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Mesolithic Miscellany

VOLUME 28: NUMBER 2
December 2020

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Abstract

Caverne X in Waulsort (Namur province, Belgium), excavated in the 19th century, revealed a burial site which was unexpectedly dated to the Final Upper Paleolithic (10,820 ± 80 BP, OxA-6856) in the 1990's. A re-examination of the collection and a new radiocarbon dating program was recently undertaken. The dates obtained on four left femurs (9285 ± 30 BP, ETH-74725; 9310 ± 30 BP, ETH-74726; 9340 ± 30 BP, ETH-74727; 9300 ± 30 BP, ETH-74728) revealed that the remains should in fact be attributed to the Early Mesolithic, consistent with 24 other ^{14}C dates obtained for eight cave sites in the Meuse Basin which range from *ca*. 9600 BP to 9000 BP. Caverne X contained 544 human remains belonging to at least nine individuals (one fetus, one perinatal/young child, one teenager, two adolescents/young adults and four adults), and 66 faunal remains consisting mainly of intrusive animals with the possible exception of a cervid antler, and one artefact (a small flint blade). Other than ochre deposits, all alterations (breakage, surface abrasion, impact scars and concretions) are post-depositional in origin. Carbon and nitrogen stable isotope analysis indicates a diet primarily based on terrestrial resources from an open landscape with proteins provided by large herbivores. Our study shows that Caverne X fits well with results already obtained for the Meuse Basin cave burials in terms of chronology, minimum number of individuals, funerary rituals and diet.

Keywords

Early Mesolithic, Belgium, cave burial, anthropology, radiocarbon dating, stable isotope analysis

Introduction

Human remains dated from the Early Holocene (*ca*. 11,700-8200 BP; Walker *et al*. 2018) are relatively rare in Western Europe (Amkreutz *et al*. 2018; Orschiedt 2018; Samsel 2018). They represent key fossils for the understanding of human biological and behavioral adaptations to rapid climate changes. In this context, we re-evaluated a skeletal assemblage from Caverne X, Waulsort, Belgium. One human tibia from the cave was directly dated by AMS in 1997 to 10,820 ± 80 BP (OxA-6856) (Cauwe *et al*. 2002), which corresponds to *ca*. 10,922-10,631 cal BC (95.4% probability)[1]. The date was considered problematic as it is notably older than other Early Holocene human remains in Belgium, which all fall between *ca*. 9700 and 8600 BP (9300 and 7500 cal BC; Toussaint 2010). Considering the antiquity of the excavation at Waulsort (19th century), and the fact that Belgian burial sites with Early Holocene human remains often contain remains from later periods, we decided to analyse the archeological material from Caverne X and attempt direct dating of several individuals. This note presents the preliminary results of the anthropological study (number of skeletal elements and minimum number of individuals) supplemented with results from other analyses (artefacts, archaeozoology, taphonomy, dating and isotopes).

Material

The Waulsort caves are a series of limestone caverns on the left bank of the River Meuse in the commune of Hastière (province of Namur) (Figure 1). Data on their precise location,

[1] OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer *et al.* 2013).

stratigraphy and association are unfortunately lost[2] (Blero 1997a; Boucquey 2010-2011, 2012). Their 19th century excavation was the first large program of exploration of natural cave sites in Belgium, and was funded by the Belgian State (Dupont 1864; Stockmans 1965, 1971). This research began in 1864 in the Meuse basin around Dinant under the auspices of the geologist and prehistorian Édouard Dupont, the second Director of the Royal Museum of Natural Sciences of Belgium from 1868 until his retirement in 1909. Nine caves (A-B, O, Q, R, T, V, V-W, X and Y) were excavated, largely in 1877 by a team of the Royal Museum of Natural Sciences of Belgium under the direction of Louis De Pauw and the field work of Auguste Collard (Stockmans 1983; Boucquey 2010-2011).

Figure 1. Location of the Waulsort site (L. Cammaert and A.-M. Wittek, ADIA).

[2] Field notes are now unfortunately lacking. Edmond Rahir, Curator at the Royal Museums of Art and History, would have read (some of) these notes in the early 20th century, which have gone missing since then (Rahir 1925; Blero 1997b). For a few days in April 1951, François Twiesselmann (Orban 2010), head of the Section of Anthropology and Prehistory of the Royal Belgian Museum of Natural Sciences, helped by two of his technicians, travelled through the region of Hastière and the caves of Waulsort, to try to locate the caves excavated in the 19th century, without success, except for cave O also known as Trou Paquot or Trou Pocaut (already mentioned in Rahir 1925).

Since its recovery, the collection has been housed at the Royal Belgian Institute of Natural Sciences (RBINS). The human and faunal remains, together with the artefacts, are stored by site in 17 wooden boxes (80 x 57 x 20 cm). Material from Caverne X is in one box, consisting of human and animal remains and a small flint blade (Rahir 1925; Boucquey 2012).

Radiocarbon dates on human bones from seven of the nine Waulsort caves were published by the Oxford Radiocarbon Accelerator Unit (Table 1; Cauwe *et al*. 2002). In agreement with what is known of the archaeology of the Meuse Basin (Cauwe 2004; Toussaint 2013), these dates revealed that two caves (A-B and Q) contain human remains from the Middle Neolithic and four caves (O, R, V and Y) from the Late Neolithic. Two further results were unexpected: the date of Caverne X (10,820 ± 80 BP) and one of two dates for cave Q (155 ± 45 BP). The second is clearly anomalous, coinciding with the 19th century excavation.

Cave	**Reference**	**^{14}C yr BP**	**cal BC/AD (2σ)***
A-B	OxA-9023	5130 ± 45	4040-3798 BC
O	OxA-6855	4170 ± 45	2890-2622 BC
Q	OxA-5314	155 ± 45	1664-1952 AD
Q	OxA-5840	4620 ± 50	3627-3118 BC
R	OxA-9024	4362 ± 45	3322-2887 BC
V	OxA-6857	4250 ± 45	3008-2673 BC
X	OxA-6856	10,820 ± 80	10,922-10,631 BC
Y	OxA-5315	4355 ± 55	3312-2882 BC

Table 1. Radiocarbon results obtained on human remains from the Waulsort burials. All measurements were undertaken at the Oxford Radiocarbon Accelerator Unit (Cauwe *et al*. 2002). *OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer *et al*. 2013).

An inventory of the Waulsort archaeological material took place in the early 20th century (Rahir 1925). First studies were achieved in the 1980's mainly on the material from Caverne Y and T (Warmenbol 1981, 1982a, 1982b, 1983a, 1983b, 1985, 1992, 1993, 1995) but the exhaustive study of all the artefacts occurred only in 2012 (Boucquey 2012). It confirmed the attribution to the Middle and Late Neolithic of most of the material. Referring to the small blade from Caverne X, Audrey Boucquey (2012) stated that it is complete, but without trace of use or retouching and can be assigned to the Epipaleolithic. She also mentioned that Caverne R contained two shouldered points (*pointes à cran*) that may also date to this period.

The first study of the human remains from the Waulsort caves was done in 1985 on the bones from Caverne T by Michel A. De Spiegeleire (De Spiegeleire 1985). The anthropological study of all the Waulsort caves was performed in 1997 by Pierre Blero for his master's thesis

(Blero 1997b). An anthropological analysis of Caverne O was published the same year (Blero 1997a). Pierre Blero estimated that Caverne X contained a minimum of eight individuals.

Methods

The skeletal remains from Caverne X have been reanalysed several times since 1997 at the RBINS. The few faunal remains recovered were identified using the reference collection of recent skeletons of the RBINS and the Royal Museum for Central Africa, Tervuren. Identification of each human skeletal fragment was carried out, and with gross morphology and pathological alterations recorded. In determination of the minimum number of individuals (MNI) we looked at bone overlaps (bones from the same side) together with apparent age differences and features such as bone size and robusticity. Osteometric data were collected following the Martin system (Bräuer 1988). Age assessment of the non-adult individuals, represented by isolated fragments, followed Schaeffer *et al*. (2009).

Macroscopic analysis of long bone fragmentation was performed to understand if breakage happened when the remains were fresh or dry, following the criteria suggested by Villa and Mahieu (1991). The presence or absence of patina on the fracture surfaces has also been recorded. This study was followed by analysis of osseous surface alterations of all the remains, both human and faunal. At the present, most bones were examined by the naked eye only, though a few have been examined under a binocular magnifier associated with a camera. Diagnosis of the modifications identified follows the methods of Domínguez-Rodrigo *et al*. (2009), Boulestin (1999) and Shipman (1981).

Considering the sample size and commingled nature of the assemblage, the sampling strategy to ensure radiocarbon dating of different individuals used overlapping bone; four left femurs were selected (F2, F3, F4 and F5). The areas sampled were chosen to avoid, as much as possible, the destruction of (1) meaningful skeletal features, and (2) breaks useful for the refitting of fragments. For F2 and F3 the sample consisted of a circular fragment of *ca*. 1 cm in diameter that was removed from the shaft. In F4 a detached fragment was used, and for F5, a piece was cut from a detached fragment.

Collagen extraction was performed at the Department of Geoscience, University of Tübingen on the human remains following Longin (1971) as modified by Bocherens *et al*. (1997). Briefly, the extraction procedure includes initial demineralisation in HCl 1M, followed by soaking in 0.125 M NaOH, and a final solubilisation in acidified water (pH = 2) before freeze-drying. The AMS radiocarbon dating was done at PSI/ETH in Zurich.

For stable isotope analysis, the samples were analysed at the Laboratory of Chronology, Finnish Museum of Natural History, University of Helsinki, using an NC 2500 elemental analyser coupled to a DeltaPlusAdvantage or a DeltaVPlus isotope ratio mass spectrometer. Measurement data for $\delta^{13}C$ and $\delta^{15}N$ were calibrated using the known values of international reference materials USGS-40 ($\delta^{13}C$ = -26.4‰, $\delta^{15}N$ = -4.5‰) and USGS-41 ($\delta^{13}C$ = +37.6‰, $\delta^{15}N$ = +47.6‰). Multiple measurements of matrix matched in-house reference materials (modern camel and elk bone) indicate an external reproducibility (1σ) of ± 0.2‰ for the $\delta^{13}C$ and $\delta^{15}N$ values respectively. The error in the reproducibility for the amounts of C and N was better than 4%. Reliability of the $\delta^{13}C$ and $\delta^{15}N$ values can be established by measuring the chemical composition of collagen, with C/N atomic ratios (C:N) ranging from 2.9 to 3.6 (DeNiro 1985) and percentages of C and N above 8 and 3%, respectively (Ambrose 1990).

Results and discussion

The first radiocarbon date

The unexpected Final Upper Paleolithic date may have two causes: an error in the dating or an uncommon burial event (or accidental death?) not otherwise reported in Belgium (unfortunately, the lack of information on the stratigraphy and association between the finds makes it impossible to archeologically confirm the second hypothesis).

This first dating was performed in 1997 when the Oxford Radiocarbon Accelerator Unit used ion-exchanged gelatin to separate amino acids using ion exchange columns. This method was abandoned due to "column bleed" in which small amounts of column packing carbon were found to sometimes be present in the extracted amino acids (Higham pers. com.). This was especially problematic for low collagen yielding bones as in the case of the tibia from Caverne X (Table 2).

Sample No.	Element	Find No.	$\%N_{bone}$	$\%C_{bone}$	Amount of coll. (mg)	Coll. yield (mg/g)	Lab. ID	^{14}C yr BP	cal BC (2σ)*
	Tibia	22/T4			6.1	<10.2	OxA-6856	10,820 ± 80	10,922-10,631
WLS-7	Left femur	L16/F4	1.0	5.0	25.2	55.5	ETH-74725	9285 ± 30	8627-8354
WLS-8	Left femur	L15/F3	0.7	4.6	6.6	14.7	ETH-74726	9310 ± 30	8638-8466
WLS-9	Left femur	L14/F2	1.6	7.6	37.6	106.7	ETH-74727	9340 ± 30	8709-8489
WLS-10	Left femur	L17/F5	1.7	7.2	32.1	90.2	ETH-74728	9300 ± 30	8634-8458

Table 2. Bone C and N percentages, amount of collagen extracted, collagen yields and radiocarbon results for the five human remains sampled from Waulsort Caverne X, including the first radiocarbon date. Coll. = collagen. *OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer *et al*. 2013).

The new radiocarbon dates

The four samples provided enough collagen to permit dating. Moreover, all the collagen considered for radiocarbon dating, as well as stable isotope measurements, fulfilled the criteria expected for good biogeochemical preservation, with C content above 30% and C:N ratios ranging from 3.0 to 3.4 (Table 3). The results of the ^{14}C dates are presented in Table 2 and Figure 2. All dates are virtually identical and fall around 9300 BP. This provides calibrated dates ranging between 8700 and 8350 BC at 2σ.

Sample No.	Element	Find No.	Coll. yield (mg/g)	%C	$\delta^{13}C$ (‰)	%N	$\delta^{15}N$ (‰)	C:N
WLS-7	Left femur	L16/F4	55.5	37.0	-21.3	12.9	9.1	3.4
WLS-8	Left femur	L15/F3	14.7	39.9	-20.0	13.7	9.4	3.4
WLS-9	Left femur	L14/F2	106.7	40.2	-20.3	14.0	9.6	3.3
WLS-10	Left femur	L17/F5	90.2	39.0	-20.3	13.6	10.1	3.3

Table 3. Stable isotope data for the four human remains sampled from Waulsort Caverne X. Coll. = collagen.

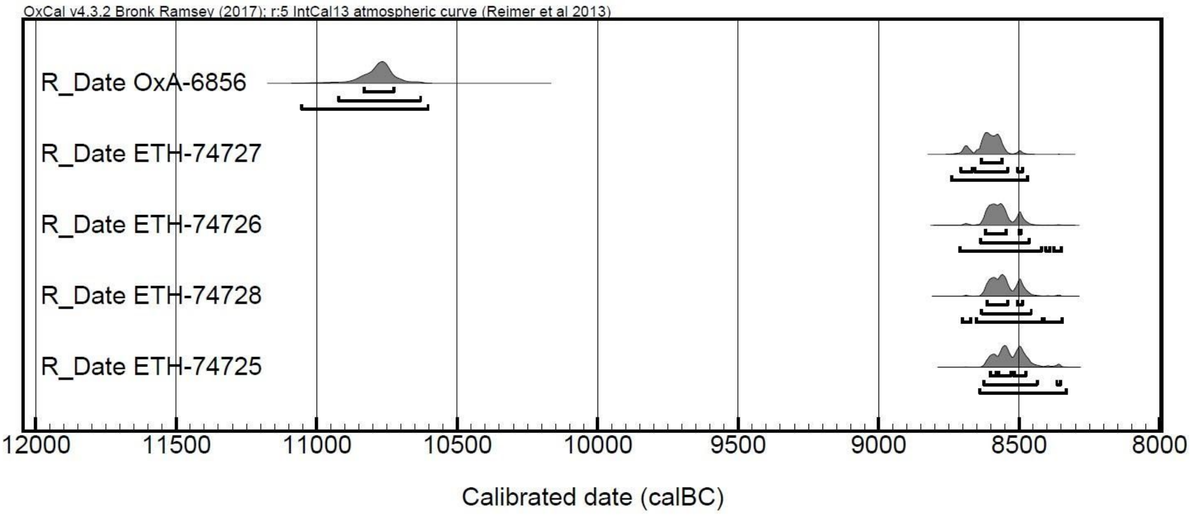

Figure 2. Calibrated radiocarbon dates of the five humans from Caverne X, Waulsort site.

The four new dates for Caverne X lie within the range of the previously published 27 dates on human bones from 11 Belgian Mesolithic cave sites (Toussaint 2010; Meiklejohn *et al.* 2014). Almost all correspond to the Early Mesolithic during the 10th and 9th millennia BC (Table 4). A single date (Trou Al'Wesse) corresponds to the Final Mesolithic (7th millennium), but it does not come from a clearly established burial context (Toussaint 2002). Table 4 does not include the Mesolithic radiometric (non-AMS) radiocarbon date from La Martina (Lv-2001) (Dewez *et al.* 1995), which is contradicted by five AMS OxA dates placing the burial in the recent Neolithic, and evidence that the initial sample was contaminated with carbonate (Toussaint and Ramon 1997).

The archeological material

Only one stone artefact, a small flint blade, was recovered from the cave. This low number is not surprising as archaeological material associated with Mesolithic burials from the Meuse Basin is always very scarce (Toussaint 2010). Boucquey (2012) concluded that this blade is

Epipaleolithic, but given the fact that it was not retouched, it could also be from other periods.

Site, location	**Lab. ID**	**Method**	**14C yr BP**	**cal BC (2σ)***	**Element**	**MNI**	**Reference**
Loverval D5, Gerpinnes	Gif A 94536	AMS	9640 ± 100	9300-8700	Bone fragments	2	Toussaint *et al.* 1996
	Lv-1506	non-AMS	9090 ± 100	8600-7950	Postcranial (320 g)		Cauwe and Toussaint 1993
Grotte Margaux, Dinant	Gif A 92354	AMS	9590 ± 110	9250-8600	Humerus fragment	7 to 10	Cauwe 1995; Toussaint 2011
	Gif A 92355	AMS	9530 ± 110	9250-8550	Humerus fragment		
	OxA-3533	AMS	9530 ± 120	9250-8550	Humerus fragment		
	OxA-3534	AMS	9350 ± 120	9150-8250	Ossicles		
	Gif A 92362	AMS	9260 ± 120	8800-8200	Humerus fragment		
	Lv-1709	non-AMS	9190 ± 100	8690-8230	Ribs (263 g)		Cauwe and Toussaint 1993
Claminforge, Sambreville	OxA-10552	AMS	9525 ± 60	9200-8600	Cervical vertebra	5	Toussaint 2002
	OxA-5451	AMS	9320 ± 75	8750-8290	Third metacarpal		Toussaint *et al.* 1996
Faille du Burin, Andenne	OxA-10585	AMS	9520 ± 55	9150-8600	Left navicular	6	Toussaint and Lacroix 2002
	OxA-8938	AMS	9345 ± 75	8800-8250	Left navicular		
	OxA-10595	AMS	9335 ± 65	8790-8330	Left navicular		
	OxA-10564	AMS	9315 ± 50	8740-8330	Left navicular		
Bois Laiterie, Profondeville	OxA-8910	AMS	9515 ± 65	9200-8600	Left humerus	4	Toussaint 2002
	OxA-8878	AMS	9445 ± 60	9150-8550	Left humerus		
	OxA-8911	AMS	9420 ± 65	9150-8450	Left humerus		
	GX-21380	AMS	9235 ± 85	8690-8270	Ossicle		Toussaint *et al.* 1998
Abri des Autours 3 (indiv. burial), Dinant	OxA 4917	AMS	9500 ± 75	9200-8600	Rib	1	Cauwe 1995; Polet and Cauwe 2007
Abri des Autours 2 (collect. burial), Dinant	OxA-5838	AMS	9090 ± 140	8750-7800	Bone	12	
Lombeau (L1), Charleroi	OxA-6441	AMS	9410 ± 70	9150-8450	Fifth metatarsal	5	Toussaint 1999
Lombeau (L2), Charleroi	OxA-6440	AMS	9360 ± 75	9100-8300	Fifth metatarsal		

Lombeau (L3), Charleroi	OxA-6445	AMS	9015 ± 80	8450-7900	Fifth metatarsal		
Petit Ri, Malonne	OxA-5042	AMS	9270 ± 90	8740-8280	Right femur fragment	11**	Jadin and Carpentier 1994
Chaleux, Dinant	OxA-5679	AMS	8730 ± 80	8200-7550	Bone	2?	Cauwe *et al.* 2002; Twiesselmann 1971
Trou Magrite, Dinant	OxA-5841	AMS	8645 ± 80	7960-7540	Bone	1?	Cauwe *et al.* 2002
Trou Al'Wesse, Modave	OxA-10561	AMS	6540 ± 45	5620-5370	Skull fragment	3	Toussaint 2002

Table 4. Radiocarbon dates and Minimum Number of Individuals (MNI) for 11 Mesolithic burial sites in Belgium (Toussaint 2010).

The human remains

Each bone has been examined, sorted and curated. The assemblage is composed of 544 identifiable fragments (Table 5) and 344 not clearly assigned to a specific bone. In addition, 66 animal bones were mixed with the human remains.

The anthropological analysis indicates that at least nine individuals were placed in this collective burial[3] (Table 5), very close to the estimate made by Blero in his master's thesis (Blero 1997b), and within the higher values observed for Belgian Mesolithic cave burials (Table 4). Only the Abri des Autours and the Petit Ri contained more individuals. At Caverne X the number of immature bones is very limited (Table 5), but at least two very young individuals can be identified: a fetal individual represented by six bones, and a slightly older juvenile represented by three bones. The first died at 28 to 32 weeks term, and was presumably stillborn. The second is a slightly older juvenile based on the size of the fragments, but poor preservation of the remains precludes precise assessment (perinatal individual?). Among the seven older individuals (as determined from metacarpals and metatarsals, Table 5), three died before reaching full skeletal maturity. One individual died between *ca*. 12 and 16 years of age (assessment based on the estimated maximum length of a right clavicle with unfused medial epiphysis), one robust individual died between *ca*. 16 and 24 years (right coxal bone) and one gracile individual died between *ca*. 17 and 29 years (based on the partial union of the medial epiphysis of a pair of clavicles). One or two of these seven individuals might have died in childbirth and been the mother of the fetus or the perinatal individual who had been buried with her child (as with burial 8 at the Mesolithic site of Vedbæk, Denmark; Albrethsen and Brinch Petersen 1976).

[3] A collective burial refers to the successive deposition of burials in the same feature over time (Knüsel 2014).

Bone	NF				MNI	Remarks concerning MNI
	Total	**Fetus**	**Perinatal / young child**	**Adolescent / adult**		
Skull	53	1	0	52	3	
Mandible	3	0	0	3	3	At least one young adult present
Tooth	18	0	0	18	2	
Cervical vertebra	16	0	0	16	4	
Thoracic vertebra	30	0	0	30	2	
Lumbar vertebra	10	0	0	10	2	
Rib	93	0	1	92	5	At least one teenager or young adult present
Clavicle	8	0	0	8	5	At least one teenager and one gracile young adult present
Scapula	6	0	0	6	2	
Humerus	5	1	1	3	4	
Radius	7	1	0	6	3	
Ulna	11	1	0	10	4	
Carpal	3	0	0	3	2	
Metacarpal	49	0	0	49	7	
Hand phalanx	55	0	0	55	5	
Coxal bone	20	0	0	20	2	At least one robust young adult present
Femur	28	1	0	27	6	
Patella	3	0	0	3	3	
Tibia	12	1	0	11	4	
Fibula	22	0	1	21	4	
Tarsal	20	0	0	20	6	
Metatarsal	47	0	0	47	7	
Foot Phalanx	25	0	0	25	5	At least one fetus, one perinatal/young child, one teenager, one gracile young adult, one robust young adult present
Totals	**544**	**6**	**3**	**535**	**90**	

Table 5: Inventory of the human remains from Waulsort Caverne X. NF = Number of Fragments; MNI = Minimum Number of Individuals.

Macroscopic analysis of long bone fragmentation suggests that breakage happened when the remains were already dry. Some of them do not show any patina, demonstrating recent fragmentation. The breakage may result from taphonomic processes like trampling, movements in the sediment matrix, falling rocks from the wall of the cave or different recent episodes of transport and manipulation. The osseous surface of the remains is rather well preserved but shows many alterations, also mainly due to trampling. Animals identified among the faunal remains, such as fox or badger (see below), may have created some of these traces through burrowing activity. Moreover, some bones are partially covered by concretions. Finally, one element is not the result of taphonomic processes, the presence of a red colour mineral (ochre?) on a few bones (Figure 3). This demonstrates active processing or burial. Use of ochre in burial ritual is attested throughout the European Mesolithic (Grünberg 2013a, 2015) and has been observed in several other Belgian Early Mesolithic cave burials, including Abri des Autours (Polet and Cauwe 2007), Grotte Margaux (Toussaint 1998, 2011), Bois Laiterie (Toussaint *et al*. 1998) and Lombeau (Toussaint 1999).

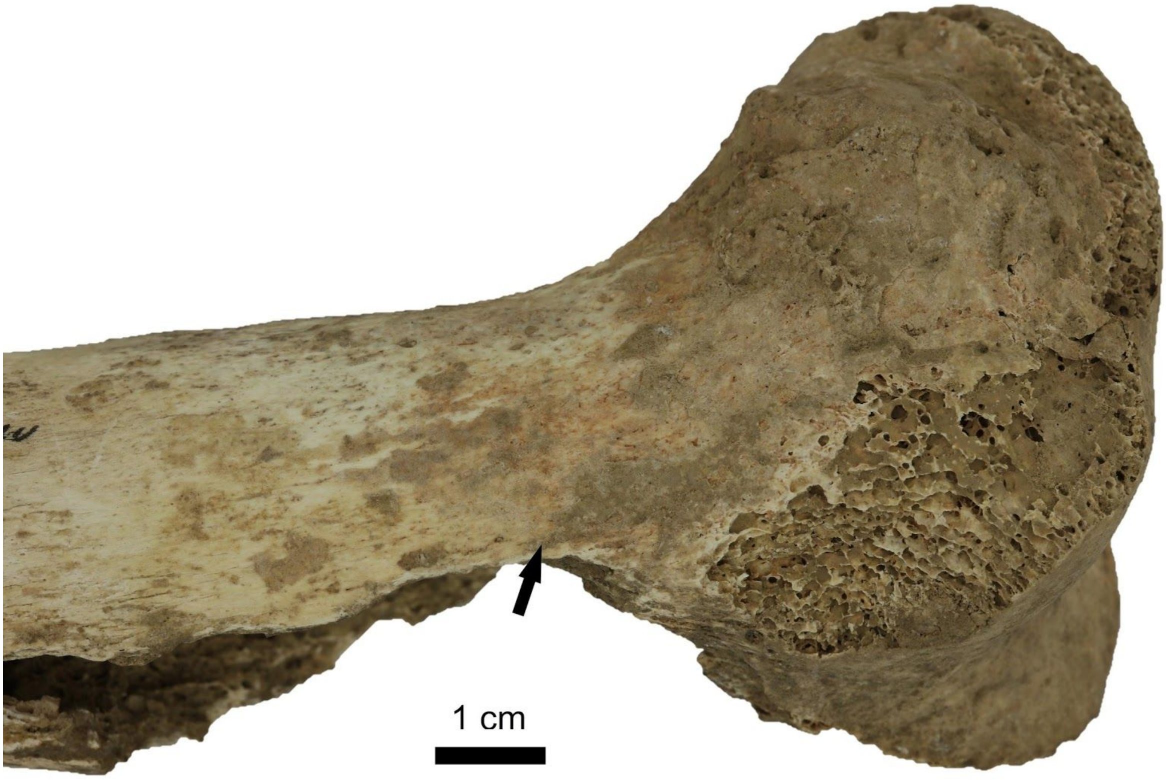

Figure 3. Red colour mineral deposit (ochre?) on the femur, F2, from Caverne X, Waulsort (→) (É. Dewamme, RBINS).

No human chewing marks, cut-marks or evidence of charring have been identified on the Caverne X remains. Of these, only flint cut-marks have been recorded from another Belgian Mesolithic cave burial, on a calvaria from Grotte Margaux (Toussaint 1997, 2011).

The faunal remains

All faunal remains belong to wild species with the exception of two bones of sheep or goat (Table 6), which indicates recent intrusions with both taxa only introduced during the

Neolithic (Zeuner 1963). Gnawing marks from a carnivore were recorded on one element, but no cut marks or other human modifications were observed. The faunal remains are considered as intrusive (*sensu* Gautier 1987); likely brought to the cave by scavengers such as badger or fox, both identified among the material. Only a fragment of cervid antler could have been introduced by humans but it is devoid of modification. Although association of faunal remains with Mesolithic burials has been regularly reported in Europe (Grünberg 2013b), this is not the case in Belgium. Of three Belgian Mesolithic burials with faunal remains reported, namely Petit Ri in Malonne (Cordy 1994), Bois Laiterie in Profondeville (Gautier 1997), and Abri des Autours in Dinant (Goffette *et al.* 2017), none were clearly associated with the graves (see Table 3 for details). On the contrary, the faunal assemblages of these three sites are chronologically heterogeneous, and traces from scavengers have been identified on animal bones from Abri des Autours, all supporting accumulation by carnivores (Goffette *et al.* 2017).

Taxa	**NISP**
Birds	
Black grouse (*Tetrao tetrix*)	1
Grey partridge (*Perdix perdix*)	1
Mammals	
Mole (*Talpa europaea*)	1
Badger (*Meles meles*)	2
Fox (*Vulpes vulpes*)	3
Wild boar (*Sus scrofa*)	1
Undetermined deer (Cervidae)*	1
Sheep or goat (*Ovis ammon* f. aries/*Capra aegagrus* f. hircus)	2
Mammal, size of hare	11
Mammal, size of sheep	17
Mammal, size of cattle/deer	8
Undetermined mammal	18
Total	**66**

Table 6. Identified faunal remains from Waulsort Caverne X. NISP = Number of identified specimens. *antler fragment.

The isotopic values

The $\delta^{13}C$ and $\delta^{15}N$ values of the human bone collagen samples from Caverne X varied from -21.3 to -20.0‰ and +9.1 to +10.1‰, respectively (Figure 4, Table 7). These data clustered with those already obtained on Early Mesolithic adults from the Meuse Basin (Bocherens *et* *al*. 2007). Published results ranged between -21.8 and -19.7‰ for $\delta^{13}C$ and between +8.4 and +10.5‰ for $\delta^{15}N$ (Figure 4). We also considered the isotopic values obtained from Early Holocene herbivores from the north of France (Leduc *et al*. 2013; Drucker *et al*. 2020) as well as fish from Abri du Pape in Belgium (Drucker *et al*. 2018) and Friesack 4 in northern Germany (Meadows *et al*. 2018). In the absence of data on local archaeological fauna, these results allow us to reconstruct a baseline for the Preboreal in the Meuse Basin (Figure 4). The isotopic shift between the collagen isotopic values of a consumer and its prey is *ca*. +1‰ for $\delta^{13}C$ and between +3 and +5‰ for $\delta^{15}N$ (Bocherens and Drucker 2003). Based on the mean values calculated for the Meuse Basin humans, including from Caverne X, we expect $\delta^{13}C$ values centering around -21.5‰ and $\delta^{15}N$ values ranging from *ca*. +4.6 to +6.6‰. The $\delta^{13}C$ and $\delta^{15}N$ values of the large herbivores from northern France cluster between -21.8 and -21.4‰, and mainly between +3.4 and +6.5‰, which correspond to the expected ranges described above. One exception is a wild boar with a very high $\delta^{15}N$ value of +8.5‰, likely linked to an omnivorous diet including a significant amount of meat protein (see Drucker *et al*. 2018). Hence, the diet of the Early Mesolithic humans from Caverne X, and other individuals from the same region and period, is primarily based on terrestrial resources. The dietary proteins were provided by large herbivores living in an open, likely sparsely wooded landscape, before the extension of the temperate dense forest.

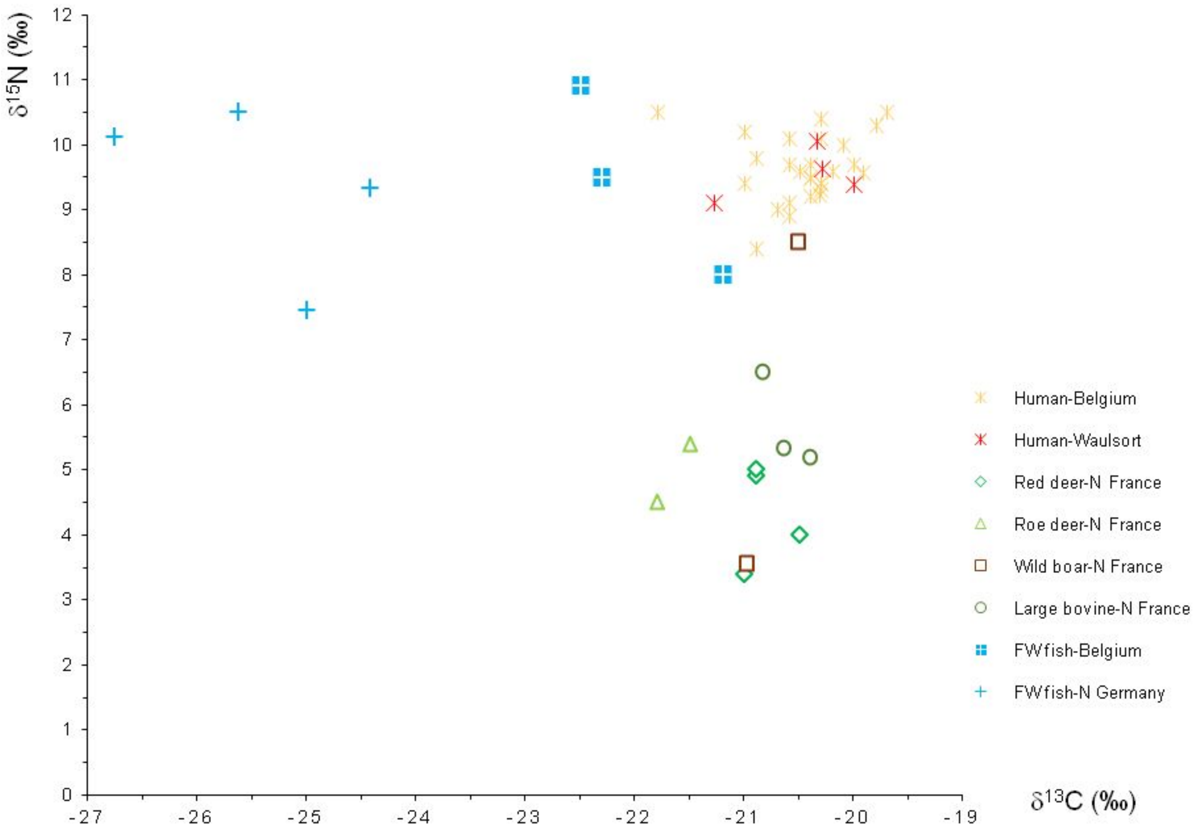

Figure 4. Plot of the $\delta^{13}C$ and $\delta^{15}N$ isotopic values of bone collagen from Mesolithic human remains from Belgium (the four individuals from Waulsort Caverne X are in red) that are plotted alongside Pre-Boreal faunal remains from Belgium, Germany and Northern France.

Site	Lab No.	Sex	Sample	Find No.	Yield (mg/g)	%C	%N	C:N	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
Caverne X	WLS-7	Undet.	Left femur	L16/F4	55.5	37.0	12.9	3.4	-21.3	9.1
Caverne X	WLS-8	Undet.	Left femur	L15/F3	14.7	39.9	13.7	3.4	-20.0	9.4
Caverne X	WLS-9	Undet.	Left femur	L14/F2	106.7	40.2	14.0	3.3	-20.3	9.6
Caverne X	WLS-10	Undet.	Left femur	L17/F5	90.2	39.0	13.6	3.3	-20.3	10.1
Loverval	MT600	Undet.	Skull	LOV 2 (CR2)	97.6	40.5	14.5	3.2	-20.2	9.6
Loverval	MT700	Undet.	Skull	LOV 1 (CR1)	85.4	40.5	14.4	3.3	-20.7	9.0
Margaux	MT800	Female	Skull	MG CR1	147.6	42.5	15.7	3.2	-20.3	9.3
Margaux	MT900	Female	Skull	MG CR2	150.7	41.9	15.4	3.2	-20.4	9.2
Margaux	MT1000	Female	Skull	MG CR3	80.8	41.6	15.3	3.2	-20.3	9.4
Margaux	MT1100	Female	Skull	MG CR4	89.5	42.6	15.6	3.2	-20.0	9.7
Margaux	MT1200	Female	Skull	MG CR5	95.3	41.6	15.3	3.2	-20.5	9.6
Margaux	MT1300	Female	Skull	MG CR6	159.6	42.0	15.4	3.2	-20.4	9.7
Margaux	MT1400	Female	Skull	MG CR7	41.6	42.4	15.6	3.2	-19.8	10.3
Margaux	MT1500	Female	Skull	MG CR8	19.4	40.3	14.9	3.2	-20.3	10.1
Margaux	MT1600	Female	Skull	MG CR9	85.9	42.8	15.8	3.2	-20.4	9.5
Bois Laiterie	MT1700	Undet.	Left humerus	BL1	44.7	42.8	15.7	3.2	-20.3	9.4
Bois Laiterie	MT1800	Undet.	Left humerus	BL2	78.7	43.6	16.0	3.2	-20.6	9.1
Bois Laiterie	MT1900	Undet.	Left humerus	BL3	77.0	42.7	15.7	3.2	-20.6	8.9
Claminforge	MT2000	Undet.	Vertebra	CLAM1	46.6	40.7	14.9	3.2	-19.7	10.5
Grotte Lombeau	MT2100	Undet.	Skull	LomB 1	32.9	38.4	14.0	3.2	-20.6	9.7
Grotte Lombeau	MT2200	Undet.	Skull	LomB 2	36.5	38.0	14.1	3.1	-20.9	9.8
Grotte Lombeau	MT2300	Undet.	Jawbone	LomB 3	100.8	42.6	15.6	3.2	-20.6	10.1
Abri des Autours 3	BM-14	Female	Rib		169.1	43.6	15.8	3.2	-20.3	9.2
Abri des Autours 2	BM-10	Female	Femur		25.2	40.7	14.8	3.2	-19.9	9.6
Abri des Autours 2	BM-44	Undet.	Ulna		27.8	31.8	12.5	3.0	-20.9	8.4
Abri des Autours 2	BM-45	Undet.	Ulna		167.1	38.2	13.7	3.3	-21.8	10.5
Abri des Autours 2	BM-46	Undet.	Ulna		62.7	40.2	14.7	3.2	-21.0	10.2
Petit Ri (Malonne)	BM-65	Undet.	Skull		151.3	41.7	15.0	3.2	-20.4	9.5

Faille du Burin	MT6800	Undet.	Right fifth metatarsal	Burin1	40.3	41.8	15.3	3.2	-20.1	10.0
Faille du Burin	MT6900	Undet.	Right fifth metatarsal	Burin2	176.0	43.5	16.0	3.2	-21.0	9.4
Faille du Burin	MT7000	Undet.	Right fifth metatarsal	Burin3	111.1	42.7	15.6	3.2	-20.3	10.4
							Mean		**-20.5**	**9.6**
							SD		**0.4**	**0.5**

Table 7. Results of collagen extraction (yield), elemental (C, N, C:N), and isotopic ($\delta^{13}C$, $\delta^{15}N$) analyses of adult individuals from Waulsort Caverne X and other Early Mesolithic sites from the Meuse Basin, Belgium.

Conclusion

The 19th century excavation of Caverne X of Waulsort uncovered a collective burial now dated to the Early Mesolithic, and not to the Final Upper Paleolithic as suggested by an initial radiocarbon analysis in the 1990's. These remains belong to a minimum of nine individuals, with a diet primarily based on terrestrial resources from open, and likely slightly wooded, landscape. Some of the deceased were sprinkled with ochre. The cave also contained intrusive faunal remains, with the possible exception of a fragment of cervid antler, and a single stone artefact. The burial of Caverne X thus fits well with previous results for Meuse Basin cave burials in terms of chronology, MNI, funerary rituals and diet.

Further research on the Caverne X individuals will include a new dating of the supposed Final Upper Paleolithic specimen, using newer AMS methods, to determine whether or not the first date was correct and a never-before seen burial event in the prehistory of the Meuse River Basin. We also plan a palaeopathological study including stress occupational markers and their non-metric traits. The data will be incorporated in large scale studies dealing with funerary rituals and lifestyle reconstruction and will allow us to document these overlooked populations.

Acknowledgments

We are grateful to Patrick Semal, head of the Heritage Department of the Royal Belgian Institute of Natural Sciences for providing us access to the Waulsort collection. We also thank Laurence Cammaert and Anne-Marie Wittek (Association pour la Diffusion de l'Information Archéologique) for drawing the map of Belgium and Éric Dewamme (RBINS) for taking the picture of the femur with ochre. Thank you to Tom Higham (Oxford Radiocarbon Accelerator Unit) for constructive discussion on the first dating of the Caverne X human performed in 1997.

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