In situ study of the Gravettian individual from Cussac Cave, Locus 2 (Dordogne, France)

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Brief Communication: *In Situ* Study of the Gravettian Individual from Cussac Cave, Locus 2 (Dordogne, France)

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KEY WORDS Upper Paleolithic; sex assessment; stature; body proportions; burial practices

ABSTRACT

Objectives: Cussac cave, discovered in 2000, is characterized by the exceptional presence of monumental engravings and human remains deposited in bear nests. Both the style of the art and a direct radiocarbon date indicate a Gravettian age. As the cave is protected as a national heritage site, only very limited access to and restricted direct interventions involving the human remains are possible. Here, we present the results of observations and measurements of Cussac L2A, represented by a virtually complete skeleton covered with a layer of clay.

Materials and Methods: A portion of the clay that covered some bones was removed in order to undertake a study of the skeleton *in situ*. The age-at-death was assessed using several indicators, especially changes on the auricular surface of the ilium. The sex was assessed using the morphology and morphometrics of the coxal bones. Cussac L2A stature, humero-femoral index, and crural index were also estimated. The dimensions of the Cussac L2A skeletal remains are compared with the other European Gravettian and Late Upper Paleolithic human remains using adjusted *Z*-Scores.

Results: The analysis indicates that Cussac L2A is probably a male who died aged between 20 and 50 years. If the sex assessment is correct, with an averaged estimated stature of 1.64 m, Cussac L2A would be one of the shorter Gravettian males.

Discussion: These results raise the importance of the new discoveries to better understand the variability of Upper Paleolithic skeletal morphology and stress the difficulties in marrying heritage preservation and scientific investigations. Am J Phys Anthropol 158:759–768, 2015.

INTRODUCTION

The European Upper Paleolithic saw the emergence of highly complex societies of Pleistocene hunter-gatherers with well-developed subsistence and social patterns (e.g. Bon, 2009). From this time period an appreciation of the nature and variation of human skeletal biology is emerging (e.g. Holliday, 1999; Formicola, 2003; Holt and Formicola, 2008; Trinkaus et al., 2014), albeit based on skeletal samples that are dispersed in time and space through the Upper Paleolithic. It has become increasingly apparent that they differed in some ways from recent (late Holocene) humans, but the extent and nature of these contrasts remain unclear. For these reasons, if we are to understand the establishment and early evolution of modern human biology, it is necessary integrate the maximum number of available Upper Paleolithic human skeletal remains into analyses. To this end, this paper presents the results of an anthropological study of a skeleton from Cussac Cave (Dordogne, France), remains that for heritage conservation reasons can only be assessed in their *in situ* positions.

Cussac Cave is located in the commune of Buisson-de-Cadouin on the right bank of the Bélingou, itself a tributary of the Dordogne. The entrance of the cave has been known since the fifties (Peyrony, 1950), but the karstic network, which is 1.7 km long, was explored for the first time in September 2000 by two spelunkers, M. Delluc and F. Massoulier. The preservation in the cave is exceptional: they indentified a series of engravings, preserved prehistoric floors, and human remains lying exposed on the cave floor (Aujoulat et al., 2001). Cussac was designated as a national heritage site in November 2000 to maintain its integrity, and since then has been the subject of works to ensure its preservation and to secure the site, under the responsibility of the Ministry of Culture (Fourment et al., 2012). Since 2010 an interdisciplinary team has been conducting the scientific study of the cave, the art, and the remains, under the supervision of J. Jaubert (Bordeaux University, France) (Jaubert et al., 2012).

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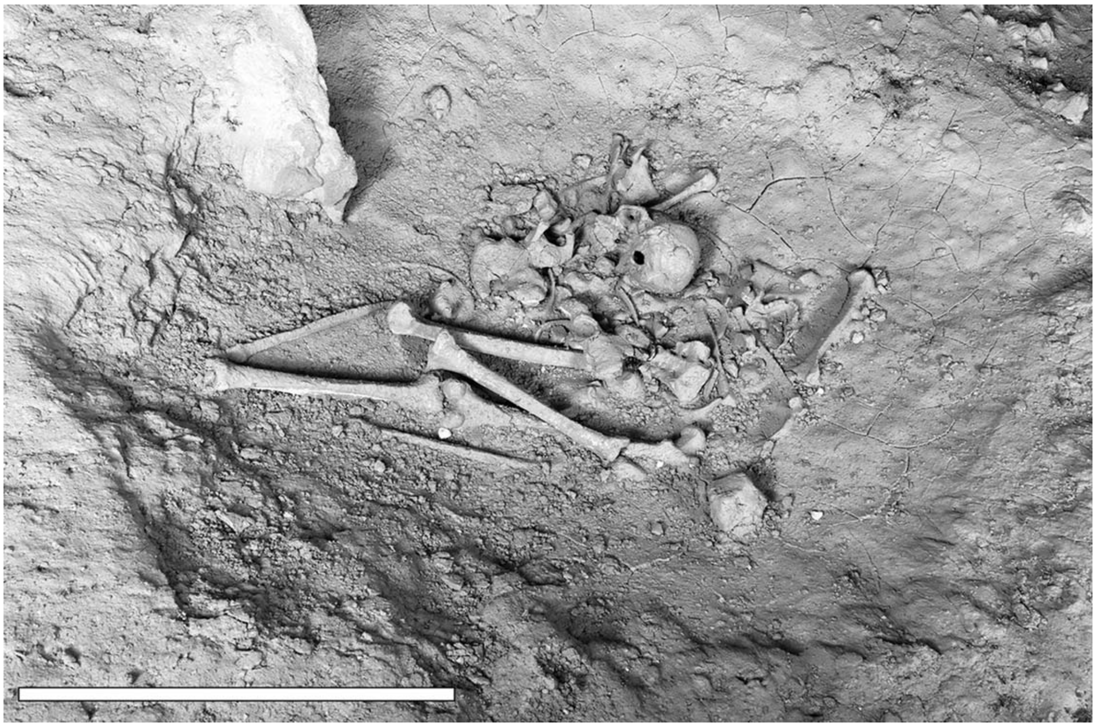

Fig. 1. Cussac Locus 2 (before the cleaning of the dental arcades, the spheno-occipital synchondrosis region, and the coxal bones). Scale: 1 m. Picture courtesy of P. Mora (Archéotransfert).

Human remains lie exposed on the cave floor, in three different loci (Aujoulat et al., 2001; Henry-Gambier et al., 2013). Locus 1 is mainly composed of long bone shaft fragments and complete or fragmented small bones (two individuals at least: Cussac L1A, and Cussac L1B) mainly seen in one bear nest. The remains from locus 2 represent a virtually complete individual (Cussac L2A[1]) in a bear nest. More than 80 bones dispersed over several square meters, from at least three individuals, have been identified for locus 3 (Cussac L3A, Cussac L3B, and Cussac L3C). Loci 1 and 2 are about 150 m from the entrance in the downstream branch of the gallery, in the concave portion of a meander; locus 3 is a large area located 80 m further into the cave (Henry-Gambier et al., 2013).

Three attempts to get direct radiocarbon dates were performed in 2001, one from each locus. Only the sample from Locus 1 provided a reliable date (Beta-156643) of 25120 ± 120 ^{14}C BP (30 290-29 560 cal BP). This date and the style of the art indicate a Gravettian age (Aujoulat et al., 2001; Henry-Gambier et al., 2013). From the locus 2, the ^{14}C date from a rib fragment gave a date of $15{,}750 \pm 50$ ^{14}C BP (Beta 156,644). However, the material dated was not identifiable as bone protein, and this result was considered as unreliable by Beta Analytic (Aujoulat et al., 2002). For the locus 3, the sample did not provide carbon for analysis. On the basis of radiometric determinations, only the first locus is undoubtedly Gravettian. However, at this stage of the study of the interdisciplinary team, the most parsimonious hypothesis is to consider that the art and the skeletal remains are contemporary (Jaubert et al., 2012; Henry-Gambier et al., 2013).

As the cave was designated as a national heritage site, only very limited access to the human remains are possible. Locus 2 is relatively close to the path used by the scientific team, contrary to loci 1 and 3 located several meters away, which makes observations very difficult and necessarily limited. The only authorized archaeological intervention concerns locus 1 (scheduled to start in 2017, after the installation of an extension to the metallic walkway), but the anthropological team also received permission to remove a portion of the clay that covered some bones of locus 2 in order to attempt to assess the sex, age-at-death and stature of the complete skeleton from this locus and these remains form the focus of this contribution.

MATERIAL AND METHODS

The locus 2

Locus 2 consists of a subcircular bear nest and the immediately adjacent areas, and includes a virtually complete skeleton at the bottom and the sides of the nest. The skull (cranium and mandible), all major long bones, clavicles, the coxal bones, the sacrum, as well as several ribs, vertebrae and bones of the hands and feet are visible (Fig. 1). However, almost all bones are more or less covered by a layer of clay. There is no evidence of more than one individual (called Cussac L2A) in this locus. Contrary to the other loci where human remains are commingled and often fragmented, the location of the bones of Cussac L2A fits the definition of an individual in an anatomical sense (Fig. 1), though only one anatomical connection, between the right femur and tibia, is

[1]There is only one individual identified for Locus 2. However, the remains of other individuals might be found under the clay, in the eventuality of an excavation. This justifies the letter A in its name.

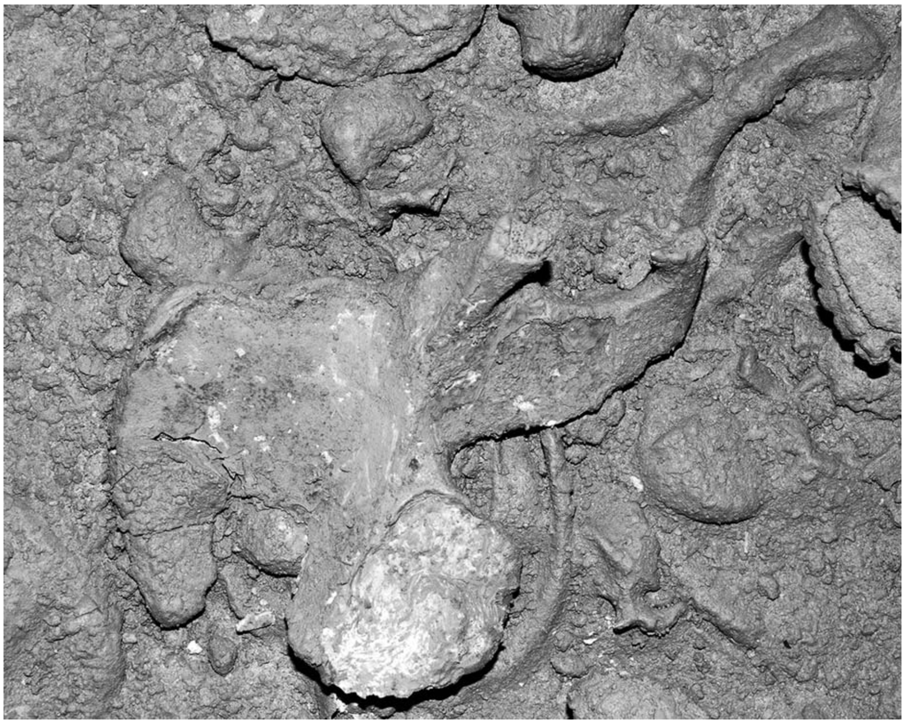

Fig. 2. Left coxal bone after the cleaning. Picture: P. Courtaud.

preserved. Even if it is impossible to reach definite conclusions without an excavation, our observations suggest a primary deposit of a corpse in ventral decubitus, lying along a North-South axis, head to the South (Aujoulat et al., 2001, 2002; Henry-Gambier et al., 2013). After the decomposition of the body, the skeleton was then disturbed by water, and covered with clay by natural accumulation (Aujoulat et al., 2001, 2002; Henry-Gambier et al., 2013).

The *in situ* study

The path to locus 2 is via a narrow passage, thanks in part to a metallic walkway (stainless steel) that passes about 40 cm from the Locus. In 2013 an extension directly above locus 2 was mounted on the walkway, allowing direct observations. In January 2014, we received authorization to remove a portion of the clay that covered some of the bones, including that covering the dental arcades, the spheno-occipital synchondrosis region, the lateral aspect of the right iliac blade and the medial surface of the left coxal bone (including the auricular surface) in order to undertake a study of the skeleton *in situ* (Fig. 2). Measurements of the coxal bones and of some long bones were taken using calipers, a cephalometer and a tape measure, without moving the bones and with the aim to leave no marks on them, on the clay that covers them, or on the bottom of the nest. The linear measurements follow the Martin system (M-#) (Bräuer, 1988).

To estimate the age-at-death, the following indicators were used: closure of the spheno-occipital synchondrosis, fusion of the iliac crest, tooth wear, and changes on the auricular surface of the ilium following Schmitt's method (Corsini et al., 2005; Schmitt, 2005). The sex was assessed using morphognostic (Brůžek, 2002) and morphometric (Murail et al., 2005) assessment of the coxal bones.

Examinations and measurements were done by two observers (P.C. and S.V.) in January 2014. They reexamined and measured the skeleton together in January 2015 to obtain consensus. They reached complete agreement for the age-at-death estimation and long bone measurements. As the sex assessment may be problematic, the results obtained by each observer will be presented.

Comparative samples

This skeleton from Cussac is compared with the other European Gravettian and Late Upper Paleolithic (LUP) human remains (Table 1). Only adult individuals with a reliable sex determination (see Henry-Gambier et al., 2002; Gambier et al., 2006; Villotte et al., 2007, 2010; Villotte, 2009) were included. Individuals with systemic pathological conditions were not taken into account and upper limb measurements of Barma Grande 2, Oberkassel 1, Barma di Caviglione 1 were not included due to localized pathological conditions (e.g. fractures).

Adjusted *Z*-Scores (Maureille et al., 2001; Scolan et al., 2012) were computed to compare the dimensions of the Cussac L2A skeletal remains to the means and standard deviations of the comparative groups, taking into account the size of these groups (Maureille et al., 2001; Scolan et al., 2012). For each measurement, the null value corresponds to the mean, and the interval between -1 and 1 includes the 95% confidence interval of each of the comparative samples. We used the adjusted *Z*-Scores in two slightly different ways. For the

TABLE 1. Comparative individuals

Gravettian	Late Upper Paleolithic
Males	
Baousso da Torre 1 (1)	Arene Candide 2 (11)
Baousso da Torre 2 (1)	Arene Candide 4 (1, 11)
Barma Grande 2 (2, 3)	Arene Candide 5 (11)
Barma Grande 5 (1, 7)	Arene Candide 10 (1, 11)
Cro Magnon 1 (1, 4, 5)	Arene Candide 12 (1, 11)
Cro Magnon 4315-4318 (1, 5)	Continenza 7 (1)
Dolní Věstonice 13 (1, 6)	Laugerie Basse 4 (1)
Dolní Věstonice 16 (1, 6)	Le Bichon (1, 12)
Grotte des Enfants 4 (1, 7, 24)	Los Azules 1 (13)
Paviland 1 (1, 8)	Oberkassel 1 (14)
Pavlov 1 (1, 6)	Romito 3 (1, 15)
Sunghir 1 (1, 9)	Romito 4 (1, 15)
Veneri Parabita 1 (1, 10)	Tagliente 2 (1, 16)
	Villabruna 1 (1, 17)
Females	
Abri Pataud 1 (1)	Cap Blanc (21)
Abri Pataud 3 (1)	Grotte des Enfants 3 (1, 7, 24)
Dolní Věstonice 3 (1, 6)	Lafaye 1 (1)
Barma di Caviglione 1 (18, 19)	Oberkassel 2 (14)
Grotte des Enfants 5 (1, 7, 24)	Romito 1 (1, 15)
Paglicci 25 (1, 20)	Romito 5 (1, 15)
Veneri Parabita 2 (1, 10)	Romito 6 (1, 15)
	St Germain la Rivière 4 (1, 22, 23)

Data from: 1: Villotte, personal observation. 2: (Formicola, 1988). 3: Holliday, personal communication. 4: (Vallois and Billy, 1965). 5: (Gambier et al., 2006). 6: (Trinkaus and Svoboda, 2006). 7: (Verneau, 1906). 8: (Trinkaus, 2000). 9: (Trinkaus et al., 2014). 10: (Mallegni et al., 2000). 11: (Paoli et al., 1980). 12: (Chauvière, 2008). 13: (Garralda, 1986). 14: (Trinkaus, in press). 15: (Mallegni and Fabbri, 1995). 16: (Corrain, 1977). 17: (Vercellotti et al., 2008). 18: Trinkaus personnal communication. 19: Brůžek personnal communication. 20: (Mallegni and Palma Di Cesnola, 1994). 21: (Bonin, 1935). 22: (Blanchard et al., 1972). 23: (Henry-Gambier et al., 2002). 24: Henry-Gambier and Brůžek personnal communication.

TABLE 3. Measurements of the Cussac L2A coxal bones using for the tool for probabilistic sex diagnosis

Measurement	Side	Obs 1	Obs 2
Cotylo-pubic width (SPU)	Left	28.7	30.3
Coxal length (DCOX M1)		214.0	216.0
Greater sciatic notch height (IIMT M15.1)		37.0	38.2
Spino-sciatic length (SS)		75.6	75.1
Spino-auricular length (SA)		76.4	78.2
Vertical acetabular diameter (VEAC M22)	Right	47.6	52.5
Ischium post-acetabular length (ISMM)		100.0	103.5
Cotylo-sciatic breadth (SIS M14.1)		38.8	37.2

See Murail et al. (2005) for definitions. *M-##* indicates measurement following the Martin system (Bräuer, 1988).

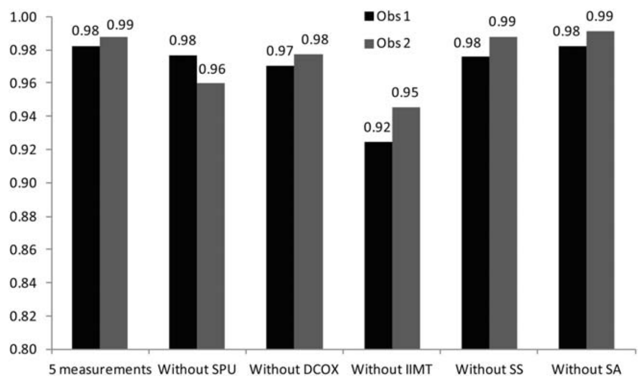

Fig. 3. Posterior probabilities of Cussac L2A (left coxal bone) being a male computed with the tool for probabilistic sex diagnosis (after Murail et al., 2005), using five variables and the five combinations of four variables.

first method, they were computed to compare the measurements of Cussac L2A to the means and standard deviations of each of the comparative groups, namely: the Gravettian males, Gravettian females, LUP males, and LUP females. In this case, the adjusted Z-Scores indicate the "probabilistic distance" between Cussac L2A and each of the reference samples, and a value outside of the interval between -1 and 1 has a $P < 0.05$ of belonging to a given reference sample. For the second method, considering Cussac L2A to be likely a male (see Results), the dimensions of the Cussac L2A skeletal remains were included in the Gravettian male sample and the whole Upper Paleolithic male sample. In this case, the calculated adjusted *Z*-Scores indicate the "probabilistic position" of Cussac L2A within these samples, and permit us to determine if the individual should be considered as an outlier.

TABLE 2. Visual determination of sex of Cussac L2A, following Brůžek (2002)

	Right side scores		Left side scores	
Characters and conditions	Obs 1	Obs 2	Obs 1	Obs 2
Preauricular surface	I	I	M	M
Development of negative relief	nr	nr	m	m
Presence of grooves or pitting	nr	nr	m	m
Development of positive relief	m	m	m	m
Great sciatic notch	F	I	F	F
Proportions of lengths of sciatic notch cords	f	i	f	f
Form of contour notch chords	m	m	m	m
Course of the contour above the posterior chord	f	f	f	f
Composite arc	nr	nr	M	M
Inferior pelvis	nr	nr	nr	nr
Ischiopubic proportion	nr	nr	nr	nr

Score for the right and left coxal bones. M: Masculine morphology. F: Feminine morphology. I: Indeterminate. nr: nonrecordable.

TABLE 4. Osteometric determinations for Cussac L2A

Bone	Measurement	M N°	Cussac Locus 2		Gravettian males					Gravettian females					LUP males					LUP females				
			Right	Left	Mean	SE	Min.	Max.	*N*	Mean	SE	Min.	Max.	*N*	Mean	SE	Min.	Max.	*N*	Mean	SE	Min.	Max.	*N*
Humerus	Max. length	1	(300.0)		361.9	15.8	336.0	378.0	5			308.0	328.0	2	310.8	13.1	290.0	331.0	9	289.3	21.1	260.0	309.0	4
Ulna	Total length	2(1)	258.0				298.0	304.0	2															
	Articular length	2	233.5		260.7	16.4	242.0	273.0	3			228		1	224.9	5.8	216.0	233.0	6	199.3	13.3	188.0	214.0	3
Coxal	Vertical acetabular diameter (VEAC)	22	50.1		58.6	2.7	54.6	61.2	7	52.3	3.8	47.3	56.2	4	53.9	2.1	51.4	56.2	7	49.2	1.7	47.6	51.0	3
	Ischial postacetabular length (ISMM)		101.8		116.9	6.1	112.0	126.5	5	103.0	5.5	97.3	110.4	4	109.5	4.9	105.8	115.4	5			93.3	104.4	2
	Cotylo-sciatic breadth (SIS)	14.1	38.0		39.8	3.3	35.2	44.4	8	35.8	4.9	31.0	42.5	4	40.4	3.4	34.8	44.8	8	34.6	2.8	32.5	38.5	4
	Cotylo-pubic width (SPU)			29.5	30.7	3.2	27.5	35.4	5			25.7	32.4	2	27.9	1.3	26.6	29.5	5			23.2		1
	Coxal length (DCOX)	1		215.0	230.5	5.9	225.0	242.0	6			203.0	205.5	2	215.7	11.1	207.0	230.0	5			190.0	198.0	2
	Greater sciatic notch height (IIMT)	15.1		37.6	37.0	3.6	33.0	42.0	6	44.9	4.0	41.5	50.0	4	42.6	4.6	33.8	46.5	6			49.0	55.5	2
	Spino-sciatic length (SS)			75.4	78.3	4.3	73.2	84.7	8	74.4	8.0	69.0	86.0	4	73.5	4.2	66.3	77.9	7	69.2	6.7	59.6	77.7	5
	Spino-auricular length (SA)			77.3	79.5	6.0	68.1	87.6	7	81.7	7.3	74.6	91.4	4	77.6	3.5	71.4	81.1	7	79.9	5.8	73.0	88.0	5
Femur	Maximum length	1	(450.0)		489.8	29.2	449.0	537.0	8	449.6	25.9	421.0	478.5	4	442.4	15.2	425.0	470.3	11	415.3	10.4	400.0	422.2	4
	Mid A-P diameter	6		32.5	35.8	3.2	30.0	39.9	11	32.8	4.8	25.9	36.6	4	31.8	2.3	27.5	35.3	14	26.6	2.3	22.5	29.5	8
	Mid M-L diameter	7		(26.2)	29.3	1.7	26.8	32.3	11	26.7	2.6	22.9	28.4	4	28.1	2.1	24.3	31.8	14	23.8	1.5	21.0	25.3	8
	Epicondylar breadth	21		(82.0)	87.6	6.6	82.0	98.0	5	81.8	2.9	79.3	85.0	3	82.9	4.2	75.5	88.0	12			77.0		1
	Medial condyle breadth	21c	30.8		26.2	2.7	23.7	29.0	3								28.2		1					
Tibia	Maximum length	1a	(365.0)	(365.0)	398.8	17.6	382.3	422.5	4			359.0	367.0	2	381.2	20.5	362.8	404.0	5	346.0	10.8	334.0	357.0	4
	Medial articular length	2	(345.0)	(345.0)	376.8	15.6	358.5	398.5	5			337.0	364.5	2	349.9	16.2	330.0	379.0	9			304.0	332.0	2
	Medial condyle depth	4a		53.5	48.5	3.3	46.0	52.3	3								48.5		1					
	Distal max. breadth	6		49.9	52.2	3.0	46.4	56.0	8			45.0	48.5	2	51.2	2.8	46.0	54.9	8	47.0	1.7	45.0	48.0	3
	Mid. A-P diameter	8		(35.0)	37.1	4.0	32.1	45.0	10	31.6	5.9	24.9	36.0	3	36.1	3.5	29.5	42.0	9			28.5	30.2	2
	Mid. M-L diameter	9		24.9	24.8	3.0	20.6	29.0	10	22.8	4.6	17.5	26.0	3	22.3	2.3	19.5	26.0	9			20.4	22.3	2
Fibula	Maximum length	1		(355.0)	402.6	22.7	369.0	434.5	7			349.0	382.0	2	361.7	17.0	336.5	393.5	10					
	Distal Max. depth			27.7			24.0	27.1	2								32.5		1					

M-## indicates measurement following the Martin system (Bräuer, 1988). "(##)" indicates a measurement with small degree of estimation. To allow comparisons, measurements from Gravettian and LUP right upper limb were used. For the lower limb, the average of measurements for the left and right sides has been calculated. Measurements for Cussac L2A coxal bones are the average between the two observers (see Table 3).

RESULTS

General observations

The skeleton displays no signs of gross pathology, i.e. there is no indication of abnormal bone formation, destruction, size, or shape. Moreover, long bone extremities are apparently free from any sign of degenerative disease. The morphology of the neurocranium and the facial skeleton is clearly modern.

Age-at-death estimation

The spheno-occipital synchondrosis appears to be closed and the left iliac crest is fused (Fig. 2) without any visible line demarcating the crest and the iliac blade (non-recordable for the right side). The epiphyses of the major long bones also appear to be fused. All the permanent teeth (including the third molars) are fully erupted. Both mandibular canines, both upper central incisors, and the left upper third molar are missing, but there is no evidence of antemortem tooth loss. The remaining teeth are worn, with moderate to large dentine exposure, but without a severe loss of crown height. All these indicators suggest a minimum age in the late second decade. For the auricular surface of the left ilium, transverse organization is absent, almost the entire surface is finely granular without porosity or dense bone, the apex is sharp and distinct, and the iliac tuberosity of the retro-auricular area is smooth (Fig. 2). Following Schmitt (2005), this indicates an age at death between 20 to 39 years with a posterior probability of 92%, or between 20 and 49, with a posterior probability of 98%.

Sex assessment

Of the five characters used in Brůžek (2002), only three can be scored for the left coxal bone due to the poor preservation of the ischio-pubic ramus (Fig. 2; Table 2). Both observers agreed for the scores of the left pre-auricular surface: there is no groove and a slightly developed piriform tubercle present. This combination usually attributed to a male morphology is also seen in some females (6.6% of the female sample in Brůžek, 2002). The composite arc appears to be absent on the left coxal bone. This is more commonly seen in males but, once again, this condition is frequent in female samples (9.1% of the female sample in Brůžek, 2002). The left greater sciatic notch displays a "female" shape (Fig. 2; Table 2). Few observations were possible for the right coxal bone (Table 2). The right greater sciatic notch displays a female (Obs. 1) or ambiguous (Obs. 2) shape, but the observation was done by looking at the posterolateral iliac surface, i.e. the opposite side for reliable scoring. A piriform tubercle on the right pre-auricular surface (a "male" feature) has been identified by touch. Thus, the right and left coxal bones of the Cussac L2A display both male and female features and the morphology alone cannot be used to securely assign a sex.

Cussac L2A's probability of being a male or female has been calculated by comparing measurements of its coxal bones to those from a worldwide database (Murail et al., 2005). The tool for probabilistic sex diagnosis (DSP) computes the probability of being male or female for any combination of at least four variables among 10. Five measurements were taken by both observers on the left coxal bone (Table 3), and the probability of Cussac L2A being male or female was calculated for the five variables and for the five combinations of four variables. In each case the probability of being a male is greater than 92%, and in all but one combination greater than 95% (Fig. 3). Only three measurements were taken on the right coxal bone (Table 3), thus the DSP tool cannot be used.

Linear measurements

Values for all maximum lengths are low (Table 4), below the range of variation known for the Gravettian male sample (except for the femur). In contrast, values for shaft diameters and long bone extremities fall well within the range of variation of the Gravettian male sample (Table 4). This indicates a rather short individual with quite robust long bones.

Two measurements (the maximum length of the humerus and the vertical acetabular diameter) are significantly below the range of variation of the Gravettian male sample, and one (the anteroposterior diameter of

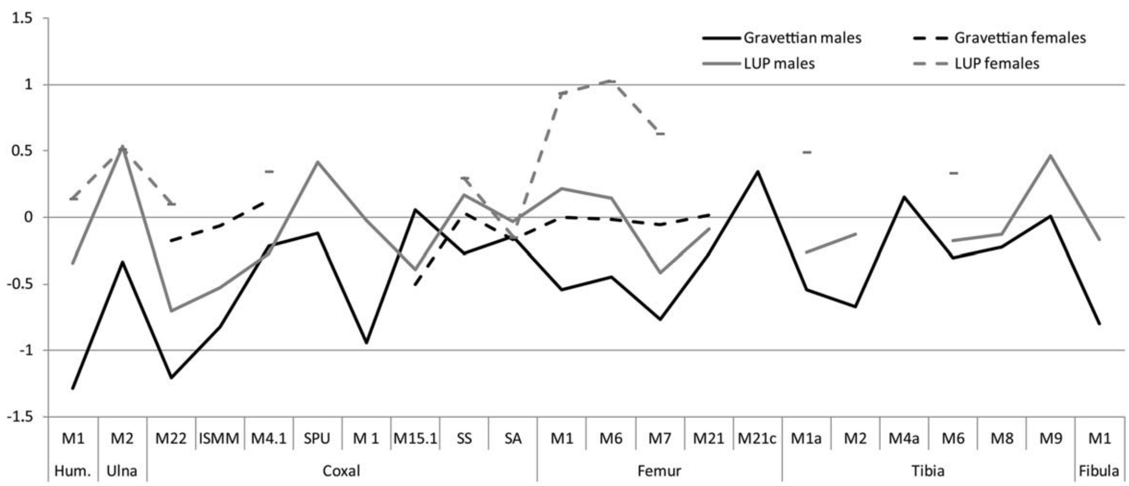

Fig. 4. Adjusted *Z*-scores of the skeletal dimensions of Cussac L2A compared with the ranges of variation of the comparative samples. The null value corresponds to the mean and the interval between −1 and 1 includes the 95% confidence interval of each of the comparative samples. M-## indicates measurement following the Martin system (Bräuer, 1988).

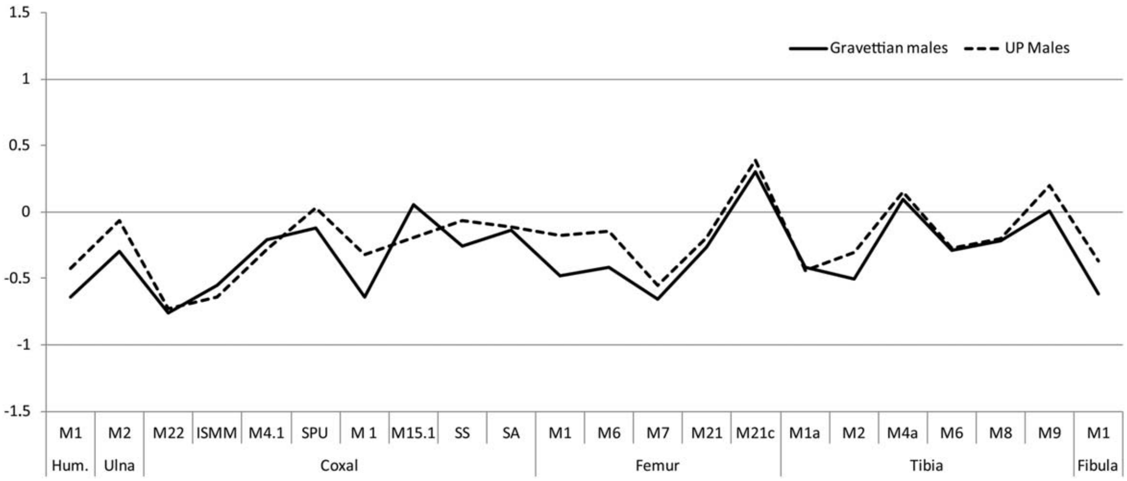

Fig. 5. Adjusted *Z*-scores of the skeletal dimensions of Cussac L2A compared with the ranges of variation of the Gravettian male sample and the whole Upper Paleolithic (Gravettian + LUP) male sample, Cussac L2A being included in these samples. The null value corresponds to the mean and the interval between −1 and 1 includes the 95% confidence interval of each of the comparative samples. M-## indicates measurement following the Martin system (Bräuer, 1988).

the mid-shaft of the femur) is significantly above the range of variation of the LUP female sample (Fig. 4). All the other measurements fall in the ranges of variation of the comparative samples. When Cussac L2A measurements are also used to calculate the mean and the standard error (i.e. the "probabilistic position" of Cussac L2A within the samples) for the Gravettian male sample and for the whole Upper Paleolithic male sample, this individual could not be considered as an outlier for any of its values (Fig. 5).

TABLE 5. Estimated stature of Cussac L2A, using Trotter and Gleser (1952) equations for African-Americans

	Estimated stature (cm)
Cussac L2A (male humerus equation)	162.9 ± 4.4
Cussac L2A (female humerus equation)	158.1 ± 4.3
Cussac L2A (male femur equation)	165.3 ± 3.9
Cussac L2A (female femur equation)	162.4 ± 3.4
Gravettian males	177.7 ± 5.4 (10)
Gravettian females	164.2 ± 6.8 (6)
LUP males	165.1 ± 3.8 (12)
LUP females	153.8 ± 4.4 (7)

Individual statures for the Gravettian and LUP samples were estimated with the same equations (for the humerus, the femur, or averaged when both estimations were possible) (mean ± standard error (number of Individuals)).

TABLE 6. Humero-femoral [(Humerus maximum length / Femur bicondylar length) × 100)] and crural [(Tibia maximum length / Femur bicondylar length] indices for Cussac L2A and the comparative samples

	Humero-femoral index	Crural index
Cussac L2A	67.1	81.6
Gravettian males	73.3 ± 3.6 (6)	84.7 ± 1.1 (5)
Gravettian females	71.0 ± 2.9 (4)	84.6 / 86.0 (2)
LUP males	70.2 ± 1.7 (10)	87.2 ± 3.1 (6)
LUP females	71.5 ± 2.8 (5)	84.5 ± 1.7 (5)

In order to compute these indices for Cussac L2A, the equation provided by Trinkaus (in press) was used to estimate femur bicondylar length from femur maximum length (BicLen = 1.013 × MaxLen – 8.7, $r^2 = 0.996$, $n = 43$). For the comparative samples, the average of measurements for the left and right sides has been calculated (mean ± standard error (number of individuals)).

Body proportions

Cussac L2A stature was estimated using Trotter and Gleser (1952) equations for African-Americans, as suggested by Formicola (2003) for European Early Upper Paleolithic specimens. The estimates, presented in Table 5, fall between 162.4 and 165.3 cm. They are well below the average Gravettian male stature (177.7 cm) and the stature of Dolní Věstonice 13 (169.7 cm), the shortest male in the Gravettian sample for this study, but close to the means for the Gravettian female sample (164.2 cm) and the LUP male sample (165.1 cm). Assuming the sex assessment is correct, Cussac L2A, with an average estimated stature of 163.7 cm (calculated from male equations), would be one of the shortest Gravettian males known to date, the shortest at present being Dolní Věstonice 15, a probable male with serious developmental abnormalities (Trinkaus et al., 2001; Trinkaus and Svoboda, 2006). The Cussac L2A humero-femoral index of 67.7 is exceeded by all Upper Paleolithic individuals but two (Oberkassel 2 and Grotte des Enfants 5); with a value of 81.2, its crural index is the lowest in the sample (Table 6). These very low values indicate that Cussac L2A has a long femur relative to the humerus and to the tibia.

DISCUSSION AND CONCLUSIONS

Based on *in situ* observations and measurements of the Cussac L2A skeleton, this individual appears to be very likely a male who died in his third or fourth decade. Males are two to three times more common than females in the Gravettian buried sample, and young adults (20 to 29 years old) are over-represented (Villotte et al., 2011a; Riel-Salvatore and Gravel-Miguel, 2013). Our results support this general trend.

Cussac L2A was short, shorter than all the non-pathological Gravettian males known to date. Four hypotheses can be posed to explain this result: Cussac

L2A might be (1) a female (incorrect sex determination), (2) not Gravettian (incorrect cultural attribution), (3) a pathological individual, or (4) a nonpathological Gravettian male of very short stature.

The sex assessment was done using two methods: one based on morphology and the other on morphometrics. It is noteworthy that the only clear female morphological trait is the shape of the greater sciatic notch and, according to Brůžek (2002, p 160), “The sexual characteristics of the sciatic notch are exceedingly difficult to use [. . .] [and] direct evaluation of notch shape is [. . .] subjective.” In contrast, there is no doubt about the male morphology of the pre-auricular surface of the left coxal bone and the presence of a real piriform tubercle on the right one. However, as both coxal bones display a set of female and male characters and some others cannot be recorded, we considered the sex as indeterminate based on morphology alone. Based on the results from the tool for probabilistic sex diagnosis (DSP), the probability of the Cussac L2A being a male, computed with several combinations of available measurements for the left coxal bone, are all above 92%. Previous studies using the same method did not reveal any substantial differences in morphological configuration between Upper Paleolithic individuals and current populations (e.g. Brůžek and Tillier, 1996; Henry-Gambier et al., 2002; Gambier et al., 2006; Villotte, 2009). The DSP tool seems to be reliable in assessments of the sex of Gravettian individuals and thus an incorrect sex determination seems unlikely. Therefore, we consider Cussac L2A to be male.

Cussac L2A measurements seem closer to LUP males than Gravettian ones (though its crural and humero-femoral indices are very low compared with those seen in both periods). Thus, the hypothesis that this individual may have not been Gravettian but from a later Upper Paleolithic group has to be discussed. There is no valid ^{14}C date confirming the cultural attribution of this individual, and on the basis of direct radiometric dating, only the first locus is undoubtedly Gravettian. However, current geoarchaeological studies in the cave do not argue for a different chronological attribution, and all the human remains identified in the cave are in the same context: in bear nests and apparently not associated with artifacts. Moreover, there is no indication that the cave was visited after the Gravettian, contrary to some other French sites with rock art, as at Trois-Frères (Arriège, France) where Magdalenian artists covered previous engravings dating to the Gravettian with paintings (Bégouën et al., 2014). Nevertheless, locus 2 differs from the two other loci by the fact that there is only one individual, represented by a virtually complete skeleton, and that it seems to be a primary burial, whereas loci 1 and 3 contain the remains of several disarticulated and incomplete individuals (apparently without crania). At this stage of the study, there is no strong argument to attribute locus 2 to a different culture, but another attempt to get a direct date for this individual seems essential.

Pathological conditions and disorders are not uncommon in the Gravettian sample (e.g. Thillaud, 1985; Trinkaus et al., 2001; Villotte et al., 2011b; Guatelli-Steinberg et al., 2013). Cussac L2A may have been an individual who was affected by a pathological condition, a developmental or growth disorder explaining its short stature and its very low crural and humero-femoral indices. However, when Cussac L2A is included in the Gravettian male sample, or in the whole Upper Paleolithic male sample, this individual is not an outlier (Fig. 5). Careful examination of the skeleton does not reveal any particular bone shape anomalies, though almost all bones are covered with clay, preventing any rigorous analysis. Moreover, palaeopathological diagnosis is often very difficult to establish even in the best conditions (study in a laboratory, with radiographs, etc.), thus we cannot reject the hypothesis that Cussac L2A may have suffered from a developmental or growth disorder producing minor skeletal alterations.

Alternatively, Cussac L2A may simply have been a very short Gravettian male. Upper Paleolithic skeletal variability (especially sexual dimorphism) is still little known, certainly due to the scarcity of well-preserved human remains for this period, and, possibly, to significant heterogeneity. Discoveries of new fossils, especially virtually complete skeletons, are thus crucial to achieve a better understanding of the variability of human skeletal morphology and past burial practices. At the same time, research on such new findings, especially when they are associated with a unique context as at Cussac, must integrate a significant heritage component.

We are well aware that the results presented in this article raise more questions than answers. However, the working conditions in the cave, which are affected by an attempt to preserve the integrity of the site, prevent further clarity at this moment. In the near future, we hope to benefit from the advances made possible by new technologies, in particular imaging: a photogrammetric record of each locus has been made by the anthropological team and three-dimensional (3D) models will be generated. Studying these models may help us to acquire more biological data on the human remains exposed on the cave floor. These models will be necessarily incomplete; however, the undersides of the bones are inaccessible to photogrammetry, and the pictures used for these models were taken only from a very restricted area to avoid trampling on the preserved surface. Moreover, clay covers a significant part of the Cussac human remains. The layer of clay fits very closely to the form of the bones and during the cleaning of the Cussac L2A coxal bones we were surprised by its unexpected thickness—several millimeters, more than a centimeter in some areas. This means that the anthropological study from 3D models will be greatly limited, especially for locus 2, where almost all bones are covered by clay. Thus, the only way to exploit this unique discovery of Gravettian fossils for a better understanding of funerary practices and biological diversity of past human populations is the careful excavation of this area and the study of the remains in laboratory. Unfortunately, such a study does not seem possible at present or in the near future.

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