Study of the morphofunctional signal of captivity on the microanatomy of a tarsal bone, the talus, in a wild ungulate, the wild boar (*Sus scrofa*)

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Contents

Abstract

Bones play a crucial role in animal locomotion, responding to mechanical stress. In many ungulates involved in the domestication process, captivity leads to a modification of the locomotor repertoire, potentially recorded in the internal structure of the bones. It is this non-heritable imprint that zooarchaeologists wish to use as new markers of the domestication process, complementing the knowledge gained from classical osteological markers of bone and tooth size reduction, which are linked to reproductive selection and genetic isolation. This preliminary study examines the impact of captivity on the microanatomy of the talus, a short bone devoid of muscular insertion, in wild boar (Sus scrofa). The study is based on a comparison between groups with different mobility patterns (natural habitat, large enclosure and stabling) and archaeological wild boars from the Mesolithic period, before the arrival of agriculture in Europe. The study is based on 3D cartographies of compact bone thickness, virtual cross-sections, and quantitative parameters obtained from microtomographic scans of the talus of these specimens. While the thickness of the compact bone does not show variations associated with captivity, the specimens that have lived partially in captivity have denser tali with a looser weave of bone trabeculae. In addition, some Late Mesolithic specimens seem to show signs of captivity. Captivity therefore seems to be identifiable on the talus of wild boars, revealing the archaeological potential of this bone.

1 Introduction

Domestication is an evolutionary process that can be defined as a multi-generational, mutualistic relationship, in which humans influence, intentionally or unintentionally, the reproduction, care and feeding of another non-human organism, causing changes in morphology, behaviour

and/or physiology [1][20][36]. It is these modifications that differentiate domesticated from wild forms [14][39].
In the case of animal domestication, this process encompasses a wide range of situations since Late Pleistocene with the grey wolf [21]and the spread of domesticated animals during the Neolithic [25][35][39]. The distinction between wild and domesticated forms can be complex because they can be sympatric [13], and domesticated animals can also return to the wild, a phenomenon known as feralization [29].

Osteological markers have been used to reconstruct a important part of the history of animal domestication with the classic markers of reduced bone and tooth size [26][28]. These phenotypical traits are part of domestication trends that are commonly referred to as "domestication syndrome", which include other phenotypic variations such as drooping ears, a curved tail and depigmentation of the skin and coat. These syndromes only appear after several generations of reproductive selection, which means that they cannot be used as morphological markers of the early stages of the domestication process [5][11][34].

Pig (*Sus domesticus*) is one of the domesticated animals with the most of the phenotypical traits of the "domestication syndrome" [34]. This last ones and the wild boars (*Sus scrofa*) have been sympatric over most of their range and could have hybridized over millennia, which makes the morphological distinction between them more complex than just a separation between wild and domesticated [6][16][23].

Methodological research (ANR DOMEXP) has been carried out on the wild boar model to test the hypothesis that bone plasticity (*i.e.,* the ability of bone to shape and remodel according to the biomechanical constraints of the environment, which is also known as Wolff's law [37][30]) would enable to record the reduction in space for mobility in a wild population, prior to any reproductive selection phenomenon. Bone plasticity would provide a quantitative marker of the reduction in space available for the mobility of wild animals, and therefore of the intensification of relations between wild animals and human societies, beyond the reach of conventional morphometric approaches in archaeozoology.
To test this hypothesis, the DOMEXP project used a genetically homogeneous wild boar (*Sus scrofa*) population to control the genetic and environmental factors influencing skeletal variation. From this populations, 24 six-month-old piglets were captured after weaning to be reared until the age of two years under two mobility reduction regimes. Geometric morphometrics' analyses have provided proof of concept that this mobility reduction in a wild ungulate population could leave morphometric prints on skulls [24]and calcaneus [17]. Microanatomical investigations have also revealed changes in the 3D topography of the cortical thickness in the humeral shaft [18].
Following the results of these previous studies, a study of the bone microanatomy of the calcaneus was carried out [10]. Together with the talus, the calcaneus forms the first row of the tarsus. These bones are frequently found in archaeological contexts due to their high compactness; the talus is rarely destroyed by carnivores [7] and is resistant to hydraulic transport [3][4]. These two bones both show functional signals, as they are particularly sensitive to changes in mobility, notably due to their anatomical position at the level of the tarsal joint [15][2][12][22][31][32][33].

Although Cottereau *et al.* (2023) suggested that the microanatomy of the calcaneus of the wild boar did not strongly reflect the regime of mobility regime, the impact of captivity on a short bone subject to predominantly compressive forces has not been studied ; the focus was on long bones [8] [9][27]and bones with muscular insertions [19]or on animals with different

locomotion patterns [38]. By continuing this analysis on the second bone of the first row of the tarsus, this study seeks to determine whether the microanatomy of the boar's talus reflects changes in the mobility regime.

The study will be based on a comparison between groups with different mobility models (natural habitat, large enclosure and stall) and archaeological wild boars from the Mesolithic (*ca* 9 700-5 200 cal. av. J.-C.), a period preceding the arrival of agriculture in Europe. The aim is to carry out a qualitative and quantitative analysis of the impact of different locomotor contexts on the internal structure of a tarsal bone, the talus, in a wild ungulate, the wild boar. This study should make it possible to identify and characterise the potential consequences of growth in captivity on the internal structure of the talus in wild boar, and to highlight distinctions between wild boar or boar reared extensively and boar reared in captivity, and thus gain a better understanding of the early stages of the domestication of the wild boar.

2 Material and methods

3 Results

4 Discussion

5 Conclusion

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