull	3	3.1					
Vertabrae-Pectoral/Pelvic girdle	20	20.8	3	1	1	**5**	***25.0***
Wings	43	44.8	5	11		**16**	***37.2***
Legs	30	31.3		2		**2**	***6.7***
TOT NISP	**96**	100.0	**8**	**14**	**1**	**23**	***24.0***
Uluzzian							
Skull	2	0.6					
Vertabrae-Pectoral/Pelvic girdle	67	19.5	7	14	1	**22**	***32.8***
Wings	140	40.8	13	39	5	**57**	***40.7***
Legs	134	39.1	3	39	6	**48**	***35.8***
TOT NISP	**343**	*100.0*	*23*	*92*	*12*	127	*37.0*
Protoaurignacian							
Skull	3	1.5					
Vertabrae-Pectoral/Pelvic girdle	20	10.2	1	4		**5**	***25.0***
Wings	88	44.9	3	19	4	**26**	***29.5***
Legs	83	42.3	1	8	4	**13**	***15.7***
Diaph. indet	2	1.0					
TOT NISP	**196**	100.0	**5**	**31**	**8**	**44**	***22.4***

Table 6
Distribution of traces of modification according to chrono-cultural phases and carcass portions. a: Human modifications; b: Human/Others modifications.

Human Modifications	Must.	Uluzz.	ProtoAurign.	NISP Mod.	NISP	NISP Mod./Mod. %
Skull			1	1	3	**33.3**
Vertabrae-Pectoral/Pelvic girdle	3	7	3	13	20	**65.0**
Wings	5	13	1	19	43	**44.2**
Legs		3		3	30	**10.0**
Total NISP	**8**	**23**	**5**	**36**	**96**	**37.5**
Human/Others Modifications	Must.	Uluzz.	ProtoAurign.	NISP Mod.	NISP	NISP Mod./Mod. %
Skull					2	
Vertabrae-Pectoral/Pelvic girdle	1	14	4	19	67	**28.4**
Wings	10	39	19	68	140	**48.6**
Legs	2	39	8	49	134	**36.6**
Total NISP	**13**	**92**	**31**	**136**	**343**	**39.7**

Table 7
Distribution of traces of modification on the anatomical elements of the wings and legs.

Anatomical elements	Human	Human/Others	Total NISP
Coracoids	4	13	66
Humerus	4	28	78
Radius-Ulna	13	27	126
Carpometacarpus	4	13	35
Total NISP	**25**	**81**	**305**
Pelvis		**1**	**8**
Femur	2	16	42
Tibiotarsus		17	61
Tarsometatarsus	2	15	67
Total NISP	**4**	**49**	**178**

coracoid of *Mareca strepera*, also considering the presence on the same element of a fresh bone fracture and localized combustion on one end.

4.3.3. Uluzzian

In the Uluzzian there are 127 remains with modifications representing 37.0% of the remains recovered in these levels (Tables 3–4). Fresh bone fractures are well represented (NISP 94) with 27.4% of the total; in 32 cases they are associated with other traces, such as complete or partial combustion (NISP 14), peeling and *arrachement* (NISP 4), notches and crushing (NISP 4), cut-marks (NISP 2), bites and pits (NISP 8).

The burnt remains are about 7% of the total; traces of peeling and *arrachement* were found on 5.0% of the specimens; notches and cracks on 2.9%, bites on 3.5%; the remains with traces of corrosion, perhaps attributed to digestion, are 2.3%. The short and superficial striae of uncertain attribution are 1.5%, while those with sure cut-marks are only 2 (0.6%).

Anthropogenic activity is evident in the amount of modified remains and in the species of birds that usually do not frequent caves (Galliformes and Anseriformes), but, above all, in the type of traces (NISP With Human MOD 23/NISP 343). Striae are visible on 7 fragments, although they are superficial and not usually well preserved (two distal humeri of *Alectoris graeca*, a proximal coracoid of *Perdix perdix* and a distal ulna of *Columba oenas*) to such an extent that some of them are of difficult attribution. Cut-marks are evident on a proximal ulna of *Pyrrhocorax graculus* and on a humerus of Eurasian Hobby. Striae on an ulna diaphysis of Accipitriformes, probably *Gyps fulvus,* are, on the other hand, problematic.

A proximal ulna of a Yellow-billed Chough (*Pyrrhocorax graculus*) presents a series of cut-marks on the *margo caudalis* under the olecranon for cutting the *musculus humerotricipitalis* and displays fresh fracture margins (Fig. 2). A first group of striae includes three short, transversal cuts and two longer, thinner and sub-parallel lateral scratches. The bottom of the striae is covered by a tenacious concretion that affects the entire proximal portion; examination with the stereomicroscope and the SEM allowed us to better evaluate the macroscopic characteristics (length, width, depth, course, syntax) with respect to the microscopic ones (secondary striae, characteristics of the edges). These cuts may probably be attributed to disarticulation or skinning for detaching the wing portion with the primary and secondary remiges.

The right mid-distal humerus of the Eurasian Hobby (*Falco subbuteo)* presents a series of cut-marks (Fig. 3). The humerus lacks the proximal end and was fractured when it was still fresh. The distal end shows two lacunae on the surface at the *sulcus scapulotricipitalis* and *processus flexorius*, probably due to the tearing of ligaments during disarticulation of the humerus from the ulna. Several striae are distributed across the diaphysis on the caudal face. The striae on the proximal end of the diaphysis are short and deep, slightly oblique, indicating a cutting/engraving action in a transverse direction to the axis of the bone (Fig. 3 and B and Fig. 4, 1-1A). A long and deep longitudinal striation, due to an engraving action, starts from these striae, reaching the mid-diaphysis (Fig. 3 and B and Fig. 4, 2-2A). Other striae are arranged in parallel bundles on the mid-distal diaphysis below this last stria. These are thin, superficial, straight, uniform, and close to one another, and may be related to scraping actions (Figs. 3, 4 and Fig. 4, 3-3A). These latter marks are made using the edge of the tool held transversally to the direction of motion. Traces of the kinds occurring on the humerus of Eurasian Hobby differ from those related to butchering on the basis of their incidence on anatomical portions yielding small amounts of meat, and of the position and/or orientation of cut-marks that are not functional in a usual butchering activity. These particular marks are due to skin incision and to scraping actions carried out to remove skin with feathers from the humerus, in order to probably detach the entire wing (i.e. also radius, ulna and carpometacarpus) with remiges, equal to 10 primary and 14 secondary feathers (but the same animal might have provided other 36 useable feathers, 24 from the second wing and 12 retrices from the tail) (Fig. 5). It must be underlined that the humerus of Eurasian Hobby is out of the ordinary for its clear and very well preserved traces, and indubitably attests the interest the Uluzzian people of Castelcivita displayed in hunting certain kinds of birds for reasons other than for food.

A fragment of a distal diaphysis of a right ulna (Fig. 6), belonging to a large Accipitriformes, has been uncertainly attributed to the Eurasian Griffon (*Gyps fulvus)* for its dimensions (Sc 2.1 cm), the flat surface in ventral view, and the distance between the tubercles (0.22 cm), comparable to those of the male specimen in the comparative collection (Borzatti Collection No. 424 Gyps *fulvus*). The bone surface is well preserved and does not show traces of gnawing or other types of damage. The diaphysis is affected by recent fractures, but

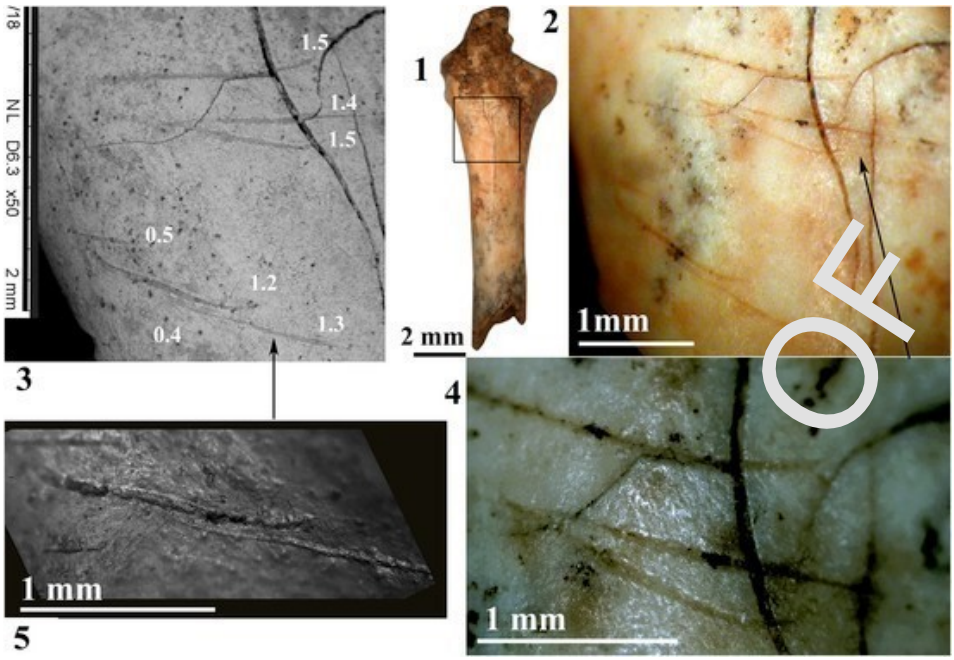

Fig. 2. Proximal ulna of Yellow-billed Chough (*Pyrrhocorax graculus*) with cut-marks. (1) localization of cut-marks; (2) detail of cut-marks with length of the striae in mm (SEM magnification); (3–4) detail of the first group of three striae (SMZ magnification); (4) detail of the second group of four striae (Metallographic magnification) (I. Fiore). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

the preserved margins display fresh bone fractures. On the fracture edge, along the line of the *papillae*, there are two striae with apparently ancient patina and sediment inside (Fig. 7). These striae display micromorphological characteristics which do not allow a certain attribution to human activity since the V-section of the main furrow and the secondary striae on its walls are not well preserved.

Traces we produced during our experimental defleshing activity were usually superficial and short and did not show all the characteristics commonly considered by scholars as being diagnostic for intentional cut-marks. It should also be underlined that some of the features displayed by the striae in general can be emphasized or not, depending on the instruments used for observation (Stereomicroscope directly on the specimen, with transmitted light on transparent resin replica, metallographic microscope, SEM). Most probably the fresh bone fracture and the notch on the ulna of the large Accipitriformes are the results of an anthropogenic manipulation, while the cuts remain more doubtful.

In the Uluzzian levels there is further evidence of carcass manipulation by humans consisting of peeling, *arrachement* and localized combustion that have been found on several long bones of *Alectoris graeca, Perdix perdix*, less frequently on *Spatula querquedula* and *Columba oenas*, and on rare remains of some species of Charadriiformes and Passeriformes. These traces of carcass manipulation are in some cases associated with fresh bone fractures (Fig. 8). The presence of bites is not always attributable to carnivore activity, especially for those specimens that have other modifications, like oval holes and crushing that could be referred to human chewing.

4.3.4. Protoaurignacian

In the Protoaurignacian surface modifications are rare and not unquestionably attributable to anthropogenic activity, even if the few fresh bone fractures and combustions were found on *Alectoris graeca* and *Perdix perdix* (Tables 3–4). A proximal femur of *Pyrrhocorax graculus* seems to preserve probably human gnawing marks. The damaged area shows fractures and marks comparable with those experimentally produced (Fig. 9). Compared to the Uluzzian evidence we note a decrease in traces connected to human activityand an increase in those indicating an activity by other carnivores.

5. Discussion

In Europe evidence for the human exploitation of birds, even if sporadic, is attested to be from the lower Pleistocene in Spain at Sima dell' Elefante in levels of over 1.0 Ma, by a fragment of radius with cuts attributed to a large bird (Huguet et al., 2013). In the Upper Pleistocene the site of Gran Dolina (Spain) yielded rare bird remains with cuts, including two small corvids, from the unit TD10-1 (Blasco et al., 2013), and a radius shaft of a medium sized bird from TD10-2 (Rodríguez-Hidalgo et al., 2017). This latter specimen displays three oblique striae on the shaft that, according to the authors, can be related to the exploitation of feathers. Evidence for feather exploitation from the site of Payre in France is directly confirmed by the discovery of residues of feather barbules on some lithic tools from level Ga (dating back to MIS7) (Hardy and Moncel, 2011).

During the Middle Palaeolithic the exploitation of corvids, especially choughs (*Pyrrhocorax graculus*, P. *pyrrhocorax*), is widely documented in several European sites: Gorham's Cave Vanguad Cave, Ibex Cave, Fumane Cave, Cova Negra etc. (Martínez-Valle et al., 2016, Laroulandie, 2010 Table 2, Peresani et al., 2011, Finlayson et al., 2012, Blasco et al., 2016; Fiore et al., 2016 Table 7). The presence and distribution of the cuts on the wing bones indicate a particular interest for feathers. In these sites the amount of bird remains spans from a few units to a few hundred, among which those with certain cut marks are consistently a small number. However it is noteworthy that these birds usually are of very small size and the action of cutting does not reach the bone at all times (in this case not leaving visible and well preserved marks) which consequently results in an underrepresentation of cut-marks. The removal of feathers or tendons requires more specific and precise actions with a higher probability of leaving marks on the bones with respect to the simple exploitation as a food resource. For this reason studies on the exploitation of birds also focus on other modifications such as burns, fractures, damages from handling of carcasses, etc. The use of corvid bones as a raw material seems to be quite unusual, the only clear evidence being a fragment of radius decorated with equidistant notches of probable *Corvus corax* fromthe

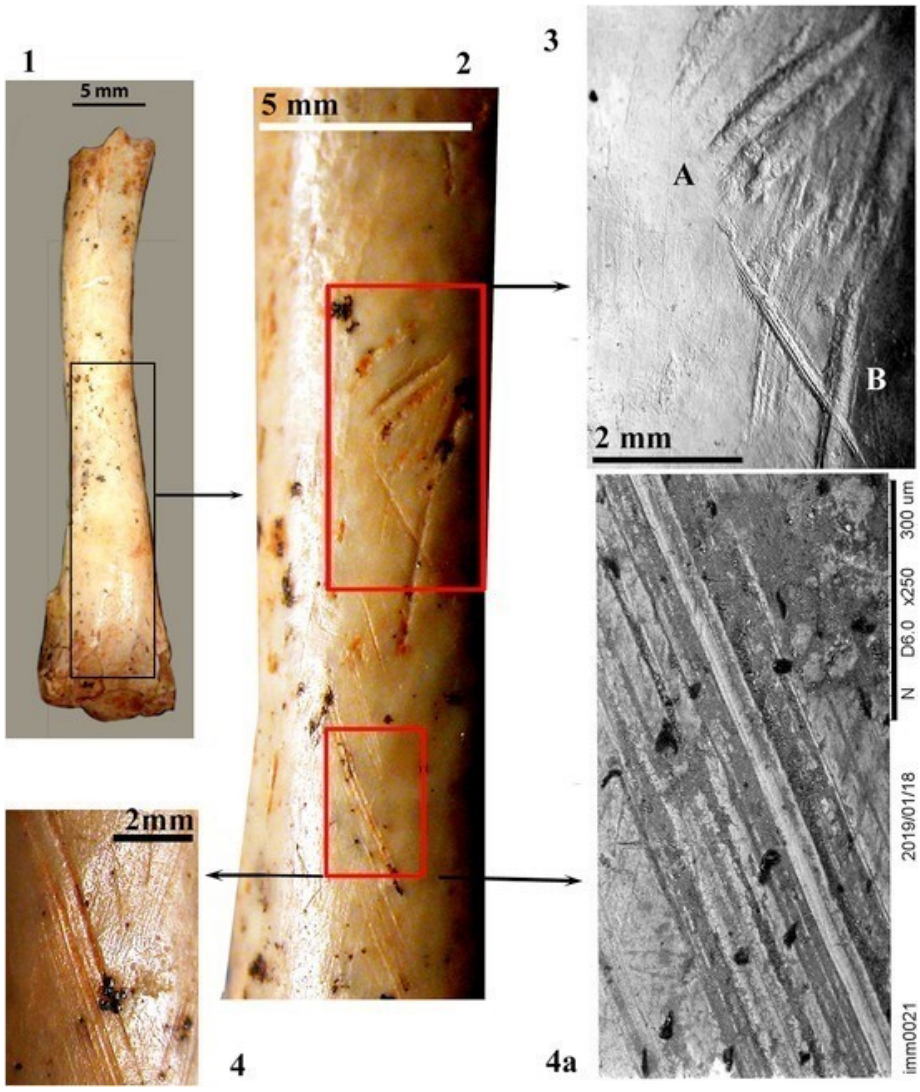

Fig. 3. The right mid-distal humerus of Eurasian Hobby (*Falco subbuteo*) with cut-marks.(1–2) Localization of cut-marks; (3) detail of the short, deep and oblique cut-marks (SMZ magnification); (4-4a) detail of the scraping (SEM magnification) (I. Fiore).

shelter of Zaskalnaya VI in Crimea (Majkić et al., 2018). Remains of raptors are even more rare than those of corvids, but often retain very significant anthropogenic marks (cuts and use wears). In particular raptor claws with marks are usually interpreted as ornaments (e.g. Fiore et al., 2004; Morin and Laroulandie, 2012; Radovcic et al., 2015; Laroulandie et al., 2016).

The exploitation of birds as a food source becomes more common at the onset of the Upper Paleolithic (Bochenski et al., 2009; Laroulandie et al., 2016) and turns into a constant in late Upper Paleolithic sites (Laroulandie, 2003; Gala et al., 2018).

In Italy numerous Mousterian sites have yielded bird remains, but these have rarely been the objects of systematic studies. Data on avifauna relating to the Uluzzian and the Protoaurignacian techno-complexes are even scantier. The osteological sample from Grotta di Castelcivita is one of the most thoroughly investigated of the Italian Upper Pleistocene, both for the quantity of its remains and for its important cultural and chrono-stratigraphic sequence (Cassoli and Tagliacozzo, 1997b; Gala et al., 2018; Gambassini, 1997; Moroni et al., 2013). To date, Castelcivita is the only site in which it is possible not only to follow with continuity the evolution of bird exploitation during the Middle to Upper Paleolithic transition, but also to have exhaustive taxonomic and taphonomic data on this activity for the Uluzzian techno-complex. The avifauna is, in fact, absent/very scarce or yet to be studied in the remaining Uluzzian sites (including the Greek ones). An exception is represented by the site of Fumane (Veneto) where the avifauna from layers A4 and A3, both attributed until now to the Uluzzian (Peresani et al., 2016), was studied by Tagliacozzo et colleagues in 2013. Layer A3 in particular contains a fair amount of bird remains (NR 215; NISP 127, NMI 26, Tagliacozzo et al., 2013, tab. 8.2). The avifaunal assemblage is dominated by the Yellow-billed Chough, the Black Grouse (*Tetrao tetrix*) and the Corncrake (*Crex crex*). Many specimens belong to the Passeriformes (mainly Corvids). Bones attributed to diurnal and nocturnal raptors are also frequent; these primarily include the Eurasian Kestrel (*Falco tinnunculus*), and the Long-Eared Owl (*Asio otus*). Human modifications have been observed on a few specimens. The exploitation marks (cut-marks, wrench and peeling) suggest that the Black Grouse and the Alpine Chough were disarticulated and defleshed (Tagliacozzo et al., 2013, tab. 9). Cuts probably related to the recovery of feathers and to disarticulation have been detected on a humerus of Alpine Chough and on a tibiotarsus of Black Grouse respectively.

However a more recent revision of the lithic materials from layers A4 and A3 induced a reconsideration of the nature of the Uluzzian presence at Fumane (Marciani et al., in this special issue). In

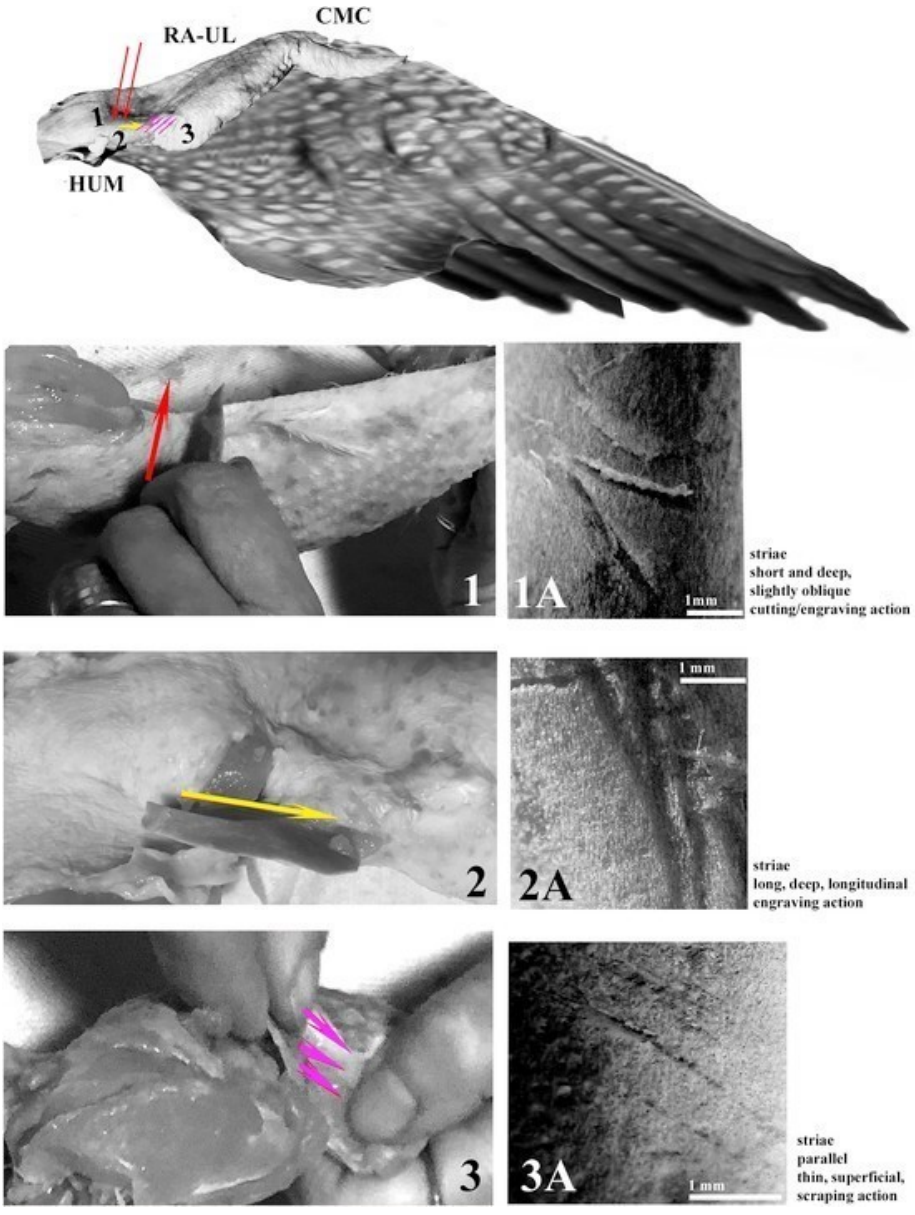

Fig. 4. The reconstruction of the sequence of anthropic interventions on humerus of *Falco subbuteo*. Experimental wing positioned on a design of wing of *Falco subbuteo*. (1–3) Sequence of cutting actions and consequent striae. (1A–3A)The experiment on modern wing of chicken, cuts made with flint flake. The cuts are located in the side opposite to the one where the feathers are inserted, so as not to destroy them (I. Fiore).

particular layer A4 has been re-assigned to the late Mousterian, while layer A3 is still under re-examination in order to investigate possible factors which led to the deviation of this assemblage from the typical Uluzzian outline represented in all the other Uluzzian sites, including Riparo del Broion (layers 1f and1g) located very close to Fumane (Peresani et al., 2019). For this reason we prefer to suspend any in depth comparisons between Castelcivita and Fumane pending the completion of this revision. Here we can only note that bird associations of Castelcivita (prevalence of the Rock Partridge and the Gray Partridge) and Fumane (prevalence of the Black Grouse and the Alpine Chough) reflect the different habitats surrounding these sites. At Fumane the exploitation of raptors for feathers is documented in the Mousterian by traces on several species (Romandini et al., 2016), while at Castelcivita cut-marks attesting to the same activity on raptors were found in the Uluzzian. During the Protoaurignazian/Aurignazian, traces of bird exploitation considerably decrease in both sites.

Several species recovered at Castelcivita, like pigeons, some diurnal and nocturnal birds of prey and some corvids, frequent caves, ravines and cliffs; therefore part of their remains are likely due to natural accumulations (Table 1). The presence of species such as Anatidae, wading birds and Galliformes, which do not frequent caves, is, on the other hand, most probably the result of human hunting. The osteological composition of the sample did not reveal any particular bone selection, reflecting a standardized exploitation of species and/or anatomical parts. Complete bones mainly belong to parts poor in meat (posterior phalanges, carpometacarpus and tarsometatarsus), while the pectoral and pelvic girdle bones, which are richer in meat, are fragmented.

Ecological data highlight climatic and environmental changes over the whole sequence, with species that reflect very different climatic conditions. There are both birds nesting in the Arctic tundra, and other frequenting wet and cold areas (whose area of sedentary life is found in the northernmost European regions). Species of alpine environment

Fig. 5. (1) *Falco subbuteo:* (2) primary remige of *Falco subbuteo* (n. 10 per wing, length: 212–214 mm); (3) secondary remige of *Falco subbuteo* (n. 14 per wing, length: 102–104 mm); (4) rectrice of *Falco subbuteo* (n. 12, length: 138–140 mm) (S. Ricci) (Data on the size of feathers from: www.featherbase.info).

are present, currently living at high altitude, in the coniferous forests and upon the rocks and cliffs of the highest mountains.

A clear change is attested between the Mousterian and the overlying levels in the climatic environmental conditions. In the Mousterian birds of rocky environments and uncovered regions are abundant, but there are also many aquatic and forest specimens. In the Uluzzian there is a marked increase in steppe species in comparison with those of rocky and aquatic environments. In the Protoaurignacian levels there is a further rarefaction of birds of aquatic and wooded habitats, which reveals a tendency towards prairie steppe environments with rocks, reflecting a colder and more arid climate. These data corroborate results obtained from the study of mammal remains.

Data from taphonomic analyses are important proxies for detecting some aspects of human behaviour. For instance the distribution of combustion traces on the various anatomical elements provides information on how the carcass was chopped to be cooked. The presence of localized burning is the result of cooking small portions, which causes the burning of the bony parts that are not protected by the meat. Intentional fracturing is not easily recognizable on bird bones as the points of impact are rare; however all fresh bone fractures have been identified with the aim of distinguishing the impact fractures from those obtained by flexion. Impact points on diaphyses are rare and there are some remains with margins fractured by flexion, identifiable due to transverse or slightly oblique fractures with a deep slit on a margin. Birds, besides being predated by humans, could be captured by other animals as shown, in some cases, by the occurrence of gnawing marks, even if these may be partly due to human chewing.

During the Mousterian there are few traces of human exploitation on avifauna remains. The ulna of chough with probable, poorly preserved, cut-marks (striae are rare, short, superficial and localized between the tubercles) could confirm the exploitation of corvids for their black feathers by Neanderthals, an activity which has already been documented in Mousterian sites (Peresani et al., 2011; Finlayson et al., 2012; Finlayson and Finlayson, 2016; Fiore et al., 2016).

In the Uluzzian levels traces of exploitation notably increase: cut-marks, localized burning, peeling, etc. The cuts on the humerus of Eurasian Hobby, on the ulna of chough and, less evident, on the ulna of probable Eurasian Griffon indicate a determined wish to recover other material than meat, as these anatomical parts are meatless. The Eurasian Hobby has a length of about 35 cm and a wingspan of 70

Fig. 6. Distal diaphysis of the right ulna of a large Accipitriformes (cf. *Gyps fulvus*). (1) Ventral view; (2) caudal view; (3) cranial view; (4) dorsal view (I. Fiore).

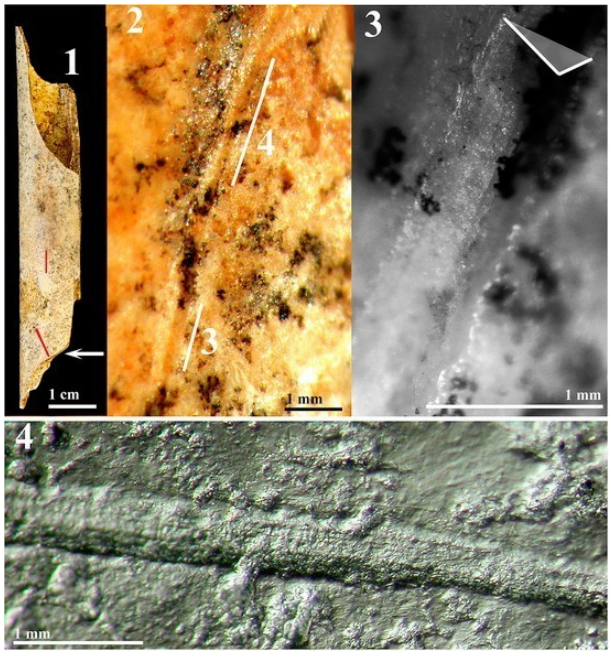

Fig. 7. Distal diaphysis of the right ulna of a large Accipitriformes (cf. *Gyps fulvus)* with probable cut-marks. (1) Localization of the striae; (2) detail of the most defined striae; (3-2 details of the striae (SMZ magnification: 3, on the sample surface and 4, on the replica) (I. Fiore).

cm; its wing feathers are slate gray, whitish or fawn below with wide longitudinal dark bands; the primary remiges are compact and tapered, with a very wide external flag tapering at the base and forming a sharp tip. The chough has a wingspan of about 80 cm and is black with violet-blue reflections; its remiges have a dark green tinge due to a trick of the light on the iridescent barbs. The Eurasian Griffon is a large vulture (wingspan 240–280 cm). Its wings are very large and long, with black remiges. Undoubtedly Feathers of these three birds might be of great interest for people living in Castelcivita as they could have several functions due to their colors, shape and size.

It is worth noting that the increase in carnivore-induced modifications on bird bones during the Protoaurignacian was not detected on mammal remains. Preliminary taphonomic studies, carried out on a small sample, indicate a presence of *Crocuta crocuta* (Masini and Abbazzi, 1997) and an activity of large carnivores across the whole anthropogenic sequence of Castelcivita, with a reduction during the Protoaurignacian (Romandini et al., in this special issue). The revision of the Protoaurignacian assemblage is still in its early stages. To date we can only state that the decrease in traces due to human activity recorded in this phase does not seem to be connected to the amount of birds since layers rsa', gic and ars are the richest in bird remains of the entire sequence. Although there are differences amongst phases in the macrofaunal association these appear to be due to environmental fluctuations rather than to intentional exploitation strategies by humans. In the absence of spatial distribution studies we are not able to detect possible changes in the occupation patterns of the excavated area, although no diversity is macroscopically identifiable. Hopefully further and more detailed studies will allow us to disentangle this questions and, especially, to understand whether taxa of carnivores responsible for modifications on bones significantly changed throughout the sequence (decrease in large carnivores affecting large mammal bones and increase in small carnivores accumulating bird remains?).

6. Conclusions

The occurrence of cut-marks on the wing bones of raptors and corvids is widespread in several Middle and Upper Paleolithic sites (Cassoli and Tagliacozzo, 1997a; Laroulandie, 2010; Peresani et al., 2011; Finlayson et al., 2012; Finlayson and Finlayson, 2016; Fiore et al., 2016). Interestingly the study of the avifauna of Castelcivita confirms that the use of cutting tools is not necessary for the exploitation of the carcass of small and medium sized birds. This notion is supported by the relatively frequent traces of combustion located only at the end of some anatomical elements, which indicate the reduction of the carcass into smaller portions by over-extension and roasting, in addition to probable traces of human gnawing. Cut-marks, even if rare, are documented on particular bird species (raptors and corvids), on specific anatomical elements, and reflect actions aimed at a precise target that focuses on the feathers of the wings. What sounds anomalous in the examined context is the small amount of clues/traces of human exploitation on bird remains in the Protoaurignacian (with respect both to the Mousterian and especially to the Uluzzian), namely in a fully Upper Palaeolithic cultural phase in which we would expect the opposite. This decrease is accompanied by an increase in the introduction inside the cave of bird remains by small-sized carnivores. In comparison with the Uluzzian we especially note a reduction in the percentages of Anatidae, while Galliformes are still well represented. These animals are preyed on by humans, but are also part of the diet of small-sized carnivores, such as foxes. As the research stands now we are not able to exclude either a change in the strategies carried out in exploiting avian resources or a different functional use of the investigated area during the Protoaurignacian. Integrating results of our taphonomic study with those from the analyses of mammalofauna and other archaeological materials will be needed in order to answer these questions with more reliable and well-grounded assumptions.

Turning back to the exploitation of feathers, humans have consistently used this resource for a wide range of purposes (ornamental, utilitarian, cultural and religious). Feathers are both soft and suitable for trapping heat (pillows and mattresses); they are useful for fletching arrows, for weaving clothes and blankets, and for writing, in the case of the goose. Feathers have also a cultural and spiritual value and are used in traditional medicine, for example, by Native Americans (Tuchman, 1994).

Owing to the variety of their uses, also documented by ethnographic evidence, understanding the functional role/s this very

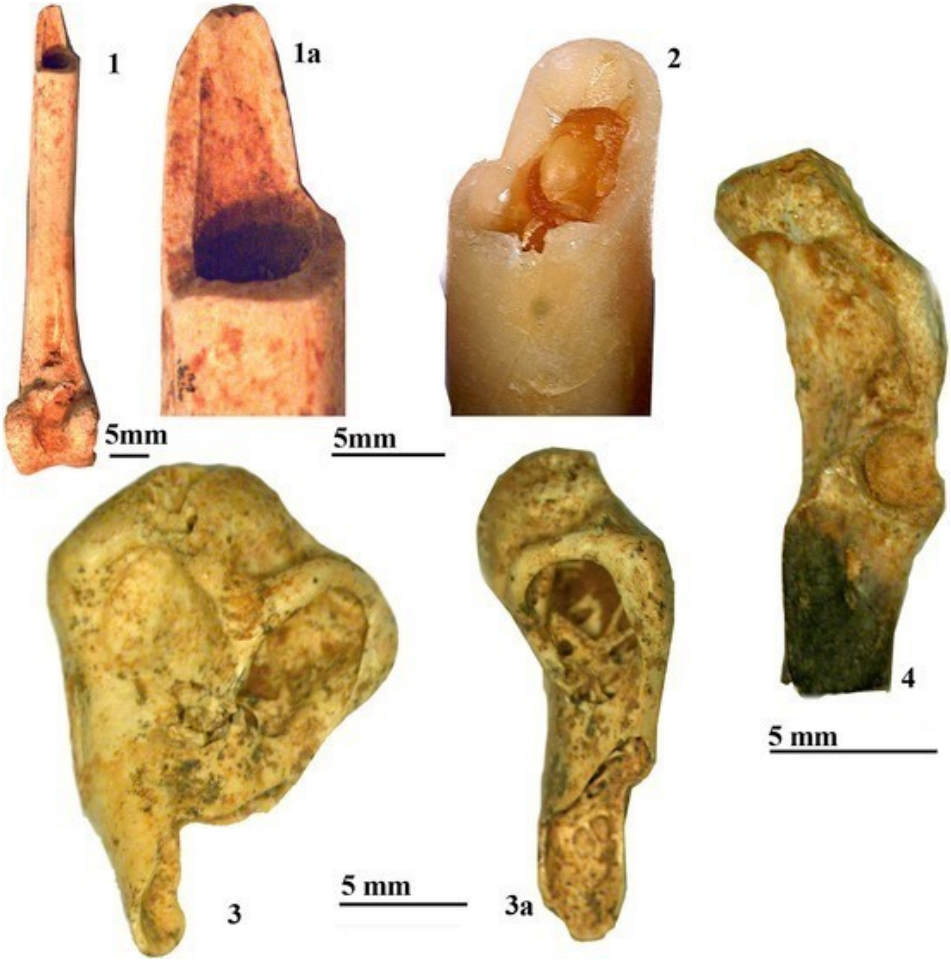

Fig. 8. (1) Distal tibiotarsus of *Alectoris graeca* (Uluzzian) with a fracture probably produced by flexion, (1a) details of the fracture; (2) femur of Helmeted Guinea fowl, experimentally produced fracture by flexion; (3) proximal humerus of *Burhinus oedicnemus* (Uluzzian) with a fracture on fresh bone, caudal and ventral view; (4) coracoid of *Alectoris graeca* (Uluzzian) with localized burning (I. Fiore).

particular resource could have played across the anthropogenic sequence of Castelcivita is not so easy; at least without having first interconnected data provided by our study with those from other classes of materials, especially the lithic industry.

Along with other research fields, studies on modalities implemented by Palaeolithic groups in the exploitation of birds can provide pivotal information on the mental templates and the technological skills which characterized different human species like Neanderthals and modern humans.

Author contributions

I.F. conceived and organized the article; A.M., F.B. and J.C. provided expertise on site sequence and materials; M.G. and A.T. identified bird remains, I.F. identified traces of modifications; I.F. and F.B. made/designed figures and illustrations; all the authors contributed to write the manuscript.

Uncited references

Blasco et al., 2010; Blasco et al., 2014; Blasco et al., 2016; Bocheński and Tomek, 2010; Romero et al., 2017.

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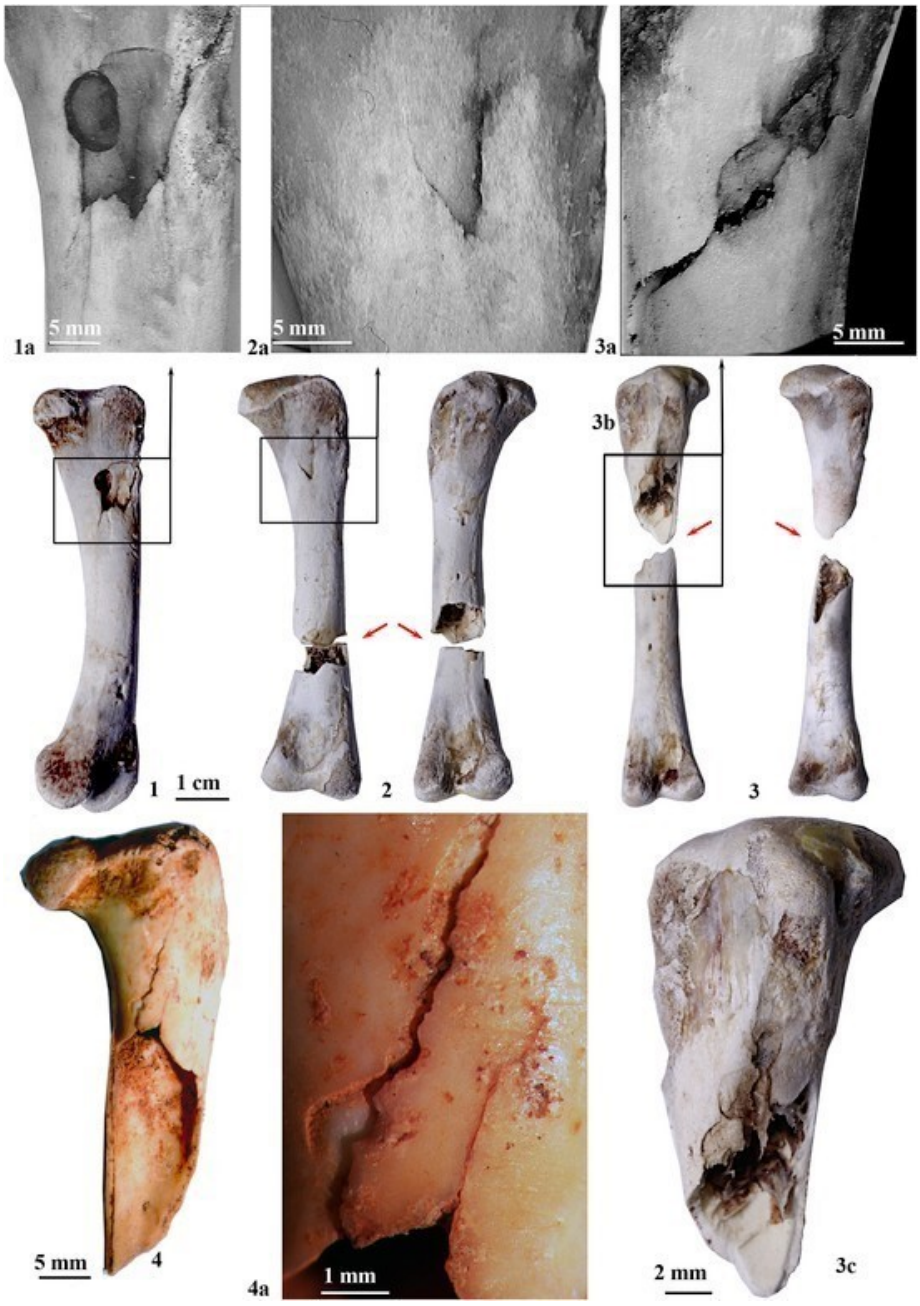

Fig. 9. Experimentally produced human gnawing marks, on the proximal ends of three left femurs were crushed by teeth to suck marrow (1 medial view, 2 cranial and caudal views, 3 lateral and cranial views). (1–3)The proximal end of a femur of *Gallus gallus* presents cracks and fractures; the red arrows indicate a fracture produced by flexion; (1a-3a) details of the damaged area; (3c) details of femur n. 3-3b, fracture produced by flexion; (4) proximal end of a femur of *Pyrrhocorax graculus* (Protoaurignacian) with probably human gnawing marks; (4a) the damaged area shows fractures and marks comparable with those experimentally produced on femur n. 3 (collapse of localized areas, cracks, crenulated edges, tooth marks) (I. Fiore). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

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