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The development of new husbandry and economic models in Gaul between the Iron Age and the Roman Period: New insights from pig bones and teeth morphometrics

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ABSTRACT

The Roman conquest of Gaul is usually perceived as the trigger of morphological changes in livestock and, more widely, the origin of an important agropastoral evolution. However, recent studies suggest that the economic transition between the Iron Age and Roman periods occurred much earlier than previously thought and was partially disconnected from Italy. This article, based on the morphometric analysis of pig teeth and bones, sheds new light on this transition. It reveals a more complex agropastoral change process, in two distinct phases, from the Middle *La Tène* period and after the creation of the Roman Empire. Moreover, it identifies two large economic models, around the Mediterranean platform and in the temperate part of Europe, with different paces of change, production objectives, and agricultural and market strategies.

1. Introduction

In zooarchaeology, the study of size variation in animal bones shows a clear change in livestock morphology (mostly, a global size increase) between the Iron Age and the Roman period (e.g. Méniel, 1984; Lepetz, 1996; Johnstone, 2004; Albarella et al., 2008; MacKinnon, 2010; Colominas et al., 2013). In Gaul (but also in other areas of the Empire), these changes are usually considered as a direct consequence of the Roman conquest (approximately at the end of the 2nd c. BC for *Gallia Narbonensis*, and at the end of the 1st c. BC for *Gallia Belgica*, *Lugdunensis* and *Aquitania*). The Roman's appropriation of these new provinces appears to have played a crucial role in the reshaping of economic and agropastoral strategies within the Empire (e.g. Goodman, 2012) and in Gaul (Lepetz et al., 2002; Ferdière et al., 2006), especially with the introduction of new morphological standards for livestock selection, the diffusion of new breeding methods or the renewal of genetic stock (e.g. the crossbreeding of local forms with Italian breeding males) (e.g. Brunaux and Méniel, 1983; Méniel, 1996; Lepetz, 1997; Forest and Rodet-Belarbi, 2002).

However, recent zooarchaeological results suggest that the size increase in livestock could have started much earlier than previously thought. Indeed, changes seem to occur, at least in the northern half of Gaul, from as early as the 3rd and 2nd c. BC (Duval et al., 2012; Nuviala, 2015). Moreover, in terms of pig husbandry, it has been shown recently that Italy only had an indirect influence over Gallic livestock (Duval et al., 2015). Therefore, in zooarchaeology, and also in archaeology (e.g. Blancquaert and Malrain, 2016), research is starting to move away from the Romanization paradigm, in order to explore the role of Gallic societies in the evolution of their husbandry strategies and economic politics. Using these new zooarchaeological insights, and the consideration of a changing economic context during the *La Tène* period in Gaul, it is argued that several centuries before the Roman conquest, pig husbandry (Duval et al., 2015, 2016) could have benefited from the political, social and economic reorganisation. This revival was triggered by urban and administrative changes, denser trade and exchange networks, new artisanal and agricultural productions and greater structuration of the agricultural landscape (Gransar, 2003; Trément, 2010; Buchsenschutz, 2015).

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Indeed, the Middle and Late Iron Age seems to be a key period for the understanding of changes in the economic organisation of Gauls, and consequently in arable and pastoral agriculture. Between the 4th and the 2nd c. BC the Gallic territory experienced the progressive establishment of a denser network of farmlands (Malrain et al., 2002; Trément, 2010; Marion, 2016). Several agricultural and technical innovations enabled increased yields: more efficient and varied iron tools for land clearing and preparation (e.g. the ploughshare – Marbach, 2004), the spread of millstones from the 4th c. BC (Amouretti and Comet, 2002; Buchsenschutz, 2004), wider use of single crop farming (Matterne, 2001), specialised productions for trade (wine and olive cultures – Brun and Laubenheimer, 2001; Brun, 2005), improvement in food storage structures (silos, granaries or ceramic pots for food storage and trade – Gransar, 2003; Barral et al., 2013), and better methods for food preservation (salt industry – Daire, 2003). In parallel with agricultural improvement and farmland structuration, people were progressively concentrated in large lowland open settlements and then Celtic towns (e.g. oppida – Pion, 2010). These settlements became a core element of the new economic and political organisation of the Gallic Iron Age. By hosting a great diversity of specialised artisanal activities and centralising production from surrounding farms, they became active trade centres (ibid.). All these changes, with the introduction of the first coins from the end of the 3rd c. BC (Buchsenschutz, 2015), led to the establishment of a production system more dedicated to trade, and the creation of wide supply networks, with Italy, around the Mediterranean and across Europe (Py, 2012; Buchsenschutz, 2015). Therefore, during this period, the new economic, administrative and social organisation generated a large-scale trading economy which probably impacted Gallic husbandry strategies.

Based on these considerations, this study aims to define more precisely the dynamics of morphological changes in Gallic pigs across the *La Tène* and Roman periods (between the 8th c. BC up until the 7th c. AD), and better understand agropastoral evolutions in the north and south of Gaul. To achieve this, we relied on two distinct studies: one using the Log Size Index (LSI) method (on bones dimensions) in order to explore the pace of global changes in pig sizes, and a second one relying on a geometric morphometric approach of molar shape to explore population histories at finer geographic and chronological scales (Cucchi et al., 2016).

2. Material and methods

2.1. Measurement analysis using the LSI

Bone linear measurements were collected from 306 archaeological sites throughout the Gallic territory (Fig. 1B). All the measurements (13 296 values taken from 9937 fully-fused bones) were taken according to Driesch (1976). Measurement data were analysed using the LSI method, developed by Simpson (1941) and adapted by Meadow (1999), which calculates the difference between the decimal logarithms of each measurement taken from archaeological material (x) and the corresponding dimensions of an individual or reference set (y): $LSI = \log(x) - \log(y)$. The set of standard measurements published by Albarella and Payne (2005) was used. Variation in the LSI was displayed on a scatter plot, with a best fit polynomial curve to visualize changes in Gallic pig sizes between the 8th c. BC and the 7th c. AD. The diagram shows both the log size mean values per site and period (individual circles).

2.2. The geometric morphometric approach

Geometric morphometrics of molar forms was chosen in order to detect ruptures and continuity in the evolution of pig morphology, and to observe populations diversity within and between two Gallic territories, both with highly distinct political and economic characteristics: *Gallia Narbonensis*, fully integrated into the Mediterranean sphere and the first Gallic territory to be conquered by Rome; and *Gallia Belgica*, in the heart of Celtic Europe and disconnected from Mediterranean trade routes (see Christol, 2010; Goodman, 2012; Buchsenschutz, 2015). From a zooarchaeological point of view, the comparison of these two areas is especially interesting as it represents the two main Gallic models in terms of food culture and farming systems (e.g. Leguilloux and Lepez, 1996; King, 1999).

The pigs' lower second molars were used as efficient phenotypic markers in tracking pig domestication processes and population histories in the archaeological records (e.g. Ervynck et al., 2007; Rowley-Conwy and Dobney, 2007; Albarella et al., 2009; Cucchi et al., 2011, 2016; Duval et al., 2015; Evin et al., 2015).

For *Gallia Narbonensis,* the analysis was based on 124 molars from three sites (Fig. 1 A2 and Table 1): (1) Lattes, both a protohistoric and antique settlement and an important Mediterranean commercial port (5th c. BC to the 1st c. AD); (2) Nîmes, chief town of its territory (1st to 3rd c. AD); and (3) Aix-en-Provence, with a pork butcher's dumping pit (2nd c. AD). From northern Gaul, we analysed 302 teeth from four sites (Fig. 1 A1 and Table 1): (1) the rural settlement of Glisy (3rd c. BC); (2) the Gallic and Roman sanctuary of Ribemont-sur-Ancre (1st c. BC and 2nd c. AD); (3) the city of Arras (1st c. BC to the 1st c. AD); and (4) the city of Amiens (1st c. AD). It should be noted that Glisy, Amiens and Ribemont-sur-Ancre are situated less than 10 km apart and were therefore able to rely on a shared husbandry catchment area with very close pig morphotypes (see Duval et al., 2015).

Molar forms were captured using 7 landmarks and 68 equidistant semi-landmarks extracted from the outline of the tooth's crown (Fig. 2), following the method developed by Duval et al. (2015) after the protocol established by Cucchi et al. (2011). The Cartesian coordinates of the landmarks and semi-landmarks were captured using tpsDIG2 v.2.16 (Rohlf, 2010a). To obtain molar shape and size variables we aligned the forms configuration using a Generalized Procrustes analysis (Rohlf and Slice, 1990) with the tpsRelw v.1.49 software (Rohlf, 2010b). Using this standardization procedure information on position, scale and orientation were removed from the Cartesian coordinates' configuration. Semi-landmarks were forced to slide on a tangent according to the bending energy algorithm (Bookstein, 1997).

The molar shape differences from the population samples were tested using a one-way Multivariate Analysis of Variance (one-way MANOVA; Pillai's test). To explore the differences between the various population samples, both spatially and temporally, we used a Canonical Variate Analysis (CVA): a multigroup form of discriminant analysis. Due to the relatively small number of specimens compared to the large number of variables generated by shape analyses, we used the dimensionality reduction method with the Principal Components Analysis (PCA) to reduce the dimensionality of the shape dataset retaining all PC axes with non-null eigenvalues (Baylac and Friess, 2005; Sheets et al., 2006). Statistical analyses and data treatment were performed using R v.2.13.1 (R Development Core Team, 2013), ade4 (Dray and Dufour, 2007), ape (Paradis et al., 2004), Rmorph libraries (Baylac, 2012), and MorphoJ software version 1.05c (Klingenberg, 2011).

3. Results

3.1. A new vision of the global evolution of pig sizes in Gaul

Over the time period of this study, the LSI shows a size decrease (Fig. 3) from at least the 8th c. BC up until the 3rd c. BC. It marks the end of a still poorly understood process, which began with the domestication process (Méniel, 1984) and which was probably related to climatic changes, selective pressure, changes in animal diet, confinement or reproduction control (Manning et al., 2015; Vigne, 2015). Pigs seem to have undergone a progressive size increase from the Middle *La Tène* period, which marks the first morphological break long before the Roman conquest. This episode clearly suggests that the improvement in Gaul's livestock management predates the political and cultural