

Pleistocene Birds of Gruta Nova da Columbeira (Bombarral-Portugal): A Paleontological and Paleoenvironmental Approach

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Abstract: Discovered in 1962, the Columbeira cave has a Mousterian sequence dated between 101 and 35 Ka (U-series) and between 28,900 and 18,000 BP 14C. Excavations recovered abundant lithic implements and provided rich assemblage of vertebrates, including mammals, reptiles, birds and a remain of *Homo neanderthalensis*. In this work, authors present the taxonomy at the level of genus and species of the bird assemblage and its possible relationship with the paleoenvironments in which they lived. Thirteen species of birds have been identified out of 283 bones. Most of these bones are very fragmented and unsuitable for identification down to species or the genus level. Nevertheless, it is possible to say that the species vary through the sequence and that the assemblage is dominated by *Pyrrhocorax*, *Corvus*, *Columba* *Turdus* and *Alectoris*.

Key words: Middle Paleolithic, caves, pleistocene, birds, Portugal.

1. Introduction

Columbeira cave is located near Bombarral (Central Portugal), ca. 60 km north of Lisbon (Fig. 1). This karsic cave was accidentally exposed in 1962 by quarries that were exploiting the north face of a ravine of the Vale Roto Canyon. The site was almost immediately excavated by the team of the Portuguese Geological Services, led by Octávio da Veiga Ferreira, who exposed nine rich archaeological levels with abundant lithics, fauna, ash and a human molar, found and identified as the first evidence of *Homo neanderthalensis* in Portugal [1-5].

Later, between 1971 and 1972, Jean Roche

excavated the remaining deposits left by Veiga Ferreira, at the back of the cave, and was able to distinguish more than 20 levels, some of them based on geoclimatic analysis of the sediments. This deposit corresponds to a fill-in that occurred between 39 and 19 ka that remobilized Mousterian artifacts [2, 5].

Overall, this cave documents the unquestionable existence of Neanderthals, associated with Mousterian between the MIS5 and early MIS3 in the westernmost coast of Iberia [3, 4, 6-8].

Zilhão, et al. [8] presented a comprehensive framework for the deposit of Columbeira cave with five main stratigraphic units that can be summarized thus: Holocene deposits; rubble of collapsed limestone chimneys; clays with artifacts introduced through chimneys, after the Mousterian occupation—Unit excavated and described by Jean Roche at the back of

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Fig. 1 Localization of the Columbeira cave.

the cave [9, 10]; Mousterian levels of sands deposits spanning a thickness of ~3 m and subdivided in nine levels, with fauna and Mousterian lithic artifacts [1].

2. Material and Methods

The present study is focused on the analysis of all the bird remains from Columbeira cave (540 remains), currently housed at the Municipal Museum of Bombarral.

To identify the paleoenvironments, authors used the methodology defined by Sanches-Marco [11]: The paleobiotope (Ph) of a certain species (sp1), which currently inhabits a determined biotope (b), will be related to the same species that lived in the past: the Pb of sp1 will be equal to the b from the current representative of this species. Thus, the probability of species sp1 having lived in the paleobiotope b is equal to 1 and can be translated by: $P_b(\text{sp1b}) = P_b(\text{sp2}) = 0.5$ [11, 12].

For the paleoclimatic analysis, a grid with the main climates was created, in which the different birds' species identified were distributed according to the mentioned methodology above.

3. Previous Studies

3.1 Columbeira's Chronology

The chronology of the archaeological deposit results from several sets of dates [7, 8, 13] (Fig. 2).

The first ^{14}C results put the basal level 8 at ~25,000 BP. This particular level provided extensive information in faunal remains, burned bones, charcoal and stone tools, whereas a Neanderthal tooth was found impregnated in a stalagmitic "islet" located at the interface with the level 7 [14]. Ferreira [14] said: " ^{14}C date obtained by Prof. Schwabedissen of Hanover indicates an age around 25,000 years, which goes to show that the Neanderthal Man of Columbeira was in the final stage of its existence and living side by side with the Cro-Magnon Man of the Upper Paleolithic". Later, *Radiocarbon* published two results from samples taken by Jean Roche back in the 1970's, from a black layer than he correlated from the lower part of the sequence recorded by Veiga Ferreira [8]. These samples, described as "carbonaceous earth" by Delibrias, et al. [13], were dated as $26,400 \pm 750$ ^{14}C BP (Gif-2703) for level 16, and $28,900 \pm 950$ ^{14}C BP (Gif-2704) for level 20. Such results apparently corroborated the Hanover date of about 25,000 years [14], but the laboratory comment to the fact that the dates are evidently too young and should be considered lower limit of ages [8]. It should be noted that Roche's work remains unpublished, largely because the dating component was unsuccessful. At the present state, these dates cannot be considered valid for the Mousterian. Later, U-Series dates on 4 faunal remains (teeth) from layers 7 and 8 gave values

between 101 and 35 ka, comprising very large margins of error (Fig. 2); therefore, they are not useful to assign a valid dating for the cave [3]. After the levels equivalent to Roche's 16 and 20, the same dating methods were used in the 1970s—application of the ABA protocol to the bulk sediment submitted, and age measurement via β -radiation counting, the results obtained were $8,000 \pm 185$ ^{14}C BP for level 16 and $14,800 \pm 120$ ^{14}C BP for level 20. As such, those results are not consistent with the hypothesis that the Hanover and Gif dates simply reflect residual contamination of Mousterian charcoal by younger carbon percolating through the sediments from above, the implication that the putative “contaminant” would in fact be the predominant sample component [8].

Recently, Carvalho, et al. [15] obtained additional radiocarbon and U-series dates: two rabbit mandibles from level 9 (AMS radiocarbon dates, in Radiocarbon dating Laboratory of Waikato University, New Zealand); and three samples (bottom, middle and top) of densely crystallized flowstone extracted from layer 1 that caps the archaeological sediments (U-series in Radiogenic Isotope Geochemistry Laboratory at the University of New Mexico) [15]. The radiocarbon dates of level 9 were not successful due to the lack of collagen. The U-series dates of level 1 yielded ages between ~ 21 and ~ 1.4 ka (Fig. 2), showing that was formed after Neanderthal occupation.

3.2 Paleontological Assemblage

In Columbeira cave, several species of carnivorous mammals were identified: *Ursus arctus*, *Crocota spelea*, *Canis lupus*, *Canis* sp, *Felis sylvestris* and *Lynx pardina spelaea*; and herbivores: *Dicerorhinus hemitoechus*, *Bos primigenius*, *Equus caballus*, *Cervus elaphus*, *Sus scrofa*, *Dama dama*, *Capreolus capreolus* and *Capra pyrenaica*. From other groups, there is mainly the presence of rabbits and turtles, in particular the species *Agrionemys* (= *Testudo*) *hermanni* [1, 15-18].

3.3 Archaeological Assemblage

The lithic assemblage of Columbeira cave has ca. 6,000 implements on quartzite, chert and quartz and is all typically Mousterian, with high values of *Levallois*, such as great quantity and variety of sidescrapers, denticulates, notches and Tayac points [3, 19, 20]. Bones tools were also found [1, 8], but have not any relation to similar patterns of the Upper Paleolithic [3]. Layers 7 and 8 are interpreted as having more intense human occupation due to the large number of finds (layer 7 = 1,880 lithics; layer 8 = 2,433). These might correspond to base camps whereas others less intense such as layers 4, 6a, and 9. Layer 6 may correspond to short periods during phases in which the cave was mainly occupied by carnivores, specially hyena, denounced by the bone remains and coprolites [3, 19].

Level	Material	Method	Result	Lab.	Reference
8 (VF)	Charcoal	C14	22.350 ± 990 (BP)	KN-199/Hv-1350	Zilhão et al, 2011
16 (JR)	Charcoal	C14	18.000 ± 185 (BP)	KN-5596	Zilhão et al, 2011
			26.400 ± 750 (BP)	Gif-2703	Delibrias et al, 1984
20 (JR)	Charcoal Silty layer	C14	14.800 ± 120 (BP)	KN-5597	Zilhão et al, 2011
			28.900 ± 950 (BP)	Gif-2704	
8 (VF)	Tool bone	U-Series	87.1 ± 6.3 Ka		Zilhão et al, 2011
7 (VF)	Tooth	U-Series	$54.4 - 27.5 + 22.2$ Ka	SMU-23851	Raposo & Cardoso, 1998
			$35.9 - 35.5 + 27.3$ Ka	SMU-235E1	
8 (VF)	Tooth	U-Series	$101.49 - 55.9 + 38.4$ Ka	SMU-236E1	Raposo & Cardoso, 1998
			$60.9 - 35.5 + 27.4$ Ka	SMU-236E1	
1 (VF)	Flowstone	U-Series	1.423 ± 75	GNdC-1 (top)	Carvalho et al, 2018
			8.654 ± 387	GNdC-1 (middle)	
			20.704 ± 2039	GNdC-1 (bottom)	

Fig. 2 Absolute dates made on the Columbeira cave.

The overall curation, and low amount of cortex assemblage suggests the lithics were mostly produced elsewhere and imported to the cave [1, 3, 19, 20].

4. Results

It was possible to determine the species of 283 fossil remains (52.5% of the total sample) from Columbeira cave. Twenty-eight species were recognized [12]. Most of them (97%) correspond to bones of the appendicular skeleton, being the majority from the wings (humerus and ulnae), while the remaining, 3% belong to the axial skeleton any bone of the cranial skeleton was identified (Fig. 3) [12, 21]. Using the remains in which it was possible to identify the species, a study was carried out on the 111 MNIs (Minimal Number of Individuals) of the 28 identified species. This relation between the species and its order allows knowing the connection of the main groups of birds found in Columbeira cave. There is a predominance of Passeriformes species over all other groups, mostly corvids that represents total of 72 individuals (64.8%). From the other groups, we must highlight the Columbiformes, with 16 individuals (14.4%) and the galliform species, with 13 (11.7%). All the other groups together represent only 9.1% of the total [12].

The remains of birds identified in Columbeira cave are from Veiga Ferreira layers 6, 6a, 7, 8 and 9 [16]. Most were recovered on layers 6 (81 bones) and 6a (104 bones), whereas layer 9 has the least remains of birds presents (Fig. 4, Table 1). The, Columbiformes and Passeriformes appear on all layers, while the other groups appear, at the most on 3 levels (Fig. 4).

4.1 Paleoenvironment Approach

The taxonomic uniformity of the species of birds identified (Fig. 4) in layers 6 to 9 indicates similar paleoclimatic conditions during their depositional period (Table 1). This indicator is similar in relation to the large mammals identified in the cave [16, 17, 22].

Through the bird's fauna analysis from Columbeira cave, it is possible to notice the predominance of the

characteristic species from the inland environments, as expected, due to its geographic location, being the marine species residual; on the other hand, there are many species' remains from dry environments (heaths, woods and forest) and almost nonexistence of wetland species. The main predominance of *Phyrrhacorax* is from the cave's surrounding area: mountain and cliffs, the habitat of the two species from this genus (*P. phyrrhacorax* in the mountain and cliffs area, and *P. graculus*, in the mountain).

The species identified are mostly from a temperate-cold climate, suggesting temperatures are slightly lower than the present. These conclusions are taken through the occurrence of some birds' species characteristic from colder climates, such as the *P. graculus* and the *L. mutus*. These data correspond to the indicators provided from the large mammals that show "a cold biotope with a dry component, although not very accentuated" [16, 17].

Comparing the Columbeira assemblage with the present-day occurrences in the area, as recorded in eBird (<https://ebird.org/portugal/home>), it is possible to see that almost all of those species still exist in the

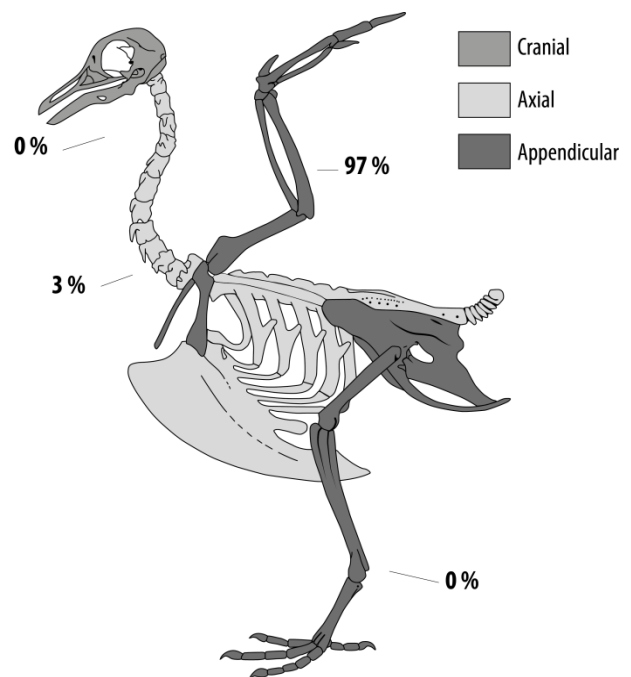


Fig. 3 Quantity and percentage of the skeleton parts represented by bird bones of the Columbeira cave.

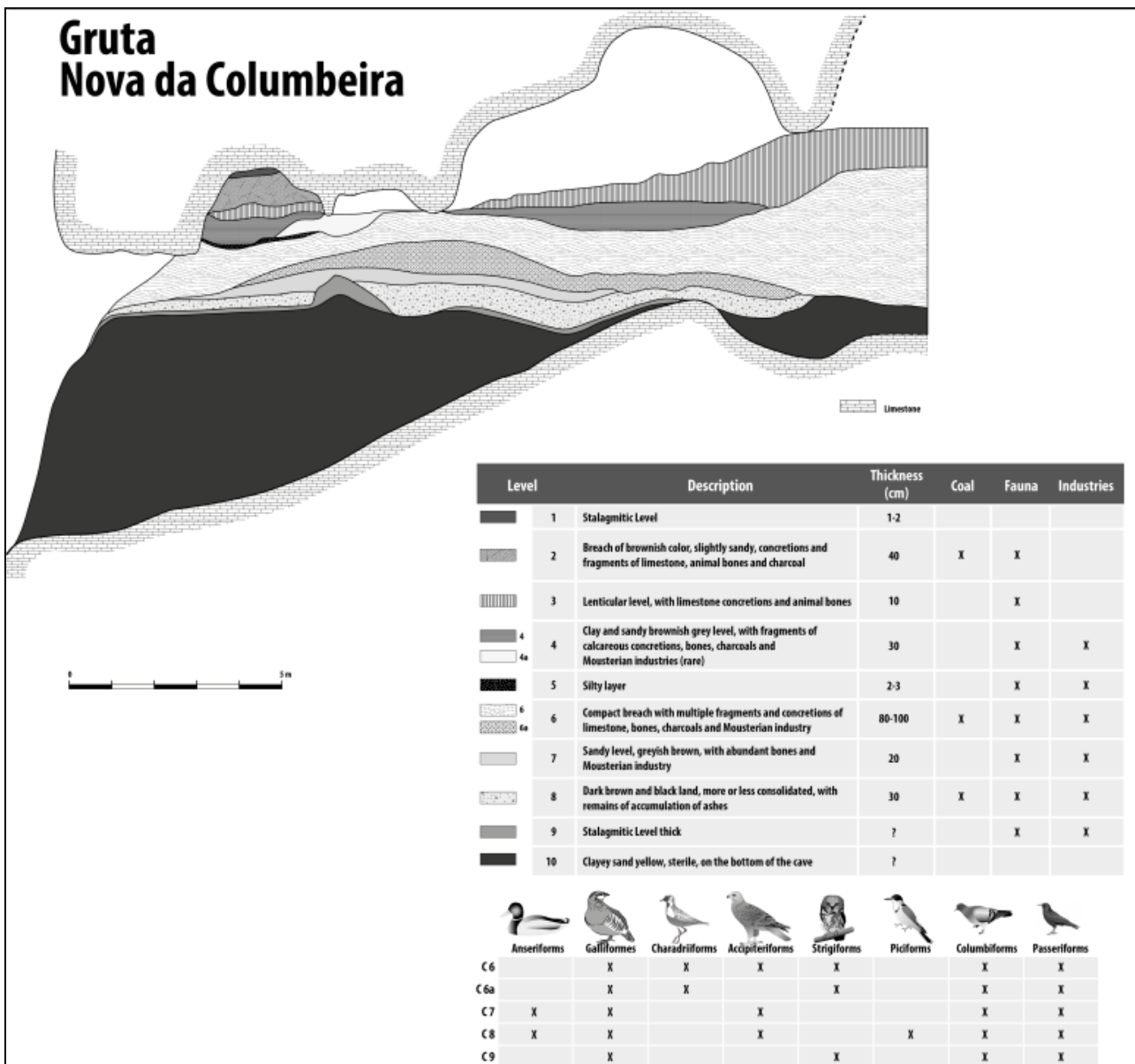


Fig. 4 Stratigraphic profile (after Refs. [1, 3 20]) and the distribution of major groups of birds by the different stratigraphic units of the Columbeira cave.

region today. However, *P. perdix* occupies both inland and terrestrial environments close to the coast but has been considered extinct for nearly a century in Portugal. Nonetheless, in 2017, an individual has been spotted near Bragança (NE region of Portugal), in January and a second one in December. But they lie some 400 km away from this cave, where the temperatures are much colder. *P. graculus* is known to live in mountainous areas above 1,300 m, in characteristic alpine environments and no individual

was ever spotted in Portugal, not even near the northern and colder borders. *C. frugilegus* is now rare in Portugal, with only a few observations in the inner south and in the Algarve, but is quite common in colder climates. Hence, and particularly because of the findings of *P. graculus*, we can suppose that there must have been periods with much colder temperatures in the area. However, in general terms, the climate must have been rather similar to the present [23-25].

Table 1 List of bird species from Columbeira cave. Distribution of species by stratigraphic layer and interpreted environment: Climate: A (wet-temperate), B (wet-cold), C (dry-temperate), D (dry-cold). TNR = Total number of remains.

Species	Layers					TNR	Climas
	C6	C6a	C7	C8	C9		
<i>Annasplatyrhynchos</i>			1	1		2	A
<i>Menalittanigra</i>			1			1	B
<i>Perdixperdix</i>		2	2			4	D
<i>Alectorisrufa</i>	4	10	6	3	2	25	C
<i>Coturnixcoturnix</i>			1			1	C
<i>Lagopusmutus</i>			1			1	D
<i>Pluvialissquatarola</i>		2				2	A
<i>Aquilachrysaetos</i>				2		2	C
<i>Falcotinuclus</i>	1					1	C
<i>Athenanoctua</i>	1				1	2	C
<i>Strixaluco</i>		2				2	C
<i>Columbalivia</i>	7	21	10			38	C
<i>Columbapalumbus</i>	1	1	2	1		5	C
<i>Picusviridissp.(?)</i>				1		1	D
<i>Pyrrhocoraxpyrrhocorax</i>	30	24	20	2	3	79	D
<i>Pyrrhocoraxgraculus</i>	16	8	4			28	C
<i>Corvusmonedula</i>	8	10	8	4		30	C
<i>Corvuscorone</i>	4	1	1	1		7	C
<i>Corvusfrugilegus</i>	2	4	3			9	C
<i>Corvuscorax</i>	1		1			2	C
<i>Picapica</i>	4	5	1		1	11	C
<i>Garrulusglandarius</i>	1					1	C
<i>Cyanopicacooki</i>		1				1	C
<i>Turdusiliacus</i>			1			1	C
<i>Turduspilaris</i>		4	2		1	7	C
<i>Turdusphilomelos</i>		1	1			2	C
<i>Turdusmerula</i>	1	8	7	1		17	C
<i>Cardueliscarduelis</i>			1			1	C
<i>Ptyonoprognerrupestis</i>			1			1	C
Total	81	104	75	16	8	284	

5. Discussion

Across Europe there has been increasing evidence that birds were used as food and as a source of elements that could be extracted and used as body ornaments. Dead birds, however, could also have been introduced by other predators or they may have used the caves to live and to nest [26-33]. Further taphonomic analysis to the assemblage is necessary to shed light on this issue.

The paleoecology study of Columbeira cave showed a larger amount of species and taxon genus from

wilderness and open field environments. However, due to the paleoecological distribution of the MNIs, there are a higher number of individuals from mountain and rocky species. The estuary and coastal areas have a very small number of individuals, which is explained by the geographic location of the site and the fact that probably the coast was further away than today. There are also a slightly larger number of individuals that inhabit wetlands which relates with the existence of two water paths nearby the Columbeira's brook and the Real river. These data are also in agreement with those of large mammals which

indicate species associated with reliefs (mountain goat), open spaces (horse), and forest patches, in more sheltered and humid places (deer) [17].

The species of Pleistocene birds identified in Columbeira cave pointed towards paleoenvironments with dry and temperate climates. Although dry climates are associated with some mammals' species and the most birds' species identified in Columbeira cave, the presence of anatids and charadriiforms, as well as the taphonomic factors, the abundance of concretions and the deposition of manganese oxides presuppose humid environments [22] during the formation of the Pleistocene deposits of the cave.

Dates from Columbeira cave point to a time span of Neanderthal occupation between 36 and 101 ka [3, 8, 15] (Fig. 2). Late Neanderthal occupation at the shore is dated to 41 ka [34, 35] and there are several sites in the Iberian Peninsula with the occurrence of Mousterian industries younger than 35 ka [3], but these contexts may need new dates with update protocols. Neanderthal extinction at west of the Ebro occurred after 37 ka [36]. From 30 ka, onwards, the climate got much colder, but Columbeira cave bird assemblage is dominated by temperate species.

These data are reinforced by the occurrence of species of mammals also associated with this type of climate. This seems to have been the overall setup before the drastic cooling of the MIS4, that seems to be related with the extinction of Neanderthals.

6. Conclusion

The bird assemblage of Columbeira cave is dominated by passerine species, and in this group, the most represented species are *C. monedula* and *P. pyrrhycorax*. The most representative skeleton part is the appendicular skeleton, particularly the upper arms. This is certainly related to the characteristics of these bones that allow them to survive better than others.

The bird assemblage covers a large number of species which have adapted to the most varied environments. Identifying the species and relating

them to the environments of the present-day representatives or of related species offers a strong indication of the prevailing environments of the past. In Columbeira cave, it seems that the species of birds are associated with dry and temperate climates, living in a surrounding area that had a paleoecotype dominated by open fields, with a strong influence of a mountain paleoecotype.

Acknowledgements

This study was supported by the FCT (Science and Technology Foundation), through project UID/Multi/00073/2013 Geosciences Center-Coimbra University. T. Pereira is funded by the project IF/01075/2013 from FCT. The authors thank Claudia Manso and Municipal Museum of Bombarral for the access to collection.

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**Pleistocene Birds of Gruta Nova da Columbeira (Bombarral-Portugal):
A Paleontological and Paleoenvironmental Approach**

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