



New data on the paleobiology of the Gravettian individual L2A from Cussac cave (Dordogne, France) through a virtual approach



Pierre Guyomarc'h^{a,*}, Mathilde Samsel^a, Patrice Courtaud^a, Pascal Mora^b, Bruno Dutailly^{a,b}, Sébastien Villotte^{a,*}

^a UMR 5199 PACEA, Université de Bordeaux, CNRS, MCC, France

^b UMS 3657 Archéovision, Université Bordeaux Montaigne, CNRS, France

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ABSTRACT

One of several elements making Cussac cave an exceptional site is the preservation of many prehistoric human remains lying on the ground, including an individual in a bear nest (Locus 2) in ventral decubitus, subject L2A. The protected status of the site does not allow for excavations or direct manipulation of the remains, at least for the near future. Thus, the tools of virtual anthropology were employed to further study this individual, after preliminary analyses *in situ* in 2014 raised several questions on its biological characteristics. A high-resolution 3D photogrammetric record of Locus 2 allowed for the virtual reconstruction of the *ossa coxarum* and cranium to be measured in TIVMI. Metric data from the *ossa coxarum* were used to apply the DSP, which indicated a male sex assessment for the left side. The linear variables and log shape ratios extracted from the cranium were compared to a reference sample composed of 46 Upper Paleolithic (UP) subjects. The cranial morphology of L2A is closer to the male variability for the UP, but displays an unusual pattern, with a short cranial height and a wide splanchnocranium. The biological peculiarities of this subject are discussed with regard to Gravettian funerary practices and the depositional context of Cussac cave.

1. Introduction

Since 2010, Cussac cave (Dordogne, France) underwent several extensive research campaigns that focused on several non-invasive archaeological and anthropological investigations (Ferrier et al., 2017; Henry-Gambier et al., 2013; Ledoux et al., 2016; Villotte et al., 2015). The cave hosts a unique combination of parietal art and human remains dating to the Gravettian (31,000–22,000 BP). The striking artistic elements consist of more than 150 engravings, mostly animal and human depictions, which represents one of the richest corpora of European parietal art for the Gravettian (Aujoulat et al., 2001; Jaubert et al., 2016). Similarly, human skeletal remains from this site significantly enriched the fossil record of the Upper Paleolithic of Europe, a period for which well-preserved human skeletons are relatively rare (Henry-Gambier, 2005). Several hundred human remains (fragments or complete bones) are scattered on the surface of the cave in at least three different *loci*.

One of the *loci*, Locus 2, consists of a well-represented skeleton - partially covered by clay - contained in a bear nest. Given the absence of duplicate elements, all the bones are attributed to the same individual, subject L2A. The current arrangement of the bones in the *locus* follows a logical anatomical pattern (Fig. 1), indicating that the

individual was deposited in *ventral decubitus* (Henry-Gambier et al., 2013; Villotte et al., 2015). The other *loci* contain commingled human remains from several individuals. The consistency between the artistic style of the parietal engravings and two ¹⁴C dates suggests that the human activity in the cave spans between 29,000 and 28,000 cal BP (Jaubert et al., 2016).

Due to its unique characteristics, the Cussac cave is now protected under the national heritage status. The site is closed to the public, and even the scientific team (*Programme Commun de Recherche*, PCR Cussac) has a relatively short window of time for intervention each year due to the high concentration of CO₂ in the cave between spring and fall. Moreover, to ensure the protection of the preserved floor, no excavations or samplings are planned in the near future. Given these limitations, the bioanthropological studies focus on non-invasive analyses, consisting, to date, of *in situ* observations and measurements of the visible elements. Using these methods, a preliminary study of L2A had been performed from a metallic walkway specially extended above the Locus 2 (Villotte et al., 2015). Before and after this study, the *locus* was virtually documented via 3D photogrammetry, allowing for additional research on these human remains.

Based on the characteristics of the auricular surface (Schmitt, 2005),

* Corresponding authors at: Université de Bordeaux, UMR 5199 PACEA, Bat B8, Allée Geoffroy St Hilaire, CS 50023, 33615 Pessac Cedex, France.
E-mail addresses: pierre.guyomarch@u-bordeaux.fr (P. Guyomarc'h), sebastien.villotte@u-bordeaux.fr (S. Villotte).



Fig. 1. Visualization of the global 3D photogrammetric record of the Locus 2 with textures (in MeshLab®, ISTI, v.1.3.4).

the first evaluation of L2A estimated an age-at-death between 20 and 49 years (Villot et al., 2015). The sex determination was done through visual scoring of the visible morphology of the *os coxae* (Brůžek, 2002), and from measurements computed in a probabilistic tool for sexual diagnosis, DSP (Murail et al., 2005). These morphometric methods applied to the left *os coxae* gave a male diagnosis. However, the presence of shared sexual traits in the morphoscopic evaluation, as well as a very low stature for this individual (outside the Gravettian range) called for further investigation into the sex of L2A (Villot et al., 2015).

Moreover, the body proportions of this individual raised the question of a possible developmental anomaly (Villot et al., 2015), an occurrence which appears to be abnormally frequent in the late Pleistocene sample (Wu et al., 2013). In addition, L2A was laid in a unique context for an Upper Paleolithic burial (a bear nest), and in *ventral*

decubitus, a very uncommon position for the Gravettian period (Henry-Gambier, 2008). A new analysis of this individual will therefore contribute to the debate on possible specific burial treatments of pathological individuals during the Upper Paleolithic (Formicola, 2007; Formicola et al., 1990, 2001; Mallegni and Fabbri, 1995; Pettitt, 2013; Sparacello et al., n.d.; Villotte et al., 2017).

To this end, we employed a high-resolution photogrammetric three-dimensional (3D) reconstruction to obtain virtual models of L2A's bones, and applied the now commonly used methods of virtual anthropology (Weber and Bookstein, 2011). We present in this report a new analysis of the L2A pelvis with the DSP method, as well as an analysis of its cranial morphology in comparison with a sample from the Upper Paleolithic.

2. Material and methods

2.1. The 3D photogrammetric model

Several photogrammetric acquisitions of the Cussac cave areas that include human remains were performed between 2012 and 2015, with global views and close-ups of the visible osseous elements. This allows for a 3D modelling and isolation of the different bones; the resulting 3D model of Locus 2 is displayed in Fig. 1. More than 700 photographs were processed with a Nikon d700 (zoom 24–70 2.8 used at 24 mm) during three different campaigns using Photoscan (Agisoft©) and PMVS (Furukawa and Ponce, 2010) software. This resulted in several 3D point clouds with a spatial resolution ranging from 1 to 0.5 mm. Points clouds were meshed and scaled using local physical scales and topographic points (with x, y, z coordinates, acquired by a Leica© total station).

2.2. Methodology for the *ossa coxarum* analysis

The 3D photogrammetric models of the *ossa coxarum* of L2A were extracted from the global model to allow more accurate measurements (Fig. 2). In order to reveal key anatomical areas for age and sex estimation, a layer of clay was removed from the left *os coxae* during one of the campaigns (Villot et al., 2015). Fig. 2 displays the 3D models of the bones after cleaning (i.e. posterior to the record in Fig. 1). The *ossa coxarum* were isolated with the Geomagic® Wrap 2014 software.

One of the most objective and reliable morphometric methods to assess the sex from the pelvic region is DSP (Murail et al., 2005). DSP has been used in the preliminary *in situ* study of Cussac L2A, and resulted in a male assessment from direct measurements of the left *os*

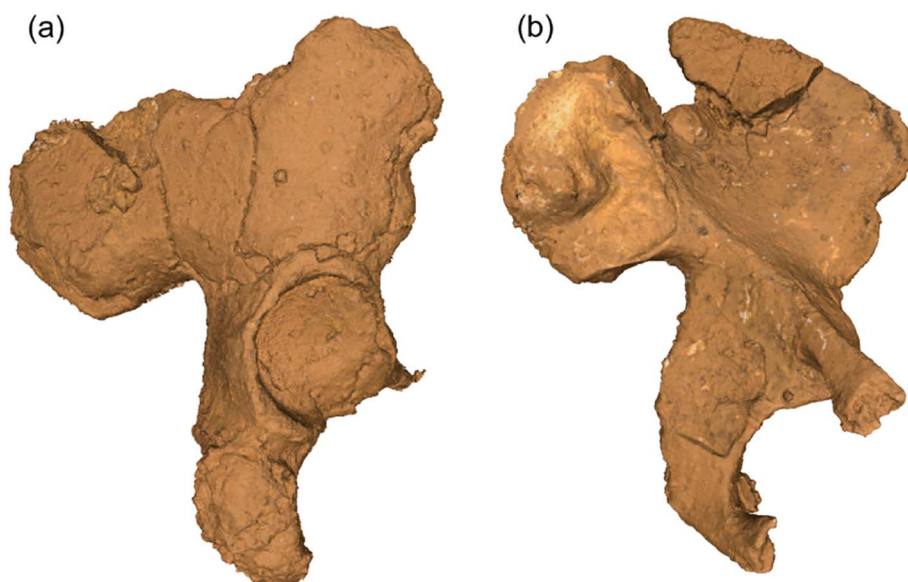


Fig. 2. Visualization of the isolated 3D models of the *ossa coxarum* of L2A with textures (in MeshLab®, ISTI, v.1.3.4): (a) right *os coxae* in lateral view; (b) left *os coxae* in medial view.

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