Gaining traction on cattle exploitation: zooarchaeological evidence from the Neolithic Western Balkans

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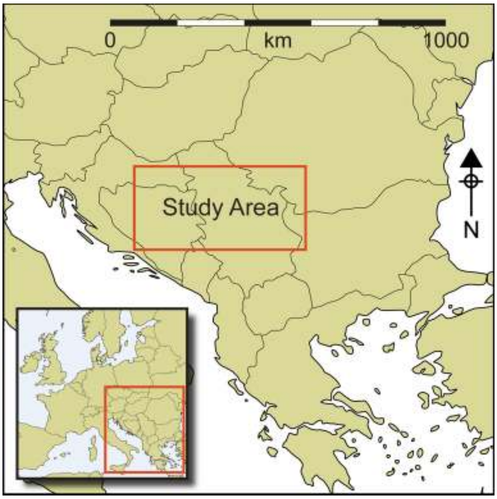

The study of the exploitation of animals for traction in prehistoric Europe has been linked to the 'secondary products revolution'. Such an approach, however, leaves little scope for identification of the less specialised exploitation of animals for traction during the European Neolithic. This study presents zooarchaeological evidence—in the form of sub-pathological alterations to cattle foot bones—for the exploitation of cattle for the occasional pulling of heavy loads, or 'light' traction. The analysis and systematic comparison of material from 11 Neolithic sites in the Western Balkans (c. 6100–4500 cal BC) provides the earliest direct evidence for the use of cattle for such a purpose.

Keywords: Balkans, Neolithic, traction, pathology, domestic cattle

Introduction

Andrew Sherratt's seminal argument for a 'secondary products revolution', or the intensification in the use of domestic livestock for dairy production, wool and traction during the Old World Chalcolithic, was initially advanced in the absence of a substantial body of zooarchaeological evidence (Sherratt 1981, 1983). Over the subsequent three decades, the acquisition of abundant and high-quality zooarchaeological data has advanced significantly our understanding of the changing roles of domestic livestock in prehistory (for extensive summaries of the relevant literature, see Greenfield 1988, 2005, 2010, 2014a). Reflecting early critiques of the model (e.g. Chapman 1982; Bogucki 1984), it is now widely

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acknowledged that the reality of these developments is more complex than originally envisioned, with no single moment or place of revolutionary change evident. Extensive research into secondary products has led to a more nuanced understanding of the scale and diversity of the early use of dairying and—to a lesser extent—wool production in both Europe and Asia (e.g. Evershed *et al.* 2008; Outram *et al.* 2012; Salque *et al.* 2012; Arbuckle 2014; Breniquet & Michel 2014; Greenfield 2014a & b; Pipes *et al.* 2014; Greenfield & Arnold 2015; Becker *et al.* 2016; Spiteri *et al.* 2016; Ethier *et al.* 2017).

In contrast, the timing of both the earliest use of traction and its later intensification remains the subject of debate. Most research into the use of cattle for traction has focused on later periods, often based on non-osteological data (e.g. Piggott 1983; Rowley-Conwy 1987; Milisauskas & Kruk 1991; Bartosiewicz *et al.* 1997; Bakker *et al.* 1999; Bondár & Székely 2011; Mischka 2011; Pétrequin *et al.* 2006). Numerous studies have accessed both osteological and non-osteological data to argue for the use of cattle for traction from the early fourth millennium cal BC onwards—parallel to the earliest evidence for carts and ploughing (e.g. Milisauskas & Kruk 1991; Bogucki 1993; De Cupere *et al.* 2000; Bălăşescu *et al.* 2005; Johanssen 2006; Lingereux *et al.* 2006; Galindo-Pellicena *et al.* 2015). The possible earlier use of cattle for traction has been suggested for Europe, but never investigated systematically (e.g. Isaakidou 2006; Tarrús *et al.* 2006). Here, we fill this research gap by providing systematic evidence for the use of domestic cattle for traction from the earliest Neolithic in the Central and Western Balkans (*c.* 6000 BC).

Prehistoric traction: what does it mean and what are we looking for?

In the study of prehistoric Europe, 'traction' is often conflated with 'ploughing', or the use of carts (e.g. Bartosiewicz 2006; Pétrequin *et al.* 2006; Bondár & Székely 2011). Fundamentally, however, traction is the use of animals as engines to pull loads. While ploughing and cartage are forms of traction, they represent only two types of activity on a much broader spectrum of exploitation practices. Such specific uses are commonly assumed to indicate the training and long-term management of specialised animals—castrated male cattle (oxen) in particular—of which identification is inferred osteologically from age profiles, sex comparisons (via increased retention of adult animals, particularly males) and pathological studies (e.g. Milisauskas & Kruk 1991; Bogucki 1993; Isaakidou 2006; Tarrús *et al.* 2006; Galindo-Pellicena *et al.* 2015). Ethnographic examples indicate that oxen are preferred, due to their greater strength and stamina, but also that cows (even while pregnant) can be used for traction when deemed necessary, or when labour demands are less intensive (Bartosiewicz *et al.* 1997; Halstead 2014). The identification of castrates in archaeological contexts is often linked implicitly with their putative exploitation for labour: castrate = oxen = traction (Milisauskas & Kruk 1991; Galindo-Pellicena *et al.* 2015). A better way of viewing traction, however, would be as a continuum, ranging from specialised animals bred and used for regular work through to animals used for more occasional pulling activities, or for regular labour over only a short number of years. The identification of the more limited use of animals for 'light' traction will inform us about how the more specialised traction-animals later developed, as well as the economic context of their emergence and maintenance.

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The available data across both the Near East and Europe during the Neolithic and Chalcolithic on the early exploitation of domesticates for other secondary products—dairy in particular—are not suggestive of specialised management for the maximising of secondary product production. Rather, the data indicate a more variable, *ad hoc* exploitation, often for prolonged periods prior to targeted management practices (see for example Arbuckle 2014; Greenfield 2014a; Spiteri *et al.* 2016; Ethier *et al.* 2017). This has led to research on both the evidence for the early use of dairy products, as well as a separate analysis of the increasing reliance on dairy products in animal management (see Greenfield 2010; Marciniak 2011). We advocate a similar approach for investigating traction by examining both the early evidence and the changes in the intensity of exploitation over time. The occasional use of a good-natured cow or young bull to haul timber would be considered traction exploitation, but one that would not necessarily alter management profiles or significantly affect bone development across an entire faunal sample (De Cupere 2000; Lin *et al.* 2016). Hence, we may expect a certain period of limited traction exploitation—confined to a few individual animals, possibly for only a portion of their lives—and which would thus not alter the larger age-at-death profiles for the herd as a whole. This article aims to identify this hypothesised early 'light' phase of cattle exploitation, and to comment on its significance for the understanding of the use of livestock for labour in prehistory.

Bone remodelling and stress

Bone surfaces remodel in response to biomechanical stress and injury. Stress can relate to carrying the weight of the live animal, as well as any additional load that is placed upon individual bone elements (Wolff 1892). Bone remodelling takes many forms, including enlargement of muscle and ligament attachments, and alterations to articular surfaces due to increased loading. Remodelling to bone surfaces can be classified into two groups (Bartosiewicz *et al.* 1997; Bartosiewicz 2008): those in response to traumatic injury and/or old age (pathological), and those resulting from increased strain (sub-pathological). The degree of remodelling in both cases relates to the intensity of the strain (over time) or injury. The intensity of sub-pathological alterations developing from repeated additional strain on an element or set of elements relates to the type, duration and intensity of work involved. With regard to the effect of traction upon cattle skeletons, sub-pathological alterations primarily affect the medial articular surfaces of foot elements (i.e. the metacarpus, metatarsus and phalanges; Bartosiewicz 2008).

Neolithic cattle in the Central and Western Balkans

To test for possible evidence for limited or 'light' traction, we investigated cattle foot bones from 12 samples, representing 11 sites covering the entire Central and Western Balkan Neolithic (*c.* 6100/6000–4500 cal BC; see Table 1). Previous zooarchaeological work in this region has shown initial diversity in Early Neolithic animal exploitation strategies, including at sites focusing on the management of ovicaprines, and at others focusing on cattle and pigs (Orton *et al.* 2016). A shift is observed across the region during the Middle and Later Neolithic to a pattern of domesticate exploitation with an increased focus on cattle and pigs,

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Table 1. Summary of site samples used in the present study. Site names are given along with cultural affiliation, calibrated radiocarbon dates (where available) and the number available for each element studied. The number of elements identified as aurochs (*Bos primigenius*) is given in brackets. The Early Neolithic cultural complex Starčevo-Körös-Criş is abbreviated here to 'SKC'.

Site no.	Site	Cultural group	Date (cal BC)	Analyst	Metacarpal	Metatarsal	Phalanx 1	Phalanx 2
	Early Neolithic: *c.* 6100/6000–5500/5400 cal BC							
1	Blagotin	SKC	6000–5900	HJG	6[1]	4[1]	3	5
2	Foeni-Salaş	SKC	6057–5971	HJG	4[1]	3	4	3
3	At Vršac	SKC	5665–5471	JSG	2	1	1	1
4	Belišće	SKC	–	JSG	12[3]	10[2]	18[1]	17[1]
5	Kneževi Vinograd	SKC/Ražište	6001–5873	JSG	17[3]	14[2]	11[4]	6[3]
	Middle Neolithic: *c.* 5500/5400–5000 cal BC							
6	Potporanj	Vinča B	5180–5062	JSG	14[3]	23[2]	16[5]	12[4]
7	Stragari	Vinča Tordoš	–	HJG	2	3[1]	7	8[1]
8	Sânandrei	Banat	–	HJG	2	1	3	2
	Late Neolithic: 5000–4500 cal BC							
	At Vršac	Vinča D	4620–4358	JSG	4[1]	6	4	3[1]
9	Petnica	Vinča D	4729–4553	HJG	2	2	1	3
10	Hermanov Vinograd	Sopot	4730–4579	JSG	33[2]	19[1]	72[8]	77[5]
11	Kosjerovo	Sopot	4728–4549	JSG	3[2]	4	12[1]	4

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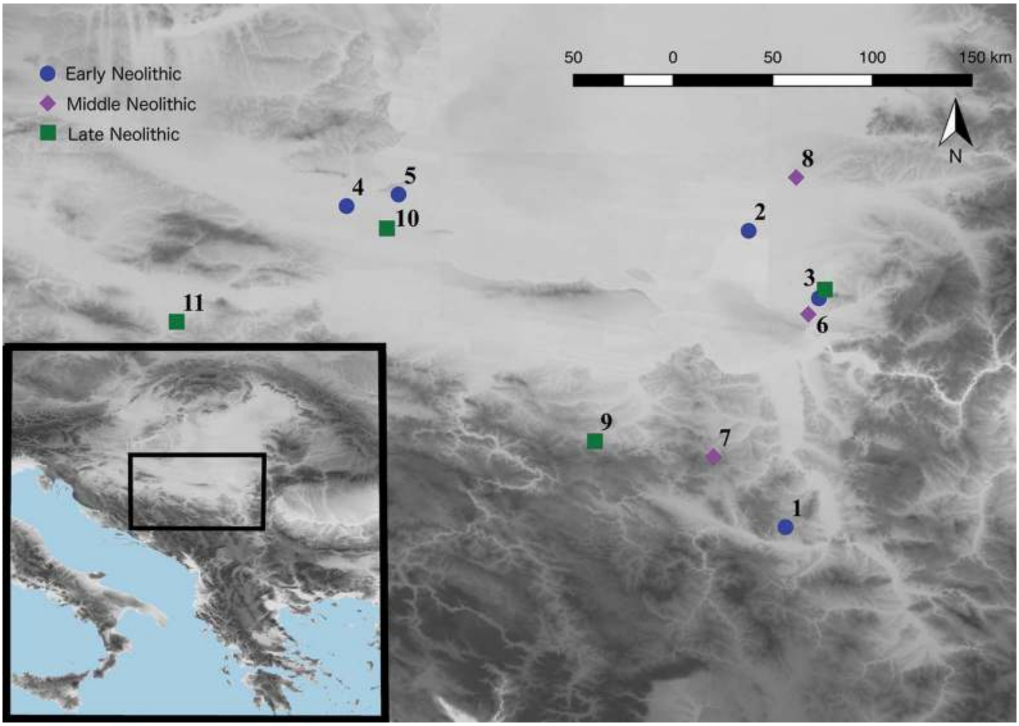

Figure 1. Locations of the sites used for this study.

paralleled in some regions with an increase in the hunting of wild animals (Greenfield 1986, 1991, 2008; Orton *et al.* 2016; Ethier *et al.* 2017). Temporal changes between these periods are observable in the age, sex and size distributions of cattle kept at sites, although there is no evidence for the retention of individuals into advanced age, for castrated males, the over-representation of male animals, or for an increase in mean body size (Greenfield 1986, 1991, 2008).

All zooarchaeological material presented here has been directly studied by the first two authors using the same protocol and recording of bone alterations following Bartosiewicz *et al.* (1997) and Lin *et al.* (2016). Seven complete and five partial assemblages were recorded. Table 1 presents an overview of the sites studied, with locations shown in Figure 1. Radiocarbon dates are available for nine site samples and are provided in the online supplementary material (OSM).

Methods

Foot elements (metacarpals, metatarsals and first and second phalanges) of both domestic cattle (*Bos taurus*) and aurochs (*Bos primigenius*) were examined for all sites. These elements were selected as they offer the best direct evidence for traction in the osteological record. These are the elements most directly affected by the stress of pulling (*vs* age or increased body weight), as well as those most commonly preserved in the archaeological record (Bartosiewicz *et al.*

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Table 2. Distribution of elements with positive (PI >2.5) indications of sub-pathological alterations relating to traction. As in Table 1, the number of aurochs elements are given in brackets.

Site	Metacarpal	Metatarsal	Phalanx 1	Phalanx 2
Early Neolithic				
Blagotin	[0]		1	2
Foeni-Salaş	[0]		1	1
At Vršac			1	
Belišće	1[0]	2[0]	3[0]	2[0]
Kneževi Vinograd	1[0]	2[0]	2[0]	3[0]
Middle Neolithic				
Potporanj	1[0]	2[0]	3[0]	2[0]
Stragari		1[0]	2	1[0]
Sânandrei			1	
Late Neolithic				
At Vršac	[0]	1	1	1[0]
Petnica		1	1	
Hermanov Vinograd	5[0]	4[0]	7[0]	3[0]
Kosjerovo		1	2	1

1997; Bartosiewicz 2008). Table 1 presents a summary of the phases represented at these sites and the number of elements analysed.

Foot elements were studied for both pathological and sub-pathological alterations. These were scored on the basis of their pathology index (PI hereafter) values following Bartosiewicz *et al.* (1997), and the distributions of PI values were compared between sites. Sub-pathological alterations consistent with traction were recorded and their frequencies per sample are given in Table 2. Measurements were also taken for the distal metapodia following the traction index osteometric system developed by Lin *et al.* (2016). The diagnostic index 'e/D1' was measured for all distal metapodia of both cattle and aurochs. This index describes the degree of remodelling and extension of the medial condyle, with a value of 0.75 or higher indicating a degree of remodelling consistent with traction usage in modern reference specimens (Lin *et al.* 2016).

The combination of the two recording systems allows for the comparison of alterations across all foot elements (PI), as well as a direct index of metapodial remodelling independent of the more subjective PI approach. Where it was possible to estimate the sex of individuals (e.g. through metrical comparisons of distal metapodia), this was included as part of the recording of pathological and osteometric data. Skeletal elements from aurochs (wild cattle, and thus not used for traction) were studied as a control group for both PI and osteometric comparisons.

Results

All studied Neolithic sites demonstrate pathological and/or sub-pathological alterations to cattle bone. The overall level of pathological or sub-pathological alterations remains low, with the majority of alterations graded as minor to moderate (grades 1–3 on the Bartosiewicz

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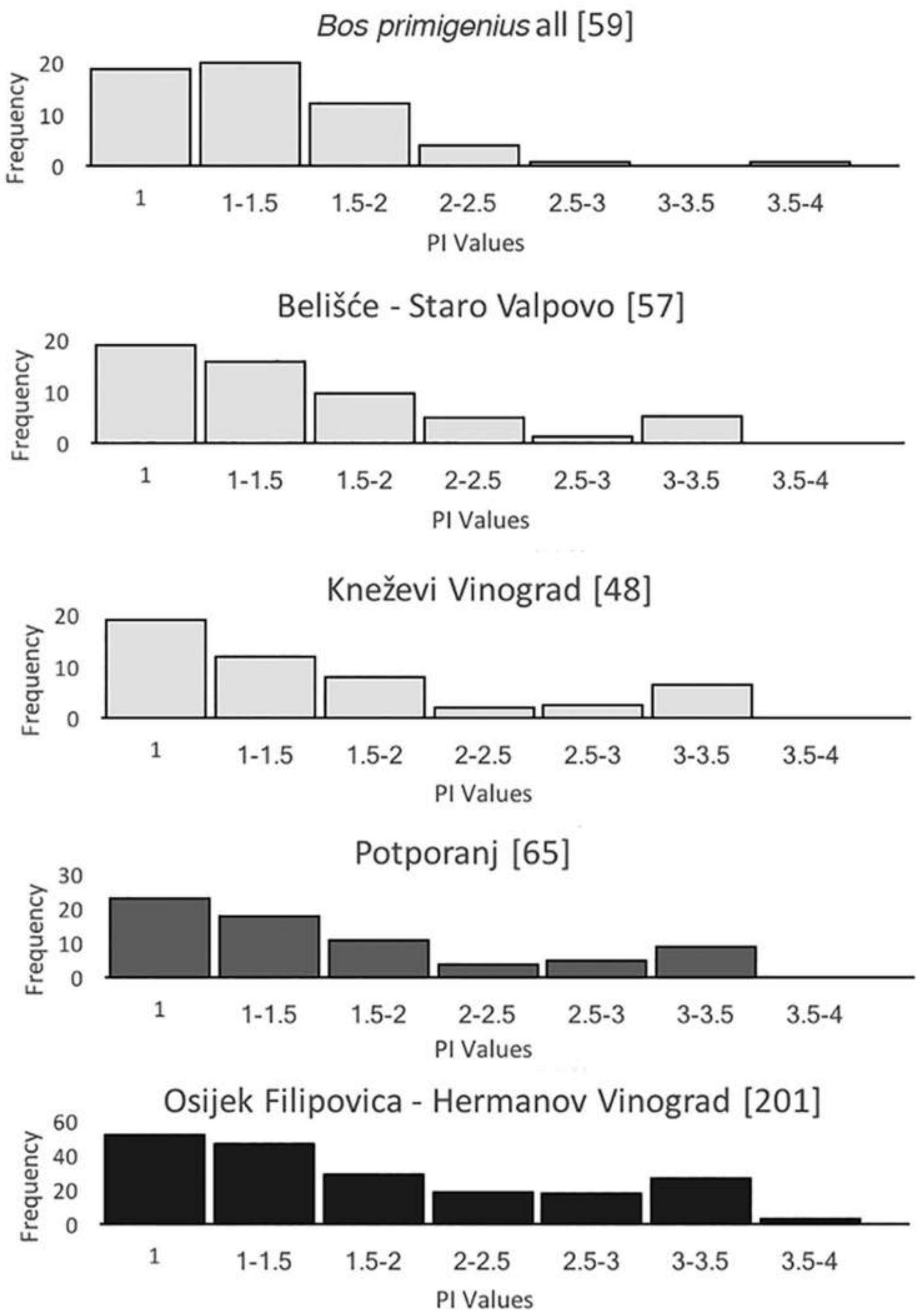

Figure 2. Distribution of pathology index (PI) values for Bos taurus *elements from the largest site assemblages examined for this study, along with* Bos primigenius *elements from all sites. PI values were assigned following Bartosiewicz* et al. *(1997).*

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Figure 3. Bos taurus *metatarsal from Kneževi Vinograd showing sub-pathological remodelling to the medial condyle resulting from traction usage. This bone was directly dated to 6015–5897 cal BC (see the OSM for details) (photographs by J. Gaastra).*

et al. (1997) system). The number of pathological or sub-pathological specimens from each site is small (see Table 2), which is consistent with data from later periods (e.g. De Cupere *et al.* 2000). All sites in the present study demonstrate a combination of age/trauma (pathological) and usage-related (sub-pathological) remodelling to bone surfaces. Pathological remodelling was identified on the remains of both domestic cattle and wild aurochs, and includes bone exostoses (additional bone growths) present at tendon and ligament attachment sites on the surfaces of phalanges and metapodia, the medial and/or lateral faces of distal metapodia and phalanges (Figures 2–3), the proximal shafts of metapodia and the posterior surfaces of proximal phalanges and metapodia.

By contrast, sub-pathological remodelling of bones from traction was identified only on domestic cattle. These include extension of the margins of the medial condyle of metapodia (Figure 4), as well as extension of the medial facet of the proximal articular surface of both first (Figure 5) and second (Figure 6) phalanges. The restriction of such sub-pathological remodelling to domestic cattle only is important, as this form of remodelling (on hind limbs in particular) has been shown to relate most directly to the motion and strain of pulling, rather than to other factors such as the age or weight of the animal (Bartosiewicz *et al.* 1997; Bartosiewicz 2008; Lin *et al.* 2016). These alterations show no chronological or geographic patterning in the frequency or intensity of remodelling (Table 2).

Previous research has shown that only a subset of the cattle population provides evidence of traction, and that the distribution of PI values is of far more importance than the sample's mean PI value in identifying traction (De Cupere *et al.* 2000). Here, PI value distributions are therefore plotted as histograms (Figure 2). The majority of elements for both taxa across all sites scored between 0–1 and 1–2. Both of these categories can be considered as indicative of normal bone development. In domestic cattle, a small proportion of each assemblage exhibited sub-pathological alterations consistent with bone remodelled due to the strain of traction (2.5–3 and 3–3.5 in PI score, see Figure 2 & Table 2). These alterations included broadening of the medial condyles for both metacarpals and metatarsals, as well as extension of the medial proximal articular facet of both first and second phalanges (see Figures 4–6). These modifications were

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Figure 4. Proximal articular surfaces of Bos taurus *anterior first phalanges from Blagotin (A) and Stragari (B). Specimen A shows broadening of the medial articular facet in comparison with a normal articular surface as seen in specimen B (photographs by J. Gaastra).*

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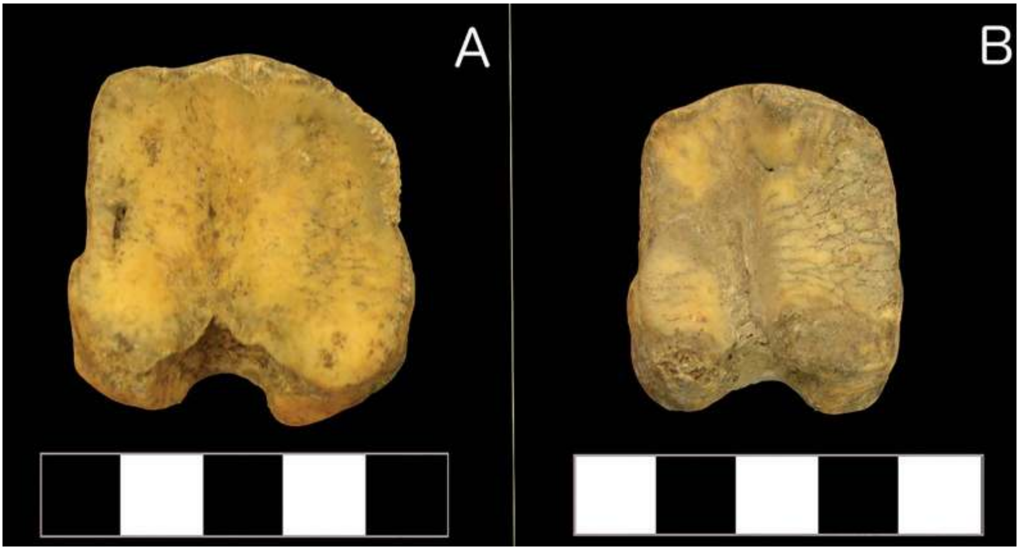

Figure 5. Proximal articular surfaces of Bos taurus *anterior second phalanges from Foeni-Salaş (A) and Blagotin (B). Specimen A shows broadening of the medial articular facet in comparison with a normal articular surface as seen in specimen B (photographs by J. Gaastra).*

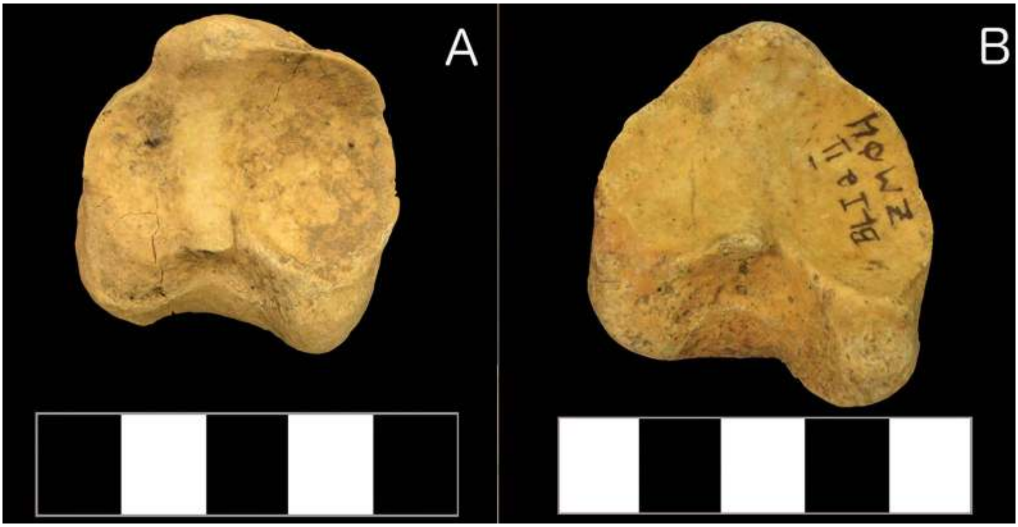

Figure 6. A first phalanx of Bos primigenius *from Potporanj with examples of age-related pathological alterations observed on foot elements (photographs by J. Gaastra).*

present on a subset of cattle elements from all three Neolithic periods. The distribution of PI values provides some indication of more extensive remodelling to cattle bones from Late Neolithic sites (Figure 2), although this variation is too small to provide any firm conclusions.

Osteometric analysis of distal metapodia following the criteria of Lin *et al.* (2016) also indicate the use of cattle for traction from at least the beginning of the Neolithic in the

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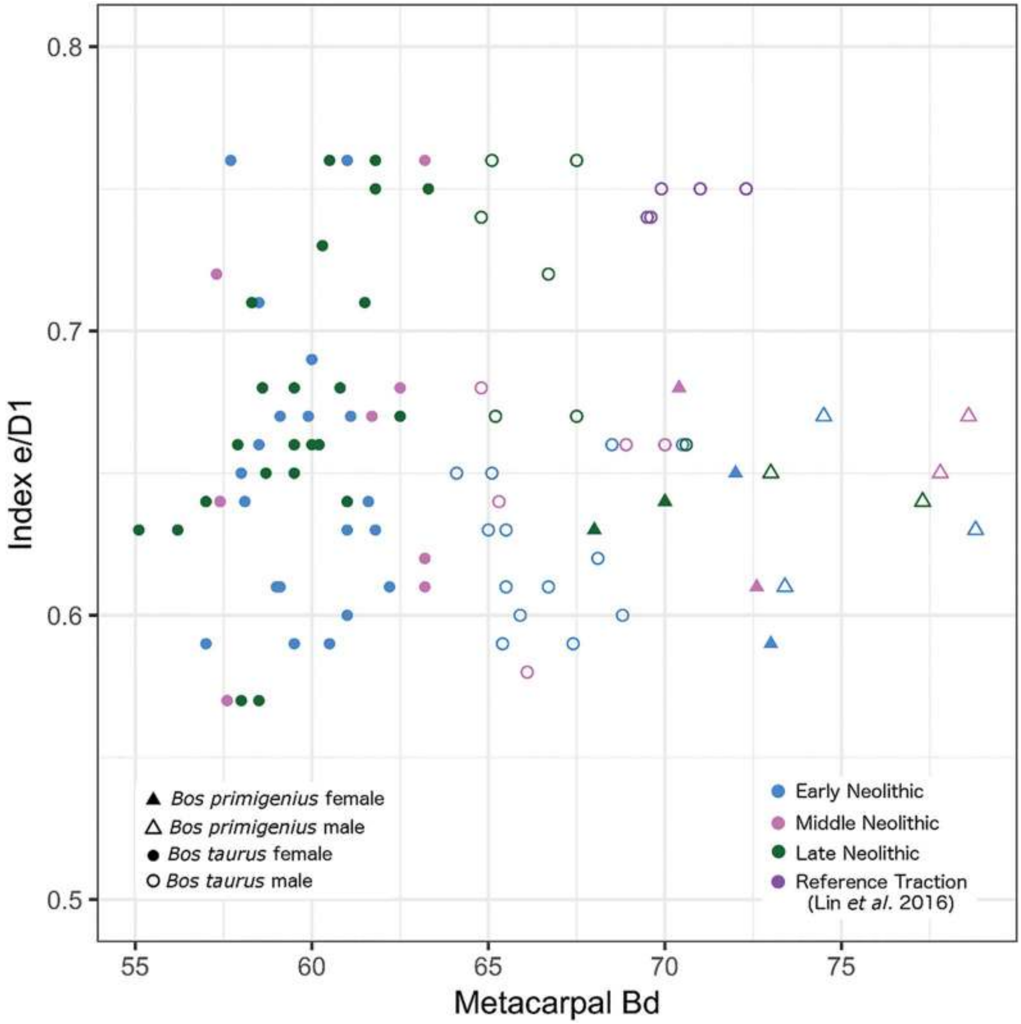

*Figure 7. Osteometric comparisons of medial remodelling of distal metacarpals from domestic cattle (*Bos taurus*) and wild aurochs (*Bos primigenius*) using the 'e/D1' index developed by Lin* et al. *(2016).*

Western Balkans. The 'e/D1' index indicates traction-positive cattle metacarpals and metatarsals from sites in all three Neolithic periods. All traction-positive metapodia came from domestic cattle only, and all had distal PI values of three or higher (Bartosiewicz *et al.* 1997). These indices can be seen in Figures 7 and 8, where the 'e/D1' index has been plotted alongside distal breadth/Bd (Lin *et al.* 2016) to indicate the sex of animals measured. From these data, we can see not only the presence of traction-positive cattle based on both distal metacarpals and metatarsals, but also a bias towards evidence from the hind limb. This is consistent with the findings of Lin *et al.* (2016), and further confirms that these sub-pathological alterations are the result of the strain of traction, which is more strongly expressed in the hind limb (Bartosiewicz 2008; Lin *et al.* 2016). These data also indicate the use of both females and males for traction during the Neolithic. Given the small sample sizes, however, it cannot

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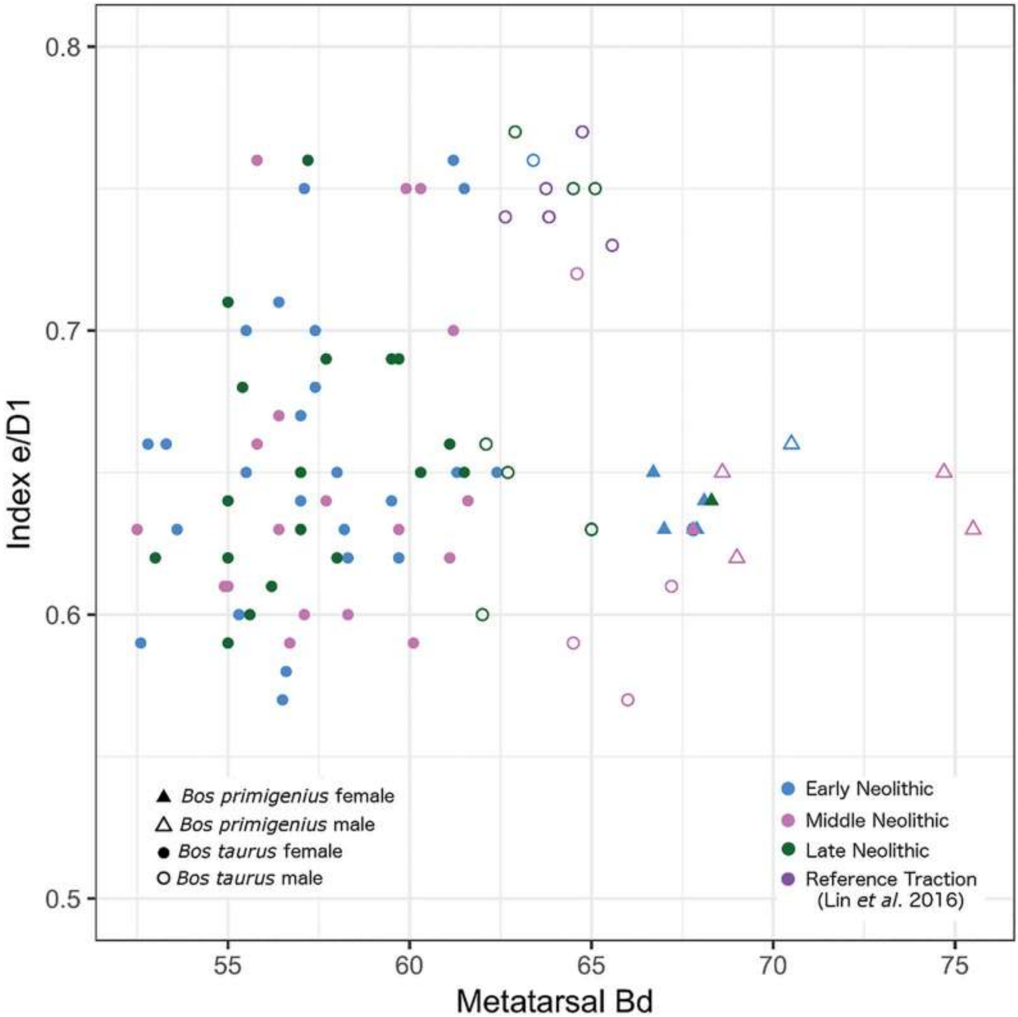

*Figure 8. Osteometric comparisons of medial remodelling of distal metatarsals from domestic cattle (*Bos taurus*) and wild aurochs (*Bos primigenius*) using the 'e/D1' index developed by Lin* et al. *(2016).*

yet be determined whether male animals were more commonly used for traction in the Late Neolithic (Figures 7–8).

Conclusion

This study has identified new evidence for the systematic use of cattle for traction that dates back to long before previous studies (e.g. De Cupere 2000; Galindo-Pellicena *et al.* 2015). The two techniques used here demonstrate that cattle—both male and female—were being used for traction from the time of their initial appearance across the Central and Western Balkans. Small numbers of animals that were used for traction are identifiable in the

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earliest Neolithic settlements—a pattern observable throughout the entire 1500-year duration of the local Neolithic, and thus presumably afterwards.

The comparative sub-pathological and osteometric analyses of cattle presented here provide firm evidence for the exploitation of cattle labour dating back far earlier than previously considered. These data indicate not only that exploitation was systematic across multiple sites over a long period, but also that cattle were used non-intensively for traction. It is also notable that this widespread, non-specific use of cattle for 'light' traction recalls similar patterns observed for contemporaneous dairy production (Greenfield 2005, 2010; Marciniak 2011; Greenfield & Arnold 2015; Spiteri *et al*. 2016). Traction was not an 'all-or-nothing' situation; we need instead to reconsider it as a more complex process, with animals used as engines in multiple ways. Our repeated identification of the exploitation of cattle for pulling heavy loads calls into question the current scope of the analysis and interpretation of the use of animals in prehistoric Europe.

These results indicate a need for researchers to employ systematic analytical techniques to document further this crucial initial phase of the use of cattle for traction, which is detectable through sub-pathological alteration of foot bone elements. This study clearly shows that cattle were exploited for traction from the onset of the Neolithic. Such studies need to be replicated in other European regions to determine the extent and duration of this form of traction. It is still unknown whether this form of 'light' traction is seen in only a selection of Neolithic groups or was a common practice across Europe. A firm understanding of the nature of early traction evidence in prehistoric Europe has significant implications for our knowledge of both management practices and the nature of labour and movement in prehistoric societies. What is now needed is a wider comparative assessment of sub-pathological evidence for cattle traction in Neolithic (and post-Neolithic) Europe to determine both how widely this pattern of early traction was distributed and at what point we begin to see evidence for specialised heavy-traction animals.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.15184/aqy.2018.178

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