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Joint health in free-ranging and confined small bovids - Implications for early stage caprine management

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This paper is dedicated to the memory of Klaus Schmidt who set me on the track of Archaeozoology.

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ABSTRACT

Human interference with the life cycle of wild ruminant species in the 10th-9th millennia BCE was essential to the 'Neolithic Revolution' in the Near East. Being a process of learning by doing, initial ruminant management must have been challenging to both founder flocks and people, but information about potential problems is hitherto lacking in the archaeological record. Here we report on a skeletal condition affecting joint health in small bovids. Detailed examination of the bone surfaces of astragalus of modern and Goitered gazelles as well as wild and domestic sheep revealed circumscribed mesoscopic lesions that we classified into five stages based on their size and properties. Our study demonstrates that intra-articular bone damage is significantly more pronounced in animals living confined to enclosures. Similar non-physiologic conditions have been evidenced in juvenile and adult sheep from early Neolithic contexts throughout Anatolia and interpreted as evidence for locomotor stress due to restricted mobility and stabling on-site. Still in the course of the early Neolithic, joint health improved significantly, implying a better mastering of sheep management over the centuries. In conclusion, pathologic profiling yields the potential for tracing initial management of captive ruminants. Apart from Southwest Asia, the methodological approach presented here seems appropriate for detecting similar developments in the human-animal relationship of behaviorally comparable medium- and large-sized herbivore taxa in other parts of the Old and New Worlds.

1. Introduction

The transition from a foraging lifestyle to plant cultivation and animal husbandry represents a milestone in the history of humankind. With respect to initial domestication efforts in cattle, sheep, goat and pig, spatio-temporal analysis of archaeofaunal assemblages across mainland SW Asia assigns a pioneer role to the 9th millennium BCE communities inhabiting the northern Fertile Crescent (Conolly et al., 2011; Ervynck et al., 2001; Helmer et al., 2005; Peters et al., 1999, 2005, 2014), yet early management of caprines has also been demonstrated beyond this region, e.g. in Central Anatolia since ~8200 BCE (Stiner et al., 2014) and the Zagros since ~8000 BCE (Zeder and Hesse, 2000).

However, the osteological markers most relevant to the recognition of early ungulate management and domestication remain a matter of debate (Dobney et al., 2013; Peters et al., 2014; Zeder, 2008). Traditionally, the presence of individuals, which are on average smaller in size than their wild ancestor was considered a good indicator for their domestic status (Bökönyi, 1989; Meadow, 1989; Peters et al., 1999, 2005, 2014; Uerpmann, 1978, 1979), but due to restocking from the wild and/or backcrossing with the wild ancestor, size decline could well be a delayed phenomenon rather than a marker of initial management and early domestication (Ervynck et al., 2001; Marshall et al., 2014; Rossel et al., 2008; Vigne et al., 2005; Zeder, 2008; Zeder and Hesse, 2000).

Sex-related demographic profiling of post-cranial elements is considered another leading edge marker to trace early management. It is based on the assumption that early animal keepers selectively culled young males at the advantage of females (Ducos, 1978; Hesse, 1978, 1984; Payne, 1973; Zeder, 2008; Zeder and Hesse, 2000), thus, leading to a relatively higher number of

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female individuals. Consequently, the proportion of smaller-bodied individuals increased. A higher number of smaller females also helps explaining the aforementioned size diminution. However, inter-site comparison of caprine datasets from sites across the northern Fertile Crescent recently concluded that selective kill-off of juvenile male caprines not necessarily occurred during initial Neolithic ungulate management (Arbuckle and Atici, 2013).

Other methods applied to trace human interference with wild sheep, goat, cattle and pig in Neolithic Southwest and East Asia include diachronic shifts in taxonomic composition and species diversity (Clutton-Brock, 1979; Davis, 1982; Horwitz, 1996; Horwitz et al., 1999; Legge and Rowley-Conwy, 2000; Peters et al., 1999, 2005, 2014). In addition, stable isotope analysis can be used to obtain insight into feeding and migration (Hongo et al., 2009; Lösch et al., 2006; Makarewicz, 2017; Makarewicz and Tuross, 2012; Pearson et al., 2007). Furthermore, ancient DNA analysis is applied to trace the development of the genetic make-up in livestock (Fernandez et al., 2005; Naderi et al., 2008; Ottoni et al., 2013). These methods can be combined with Geometric Morphometrics, an approach investigating morphological change in bones and teeth based on shape whilst omitting size (Evin et al., 2013; Owen et al., 2014; Çakırlar et al., 2018; Vigne et al., 2005). Beyond osteology, the presence of extensive dung layers in early Neolithic villages are indicative of ungulate management as well (Brochier, 1993; Özbaşaran, 2012; Stiner et al., 2014).

Although it can be safely assumed that health problems in animals represented a major challenge to early Neolithic communities practicing ungulate management, reported cases concern single individuals and include traumata and oral pathologies (Bökönyi, 1977; Russell, 2010; Simmons et al., 1988). Yet the conditions hitherto documented are not exclusive to stock raised in captivity, since known to occur in wild ungulates too (Lignereux et al., 1995). Typical for domestic stock, however, is the widened repertoire of arthropathies due to novel modes of exploitation, in particular their use for labor (Baker and Brothwell, 1980; Bartosiewicz et al., 1997; von den Driesch, 1975). However, none of the aforementioned osteopathies can be claimed to offer insight into overall ungulate health status.

Here we report on a novel pathological marker observed in the articular joints of medium-sized ruminants. The condition in question causes alterations of the bone's articular surface in form of mesoscopic lesions. In focus here is articular damage of the ankle bone (talus, astragalus), a skeletal element frequently found in archaeological sites worldwide. First, a scoring system for recording mesoscopic intra-articular lesions in ruminant tali is proposed and applied to 10th millennium BCE sheep and gazelle populations living under natural conditions and modern reference populations representing wild as well as animals living in captivity. The resulting pathologic profiles are then compared with those of sheep collected in early Neolithic Anatolian archaeological sites marking the transition from hunting to herding. Discussion centers on the etiology of intra-articular mesoscopic lesions in the ankle bone and associated problems. We conclude by addressing the cultural implications of this first population-based approach for the study of skeletal health in ruminants and early human interference with stock-on-the-hoof.

2. Materials and methods

In the frame of this study, a total of 1721 ankle bones from archaeological and modern *Ovis* and *Gazella* were investigated, which will be explained in detail below. For the populations used as baselines, the living conditions (e.g., mobility or nutrition) as well as life data (e.g., sex, age-at-death, parents) are well documented (see below) so that they can be used to develop the pathology scoring system, to trace the pathologic processes and understand their etiology. In a second step the scoring system will be applied to archaeological populations.

2.1. Baseline populations

Most data for the individuals of these populations are available in the records of the institutions. Age-at-death data were adopted from the records, if present, or estimated based on epiphyseal fusion and dental data of the skeletons (Zeder, 2006). Apart from modern wild and domestic sheep (see below) two populations of Goitered gazelles (*Gazella subgutturosa*) are included as reference groups (Table 1).

A first baseline considers ankle bones of Goitered gazelle (*Gazella subgutturosa*) excavated at PPN Göbekli Tepe (GT G). Living in the same landscape and facing similar climatic conditions compared to local wild sheep, pathology load in ankle bones of this species would provide a guidance value for a non-caprine wild ruminant species (= reference group) hunted by early Neolithic groups. Since dealing with separate bones for these specimens neither sex or age-at-death are known. Living conditions are inferred from the fact that these gazelles were hunted and therefore lived without any anthropogenic constraints. Specimens are stored in the Göbekli Tepe excavation depot at Şanlıurfa.

A population of late 20th century CE *G. subgutturosa* confined to zoological gardens constitutes the second baseline (Zoo G). This assemblage represents a wild species living in an anthropogenic environment since generations. For these gazelle specimens both age-at-death and sex were documented in the zoo. Specimens analyzed are housed in the Bavarian State Collection of Anthropology and Palaeoanatomy, Munich.

A third baseline (Og) considers 19th-20th century CE Asiatic mouflon (*Ovis gmelini*, Blyth 1841; nomenclature see Damm and Franco (2014)) collected during several expeditions in Iraq and Iran and housed in the Field Museum of Natural History, Chicago (Lay, 1967; Zeder, 2006). The bones of these individuals provide a signature typical of wild Asiatic mouflon adapted to meet the climatological, nutritional, physiological, and locomotor challenges of the Zagros Mountains. The sex of these skeletons was documented during field work while age-at-death was estimated based on dental data and epiphyseal fusion.

Skeletons of late 19th-early 20th century CE sheep breeds and populations raised in enclosures constitute a fourth baseline. From the large series stored in the Museum für Haustierkunde, “Julius Kühn”, Halle, we analyzed representative numbers of adult sheep pertaining to the breed “Karakul” (KA) and the population “Swiss Mountain sheep” (SM). The Karakul sheep is a fat-tailed breed native to the Central Asiatic steppes which was bred for their tail fat, their wool and the curly-haired pelt of the fetal and newborn lambs. The first animals were imported from Bukhara (present-day Uzbekistan) to Halle in 1903 (Frölich, 1928; Tänzer, 1928; Wussow, 2013). The breeding program included several crossings with other breeds but for this study only pure-bred Karakuls either imported from Bukhara or their descendants were considered. The Swiss Mountain sheep is a heterogeneous population of rather primitive sheep types purchased in different mountainous regions of Switzerland. Since penned permanently for several generations, both populations witnessed limited movement. In these Karakul and Swiss Mountain sheep feeding conditions were essentially the same. For both populations life data (acquisition, parents, sex and age-at-death) were documented in the records of the museum.

Finally, the feral Soay (SA) sheep population living on St. Kilda in the Outer Hebrides was chosen as the fifth baseline. Although descending from domestic flocks, Soay sheep nowadays survive as feral populations with rare contact to humans (Campbell, 1974;