

A LATE GLACIAL PALAEOLITHIC DOG FROM GOYET (THIRD CAVE, BONE LEVEL A1), BELGIUM

Abstract

Most researchers accept that by the end of the Pleistocene dogs were part of the daily life of prehistoric hunter-gatherers. Recent analyses of the mammal assemblages from the third cave of Goyet (Belgium) reveal that a large component of the material from bone level A1 postdates the Last Glacial Maximum. The biometric study of the large canid remains from this level shows that an ulna can be described as from a medium-sized Palaeolithic dog with an estimated body mass of ~20 kg. A direct AMS ¹⁴C date of the bone demonstrates that the dog lived during the Bølling/Allerød interstadial. Human and carnivore modifications of the bone indicate that the animal was dismembered by a contemporaneous human individual, likely to obtain its meat, and then gnawed by a canid-sized carnivore. Presumably, Palaeolithic dogs fulfilled diverse roles in Late Palaeolithic societies including as a source of food.

Keywords

Palaeolithic dog, Late Palaeolithic, Western Europe, cynophagy

INTRODUCTION

The timing of the beginning of the domestication process of the wolf is controversial, but most researchers agree that dogs were living together with people at the end of the Pleistocene. Remains of this togetherness were famously found at Bonn-Oberkassel in Germany where two dogs were buried together with a man and a woman (Nobis, 1979, 1986; Street, 2002; Street et al., 2015; Janssens et al., 2018). In France, an intentional double dog burial, dating from the Late Palaeolithic, was recently detailed (Boudadi-Maligne et al., 2020). Much older canid remains, dating from before the Last Glacial Maximum (LGM), an extremely cold and dry period ranging in age from 23,000 years to 19,000 years ago (Mix et al., 2001), have been attributed to incipient dogs (e.g., Germonpré et al., 2012, 2015). One such remain is the canid skull (**Fig. 1**) found in the third cave of Goyet, in Belgium. With a calibrated age of ~35,700 cal BP this canid would be the oldest domesticated animal known so far (Germonpré et al., 2009, 2012, 2018). However, these attributions are subject to controversy (Boudadi-Maligne and Escarguel, 2014; Morey, 2014; Drake et al., 2015; Janssens et al., 2016, 2019; but for a rebuttal see Galeta et al., 2021).

The Goyet caves are situated in the Condroz, a region south of the Sambre and Meuse valleys in Belgium. The Condroz landscape is characterised by steep-sided valleys cutting through plateaux of relatively constant altitudes, locally reaching 350 m (Denis, 1992). The third cave of Goyet is part of a large karstic system that lies on the right bank of the Samson, a tributary of the Meuse River, at ca. 15 m above the river. Edouard Dupont, who excavated this cave in the 1860s, recovered here numerous Pleistocene mammal bones, human remains and large quantities of Middle and Upper Palaeolithic artefacts (Dupont, 1872; Germonpré, 2001; Flas, 2008; Pirson et al., 2012). It is the only site in the world where human remains from populations dating from the Mousterian, Aurignacian, Gravettian and the Magdalenian have been found at the same location (Rougier et al., 2016; Posth et al., 2016; Fu et al., 2016). The radiocarbon

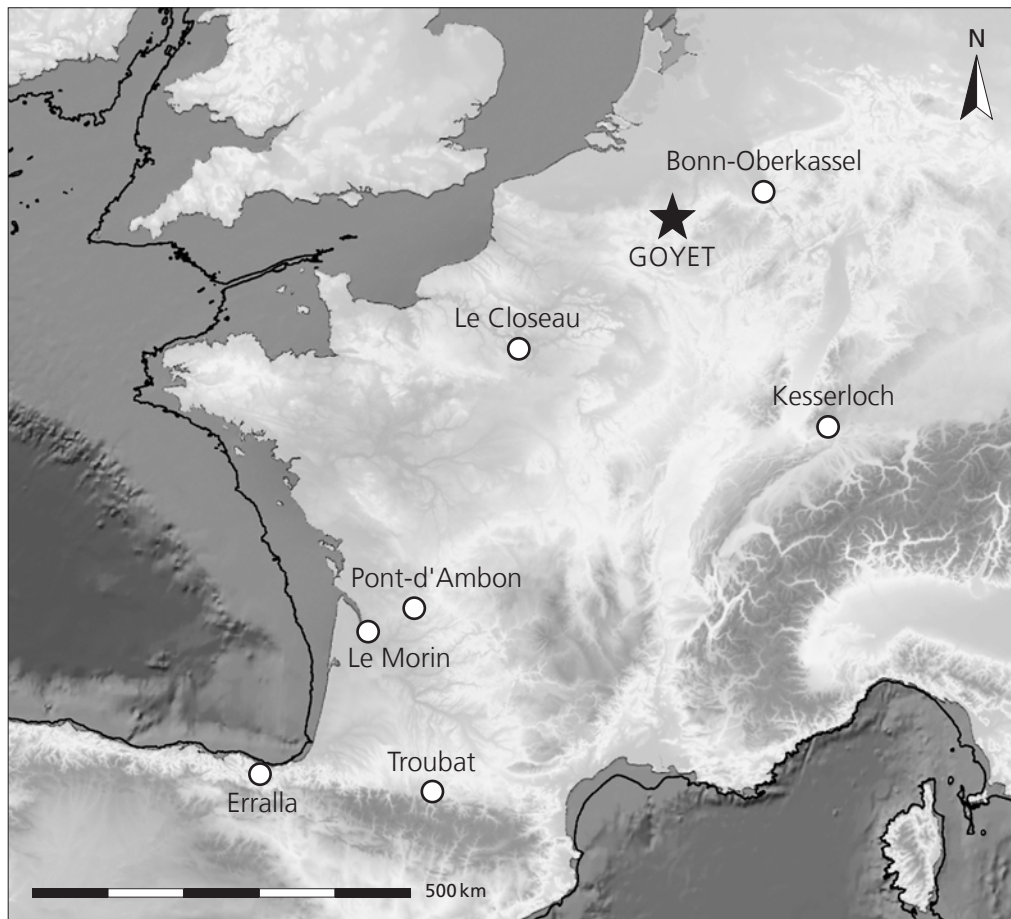


Fig. 1 Map with the most important sites discussed in the text; the estimated coastline (at -80m) during MIS3 is based on Zickel, M., Becker, D., Verheul, J., Yener, Y., Willmes, C. CRC 806 Database: Paleocoastlines GIS dataset [08.02.2021]. – (Available from <http://crc806db.uni-koeln.de/dataset/show/paleocoastlines-gis-dataset1462293239/>).

dates show that occupations of the cave date from before the LGM, from the LGM and from the post-LGM (Tab. 1).

The age dispersion of several AMS ^{14}C dates and the refitting of human bones originating from different horizons indicate that at least part of the content of the bone levels recognized by Dupont is mixed, likely because Duponts' excavations methods have not met today's standards (Germonpré, 2001; Rougier et al., 2016). At the entrance of the third cave, in Chamber A, Dupont discovered in the three uppermost levels, a large number of Middle and Upper Palaeolithic artefacts, human remains and many bones of Pleistocene mammals (Dupont, 1872; Germonpré, 2001; Rougier et al., 2016). The artifacts can be assigned to the Mousterian, Lincombian-Ranisian-Jerzmanowician, Aurignacian, Gravettian, Magdalenian, Neolithic and to historical times and show that the cave was recurrently occupied from the Pleniglacial on. Unfortunately, it is not always clear from which level the artefacts originated (Dewez, 1987; Dupont, 1872; Lopez Bayon et al., 1997; Otte, 1979; Otte and Groenen, 2001; Ulrix-Closset, 1975; Flas, 2008; Pirson et al., 2012). At the rear of Chamber A and in Chamber B, Dupont (1872) distinguished a fourth and a fifth bone-bearing level, containing mainly cave bear, cave lion, and cave hyena remains. Apart from the stratigraphic attribution of the finds, Dupont distinguished three types of bone assemblages at Goyet. A first type, found at the entrance of

AMS #	Level	RBINS #	¹⁴ C Date [BP]	cal BP (95%)	Taxon	Element	Human modifications	Reference
Level A1, post-LGM dates								
RICH-27945	A1	Vert00-247/ 2812-6	11,785	±48	<i>C. familiaris</i> (Palaeolithic dog)	ulna	cut-marks, red stains, gnawing	this study
UtC 8957	A1	2813-33	12,560	±50	<i>Equus</i> sp.	MC acc	cut-marks, red stains	Germonpré, 2001
GrA-3238	A1	2783-49	12,620	±90	<i>O. moschatius</i>	phalanx	cut-marks	Germonpré, 1997
GrA-3237	A1	2380-6	12,770	±90	<i>Equus</i> sp.	vertebra	cut-marks, red stains	Germonpré, 1997
OxA-V-2223-48	A1	2832-2	12,775	±55	<i>Equus</i> sp.	MC	impact marks	Stevens et al., 2009
OxA-32248	A1	2811-48	12,960	±65	<i>U. arctos</i>	canine	red stains	Ersmark et al., 2019
KIA-25296	A1	2812-10	13,680	±60	<i>C. lupus / familiaris</i>	humerus		Germonpré et al., 2009
Level A1, LGM date								
OxA-6592	A1	2814-34	16,320	±140	<i>C. antiquitatis</i>	phalanx		Stevens et al., 2009
Level A1, pre-LGM dates								
OxA-11291	A1	2814-28	23,560	±230	<i>C. antiquitatis</i>	phalanx	cut-marks	Stuart and Lister, 2012
OxA-11292	A1	2815-2	23,940	±180	<i>M. primigenius</i>	humerus		Barnes et al., 2007
GrA-3239	A1	2812	27,230	±260	<i>C. crocuta</i>	calcaneus		Germonpré, 1997
OxA-12120	A1	2814	29,330	±160	<i>C. antiquitatis</i>	M3		Stuart and Lister, 2012
OxA-V-2223-44	A1	2832-2	31,750	±200	<i>Equus</i> sp.	MC	impact marks	Stevens et al., 2009
OxA-11294	A1	2815-24	32,280	±280	<i>M. primigenius</i>	ivory		Palkopoulou et al., 2013
OxA-11293	A1	2815-8	32,840	±340	<i>M. primigenius</i>	molar		Palkopoulou et al., 2013
UtC 8958	A1	2812	35,000	±400	<i>C. crocuta</i>	P4		Germonpré, 2001
OxA-20997	A1	2815-24	35,650	±600	<i>M. primigenius</i>	ivory		Palkopoulou et al., 2013
GrA-9605	A1	2811-43	38,770	+1180 -1030	<i>U. spelaeus</i>	pisiform		Germonpré and Sablin, 2001
Post-LGM dates of other bone levels								
KIA-13550	A3	2763	10,640	±50	<i>U. arctos</i>	mandible		Germonpré, 2001
KIA-22275	A2	2830-23	12,380	±60	<i>A. lagopus</i>	humerus		Dalén et al., 2007
GrA-46168	?	Goyet Q2	12,650	±50	<i>H. sapiens</i>	humerus	red stains	Posth et al., 2016
OxA-12121	A2	2770-1	12,775	±50	<i>O. moschatius</i>	MT	cut-marks	Germonpré and Hämmäläinen, 2007

Tab. 1 AMS ¹⁴C dates and calibrated ages available for the bone assemblage from the first bone level A1 from the third cave of Goyet and AMS ¹⁴C dates and calibrated ages available for other bone assemblages dating from the post-LGM.

Goyet third cave	Anthropogenic traces										Carnivore traces	
	NISP	NISP [%]	MNI	MNI [%]	red stains NISP	red stains NISP [%]	cut-marks NISP	cut-marks NISP [%]	tools/orn. NISP	tools/orn. NISP [%]	gnawing NISP	gnawing NISP [%]
<i>Lepus</i> sp.	3	0.2	1	1.0								
<i>Canis lupus/familiaris</i>	18	1.4	3	3.0	1	5.6	4	22.2	2	11.1	4	22.2
<i>Vulpes</i> sp.	48	3.8	6	6.0	4	8.3	2	4.2	2	4.2	4	8.3
<i>Ursus arctos</i>	5	0.4	1	1.0								
<i>Ursus spelaeus</i>	193	15.3	14	14.0							6	3.1
<i>Mustela putorius</i>	1	0.1	1	1.0								
<i>Meles meles</i>	7	0.6	2	2.0								
<i>Crocuta crocuta spelaea</i>	42	3.3	5	5.0								
<i>Mammuthus primigenius</i>	40	3.2	2	2.0	5	8.8			3	7.5	2	5.0
<i>Equus</i> sp.	533	42.2	13	13.0	22	4.1	24	4.5	22	4.1	15	2.8
<i>Coelodonta antiquitatis</i>	43	3.4	3	3.0	4	9.3	2	4.7			1	2.3
<i>Cervus elaphus</i>	13	1.0	2	2.0							6	46.2
<i>Capreolus capreolus</i>	6	0.5	2	2.0			1	16.7				
<i>Rangifer tarandus</i>	250	19.8	39	39.0	17	6.8	8	3.2	7	2.8	78	31.2
<i>Bison priscus/Bos primigenius</i>	33	2.6	2	2.0			1	3.0				
<i>Ovibos moschatus</i>	4	0.3	1	1.0			3	75.0				
<i>Rupicapra rupicapra</i>	3	0.2	1	1.0								
<i>Capra ibex</i>	9	0.7	2	2.0	4	44.4	1	11.1				
Bovidae	13	1.0										
Total NISP	1,264	100	100	100	57	4.5	46	3.6	36	2.8	116	9.2

Tab. 2 Minimum Number of Identified Specimens per taxon (NISP) and Minimum Number of Individuals (MNI) of the mammal assemblage from the first bone level A1 from the third cave of Goyet with the frequencies of anthropogenic and carnivore traces.

Nr. collection	Element	Anthropogenic traces			Carnivore traces	Remarks
		red stains	cut-marks	ornam.	gnawing marks	
2751	C			×		
2751	C			×		
2812-1	C upper					
2812-2	C upper					
2812-3	C upper					
2812-4	C lower					
2812	p4 lower					
2812-5	mandible					
2812	atlas					
2812-10	humerus distal part				×	AMS and isotopes (Germonpré et al., 2009: G-5)
2812-9	humerus diaphysis				×	Isotopes (Germonpré et al., 2009: G-2)
Vert00-247/ 2812-6	ulna proximal	×	×		×	AMS
2812-8	radius diaphysis		×		×	Isotopes (Germonpré et al., 2009: G-7)
2812	radius diaphysis		×		×	
2812-11	femur caput					
2812	MC I		×			
2812-7	MT II					
2812	phalanx I					

Tab. 3 Minimum Number of Identified Specimens per taxon (NISP) and Minimum Number of Individuals (MNI) of the large canid assemblage from the first bone level A1 from the third cave of Goyet with the frequencies of anthropogenic and carnivore traces.

the cave, is associated with lithic and osseous artefacts. A number of bones displays traces of anthropogenic manipulation such as cut-marks and impact traces (Tabs. 2-3). The second type of bone accumulation concerns remains from cave bears, cave hyenas and cave lions. Their bones were discovered in the deep, darker parts of the cave, sometimes in anatomical connection. The last type consists of skeletal elements from herbivores that show gnawing traces, likely from hyenas (Dupont, 1872; Germonpré, 1996). The lithic and osseous material from the first, upper, bone level A1 from Goyet represents, according to Dewez (1987), several late Upper Palaeolithic occupations that could be related to an older, a middle (comparable to the occupation at the nearby Trou de Chaleux cave) and a younger (Creswellian?) Magdalenian. Spectacular finds from the first bone level include a double-barbed bone harpoon, a perforated baton (*bâton percé*) figuring a salmonid and a necklace, found *in situ*, composed of deciduous incisors from horses, incisors from bovids and two bone fragments shaped as bovid incisors (Dupont, 1872; Van Wetter, 1920; Dewez, 1987; Germonpré, 1996). In this study, we detail the remains from the large canids found in the first bone level (A1) at the third cave of Goyet.

		Mandible AL m1-m3						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5	1			47.50				
Palaeolithic dogs	33	41.90	44.15	45.77	46.14	46.89	47.81	1.97
Archaic dogs	39	33.2	35.00	36.44	36.7	37.2	41.72	1.78
Pleistocene wolves	37	43.00	45.86	47.39	47.17	48.82	52.5	2.12
Recent northern wolves	38	43.2	45.30	46.74	46.6	48.3	50.1	1.87

		Mandible CL m1						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				27.80				
Palaeolithic dogs	40	24.00	27.42	28.53	28.60	30.00	31.89	1.82
Archaic dogs	39	20.44	21.50	22.45	22.49	24.00	25.13	1.22
Pleistocene wolves	40	28.00	28.75	29.93	29.66	30.88	32.60	1.50
Recent northern wolves	39	26.70	28.10	29.48	29.40	30.40	33.40	1.56

		Mandible CW m1						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				11.10				
Palaeolithic dogs	33	10.64	11.43	11.93	11.80	12.53	14.15	0.78
Archaic dogs	39	8.06	8.60	9.09	9.10	9.41	10.50	0.87
Pleistocene wolves	39	10.80	11.53	12.07	12.04	12.60	13.30	0.66
Recent northern wolves	39	9.90	11.40	11.86	11.80	12.30	14.60	0.85

		Mandible GB corpus						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-5				14.10				
Palaeolithic dogs	34	13.10	14.71	15.66	15.50	16.45	18.25	1.30
Archaic dogs	40	11.03	11.90	12.61	12.60	13.30	14.72	0.87
Pleistocene wolves	39	13.21	14.54	15.48	15.47	16.39	18.40	1.25
Recent northern wolves	38	11.70	13.65	14.43	14.66	15.40	16.70	1.27

		Humerus Bd						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-10	1			42.50				
Palaeolithic dogs	2	29.20		31.90	31.90		34.50	3.75
Roman dogs Belgium	8	22.90	26.15	29.10	28.90	32.15	36.10	4.25
Recent archaic dogs	11	30.50	36.90	38.28	39.60	41.10	42.00	3.44
Pleistocene wolves	11	39.20	40.90	43.46	43.00	47.00	47.20	2.97
Holocene wolves	3	39.70	39.70	45.00	46.50	48.80	48.80	4.73
Recent northern wolves	6	43.10	44.90	46.68	46.55	47.35	47.50	1.65
<i>dog-like in size</i> *				≤ 39.00				
<i>large canid</i>			39.01		46.99			
<i>wolf-like in size</i> *				≥ 47.00				

Tab. 4 Individual measurements of the Goyet large canid elements from the first bone level (A1) compared with the observed ranges (minimum, 25 % percentile, mean, median, 75 % percentile, maximum) and the standard deviation of measurements, according to von den Driesch (1976), of the data sets from Palaeolithic dogs, Belgian Roman dogs, recent archaic dogs, Pleistocene wolves, Holocene wolves and recent northern wolves; see text for more information. * from Germonpré et al. (2017).

		Ulna Bpc						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-6 (dog-like in size)	1			17.00				
Palaeolithic dogs	2	14.40		15.90	15.90		17.40	2.12
Roman dogs Belgium	6	12.00	12.53	15.02	15.70	16.95	17.10	2.23
Recent archaic dogs	10	16.40	19.36	20.55	21.06	23.16	23.26	2.02
Pleistocene wolves	3	22.90		24.20	23.90		25.80	1.47
Recent northern wolves	2	22.60		23.20	23.20		23.80	0.85
<i>dog-like in size</i> *				≤ 22.50				
<i>large canid</i>			22.51		24.49			
<i>wolf-like in size</i> *				≥ 24.50				

		Femur DC						
Measurements	n	min	25 % quantile	mean	median	75 % quantile	max	sd
Goyet 2812-11	1			23.54				
Palaeolithic dogs								
Roman dogs Belgium	5	12.80	14.30	16.98	17.80	19.25	19.40	2.73
Recent archaic dogs	10	17.80	20.35	21.90	22.15	24.03	24.90	2.19
Pleistocene wolves	1			26.80				
Holocene wolves	1			27.90				
Recent northern wolves	5	23.90	24.15	25.74	25.90	27.25	27.50	1.58
<i>dog-like in size</i>				≤ 23.00				
<i>large canid</i>			23.01		25.99			
<i>wolf-like in size</i>				≥ 26.00				

Tab. 4 (continued)

MATERIAL AND METHODS

The material excavated by Dupont is housed at the Royal Belgian Institute of Natural Sciences (RBINS) in Brussels (Belgium). Complete and fragmentary skeletal elements were counted in Number of Identified Specimens (NISP) and in Minimum Number of Individuals (MNI) (Lyman, 1994). The anthropogenic cut- and impact marks and the gnawing traces on the canid remains were compared with the descriptions in Binford (1981), Lyman (1994) and Fernández-Jalvo and Andrews (2016). Carnivore use of the skeletal remains is examined by looking for indications of consumption traces. Carnivore damage is described based on Haynes (1983), Fosse et al. (2012) and Fernández-Jalvo and Andrews (2016).

The dates in the text and tables are calibrated in calendar years before 1950 (BP) and are derived from the AMS radiocarbon dates given in **Table 1**. All dates have been calibrated using the Oxcal 4.3 online program (<https://c14.arch.ox.ac.uk/oxcal/OxCal.html>).

Biometric measurements of the mandible, given in mm, were taken according to von den Driesch (1976). The following variables were measured: ALm1m3: the alveolar length of the molar row m1-m3; CLm1: the crown length of the carnassial; CWm1: the crown breadth of the carnassial; GBcorpus: the greatest thickness of the mandible (below m1). All reference groups are adapted from Germonpré et al. (2015) and contain only adults with completely erupted teeth, showing at least slight wear. The reference group of the Palaeolithic dogs consist of large canids dating from the Upper Palaeolithic found at the Gravettian site of Předmostí (Czech Republic), the Gravettian site of Kostënki-8, of eastern post-LGM dogs from the Epigravettian site of

Eliseevichi and the late Upper Palaeolithic site of Verholenskaya in Russia (Germonpré et al., 2015) and of Western post-LGM dogs from the German Bonn-Oberkassel site (Nobis, 1986; Street et al., 2015), the Swiss Kesslerloch site (Napierala and Uerpmann, 2012), and from the French sites of Le Closeau (Pionnier-Capitan et al., 2011) and Le Morin (Boudadi-Maligne et al., 2012). The reference group of the Pleistocene wolves includes fossil wolves from Trou des Nutons and Caverne Marie-Jeanne (Belgium), Předmostí (Czech Republic), Mezin (The Ukraine) and Kostënki-17/II (Russia). The reference group of recent northern wolves is composed of Palaeartic wolves from Belgium, Sweden and Russia, including different populations from the Russian Plain to Kamchatka, dating from the 19th and 20th century. The Archaic dog group is composed of recent northern dogs from Siberia, Sakhalin Island, and Greenland, all dating from the 19th and 20th centuries, and two Holocene prehistoric dogs: a Siberian dog from Shamanka, with a calibrated age range of 7280-7425 years BP (Losey et al., 2011, 2013) and an English dog found at a ritual site near Cambridge dating from the Bronze Age (Baxter, 2007). For more details on these reference groups see Germonpré et al. (2015).

Measurements on the postcranial bones studied here, given in mm, were taken according to von den Driesch (1976). The following dimensions could be taken: the distal breadth (Bd) of the humerus, the greatest breadth across the coronoid process (BPC) of the ulna and the greatest depth of the femoral caput (DC). This material is compared with several reference groups. The first reference group consists of Pleistocene wolves from the cave of Trou des Nutons in Belgium, the sites of Jaurens, Maldidier, Le Morin and Abri Pataud in France (Boudadi-Maligne, 2010; Boudadi-Maligne et al., 2012, 2020) and the National Geographical cave in the Primorskii territory in Russia (Baryshnikov, 2015). A second reference group composed of Eurasian wolves contains recent northern wolves from Sweden and Russia (Germonpré et al., 2017). The Holocene wolves contain the smallest and the largest specimens from the Danish postglacial wolves given in Aaris-Sørensen (1977), a Neolithic wolf from Lokomotiv, Siberia (Losey et al., 2011) and a Roman wolf from Braives (Belgium). The Palaeolithic dog groups includes canids from Upper Palaeolithic sites in Spain (Erralla: Altuna and Mariezkurrena, 1985; Vigne, 2005) and France (Le Morin: Boudadi-Maligne et al., 2012; Troubat: Boudadi-Maligne et al., 2020; Pont d'Ambon, Montespan: Pionnier-Capitan et al., 2011). The Belgian Roman dogs are from the Braives and Wichelen sites. The recent archaic dog group is composed of recent northern dogs from Siberia, Sakhalin and Greenland and of specimens from Siberian husky and chow chow.

As discussed in Germonpré and Sablin (2017) and Germonpré et al. (2017), we presume that the mean lengths and widths of the long bones are likely smaller in Palaeolithic dogs than in Pleistocene wolves. We propose that limb bones of large canids can be termed "dog-like in size" when at least one of their measurements falls inside the observed range of the "recent archaic dogs" and is smaller than the lower limit of the observed ranges in the wolf groups in our data set (cf. Germonpré and Sablin, 2017). The canid specimens can be described as "wolf-like in size" when the measurements on the long bone fall outside the observed ranges (rounded to the next digit) of these measurements from the "recent archaic dog" group and if at least one dimension of the bone is larger than the largest mean of this measurement in the wolf groups from our data set. These assumptions can be summarized as a "less-than or equal" or a "greater-than or equal" value of the measurements and are listed in **Table 4** (cf. Germonpré and Sablin, 2017; Germonpré et al., 2017). The long bones whose measurements do not correspond to either of these assumptions are considered here as "large canids" (**Tab. 4**). This naming does not exclude, however, that such specimens could be dogs.

The body mass estimates (BMe) of the large canids in this study were calculated based on the regression equations given in Losey et al. (2016) on the basis of wolf limb dimensions (Losey et al., 2016: tab. 4). The following regression equations were used for the following measurements:

$$\text{humerus Bd: } \ln\text{BMe} = 1.781 \times \ln\text{Bd} - 3.094 \quad (r^2 = 0.670)$$

$$\text{ulna BPC: } \ln\text{BMe} = 1.795 \times \ln\text{BPC} - 2.082 \quad (r^2 = 0.620)$$

$$\text{femur DC : } \ln\text{BMe} = 2.377 \times \ln\text{DC} - 4.090 \quad (r^2)$$

RESULTS

The AMS ^{14}C dates available for the first bone level A1 are given in **Table 1**. In addition, AMS ^{14}C dates pertaining to the post-LGM, but on bones originating from other bone levels or unknown stratigraphic origin, are also given in **Table 1**. The calibrated ages (at 95 % probability) of the post-LGM bones range from 16,780 cal BP to 12,540 cal BP. The calibrated ages from bones with human modifications range from 15,750 cal BP to 13,480 cal BP. The calibrated age of the human humerus (15,230 cal BP - 14,780 cal BP) falls in the range of the calibrated ages of the mammal bones with human modification dating from the post-LGM. The calibrated AMS ^{14}C age of ca. 13,500 cal BP of the ulna 2815-6 is younger than the majority of the post-LGM dates at Goyet. About half of the AMS ^{14}C dates from the bone assemblage A1 point to a pre-LGM occupation of the cave by predators like cave bears, cave hyenas and modern humans.

The dominant species in bone level A1, both in NISP and MNI frequency, are horse, reindeer and cave bear (**Tab. 2**). In the A1 assemblage, cut-marks are present on 3.6 % of the identified bones. About 4.5 % of the identified bones show red stains (**Tab. 2**). In particular, bone tools or ornaments such as perforated teeth, and elements such as the marrow-rich metapodials carry red stains (Germonpré, 1996). Gnawing marks are present in somewhat higher frequencies, with 9.2 % of the bones, and especially those of red deer and reindeer, displaying evidence of carnivore actions (**Tab. 2**). In general, the gnawed bones are lightly damaged, with scratches on the compact bones. In addition, a few furrows and gouging on cancellous parts occur (Germonpre, 1996).

Table 3 lists the distribution of the skeletal elements of large canids from bone level A1. Elements of almost all body parts are represented, from loose teeth, including perforated canines, over a vertebra to a metatarsus. The four measurements on the canid lower jaw 2812-5 do not permit to assign the mandible to a specific reference group. Their values fall in the overlapping ranges of the dog and wolf groups in our data set (**Tab. 4**). The distal breadth of the humerus 2812-10 (Bd: 42.5 mm) is larger than the maximal width expected for Palaeolithic dogs (**Tab. 4**). Although this humerus is wider than the maximum value (≤ 39.0 mm) for dogs in our data set, this width does not exceed the mean value for this dimension of the wolf reference groups (**Tab. 4**). It can thus not be described as a wolf-like canid in size, it falls in the size range of a large canid. This canid had an estimated body mass of about 36 kg (**Tab. 5**).

The border of the coronoid process of the ulna 2812-6 is not pristine and the greatest breadth across the coronoid process (BPC) is estimated at 17 mm. This width falls in between the values of these measurements of the Palaeolithic dogs from Troubat (Boudadi-Maligne et al., 2020) and Pont d'Ambon (Pionnier-Capitan et al., 2011) and is smaller than the expected threshold (≤ 22.5 mm) proposed for this measurement for Palaeolithic dogs (**Tab. 4**). The estimated body mass of this Palaeolithic dog is about 20 kg; the Pont d'Ambon and Troubat dogs have estimated body masses of about 15 and 21 kg, respectively (**Tab. 5**). Short, transverse cut-marks are present on the medial side of the olecranon of ulna 2812-6 and resemble the RCp-3 marks on reindeer ulnae as described by Binford (1981) (**Fig. 2**). In addition, an isolated, short, transverse cut-mark occurs on the diaphysis. On the distal half of the diaphysis longitudinal cut-marks are present. Red stains occur distally on the diaphysis and on the cancellous bone, proximally. Furthermore, the olecranon process has been chewed (**Fig. 2**). On the medial side of the ulna, a clear round puncture mark with bone fragments inserted in the pit can be distinguished. It overlies some of the medial short cut-marks. The size of the impression is 7.5 mm \times 7 mm. Proximally to this mark, at a distance of 11.8 mm, the outer border of a second impression can be distinguished at the remaining proximal rim of the olecranon.

Three other skeletal elements from large canids bear cut-marks. On two radius diaphyses, the proximally placed cut-marks resemble those described by Binford (1981) on reindeer radii (RCp-6). On the first metacarpal, cut-marks are present on the distal half of the bone, just above the distal epiphysis.

The last canid element that could be measured is a proximal femur fragment (2812-11). The greatest depth of the femoral caput (DC: 23.54mm) slightly exceeds the expected value (≤ 23.00 mm) proposed for this measurement for Palaeolithic dogs (Tab. 4). This large canid had an estimated body size of about 30.5 kg (Tab. 5).

DISCUSSION

The bone assemblage from level A1 represents a palimpsest with remains from mammals dating from pre- and post-LGM periods (Tab. 1). The calibrated dates of the post-LGM scatter range from before the onset of the Late Glacial warming up to the Younger Dryas (16,780 years BP - 12,540 cal BP; cf. Rasmussen et al., 2014). Most of the post-LGM bones that show anthropogenic traces date, just as the human bone, from before the Late Glacial interstadial complex GI 1 (Tab. 1), that began about 14,700 years ago (Rasmussen et al., 2014). The calibrated AMS ^{14}C age of the ulna 2812-6 from a Palaeolithic dog falls in the range 13,740-13,480 cal BP and places this animal into the Bølling/Allerød interstadial, most likely into GI-1c (cf. Rasmussen et al., 2014). Possibly this Late Palaeolithic dog and its "owners" lived in the vicinity of Goyet during the transitional period from the Late Magdalenian to the Late Palaeolithic (*Feder-*

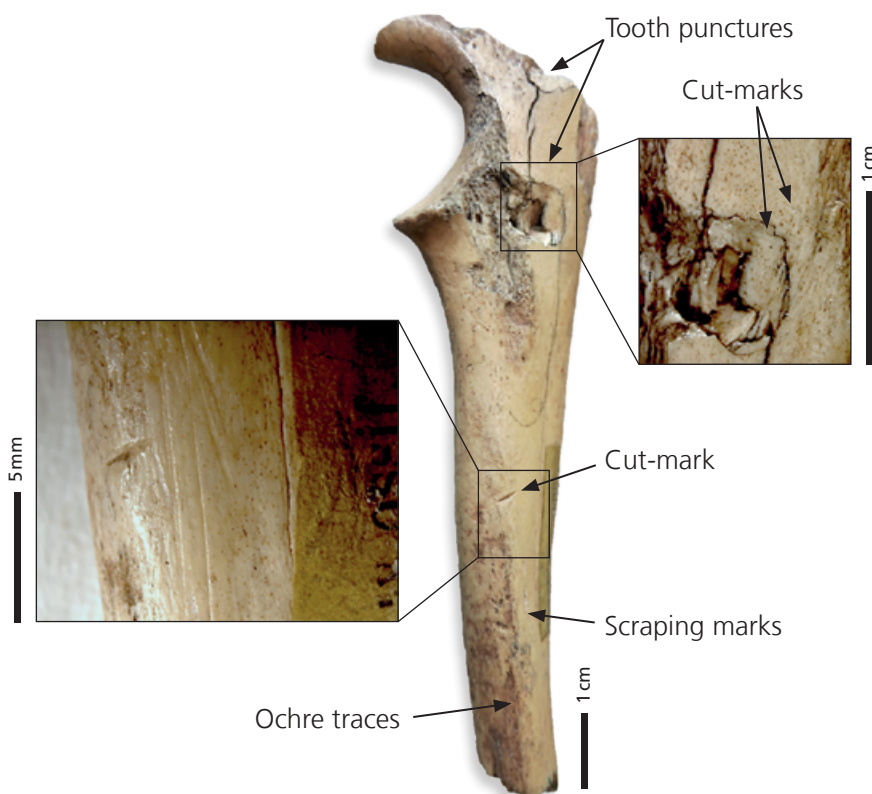


Fig. 2 Ulna Vert00-247/2812-6 described as from a Palaeolithic dog with cut-marks underlying one of the tooth impressions, with a transversal cut-mark, with scraping on the distal half of the diaphysis and with red stains on the distal half and the proximal end.

Measurements	BMe kg (Humerus Bd)			
	n	min	mean	max
Goyet 2812-10	1		36.0	
Palaeolithic dogs	2	18.5	21.7	24.8
Roman dogs Belgium	8	12.0	18.3	26.9
Recent archaic dogs	11	19.9	29.9	35.3
Pleistocene wolves	11	32.1	37.5	43.4
Holocene wolves	3	31.9	39.9	46.1
Recent northern wolves	6	36.9	41.6	46.1

Measurements	Bme kg (Ulna Bpc)			
	n	min	mean	max
Goyet 2812-6 (dog-like in size)	1		19.9	
Palaeolithic dogs	2	15.0	17.9	21.0
Roman dogs Belgium	6	10.8	16.1	20.4
Recent archaic dogs	10	18.9	28.3	35.4
Pleistocene wolves	3	34.4	38.0	42.6
Recent northern wolves	2	33.6	35.2	36.9

Measurements	BMe kg (Femur DC)			
	n	min	mean	max
Goyet 2812-11	1		30.5	
Roman dogs Belgium	5	7.2	14.0	19.3
Recent archaic dogs	10	15.7	25.7	34.9
Holocene wolves	1		45.7	
Recent northern wolves	5	31.6	37.7	44.2

Tab. 5 The estimated body mass (BMe) of the Goyet large canid elements from the first bone level (A1) compared with the observed ranges (minimum, 25 % percentile, mean, median, 75 % percentile, maximum) and the standard deviation of the BMe of the data sets from Palaeolithic dogs, Belgian Roman dogs, recent archaic dogs, Pleistocene wolves, Holocene wolves and recent northern wolves; see text for more information.

messergruppen). The dog's remains were modified by prehistoric people as evidenced by cut-marks, after which handling the bone was gnawed by a canid-sized carnivore (see below). It is somewhat younger than the Palaeolithic dogs from the French Magdalenian site of Montespan (ca. 15,500-13,500 cal BP; Pionnier-Capitan et al., 2011), the Magdalenian site Le Morin (ca. 14,500 cal BP) (Boudadi-Maligne et al., 2012), the Azilian site Le Closeau, locus 46 (ca. 14,940-13,950 cal BP; Pionnier-Capitan et al., 2011; Bignon-Lau, 2020), and the dogs from the Swiss Magdalenian Kesslerloch cave (ca. 14,600-14,100 cal BP; Napierala and Uerpmann, 2012). The Palaeolithic dog from Goyet (A1) is comparable in age to the Late Glacial dog from the German site of Bonn-Oberkassel site (ca. 14,800-13,320 cal BP) (Street et al., 2015). It is somewhat older than the Azilian dogs from the French sites of Troubat (ca. 12,700-12,520 cal BP) (Boudadi-Maligne et al., 2020) and Pont d'Ambon (ca. 12,900-12,400 cal BP) (Pionnier-Capitan et al., 2011).

Remains from horse, reindeer and cave bear dominate the Goyet bone assemblage A1. Body parts of several species have been manipulated by prehistoric humans as shown by the presence of cut-marks (3.6 % of

NISP), tools and ornaments (2.8 % of NISP) and stains of red colourant (4.5 % of NISP) (**Tab. 2**). Interesting to note is that the human humerus Goyet-Q-2, from a male child, also shows ochre stains (Fu et al., 2016; Rougier et al., 2016). The cut-marks on the mammal bones are related to skinning, dismembering and filleting (Germonpré, 1996). Carnivore induced damage, such as gnawing, punctures, furrowing, gouging and scratches, can be discerned especially on red deer and reindeer elements, including shed antlers (Germonpré, unpublished results), and also on bones of large canids (**Tables 2-3**). The features of the carnivore damages compare well with those induced by wolves as described by Haynes (1983) and Fosse et al. (2012). The stable isotopes of several large canid elements from level A1 have previously been analysed to reconstruct the diet of these animals (Germonpré et al., 2009). The results of humerus 2812-10 indicates that this large canid ate mainly horse meat (Germonpré et al., 2009: G5). The diet of the individual providing the other humerus (2812-9) was dominated by horse and bison meat (Germonpré et al., 2009: G-2). The stable isotopes analysis of radius 2812-8 revealed that this canid consumed mainly horse meat (Germonpré et al., 2009: G-7).

Human manipulation on remains from large canids can be discerned on several skeletal elements. Two canines were perforated and likely used as pendants. They testify of a symbolic utility (cf. Germonpré et al., 2018; Fosse et al., 2019). On the two radius diaphyses, cut-marks are present that are comparable to the filleting marks RCp-6, described by Binford (1981) on reindeer radii. Cut-marks, present on the distal half of the first metacarpal, were probably inflicted while the animal was skinned.

Of the four skeletal elements measured in this study, the sizes of three specimens (a mandible, a humerus, and a femur) fall in the overlapping size ranges of the dog and wolf groups in our data sets, although the femur is barely larger than the threshold for Palaeolithic dogs (**Tab. 4**). The ulna 2812-6 falls within the range of Palaeolithic dogs, based on the relatively small size of the breadth across the coronoid process (ca. 17 mm) (**Fig. 2**). The calibrated age range of the ulna 2812-6 (**Tab. 1**) indicates that this Palaeolithic dog lived during the Allerød. Its estimated body mass is about 20 kg and falls into the observed ranges of the Belgian Roman dogs and the “recent archaic dogs” of our data set. It is, just as the dogs from the Azilian site of Troubat (Boudadi-Maligne et al., 2020), a medium-sized dog. Several cut-marks are present on ulna 2812-6. Short, transverse marks on the proximal medial surface resemble the RCp-3 cut-marks on reindeer ulnae, described by Binford (1981) that are made during the dismembering process. This canid was dismembered possibly in preparation to be consumed. In addition, a transverse cut-mark is present on the diaphysis. On the distal half of the diaphysis longitudinal marks occur that could be related to scraping, maybe for tendon or periosteum removal.

Furthermore, the oleocranon process of the ulna 2812-6 of the Palaeolithic dog (**Fig. 2**) is chewed in a manner akin to the chewing of oleocranon processes of red deer by wolves, figured in Fosse et al. (2012: Fig. 4), and those of sheep chewed by dogs in Fernández-Jalvo and Andrews (2016: Fig. A.376) and resembles a carnivore-gnawed ulna from the Gravettian Předmostí site (Germonpré et al., 2017: Fig. 19). On the medial side of the ulna two traces of puncture marks are present. Inside the completely preserved puncture mark, probably made by the cusp of a premolar, the bone surface is displaced into the bone's interior (**Fig. 2**). The large size of the puncture (7.5 mm × 7 mm) is similar to the size of tooth impressions made by large carnivores (wolves, hyenas, bears) as studied in the Pleistocene bone assemblage from the Arrikutz cave in Spain (Fernández-Jalvo and Andrews, 2016) and the tooth marks made by large carnivores analysed in Andrés et al. (2012). The size of the tooth impression combined with the relatively small distance (11,8 mm) between the two tooth marks could suggest that the impressions were made by a P3 and a P4 from a large canid. Taking into account that cut-marks occur underlying the tooth impression, it is possible that remains of this dog were given by its prehistoric masters to other dogs to feed upon, or that dogs or wolves scavenged the refusal of the human occupants left in the cave. Further examinations of this ulna,

including biogeochemical and genetic analyses, are currently undertaken and results will be published in a forthcoming paper.

In Central and Eastern Europe, Palaeolithic dogs and/or 'dog-like in size' canids occur at sites with mammoth mass accumulations, pre-dating (Předmostí, Kostenki-1/I, Kostenki 11/Ia, Kostenki-21) and post-dating (Eliseevichi, Yudinovo, Mezin, Mezhirich) the LGM. In most of these sites direct or indirect evidence of mammoth hunting is present (Pidoplichko, 1998; Sablin and Khlopachev, 2002; Germonpré et al., 2009, 2012, 2015; Germonpré and Sablin, 2017; Reynolds et al., 2019). We have postulated that Palaeolithic dogs could have been used as pack animals to help transport mammoth body parts from the kill to the camp site (Germonpré et al., 2012) and as sentinels to protect stored mammoth meat at the latter (Germonpré et al., 2020). In addition, during pre-LGM times, Upper Palaeolithic people could have used the protection offered by the large Palaeolithic dogs against Pleistocene predators. Once pachyderms like the woolly mammoth and the rhino, and carnivores like the cave hyena, cave lion and cave bear became rare or extinct, the presence of larger Palaeolithic dogs would have been less useful. In Western Europe, medium-sized Palaeolithic dogs would then have been more opportune, as they would have required less food (Germonpré et al., 2009, 2012, 2020). Nevertheless, such dogs could have occupied several roles in late Upper Palaeolithic and Late Palaeolithic societies. They could have acted as hunting companions, sentinels, been kept for their fur, meat and fat and participated with body and soul in ceremonies (Germonpré et al., 2020). The double-human-and-dog burial from Bonn-Oberkassel (Street et al., 2015; Janssens et al., 2018) could suggest, based on ethnographic evidence, that the soul of the dead/killed dog would have been needed to guide the human souls to the afterworld (cf. Kretschmar, 1938; Schwartz, 1997), or that the dogs could have been killed to display the high status of their masters (cf. Hayden and Schulting, 1997). In life, the young Oberkassel dog most likely was suffering from a canine distemper infection and was taken care of for several months, indicating how important this pup was to its "owners" (Janssens et al., 2018). In southern France, at the Grotte-Abri du Moulin (Troubat), there is evidence of an intentional double burial of two dogs (Boudadi-Maligne et al., 2020), dating to the Younger Dryas stadial. At the Upper Palaeolithic cave of Goyet, based on the cut-marks on the radii and the ulna, cynophagy was probably practiced just as at the late Upper Palaeolithic French sites of Le Morin (Boudadi-Maligne et al., 2012) and Pont-d'Ambon (France) (Pionnier-Capitan et al., 2011).

CONCLUSION

Although the timing of the onset of the domestication process of the wolf is highly debated, most researchers agree that by the end of the Pleistocene domestic dogs were part of the daily life of prehistoric hunter-gatherers. The AMS ¹⁴C dates on bones from level A1 of the third cave of Goyet indicate that at least part of this material dates from the post-LGM. Several canid bones from level A1 were modified by Upper Palaeolithic humans; the carcasses of some animals were skinned, dismembered and filleted, presumably in order to obtain the skin and meat. Other elements (canines) were perforated or came into contact with red ochre powder (ulna). Moreover, the dismembered ulna was gnawed by a carnivore, likely a canid. The size of the ulna permits to describe this element as from a Palaeolithic dog. Its calibrated age places this animal into the Bølling/Allerød interstadial. With an estimated body mass of ~20 kg it is comparable in size to other Late Palaeolithic dogs from Western Europe. The handling of the canid bodies and bones at Goyet hints to the existence of a complex relationship, including cynophagy, between humans and large and medium-sized canids during the Late Palaeolithic.

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REFERENCES

- Aaris-Sørensen, K., 1977. The subfossil wolf, *Canis lupus* L., in Denmark. *Videnskabelige Meddelelser Dansk Naturhistorisk Forening* 140, 129-146.
- Altuna, J., Mariezkurrena, K., 1985. Bases de subsistencia de los pobladores de Erralla: macromamíferos. *Munibe (Antropología-Arkeología)* 37, 87-17.
- Andrés, M., Gidna, A.O., Yravedra, J., Domínguez-Rodrigo, M., 2012. A study of dimensional differences of tooth marks (pits and scores) on bones modified by small and large carnivores. *Archaeological and Anthropological Science* 4, 209-219.
- Barnes, I., Shapiro, B., Lister, A., Kuznetsova, T., Sher, A., Guthrie, D., Thomas, M.G., 2007. Genetic structure and extinction of the woolly mammoth, *Mammuthus primigenius*. *Current Biology* 17, 1072-1075.
- Baryshnikov, G.F., 2015. Late Pleistocene Canidae remains from Geographical Society Cave in the Russian Far East. *Russian Journal of Theriology* 14, 65-83.
- Baxter, I.L., 2007. Skeleton of an Early-Middle Bronze Age dog with spondylitis deformans from the Babraham Road Park and Ride site, Cambridge, U.K. *Archaeofauna* 16, 109-116.
- Bignon-Lau, O., 2020. About the Early Azilian Way of Life in the Paris Basin: Economical and Spatial Insights from Zooarchaeological Data. In: Grimm, S.B., Weber, M.J., Mevel, L., Sobkowiak-Tabaka, I. (Eds.), *From the Atlantic to beyond the Bug River. Finding and defining the Federmesser-Gruppen/Azilian*. RGZM Tagungen 40, Verlag des Römisch-Germanisches Zentralmuseums, Mainz, pp. 25-50.
- Binford, L.R., 1981. *Bones. Ancient men and modern myths*. Academic Press, New York.
- Boudadi-Maligne, M., 2010. *Les Canis pléistocènes du sud de la France: approche biosystématique, évolutive et biochronologique*. Thèse pour obtenir le grade de Docteur. MS, Université Bordeaux 1, Spécialité: Préhistoire et Géologie du Quaternaire, Bordeaux, France.
- Boudadi-Maligne, M., Escarguel, G., 2014. A biometric re-evaluation of recent claims for Early Upper Palaeolithic wolf domestication in Eurasia. *Journal of Archaeological Science* 45, 80-89.
- Boudadi-Maligne, M., Mallye, J.-B., Ferrière, J.-G., Costamagno, S., Barshay-Szmidt, C., Deguilloux, M.F., Pémonge, M.H., Barbaza, M., 2020. The earliest double dog deposit in the Palaeolithic record: The case of the Azilian level of Grotte-abri du Moulin (Troubat, France). *International Journal of Osteoarchaeology* 30, 382-394.
- Boudadi-Maligne, M., Mallye, J.-B., Langlais, M., Barshay-Szmidt, C., 2012. Des restes de chiens magdaléniens à l'abri du Morin (Gironde, France). Implications socio-économiques d'une innovation zootechnique. *PALEO* 23, 39-54.
- Dalén, L., Nyström, V., Valdiosera, C., Germonpré, M., Sablin, M., Turner, E., Angerbjörn, A., Arsuaga J.L., Götherström, A., 2007. Ancient DNA reveals lack of postglacial habitat tracking in the arctic fox. *Proceedings of the National Academy of Sciences* 104, 6726-6729.
- Denis, J., 1992. *Géographie de la Belgique*. Crédit Communal de Belgique, Bruxelles.
- Dewez, M., 1987. *Le Paléolithique supérieur récent dans les grottes de Belgique*. Publications d'Histoire de l'Art et d'Archéologie de l'Université Catholique de Louvain 57. Louvain-la-Neuve.
- Drake, A.G., Coquerelle, M., Colombeau, G., 2015. 3D morphometric analysis of fossil canid skulls contradicts the suggested domestication of dogs during the late Paleolithic. *Scientific Reports* 5, 1-8.
- Dupont, E., 1872. *Les temps préhistoriques en Belgique. L'Homme pendant les âges de pierre dans les environs de Dinant-sur-Meuse*. C. Muquardt, Bruxelles.
- Ersmark, E., Baryshnikov, G., Higham, T., Argant, A., Castaños, P., Döppes, D., Gasparik, M., Germonpré, M., Lidén, K., Lipecki, G., Marciszak, A., Miller, R., Moreno-García, M., Pacher, M., Robu, M., Rodriguez-Varela, R., Rojo Guerra, M., Sabol, M., Spassov, N., Storå, J., Valdiosera, C., Villaluenga, A., Stewart, J.R., Dalén, L., 2019. Genetic turnovers and northern survival during the last glacial maximum in European brown bears. *Ecology and Evolution* 9, 5891-5905.
- Fernández-Jalvo, Y., Andrews, P., 2016. *Atlas of taphonomic identifications: 1001+ Images of Fossil and Recent Mammal Bone Modification*. Springer, Dordrecht.
- Flas, D., 2008. *La transition du Paléolithique moyen au supérieur dans la plaine septentrionale de l'Europe*. Société Royale Belge d'Anthropologie et de Préhistoire, Bruxelles.
- Fleming, K., Johnston, P., Zwart, D., Yokoyama, Y., Lambeck, K., Chappell, J., 1998. Refining the eustatic sea-level curve since the last glacial maximum using far- and intermediate-field sites. *Earth and Planetary Science Letters* 163, 327-342.
- Fosse, P., Fourvel, J.B., Madelaine, S., 2019. L'exploitation des grands carnivores au Paléolithique (supérieur): quelques données archéo(zoo)logiques. In: Cretin, C., Madelaine, S. (Eds.), *Animaux rares, Gibiers inattendus, Reflets de la biodiversité*. Musée national de Préhistoire, Les Eyzies, pp. 61-72.
- Fosse, P., Wajrak, A., Fourvel, J.B., Madelaine, S., Esteban-Nadal, M., Cáceres, I., Yravedra, J., Brugal, J.P., Prucca, A., Haynes, G., 2012. Modification by modern wolf (*Canis lupus*): a taphonomic

- study from their natural feeding places. *Journal of Taphonomy* 10, 197-217.
- Fu, Q., Posth, C., Hajdinjak, M., Petr, M., Mallick, S., Fernandes, D., Furtwängler, A., Haak, W., Meyer, M., Mittnik, A., Nickel, B., Peltzer, A., Rohland, N., Slon, V., Talamo, S., Lazaridis, I., Lipson, M., Mathieson, I., Schiffels, S., Skoglund, P., Derevianko, A.P., Drozdov, N., Slavinsky, V., Tsybankov, A., Grifoni Cremonesi, R., Mallegni, F., Gély, B., Vacca, E., González Morales, M.R., Straus, L.G., Neugebauer-Maresch, C., Teschler-Nicola, M., Constantin, S., Moldovan, O.T., Benazzi, S., Peresani, M., Coppola, D., Lari, M., Ricci, S., Ronchitelli, A., Valentin, F., Thevenet, C., Wehrberger, K., Grigorescu, D., Rougier, H., Crevecoeur, I., Flas, D., Semal, P., Mannino, M.A., Cupillard, C., Bocherens, H., Conard, N.J., Harvati, K., Moiseyev, V., Drucker, D.G., Svoboda, J., Richards, M.P., Caramelli, D., Pinhasi, R., Kelso, J., Patterson, N., Krause, J., Pääbo, S., Reich, D., 2016. The genetic history of Ice Age Europe. *Nature* 534, 200-205.
- Germonpré, M., 1996. Preliminary results on the mammals of the Magdalenian upper horizon of Goyet (Belgium). *Notae Praehistoricae* 16, 75-85.
- Germonpré, M., 1997. The Magdalenian upper horizon of Goyet and the late Upper Palaeolithic recolonisation of the Belgian Ardennes. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre* 67, 167-182.
- Germonpré, M., 2001. A reconstruction of the spatial distribution of the faunal remains from Goyet, Belgium. *Notae Praehistoricae* 21, 57-65.
- Germonpré, M., Hämäläinen, R., 2007. Fossil bear bones in the Belgian Upper Palaeolithic: the possibility of a proto-bear ceremonialism. *Arctic Anthropology* 44, 1-30.
- Germonpré, M., Lázníčková-Galetová, M., Jimenez, E.-L., Losey, R., Sablin, M., Bocherens, H., Van den Broeck, M., 2017. Consumption of canid meat at the Gravettian Předmostí site, the Czech Republic. *Fossil Imprint* 73, 360-382.
- Germonpré, M., Lázníčková-Galetová, M., Losey, R.J., Rääkkönen, J., Sablin, M.V., 2015. Large canids at the Gravettian Předmostí site, the Czech Republic: the mandible. *Quaternary International* 359-360, 261-279.
- Germonpré, M., Lázníčková-Galetová, M., Sablin, M., 2012. Palaeolithic dog skulls at the Gravettian Předmostí site, the Czech Republic. *Journal of Archaeological Science* 39, 184-202.
- Germonpré, M., Lázníčková-Galetová, M., Sablin, M.V., Bocherens, H., 2018. Self-domestication or human control? The Upper Palaeolithic domestication of the dog. In: Stépanoff, C., Vigne, J.-D. (Eds.), *Hybrid Communities, Biosocial Approaches to Domestication and Other Trans-species Relationships*. Routledge, London, pp. 39-64.
- Germonpré, M., Lázníčková-Galetová, M., Sablin, M.V., Bocherens, H., 2020. Could incipient dogs have enhanced differential access to resources among Upper Palaeolithic hunter-gatherers in Europe? In: Moreau, L. (Ed.), *Social inequality before farming? Multidisciplinary approaches to the study of social organisation in prehistoric and extant hunter-gatherer-fisher societies*. Cambridge: McDonald Institute Conversations [Book Chapter eBook]; <https://doi.org/10.17863/CAM.60631>.
- Germonpré, M., Sablin, M., 2001. The cave bear (*Ursus spelaeus*) from Goyet, Belgium. The bear den in Chamber B (bone horizon 4). *Bulletin de l'Institut royal des Sciences Naturelles de Belgique, Série Sciences de la Terre* 71, 209-233.
- Germonpré, M., Sablin, M.V., 2017. Chapter 2. Humans and mammals in the Upper Palaeolithic of Russia. In: Albarella, U., Russ, H., Vickers, K., Viner-Daniels, S. (Eds.), *Oxford Handbook of Zooarchaeology*. Oxford University Press, Oxford, pp. 25-38.
- Germonpré, M., Sablin, M.V., Stevens, R.E., Hedges, R.E.M., Hofreiter, M., Stiller, M., Després, V.R., 2009. Fossil dogs and wolves from Palaeolithic sites in Belgium, the Ukraine and Russia: osteometry, ancient DNA and stable isotopes. *Journal of Archaeological Science* 36, 473-490.
- Hayden, B., Schulting, R., 1997. The Plateau interaction sphere and Late Prehistoric Cultural Complexity. *American Antiquity* 62, 51-85.
- Haynes, G., 1983. A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb bones. *Paleobiology* 9, 164-172.
- Janssens, L., Giemsch, L., Schmitz, R., Street, M., Van Dongen, S., Crombé, P., 2018. A new look at an old dog: Bonn-Oberkassel reconsidered. *Journal of Archaeological Science* 92, 126-138.
- Janssens, L., Perri, A., Crombé, P., Van Dongen, S., Lawler, D., 2019. An evaluation of classical morphologic and morphometric parameters reported to distinguish wolves and dogs. *Journal of Archaeological Science* 23, 501-533.
- Janssens, L., Spanoghe, I., Miller, R., Van Dongen, S., 2016. Can orbital angle morphology distinguish dogs from wolves? *Zoomorphology* 135, 149-158.
- Kretschmar, F., 1938. *Hundestammvater und Kerberos I*. Strecker und Schröder, Stuttgart.
- Losey, R.J., Bazaliiskii, V.I., Garvie-Lok, S., Germonpré, M., Leonard, J.A., Allen, A.L., Katzenberg, M.A., Sablin, M.V., 2011. Canids as persons: Early Neolithic dog and wolf burials, Cis-Baikal, Siberia. *Journal of Anthropological Archaeology* 30, 174-189.
- Losey, R.J., Garvie-Lok, S., Leonard, J.A., Katzenberg, M.A., Germonpré, M., Nomokonova, T., Sablin, M.V., Goriunova, O.I., Berdnikova, N.E., Savel'ev, N.A., 2013. Burying dogs in ancient Cis-Baikal, Siberia: temporal trends and relationships with human diet and subsistence practices. *PLOS ONE* 8, e63740.
- Losey, R.J., McLachlin, K., Nomokonova, T., Latham, K., Harrington, L., 2016. Body mass estimates in dogs and North American gray wolves using limb element dimensions. *International Journal of Osteoarchaeology* 27, 180-191.
- Lopez Bayon, I., Otte, M., Léotard, J.M., Straus, L.G., 1997. L'occupation des grottes au Paléolithique supérieur. In: Corbiau, M.H. (Ed.), *Le patrimoine archéologique de Wallonie*. Division du Patrimoine, Namur, pp. 114-116.
- Lyman, R.L., 1994. *Vertebrate taphonomy*. Cambridge University Press, Cambridge.
- Mix, A.C., Bard, E., Schneider, R., 2001. Environmental processes of the ice age: land, oceans, glaciers (EPILOG). *Quaternary Science Reviews* 20, 627-657.
- Morey, D.F., 2014. In search of Paleolithic dogs: a quest with mixed results. *Journal of Archaeological Science* 52, 300-307.
- Napierala, H., Uerpman, H.-P., 2012. A 'new' Palaeolithic dog from central Europe. *International Journal of Osteoarchaeology* 22, 127-137.
- Nobis, G., 1979. Der älteste Haushund lebte vor 14000 Jahren. *Umschau in Wissenschaft und Technik* 79, 610.

- Nobis, G., 1986. Die Wildsäugetiere in der Umwelt des Menschen von Oberkassel bei Bonn und das Domestikationsproblem von Wölfen im Jungpaläolithikum. *Bonner Jahrbücher* 186, 368-376.
- Otte, M., 1979. *Le paléolithique supérieur ancien en Belgique*. Monographies d'Archéologie Nationale 5. Musees Royaux d'Art et d'Histoire, Bruxelles.
- Otte, M., Groenen, M., 2001. Le Paléolithique supérieur en Belgique. *Anthropologica et Praehistorica* 112, 39-48.
- Palkopoulou, E., Dalén, L., Lister, A.M., Vartanyan, S., Sablin, M., Sher, A., Nyström Edmark, V., Brandström, M.D., Germonpré, M., Barnes, I., Thomas, J.A., 2013. Holarctic genetic structure and range dynamics in the woolly mammoth. *Proceedings of the Royal Society of London B* 280, 2013, 1910.
- Pidoplichko, I.G., 1998. *Upper Palaeolithic dwellings of mammoth bones in the Ukraine: Kiev-Kirillovskii, Gontsy, Dobranichevka, Mezin and Mezhirich*. BAR International Series 712. Hadrian Books, Oxford.
- Pionnier-Capitan, M., Bemilli, C., Bodu, P., Célérier, G., Ferrié, J.-G., Fosse, P., Garcià, M., Vigne, J.-D., 2011. New evidence for Upper Palaeolithic small domestic dogs in South-Western Europe. *Journal of Archaeological Science* 38, 2123-2140.
- Pirson, S., Flas, D., Abrams, G., Bonjean, D., Court-Picon, M., Di Modica, K., Draily, C., Damblon, F., Haesaerts, P., Miller, R., Rougier, H., Toussaint, M., Semal, P., 2012. Chronostratigraphic context of the Middle to Upper Palaeolithic transition: Recent data from Belgium. *Quaternary International* 259, 78-94.
- Posth, C., Renaud, G., Mitnik, A., Drucker, D.G., Rougier, H., Cuvillard, C., Valentin, F., Thevenet, C., Furtwängler, A., Wißing, C., Francken, M., Malina, M., Bolus, M., Lari, M., Gigli, E., Capecchi, G., Crevecoeur, I., Beauval, C., Flas, D., Germonpré, M., van der Plicht, J., Cottiaux, R., Gély, B., Ronchitelli, A., Wehrberger, K., Grigorescu, D., Svoboda, J., Semal, P., Caramelli, D., Bocherens, H., Harvati, K., Conard, N.J., Haak, W., Powell, A., Krause, J., 2016. Pleistocene Mitochondrial Genomes Suggest a Single Major Dispersal of Non-Africans and a Late Glacial Population Turnover in Europe. *Current Biology* 26, 1-7.
- Rasmussen, S.O., Bigler, M., Blockley, S.P., Blunier, T., Buchardt, S.L., Clausen, H.B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S.J., Fischer, H., Gkinis, V., Guillevic, M., Hoek, W.Z., Lowe, J.J., Pedro, J.B., Popp, T., Seierstad, I.K., Steffensen, J.P., Svensson, A.M., Vallonga, P., Vinther, B.M., Walker, M.J.C., Wheatley, J.J., Winstrup, M., 2014. A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. *Quaternary Science Reviews* 106, 14-28.
- Reynolds, N., Germonpré, M., Bessudnov, A.A., Sablin, M.V., 2019. The Late Gravettian site of Kostënki 21 Layer III, Russia: interpreting the significance of intra-site spatial patterning using lithic and faunal evidence. *Journal of Paleolithic Archaeology* 2, 160-210.
- Rougier, H., Crevecoeur, I., Beauval, C., Flas, D., Posth, C., Wißing, C., Furtwängler, A., Germonpré, M., Gómez-Olivencia, A., Semal, P., van der Plicht, J., Bocherens, H., Krause, J., 2016. The Troisième caverne of Goyet (Belgium): An exceptional site with both Neandertal and Upper Paleolithic human remains. *Abstracts 6th Annual Meeting of the European Society for the study of Human Evolution*, 14-17 September 2016, Madrid, Spain.
- Sablin, M.V., Khlopachev, G.A., 2002. The earliest Ice Age dogs: evidence from Eliseevichi. *Current Anthropology* 43, 795-799.
- Schwartz, M., 1997. *A history of dogs in the early Americas*. Yale University Press, New Haven.
- Stevens, R.E., Germonpre, M., Petrie C.A., O'Connell T.C., 2009. Palaeoenvironmental and chronological investigations of the Magdalenian sites of Goyet Cave and Trou de Chaleux (Belgium), via stable isotope and radiocarbon analyses of horse skeletal remains. *Journal of Archaeological Science* 36, 653-662.
- Street, M., 2002. Ein Wiedersehen mit dem Hund von Bonn-Oberkassel. In: Hutterer, R. (Ed.), *Animals in History: Archaeozoological Papers in Honour of Günter Nobis (1921-2002)*. *Bonner Zoologische Beiträge* 50, 269-290.
- Street, M., Napierala, H., Janssens, L., 2015. The late Palaeolithic dog from Bonn-Oberkassel in context. In: Giemsch, L., Schmitz, R.W. (Eds.), *The Late Glacial Burial from Oberkassel Revisited. Rheinische Ausgrabungen* 72, 253-273.
- Stuart, A.J., Lister, A., 2012. Extinction chronology of the woolly rhinoceros *Coelodonta antiquitatis* in the context of late Quaternary megafaunal extinctions in northern Eurasia. *Quaternary Science Review* 51, 1-17.
- Ulrix-Closset, M., 1975. *Le paléolithique moyen dans le bassin mosan en Belgique*. Editions Universa, Wetteren.
- Van Wetter, G., 1920. *Les origines de la parure aux temps paléolithiques*. Mémoires de l'Académie royale de Belgique, Classe des Beaux-Arts 1. Hayez, Bruxelles.
- Vigne, J.-D., 2005. L'humérus de chien magdalénien de Erralla (Gipuzkoa, Espagne) et la domestication tardiglaciare du loup en Europe. *Munibe (Antropologia-Arkeologia)* 57, 279-287.
- von den Driesch, A., 1976. *A guide to the measurement of animal bones from archaeological sites*. Peabody Museum Bulletins, Harvard University Bulletin 1. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge.

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