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Towards the identification of the exploitation of cattle labour from distal metapodials

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ABSTRACT

The exploitation of cattle labour in agriculture and transport, prior to large-scale mechanisation, has significantly helped shape the development course of human societies. This paper addresses the question of how to recognise cattle traction using refined techniques derived from control bone samples. We propose a detailed examination of morphometrics from distal metapodials for this purpose. Our results show that metric datasets from specific parts of these elements demonstrate a separation between traction and non-traction groups. Statistical analyses support such separation, encouraging the application of this model to shed light on ancient animal labour exploitation. This model is additionally well suited to fragmentary materials – distal metapodials rather than the whole elements – enabling its wide potential application in zooarchaeological research.

1. Introduction

The use of cattle for their labour was as significant a change in human history as the invention of the combustion engine for modern societies. Cattle traction, as one the three mainstays of the Secondary Products Revolution envisaged by Andrew Sherratt (1981), is crucially distinct from the use of the animal for raw materials like food and clothing, in that it converts animal nutrient energy to expand human capability (Bogucki, 1993). Cattle were exploited for their power from at least the fourth millennium BC, several millennia after their initial domestication, in the Near East and then this innovation was distributed to other parts of the Old World (Bakker et al., 1999; Greenfield, 2010; Piggott, 1992: 18; Sherratt, 1981). The employment of cattle labour facilitated plough farming and hence the intensification and expansion of agriculture, together with long-distance trade communication by cart transport (Greenfield, 2010). Although not all societies were affected evenly in their unique socio-economic contexts, cattle traction overall enabled the wider spread and movement of populations, the evolution of smaller household economies, and the development of social complexity and the early civilisations (Bogucki, 1993; Greenfield, 2010; Greenfield et al., 1988; Sherratt, 1981, 1983).

Given this significance, diverse lines of evidence (e.g. textual records, pictographic scripts, scenes, and archaeological artefacts) have been employed to shed light on cattle traction (Anthony, 1995; Bakker et al., 1999; Flower and Evans, 1967; Milisauskas and Kruk, 1991; Sherratt, 1981). While these avenues of inquiry may provide direct information, finds of such evidence are usually on a very limited scale in archaeology. In order to counterbalance this, cattle bones from archaeological sites have also been investigated. According to Wolff's Law (Wolff, 1892), long-term external stresses, such as traction, lead to transformation on bones. Following this principle, successful recognition of intensive lifetime physical activities on human bones has been achieved (Jones et al., 1977; Ryan and Shaw, 2015; Shaw and Stock, 2013). Likewise, examination of the extent and location of specific osteological pathologies can determine the possible work history of particular individual animals (Bartosiewicz et al., 1993, 1997; De Cupere et al., 2000; Higham et al., 1981; Isaakidou, 2006; Johannsen, 2005).

Out of the entire corpus of skeletal elements, metapodials are ideally suited for the examination of cattle traction activity. First, the terminal elements (such as metapodials) are expected to suffer the main impact when involved in the pulling of heavy loads (Bartosiewicz et al., 1997: 11). Second, additional information, such as sexual dimorphism, can also be revealed from the study of metapodials (Degerbøl and Fredskild, 1970; Legge and Rowley-Conwy, 1988; Thomas, 1988), enabling us to further explore

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which sex was chosen for traction. Third, metapodial pieces have high survival chances on archaeological sites because of their robust structure (De Cupere et al., 2000).

Therefore, in this study, we present a means of identifying draught cattle by morphometric data collected on distal metapodials of individuals of known life and work history. We believe that this makes a methodological contribution to the problem of identifying traction pathologies in cattle. Relevant statistical analyses follow to check the confidence levels of this method. Finally, we evaluate this method with notes of caution and discuss its potential for the future studies.

2. Materials and methods

The development of mechanised agriculture and transport during the past decades has led to major decline in the practice of cattle traction. Fortunately, we successfully built up a database of control samples including both traction and non-traction individuals from a range of diverse breeds. The traction group (Appendix A) consists of two breeds: 18 castrated Romanian Grey and Brown, and three castrated Jersey males.

The non-traction group involves both modern and ancient samples. The modern group comprises a range of meat/dairy cattle breeds without documented traction history across Eurasia. Breeds include the Romanian Grey and Brown, the Scottish Highland, the Red Danish, the Chillingham, the Jersey, the Shorthorn, the Swedish Mountain, the Chinese Yellow, and so forth. Detailed information on the breeds can be found in Appendix B. The ancient group (Appendix C) consists of Pleistocene wild aurochs (*Bos primigenius*) from the Palaeolithic site of Lingjing in central China. Considering the period of the Lingjing site (*c.* 100,000 BP), aurochs from this site are not expected to be involved in any traction activity and are thus added here to complement the non-traction group of modern domestic cattle.

Based on the aforementioned control samples, we developed a detailed measuring system focusing on the distal metapodials (Fig. 1). Measurements for the depth and breadth of medial and lateral condyles were included (Appendix D). Given the fact that absolute size differences exist between sexes, the ratio of specific breadth against depth measurements from the same element was also calculated to mitigate against the effects of these characteristics. The following results and analyses were processed using the software packages SPSS and PAST.

3. Results

3.1. Scatterplots for cattle group separation

Results and analyses are presented separately for the metacarpals and metatarsals. Samples from each anatomical element are divided by work history (traction, meat/dairy or Palaeolithic wild), sex (male, castrated or female), and breed.

Figs. 2 and 3 exhibit the scatterplots of metacarpals and metatarsals respectively. They employ “Bd” (distal breadth) as the X-axis and the ratio of “e/D1” (see Fig. 1 for exact meanings of “e” and “D1”) as the Y-axis. After many tests on the control samples, the scatterplot of “Bd” against “e/D1” performed best in distinguishing between the traction and non-traction groups.

From Fig. 2, it can be seen that the traction group occupies the upper right region in this scatterplot, and the scatter is vertically stretched. This trend quantifies the increased “e/D1” values of the distal metacarpals in these animals as opposed to their non-traction counterparts. Generally, this group is distinctive from other assemblages with only a small overlap with modern meat males. Groups of meat males, castrates, and females lie in the lower left area and share a large common coverage irrespective of sex or breed. Samples of Palaeolithic wild aurochs occupy the lower right corner, with considerably greater distal breadths (Bd) of metacarpals but without the remarkable increased “e/D1” seen in the domestic draught cattle group.

Metatarsals exhibit a similar separation between non-traction and traction animals (Fig. 3). Overall, the groups of modern traction, modern meat/dairy, and Palaeolithic wild aurochs occupy the upper right, lower left, and lower right regions respectively in this plot. Even though the range of modern traction samples is not as vertically stretched as the metacarpals, the traction group is still remarkably distinctive from the others.

The main purpose of establishing models based on the control samples is to eventually employ these techniques on archaeological cattle – to identify any possible traction group in the whole assemblage. From current analysis of metapodials, it seems that individual measurements do not work well when large-sized cattle, such as aurochs, are involved. The measurement values of “Bd” for aurochs seem even greater than that of traction cattle in the plots above. However, together with certain breadth-depth ratios (the “e/D1” in this case), the traction cattle can be separated from the larger body-sized aurochs.

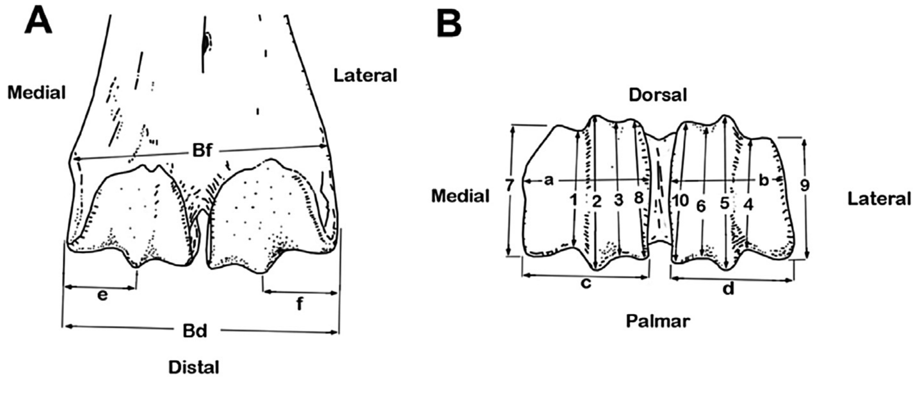

Fig. 1. Locations of detailed measurements taken on metapodials (left metacarpal shown in this figure). (A) Dorsal view: “Bf” = measurement of the epiphyseal line; “e” = greatest breadth from medial condyle ridge to medial articulation edge; “f” = counterpart to “e” on the lateral side. (B) Distal view: “1” = minimum depth of the medial condyle; “2” = depth of the medial condyle ridge; “3” = depth of the concave part between the ridge and the lateral edge on the medial condyle; “7” = depth of the most medial edge of the medial condyle; “8” = depth of the most lateral edge of the medial condyle. “4”, “5”, “6”, “9”, and “10” are the same measurements taken on the lateral condyle. All depth indices are recorded as “D (Depth)” followed by the index numbers. “a” = breadth of the most distal end of the medial condyle; “b” = counterpart to “a” on the lateral condyle; “c” = greatest breadth of the medial condyle on the palmar side; “d” = counterpart to “c” on the lateral condyle. (Courtesy of U. Albarella for the basic drawing with more measurements added by M. Lin).